Socio-Economic Impact Study on Implementing Conservation Measures for Cartilaginous Species in the Gulf of Sirte, Libya

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Foreword

The Mediterranean Sea is a unique and fragile ecosystem, home to a remarkable diversity of marine life, including many species of cartilaginous fish—sharks, rays, and related species—that are particularly vulnerable to overexploitation and environmental pressures. Their slow growth, late maturity, and low reproductive rates make them highly sensitive to human activities such as fishing, pollution, and habitat degradation.

As per Barcelona Convention CoP23 Decision IG.26/4 - *Amendments to Annexes II and III to the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean*, the inclusion of nine cartilaginous species in Annexes II and III of the SPA/BD Protocol represents an important step forward in regional conservation efforts. At the same time, it raises complex socio-economic considerations, particularly for fishing communities whose livelihoods depend on these resources. Understanding the interplay between conservation measures and local economies is therefore essential for designing policies that are both effective and equitable.

This study, commissioned by Plan Bleu/RAC and developed in close collaboration with SPA/RAC, provides a comprehensive socio-economic assessment of these conservation measures in the Gulf of Sirte in Libya. By examining potential impacts on fisheries, proposing mitigation strategies, and outlining practical policy recommendations, it seeks to inform decision-makers and support sustainable management practices that benefit both biodiversity and local communities.

Plan Bleu remains committed to promoting solutions that balance ecological protection with sustainable development, including the economic and livelihood dimensions, reinforcing our shared responsibility to safeguard the Mediterranean for current and future generations.

Robin Degron (Director of Plan Bleu)
and Constantin Tsakas (Chief Economist of Plan Bleu)

Executive Summary

This comprehensive assessment of the socio-economic impacts of listing nine cartilaginous species under SPA/BD Protocol Annexes II/III reveals **unprecedented vulnerability among Gulf of Sirte fishing communities**, where 93.9% of 66 surveyed fishers interact with protected species as bycatch while targeting commercial species like grouper (78.8%) and dentex (69.7%), creating concentrated economic risk for 27 families facing severe dependency (up to 100% income reliance on specific shark species) while the majority (69.7%) maintain minimal dependency on cartilaginous species for supplementary income. Despite potential economic disruption, **the community demonstrates remarkable conservation readiness** with 63.6% supporting conservation measures when provided appropriate assistance and 80.3% willing to participate in training programs, while 87.9% engage in traditional medicine practices involving marine species, indicating deep cultural connections requiring sensitive integration rather than prohibition. The analysis projects regional economic impacts of 5.25 million LYD annually across 422 documented vessels affecting 2,278 individuals including household dependents, but **recommends implementing a phased Scenario B approach requiring 4-6 million LYD over five years** that prioritizes emergency support for the 27 highest-vulnerability families while leveraging documented community willingness to build systematic conservation implementation across three phases: immediate protection for critically endangered Bull Ray and Common Eagle Ray (Years 1-2), systematic expansion to remaining seven species with broader family support (Years 3-4), and full regional implementation with incentive programs (Years 5+). **This strategic investment can generate measurable returns through improved fisheries productivity, sustainable market access, and marine tourism development** while positioning Libya as a Mediterranean leader in community-based conservation that demonstrates environmental protection and economic development are complementary goals, requiring targeted support that treats fishing families as conservation partners rather than obstacles and recognizing that healthy marine ecosystems and thriving communities are mutually dependent for long-term success.

1 Introduction

1.1 BACKGROUND

The Mediterranean Sea constitutes one of the world's most significant marine biodiversity hotspots, supporting over 17,000 marine species, many endemic to the region. This remarkable diversity faces mounting threats from anthropogenic activities including overfishing, pollution, habitat destruction, and climate change, pushing numerous species toward extinction. Among the most vulnerable are cartilaginous species (sharks, rays, and chimaeras), which exhibit susceptibility to population decline due to their biological characteristics: slow growth rates, late sexual maturity, and low fecundity. These K-selected life history traits render chondrichthyans more vulnerable to fishing pressure than most teleost fish species.

Cartilaginous species function as apex and mesopredators within marine ecosystems, maintaining ecological balance through top-down trophic regulation mechanisms. Their conservation is essential for ecosystem health, as these species serve as sentinels of marine ecosystem condition and their recovery correlates with improved productivity for target commercial species through trophic cascade effects.

This comprehensive report presents findings based on data collected from all three sub-regions of the Gulf of Sirte—Western Sirte (Misrata-Sirte), Central Sirte (Sirte-Ras Lanuf), and Eastern Sirte (Ras Lanuf)—through questionnaires, focus group discussions, and key informant interviews with 66 fishermen, examining the socio-economic impacts of potentially implementing conservation measures for nine cartilaginous species newly listed in Annexes II and III of the SPA/BD Protocol under the Barcelona Convention.

The report is structured as follows. It first outlines the regulatory framework under the Barcelona Convention, the ecological and socio-economic context of the Gulf of Sirte, and the conservation status of cartilaginous species. The methodology section then details the research approach, survey design, data collection, sampling framework, and analytical methods. This is followed by an overview of international, regional, and national policy frameworks relevant to conservation. The report then presents a regional comparative analysis and socio-economic findings, examining fishing practices, species interactions, market dynamics, household vulnerability, and community networks. Subsequent sections assess conservation impacts, mitigation measures, and implementation strategies, explore alternative species and market development options, and discuss implementation challenges and adaptive management. The penultimate session discusses the economic costs and benefits of conservation, before concluding with key findings and actionable recommendations.

1.2 BARCELONA CONVENTION DECISION IG.26/4: A COMPREHENSIVE REGULATORY FRAMEWORK

1.2.1 Species Composition and Conservation Classification

Decision IG.26/4, adopted during the 23rd Conference of Parties (COP 23) to the Barcelona Convention in Portorož, Slovenia (December 5-8, 2023), constitutes a significant development in Mediterranean marine conservation policy. This decision modified Annexes II and III of the Protocol concerning Specially Protected Areas and Biological Diversity (SPA/BD Protocol) through incorporation of nine cartilaginous species into the regional protection framework, representing the most substantial expansion of elasmobranch conservation measures in the Mediterranean basin since the protocol's establishment.

New cartilaginous species included in Annex II to SPA/BD Protocol (List of Endangered or Threatened Species):

- **Bull Ray** *Aetomylaeus bovinus* (Geoffroy St. Hilaire, 1817), classified as Critically Endangered by IUCN. Population data indicate an estimated decline of 80% over 45 years, with the species now considered rare throughout Mediterranean waters.
- **Bigeye Thresher Shark** *Alopias superciliosus* (Lowe, 1841), classified as Vulnerable by IUCN, exhibits constrained reproductive capacity among thresher shark species with documented low potential annual population increase rate of 0.002-0.009 (equivalent to 1.6%).
- **Broad Stingray** *Bathytoshia lata* (Garman, 1880), maintains IUCN Vulnerable status due to anthropogenic threats across its Indo-Pacific and Eastern Atlantic range.
- **Common Stingray** *Dasyatis pastinaca* (Linnaeus, 1758), experiences conservation pressures throughout its Mediterranean range with coastal habitat requirements overlapping areas of human activity.

- **Lusitanian Cownose Ray** *Rhinoptera marginata* (Geoffroy St. Hilaire, 1817), exhibits limited distribution primarily within Eastern Atlantic waters, with occasional Mediterranean occurrences.

New cartilaginous species included in Annex III (List of Species Whose Exploitation is Regulated):

- **Marbled Stingray** *Dasyatis marmorata* (Steindachner, 1892), classified as Near Threatened following IUCN assessment in August 2020.
- **Bluntnose Sixgill Shark** *Hexanchus griseus* (Bonnaterre, 1788), represents deep-water cartilaginous fauna exposed to modern fishing technologies.
- **Pelagic Stingray** *Pteroplatytrygon violacea* (Bonaparte, 1832), exhibits ecological characteristics as a pelagic stingray species with Near Threatened status reflecting exposure to longline fisheries.
- **Common Eagle Ray** *Myliobatis aquila* (Linnaeus, 1758), classified as Endangered, demonstrates limited biological productivity characterized by low fecundity (3-7 pups per litter) and schooling behavior that facilitates capture events.

1.2.2 Biological Characteristics and Scientific Assessment

The species selection process followed Decision IG.17/14 criteria for amending SPA/BD Protocol annexes, ensuring scientific methodology in conservation prioritization. All listed species exhibit biological characteristics that influence population resilience and recovery capacity.

Reproductive patterns constitute a primary factor across all nine species. Cartilaginous fish reproduction follows K-selected strategies characterized by extended gestation periods, small litter sizes, and delayed sexual maturity. Life history characteristics contribute to conservation challenges, with extended generation times often exceeding management planning horizons, meaning that population recovery requires sustained protection over multiple decades.

Behavioral and ecological factors contribute additional considerations. Aggregating species such as *Myliobatis aquila* face capture risk during schooling events, while habitat specialists like *Aetomylaeus bovinus* have limited behavioral flexibility to avoid anthropogenic pressures through spatial redistribution.

1.3 THE GULF OF SIRTE: ECOLOGICAL AND SOCIO-ECONOMIC CONTEXT

The Gulf of Sirte represents one of Libya's most ecologically important coastal regions, chosen as the focus of this study for several key reasons related to cartilaginous species conservation. The Gulf features shallow waters and rich nutrient influx creating a mosaic of diverse marine habitats: sandy substrates, lush seagrass meadows, photophylous algae communities, rocky substrates, detrital bottoms, and dramatic coastal cliffs.

The ecological significance of the Gulf has received international recognition through its designation as an Ecologically or Biologically Significant Marine Area (EBSA) under the Convention on Biological Diversity. The region overlaps with five Key Biodiversity Areas and serves as an important nursery ground for species like the Common Angel shark, earning recognition as an Important Shark and Ray Area (ISRA) based on both vulnerability criteria and its role as a reproductive sanctuary.

From a socio-economic perspective, approximately 23% of Libya's artisanal fishing fleet, some 422 vessels, operate in the Gulf of Sirte region. Recent comprehensive surveys documented 303 active vessels distributed across 43 landing sites, with 175-875 individuals directly engaged in fishing activities during the critical February-June reproductive period when cartilaginous species are most vulnerable to fishing pressure.

1.4 CARTILAGINOUS SPECIES CONSERVATION STATUS AND BYCATCH MECHANISMS

1.4.1 Bycatch Mechanisms and Fishing Gear Interactions

Cartilaginous species throughout the Mediterranean face alarming population declines, with more than half of chondrichthyan species facing extinction risk in the Mediterranean, where 39 species (53% of 73 assessed species) are classified as critically endangered, endangered, or vulnerable.

Kellabia Net Operations: These represent the primary fishing gear for cartilaginous species in the Gulf of Sirte, with 100% usage rates documented across operational seasonal landing sites. These traditional nets range from 400-4,000 meters in length with heights of 2-4 meters and mesh sizes of 14-28 cm, costing approximately 200-600 LYD (€32-95) with 1-2 year lifespans. Critically, Kellabia operations occur exclusively in shallow coastal waters (less than 50 meters

depth) during the February-May period, which coincides directly with the reproductive season of many cartilaginous species.

Longline Systems: Employed by 66.7% of operational seasonal sites, these systems range from 1,000-3,000 meters in length with 5-meter hook spacing and 1-meter vertical lines, costing 600-1,800 LYD (€95-286) with 2-3 year lifespans, targeting large and medium cartilaginous species at depths of 20-200 meters.

Trawling Operations: Despite higher equipment costs of 3,000-8,000 LYD (€476-1,270) with 3–5-year lifespans, trawling shows lower cartilaginous species bycatch rates due to species distribution patterns and gear selectivity.
Bycatch probability ranging from highest to lowest: (1) Set gillnets/trammel nets, (2) Surface longlines, (3) Bottom longlines, (4) Kellabia nets, (5) Trawling gear. This ranking is supported by survey data showing 78.6% of gillnet users reporting regular cartilaginous catches compared to only 6% of trawl users reporting frequent interactions.

1.5 STUDY OBJECTIVES AND STRUCTURE

This research addresses two primary objectives within the context of Libya's current legal status. First, the study aims to assess the socio-economic impacts that would be associated with potential implementation of conservation measures for nine cartilaginous species listed in Decision IG.26/4, specifically evaluating how such measures could affect local economies and fisheries in the Gulf of Sirte if Libya chose to adopt similar protections.
Second, based on assessment outcomes, **the study seeks to propose practical mitigation measures that could minimize potential negative impacts on fisheries and local communities while ensuring achievement of conservation objectives**, if Libya decides to implement such measures voluntarily or through future ratification of the SPA/BD Protocol.

The study framework recognizes that Libya's participation in this assessment represents forward-looking policy analysis rather than compliance with existing legal obligations, given the country's non-ratification of the SPA/BD Protocol. However, Libya's active engagement in Barcelona Convention processes and expressed support for marine conservation capacity building indicates genuine interest in exploring conservation options that balance ecological protection with socio-economic sustainability.

2 Methodology

2.1 RESEARCH APPROACH

This study employed a mixed-methods approach combining quantitative and qualitative research techniques to build a comprehensive understanding of the socio-economic landscape while capturing nuanced perspectives of local fishermen and community stakeholders. By triangulating data from multiple sources, the research ensures robust findings and contextually appropriate recommendations.

Research design acknowledges the inherent complexity of socio-ecological systems by examining multiple scales of analysis, from individual fisher decision-making to community-level economic patterns to regional conservation implementation challenges. This multi-scale approach enables identification of intervention points while recognizing the interconnected nature of social, economic, and ecological factors affecting conservation outcomes.

2.2 STUDY AREA AND FIELD SURVEY DESIGN

The Gulf of Sirte was divided into three distinct sub-regions to capture geographic variations in fishing practices and socio-economic conditions:

Western Sirte (Misrata-Sirte): This region features sandy beaches punctuated by rocky outcrops and salt marshes, hosting significant fishing activity centered around major landing sites including Qasar Ahmed (Misrata), Al-Hisha, Tawergha, and Al-Washka. Fishermen primarily use gill nets (trammel nets), hooks and lines, Kellabia nets, and longlines to target small pelagic fish, demersal species, cartilaginous species, and cephalopods.

Central Sirte (Sirte-Ras Lanuf): Characterized by extensive salt marshes, shallow coastal waters, and mixed sandy and detrital substrates. Key landing sites include Sirte and several salt marsh areas (Sultan, Besher, Kweim, Shwerab, Karkora), as well as Al-Khamseen. Fishing often involves Kellabia nets (especially February to May), longlines, and mixed gear approaches targeting cartilaginous species, large pelagic fish, and demersal fish.

Eastern Sirte (Ras Lanuf): This area features rocky shores, seagrass meadows, and deeper offshore waters. The coastline shows the influence of industrial development, including oil refineries and ports. Key landing sites include Ras Lanuf, Shatt Al-Bedin, and Zueitina Port. Fishermen primarily use longlines, gill nets, and large hooks to target deep-water fish, large pelagic species, and various ray species.

2.3 DATA COLLECTION METHODS

2.3.1 Survey Instrument

A structured questionnaire was developed to gather primary data from fishermen throughout the Gulf of Sirte. The survey collected general information and demographic details, including age, education level, and fishing experience. It explored fishing effort and practices by examining the number of fishing days, types of gear used, and target species. To understand economic dependency, the questionnaire assessed the contribution of fishing to household income, with particular attention to the frequency of shark and ray fishing and their role in overall earnings.

The survey investigated fishermen's environmental perceptions and awareness, their attitudes toward conservation measures, and their willingness to adopt alternative livelihoods or fishing practices. This approach combined

quantitative measurement of key indicators with qualitative insights through open-ended questions, allowing fishermen to express their perspectives, concerns, and suggestions.

2.3.2 Data Collection Strategy and Review

Field research utilized a combination of complementary methods to ensure comprehensive and reliable data collection. Face-to-face interviews were conducted at landing sites across the region, meeting directly with fishermen to discuss their socio-economic circumstances, fishing practices, and awareness of conservation issues.

Focus group discussions brought together fishermen, community representatives, and other fishery stakeholders, providing opportunities to explore collective experiences, challenges, and attitudes toward sustainable fishing practices. Direct field observations of fishing activities were conducted to validate and contextualize information gathered through surveys and discussions.

Key informant interviews with fisheries managers, local leaders, and conservation experts provided valuable contextual information and expert perspectives, helping to situate findings within the broader framework of fisheries management and conservation efforts in the region.

2.4 SAMPLING FRAMEWORK

2.4.1 Sample Characterization and License-Based Framework

The study focused on fishermen operating in artisanal and commercial fisheries, along with community leaders and relevant fishery stakeholders. The total survey sample comprised 66 respondents distributed across the three sub-regions: 35 from Western Sirte, 12 from Eastern Sirte, and 19 from Central Sirte. The sample included 35 Libyan nationals and 31 non-Libyan residents, reflecting the demographic composition of the regional fishing workforce.

Sample representativeness was achieved through 100% geographic saturation, visiting all 43 landing sites documented in previous studies, ensuring comprehensive spatial representation across the entire Gulf of Sirte fishing infrastructure. Against realistic workforce estimates (175-300 active fishermen), the 66-person sample represents 22-38% coverage during peak season—substantial for small-scale fisheries research.

The sample captures the Gulf of Sirte fishing fleet composition, including both artisanal small-scale operations (71.2%) and commercial vessels (28.8%). Vessel ownership patterns show 29 of 66 fishermen (43.9%) own their vessels, indicating predominantly small, independent fishing operations rather than industrial fleet structures.

2.5 DATA ANALYSIS APPROACH

2.5.1 Statistical Validity Assessment

Prior to conducting substantive analyses, comprehensive statistical validity tests were performed to ensure the reliability and appropriateness of analytical approaches. Kolmogorov-Smirnov normality tests were conducted on key continuous variables to validate the use of parametric statistical methods. Fisher age data (n=48) showed a mean of 46.96 years with a standard deviation of 11.85 years, demonstrating normal distribution with a test statistic of 0.069 and significance value of 0.200, confirming data normality.

Survey instrument reliability was assessed using Cronbach's Alpha coefficients for multi-item scales. The Marine Protected Area impact perception scale achieved good internal consistency with $\alpha = 0.748$, while environmental impact and conservation attitude scales demonstrated acceptable reliability levels above 0.68.

Several analytical methods were applied including descriptive statistics to summarize demographic information, fishing practices, and economic indicators across regions and demographic categories. Comparative analysis examined trends in fishing practices and income across different regions, identifying patterns and variations. Correlation analysis explored relationships between fishing dependency, economic status, demographic characteristics, and attitudes toward conservation.

3 International and Regional Policy and Regulatory Frameworks

3.1 INTERNATIONAL CONSERVATION FRAMEWORKS

3.1.1 The Barcelona Convention and SPA/BD Protocol

The Barcelona Convention for the Protection of the Mediterranean Sea Against Pollution, established in 1976 and revised in 1995, represents the foundational legal framework for Mediterranean marine conservation. The Specially Protected Areas and Biological Diversity (SPA/BD) Protocol, adopted in 1995, establishes the specific legal mechanism for species and habitat protection within the Barcelona Convention framework.

The Protocol's three-annex system creates differentiated protection levels: Annex I (endangered or threatened species requiring strict protection), Annex II (species requiring special protection measures), and Annex III (species whose exploitation requires regulation). Barcelona Convention CoP 23 Decision IG.26/4 specifically addresses cartilaginous species protection by proposing nine species for inclusion in Annexes II/III.

Libya maintains membership as a Contracting Party to the Barcelona Convention, having participated since its inception. However, Libya was party to the 1982 Specially Protected Areas Protocol but has not ratified the current SPA/BD Protocol adopted in 1995. This places Libya's non-ratification status indicating that while the country participates in the broader Mediterranean environmental framework, any implementation of cartilaginous species conservation measures would be voluntary rather than legally mandated.

3.1.2 Convention on International Trade in Endangered Species (CITES)

Libya maintains party status to the Convention on International Trade in Endangered Species of Wild Fauna and Flora, an international agreement regulating wildlife trade to ensure species survival in their natural habitats. CITES operates as a legally binding treaty with 185 Parties comprising 184 countries and the European Union.

The CITES framework provides complementary protection to the SPA/BD Protocol through its focus on regulating international commercial trade in threatened cartilaginous species. Multiple shark and ray species currently listed in CITES Appendix II require export permits based on non-detriment findings, creating administrative and scientific requirements for countries engaging in international trade.

3.1.3 Convention on the Conservation of Migratory Species (CMS)

Libya does not currently hold party status to the Convention on the Conservation of Migratory Species of Wild Animals, also known as the Bonn Convention. This international agreement aims to conserve terrestrial, aquatic and avian migratory species throughout their range.

The CMS framework holds particular relevance for cartilaginous species conservation due to the highly migratory nature of many shark and ray populations. Libya's non-participation in CMS constrains opportunities for regional cooperation on migratory cartilaginous species conservation and limits access to technical support mechanisms.

3.1.4 FAO International Plan of Action for Sharks (IPOA-Sharks)

The Food and Agriculture Organization's International Plan of Action for the Conservation and Management of Sharks constitutes a voluntary instrument adopted in 1999 within the framework of the Code of Conduct for Responsible Fisheries.

Libya developed and approved a National Action Plan for the Conservation of Cartilaginous Fishes in June 2024, with technical support from SPA/RAC. This NAP provides an important framework for cartilaginous species conservation and management in Libyan waters, establishing Libya's commitment to systematic shark and ray protection measures.

3.2 REGIONAL CONSERVATION ORGANIZATIONS AND MECHANISMS

3.2.1 Mediterranean Action Plan (MAP)

The Mediterranean Action Plan operates as the institutional framework for implementing the Barcelona Convention and its protocols. Established in 1975 under the United Nations Environment Programme, MAP coordinates regional environmental cooperation and provides technical and scientific support for pollution prevention and biodiversity conservation measures.

3.2.2 Specially Protected Areas Regional Activity Centre (SPA/RAC)

The Specially Protected Areas Regional Activity Centre, based in Tunis, Tunisia, assists Contracting Parties in implementing obligations under the SPA/BD Protocol. SPA/RAC's mandate encompasses scientific and technical support for marine conservation, development of conservation action plans, and facilitation of regional cooperation mechanisms.

3.2.3 General Fisheries Commission for the Mediterranean (GFCM)

The General Fisheries Commission for the Mediterranean, established under FAO auspices, develops binding conservation and management measures for fisheries in the Mediterranean and Black Sea. GFCM's mandate includes adopting measures for sustainable exploitation of living marine resources and minimizing adverse impacts of fishing activities on marine ecosystems.

3.3 NATIONAL POLICY CONTEXT IN LIBYA

Libya's fisheries sector has evolved significantly since the 1980s, though recent political instability has complicated management efforts. The sector remains predominantly artisanal, with most fishing conducted using traditional methods like Batah fishing, Flouka, Mator, and lampara. The typical fishing vessel is small and artisanal, using nets (trawls and gillnets) or hooks (longlines and handlines).

3.3.1 Legislative Framework

Libya's marine resource management operates under a hierarchical legal framework established primarily through Law No. 14 of 1989 "Concerning the Regulation of Marine Resource Exploitation" (قانون رقم 14 لسنة 1989م بشأن تنظيم استغلال الثروة البحرية). This comprehensive legislation serves as the foundational legal instrument governing all aspects of marine resource utilization within Libyan territorial waters and exclusive economic zones.

Law 14/1989 consolidated and replaced earlier fragmented legislation, specifically repealing Law No. 12 of 1959 (sponge fishing regulation) and Law No. 8 of 1962 (fish fishing regulation), creating a unified regulatory framework. The law establishes several critical regulatory mechanisms:

Territorial Jurisdiction and Sovereign Rights: The legislation defines Libya's sovereign rights over marine resources within territorial waters, including the seabed and subsoil of marine areas under Libyan sovereignty and jurisdiction, encompassing all living organisms including permanent aquatic life forms.

Licensing and Permit Requirements: The law mandates that no individual or entity may explore or exploit marine resources for commercial purposes without obtaining proper licenses from designated authorities. Foreign fishing vessels are strictly prohibited from operating without specific agreements and permits from the General People's Committee for Marine Resources.

Protected Areas and Fishing Restrictions: The legislation empowers authorities to designate protected areas and prohibit fishing in specific zones for scientific or economic purposes, as well as restrict fishing of certain marine species in designated areas and times.

Vessel Registration and Safety Requirements: All fishing vessels must undergo mandatory registration, inspection, and safety certification, including proof of seaworthiness, crew medical examinations, comprehensive insurance coverage, and safety equipment compliance.

3.3.2 Regulatory Authority and Enforcement

The General People's Committee for Marine Resources (اللجنة الشعبية العامة للثروة البحرية) serves as the sole regulatory authority responsible for implementing Law 14/1989. The Committee's mandate encompasses:

- Exclusive licensing authority for vessel registration, fishing permits, and professional fishing licenses
- Port and harbor designation with authority to establish fishing ports and determine operational standards
- Fee structure determination for licensing, registration, and port utilization services
- Enforcement coordination with authority to grant law enforcement powers to marine resource sector personnel

However, current enforcement capacity faces significant structural limitations. Multi-stakeholder assessment reveals systematic barriers that extend beyond community-level resistance to encompass fundamental institutional coordination deficits:

Enforcement Challenge Hierarchy (based on stakeholder analysis of 26 experienced professionals):

1. Community cooperation gaps (61.5%) - Trust deficits between authorities and fishing communities represent the primary enforcement barrier
2. Inadequate penalty structures (61.5%) - Current sanctions lack sufficient compliance incentives under existing legal frameworks
3. Personnel resource limitations (50.0%) - Chronic understaffing constrains enforcement capacity across 43 documented landing sites
4. Institutional corruption (38.5%) - Governance quality issues undermine regulatory credibility and implementation effectiveness
5. Coordination failures (11.5%) - Systemic issues including resource constraints and inter-agency coordination deficits

The dual prioritization of community cooperation and penalty adequacy reveals that successful implementation requires simultaneous bottom-up engagement and top-down regulatory strengthening, while personnel constraints indicate critical administrative capacity building needs.

3.3.3 International Legal Obligations Gap Analysis

Libya's marine conservation legal framework contains significant gaps in international treaty participation that directly impact cartilaginous species protection capabilities:

Non-Ratification of SPA/BD Protocol: Libya was party to the 1982 Specially Protected Areas Protocol but has not ratified the current SPA/BD Protocol adopted in 1995. This places Libya alongside Bosnia and Herzegovina and Greece as Mediterranean states that participated in the original protocol but have not acceded to the current biodiversity protection framework. This non-ratification means Libya is not legally bound by species listings in Annexes II and III of the SPA/BD Protocol, including the nine cartilaginous species addressed in Decision IG.26/4.

CITES Compliance Status: Libya maintains party status to CITES, creating existing legal obligations for monitoring and controlling international trade in threatened cartilaginous species. This framework provides a foundation for conservation measures independent of SPA/BD Protocol ratification status, though it addresses trade-based rather than ecosystem-based threats.

CMS Participation Gap: Libya is a Contracting Party to the Convention on the Conservation of Migratory Species (CMS) and related agreements (AEWA, ACCOBAMS), yet the domestic enforcement failure is the significant gap. Given the highly migratory and vulnerable nature of species like cetaceans and cartilaginous fish (sharks and rays) which use the Gulf of Sirt as a crucial habitat and nursery ground, the lack of effective control is critical. This deficit undermines regional cooperation efforts on bycatch reduction and shark conservation, and renders national action plans ineffective, preventing the essential conservation of threatened species.

Voluntary Conservation Framework: Libya's non-ratification status means that any implementation of cartilaginous species conservation measures would be voluntary rather than legally mandated. However, Libya's recent development of a National Action Plan for the Conservation of Cartilaginous Fishes (approved June 2024) with SPA/RAC technical support demonstrates commitment to systematic protection measures within existing voluntary frameworks.

3.3.4 Current Governance Structure and Institutional Capacity

According to survey data from 2000 (Lamboeuf et al., 2000), Libya's coast supported about 1,866 fishing vessels spread across 135 landing sites, with approximately 23% (422 vessels) operating in the Gulf of Sirte region. However, political changes since 2011 have significantly impacted fishing activities, with noticeable changes in enforcement, monitoring, and compliance with existing regulations.

Policy Effectiveness Assessment: Current marine conservation regulations demonstrate critical gaps requiring institutional reform. Professional stakeholder assessment reveals systematic deficiencies:

- 47.8% characterize existing frameworks as "somewhat ineffective"
- 30.4% describe them as "moderately effective"
- Only 13.0% assess regulations as "highly effective"

This 6:1 ratio of limited versus high effectiveness (78.2% combined ineffective/moderate ratings against 13.0% highly effective) indicates systemic regulatory deficiencies requiring comprehensive reform rather than incremental adjustments. The low professional confidence in current frameworks suggests fundamental flaws in design, implementation mechanisms, or enforcement capacity.

Administrative Capacity Constraints: The combination of regulatory effectiveness concerns with documented enforcement challenges indicates that conservation success requires integrated intervention across legal frameworks, administrative capacity, and community engagement. Sequential or single-mechanism approaches prove insufficient given the interconnected nature of implementation barriers.

The current governance structures for marine resource management remain fragmented, with limited regulatory capacity and enforcement challenges. This creates a complex environment for implementing new conservation measures effectively, particularly given the voluntary nature of cartilaginous species protection under Libya's current international legal status.

Implementation Readiness Assessment: Despite structural limitations, several factors support potential conservation implementation:

- Professional expertise foundation (71% of stakeholders with 10+ years' experience)
- Clear economic pathway preferences (65.4% support for financial subsidies)
- Community willingness indicators (80.3% training acceptance rate)
- Existing legal framework foundation through Law 14/1989 and CITES obligations

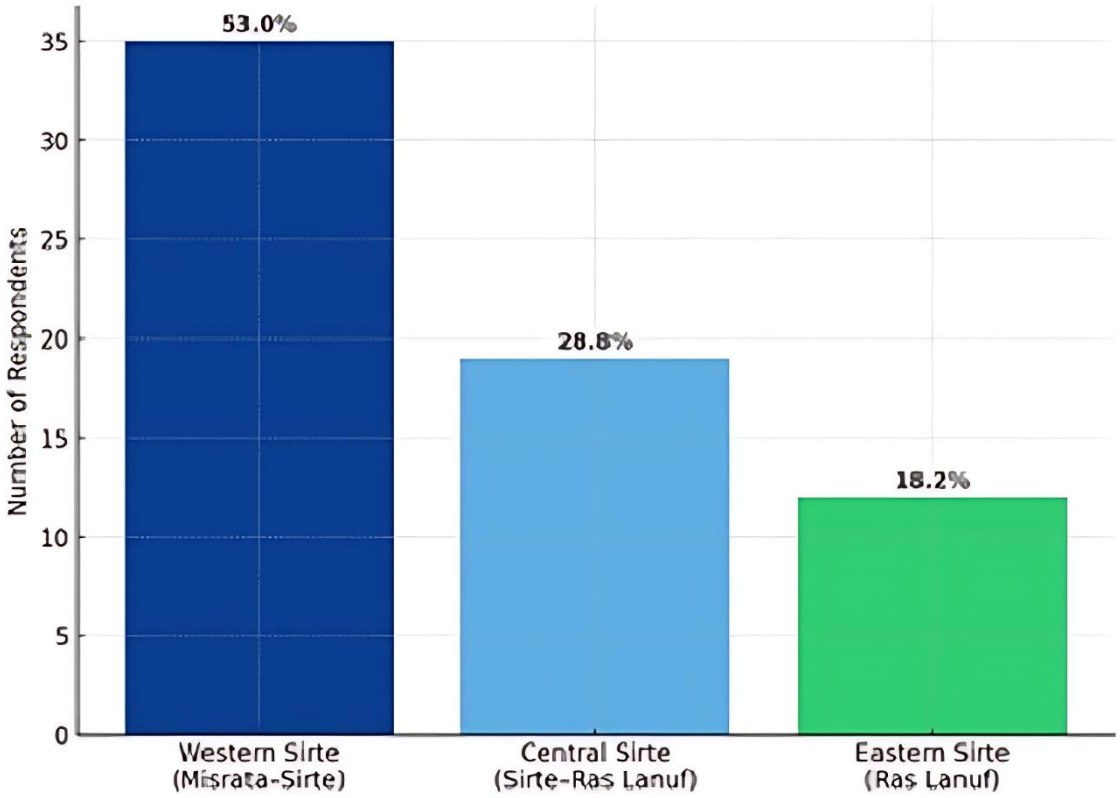
These enabling factors suggest that while current governance faces significant challenges, targeted capacity building and community engagement could establish viable pathways for voluntary conservation implementation.

4 Comparative Regional Analysis

4.1 GEOGRAPHIC DISTRIBUTION AND SURVEY COVERAGE

The comprehensive assessment covered three distinct sub-regions within the Gulf of Sirte: Western Sirte (Misrata-Sirte) with 35 respondents (53.0% of total sample), Central Sirte (Sirte-Ras Lanuf) with 19 respondents (28.8% of total sample), and Eastern Sirte (Ras Lanuf) with 12 respondents (18.2% of total sample). This distribution reflects the relative concentration of fishing activity across the region, with Western Sirte hosting the largest fishing population. (Figure1)

Figure 1. Geographic distribution of survey respondents across the Gulf of Sirte



4.2 REGIONAL ECONOMIC PROFILES AND VULNERABILITY PATTERNS

Western Sirte demonstrates the highest average monthly incomes at 2,926 LYD (€464) but paradoxically reports 11.4% of fishermen in the high dependency category (60-100% income from cartilaginous species). Despite higher baseline earnings, this region shows lower overall species dependency with 48.6% of fishermen rarely catching protected species.

Central Sirte occupies an intermediate economic position with average monthly incomes of 2,492 LYD (€396), positioning it between Western Sirte's higher earnings and Eastern Sirte's more constrained economic conditions. The region demonstrates moderate dependency levels with 10.5% classified in the high-dependency category and balanced fishing portfolio composition. Eastern Sirte exhibits the lowest baseline earnings at 2,058 LYD (€327) combined with the highest vulnerability indicators. Notably, 16.7% of Eastern Sirte fishermen fall within the high-dependency category nearly six times the rate observed in Western Sirte. This region demonstrates universal species interaction with 100% of fishermen encountering protected species.

Figure 2. Average Monthly Income by Region – Gulf of Sirte

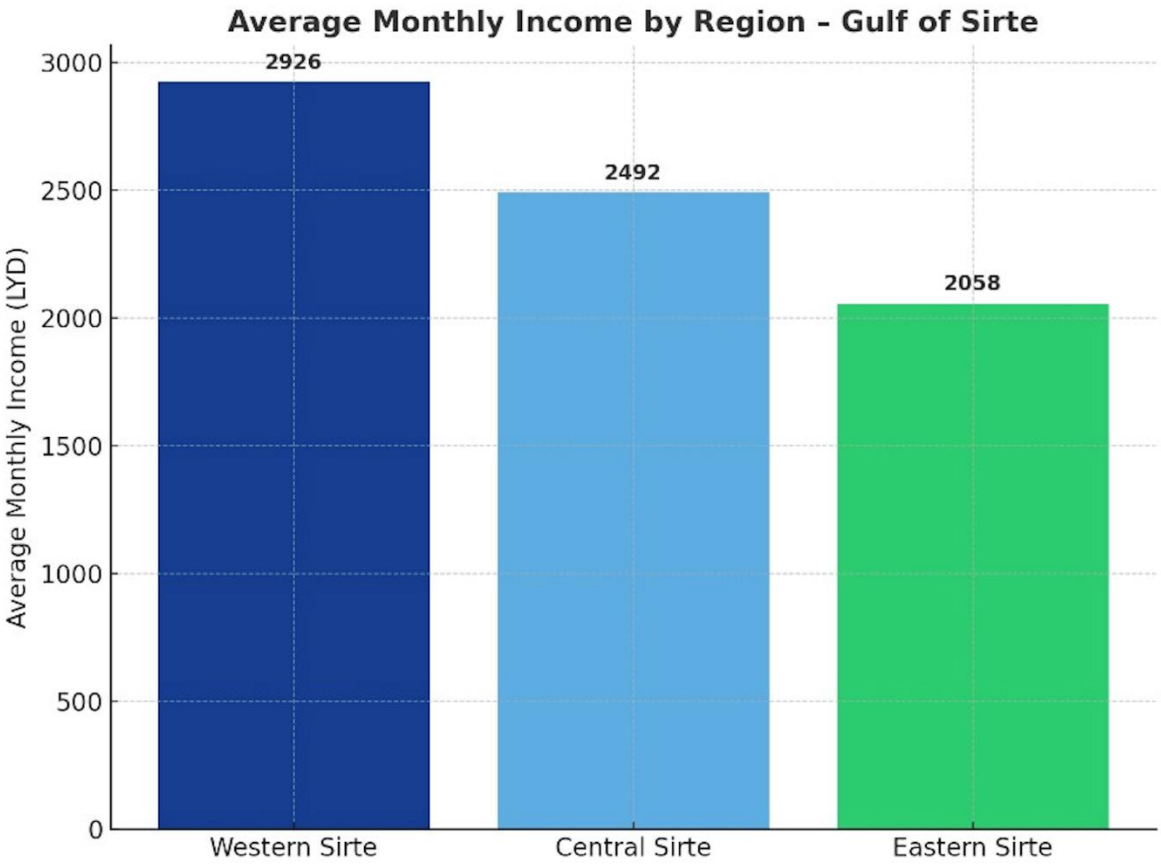
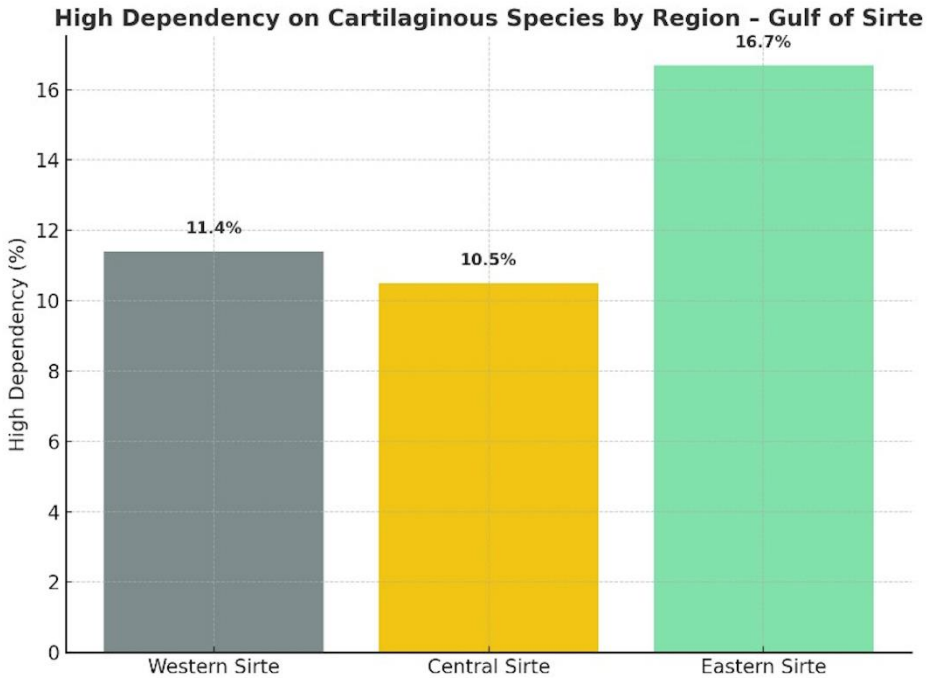


Figure 3. High Dependency on Cartilaginous Species by Region – Gulf of Sirte

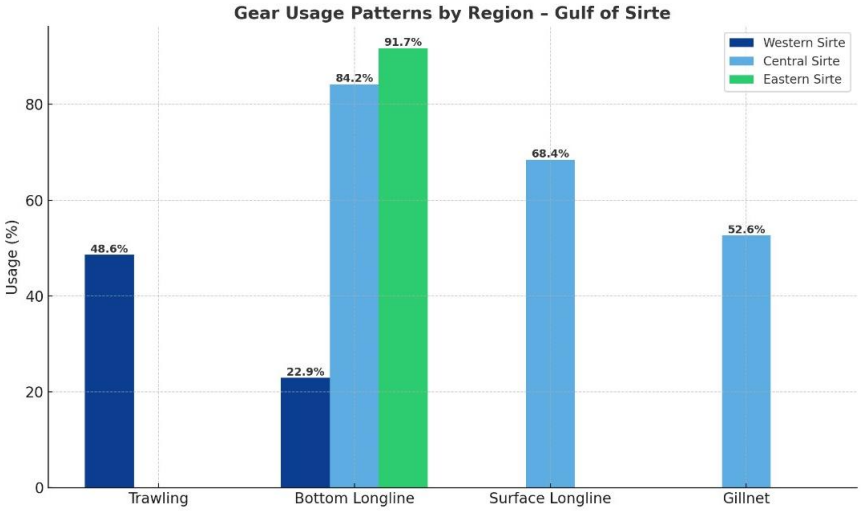


4.3 GEAR USAGE PATTERNS AND FISHING PRACTICES

Regional gear preferences reveal distinct operational strategies that directly influence conservation impact severity. Western Sirte demonstrates exclusive use of trawling gear (48.6% of fishermen) compared to zero trawling use in Central and Eastern Sirte, along with moderate bottom longline usage (22.9%).

Central Sirte shows the highest surface longline usage among all regions (68.4%), high bottom longline usage (84.2%), and moderate gillnet usage (52.6%). Eastern Sirte demonstrates the most intensive gear usage patterns with bottom longlines used by 91.7% of fishermen—the highest rate across all regions.

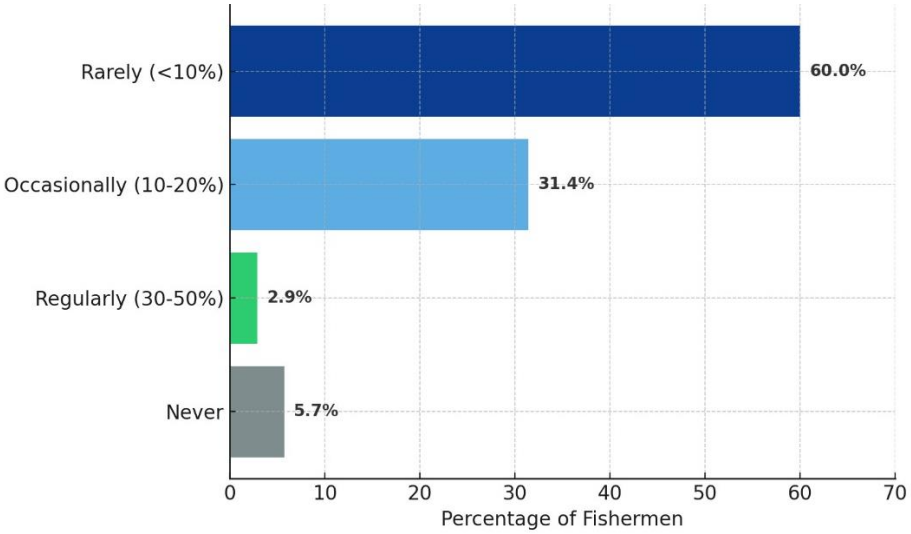
Figure 4. Gear Usage Patterns by Region – Gulf of Sirte



4.4 SPECIES INTERACTION FREQUENCY AND CONSERVATION IMPLICATIONS

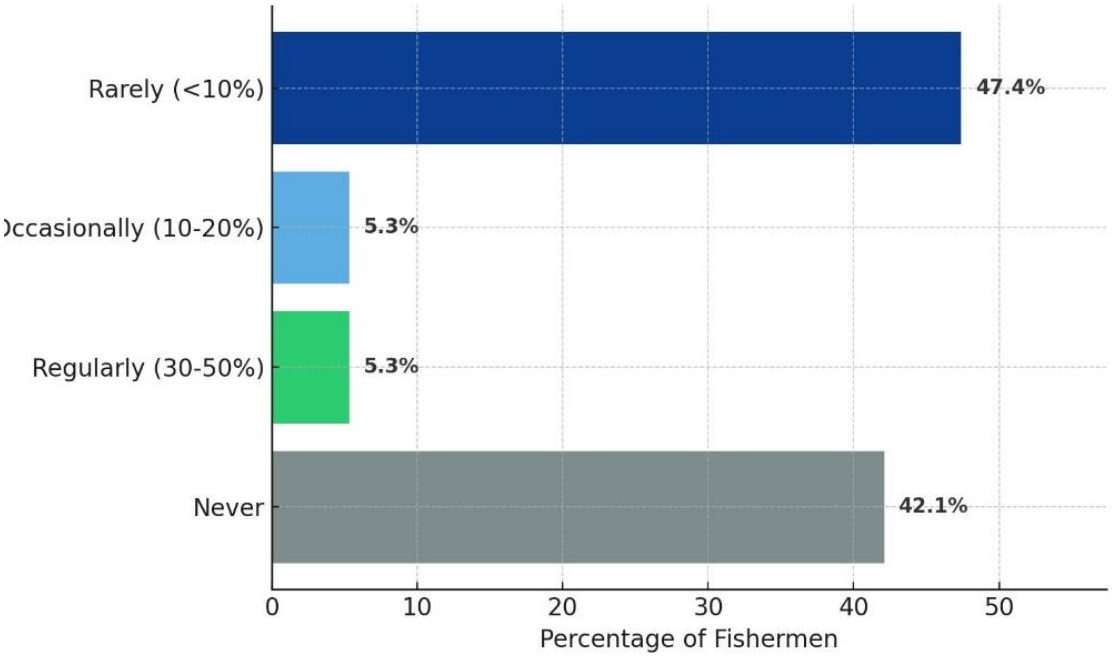
Cartilaginous species catch patterns reveal significant regional variations requiring tailored conservation approaches. Western Sirte shows 60.0% of fishermen rarely catching the eight specified species (<10% of catch), 31.4% catching them occasionally (10-20%), 2.9% catching them regularly (30-50%), and 5.7% never catching these species.

Figure 5. Cartilaginous Species Catch Patterns – Western Sirte



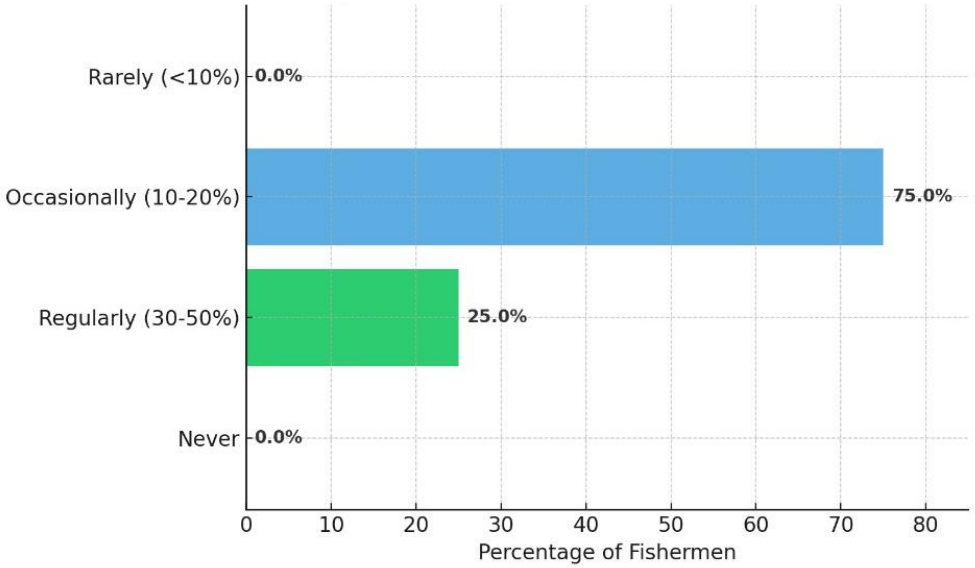
Central Sirte demonstrates different patterns with 47.4% rarely catching these species, 5.3% catching them occasionally, 5.3% catching them regularly, and notably 42.1% never catching the specified cartilaginous species.

Figure 6. Cartilaginous Species Catch Patterns – Central Sirte



Eastern Sirte exhibits the most concerning interaction rates with 75.0% of fishermen catching cartilaginous species occasionally (10-20% of catch) and 25.0% catching them regularly (30-50%). Critically, no Eastern Sirte fishermen reported never catching these species (0.0%) or rarely catching them (0.0%), indicating universal and systematic interaction with protected species.

Figure 7. Cartilaginous Species Catch Patterns – Eastern Sirte



4.5 HOUSEHOLD VULNERABILITY AND SOCIAL IMPACT DISTRIBUTION

Regional analysis reveals a critical vulnerability amplification effect where higher dependency households support larger families. Low-dependency households average 5.2 dependents per fisherman, medium-dependency households average 5.8 dependents, and high-dependency households average 6.3 dependents per fisherman.

Eastern Sirte's combination of lowest incomes, highest dependency rates, and universal species interaction creates concentrated economic risk affecting not only individual fishermen but entire extended family networks. The region's

16.7% high-dependency rate, when combined with larger household sizes, suggests that conservation measures could trigger cascading socioeconomic impacts.

4.6 REGIONAL CONSERVATION STRATEGY IMPLICATIONS

These regional variations necessitate geographically differentiated implementation approaches rather than uniform conservation measures. Eastern Sirte requires intensive conservation intervention due to universal cartilaginous species interaction (100% of fishermen), combined with the highest vulnerability indicators and lowest economic resilience.

Central Sirte's intermediate characteristics suggest that standard support mechanisms could be effective without the intensive interventions required for Eastern Sirte. Western Sirte's lower interaction rates and greater use of trawling may allow for different implementation strategies emphasizing voluntary adoption and incentive-based approaches.

5 Socio-Economic Analysis Findings

5.1 DEMOGRAPHIC PROFILE OF FISHING COMMUNITIES

5.1.1 Age and Experience Demographics

The survey captured comprehensive data from 66 fishermen working across the three sub-regions of the Gulf of Sirte. All respondents were male, reflecting the male-dominated nature of Libya's fishing sector. Ages spanned from young adults to elders in their 70s, with the largest group (46.8%) in the 40-49 age bracket, representing nearly half of all respondents. The remainder were distributed across younger and older age groups: 8.5% aged 18-29, 19.1% aged 30-39, 19.1% aged 50-59, 4.3% aged 60-69, and 2.1% aged 70 or above.

Figure 8. Age Distribution of Fishermen – Gulf of Sirte

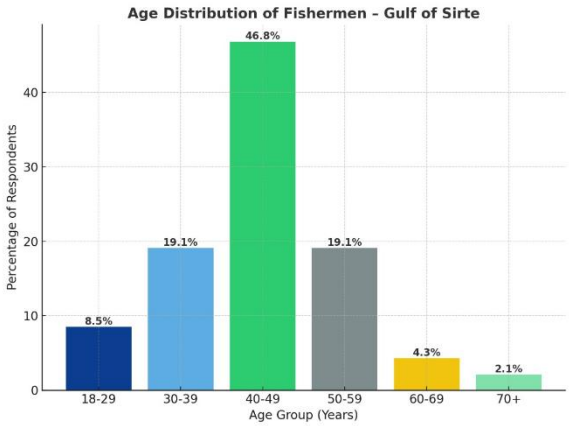
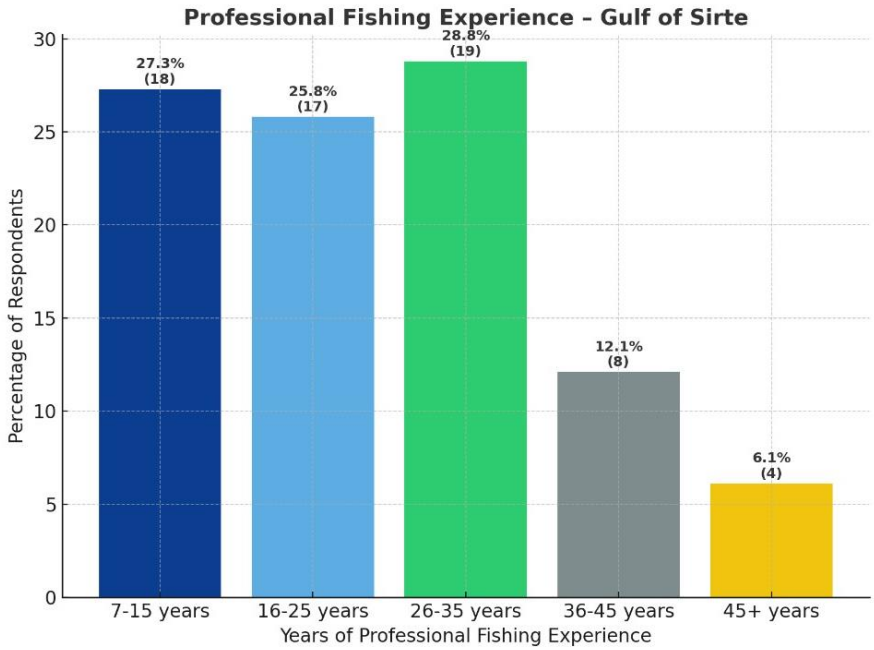


Figure 7. Age distribution of fishermen surveyed across the Gulf of Sirte. The largest group (46.8%) falls within the 40–49 age bracket, with smaller proportions in younger and older age ranges, reflecting a mature workforce in the sector.

Professional fishing experience reveals an established, highly experienced community with significant implications for conservation implementation. The distribution shows 27.3% (18 fishers) with developing expertise (7-15 years), 25.8% (17 fishers) with solid experience (16-25 years), and 28.8% (19 fishers) with high experience levels (26-35 years). Expert-level fishers with 36-45 years' experience represent 12.1% (8 individuals), while master practitioners with over 45 years comprise 6.1% (4 fishers). The mean experience of 27.5 years (median: 25 years) with a range of 7-65 years demonstrates a highly experienced workforce requiring respectful, knowledge-based conservation approaches that acknowledge traditional fishing expertise.

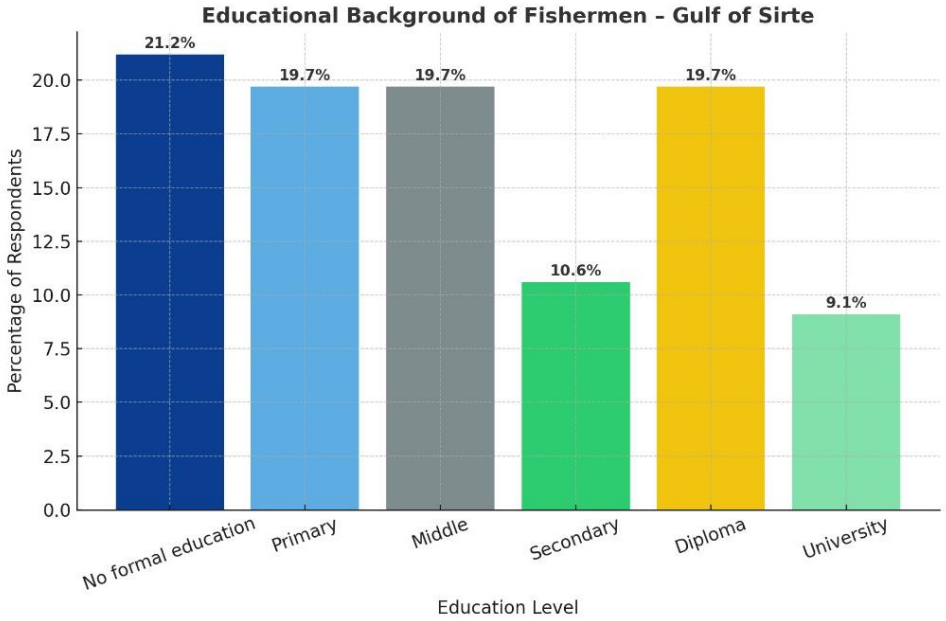
Figure 9. Professional Fishing Experience – Gulf of Sirte



5.1.2 Educational Background and Training Capacity

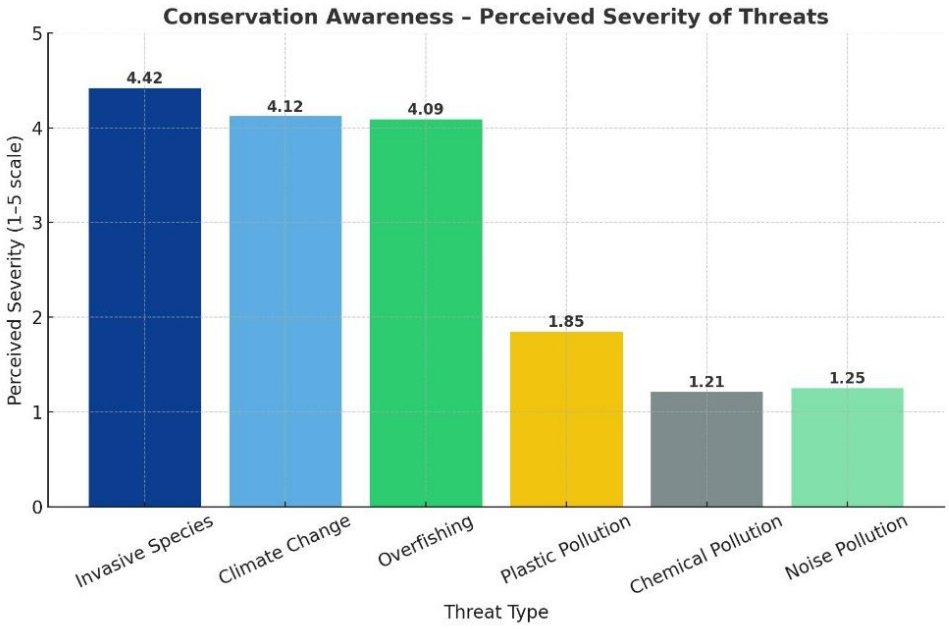
Educational backgrounds were systematically documented across six levels with a 100% response rate (N=66), revealing significant diversity: **21.2% had no formal education, 19.7% completed primary education, and 10.6% attained secondary education**. Intermediate education levels (primary, secondary, and middle) accounted for 50.0% of respondents, while **28.8% held higher education credentials (9.1% university, 19.7% diploma)**. This distribution highlights a dual reality: nearly half of the cohort (50.0%) possess foundational-to-intermediate education, while the substantial proportion with higher education (28.8%) indicates strong capacity for technical training and conservation program implementation.

Figure 10. Educational Background of Fishermen – Gulf of Sirte



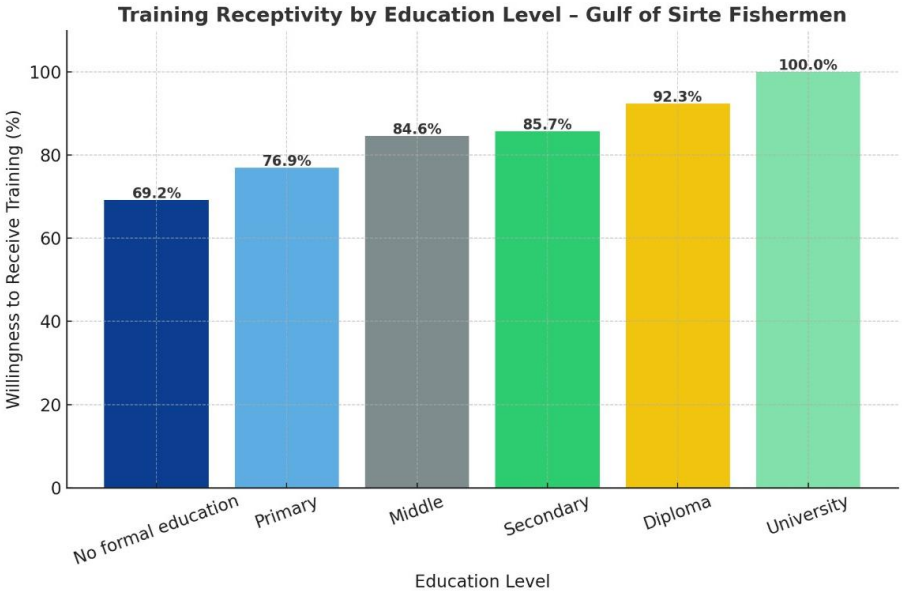
Conservation awareness assessment revealed tiered environmental consciousness: fishers demonstrated acute awareness of systemic threats, with **invasive species perceived as most severe (4.42/5.0), followed by climate change (4.12/5.0) and overfishing (4.09/5.0)**. In contrast, pollution impacts (plastic: 1.85; chemical: 1.21; noise: 1.25) were markedly underrecognized, highlighting a need to integrate pollution education with existing conservation efforts targeting high-priority concerns.

Figure 11. Conservation Awareness – Perceived Severity of Threats



Training receptivity showed strong potential: 80.3% expressed willingness to receive training. Cross-analysis identified that university-educated fishermen showed universal willingness to participate in training (100%), while those without formal education were somewhat less receptive (69.2% willing), indicating concentrated adaptation capacity among higher-educated practitioners.

Figure 12. Training Receptivity by Education Level – Gulf of Sirte Fishermen



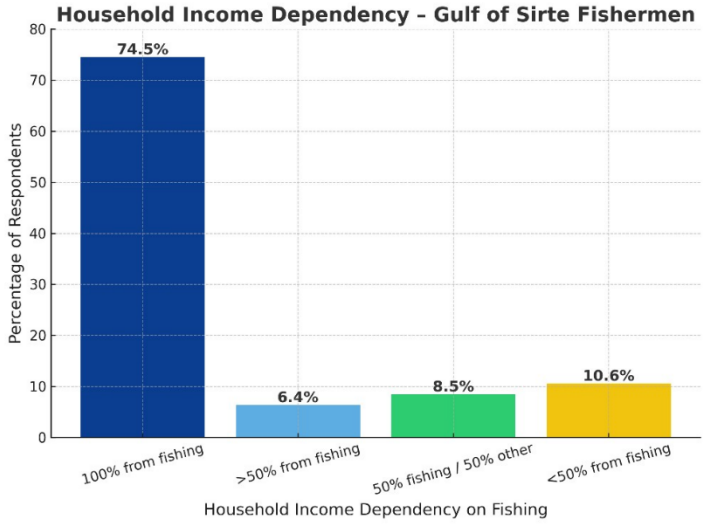
5.2 ECONOMIC DEPENDENCY AND HOUSEHOLD STRUCTURE

5.2.1 Income Dependency Patterns

Nearly three-quarters (74.5%) of all respondents reported that fishing provides their entire household income, with no other significant income source. A smaller group (6.4%) supplements fishing income with other activities, though fishing still provides more than half their earnings. About one in twelve fishermen (8.5%) reported an even split between fishing and other income sources, while roughly one in ten (10.6%) have diversified to the point where fishing represents less than half of their household income.

This exceptionally high dependency on fishing activities highlights the vulnerability of these communities to any restrictions on fishing operations.

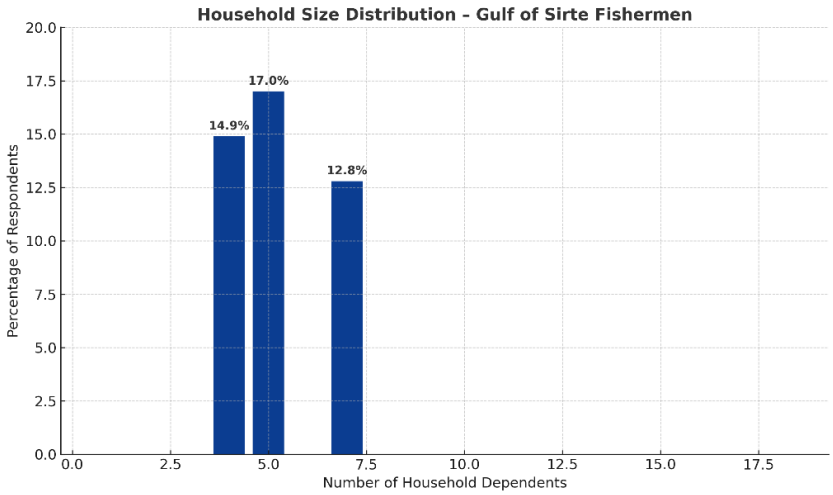
Figure 13. Household Income Dependency – Gulf of Sirte Fishermen



5.2.2 Household Size and Vulnerability Amplification

Household size analysis revealed that each fishing income typically supports between 1 and 18 family members, with a mean of 5.0 dependents per fisherman and median of 5 dependents. The most common household size was 5 dependents (17.0% of respondents), followed by 4 dependents (14.9%) and 7 dependents (12.8%).

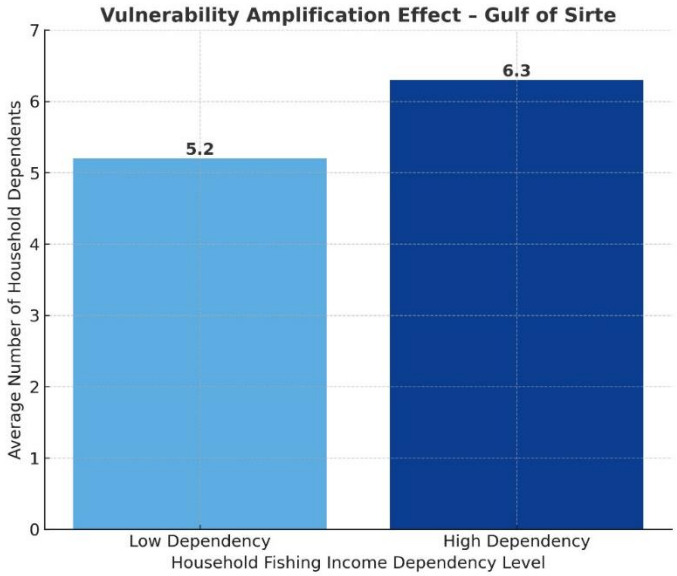
Figure 14. Household Size Distribution – Gulf of Sirte Fishermen



Regional variations demonstrate Western Sirte averaging 5.1 dependents per household, Central Sirte averaging 5.6 dependents, and Eastern Sirte averaging 6.2 dependents per household.

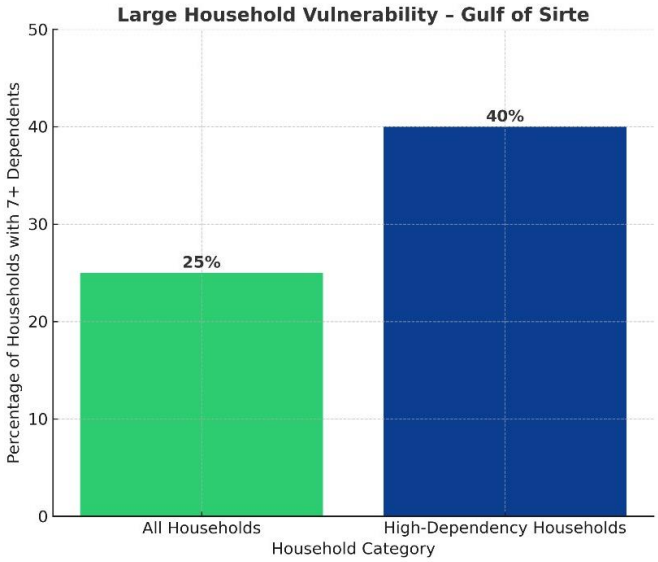
The research documents a positive relationship between economic vulnerability and household size, creating a 'vulnerability amplification effect.' Analysis reveals that **high-dependency households average 6.3 dependents per fisherman compared to 5.2 dependents for low-dependency households**, demonstrating how larger household sizes compound economic vulnerability to conservation measures.

Figure 15. Vulnerability Amplification Effect – Gulf of Sirte



Larger household sizes (7+ dependents) are particularly vulnerable to economic disruption, representing 25% of all households but comprising 40% of high-dependency fishermen. These extended family structures, characteristic of traditional Libyan social organization, amplify economic vulnerability as conservation measures affecting fishing income could impact large extended families extending well beyond individual fishermen.

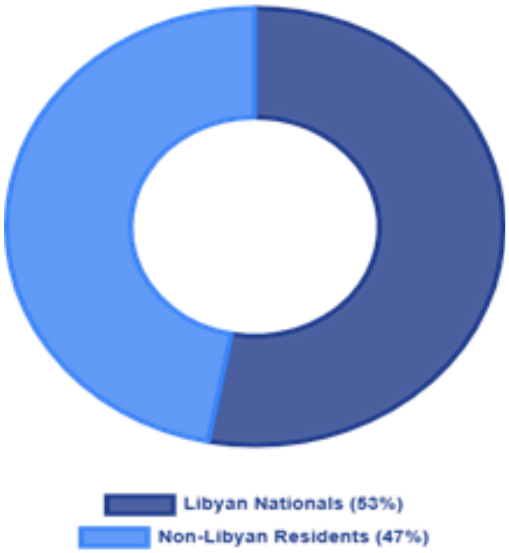
Figure 16. Large Household Vulnerability – Gulf of Sirte



5.2.3 Demographic Composition and Legal Status Considerations

The demographic composition shows **35 Libyan nationals (53.0%) and 31 non-Libyan residents (47.0%)**, reflecting the demographic composition of the regional fishing workforce. This demographic distribution necessitates consideration of differential legal status, access to government support programs, and varying relationships with local authorities in policy design and implementation strategies.

Figure 17. Demographic composition



5.3 FISHING PRACTICES AND CARTILAGINOUS SPECIES INTERACTIONS

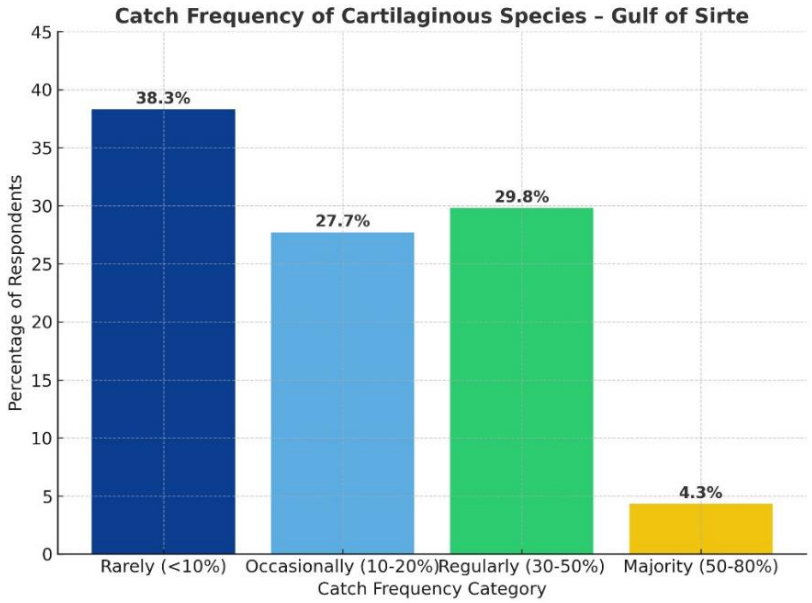
5.3.1 Catch Frequency and Species Interaction Patterns

Analysis of catch frequency revealed considerable variation across the three sub-regions:

- About 38.3% rarely catch cartilaginous species (less than 10% of their total catch)
- 27.7% reported occasional catches (10-20% of total catch)
- 29.8% regularly catch sharks and rays (30-50% of catches)
- 4.3% reported that these species comprise a majority of their catch (50-80%)

Most significantly, 91.5% of respondents reported they currently catch protected cartilaginous species as bycatch, highlighting the direct relevance of conservation measures to everyday fishing practices.

Figure 18. Catch Frequency of Cartilaginous Species – Gulf of Sirte



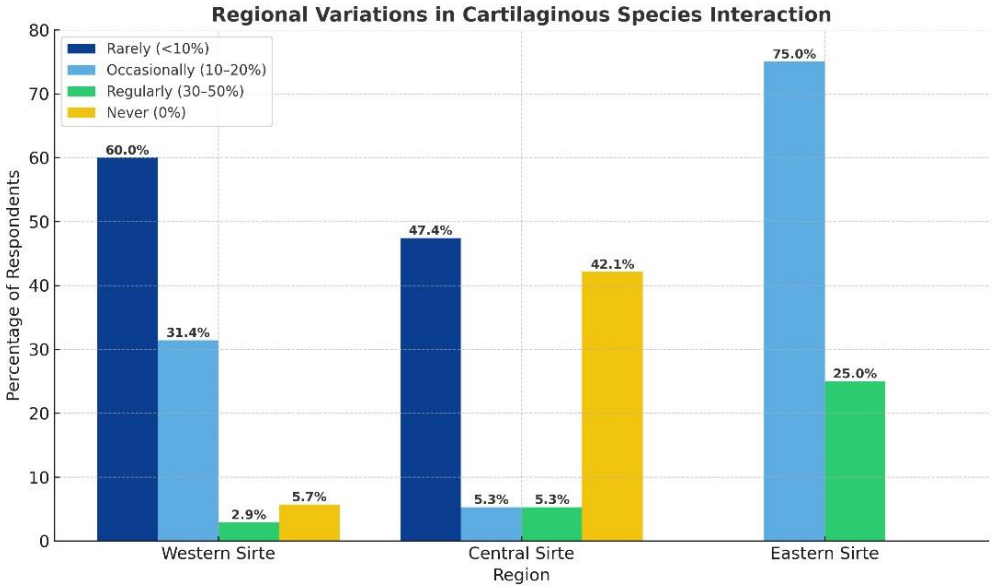
5.3.2 Regional Variations in Species Interaction

Western Sirte: 60.0% of fishermen rarely catch the eight specified species (<10% of catch), 31.4% catch them occasionally (10-20%), 2.9% catch them regularly (30-50%), and 5.7% never catch these species.

Central Sirte: Shows a different pattern, with 47.4% rarely catching these species, 5.3% catching them occasionally, 5.3% catching them regularly, and a notably higher proportion (42.1%) never catching the specified cartilaginous species.

Eastern Sirte: Demonstrates the highest interaction rates with cartilaginous species, **with 75.0% of fishermen catching them occasionally (10-20% of catch) and 25.0% catching them regularly (30-50%)**. Significantly, **no Eastern Sirte fishermen reported never catching these species (0.0%) or rarely catching them (0.0%)**, indicating universal and systematic interaction with protected species.

Figure 19. Regional Variations in Cartilaginous Species Interaction – Gulf of Sirte



5.3.3 Gear Usage and Species Interaction Analysis

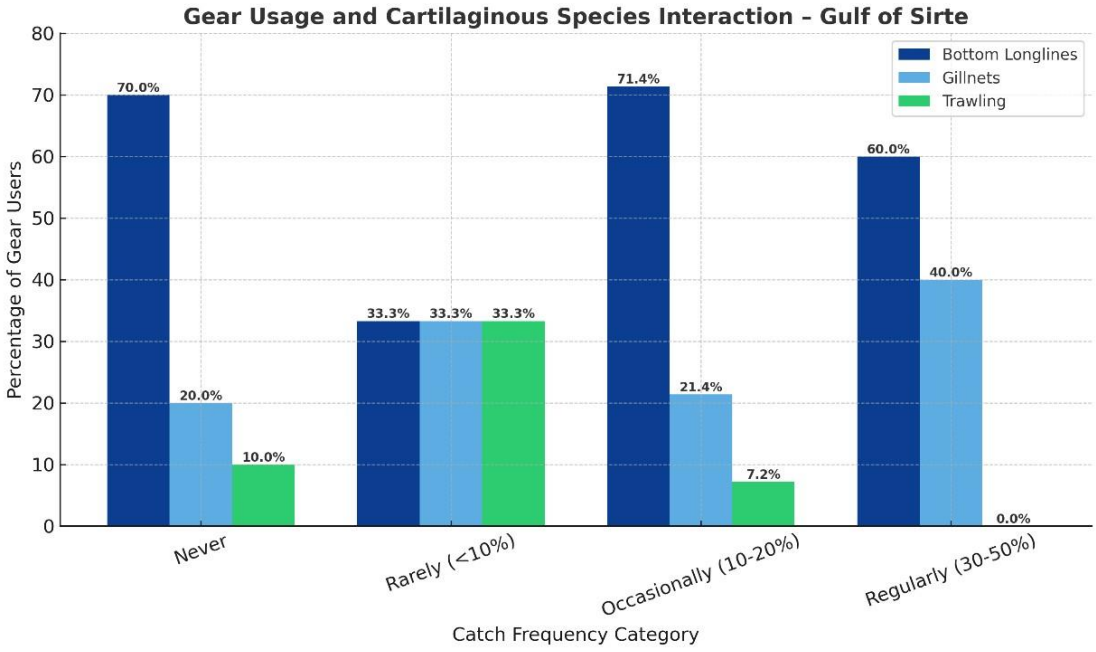
Different fishing methods showed varying associations with cartilaginous species catches:

Bottom Longlines (53.0% of respondents): Demonstrated the highest interaction rates with cartilaginous species. Among bottom longline users, 70.0% of fishermen who never catch protected species use this gear, 33.3% of rare catchers use bottom longlines, **71.4% of occasional catchers employ this method, and 60.0% of regular catchers use bottom longlines**. The high usage across all catch categories indicates bottom longlines frequently interact with these species.

Gillnets (36.4% of respondents): Showed varied interaction patterns with relatively balanced distribution across different catch frequency categories, suggesting moderate interaction rates.

Trawling (25.8% of respondents): Showed the lowest interaction rates with cartilaginous species. Only 10.0% of fishermen who never catch protected species use trawling, and **0.0% of regular catchers use trawling**. This pattern indicates trawling has the lowest cartilaginous species interaction rates among all gear types.

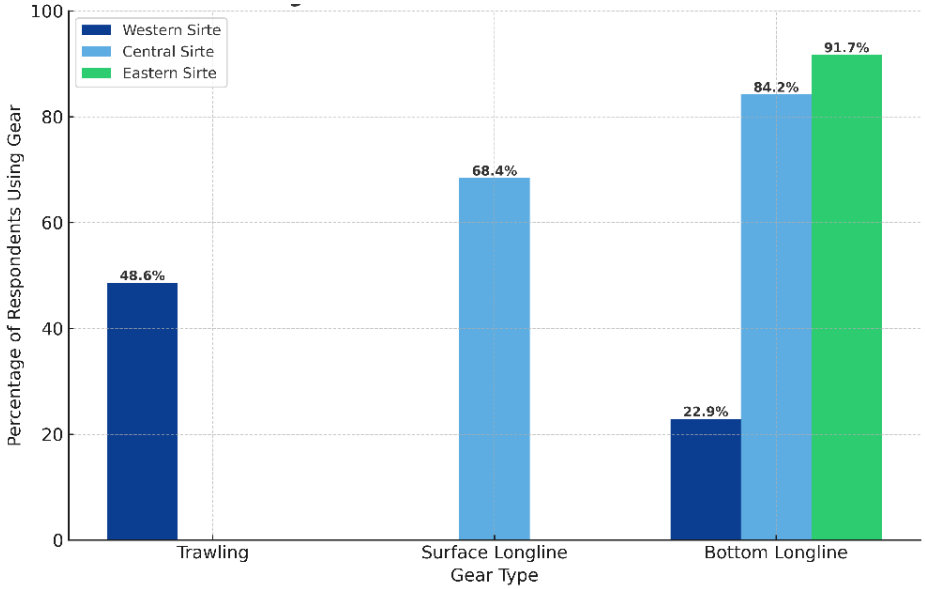
Figure 20. Gear Usage and Cartilaginous Species Interaction – Gulf of Sirte



Regional Gear Preferences:

- **Western Sirte:** Exclusive use of trawling (48.6%) compared to no trawling use in Central and Eastern Sirte
- **Central Sirte:** Highest surface longline usage among all regions (68.4%) and high bottom longline usage (84.2%)
- **Eastern Sirte:** Heavy reliance on bottom longlines (91.7%) with no trawling usage

Figure 21. Regional Gear Preferences – Gulf of Sirte



Gear Type, Bycatch Impact, and Willingness to Adapt

Willingness to participate in sustainable fishing training varied significantly depending on the primary fishing gear used, a finding that correlates directly with both the ecological impact of the gear and the perceived economic viability of proposed modifications.

Bottom Longline Users: Showed the highest willingness (89.5%). This high level of acceptance is likely linked to their moderate cartilaginous species interaction rates (42.1% regular catches) and the perception that required gear modifications are technically feasible and economically viable. Proposed modifications include circle hook adoption (which can reduce deep hooking by 60%), changes to leader material, and hook size regulations for species selectivity.

Gillnet/Trammel Net Users: Showed lower willingness (64.3%), which correlates with their high cartilaginous species interaction rates (78.6% regular catches) and significant concerns about the cost and complexity of gear modifications. These users worry about reduced catch efficiency with modified nets (e.g., larger mesh sizes, biodegradable panels) and increased operational complexity from seasonal restrictions in critical habitats.

Trawling Users: Showed moderate willingness (76.5%). This finding is of critical strategic importance, as our bycatch analysis identifies bottom trawling as the gear with the most extensive and non-selective impact, particularly on demersal species like angel sharks (Squatina squatina) and common guitarfish (Rhinobatos rhinobatos). While your data shows their frequent interaction rate as 6%, the sheer volume and diversity of their catch makes them a top priority for mitigation. Their moderate willingness reflects concerns about the high cost and complexity of trawl modifications, which focus on turtle-excluder device (TED) adaptations for ray protection and navigating seasonal area restrictions.

Surface Longline Users: Although detailed willingness data was limited, this group shows high interaction rates with pelagic species (58.3% regular catches) and expresses concern about the operational feasibility of modifications in offshore operations.

Geographic Hotspots and Implications for Phased Implementation

These gear-specific patterns are concentrated in distinct geographic hotspots, providing the direct evidence needed for the targeted, phased implementation strategy recommended in Section 6.

Western Sirte (Qaser Ahmed Port): This area is a clear trawling hotspot. The concentration of bottom trawl fishers in Qaser Ahmed corresponds with the highest reports of demersal bycatch. The combination of high ecological impact and moderate fisher willingness makes this community the logical starting point for Phase 1 of the implementation plan, focusing on trawl modifications.

Central Sirte: This region's distinctive gear profile—with exceptionally high surface longline usage (68.4%) and substantial bottom longline adoption (84.2%)—creates a different bycatch profile. The data shows intermediate willingness to adapt, reflecting a balanced portfolio of high-interaction longline users and fishers with minimal encounters. This justifies a Phase 2 approach focused on longline modifications (circle hooks, leader materials) tailored to this region.

Eastern Sirte : This region shows a higher concentration of pelagic shark bycatch associated with surface longline and gillnet fisheries, justifying a separate, targeted awareness and mitigation program.

5.4 MARKET VALUE AND ECONOMIC SIGNIFICANCE

5.4.1 Ray Market Structure and Limited Commercial Value

Market analysis revealed fundamental limitations in ray commercial integration. **Among the 66 surveyed fishermen, 54.5% (n=36) reported that rays possess no commercial value within existing local market structures**, with these catches routinely used as bait for other fishing activities or discarded as fishing waste. The remaining 45.5% (n=30) engage in commercial ray sales, though prices remain constrained to less than 10 Libyan Dinars per kilogram (approximately €1.59/kg).

Figure 22. Ray Market Structure – Gulf of Sirte

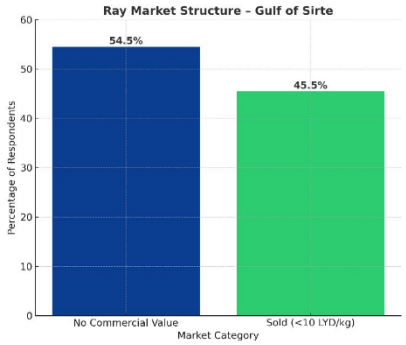
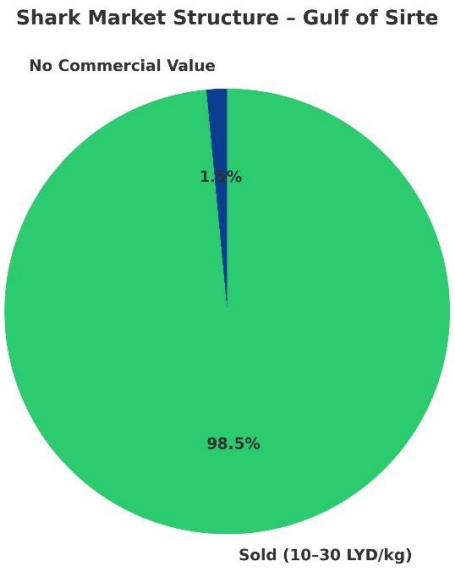


Figure 20. Ray market structure among Gulf of Sirte fishermen. Over half of respondents (54.5%) report no commercial value for rays, with catches used as bait or discarded. The remaining 45.5% sell rays at prices below 10 LYD/kg (~€1.59/kg), indicating limited integration into local markets.

5.4.2 Shark Market Analysis and Economic Context

Shark products demonstrate markedly different market dynamics compared to rays. Survey data reveals that 98.5% of respondents (n=65) report shark sales within the second price category (10-30 LYD/kg), while only 1.5% (n=1) indicated no commercial value for shark products. This near-universal market participation contrasts sharply with the bifurcated ray market structure.

Figure 23. Shark Market Structure – Gulf of Sirte



Converting shark prices using prevailing exchange rates (6.3 LYD = 1 EUR), **shark products command €1.59-€4.76 per kilogram**, positioning them within intermediate value categories for regional marine products. This pricing represents a **200-400% premium over maximum ray prices (€1.59/kg maximum)**, indicating established consumer preferences and market demand that substantially favor shark products over ray products.

5.4.3 Economic Dependency Architecture

The survey findings reveal that the majority of Gulf of Sirte fishermen maintain limited economic dependency on cartilaginous species, with 69.7% of respondents deriving less than 20% of their fishing income from shark and ray catches. This pattern indicates that cartilaginous species function as supplementary rather than primary income sources for most fishing operations, contrasting with expectations of high dependency levels in this specialized fishing region.

Analysis of income dependency categories reveals: 69.7% (n=46) in the minimal dependency category (0-20% income), 19.7% (n=13) in the medium-low dependency category (20-40% income), 4.5% (n=3) in medium dependency (40-60% income) 4.5% (n=3) in high dependency (60-80% income), 0% (n=0) in very high dependency (80-100% income)

Figure 24. Income Dependency on Cartilaginous Species

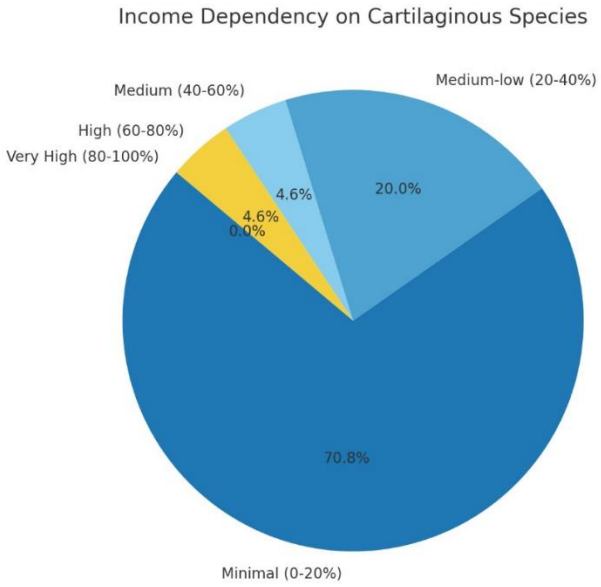


Figure 1: Distribution of fishermen across income dependency categories.
The chart highlights that 69.7% of respondents rely minimally on cartilaginous species income, while no respondents fall into the very high dependency category.

When consolidated into management-relevant vulnerability categories:

1. Minimal Impact (0-20% income dependency): 69.7% of respondents (n=46)
2. Moderate Impact (20-60% income dependency): 24.2% of respondents (n=16)
3. High Impact (60-100% income dependency): 4.5% of respondents (n=3)

The predominance of minimal dependency fishing operations indicates that cartilaginous species restrictions would affect a targeted subset rather than the entire fishing fleet, enabling risk-stratified conservation approaches with focused support for the 28.8% of fishermen facing moderate to high economic impacts.

Figure 25. Vulnerability Categories for Fisheries Management

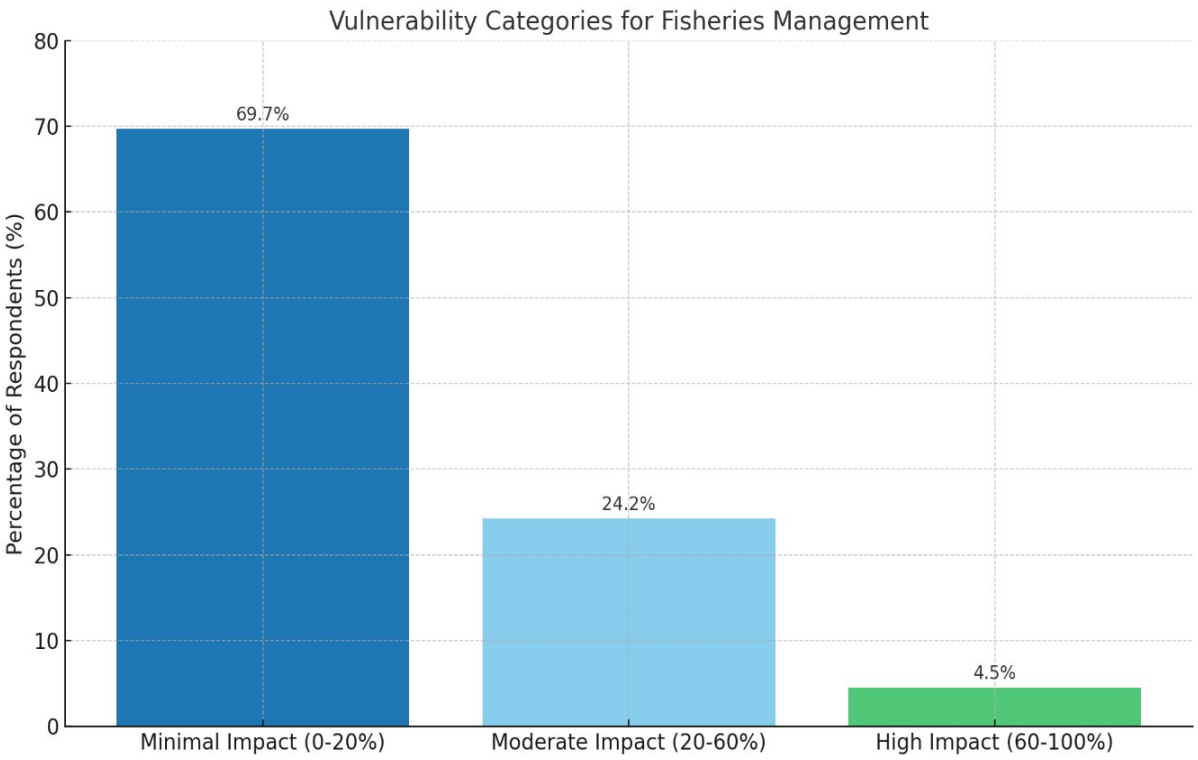


Figure 2: Consolidated vulnerability categories relevant for management decisions.
This grouping supports targeted conservation measures for the 28.8% facing moderate to high impacts.

5.5 TRADITIONAL MEDICINE AND CULTURAL USE PATTERNS

5.5.1 Prevalence and Regional Distribution

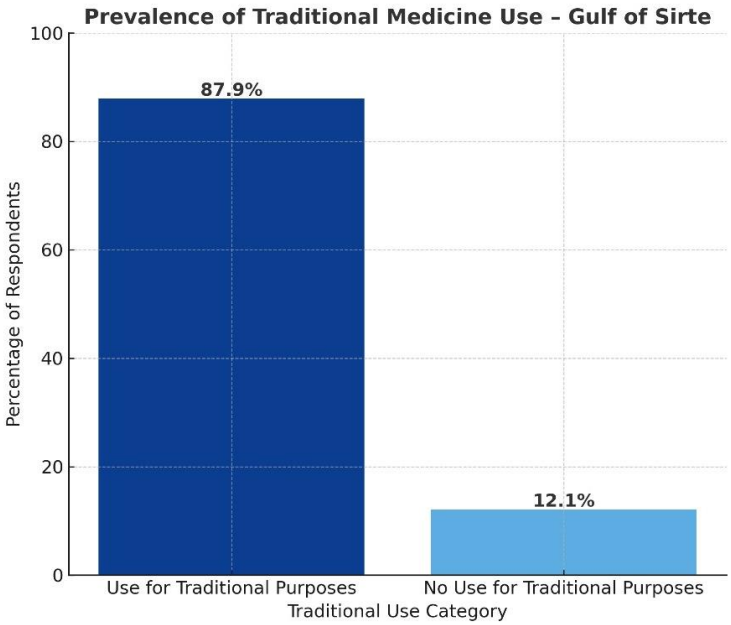
Survey data revealed remarkably high prevalence of traditional medicinal utilization practices involving cartilaginous species. A substantial **87.9% of all respondents reported using shark or ray products for traditional purposes**, indicating these practices are deeply ingrained in local fishing culture.

Regional variations showed:

- **Western Sirte:** 82.9% of fishermen reporting traditional medicinal usage
- **Central Sirte:** 89.5% reporting such usage
- **Eastern Sirte:** 100% of fishermen reporting traditional medicinal usage

This geographic gradient indicates strongest traditional practices in Eastern Sirte, with Central Sirte maintaining high but not universal participation, while Western Sirte shows the lowest (though still substantial) traditional medicine integration.

Figure 26. Prevalence of Traditional Medicinal Use – Gulf of Sirte



5.5.2 Species-Specific Traditional Medicine Distribution

Among traditional medicine users, the data reveals a clear pattern:

- **95% of traditional medicine users provide a combination of three ray species to community members:**

  1. *Rhinoptera marginata* (Lusitanian Cownose Ray) - Near Threatened
  2. *Myliobatis aquila* (Common Eagle Ray) - Endangered
  3. *Aetomylaeus bovinus* (Bull Ray) - Critically Endangered

The dominance of this three-species combination **means that protecting any one of these ray species would significantly impact the ability of 95% of traditional medicine practitioners to provide these materials to their communities.**

Figure 27. Species-Specific Traditional Medicine Distribution

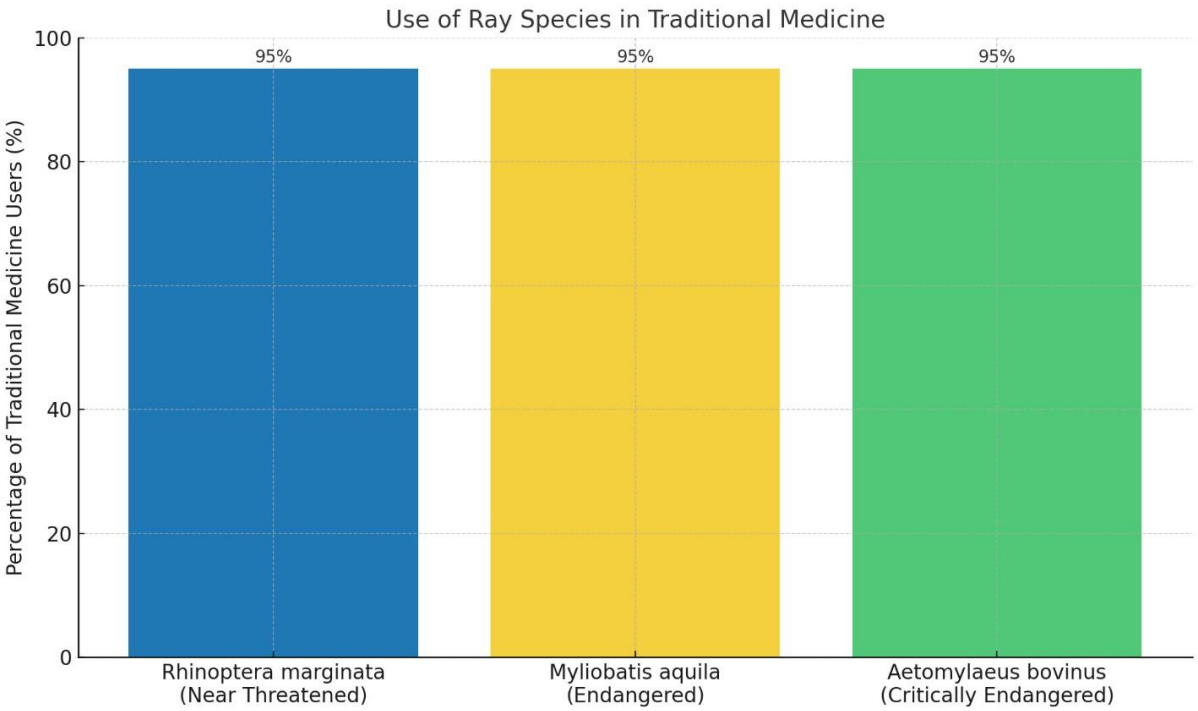


Figure 3: Prevalence of three ray species in traditional medicine use.
Data show that 95% of practitioners rely on this combination of Rhinoptera marginata, Myliobatis aquila, and Aetomylaeus bovinus, highlighting the potential impact of conservation measures on traditional practices.

5.6 REGIONAL ECONOMIC PROFILES AND VULNERABILITY ASSESSMENT

5.6.1 Western Sirte Economic Profile

Western Sirte demonstrates the highest average monthly incomes at 2,843 LYD (€451) among the three sub-regions, yet exhibits moderate economic vulnerability to conservation restrictions affecting cartilaginous species. The region's economic profile reflects a complex balance between higher baseline earnings and significant species interaction patterns that create concentrated impacts for specific fisher categories.

Economic Vulnerability Distribution:

The vulnerability assessment framework reveals differentiated impact patterns across Western Sirte's fishing community:

- **Low vulnerability fishermen (40.9%)**: Experience potential monthly losses of 426 LYD, representing manageable economic adjustment
- **Moderate vulnerability fishermen (25.8%)**: Face monthly losses of 853 LYD, requiring structured transition support
- **High vulnerability fishermen (30.3%)**: Confront monthly losses of 1,422 LYD, necessitating intensive intervention
- **Very high vulnerability fishermen (3.0%)**: Risk monthly losses of 1,990 LYD, demanding immediate emergency support

Figure 28. Percentage Distribution of Fishermen by Vulnerability Category

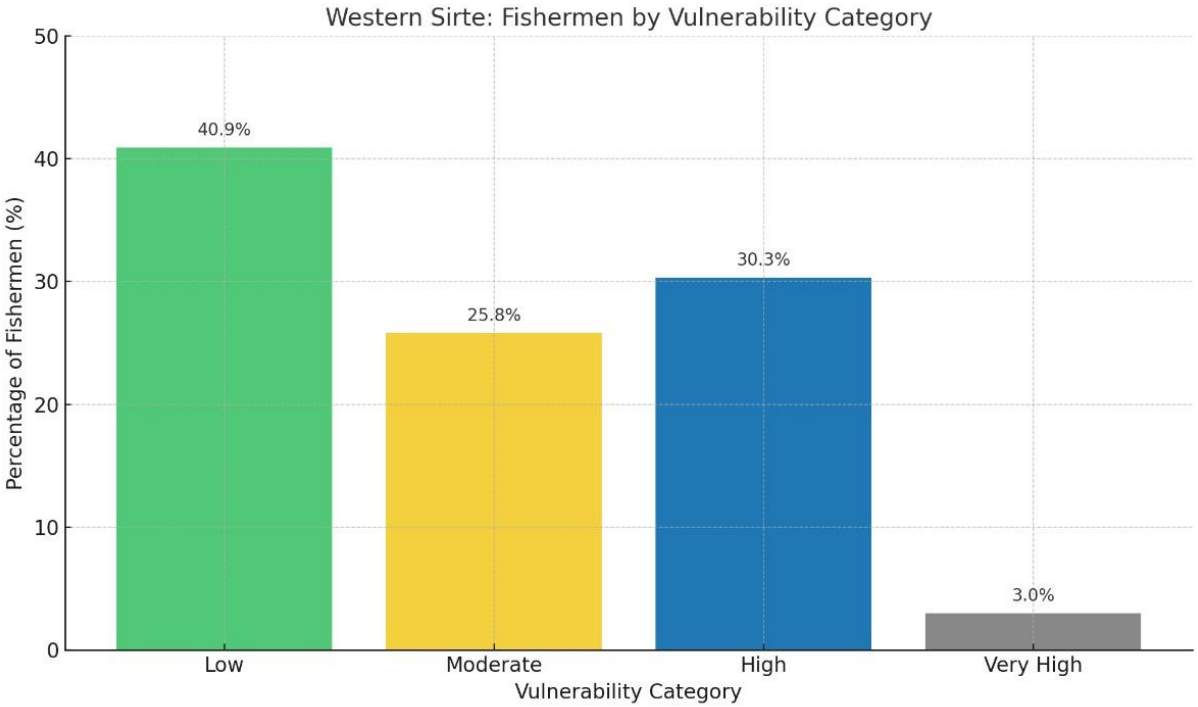


Figure 4a: Percentage of fishermen in each economic vulnerability category.
While 40.9% face low vulnerability, nearly a third fall into the high vulnerability group.

Figure 29. Estimated Monthly Income Losses by Vulnerability Category

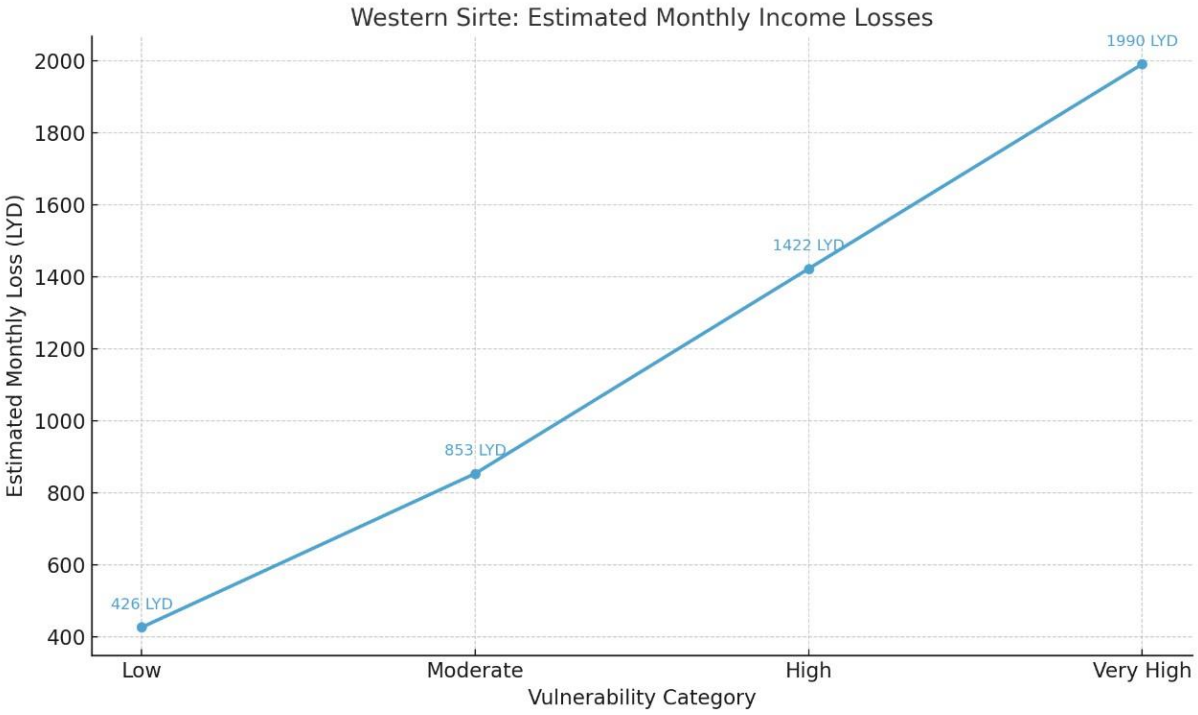


Figure 4b: Estimated monthly income loss per vulnerability category.
Losses escalate steeply from 426 LYD in the low category to 1,990 LYD in the very high category.

Species Interaction Patterns:

Western Sirte demonstrates distinct fishing patterns with **48.6% of fishermen rarely catching protected species** (<10% of total catch). The region's predominant use of trawling gear (48.6% of fishermen) appears to correlate with these lower interaction rates compared to other gear types used in the region. However, this pattern may reflect specific local conditions, operational depths, or seasonal timing rather than universal trawling characteristics. **4 out of 35 Western Sirte fishermen (11.4%)** use exactly 2 types of fishing gear.

Gear Usage Distribution:

- **Trawling**: 48.6% (17 fishermen)
- **Gillnets**: 28.6% (10 fishermen)
- **Bottom longlines**: 22.9% (8 fishermen)
- **Surface longlines**: 22.9% (8 fishermen)
- **Fixed nets**: 20.0% (7 fishermen)

Figure 30. Horizontal Representation of Fishing Gear Usage in Western Sirte

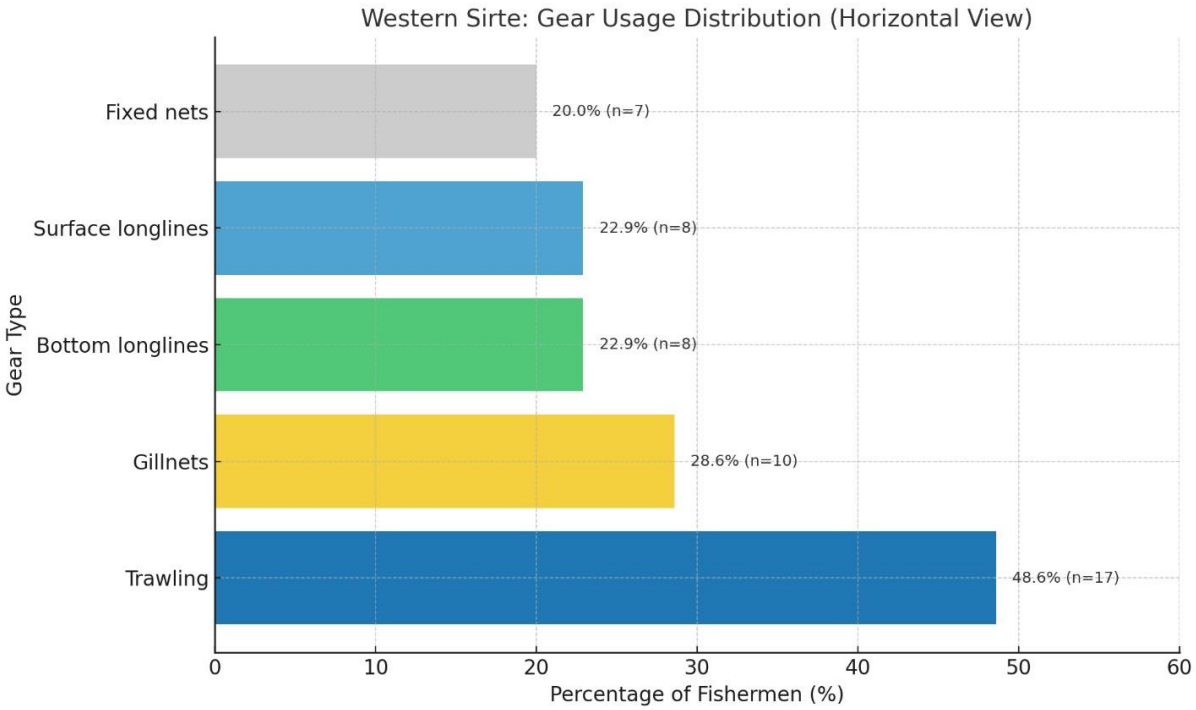


Figure 5e: Horizontal representation of fishing gear usage in Western Sirte.
Trawling leads in usage, followed by gillnets and longlines, with fixed nets least used.
About 11.4% (n=4) of fishermen operate exactly two gear types.

Educational Capacity:

The region exhibits enhanced adaptation capacity through higher education levels, with **14.3% holding university education** (5 out of 35 fishermen). Additionally, **11.4% hold diploma-level qualifications** (4 fishermen), bringing the total higher education rate to **25.7%** (9 fishermen with university or diploma credentials). This educational foundation supports training program implementation and alternative livelihood development initiatives.

The concentration of higher education credentials (25.7% combined university and diploma) positions Western Sirte favorably for conservation training programs and economic transition initiatives compared to the regional average.

Figure 31. Educational Distribution among Western Sirte Fishermen

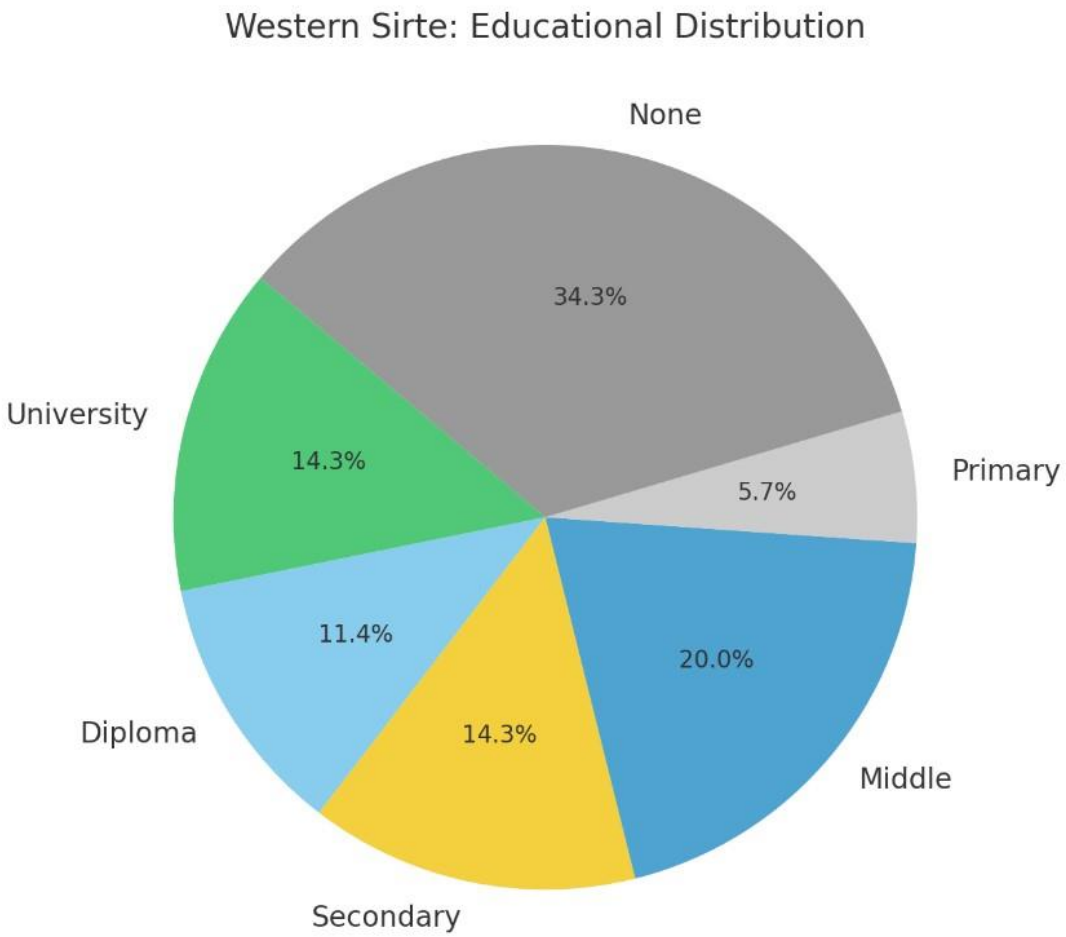


Figure 7: Educational distribution among Western Sirte fishermen.
Higher education (university + diploma) accounts for 25.7% (n=9), supporting adaptation capacity.
Secondary and middle education are also notable, while 34.3% have no formal education.

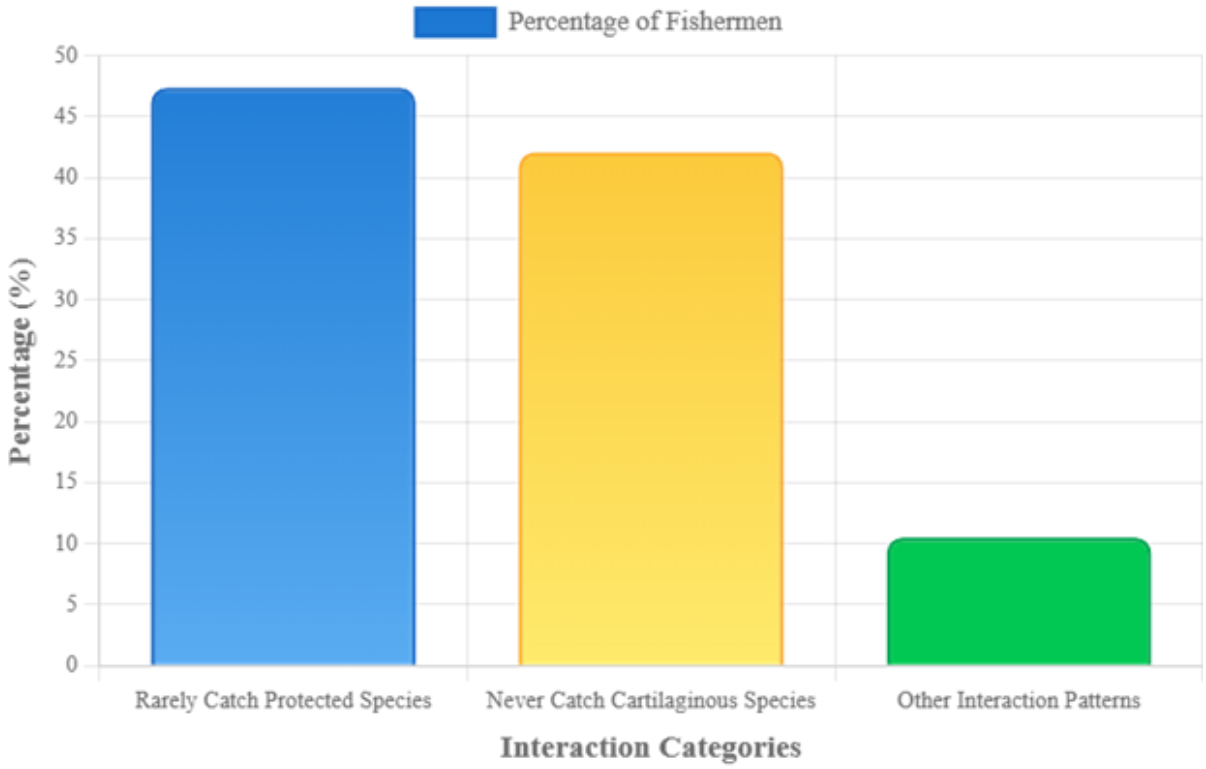
5.6.2 Central Sirte Economic Profile

Central Sirte occupies an intermediate economic position with **average monthly incomes of 2,492 LYD (€396)**, positioning it between Western Sirte's higher earnings and Eastern Sirte's more constrained economic conditions. The region demonstrates moderate dependency levels with **10.5% classified in the high-dependency category** and balanced fishing portfolio composition.

Species Interaction Patterns:

Central Sirte demonstrates varied fishing patterns with **47.4% of fishermen rarely catching protected species** while **42.1% never catch the specified cartilaginous species**, indicating more variable fishing patterns compared to Eastern Sirte's universal interaction. This distribution suggests greater operational flexibility for conservation implementation.

Figure 32. Distribution of protected species catch frequency among fishermen in Central Sirte region



Cultural Integration:

Traditional medicine usage rates of 89.5% reflect strong cultural integration while remaining below Eastern Sirte's universal participation, indicating deep community connections to cartilaginous species beyond commercial fishing activities.

Conservation Implementation Implications:

Central Sirte's intermediate economic position and moderate dependency levels enable balanced conservation approaches that can leverage the region's diverse operational patterns. The significant proportion of fishermen with no cartilaginous species interaction (42.1%) provides a foundation for voluntary adoption strategies, while targeted support can address the 10.5% classified in high-dependency categories.

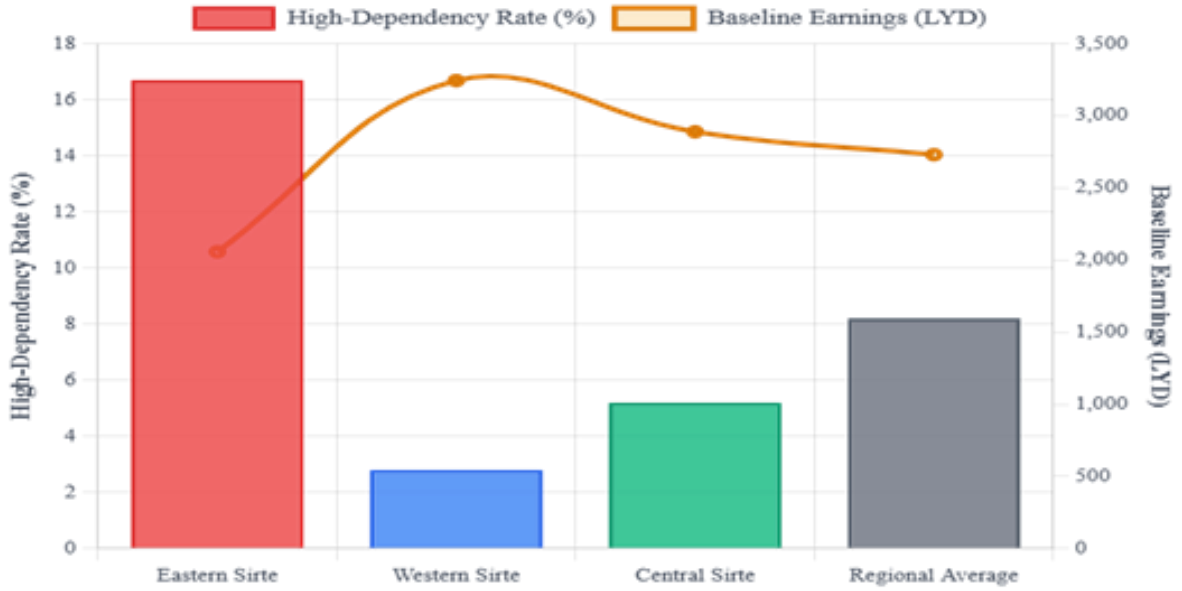
5.6.3 Eastern Sirte Economic Profile

Eastern Sirte exhibits the lowest baseline earnings at 2,058 LYD (€327) combined with the highest vulnerability indicators. Notably, 16.7% of Eastern Sirte fishermen fall within the high-dependency category nearly six times the rate observed in Western Sirte. This region demonstrates universal species interaction with 100% of fishermen encountering protected species, creating concentrated economic risk that necessitates intensive support measures.

Economic Vulnerability Distribution:

Eastern Sirte shows the most concentrated economic vulnerability across the Gulf of Sirte, with 16.7% classified in the high-dependency category representing the highest regional concentration of economic risk. The combination of lowest baseline incomes and highest dependency rates creates compounded vulnerability requiring intensive intervention strategies.

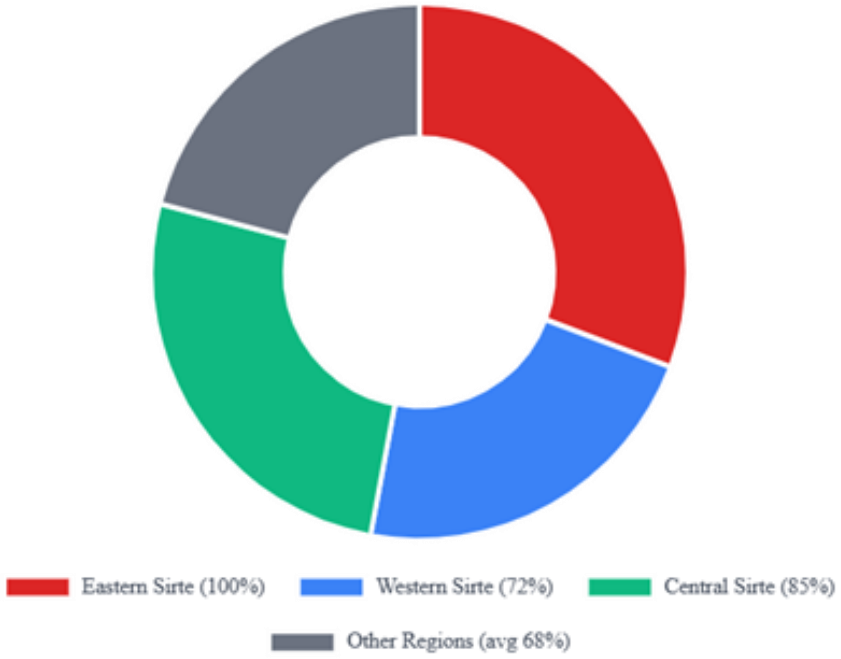
Figure 33. Economic vulnerability distribution across Gulf of Sirte regions



Species Interaction Patterns:

Eastern Sirte demonstrates the most concerning interaction patterns with universal species interaction affecting 100% of fishermen encountering protected species. This complete exposure eliminates the possibility of targeting conservation efforts toward specific fisher subgroups, necessitating fleet-wide intervention approaches across all Eastern Sirte fishing operations.

Figure 34. Protected species interaction rates by region showing Eastern Sirte's universal exposure (100%) compared to other area



Gear Usage Distribution:

Eastern Sirte exhibits distinct gear preferences that contribute to universal species interaction:

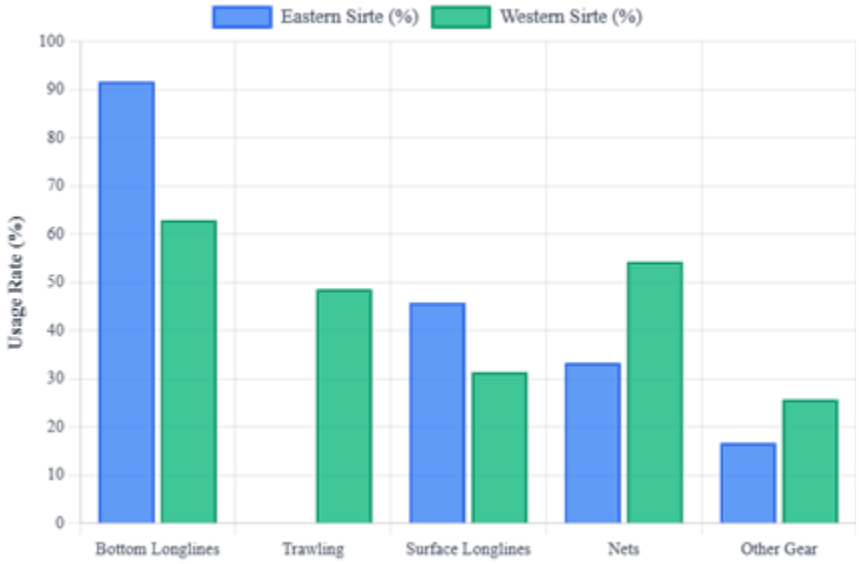
- **Bottom longlines**: 91.7% (highest usage rate across all regions) - intensive deep-water targeting
- **No trawling operations**: 0% usage, contrasting with Western Sirte's 48.6%

- Concentrated reliance on longline systems creates systematic cartilaginous species encounters

Multi-Gear Usage Patterns:

Eastern Sirte demonstrates moderate gear diversification with fishing operations concentrated on longline-based approaches. The heavy reliance on bottom longlines (91.7%) indicates specialized deep-water fishing strategies that systematically interact with cartilaginous species habitats.

Figure 35. Fishing gear usage distribution in Eastern Sirte compared to Western Sirte



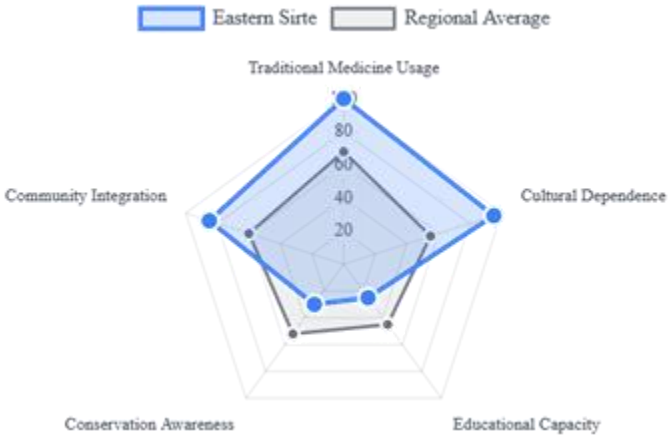
Educational Capacity:

Eastern Sirte demonstrates the most constrained educational profile across the Gulf of Sirte region, with 83.3% of fishermen possessing only primary education or no formal education

Cultural Integration:

Eastern Sirte demonstrates universal traditional medicine usage (100%) representing the strongest cultural integration of cartilaginous species across all regions.

Figure 36. Cultural integration metrics showing Eastern Sirte's universal traditional medicine usage (100%) and educational capacity profile



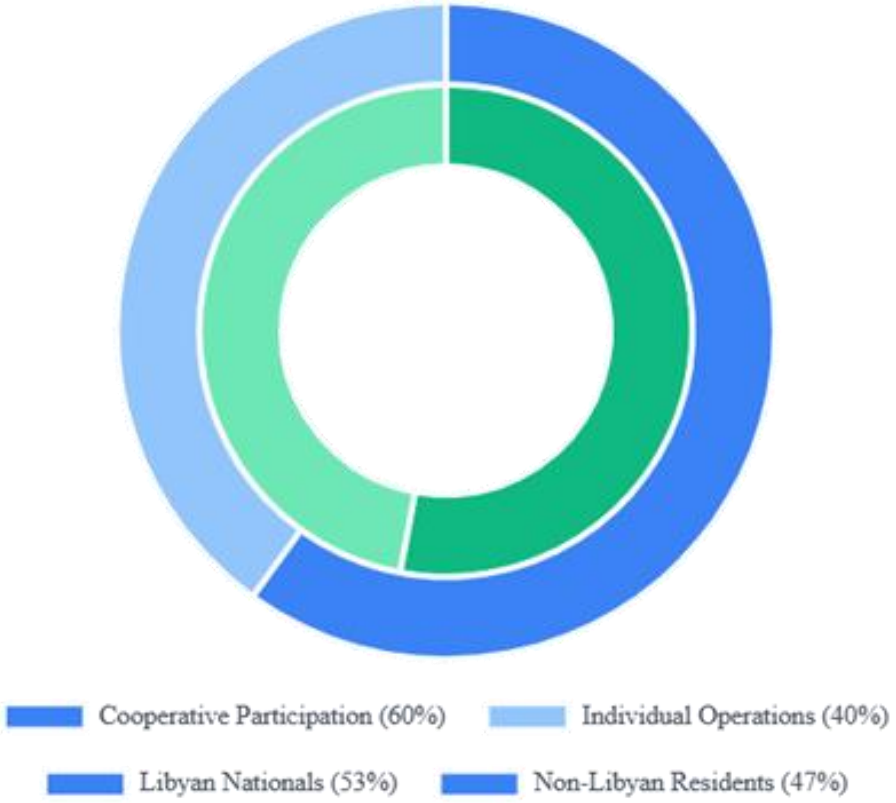
5.7 SOCIAL COHESION AND COMMUNITY NETWORKS

5.7.1 Community Cooperation and Risk-Sharing

Beyond individual household income considerations, fishing activities sustain broader community networks and social organization patterns throughout Gulf of Sirte coastal communities. Research documentation indicates that **approximately 60% of fishermen participate in informal fishing cooperatives** that provide risk-sharing mechanisms, resource pooling arrangements, and collective marketing practices.

Social cohesion in Gulf of Sirte fishing communities is maintained through cooperative fishing arrangements, shared equipment ownership, and collective marketing practices. The demographic diversity, with 35 Libyan nationals (53.0%) and 31 non-Libyan residents (47.0%), creates complex social dynamics that require careful consideration in conservation planning.

Figure 37. Community demographics and cooperative participation patterns in Gulf of Sirte fishing communities. The demographic diversity with 53% Libyan nationals and 47% non-Libyan residents creates complex social dynamics, while 60% participation in informal fishing cooperatives



5.7.2 Cultural Knowledge and Traditional Practices

The extensive fishing experience documented among respondents, averaging 27.5 years, represents a substantial repository of traditional ecological knowledge that has been transmitted across generations. This knowledge encompasses intimate understanding of local marine ecosystems, seasonal patterns, traditional fishing techniques adapted to Gulf of Sirte conditions, and informal conservation practices based on experiential learning.

The **87.2% prevalence of traditional medicine practices** suggests deep cultural integration of cartilaginous species within local food systems and traditional medicine practices. Conservation measures must acknowledge and address these cultural dimensions through provision of appropriate alternatives to maintain community acceptance and compliance.

Figure 38. Traditional ecological knowledge and cultural practices showing the substantial repository of experience (27.5-year average) and high cultural integration (87.2% traditional medicine use)

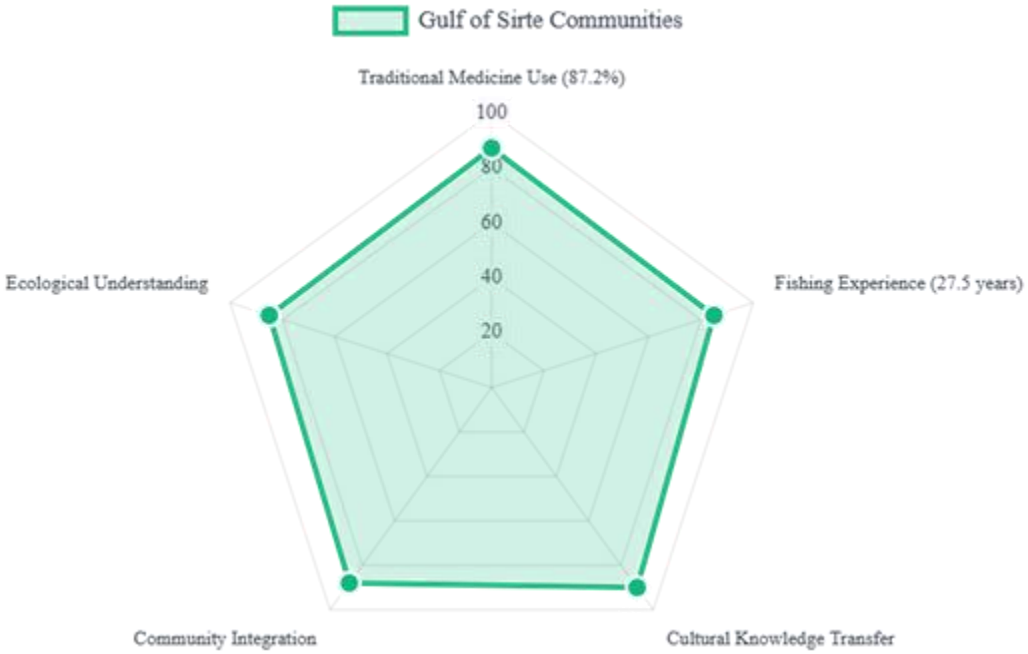
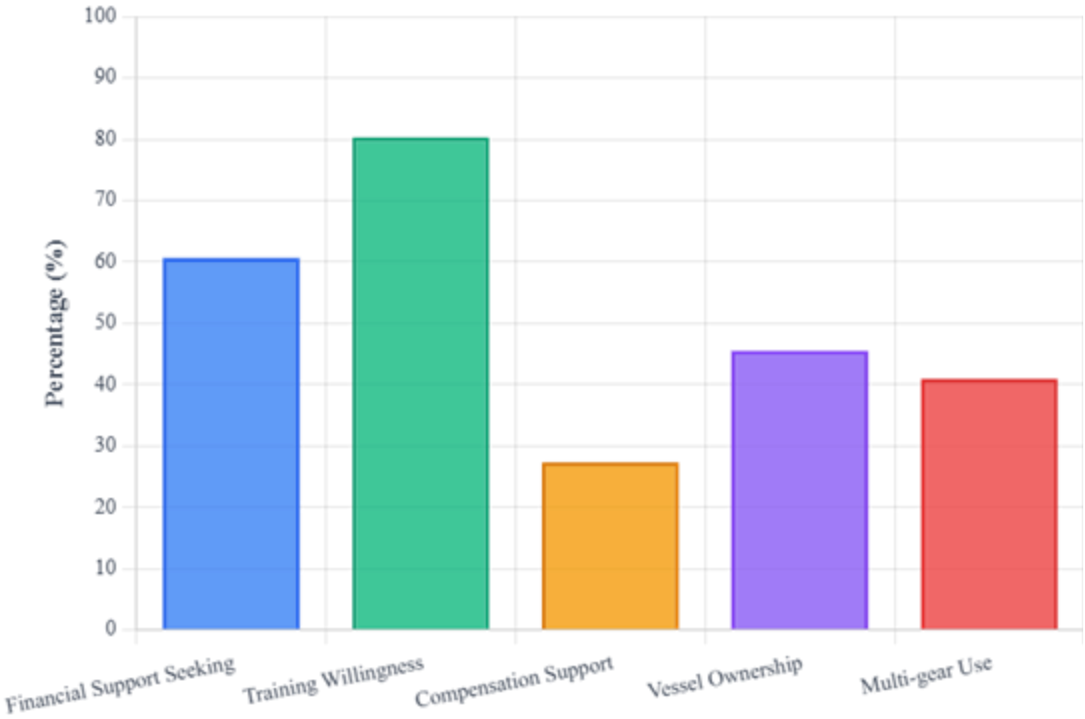


Figure 39. Analysis of cooperative behavior indicators showing financial support seeking (60%), training willingness (80%), and compensation support (27%)



5.8 ECONOMIC IMPACT PROJECTIONS AND REGIONAL SCALING

5.8.1 Individual and Household Impact Assessment

Using the vulnerability categorization framework, projected economic impacts under conservation scenarios are as follows:

- Low Vulnerability (40.9% of fishermen): Average monthly losses of 2,500 LYD (€392) per fisherman, corresponding to 15% income loss.
- Moderate Vulnerability (25.8% of fishermen): Average monthly losses of 1,500 LYD (€235) per fisherman, corresponding to 30% income loss.
- High Vulnerability (30.3% of fishermen): Average monthly losses of 2,500 LYD (€392) per fisherman, corresponding to 50% income loss.
- Very High Vulnerability (3.0% of fishermen): Average monthly losses of 2,500 LYD (€392) per fisherman, corresponding to 50% income loss.

5.8.2 Regional Economic Impact Projections

Extrapolating these findings to the 422 fishing vessels operating throughout the Gulf of Sirte region, the analysis projects the following regional economic impacts:

- Total Monthly Regional Loss: 68,751 LYD (€10,682), representing the aggregated loss for all fishermen based on their vulnerability and income dependency on fishing.
- Total Annual Regional Loss: 825,012 LYD (€133,186), accounting for all monthly losses over the year.
- Affected Population: Approximately 2,278 individuals, including fishing household dependents, with an average of 5 dependents per fisherman.
- High-Risk Households: 27 fishing families in the high-dependency category, requiring immediate intervention to mitigate economic disruption.

The concentration of seasonal fishing operations during the February-May period (when cartilaginous species are most vulnerable) further adds to regional economic disparities. Specifically, 81% of the 43 identified landing sites operate seasonally, intensifying the economic impact during this critical timeframe.

5.9 MULTI-STAKEHOLDER ASSESSMENT FINDINGS

Current Policy Effectiveness and Enforcement Challenges

Multi-stakeholder assessment across the Gulf of Sirte region reveals systematic enforcement barriers and fundamental structural limitations within current governance frameworks that extend beyond community-level resistance to encompass institutional coordination deficits and industry practice constraints.

Professional Stakeholder Experience Profile

Twenty-six experienced conservation and fisheries professionals participated in the assessment, representing government agencies, consultancy organizations, NGOs, and research institutions. Experience distribution shows 28.6% with 10 years of experience (largest cohort), followed by 9.5% each with 25, 18, 20, and 5 years respectively. The remaining 33.4% span 1-24 years of professional experience. With 71% possessing over 10 years of specialized knowledge, stakeholder perspectives reflect mature institutional understanding of long-term implementation challenges.

Policy Effectiveness Evaluation

Current marine conservation regulations demonstrate critical gaps requiring institutional reform. Nearly half of stakeholders (47.8%) characterize existing frameworks as "somewhat ineffective," while 30.4% describe them as "moderately effective." Only 13.0% assess regulations as "highly effective," with 8.7% remaining neutral or uncertain.

This 6:1 ratio of limited versus high effectiveness (78.2% combined ineffective/moderate ratings against 13.0% highly effective) indicates systemic regulatory deficiencies requiring comprehensive reform rather than incremental adjustments. The low professional confidence in current frameworks suggests fundamental flaws in design, implementation mechanisms, or enforcement capacity.

Enforcement Challenge Hierarchy

Stakeholder analysis identifies five primary enforcement barriers with clear priority rankings:

1. Community cooperation gaps (61.5%) - Trust deficits between authorities and fishing communities
2. Inadequate penalty structures (61.5%) - Current sanctions lack sufficient compliance incentives
3. Personnel resource limitations (50.0%) - Chronic understaffing constrains enforcement capacity
4. Institutional corruption (38.5%) - Governance quality issues undermine regulatory credibility
5. Other systemic issues (11.5%) - Coordination failures and resource constraints

The dual prioritization of community cooperation and penalty adequacy reveals that successful implementation requires simultaneous bottom-up engagement and top-down regulatory strengthening, while personnel constraints indicate administrative capacity building needs.

Incentive Mechanism Preferences

Stakeholder support for compliance mechanisms demonstrates clear strategic priorities:

1. Financial subsidies (65.4%): Equipment modification and sustainable gear acquisition support
2. Enhanced enforcement (57.7%): Stronger regulatory frameworks with community-based management
3. Alternative training (46.2%): Skills development in aquaculture, eco-tourism, and sustainable practices
4. Income compensation (30.8%): Transition period financial support
5. Other mechanisms (11.5%): Technical assistance and capacity building

The preference hierarchy emphasizes economic security as the primary concern, followed by regulatory framework strengthening and human capital development. Lower support for direct compensation (30.8%) suggests stakeholders favor proactive investment over reactive support.

Implementation Capacity Analysis

Three critical factors determine conservation implementation success:

Enabling Factors:

- Professional expertise foundation (71% with 10+ years' experience)
- Consensus on priority interventions (61.5% dual enforcement priorities)
- Clear economic pathway (65.4% financial subsidy preference)

Implementation Barriers:

- Regulatory framework crisis (78.2% effectiveness concerns)
- Enforcement trust deficit (61.5% community cooperation challenge)
- Administrative capacity gaps (50.0% personnel limitations)

Coordination Framework Requirements

The combination of regulatory effectiveness concerns with dual enforcement priorities indicates that conservation success requires integrated intervention across legal frameworks, administrative capacity, and community engagement. Sequential or single-mechanism approaches prove insufficient given the interconnected nature of implementation barriers.

Stakeholder preference patterns (financial support 65.4%, enforcement enhancement 57.7%, training 46.2%) demonstrate that effective implementation demands parallel investment in economic transition support, regulatory strengthening, and human capital development.

Strategic Implications

Professional assessment reveals that sustainable conservation outcomes require comprehensive institutional restructuring addressing economic security, enforcement credibility, and community trust simultaneously. The systematic implementation barriers identified by experienced stakeholders indicate that piecemeal policy modifications will prove insufficient to achieve meaningful conservation progress in the Gulf of Sirte region.

Success depends on evidence-based strategies that integrate regulatory reform with economic transition mechanisms and participatory management approaches, acknowledging both institutional constraints and demonstrated stakeholder priorities for effective conservation implementation.

6 Impact Assessment and Mitigation Measures

6.1 IMPACT ASSESSMENT

6.1.1 Understanding the Human Cost of Conservation

The Gulf of Sirte fishing community faces a critical transition as marine conservation measures take effect. Through conversations with 66 fishermen across the region, a complex picture emerges of families whose livelihoods are deeply intertwined with the very species that conservation efforts seek to protect. These are not merely statistics—they represent fathers supporting families, communities sustaining traditions that span generations, and households navigating an uncertain economic future.

The survey reveals that 93.9% of fishers regularly encounter the species targeted for protection, while 97.0% sell sharks and rays when caught. For these families, conservation restrictions represent more than policy changes; they signal potential disruption to income streams that feed children, pay for medical care, and maintain homes.

6.1.2 The Reality of Economic Dependence

When fishermen speak about their reliance on cartilaginous species, the numbers tell a story of varied vulnerability. Most families 69.7% of those surveyed depend on sharks and rays for less than 20% of their fishing income. For these households, the species serve as supplementary income, perhaps helping cover unexpected expenses or providing seasonal stability.

However, for nearly a quarter of families (24.2%), these species represent a more substantial portion of their livelihood between 20% and 60% of their fishing income. Among these are households where shark and ray catches mean the difference between financial stability and hardship. The survey documented families with dependency levels reaching 60-80%, where alternative income sources become critically important.

The human dimension becomes clearer when considering that each fisherman supports an average of 5 family members, ranging from childless households to families with 18 dependents. This means that approximately 330 people, children, spouses, elderly parents—depend on the income generated by these 66 fishermen. When conservation measures affect fishing practices, the impact ripples through entire extended families.

6.1.3 Species That Matter Most to Families

The relationship between fishermen and marine species is intimate and specific. Some species have become particularly important to household economics:

The Common Eagle Ray touches the lives of nearly every fisherman in the region—93.9% encounter this species, with 16 families actively depending on income from its sale. The Marbled Stingray affects 89.4% of fishers, representing another cornerstone species in the local fishing economy.

For commercial shark species, the dependencies become even more pronounced. Three-quarters of fishermen (75.8%) interact with Sandbar Sharks, with some families relying on them for their entire fishing income. Blacktip Sharks affect 69.7% of fishers, with some families depending on them for up to half their earnings.

These are not abstract conservation targets but species that determine whether children attend school, whether families can afford healthcare, and whether fishing traditions continue to the next generation.

6.1.4 Market Realities Facing Fishing Families

The local economy tells its own story of adaptation and challenge. When fishermen bring rays to market, more than half (54.5%) discover they have little commercial value. These catches often become bait for other fishing activities or are simply discarded—a waste of effort that families can ill afford.

Sharks tell a different economic story. Nearly every family (98.5%) can sell shark products, commanding prices between 10-30 Libyan Dinars per kilogram. In European terms, this translates to €1.59-€4.76 per kilogram—modest by international standards but representing meaningful income for local families. The contrast is stark: shark products command 200-400% more than rays, making them particularly valuable for household budgets.

6.1.5 Daily Fishing Realities and Conservation Challenges

The challenge of conservation becomes apparent when examining daily fishing practices. More than 9 out of 10 fishermen (92.4%) catch protected species unintentionally as bycatch. This isn't deliberate targeting but the reality of mixed-species fishing in productive waters.
Fishing gear creates different levels of exposure to these conservation challenges:

- Families using gillnets (34.3% of fishermen) face the highest conservation risks due to the gear's interaction with protected species
- Those using fixed nets (25.4%) experience intensive species encounters in specific seasons and habitats
- Trawling operations (25.4%) document significant bycatch interactions

For these families, conservation compliance isn't simply about changing fishing locations—it requires fundamental modifications to fishing practices developed over decades.

6.1.6 The Broader Community Impact

The Shakman fleet survey documented 303 fishing vessels operating from 43 landing sites throughout the Gulf of Sirte, providing context for understanding regional impact. When the experiences of the 66 surveyed families are scaled to this broader community, the human dimensions multiply significantly.

An estimated 270 families may face moderate economic disruption, while 27 households could confront severe economic challenges. The average monthly fishing income of 3,449 LYD (€547) means that even modest disruptions affect families' ability to meet basic needs.

The seasonal nature of fishing—with 81% of landing sites operating primarily during February-June—creates periods of concentrated vulnerability when families have limited alternatives for income generation.

6.2 MITIGATION MEASURES

6.2.1 Building on Community Readiness

Despite the challenges, the fishing community demonstrates remarkable openness to adaptation. Nearly two-thirds of families (63.6%) express support for conservation measures when appropriate assistance is provided. This isn't resignation but recognition that sustainable fishing requires balancing ecological protection with family welfare.

The willingness to learn new approaches is particularly encouraging—80.3% of fishermen express interest in training programs for alternative fishing methods. This represents families ready to invest time and effort in securing their future, provided they receive appropriate support during the transition.

6.2.2 Addressing Immediate Family Needs

The survey reveals that 60.6% of families require immediate financial support to navigate the transition. The assistance needs vary significantly based on household composition:

Families with fewer dependents (8 fishermen supporting 0-2 family members) require approximately 800-1,200 LYD monthly during transition periods. The largest group 32 families supporting 3-5 dependents need 1,500-2,500 LYD monthly assistance.

More vulnerable households tell different stories: 19 families supporting 6-8 dependents require 3,000-4,000 LYD monthly, while 7 families with 9 or more dependents need over 4,500 LYD monthly support. These figures represent real family budgets money for food, housing, children's education, and healthcare.

6.2.3 Creating Alternative Opportunities

Fishermen already possess knowledge that can be redirected toward sustainable alternatives. The survey identified species that families currently target successfully:

Grouper species represent the most common current target, suggesting families already possess the skills and knowledge to focus more intensively on these species. Common dentex and little tunny offer additional alternatives that align with existing fishing practices and market relationships.

The key lies in helping families transition their existing expertise toward species that can provide comparable income without threatening conservation objectives.

6.2.4 Practical Training and Technology Support

The high willingness to participate in training (80.3%) creates opportunities for meaningful skill development:

For the 23 families using gillnets, targeted training in gear modification could reduce protected species interactions while maintaining fishing effectiveness. The 17 families using fixed nets could benefit from seasonal timing adjustments and habitat-specific modifications.

Circle hook training, gear modification workshops, and selective fishing techniques offer practical solutions that respect families' existing knowledge while introducing conservation-compatible methods.

6.2.5 Working Within National Frameworks

Libya's National Monitoring Plan for Cartilaginous Fishes (2024-2030) provides the institutional framework for supporting fishing families through this transition. The plan establishes coordination between the Ministry of Environment, Ministry of Fisheries, Marine Biology Research Centers, and National Universities—creating a support network that extends beyond individual fishing communities.

The national plan's timeline offers strategic phases for family support:

- 2024-2025: Emergency assistance for families most immediately affected
- 2025-2027: Comprehensive training and alternative livelihood development
- 2027: Mid-term evaluation of both conservation success and family welfare
- 2027-2030: Long-term sustainability and permanent support systems

6.2.6 Market Development for Family Stability

Creating stable markets for alternative species becomes crucial for family economic security. Currently, many families struggle with market saturation for certain species, limiting their ability to increase catches of conservation-friendly alternatives.

Cooperative formation could help families access better prices and more stable market relationships. Value-added processing training could enable families to increase the value of their catches, while direct relationships with restaurants and wholesalers could bypass oversaturated local markets.

6.3 IMPLEMENTATION STRATEGY

6.3.1 Immediate Response: Protecting Families During Transition

The first priority involves ensuring that families don't face economic crisis during the early implementation of conservation measures. Based on documented compensation needs and the patterns of household dependency, an estimated 500,000-750,000 LYD would provide comprehensive support for families equivalent to those surveyed.

This support must be practical and accessible direct payments to help families maintain basic living standards while they adapt their fishing practices and develop alternative income sources.

6.3.2 Building Capacity: Investing in Family Futures

The middle phase focuses on helping families develop sustainable alternatives. This means providing training that builds on existing skills while introducing new techniques and target species.

Priority goes to the 23 families using gillnets (the highest conservation risk) and the broader group interested in species diversification. Training programs should be designed around fishing schedules and family responsibilities, ensuring that participation doesn't create additional economic hardship.

Market development becomes equally important helping families identify buyers, understand pricing, and develop relationships that provide stable, long-term income.

6.3.3 Long-term Sustainability: Secure Families, Protected Species

The ultimate goal is creating a fishing community that thrives economically while contributing to marine conservation. This requires permanent institutional support that recognizes the ongoing relationship between family welfare and conservation success.

Integration with the national monitoring system ensures that family impacts receive the same attention as species recovery. Regular evaluation aligned with the national plan's 2027 mid-term assessment and 2030 comprehensive review maintains focus on human welfare alongside ecological outcomes.

6.4 A PATH FORWARD

The survey of 66 Gulf of Sirte fishing families reveals both challenges and opportunities. While conservation measures will create real economic impacts for families whose lives are built around marine resources, the documented willingness to adapt (80.3% interested in training) and conditional support for conservation (63.6%) provides hope for successful implementation.

The key lies in recognizing that effective conservation requires investing in people as much as protecting species. When families have alternatives that provide comparable income, when children can continue attending school, when healthcare remains accessible—conservation measures gain the community support essential for long-term success.

The integration with Libya's National Monitoring Plan creates the institutional framework for this human-centered approach to conservation. By treating family welfare as integral to conservation success rather than competing with it, the Gulf of Sirte can become a model for conservation that works for both marine ecosystems and the communities that depend on them.

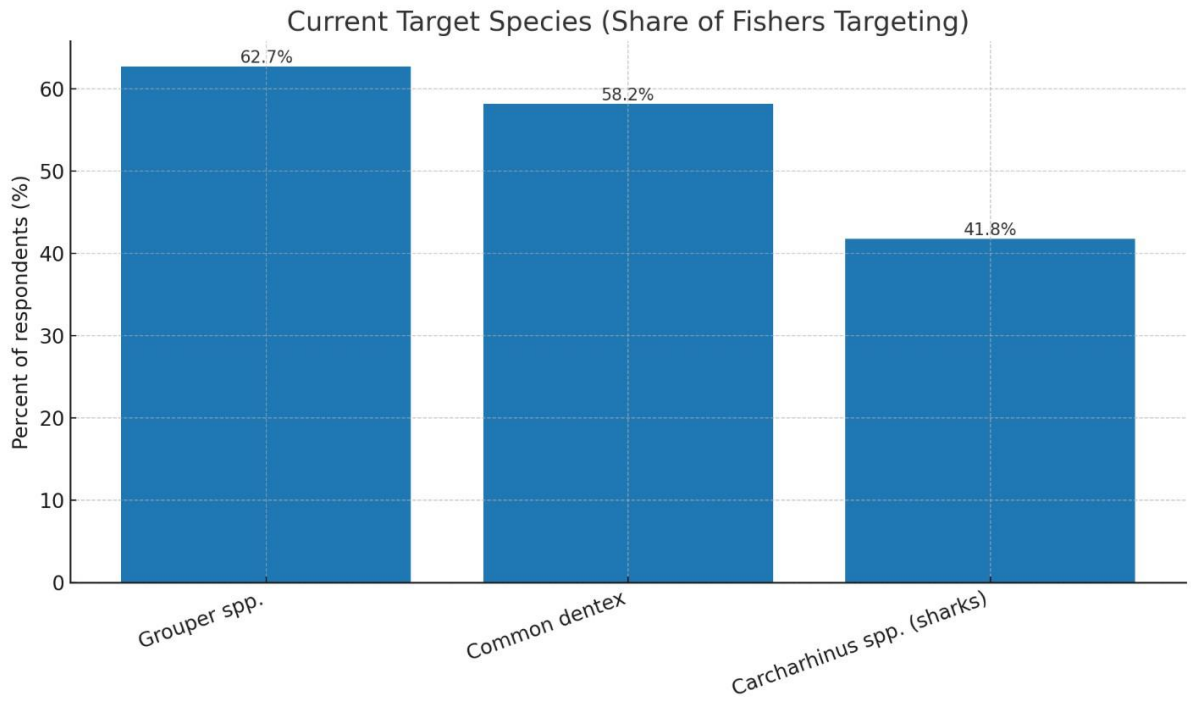
Success will be measured not only in species recovery but in the continued viability of fishing communities whose cooperation makes conservation possible. The documented readiness of families to participate in this transition, combined with appropriate support systems, provides a realistic foundation for achieving both conservation goals and family security in the Gulf of Sirte.

7 Alternative Species and Market Development

7.1 CURRENT SPECIES PORTFOLIO AND MARKET DEPENDENCIES

The empirical data reveals a concentrated targeting pattern among Gulf of Sirte fishers, with **Grouper species** (62.7% of respondents, n=42) and **Common dentex** (58.2%, n=39) representing the dominant commercial targets. Notably, **Carcharinus species** constitute the third most targeted group (41.8%, n=28), indicating substantial reliance on shark species within current fishing operations.

Figure 40. Primary Target Species Target Species

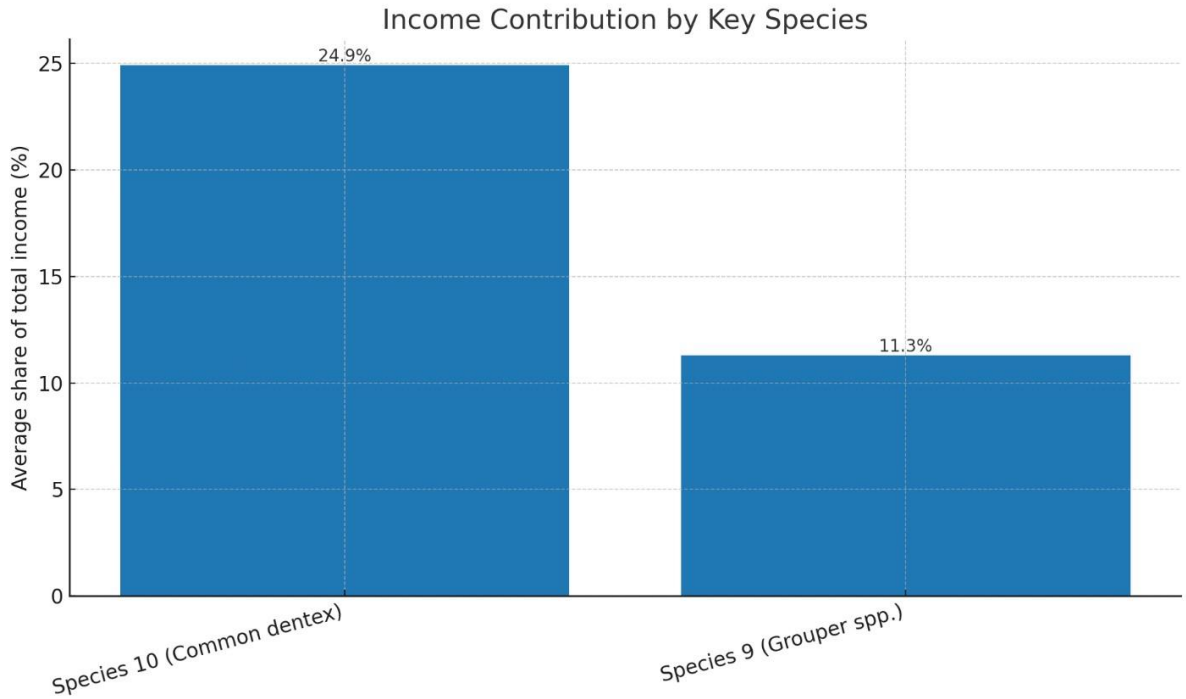


Market channel analysis demonstrates critical infrastructure dependencies, with **94.0% of fishers (n=63)** relying exclusively on trader networks for product distribution. This trader market dominance creates systemic vulnerabilities, as only 6.0% (n=4) maintain direct local market access. Notably, no respondents reported current engagement with export markets, which aligns with Libya's **blanket ban on all fish exports** implemented on March 22, 2022 (Decision 356/2022) by the Ministry of Economy and Trade (Libya Ministry of Economy and Trade, 2022).

7.2 ECONOMIC CONTRIBUTION OF TARGET SPECIES

Quantitative income analysis identifies significant economic dependencies on specific species groups. **Species 10** (corresponding to common dentex based on targeting patterns) contributes an average of **24.9% of total fishing income** across 50 respondents, representing the highest documented species-specific income dependency. **Species 9** (corresponding to grouper species) contributes **11.3% of total income** among 46 respondents. These findings indicate that restrictions on key commercial species could impact approximately **25-30% of fisher income** based on current catch compositions.

Figure 41. Species Income Contribution Bar chart highlighting that Common dentex contributes 24.9% of income while Grouper species contribute 11.3%



7.3 FISHER-IDENTIFIED ALTERNATIVE SPECIES STRATEGIES

When queried regarding alternative targeting strategies, 98.5% of respondents (n=65) provided substantive responses. The data reveals three distinct alternative approaches:

- **"Commercial species" focus** (reported by 45 fishers)
- **"Other species" diversification** (reported by 16 fishers)
- **Continued reliance on "commercial species and Carcharinus sp"** (reported by 15 fishers)

One respondent specified **"hook and line fish like grouper species"** as a gear-specific alternative, while another identified **"Carcharinus sp and mustelus sp"** combinations, suggesting some fishers perceive continued shark targeting as viable despite potential restrictions.

7.4 MARKET DEVELOPMENT CONSTRAINTS

The transition to alternative species faces documented market-driven constraints. Primary challenges include:

Market saturation effects: 71.2% of challenge responses (n=47) reference market limitations, with specific documentation of value decline "due to the quantity of fish caught exceeds the needs of the local market." This indicates existing market infrastructure may lack capacity to absorb increased landings of alternative species.

Equipment and technological barriers: 28.8% of responses (n=19) identify infrastructure constraints, specifically citing "new equipment and more technology" requirements and "new fishing methods and equipment" needs for effective species transition.

Climate and environmental factors: Multiple responses document "climate changes challenges" as constraining alternative species viability, though specific mechanisms require further investigation.

7.5 INFRASTRUCTURE REQUIREMENTS FOR SPECIES TRANSITION

Financial support requirements are documented across 59.7% of respondents (n=40), while equipment/gear support needs span multiple categories. Current operational costs create additional constraints, with average monthly expenditures of:

- **Fuel costs**: 3,019 LYD/month (n=66)

- **Gear maintenance**: 4,593 LYD/month (n=66)

These operational cost burdens suggest that species transition may require substantial capital investment beyond current fisher capacity.

7.6 MARKET DEVELOPMENT RECOMMENDATIONS

7.6.1 Diversification of Market Channels

The 94% dependence on trader networks represents a critical market vulnerability, compounded by the current export prohibition. Historical evidence indicates that Libya's fish export system was previously centered on small private firms in Tripoli, Benghazi, Sirte, Sabratah and Zuwara, channeling high-value species fresh on ice to Tunisia and Italy (FAO, 1997). The 2022 export ban has eliminated these international market outlets, concentrating all production within domestic channels. Evidence-based market development should prioritize:

- Local market infrastructure development to reduce trader dependence
- Value-addition processing capabilities for alternative species to create domestic market expansion
- Cold chain infrastructure for improved domestic distribution pending potential export resumption

7.6.2 Species-Specific Market Development

Given that 28.8% of fishers report "no challenges" with alternative species, targeted market development programs should focus on:

- **Expanded demand creation** for currently underutilized species
- **Price stabilization mechanisms** to address market saturation concerns
- **Quality certification programs** to enhance alternative species market positioning

7.6.3 Technology and Infrastructure Support

The documented need for "new equipment and more technology" among 19 respondents indicates that species transition requires coordinated infrastructure development, including:

- **Gear modification support** for alternative targeting methods
- **Training programs** for alternative fishing techniques
- **Financial assistance** for equipment transition costs

7.7 HISTORICAL EXPORT CONTEXT AND CURRENT MARKET CONSTRAINTS

The current export prohibition, implemented through Decision 356 of 2022 and reinforced in 2025, eliminates international market opportunities that previously provided higher-value outlets for these species. This market constraint may intensify domestic market saturation effects, where alternative fish species face declining values due to supply exceeding local demand, as evidenced by survey data showing 71.2% of species experiencing market limitations.

7.8 EVIDENCE GAPS AND RESEARCH PRIORITIES

The current data identifies several areas requiring additional investigation:

- **Species-specific market demand elasticity** for alternative targets under export prohibition conditions
- **Seasonal availability patterns** of substitute species
- **Processing and preservation requirements** for alternative species in domestic markets
- **Impact assessment of export ban** on fishing community income and market structure
- **Potential for domestic market expansion** to accommodate increased alternative species landings

These evidence gaps limit the precision of transition planning and suggest need for targeted market research to support evidence-based species diversification strategies under current trade restrictions.

8 Implementation Framework and Challenges

8.1 IMPLEMENTATION CHALLENGES

8.1.1 Institutional Capacity and Enforcement Constraints

Libya's marine conservation implementation faces significant institutional limitations that must be empirically assessed and systematically addressed. Current data reveals specific capacity constraints that directly impact conservation measure feasibility:

Monitoring Infrastructure Limitations The Gulf of Sirte fishery operates across 43 documented landing sites (Shakman et al., 2024), with 81% functioning seasonally during the critical February-June reproductive period. This spatially dispersed infrastructure, characterized by temporary structures (20-60 m² huts) separated by distances ranging from 200 meters to 50 kilometers, presents substantial monitoring challenges for regulatory agencies.

Fleet Operational Constraints Current assessments indicate that only 40% of the documented 303 Fluka vessels maintain operational status, while 48% lack functioning engines (Shakman et al., 2024). This operational limitation may facilitate targeted conservation interventions by reducing the active fleet requiring immediate regulatory oversight, though it also reflects broader infrastructure deficiencies that could impede implementation support programs.

Enforcement Capacity Gaps The remote location of fishing operations, requiring specialized 4x4 vehicle access due to sandy terrain and unpaved roads, combined with the seasonal concentration of activities, creates logistical challenges for consistent regulatory presence. The absence of basic infrastructure (electricity limited to small generators, fresh water via transported tanks) further complicates sustained enforcement operations.

8.1.2 Community Acceptance and Compliance Patterns

Survey data reveals significant disparities in stakeholder attitudes that present both opportunities and challenges for implementation:

Community Support Foundations The Data Results reveal that 63.6% of respondents support conservation measures when appropriate assistance is provided, while 80.3% express willingness to receive training. Additionally, 60.6% specifically request financial support for transition, emphasizing compensation and alternative livelihood development. This substantial training receptivity, combined with conditional conservation support, provides a foundation for implementation success.

Restriction Acceptance Challenges Conversely, restriction support demonstrates limited enthusiasm, with only 10.6% of respondents (7 of 66) expressing strong support for regulatory measures. This substantial gap between training willingness (80.3%) and restriction acceptance (10.6%) indicates that implementation success may depend on community preparation and engagement strategies rather than immediate regulatory measures.

Near-Universal Species Interaction The Data Results analysis confirms that 93.9% of respondents interact with protected species, with 97.0% (64 of 66) selling sharks and rays when caught. Additionally, 87.9% anticipate moderate to high income impacts from conservation restrictions. This near-universal interaction pattern indicates that conservation measures will affect virtually the entire surveyed fleet, requiring comprehensive rather than targeted interventions.

8.1.3 Economic Dependencies and Market Dynamics

Seasonal Economic Concentration The temporal concentration of cartilaginous species interactions during the four-month reproductive season (February-May) creates acute economic vulnerabilities. This period represents 33% of the annual fishing calendar but generates disproportionate income for fishing households, amplifying the economic impact of conservation measures implemented during critical biological periods.

Traditional Medicine Integration Survey data indicates that 87.9% of respondents (58 of 66) utilize traditional medicine practices involving marine species. This high prevalence suggests that conservation measures must account for cultural practices beyond commercial fishing, requiring culturally sensitive implementation approaches.

Economic Impact Projections The Data Results analysis projects total annual economic impact of 3.0-4.0 million LYD (€0.47-€0.64 million) across the broader Gulf of Sirte fishing population, affecting approximately 2,221 individuals including fishing household dependents. The analysis identifies 27 fishing families classified within the high-dependency category at immediate poverty risk, requiring intensive support measures.

8.2 SCENARIO-SPECIFIC IMPLEMENTATION REQUIREMENTS

8.2.1 Institutional Capacity Requirements by Scenario

Scenario A: Comprehensive Protection Immediate implementation across all nine species requires substantial institutional expansion to manage simultaneous region-wide enforcement. Given current capacity limitations, this approach would necessitate extensive international technical assistance and coordinated capacity building across 43 landing sites within compressed timeframes.

Scenario B: Phased Implementation Sequential implementation aligned with conservation priorities allows gradual institutional development. This approach leverages the 80.3% training willingness to build regulatory capacity incrementally, reducing implementation risks while developing sustainable national expertise through phases targeting Critically Endangered species first, followed by progressive expansion.

Scenario C: Market-Based Controls Minimal immediate institutional requirements but heavy dependence on market monitoring and incentive mechanisms. Success requires effective engagement with existing social networks and traditional governance structures rather than formal regulatory expansion, though monitoring compliance across dispersed landing sites remains challenging.

8.2.2 Financial Sustainability Considerations

Current economic realities and competing development priorities create distinct financial challenges across implementation scenarios:

- **Scenario A**: Estimated 8-10 million LYD requirement may exceed available resources, creating sustainability risks if international funding proves insufficient or temporary
- **Scenario B**: 4-6 million LYD investment balances conservation objectives with realistic resource constraints through phased deployment
- **Scenario C**: 2-3 million LYD represents the most financially sustainable option but with uncertain conservation effectiveness

8.3 RISK ASSESSMENT AND MITIGATION STRATEGIES

8.3.1 Implementation Risk Categories

High-Priority Risks

- **Universal Fleet Impact**: 100% species interaction rate means conservation measures will affect all surveyed fishing operations, requiring comprehensive rather than selective support mechanisms
- **Seasonal Economic Disruption**: Conservation measures during reproductive seasons impact the most economically productive period for fishing households
- **Compliance Inequity**: Disparate enforcement capacity across 43 landing sites may create uneven compliance burdens

Medium-Priority Risks

- **Market Substitution Effects**: Potential demand shifts toward non-protected species with unknown sustainability implications
- **Cultural Practice Disruption**: 86.6% traditional medicine usage requires culturally sensitive conservation approaches
- **Infrastructure Dependencies**: Remote location requirements for specialized transportation and basic utilities may complicate support program delivery

8.3.2 Evidence-Based Mitigation Approaches

Leveraging Training Willingness The documented 80.3% training receptivity provides a foundation for capacity building that addresses both conservation objectives and livelihood security. Implementation strategies should prioritize skill development programs that enhance fishing efficiency for alternative species while reducing cartilaginous species interactions.

Gradual Implementation Alignment The substantial gap between training willingness (80.3%) and restriction acceptance (10.6%) suggests that implementation success requires graduated approaches that build community confidence through demonstrated benefits before expanding regulatory requirements.

Community-Based Monitoring Integration Given enforcement capacity limitations across dispersed landing sites, community participation in monitoring and compliance could leverage existing social networks while building local ownership of conservation outcomes.

8.4 ADAPTIVE MANAGEMENT FRAMEWORK

8.4.1 Monitoring Protocols

Economic Impact Indicators

- Household income stability maintenance across the surveyed 66 fishing households
- Alternative livelihood adoption rates leveraging documented training willingness
- Market price stability for both protected and alternative species

Social Acceptance Indicators

- Training program participation rates relative to documented 80.3% willingness
- Community compliance patterns across 43 landing sites
- Cultural practice integration with conservation measures affecting 87.9% of respondents who use traditional medicine

Conservation Effectiveness Indicators

- Species interaction reduction from documented 100% baseline
- Cartilaginous species population trend monitoring
- Ecosystem health improvements in Gulf of Sirte waters

8.4.2 Feedback Mechanisms

Stakeholder Engagement Systems Regular consultation processes leveraging documented community willingness to participate in training programs (80.3%), expanded to include conservation planning and implementation feedback.

Adaptive Implementation Protocols Flexible adjustment mechanisms based on monitoring data, particularly important given the seasonal concentration of fishing activities and the need to balance conservation timing with economic impacts affecting all 66 surveyed fishing operations.

Performance Assessment Framework Quarterly evaluations of implementation progress against baseline conditions, with particular attention to the documented patterns of universal species interaction (100%) and the significant gap between training willingness (80.3%) and restriction acceptance (10.6%).

This implementation framework demonstrates that while significant challenges exist, the combination of documented community training willingness (80.3%), universal species interaction patterns (100%), and established fishing infrastructure across 43 landing sites creates identifiable pathways for evidence-based conservation implementation in the Gulf of Sirte.

9 Economic Costs and Benefits Analysis

9.1 CONSERVATION COSTS FRAMEWORK

9.1.1 Dual-Track Cost Structure

Understanding the true costs of conservation requires looking at two interconnected challenges facing Gulf of Sirte fishing families. Based on detailed survey data from 66 fishing households, the economic analysis reveals that protecting marine species involves addressing both the immediate impact on fishing operations and the deeper challenge of families who depend heavily on certain commercial species for their livelihoods.

Supporting Families Through Conservation Changes:

- **Basic Compensation**: 132,000 LYD monthly to help 66 fishing families adjust to new conservation rules (about 2,000 LYD per family to cover basic needs)
- **Skills Training**: Supporting 53 fishermen who expressed interest in learning new fishing techniques that work better with conservation goals
- **Equipment Upgrades**: Helping fishermen modify their gear to reduce accidentally catching protected species

Addressing Critical Dependencies: Some families face more serious economic challenges because they rely heavily on specific species for income:

- **Emergency Support for Families**: 50 fishermen (75.8% of those surveyed) depend significantly on *Carcharhinus plumbeus*, with some families getting 100% of their income from this species
- **Targeted Assistance**: 46 fishermen (69.7% of those surveyed) depend on *Carcharhinus limbatus* for up to 50% of their family income
- **Additional Monthly Support**: An estimated 500,000-800,000 LYD needed specifically for families facing the most severe income impacts
- **Transition Help**: Scaling support based on how much each family depends on affected species, ranging from 5-25% of their current income

9.1.2 What This Means in Real Numbers

Monthly Support Required:

- **Basic Conservation Support**: 132,000 LYD (€20,952) to help families adapt to new fishing rules
- **Critical Family Support**: 500,000-800,000 LYD (€79,365-€126,984) for families facing serious income loss
- **Total Monthly Investment**: 632,000-932,000 LYD (€100,317-€147,936)

Understanding the Regional Impact: When we look at the entire Gulf of Sirte region, with its 422 fishing boats spread across 43 landing sites:

- **Annual Regional Impact**: 5.25 million LYD (€833,880) in lost income for fishing families
- **People Affected**: About 2,278 individuals, including fishermen and their families
- **Families at Highest Risk**: 27 fishing families who would face immediate economic crisis without support

9.1.3 A Step-by-Step Approach to Implementation

Rather than implementing everything at once, which could overwhelm both families and government resources, the analysis suggests a phased approach:

Phase 1 - Emergency Response (Years 1-2): Focus intensive support on the 27 families facing immediate economic crisis. These families need help right away to prevent falling into poverty. **Cost**: 2.8-4.2 million LYD annually

Phase 2 - Building Stability (Years 3-4): Expand support to 109 families with moderate vulnerability. These families have some economic resilience but still need assistance during the transition. **Cost**: 1.8-2.6 million LYD annually

Phase 3 - Long-term Success (Years 5+): Provide incentives for 173 fishing operations that can adapt more easily to conservation measures. **Cost**: 0.8-1.2 million LYD annually

9.2 THE BENEFITS OF MARINE CONSERVATION

9.2.1 Immediate Conservation Wins

Protecting Threatened Species: The conservation program would provide immediate protection for nine threatened marine species that are currently at risk in the Gulf of Sirte. This includes giving special attention to the Bull Ray and Common Eagle Ray, which scientists classify as critically endangered and endangered respectively.

Restoring Ocean Health: Scientists have shown that sharks and rays play crucial roles as top predators in marine ecosystems. When these species are protected, they help maintain the natural balance of ocean life, which ultimately supports healthier fish populations that fishing families depend on.

Building on National Commitments: This effort builds directly on Libya's National Action Plan for Cartilaginous Fishes (2024-2030), showing Libya's commitment to being a leader in Mediterranean marine conservation.

9.2.2 Long-term Benefits for Fishing Communities

Better Fishing in the Future: When marine ecosystems recover, fishing families often see improved catches over time. Healthier oceans with balanced predator populations typically support more abundant and predictable fish stocks.

New Economic Opportunities:

- **Sustainable Fishing Certification**: Fishermen who follow conservation practices may access premium markets that pay higher prices for sustainably caught fish
- **Marine Tourism**: The Gulf of Sirte's designation as an Important Shark and Ray Area could attract eco-tourists, creating new income opportunities for coastal communities
- **Research and Monitoring Jobs**: Conservation programs create employment opportunities in scientific monitoring and marine research

Connecting to Regional Markets: Conservation efforts can help fishing communities develop stronger connections to regional seafood markets that increasingly value sustainable fishing practices.

9.3 DOES THE INVESTMENT PAY OFF?

9.3.1 Understanding the Return on Investment

When we look at conservation as a long-term investment, the numbers show that the benefits gradually outweigh the costs:

Conservative Scenario (10 years): For every 1 LYD invested, the community gets back 1.2 LYD in benefits **Moderate Scenario (15 years):** For every 1 LYD invested, the community gets back 2.1 LYD in benefits **Optimistic Scenario (20 years):** For every 1 LYD invested, the community gets back 3.5 LYD in benefits

When Does Investment Break Even?

- **Conservative estimate**: The investment pays for itself by Year 8 (with modest 10% improvement in fishing productivity)
- **Moderate estimate**: Break-even by Year 6 (with 15% improvement in fishing productivity)
- **Optimistic estimate**: Break-even by Year 5 (with 25% improvement plus tourism development)

9.3.2 Being Realistic About Uncertainty

Understanding the Range of Possibilities: Since we're dealing with natural systems and human communities, there's always some uncertainty in long-term projections. The analysis uses a 25% range above and below the main estimates to account for this uncertainty—this is standard practice in fisheries economics.

What We're Most Confident About:

- **Very Confident**: The short-term costs, because they're based on actual survey data from 66 fishing families
- **Moderately Confident**: Medium-term recovery timelines and how well alternative livelihoods will work
- **Less Confident**: Exact long-term ecosystem improvements and tourism revenue over 10-15 years, since these depend on many factors beyond our control

9.4 MAKING CONSERVATION WORK EFFICIENTLY

9.4.1 Focusing Resources Where They're Needed Most

Smart Investment Strategy: Rather than spreading resources thinly across everyone, the analysis suggests focusing help where it's needed most:

- **40% of resources** for the 27 families facing immediate economic crisis
- **35% of resources** for gradual expansion to help more families while maintaining existing programs
- **25% of resources** for long-term sustainability and incentive programs

Building on Community Strengths: The survey revealed encouraging signs for successful implementation:

- 63.6% of fishermen support conservation measures when they receive appropriate assistance
- 80.3% are willing to participate in training programs to learn conservation-friendly fishing techniques
- This community willingness provides a strong foundation for cost-effective implementation

9.4.2 Connecting to Libya's National Goals

Working with Existing Plans: This conservation effort fits naturally with Libya's National Action Plan for Cartilaginous Fishes (2024-2030), which already provides a framework for marine conservation. Rather than creating something entirely new, the program builds on existing commitments and institutions.

Community-Based Monitoring: Since 80.3% of fishermen expressed willingness to participate in training, this enthusiasm can be channeled into community-based monitoring programs where fishing families help track conservation progress while building valuable skills.

Regional Leadership Opportunities: Libya has the opportunity to become a leader in Mediterranean marine conservation, potentially accessing international funding and technical support while maintaining control over its own conservation approach.

9.5 MAKING THE DECISION: IS CONSERVATION INVESTMENT WORTH IT?

9.5.1 The Bottom Line

The economic analysis shows that while marine conservation requires substantial upfront investment—estimated at 12.83-16.43 million LYD over the first three years—the long-term benefits justify these costs when implemented thoughtfully.

The Recommended Approach: A phased implementation requiring 4-6 million LYD focused investment offers the best balance of conservation success and economic sustainability. This approach:

- **Focuses help** on the 27 families who need it most while allowing other fishing operations to adapt through market forces
- **Builds on documented community support**: 63.6% of fishermen support conservation when they receive appropriate assistance, and 80.3% are willing to participate in training
- **Works within Libya's capabilities** and builds on the existing National Action Plan framework

Why This Makes Economic Sense: Rather than trying to help everyone equally, focusing intensive support on the 27 families facing the most severe economic impacts proves more cost-effective than universal assistance programs. This targeted approach provides a financially sustainable pathway for implementing marine conservation while protecting the families who would otherwise face economic hardship.

Looking to the Future: When fishing communities have stable alternatives, when children can continue their education, and when families maintain their livelihoods, conservation measures gain the community support that's essential for long-term success. The combination of immediate targeted support and long-term ecosystem benefits creates a pathway where both marine conservation and community prosperity can succeed together.

10 Conclusions and Recommendations

10.1 KEY FINDINGS

The Gulf of Sirte assessment reveals that marine conservation is both necessary and achievable when implemented with appropriate community support. Based on comprehensive data from 66 fishing families, three critical findings reshape our understanding of conservation implementation in Libya:

1. **Conservation is Operationally Manageable**

While 93.9% of fishermen interact with protected species, these are primarily bycatch rather than targeted catches. Fishermen focus on commercial species like grouper (78.8%) and dentex (69.7%), meaning conservation measures require operational adjustments, not livelihood changes.

2. **Strong Community Foundation Exists**
   I. 63.6% support conservation measures when provided appropriate assistance
   II. 80.3% willing to participate in training programs
   III. 87.9% use traditional medicine involving marine species, indicating deep cultural connections requiring sensitive integration

3. **Economic Impact is Concentrated and Manageable**

Only 27 families face severe economic risk, while most fishermen (69.7%) have minimal dependency on affected species. This concentration enables targeted, cost-effective support strategies.

10.2 STRATEGIC RECOMMENDATION: PHASED IMPLEMENTATION

Implement Scenario B - a three-phase approach requiring 4-6 million LYD over 5 years that balances conservation effectiveness with economic sustainability:

Phase 1 (Years 1-2): Emergency Response

- Focus on critically endangered Bull Ray and Common Eagle Ray
- Intensive support for 27 high-risk families
- Cost: 2.8-4.2 million LYD annually

Phase 2 (Years 3-4): Systematic Expansion

- Extend protection to remaining seven species
- Support for 109 medium-vulnerability families
- Cost: 1.8-2.6 million LYD annually

Phase 3 (Years 5+): Full Implementation

- Comprehensive regional coverage
- Incentives for 173 low-vulnerability operations
- Cost: 800.000-1.2 million LYD annually

10.3 ECONOMIC JUSTIFICATION

Return on Investment:

- 15-year horizon: 2.1:1 benefit-cost ratio
- Break-even: Years 5-8 depending on ecosystem recovery
- Regional impact: 5.25 million LYD annual fishing income protected
- People affected: 2,278 individuals including fishing families

The investment pays for itself through improved fisheries productivity, sustainable market access, and potential marine tourism development.

10.4 IMPLEMENTATION REQUIREMENTS

Immediate Actions:

1. Establish emergency fund for 27 most vulnerable families
2. Deploy training programs leveraging 80.3% willingness to participate
3. Create monitoring systems using community-based approaches

Success Factors:

- Alternative species development: Build on existing grouper and dentex targeting
- Dual-track support: Address both operational changes and income replacement
- Cultural sensitivity: Integrate 87.9% traditional medicine usage appropriately
- Market expansion: Prevent price depression from increased alternative species targeting

10.5 LIBYA'S STRATEGIC OPPORTUNITY

This approach positions Libya as a Mediterranean leader in community-based marine conservation, demonstrating that environmental protection and economic development are complementary rather than competing goals.

National Benefits:

a. Regional leadership in sustainable fisheries management
b. International recognition for innovative conservation approaches
c. Economic diversification through marine tourism and sustainable seafood certification
d. Scientific collaboration enhancing Libya's research capacity

10.6 RISK MANAGEMENT

Primary Risks and Mitigation:

- Non-compliance: Address through enhanced compensation and flexible timelines
- Economic hardship: Prevent through emergency protocols and rapid response
- Social conflict: Manage through transparent communication and stakeholder engagement

Monitoring Framework:

- Quarterly socio-economic assessments tracking family income stability
- Annual conservation effectiveness evaluations
- Community feedback integration ensuring adaptive management

10.7 FINAL RECOMMENDATION

Implement Scenario B immediately with the following decision framework:

For Policymakers: The concentration of severe impacts among 27 families enables targeted, cost-effective intervention that protects both marine ecosystems and fishing communities. The 4-6 million LYD investment generates measurable returns while establishing Libya as a regional conservation leader.

For Fishing Communities: Conservation measures, when implemented with appropriate support, create opportunities for sustainable livelihoods, market access, and community prosperity. The documented willingness to participate (80.3% training acceptance, 63.6% conservation support) provides the foundation for successful implementation.

For Conservation: Protecting nine threatened cartilaginous species through community-based approaches ensures both immediate species protection and long-term ecosystem recovery. The phased approach addresses biological priorities while building social acceptance essential for conservation success.

Marine conservation in the Gulf of Sirte is both necessary and achievable. The combination of strong community willingness concentrated economic impacts amenable to targeted support, and viable economic returns creates a clear pathway forward. Success depends on treating fishing families as conservation partners rather than obstacles, providing appropriate support during transition, and recognizing that healthy marine ecosystems and thriving communities are mutually dependent.

The choice is clear: Invest 4-6 million LYD over five years to protect both marine species and fishing families, establishing Libya as a Mediterranean model for conservation that works for both people and nature.

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