Original Research Article
ISSN: **3041-5357**
Journal homepage: https://diversity.researchfloor.org/

Journal of Diversity Studies

Occurrence and Bycatch Records of the Critically Endangered Angel Shark (*Squatina squatina* Linnaeus, 1758) in the Coastal Waters of the Gaza Strip, Palestine

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ABSTRACT

The Angel Shark (Squatina squatina Linnaeus, 1758) is a Critically Endangered species that has undergone severe declines throughout the Mediterranean Sea. Information on its occurrence in the southeastern Mediterranean remains limited. This study documents rare records of the Angel Shark from the coastal waters of the Gaza Strip, Palestine, and provides baseline information on its occurrence, habitat, capture methods, and fishery interactions. Data were obtained through field surveys at fisheries landing sites and fish markets, complemented by interviews with fishermen, fish traders, and fisheries officials. Recorded specimens measured approximately 70–150 cm in total length, suggesting the presence of different ontogenetic stages, and exhibited the characteristic morphological features of the Angel Shark. Occurrences were highly sporadic, with no clear spatial or seasonal pattern. The species was consistently associated with sandy continental shelf habitats and was captured exclusively as incidental bycatch, mainly by bottom trawls, and less frequently by gillnets, trammel nets, and bottom longlines. Annual landings were estimated at fewer than 12 individuals, and most captured specimens were retained for local consumption. Local Ecological Knowledge (LEK) confirmed that the Angel Shark is among the rarest sharks encountered in Gaza Strip fisheries. This study constitutes the first focused record of the Angel Shark from Palestinian Mediterranean waters, confirming the species' persistence in the southeastern Mediterranean despite its apparent rarity. Improved bycatch monitoring, species-specific reporting, and regional conservation efforts are recommended to support the conservation of this Critically Endangered shark.

Keywords: *Angel Shark; Squatina squatina; Elasmobranchs; Bycatch; Artisanal Fisheries; Conservation; Critically Endangered Species; Mediterranean Sea; Gaza Strip; Palestine.*

Citation: Abdel Fattah N. Abd Rabou [2026]. Occurrence and Bycatch Records of the Critically Endangered Angel Shark (*Squatina squatina* Linnaeus, 1758) in the Coastal Waters of the Gaza Strip, Palestine. *Journal of Diversity Studies.*
DOI: https://doi.org/10.51470/JOD.2026.5.1.221

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Article History: *Received 13 February 2026 | Revised 15 March 2026 | Accepted 12 April 2026 | Available Online May 16, 2026*

1. INTRODUCTION

The Mediterranean Sea (2,500,000 km^2) is recognized as one of the world's most important marine biodiversity hotspots, supporting a rich assemblage of marine organisms despite occupying less than 1% of the global ocean surface [1] [2]. Its unique geographic position between Europe, Asia, and Africa, combined with diverse habitats ranging from coastal lagoons and seagrass meadows to deep-sea environments, has promoted the evolution and persistence of numerous marine taxa [3]. Among its most ecologically significant vertebrates are the cartilaginous fishes (Class Chondrichthyes), which include sharks, rays, skates, and chimaeras. These species play vital roles in maintaining marine ecosystem structure and function through their positions as apex predators, mesopredators, and benthic consumers [4]-[6].

The Mediterranean Sea harbors one of the richest chondrichthyan assemblages worldwide, with more than 80 species of sharks and rays reported from its waters. Nevertheless, many Mediterranean cartilaginous fishes have experienced substantial population declines over recent decades as a result of overfishing, bycatch, habitat degradation, pollution, coastal urbanization, and climate-related environmental changes [7]-[9]. Because many elasmobranchs exhibit slow growth, delayed sexual maturity, low reproductive rates, and long life spans, they are particularly vulnerable to anthropogenic pressures and often recover slowly following population depletion [10].

Sharks constitute an important component of Mediterranean marine ecosystems and occupy a broad range of ecological niches. They contribute significantly to the regulation of prey populations and the maintenance of trophic balance within marine food webs [11]. Historically, several shark species were abundant throughout the Mediterranean Basin; however, intensive fishing activities have caused severe reductions in many populations. Consequently, the Mediterranean Sea is currently considered one of the global regions most affected by elasmobranch declines, with numerous shark species classified as Vulnerable, Endangered, or Critically Endangered by the International Union for Conservation of Nature (IUCN) [12] [13].

Among the shark fauna of the Mediterranean Sea, Angel Sharks (Order: Squatiniformes; Family: Squatinidae) represent a unique evolutionary lineage and are regarded as one of the most threatened groups of elasmobranchs in the region. Angel Sharks differ markedly from typical sharks in possessing strongly flattened bodies, broad wing-like pectoral fins, dorsally positioned eyes, and cryptic coloration that allows them to remain concealed on sandy and muddy seabeds. These adaptations enable them to function as highly effective ambush predators that feed primarily on fishes, cephalopods, and crustaceans [14]. Due to their benthic lifestyle and close association with coastal habitats, Angel Sharks are particularly susceptible to capture by bottom trawls, gillnets, trammel nets, and other demersal fishing gears [15].

The Mediterranean Sea supports three native angel shark species: The Angel Shark (*Squatina squatina* Linnaeus, 1758), the Sawback Angelshark (*Squatina aculeata* Cuvier, 1829), and the Smoothback Angelshark (*Squatina oculata* Bonaparte, 1840) [15]. All three species have experienced severe population declines and are currently classified as Critically Endangered due to extensive range contractions, overexploitation, and ongoing habitat degradation throughout much of their historical distribution [15]-[20]. Recent records of the Smoothback Angelshark and the Sawback Angelshark from various Mediterranean localities have emphasized the importance of documenting rare angel shark occurrences, particularly in regions where scientific information remains limited [21]-[27]. Furthermore, updated records of the Smoothback Angelshark from the eastern Mediterranean indicate that remnant populations persist despite their highly fragmented distribution [28]. Accurate identification of angel sharks remains an additional challenge, as the close morphological resemblance between the Angel Shark and the Sawback Angelshark can lead to misidentification, particularly in fisheries-dependent datasets and historical records [29].

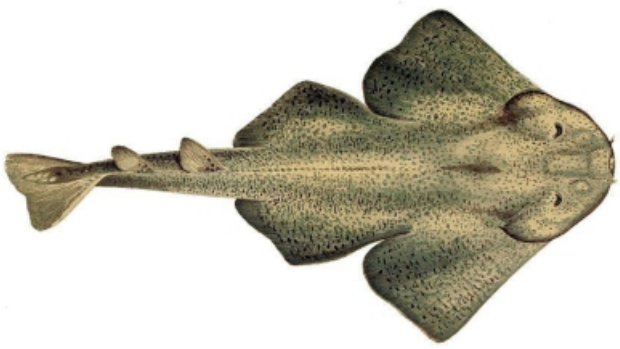

Figure 1: The Critically Endangered Angel Shark (Squatina squatina Linnaeus, 1758), showing its flattened body, broad pectoral fins, dorsally positioned eyes, and cryptic coloration adapted for concealment on sandy and muddy seabeds.
Source: *https://en.wikipedia.org/wiki/Squatina_squatina*

The Angel Shark (*Squatina squatina* Linnaeus, 1758), also known as the Common Angel Shark, is considered one of the most emblematic and critically threatened elasmobranchs inhabiting the Mediterranean region (Figure 1). Historically, the species was widely distributed throughout the northeastern Atlantic Ocean, Mediterranean Sea, and Black Sea, where it inhabited coastal and continental shelf environments characterized by sandy, muddy, and mixed substrates [30]-[41]. The species is generally sedentary, spending much of its time partially buried in sediment while waiting for prey to approach. Such behavior, coupled with its preference for shallow coastal habitats, has made it particularly vulnerable to fisheries exploitation and habitat disturbance [15].

During the twentieth century, populations of the Angel Shark declined dramatically throughout most of their historical range. The species has disappeared from many areas where it was formerly common, and current records are generally limited to isolated captures, fishery bycatch, or sporadic observations [12] [42]. As a result, the Angel Shark is currently listed as Critically Endangered (CR) on the IUCN Red List of Threatened Species, reflecting severe population reductions and continuing threats from fisheries and habitat degradation [43].

Recent studies have documented surviving populations and occasional records of the Angel Shark from several Mediterranean countries, including Türkiye, Tunisia, Algeria, Malta, Cyprus, Greece, Egypt, and Lebanon [44]-[55]. These reports indicate that although the species has become rare throughout much of the Mediterranean Basin, remnant populations continue to persist in certain localities. Consequently, every confirmed record contributes valuable information concerning the species' distribution, population status, habitat use, and conservation requirements [41].

The southeastern Mediterranean Sea remains one of the least studied regions regarding cartilaginous fish diversity and conservation. Within this region, the coastal waters of the Gaza Strip constitute a relatively small but ecologically important marine area supporting diverse fish communities and valuable fishery resources [56]-[58]. Recent investigations have increasingly revealed the presence of several rare, threatened, and globally significant elasmobranch species in the Gaza Strip's marine ecosystem, including the Bluntnose Sixgill Shark (*Hexanchus griseus*), Shortfin Mako Shark (*Isurus oxyrinchus*), Giant Devil Ray (*Mobula mobular*), Honeycomb Whipray (*Himantura uarnak*), Angular Roughshark (*Oxynotus centrina*), Whale Shark (*Rhincodon typus*), Scalloped Hammerhead Shark (*Sphyrna lewini*), carcharhinid sharks, guitarfishes, electric rays, and the Spiny Butterfly Ray (*Gymnura altavela*) [59]-[69]. These findings emphasize the regional importance of the Gaza Strip waters as a habitat, migratory route, and occasional refuge for several threatened cartilaginous fishes.

Despite the growing documentation of sharks and rays from the Gaza Strip, information concerning the occurrence of the Angel Shark remains extremely limited. Given the species' Critically Endangered status and its rarity throughout the Mediterranean Sea, documenting any occurrence in Palestinian waters is of considerable scientific and conservation importance. Therefore, the present study reports rare occurrence and bycatch records of the Critically Endangered Common Angel Shark (*Squatina squatina* Linnaeus, 1758) from the Mediterranean coastal waters of the Gaza Strip, Palestine, providing important baseline information on its local occurrence, capture circumstances, and interactions with artisanal fisheries. The study contributes to the understanding of the species' current distribution in the southeastern Mediterranean and highlights the significance of Palestinian coastal waters for the conservation.

2. METHODOLOGY

2.1 Data collection and field surveys

This descriptive study was based on repeated field surveys conducted at major fisheries landing sites and fish markets along the Gaza Strip coast. These locations represent the principal points where marine organisms, including cartilaginous fishes, bony fishes, and commercially important invertebrates, are landed, traded, and made available for public sale.

During field visits, available Angel Shark (*Squatina squatina* Linnaeus, 1758) specimens were examined whenever encountered, and morphometric measurements were obtained when specimen condition and accessibility permitted. Photographic records were also collected opportunistically to support species identification and documentation. To enhance the field-based observations, supplementary information was gathered through semi-structured interviews with experienced fishermen, fish traders, and officials from the General Directorate of Fisheries of the Ministry of Agriculture. These consultations provided valuable insights into the occurrence, capture methods, local abundance, utilization, and fishery interactions of the Angel Shark in the Gaza Strip waters.

The Angel Shark is readily distinguished from other shark species occurring in the Gaza Strip by its unique body form. The species possesses a markedly dorsoventrally flattened body, broad wing-like pectoral fins, and enlarged pelvic fins, giving it a superficial resemblance to batoid fishes (see Figure 1). In contrast, most shark species recorded from Palestinian Mediterranean waters exhibit the typical streamlined, fusiform body shape characteristic of sharks. Owing to its distinctive appearance, the Angel Shark is easily recognized by local fishermen and fish market workers, thereby facilitating reliable identification during interviews and field observations.

2.2 Study area and fisheries context

The Gaza Strip lies along the southeastern Mediterranean coast (Figure 2), extending approximately 42 km and covering about 365 km^2. Its coastal waters support an important small-scale fisheries sector involving more than 4,500 fishermen and over 1,800 fishing vessels. Local fisheries employ various gears, including trammel nets, gillnets, longlines, handlines, trawlers, and small purse seines, targeting pelagic and demersal fishes, cephalopods, and crustaceans. Cartilaginous fishes, including sharks and batoids, are regularly encountered as bycatch and occasionally targeted, reflecting their ecological importance and exposure to fishing pressure in Gaza Strip waters [56] [58] [70] [71].

Figure 2: Map of Palestine showing the location of the Gaza Strip along the southeastern Mediterranean coast.

3. RESULTS

3.1 Species Identification and Morphological Characteristics

The Angel Shark (*Squatina squatina* Linnaeus, 1758) recorded from the Gaza Strip (**Figure 3**) exhibited all diagnostic morphological characteristics consistent with descriptions from the Mediterranean and northeastern Atlantic populations. The body was strongly dorsoventrally flattened, with greatly expanded pectoral fins forming a broad disc-like structure that gives the species a batoid-like appearance. The eyes and spiracles were positioned dorsally, while the mouth and gill slits were located on the ventral side, consistent with its benthic lifestyle. The dorsal coloration of examined individuals ranged from light brown to grey, with irregular darker markings that likely enhance camouflage against sandy and muddy substrates. The ventral surface was uniformly pale white. These descriptive features are in total accordance with Kabasakal & Kabasakal [32] and other textbooks. No morphological abnormalities or deviations from published descriptions were observed in the examined specimens [72]. Recorded individuals ranged in total length from approximately 70 to 150 cm. Based on fishermen reports and market observations, both subadult and adult size classes were represented, although smaller juveniles were less frequently encountered. Local fishermen and fish traders identified the species using several vernacular names, including Malak al-Baḥr, Samakat al-Malāk, Al-Qirsh al-Mufallaṭaḥ, Al-Qirsh al-Malā'iki, and Al-Hamama. These names were consistently applied across different landing sites, indicating strong local recognition of the species despite its rarity.

Figure 3: A specimen of the Angel Shark (Squatina squatina Linnaeus, 1758) caught from the marine ecosystem of the Gaza Strip
Source: *General Directorate of Fisheries, Ministry of Agriculture*

3.2 Occurrence Records and Spatial Distribution

Records of the Angel Shark in the Gaza Strip were obtained from multiple fish landing sites distributed along the coastal zone. These records were documented through repeated field visits to fish markets and landing areas, as well as through fishermen interviews conducted during the study period. The occurrence of the species was highly sporadic and irregular across both space and time. No consistent presence was observed at any specific landing site, and records were scattered among different locations along the coastline. The available evidence did not indicate any aggregation areas or spatial hotspots of occurrence within the surveyed fisheries landing points.

3.3 Catch Frequency and Temporal Pattern

Encounters with the Angel Shark were extremely rare and unpredictable based on combined field observations and fishermen testimonies. Most fishermen reported either a single encounter or only a few captures over long periods of fishing activity, while some reported never having observed the species directly. Due to the limited number of records, no clear seasonal or temporal pattern of occurrence could be established. Captures appeared to be incidental and occurred at irregular intervals throughout different fishing periods without any apparent seasonal concentration.

3.4 Habitat Associations

Information obtained from fishermen and landing site observations indicated that all recorded specimens originated from coastal continental shelf environments. These areas are characterized primarily by sandy and soft-bottom substrates, which are typical habitats for benthic elasmobranch species. Fishing grounds where the species was encountered were generally located in shallow to moderately deep waters of the continental shelf. No records were associated with rocky reef habitats or offshore pelagic environments, suggesting a strong association with demersal sandy habitats within the Gaza Strip marine area.

3.5 Fisheries Interactions and Capture Methods

The Angel Shark was consistently reported as incidental bycatch rather than a targeted species in Gaza Strip fisheries. Captures were associated primarily with demersal fishing operations conducted along the continental shelf. The main fishing gears responsible for captures included bottom trawl nets, followed by bottom-set gillnets and trammel nets, with occasional records linked to bottom longlines. Among these, bottom trawling was identified as the most frequently associated gear type due to its direct interaction with benthic habitats where the species resides. Most captured individuals were landed either dead or in poor physical condition, and no evidence of live release practices or post-capture survival handling was documented among fishermen.

3.6 Market Observations and Landing Condition

Field observations at fish markets indicated that the presence of the Angel Shark was irregular and dependent entirely on incidental capture events. The species was not consistently available in daily market supplies and appeared only when bycatch events occurred. Landed specimens were typically sold either whole or partially processed at landing sites prior to distribution in local markets. Market availability was therefore highly opportunistic and did not reflect a continuous or structured fishery supply chain.

3.7 Utilization and Consumption Patterns

Interviews with fishermen and fish traders revealed that captured Angel Sharks were generally retained for local consumption. Utilization was opportunistic and included direct sale in local markets as well as household consumption. The species was also incorporated into traditional seafood dishes, most notably "*Sayadieh*", a widely consumed Palestinian fish dish consisting of rice, spices, and cooked fish. No evidence of export-oriented trade or specialized commercial targeting was recorded, and utilization was entirely dependent on incidental landings.

3.8 Catch Estimates and Fisheries Reports

Based on combined interviews with fishermen, fishmongers, and fisheries officials, the estimated annual catch of the Angel Shark in the Gaza Strip is extremely low. Reports suggest that fewer than approximately 12 individuals are landed annually, although this estimate is associated with considerable uncertainty due to incomplete reporting systems and the absence of formal catch documentation. Misidentification and unrecorded landings were also identified as contributing factors to uncertainty in catch estimation. Despite low capture numbers, nearly all individuals landed are retained, indicating that bycatch mortality is effectively equivalent to capture frequency.

3.9 Local Ecological Knowledge (LEK) Observations

Fishermen consistently described the Angel Shark as one of the rarest shark species encountered in local fisheries. Experienced fishermen reported only one to a few encounters throughout their entire fishing careers, while some reported no direct observations at all. The species was consistently associated with sandy bottom habitats and demersal fishing grounds. Despite its rarity, recognition of the species among fishermen was high due to its distinctive morphology and occasional appearance in landings.

4. DISCUSSION

The present study provides one of the few contemporary confirmations of the continued occurrence of the Critically Endangered Angel Shark (*Squatina squatina* Linnaeus, 1758) in the southeastern Mediterranean Sea, with the first focused documentation from the coastal waters of the Gaza Strip, Palestine. Although records were extremely rare and opportunistic, they confirm that the species persists in this region despite its severe historical decline across most of its distribution range.

Historically, the Angel Shark was widely distributed throughout the Mediterranean Sea, northeastern Atlantic Ocean, and Black Sea, occupying shallow coastal and continental shelf habitats characterized by sandy and muddy substrates [15] [73]. However, during the past century, the species has undergone dramatic population declines due to intensive fishing pressure, habitat degradation, and coastal anthropogenic impacts. These pressures have resulted in severe range contractions, with many former populations now reduced to sporadic captures or complete local extirpations. Consequently, the species is currently classified as Critically Endangered on the IUCN Red List [43].

The rarity of records in the Gaza Strip is consistent with patterns observed across the Mediterranean basin. Recent studies from the western, central, and eastern Mediterranean have reported similarly fragmented populations and extremely low encounter rates [47] [54] [74] [76]. These findings suggest that the Angel Shark now persists primarily as isolated remnant populations rather than forming continuous distributions. In this context, the Gaza Strip records add to growing evidence that marginal coastal areas of the southeastern Mediterranean may still provide limited refuge habitats for the species.

The recorded specimens (70–150 cm TL) encompass size classes ranging from immature individuals to potentially mature adults, considering that male Angel Sharks attain sexual maturity at approximately 80–132 cm TL and females at 128–169 cm TL [13]. This size range suggests that the individuals recorded in the Gaza Strip waters may represent different ontogenetic stages. The occurrence of both smaller and larger specimens is particularly noteworthy because records of multiple size classes can provide valuable information on habitat use and population persistence in regions where the species has become exceedingly rare [13] [19]. Although the limited number of observations prevents identification of nursery or breeding habitats, these findings indicate that the coastal waters of the Gaza Strip remain part of the contemporary distribution range of the species in the southeastern Mediterranean.

Ecologically, the association of the Angel Shark with sandy continental shelf habitats reflects its specialized benthic ambush-predatory lifestyle.

The species typically remains partially buried in soft sediments while waiting for prey, including fishes, cephalopods, and crustaceans [77] [78]. This ecological specialization increases its vulnerability to bottom-contact fishing gears, particularly trawls and demersal nets that operate directly within its habitat range [79] [80]. The dominance of such gears in the Gaza Strip fisheries likely explains the continued incidental capture of this species despite its extreme rarity.

The fisheries-dependent nature of the records highlights the importance of small-scale fisheries as a primary source of biodiversity information in data-poor regions. Fish landing sites, market surveys, and fishermen interviews remain essential tools for detecting rare and cryptic elasmobranch species in the absence of systematic scientific monitoring [81]-[83]. In this study, these approaches provided complementary evidence confirming the continued presence of the species in local waters.

Local Ecological Knowledge (LEK) further strengthened the interpretation of rarity. The consistent perception among experienced fishermen that the Angel Shark is among the rarest species encountered in local fisheries aligns with findings from other Mediterranean regions [84]-[86]. The convergence between LEK and field observations supports the conclusion that the species currently occurs at extremely low abundance in the Gaza Strip.

Despite the rarity of the Angel Shark, continued capture and retention of individuals raises significant conservation concerns. Even low levels of bycatch mortality can have severe population-level effects in species characterized by slow growth, late maturity, and low reproductive output [87] [88]. The absence of live-release practices further increases the conservation impact of each capture event, as mortality appears to be near total following capture.

The occurrence of the Angel Shark in the Gaza Strip should also be viewed within the broader context of increasing records of threatened elasmobranchs in the southeastern Mediterranean. Recent documentation of species such as *Hexanchus griseus*, *Isurus oxyrinchus*, *Mobula mobular*, and *Sphyrna lewini* indicates that this region supports a diverse assemblage of vulnerable cartilaginous fishes [61]-[69] [89]. This pattern suggests that Gaza Strip waters may function as an ecological corridor or intermittent habitat for multiple wide-ranging species of conservation concern. From a conservation and fisheries management perspective, these findings underscore the urgent need to improve monitoring of elasmobranch bycatch; enhance species-specific reporting in fishery statistics, and implement fisher-based monitoring programs. Furthermore, strengthened regional collaboration among Mediterranean countries is essential to improve knowledge of the Angel Shark population status, distribution, and trends, thereby supporting the development and implementation of effective conservation and management measures [54] [85].

Utilization of captured Angel Sharks in the Gaza Strip remains entirely opportunistic and consists primarily of direct sale in local fish markets and household consumption. Similar utilization patterns have been documented elsewhere in the Mediterranean Sea, where incidentally captured Angel Sharks are commonly retained for human consumption rather than released. For example, recent records from northern Tunisia reported specimens of the Angel Shark landed by artisanal fisheries and subsequently marketed for local consumption (Figure 4), reflecting the continued exploitation of the species despite its Critically Endangered conservation status [74].

Historical studies from Tunisia have likewise indicated that Angel Sharks formed part of local fishery landings and entered regional seafood markets [30] [88]. Similar situations have been reported from other Mediterranean countries where captures are generally associated with bycatch from bottom trawls, gillnets, and other demersal fishing gears, with most individuals retained after capture because of their commercial value as food fish [15] [90].

Figure 4. Specimens of the Critically Endangered Angel Shark (Squatina squatina Linnaeus, 1758) captured off the northern coast of Tunisia (Central Mediterranean Sea), showing the (A) dorsal view and (B) ventral view [Source: Rafrafi-Nouira et al., 2023].

In the Gaza Strip, captured specimens are occasionally prepared in traditional seafood dishes, particularly "*Sayadieh*", demonstrating that the species remains integrated into local food practices whenever available. Although current capture levels are extremely low, the complete retention of landed individuals eliminates any possibility of post-capture survival and may further hinder recovery of already depleted populations. Moreover, consumption of angel shark meat may raise potential public health concerns because elasmobranchs are known to bioaccumulate trace metals and other contaminants, and recent toxicological assessments have demonstrated potential health risks associated with the consumption of angel shark species in some regions [91] [92]. Consequently, the continued utilization of incidentally captured Angel Sharks represents not only a conservation challenge but also a topic warranting further investigation from fisheries management and food-safety perspectives.

5. CONCLUSION

This study confirms the continued but highly rare occurrence of the Critically Endangered Angel Shark (*Squatina squatina* Linnaeus, 1758) in the coastal waters of the Gaza Strip and provides important baseline evidence from a poorly studied region of the southeastern Mediterranean Sea. The species was consistently recorded as incidental bycatch in demersal fisheries operating over sandy continental shelf habitats, with no indication of targeted exploitation. Although occurrence records were extremely limited, their confirmation is ecologically and conservation-wise significant, as they demonstrate that the species persists in the region despite severe historical declines across the Mediterranean basin.

The findings further highlight the continued vulnerability of the species due to bycatch mortality in bottom-contact fishing gears.

The study also demonstrates the value of integrating fisheries-dependent data sources, including landing site surveys, market observations, and Local Ecological Knowledge (LEK), as effective tools for documenting rare and data-deficient marine species in understudied coastal systems. Overall, the presence of the Angel Shark, alongside other threatened elasmobranchs in Gaza Strip waters, underscores the ecological importance of this coastal ecosystem within the southeastern Mediterranean. Strengthening fisheries monitoring, improving reporting accuracy, and enhancing regional conservation coordination are urgently required to support the long-term persistence of this Critically Endangered species.

ACKNOWLEDGMENTS

The author gratefully acknowledges the General Directorate of Fisheries at the Ministry of Agriculture for its valuable support and cooperation during the course of this study on the Critically Endangered Angel Shark (*Squatina squatina* Linnaeus, 1758). Sincere thanks are also extended to the fishermen, fish traders, and fish market workers of the Gaza Strip for their collaboration, field assistance, and willingness to share observations and information that contributed significantly to the documentation of this rare species.

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