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Using Local Ecological Knowledge (LEK) to inform the multi-habitat life cycle of wreckfish: A Ligurian Sea case study for Mediterranean conservation

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Abstract

Local Ecological Knowledge (LEK) from fishers and sea users is invaluable for reconstructing the occurrences of data-deficient and vulnerable fish species, particularly target species. This study explores the distribution patterns of the data-deficient wreckfish *Polyprion americanus* in the Ligurian Sea (NW Mediterranean Sea) using semi-structured interviews with 40 sea users (27 fishers and 13 observational data providers). We identified key habitats associated with five main size classes of wreckfish, from surface waters to 1000 m depth, including vulnerable ecosystems like seamounts and cold-water coral habitats. Smaller individuals (0-1.5 kg) were mainly found in pelagic habitats, frequently near floating objects, while larger individuals (>3 kg) were common in slope and seamount habitats. Abundance declines across all size classes were attributed to overfishing and, according to some respondents, a reduction in floating debris may have specifically affected the presence of smaller individuals. Fishing techniques varied by size class, with technological advances notably impacting larger individuals near seamounts. The study supports LEK as a valuable complementary information source to conventional research, advocating for updated conservation measures, including revised size limits and enhanced protection of vulnerable habitats.

Keywords: Data Deficient; overfishing; *Polyprion americanus*; seamount; size limit; vulnerable habitats.

Introduction

The wreckfish *Polyprion americanus* (Bloch & Schneider, 1801) (Family Polyprionidae), is a marine fish characterized by a worldwide distribution, including the Mediterranean Sea (Ball *et al.*, 2000). Known for its impressive longevity (up to 80 years; Lytton *et al.*, 2015) and maximum size (up to 2 m, 100 kg; Roberts, 1989), it exhibits distinct pelagic juvenile and demersal adult phases (Tortonese, 1975; Sedberry *et al.*, 1996). Juveniles are commonly found below floating objects, while adults inhabit benthic environments, often near wrecks or areas of underwater relief, up to 1000 m depth (Bini, 1970; Sedberry *et al.*, 1996; Ball *et al.*, 2000). Globally, the wreckfish is an ecologically and economically significant species, serving as a large-sized predator in marine ecosystems and considered a promising candidate for aquaculture (Papandroulakis *et al.*, 2004; Pérez *et al.*, 2019). However, its late maturation age (>7 years) (Carbonara *et al.*, 2003; Peres & Klippel, 2003; Wakefield *et al.*, 2013) along with suspected spawning aggregations (Smith, 1949; Menni & López, 1979; Ryall & Hargrave, 1984; Peres & Klippel, 2003; Button *et al.*, 2021) make it highly vulnerable to overfishing. Limited knowledge on its life cycle, biology and ecology (Hardy, 1978; Carbonara *et al.*, 2003) further complicates effective assessment and management. This lack of information is reflected in the wreckfish's classification as Data Deficient in the IUCN Red List global assessment (Sadovy, 2003).

In the Mediterranean Sea, the wreckfish is considered of minor commercial importance due to its low occurrence in commercial catches, with limited data on abundance and population trends (Yokes *et al.*, 2011). Therefore, it is also classified as Data Deficient in the Mediterranean by the IUCN Red List (Yokes *et al.*, 2011), although recent regional assessments range from Near Threatened (European assessment; Collette *et al.*, 2015) to Vulnerable (Italian assessment; Relini *et al.*, 2017), reflecting potential population declines. Despite these concerns, the only conservation measure currently in place in the Mediterranean Sea is the minimum landing and marketing size, equaling 45 cm, as outlined in Council Regulation (EC) No. 1967/2006 (European Council, 2006). However, this size limit lacks any biological basis, as it was set to match the size established for groupers (family Epinephelidae) based on the wreckfish's grouper-like traits.

In the Mediterranean region, the species may hold historical and cultural significance. Curiously, it is depicted in ancient coinage from Akragas (modern Agrigento, Sicily) dating back to the late 6th-early 5th century BCE (Imhoof-Blumer & Keller, 1889; Ward, 1902; Rizzo, 1946). The fish representation on coins likely reflects its abundance and importance as a food resource. In the Mediterranean, wreckfish are caught by diverse fishing tools across various habitats. The species is primarily targeted by angling and bottom longlines (Bini, 1970; Yokes *et al.*, 2011), but it is also caught by bottom trawlers (Smith, 1949; Bini, 1970) and swordfish longlines (Garibaldi, 2015). Fishing activities may impact wreckfish populations, in the Mediterranean and beyond, as studies have shown that many individuals caught and marketed are below the size of sexual maturity, estimated to be 80-90 cm total length (Carbonara *et al.*, 2003; Peres & Klippel, 2003; Diogo & Pereira, 2013; Mavruk *et al.*, 2018). For instance, most wreckfish marketed in Galicia were found to be immature (Linares *et al.*, 2021), while those caught in the Azores and off Turkey were, on average, below the size of sexual maturity. High demand and rising costs have also led to frequent mislabeling of cheaper fish species (e.g., the Nile perch *Lates niloticus*) as wreckfish (Asensio *et al.*, 2002).

Based on the above, further research is needed to assess wreckfish population status and inform science-based conservation measures. Monitoring wreckfish populations, however, is extremely challenging. In the Mediterranean Sea, fishing experimental surveys (D'Onghia *et al.*, 2012) and deep remotely operated vehicles (ROV) are the most commonly used study methods (Canese & Bava, 2015; D'Onghia *et al.*, 2015; Bo *et al.*, 2021). Yet, the use of ROV has provided only a few occasional records of wreckfish in the region (Canese & Bava, 2015; D'Onghia *et al.*, 2015).

In recent years, Local Ecological Knowledge (LEK) has become a valuable resource for research, particularly for understanding the biology and ecology of commercially important fish species, especially when scientific data is scarce or unavailable (Johannes, 1978; Johannes *et al.*, 2000; Hamilton *et al.*, 2012). LEK is a valuable means of assessing trends in fish abundance, identifying key habitats, and understanding life cycles, often offering information that is difficult to obtain through traditional scientific approaches. The value of LEK has been more and more recognized as crucial for achieving management and conservation goals (Azzurro *et al.*, 2019; Silvano *et al.*, 2023). LEK, in fact, can be a precious complementary source of information integrating scientific knowledge, and a bridge between communities and conservation goals, as it may offer insights into sustainable and customary practices, support dialogue and ultimately promote community-based conservation (Silvano *et al.*, 2017).

This study aimed to collect past and present occurrence data of the wreckfish in the Ligurian Sea (NW Mediterranean Sea) using LEK. The Ligurian Sea was selected as a case study within the Mediterranean basin, described as a "miniature ocean" (Bethoux *et al.*, 1999; Lejeusne *et al.*, 2010), due to its unique oceanographic and geomorphological characteristics, which make it an ideal setting for investigating the entire life cycle of the species. These features include a narrow continental shelf (10-20 km) (Relini, 2007), steep slopes with submarine canyons, and a permanent cyclonic circulation driven by the Western Corsica/Mediterranean Current (WCC) and the Tyrrhenian Current (TC) (Cattaneo-Vietti *et al.*, 2010; Canepa *et al.*, 2015), which promotes nutrient upwelling and high primary productivity (Cattaneo-Vietti *et al.*, 2010). Such conditions influence the reproductive biology and recruitment of many species, including commercially important fish (Cattaneo-Vietti *et al.*, 2010). Furthermore, the Ligurian Sea coasts are highly urbanized and host >80 marinas, and numerous harbours and ports serving as key hubs for trade, tourism, and maritime activity (Cattaneo-Vietti *et al.*, 2010). Therefore, these areas increase the likelihood of interaction between local sea users, and marine resources and ecosystems. Historical data (1898) report the wreckfish as a common year-round catch in the Ligurian Sea (Cattaneo-Vietti *et al.*, 1985). However, catches in the area have declined, with no recent records from surveys conducted in habitats where the species was once commonly fished (Bo *et al.*, 2021).

This study aims to utilise LEK to address knowledge gaps concerning wreckfish habitat usage throughout its life cycle, the status of Ligurian wreckfish populations, and the fishing practices impacting the species. Our primary aim is to contribute to the assessment of the species' conservation status and provide relevant information potentially useful for the management and conservation of the wreckfish populations in the Mediterranean.

Materials and Methods

Records of the past and present occurrence of wreckfish in the Ligurian Sea were collected using a Local Ecological Knowledge (LEK) approach. Individual interviews were conducted with various sea users, employing two types of structured questionnaires (see Annex) to collect two categories of data: 1) fishing data, including information from both recreational and professional fishing activities, and 2) observational data provided by boaters, whale watchers, technical divers, dive photographers, and fish vendors. Informed consent was obtained verbally from all individual participants included in the study, as this was the most appropriate method for the research context. Participants were assured of their anonymity, with any identifying information removed unless they explicitly chose to disclose it. Formal ethical approval was not required for this study, as per local regulations; however, ethical standards were met through the careful handling of sensitive data and the respect for participants' privacy.

Since the interviewees included people without a scientific background and non-professional fishers, we first ensured they could accurately identify the wreckfish by showing them pictures of grouper species found in the same areas. The interviewees were asked the geographical areas and periods in which wreckfish were caught or observed, and on changes in the species' abundance over the years. Respondents were asked about the size (either weight or total length) and the number of specimens caught or observed per encounter, including size and number ranges when multiple individuals were caught or seen. Additional details collected from fishers included the fishing gear used to catch wreckfish, whether the gonads appeared mature, the co-occurring fish species, and the market value of wreckfish. Photographs of wreckfish specimens were collected whenever available and published with the consent of the interviewees.

Respondents consistently reported wreckfish size in terms of weight rather than length. Accordingly, for the analyses, wreckfish were categorised into size classes by weight. However, to allow comparison with previous studies that report size in terms of length, weight data were occasionally converted to estimated total length (TL) using the wreckfish length-weight relationship from FishBase (Froese & Pauly, 2024).

Key habitat types were identified at geomorphological scale based on the information gathered in the interviews. To infer the distribution and life cycle of the wreckfish, the presence of each size class across the main habitat types was assessed based on the number of respondents reporting their occurrence.

For each size class, the wreckfish conservation status was assessed based on respondent's reports of temporal abundance trends, which were classified as 'decreasing', 'stable', 'increasing' or 'NA' if respondents were unable to determine a trend, and summarised in a bar chart. Additionally, data on the types of fishing gear used to catch wreckfish were illustrated and analysed to determine the use of specific gear for each size class using bar charts.

Chi-square tests were used to determine the dependencies of habitat types, temporal abundance trends and employed fishing gears with the size classes of wreckfish.

Results

Forty interviews took place between April 2022 and December 2024. Of these, 27 were addressed exclusively to fishers, including both professional and recreational fishers, while 13 were addressed to individuals who provided observational data, some of them being also engaged in recreational fishing. Interviewees were identified through local contacts or approached directly at local harbours, using a convenience sampling approach (see Bennett *et al.*, 2024).

Reported wreckfish were divided into five size classes, based on those most commonly indicated by the respondents (0-0.4 kg, 0.4-1.5 kg, 1.5-3 kg, 3-10 kg, >10 kg). Five main habitat types were identified - pelagic neritic, pelagic oceanic, continental shelf break, slope, seamount - based on the depth at which specimens were recorded. For pelagic individuals, habitat classification was based on their position relative to the bottom, with pelagic neritic over the continental shelf and pelagic oceanic beyond it, over the continental slope and abyssal plain. Demersal habitats were defined by bottom depth. Specifically, the depth of 200 meters was used as a threshold to distinguish pelagic neritic from pelagic oceanic habitats, and continental shelf from slope habitats (Enrichetti *et al.*, 2019). There was a significant dependency between habitats and size classes ($\chi^2 = 89.56$, df = 16, P < 0.001). In pelagic neritic and oceanic habitats, smaller size classes (0-0.4 kg and 0.4-1.5 kg ranges) were highly prevalent, with almost the same relative abundances. The occurrences of larger size classes were significantly lower and no records were registered for the >10 kg class. On the continental shelf break, smaller size classes were absent and only mid-to-large size classes were represented, with a dominance of the 3-10 kg class. In slope habitats, including canyons and cold-water coral frameworks of living and dead (thanatocenosis) *Desmophyllum pertusum* and *Madrepora oculata* (Bo *et al.*, 2023), the size distribution was similar to that of the shelf break, with the 3-10 kg class being dominant and a slightly higher frequency of 1.5-3 kg individuals. Seamounts were characterized only by the two largest size classes, with a dominance of the >10 kg class. The presence of each size class per habitat type is illustrated in Table 1.

In terms of the maximum number of specimens reported per encounter or fishing trip, smaller-sized individuals were observed and fished in groups of up to 50 specimens in pelagic habitats (e.g., Fig. 1).

Considering larger-sized individuals (>10 kg), the most remarkable catches were made in previously unexploited seamount habitats. Notably, 20 specimens of about 20 kg were caught in a single event at the Ulisse seamount in June 1973 (Bo *et al.*, 2021), while a maximum of 34 individuals were caught in a single event sometime between 1973 and 1976 off Capo Corso. The interviews revealed a decline in the occurrence of most size classes over time (Fig. 2). Although a decrease in abundance was the most common response for almost all size classes, there was a large incidence of 'NA', especially for the smaller classes. For the 0.4–1.5 kg wreckfish, 'NA' was the most frequent answer rather than a reported decline in abundance (Fig. 2).

There was no dependency between trends in abundance over time and size classes, i.e. the abundance of wreckfish tended to decline independently of size (χ^2 = 8.63, df = 12, $P = 0.734$). Respondents suggested that the decline of the smallest class individuals, reported by most interviewees to occur since the early 2000s, was likely due to harvest but also to a general reduction in floating

Table 1. Summary table showing the number of respondents reporting the presence of *Polyprion americanus* specimens, categorized by size class and habitat type.

	Size class (kg)				
Habitat type	0-0.4	0.4-1.5	1.5-3	3-10	>10
Pelagic Neritic	10	18	6	3	0
Pelagic Oceanic	9	15	6	2	0
Continental shelf-break	0	0	1	4	1
Slope	0	1	7	13	4
Seamount	0	0	0	5	7

Fig. 1: Around 30 juvenile wreckfish (0.4-0.5 kg, centre of the photo) were caught on a single fishing trip near an offshore buoy (pelagic oceanic habitat) in the early 1990s, alongside common dentex *Dentex dentex*, black seabream *Spondyliosoma cantharus*, and rudderfish *Centrolophus niger*. Photograph published with the consent of an interviewee, modified to preserve anonymity.

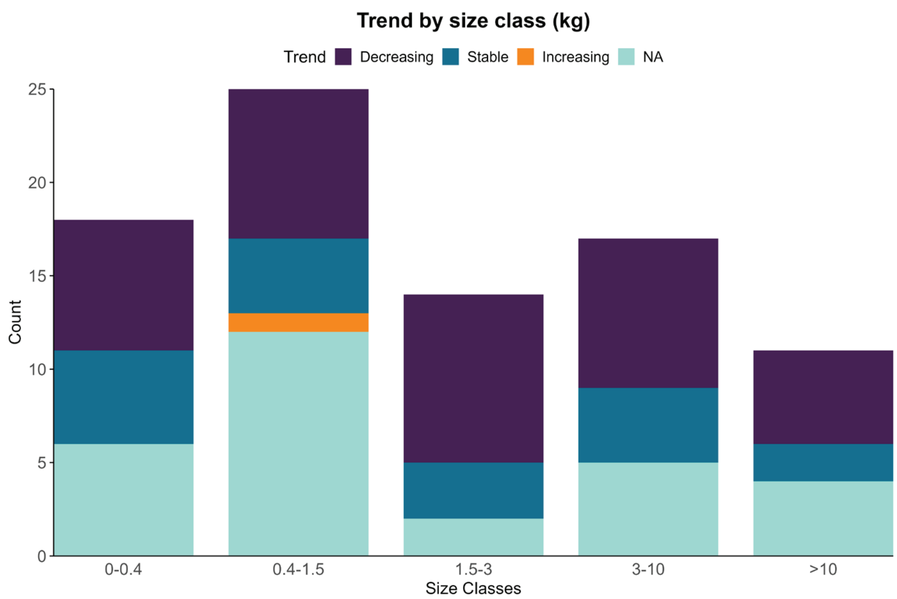

Fig. 2: Grouped bar plot showing the number of respondents reporting the trend (decreasing, stable, or increasing) over time for each identified wreckfish size class (kg) or not providing information (NA).

marine debris, with which small wreckfish are often associated. For larger individuals, respondents emphasized the critical impact of technological advancements in fishing gears. Large individuals, considered fishing trophies, are still caught around seamounts by fishers willing to travel far from the coast and spend significant amounts on fuel when weather conditions are ideal (i.e., flat calm seas and sunny weather).

The analysis of fishing gears used to catch wreckfish revealed a wide range of techniques employed differently across size classes. To clarify our results, we grouped fishing gears into nine categories (Fig. 3).

Bottom longlines and bottom fishing with rods (typically at depths of several hundred meters using electric reels) were reported as the most commonly used techniques, primarily targeting larger size classes. Following these, under-boat lines (baited or with artificial jigs) were frequently used to catch smaller individuals in pelagic habitats near the surface. When lines were not used, other tools such as spearguns, harpoons, and hand nets were employed to catch small pelagic wreckfish. Fishing techniques involving nets were reported less frequently. Both professional and recreational fishers have reported catching wreckfish using "lampara" net fishing that uses a light source, blue strobe lights attached to gillnets, or light baits paired with fishing lines and electric reels as both juveniles (Boero & Guzzardi, 2003) and adults (Ryall & Hargrave, 1984) are known to be attracted to lighted objects.

There was a significant dependency between fishing gear types and size classes ($\chi^2 = 67.38$, df = 32, $P < 0.001$, Fig. 4). Intermediate-sized individuals were caught using nearly all gear types. The 0.4-1.5 kg size class was primarily harvested at the surface with under-boat lines, while the 1.5-3 kg size class was most commonly caught with longlines. The smallest individuals (0-0.4 kg) were caught exclusively with surface fishing methods (spearfishing, harpooning, hand nets, under-boat lines, and seines), whereas the largest ones were almost exclusively caught using longlines and bottom fishing. However, the 3-10 kg specimens were occasionally captured with gillnets or trawling.

Most interviewees did not observe mature gonads in captured specimens, except for one recreational fisher who reported observing them in specimens of >10 kg during summer in slope habitats characterized by cold-water coral frameworks. Another fisher identified a 33 kg individual as female, though with immature gonads.

In terms of species associations, some respondents reported that wreckfish share their habitat with other species, particularly in their juvenile stage. Juvenile wreckfish were mainly observed under floating debris or buoys (Fig. 5), where they were frequently found alongside juveniles of the rudderfish *Centrolophus niger* or the imperial blackfish *Schedophilus ovalis*, occasionally with the pilotfish *Naucrates ductor*, and more rarely with the common dolphinfish *Coryphaena hippurus* or the tripletail *Lobotes surinamensis*. Larger demersal wreckfish were mainly found in areas where the blackspot seabream *Pagellus bogaraveo* was fished. This latter species likely represents a relevant component of the wreckfish diet, as several respondents reported instances of *P. bogaraveo* being preyed upon by wreckfish while hooked in fishing lines.

Interviewees reported that reaching wreckfish fishing grounds, located tens of miles offshore, requires significant time and costs. Nevertheless, interviewees reported also that the wreckfish commercial value remains fairly lower than that of most other species caught and marketed in the study area. For professional fishers, wreckfish is often caught as bycatch on gear targeting other species, such as *Brama brama*, *Lepidopus caudatus*, *Merluccius merluccius*, *P. bogaraveo, S. ovalis*, *Xiphias gladius*. Moreover, fishers reported that large adult individuals are not in demand, either by restaurants or customers, as their consumption results in excessive waste due to the high density of the skeletal structure and cranial bones, which contribute to a high percentage of inedible parts.

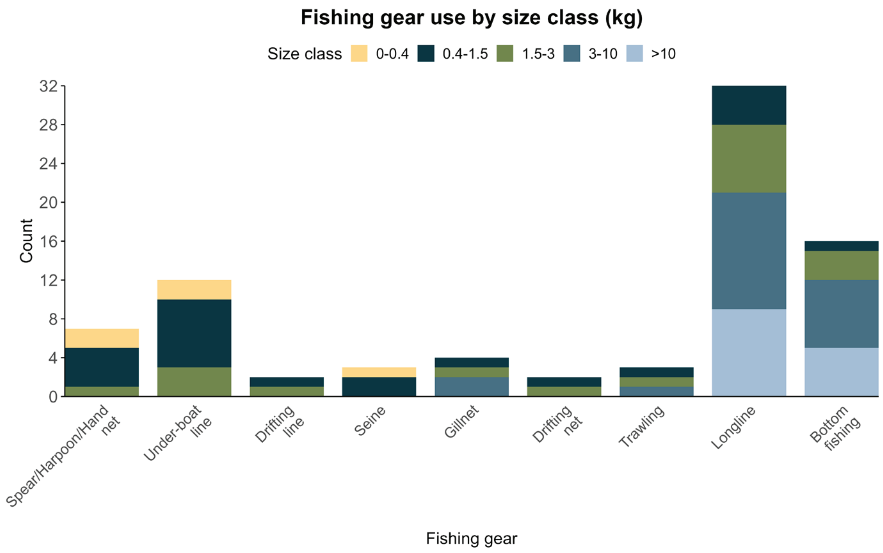

Fig. 3: Stacked bar plot showing the types of fishing gear and the number of respondents who reported using them by wreckfish size class (kg).

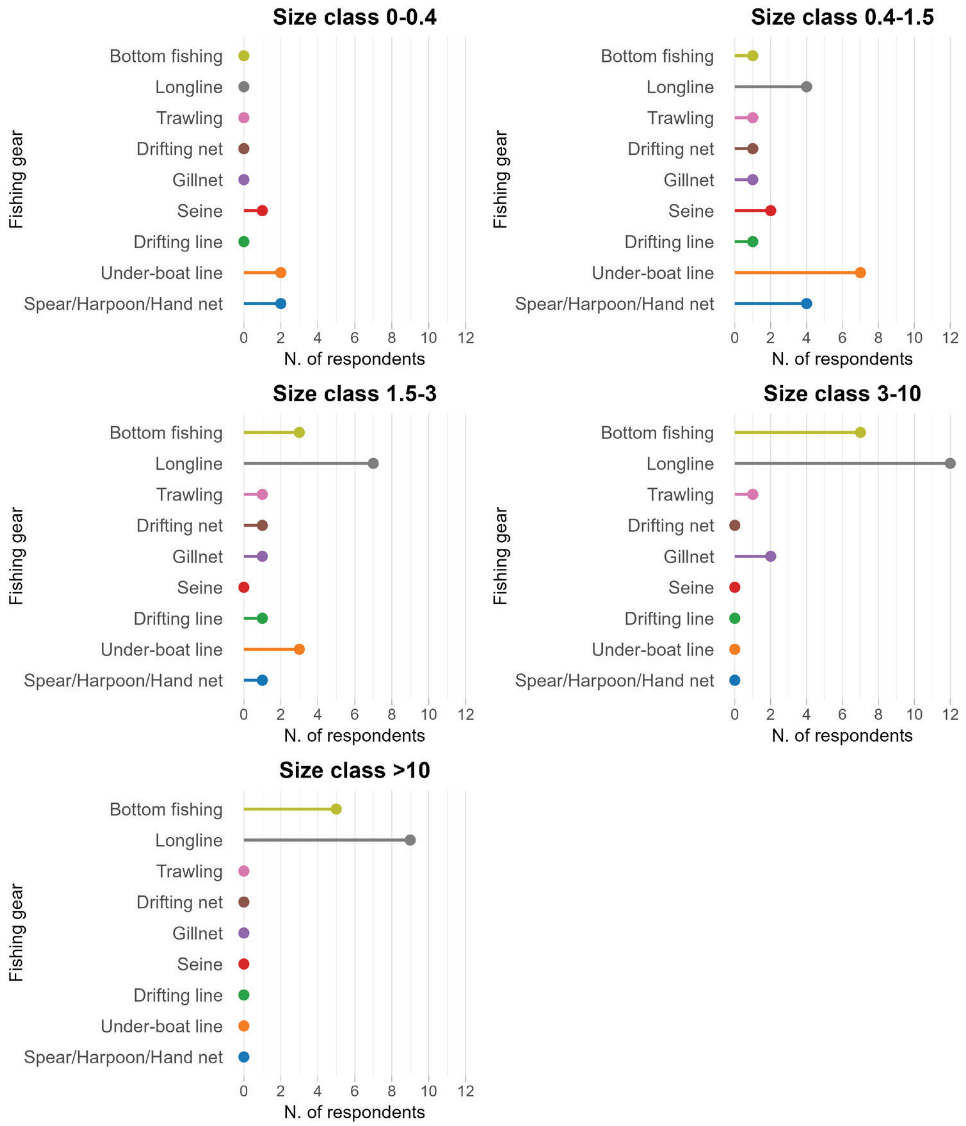

Fig. 4: Lollipop plots showing the types of fishing gear and the number of respondents who reported using them to target each of the five wreckfish size classes (kg).

Discussion

In this study, Local Ecological Knowledge (LEK) provided insights into the wreckfish population in the Ligurian Sea. In particular, LEK helped improve the available knowledge on habitat use, assess conservation status, and identify the main types of fishing gear impacting wreckfish in the study area. This region is particularly suitable for studying deep-water species through LEK, as its narrow continental shelf and accessible deep-sea features (e.g., slopes and seamounts) enable frequent interactions between fishers and target species like the wreckfish. Our results highlight a clear ontogenetic shift in habitat use across three broad life stages: pelagic juveniles, demersal subadults, and large adults. These findings contribute to existing knowledge of the species' life cycle (Fig. 6) while also revealing new patterns specific to the Ligurian Sea.

Wreckfish juveniles (0-1.5 kg) were primarily found in pelagic habitats and typically associated with floating objects, as previously reported elsewhere (Sedberry *et al.*, 1999), with no apparent spatial segregation by size between neritic and oceanic domains. This is likely related to the fact that the wreckfish is known to have a prolonged pelagic phase during which marine currents likely influence juvenile dispersal and population gene flow throughout its geographic range (Ball *et al.*, 2000). Such dynamics help to explain the occasional yet recurrent presence of juveniles in shallow areas such as the Gulf of Trieste in the northern Adriatic Sea (Bettoso *et al.*, 2020). Juveniles were found under various types of objects, including buoys - as previously documented in the literature (Relini *et al.*, 1994; Deudero & Morales-Nin, 2000; Andaloro *et al.*, 2007) - as well as branches, crates, debris, and even live or dead organisms such as the loggerhead sea turtle *Caretta caretta*. In some coastal fishing villages along the Ligurian Sea, the wreckfish is known as '*mangia-morti*' (literally 'dead-people eater') as juveniles were found under floating cadavers, often the remains of crew members from ships torpedoed and sunk during World War II (Gambazza S., personal communication).

The 1.5-3 kg size class marked the onset of the demersal phase, with individuals reported both in pelagic

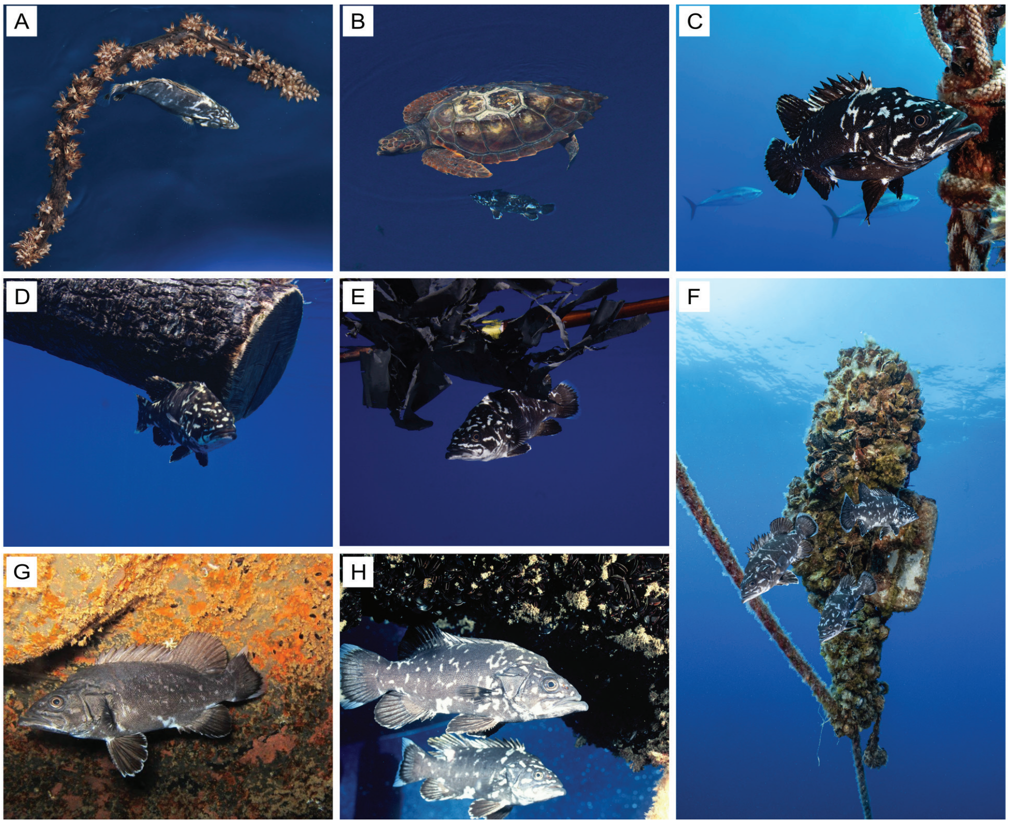

Fig. 5: Objects under which juvenile *Polyprion americanus* were observed. (A) A branch colonized by the barnacle *Lepas anatifera*; (B) A loggerhead sea turtle *Caretta caretta*; (C) A mooring rope for dive boats at the wreck of the Haven oil tanker (a technical diving site) - Close-up of a juvenile in front of two *Thunnus thynnus* specimens; (D) A floating log; (E) A lost fishing gear marker; (F) A mooring buoy at the wreck of the Haven oil tanker; (G) An offshore buoy 2 miles from the coast; (H) An offshore oil platform. Pictures shared with the consent of the photographers: (A, B): Gianni Lucchi; (C): Alessandro Grasso; (D, E): Enrico Maggioni; (F): Marco Panico; (G): Paolo Cappucciati; (H): Vincenzo Paolillo.

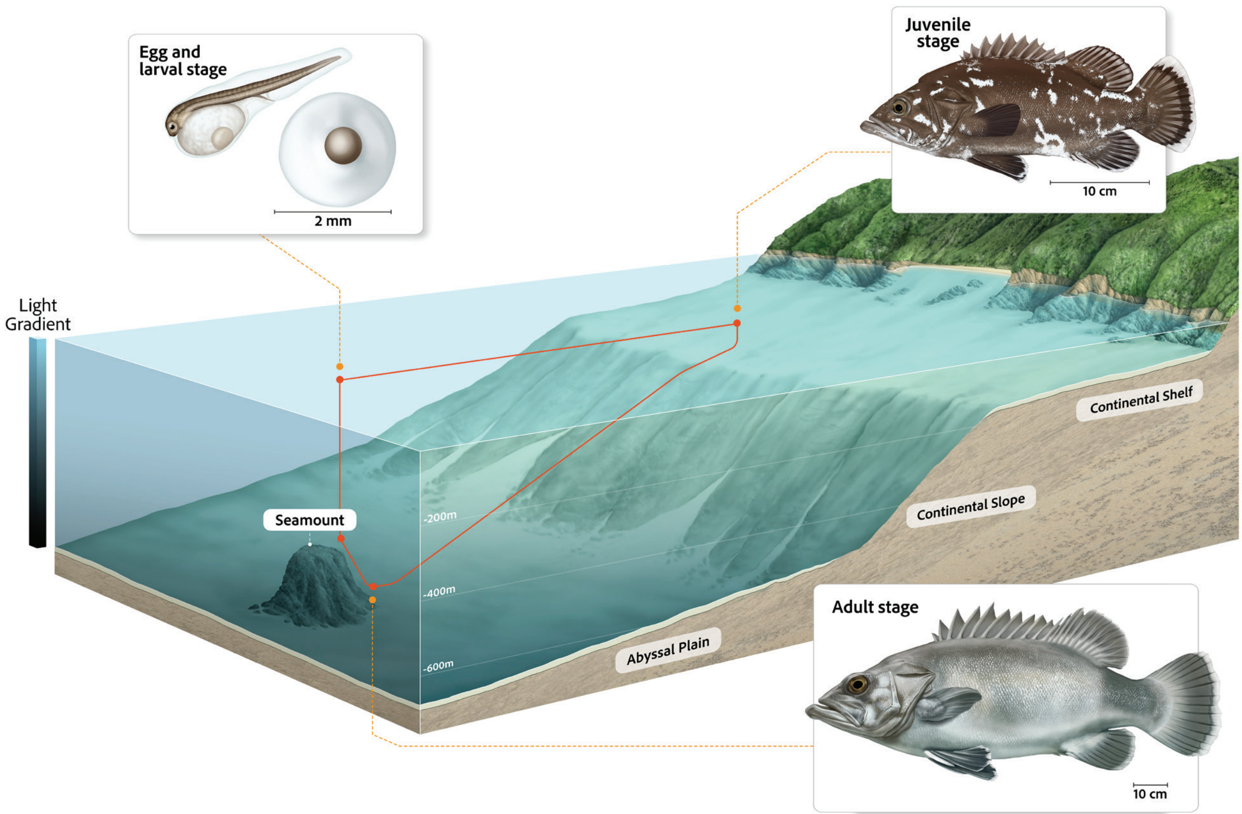

Fig. 6: Life cycle of the wreckfish in the Ligurian Sea. Image created by Stefano Trainito, modified and used with permission.

waters and near the seabed, particularly along the shelf break and slope. This size class corresponds to individuals measuring 45-57 cm TL, which aligns with reported recruitment sizes in the literature - ranging from 46 to 66 cm TL - in the northern distribution range of the species (Atlantic and Mediterranean waters) (Roberts, 1977, 1989; Relini *et al.*, 1994; Sedberry *et al.*, 1998; Deudero & Morales-Nin, 2000; Machias *et al.*, 2003; Andaloro *et al.*, 2007). In fact, the timing of recruitment seems to be influenced by size, alongside ambient temperature, and is accompanied by morphological changes (Machias *et al.*, 2003).

Subadult wreckfish (3-10 kg) were primarily reported along the shelf break and slope habitats, while adults (>10 kg) were mostly found near seamounts. This distribution pattern suggests an ontogenetic habitat shift culminating in adult residency in offshore areas. In some regions, the slope is known as a relevant habitat for adult wreckfish and for spawning, which is reported to occur in deep waters (>400 m) (Glukhov & Zaferman, 1982; Sedberry *et al.*, 1999, 2006). The wreckfish is a gonochoric species (Roberts, 1989) that likely forms spawning aggregations. In the western North Atlantic, spawning occurs on the Blake Plateau, particularly in an area of high relief and upwelling known as the Charleston Bump, which rises from the continental slope (Brooks & Bane, 1978; Sedberry *et al.*, 1996). In the Southwestern Atlantic, potential spawning aggregations have been suggested along the continental slope (300-500 m) off southern Brazil, based on gonadal analysis and commercial catch data (Peres & Klippel, 2003). In South Africa, remote observations near deep cold-water corals on the Amathole shelf-edge have also indicated possible spawning aggregation behavior (Button *et al.*, 2021). These spawning sites share common environmental conditions, such as high pressure, absence of light, rocky bottoms, the presence of ridges/relief, and upwelling.

However, in the Ligurian Sea, the shelf break and slope do not appear to serve as primary spawning areas. While the 3-10 kg size class partially overlaps with the reported maturation range (8-11 kg, FishBase; Froese & Pauly, 2024), most individuals in this size class are likely still immature. This is further confirmed by fishers, who never observed mature gonads in individuals of this size. In contrast, the presence of larger fish on seamounts supports the hypothesis that spawning may occur in these offshore, structurally complex habitats.

Identifying spawning sites is essential for protecting critical habitats for reproduction, yet the depth range of wreckfish poses a challenge for locating these areas and few data exist on its reproductive activity. While research has been conducted on wreckfish reproductive development (age at maturity, gonadal development, and fecundity), no direct observations on its spawning behaviours exist, neither in captivity, where male breeding behaviours may be impaired (Papadaki *et al.*, 2018), nor in the wild. Wreckfish spawn over a protracted period, typically from late autumn to early spring, though timing varies by region. Reported spawning periods include November-May in the North-Atlantic (Sedberry *et al.*, 2006), January-April in the Gulf of Naples (Bini, 1970), late autumn-winter in the North-Western Ionian Sea (Carbonara *et al.*, 2003) and February-March (late winter to early spring) in the Eastern Mediterranean (Cretan Sea) (Bini, 1970). However, spawning has also been reported in July (summer) in the Strait of Messina (Bini, 1970). Juvenile wreckfish are most abundant in surface waters during summer in Mallorca (July-August) and the Ligurian Sea (August) (Relini *et al.*, 1994; Deudero & Morales-Nin, 2000) and in autumn-winter (October-March) off Sicily (Andaloro *et al.*, 2007). In our study, most fishers reported never having found mature gonads in captured specimens, except one interviewee. The near absence of reported mature gonads in caught fish is likely due to fishing trips to seamounts occurring only during the “good season” (late spring and summer), a period that does not coincide with the primary spawning season identified in recent literature.

While the IUCN classifies wreckfish as Data Deficient in the Mediterranean and Vulnerable in Italy, our findings indicate a population decline across all size classes or life stages. Overfishing is likely to be a key factor, with numerous fishing techniques directly or indirectly targeting wreckfish. During the pelagic phase, juveniles are caught using hand lines or rod-and-reel setups, often baited with natural or artificial lures. Fishers described juvenile wreckfish as highly voracious, making them easy to catch in large numbers. Other fishing methods also impact this stage, contributing to its vulnerability. Respondents reported catching dozens of juvenile wreckfish in single events, suggesting that this species may be at risk of overexploitation at early life stages. Uncontrolled catches of juveniles could lead to ‘growth overfishing’, where excessive capture of juveniles prevents individuals from reaching reproductive maturity. This is particularly concerning given the minimum legal size of 45 cm, which is below the species’ size at maturity (~80-90 cm total length). The fishing of juvenile wreckfish is likely to have occurred since historical times, as their presence in surface waters makes them more accessible than adults. This is supported by an artwork from Santorini, Greece (1500 B.C.), which depicts a man carrying multiple common dolphinfish *C. hippurus* (Begossi & Caires, 2015), a species that shares the pelagic habitat with wreckfish. Juvenile wreckfish were reported to share “shaded environments” with the juveniles of other species known to be attracted to floating objects (Castro *et al.*, 2001), including *C. niger* and *S. ovalis*, both common in the Ligurian Sea, and the rare *L. surinamensis*. Similarly, *N. ductor* and *C. hippurus* are frequently associated with floating objects and may be vulnerable to the same fishing techniques during juvenile stages. Respondents also suggested that juvenile wreckfish encounters have declined due to reduced marine debris. Legislative actions (EU, 2000), mild negative trends in summer rainfall in the northern Ligurian Sea (1998-2017) (Kalimeris & Kolios, 2019), and a general decrease in waste may have reduced the number of floating objects serving as shelters for juveniles, while also offering fewer opportunities for people traveling at sea to encounter wreckfish near floating wreckage.

As wreckfish recruit on the continental shelf, slope, or seamounts, they become susceptible to longline and bottom fishing. Longlines are used by both professional and recreational fishers, while bottom fishing is mostly practiced by advanced recreational fishers using highly technological equipment (e.g., electric reel). Unlike in other regions, like the Southern Atlantic (Gauvin *et al.*, 1994), wreckfish is rarely the primary target of fishing operations in the study area. Instead, it is usually caught incidentally during multi-species fishing for *P. bogaraveo, Brama brama, Lepidopus caudatus, Merluccius merluccius, S. ovalis, Xiphias gladius*, and other less common species. In shelf and slope habitats, medium-sized wreckfish (1.5–10 kg) are also caught as bycatch in gillnets or trawling operations.

The main reason for the decline of medium- and large-sized wreckfish is thus likely overfishing. Furthermore, the deep-water habitats inhabited by wreckfish are home to fragile structural organisms, such as cold-water corals, which can be easily damaged by fishing gear (Bo *et al.*, 2021). Cold-water coral habitats are recognised as vulnerable habitats (Bo *et al.*, 2021) that serve as nurseries and spawning grounds for many commercially valuable species (Baillon *et al.*, 2012).

Our study, in conclusion, highlights the importance of protecting habitats critical to different ontogenetic stages of wreckfish, from pelagic zones to offshore, deep-water spawning habitats, and suggests the need for enhanced protection measures in these critical areas. These findings also emphasize the need to update the minimum legal size for this species in the Mediterranean Sea to prevent overfishing, as both juveniles and adults are particularly vulnerable to fishing pressure. Although further biological and ecological data are needed to advance our knowledge on the species and assess its conservation status, the LEK-based information presented here provides new insights into the wreckfish life cycle and its fishery in the Ligurian Sea. Notably, the consistency of responses across different sea users (i.e., fishers and other categories of observers) reinforces the reliability of the patterns identified. Nonetheless, some limitations of LEK must be acknowledged, such as the lack of information on sex or maturity. Despite these gaps, the results provide valuable data for local population assessments and the development of management and conservation measures at the Mediterranean scale.

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Appendix

This document contains the two types of questionnaires used in the study: the Fishing Data questionnaire and the Observation Data questionnaire.

FISHING DATA QUESTIONNAIRE

INFORMATION ON CATCHES

1. Have you ever caught wreckfish?
2. The first time you caught it, how could you be sure it was this species?
3. In which years and seasons did you catch it?
4. How many specimens (approximately) have you caught, and where? Please indicate the locations.
5. What gear did you use? Has it remained the same over the years? (Please specify the exact years, if possible)
6. What is the size range (length/weight) of the specimens you have caught?
   - Minimum size:
   - Most common size:
   - Maximum size:
7. Have you ever opened (gutted) the captured specimens?

If so:
   - Have you identified male/female specimens and/or observed eggs/milt?
   - Have you recognized what the specimen has eaten?
8. In general, where is the wreckfish most likely to be caught?

Wreckfish size	Season	Habitat	Depth	Site (whenever possible)

9. Over time, how has the trend in catches changed?

		From what year to what year	Size
■	Stable		
■	Increasing		
■	Decreasing		
■	NA		

10. Do you remember any exceptional catches of other fish species (very large ones and/or with eggs/milt)?

SOCIO-ECONOMIC INFORMATION

11. Have you ever sold wreckfish, and at what price?

12. During the same period, at what price did you sell the following:

   - Sea bass __________
   - Dusky grouper __________
   - Common dentex __________
13. Who did you mainly sell your catch to?

   - Private individuals ____%
   - Restaurateurs/Hoteliers ____%
   - Wholesalers ____%
   - Fishers ____%

14. Who do you currently sell the specimens to, and how much do you earn from selling them? Is there demand for them?

15. Do you know if there is a minimum catch size?

OBSERVATION DATA QUESTIONNAIRE

INFORMATION ON OBSERVATIONS

1. Have you ever seen a wreckfish?
2. The first time you saw it, how could you be sure it was this species?
3. In which years and seasons did you observe it?
4. Total number of trips (from year ____ to year ____):
5. Number of trips/observation frequency where floating wreckage was recorded **without** wreckfish:
6. Number of trips/observation frequency where floating wreckage was recorded **with** wreckfish:
7. How many specimens (approximate number) have you seen in total, and in which areas? Please indicate the sites, whenever possible.
8. What is the minimum, maximum, and most frequently observed number of specimens per floating wreckage/site?
   - Minimum n°/range:
   - Most common n°/range:
   - Maximum n°/range:
9. What is the size range (length/weight) of the observed specimens?
   - Minimum size:
   - Most common size:
   - Maximum size:
10. What type of floating wreckage were the wreckfish found under?
11. Were other species present as well?
12. In general, where is it most likely to see wreckfish?

Wreckfish size	Season	Habitat	Depth	Site (whenever possible)

13. Over time, how has the frequency of observations changed?

		From what year to what year	Size
■	Stable		
■	Increasing		
■	Decreasing		
■	NA		

Specific record information of *Polyprion americanus*
especially if more than one individual was observed

	Observation #1	Observation #2	Observation #3	Observation #4	Observation #5
Photo ID (if available)					
Size (total length or weight)					
N. of specimens					
Wreckage type					
Area or depth					
Weather conditions					
Date or season					
Co-occurring species					