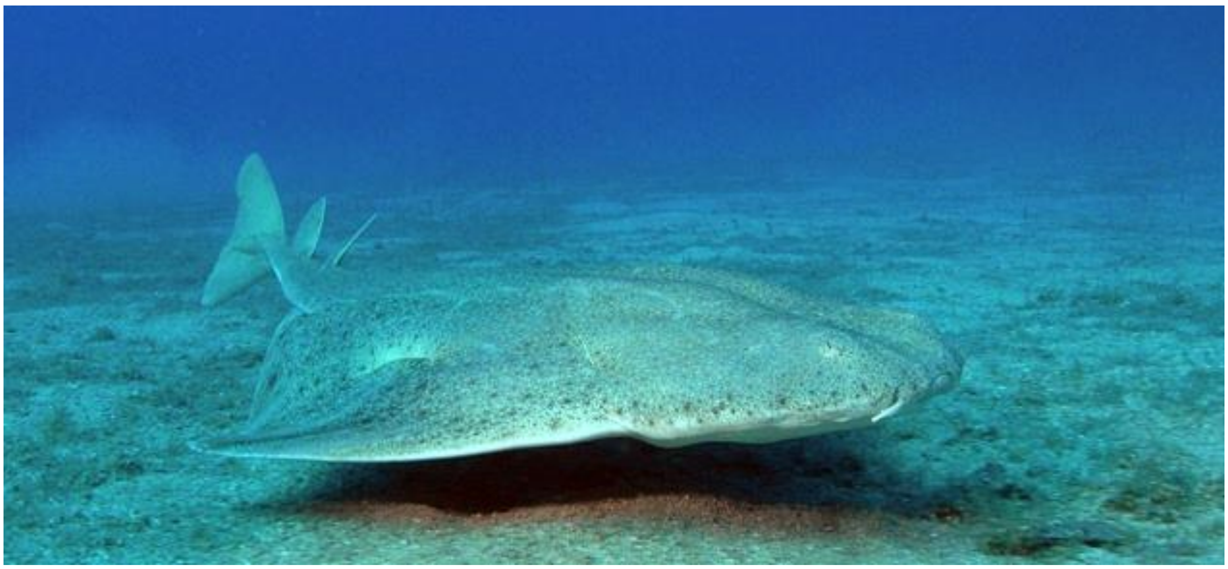
Status Review Report of 3 Species of Angelsharks: S*quatina aculeata, S. oculata, and S. squatina*


Credit: *S. squatina* photograph by Philippe Guillaume, distributed under a CC-BY 2.0 license

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EXECUTIVE SUMMARY

This report was produced in response to a petition received from WildEarth Guardians on July 15, 2013, to list 81 marine species as endangered or threatened under the Endangered Species Act (ESA). On November 6, 2013, NMFS announced in the *Federal Register* that the petition presented substantial information that listing may be warranted for five of the petitioned angelshark species and requested information on these species from the public (78 FR 66675). Subsequently, NMFS initiated a status review of these species. This report is the status review for three of the five angelshark species, namely, *Squatina aculeata*, *Squatina oculata*, and *Squatina squatina*. This report summarizes available data and information on these three angelshark species and presents an evaluation of their status and extinction risk.

Squatina aculeata, more commonly referred to as the sawback angelshark, historically occurred throughout central and western Mediterranean waters and the eastern Atlantic, from Morocco to Angola, in depths of 30 m to 500 m. However, recent records point to its presence in the eastern Mediterranean as well, specifically the Aegean and Levantine Seas. Based on available historical information, anecdotal observations, and fisheries survey and catch data, it appears the species may no longer be found in the Adriatic Sea or central Aegean Sea. Although once present in commercial landings and characterized as abundant in certain Mediterranean waters in the 1970s (e.g., within the Tyrrhenian Sea and Tunisian waters), the available information suggests the species is presently a rare occurrence throughout its historical Mediterranean range, with evidence of potential extirpations in the Ligurian and Tyrrhenian Seas, off the Balearic Islands and in the Catalan Sea. Similarly, in the eastern Atlantic, the available information suggests the species was abundant off the west coast of Africa in the 1970s but has since undergone declines to the point where it is now a rare occurrence in these waters.

Squatina oculata, more commonly referred to as the smoothback angelshark, historically occurred throughout the Mediterranean Sea and eastern Atlantic, from Morocco to Angola, in depths of 20 m to 560 m. Based on available historical information, anecdotal observations, and fisheries survey and catch data, it appears the species may be rare throughout most of its Mediterranean range, with the exception of the central Mediterranean and the Levantine Sea, where qualitative descriptions of the species characterize it as common. However, these characterizations date back almost 10 years and, as such, the current status of the population in these areas is unknown. The species is also thought to be possibly extirpated in the Aegean Sea, Ligurian and Tyrrhenian Seas, off the Balearic Islands and in the Catalan Sea. In the eastern Atlantic, the available data indicate the species may have been common off the west coast of Africa back in the 1970s and 1980s, but has since undergone declines to the point where it is now rarely observed in these waters.

Squatina squatina, referred to as the common angelshark, is the most northerly distributed of the three angelshark species. Its historical range extended along the eastern Atlantic, from Scandinavia to Mauritania, including the Canary Islands, and it was also found in the English Channel, throughout the Mediterranean and Black Seas. It occurs in depths of 5 m to 150 m and may also be observed in estuaries and brackish waters. Although there are no population estimates for *S. squatina*, historical records and anecdotal reports indicate that *S. squatina* was commonly observed in the North Sea, off the coasts of England and Ireland, within the Bay of Biscay and in the Mediterranean Sea. Comparisons of historical and current catch and survey data suggest significant declines in *S. squatina* population throughout its historical range, with the species possibly extirpated from the western English Channel, North Sea, Baltic Sea, Ligurian and Tyrrhenian Seas, Black Sea, Catalan Sea, and portions of the Adriatic Sea. Presently, the only part of its range where the species is still a common occurrence is off the Canary Islands; however, this area comprises an extremely small portion of the species' range and its present abundance in this portion remains uncertain.

The decline in these *Squatina* species is mainly attributed to the historical and current overutilization of these species by demersal fisheries. Because angelsharks are sedentary, bottom-dwelling species, they are highly susceptible to being caught in trawl fisheries. Additionally, given their low productivity, they are unable to quickly rebound from threats that decrease their abundance. Consequently, as the demersal fisheries expanded throughout the Mediterranean and eastern Atlantic in the 1890s, through the use of steam-powered trawlers, the *Squatina* species began to experience declines to the point where they are now extirpated from large portions of their historical range. The remaining *Squatina* populations are likely small, fragmented, isolated, and in decline, with a high likelihood of being strongly influenced by stochastic or depensatory processes. These species continue to be threatened with overutilization as the demersal fisheries that historically contributed to their declines remain active throughout their respective ranges. With trawling providing the greatest economic return in the fishery sector operating throughout the Mediterranean, it is unlikely that this threat will decrease in the near future. Overutilization by artisanal and recreational fisheries are also threats to the *Squatina* species, with existing regulatory mechanisms inadequate to decrease fishing mortality in these and the commercial demersal fisheries to the point where further declines in the species are unlikely. Given the species' demographic risks and the present threats that continue to contribute to the decline of existing populations, I conclude that *S. aculeata*, *S. oculata*, and *S. squatina* are presently at a high risk of extinction throughout their respective ranges.

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INTRODUCTION

Scope and Intent of the Present Document

This document is the status review of three *Squatina* species: the sawback angelshark (*Squatina aculeata*), smoothback angelshark (*Squatina oculata*) and the common angelshark (*Squatina squatina*). This status review is in response to a petition[1] to list 81 species as threatened or endangered under the Endangered Species Act (ESA). Under the ESA, if a petition is found to present substantial scientific or commercial information that the petitioned action may be warranted, a status review shall be promptly commenced (16 U.S.C. 1533(b)(3)(A)). The National Marine Fisheries Service (NMFS) determined the petition had sufficient merit for consideration and that a status review was warranted for 27 of the 81 species (see http://www.nmfs.noaa.gov/pr/species/petition81.htm for the Federal Register notices), including the three *Squatina* species.

This document is the scientific review of the biology, population status and future outlook for the three *Squatina* species. The conclusions in this status review are subject to revision should important new information arise in the future. Where available, I provide literature citations to review articles that provide even more extensive citations for each topic. Public comments, data and information were reviewed through June 2016.

LIFE HISTORY AND ECOLOGY

Taxonomy and Distinctive Characteristics

Angelsharks belong to the family Squatinidae (Order: Squatiniformes) and are recognized by their batoid shape. Their mouth and nostrils are terminal, with barbels on the anterior margin. Their eyes and large spiracles are found on the dorsal surface of the head, with gill slits on the side of the head. They have two small spineless dorsal fins, which are found behind the pelvic fins, a long tail and caudal fin, but no anal fin (Froese and Pauly 2014). Species identification of angelsharks is mainly conducted through the examination of these external characteristics, but the taxonomy is often considered to be problematic since several species are morphologically similar with overlapping characters (Vaz and de Carvalho 2013). Since 1984, 11 additional *Squatina* species have been recognized (Compagno 1984; Froese and Pauly 2014), bringing the present total to 23 identified *Squatina* species. Recent research suggests there are currently undescribed species, indicating that the taxonomy of the angel sharks may still be unresolved (Stelbrink *et al.* 2010; Vaz and de Carvalho 2013).

[1] (1) WildEarth Guardians submitted to U.S. Secretary of Commerce, Acting through the National Marine Fisheries Service, an Agency within the National Oceanic and Atmospheric Administration, July 15, 2013, "Petition to list eighty-one marine species under the Endangered Species Act."

Squatina aculeata (Cuvier, 1829), the sawback angelshark, is distinguished from other angelsharks by its row of dorsal spines (sword-like bony structure) down the middle of its body, with spines also located on the snout and above the eyes. The sawback angelshark also has fringed nasal barbels and anterior nasal flaps on its body (Figure 1; Compagno 1984).

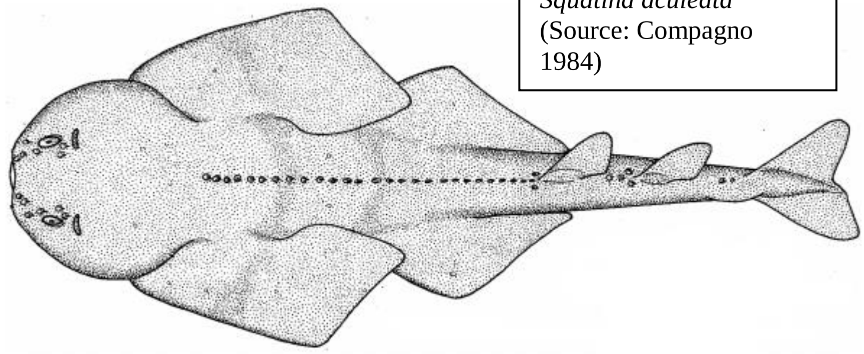

Figure 1. Dorsal view of *Squatina aculeata* (Source: Compagno 1984)

Squatina oculata (Bonaparte, 1840), the smoothback angelshark, is distinguished from other angelsharks by its big thorns (sharp, tooth-like structures on the skin) that are present on the snout and above the eyes, a first dorsal fin that originates well behind the pelvic rear tips, and noticeable white spots in symmetrical patterns on the pectoral fins and body (Figure 2; Compagno 1984).

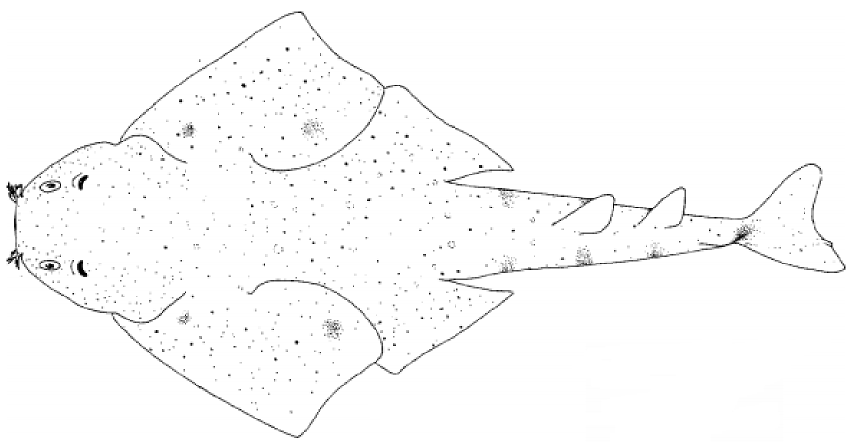

Figure 2. Dorsal view of *Squatina oculata* (Source: Compagno 1984)

Squatina squatina (Linnaeus, 1758), the common angelshark, is distinguished from other angelsharks by its simple and conical nasal barbels, high and wide pectoral fins, small spines that are present on snout and above eyes and may also be present down middle of back, and lateral trunk denticles that are very narrow with sharp-cusped crowns (Figure 3; Compagno 1984).

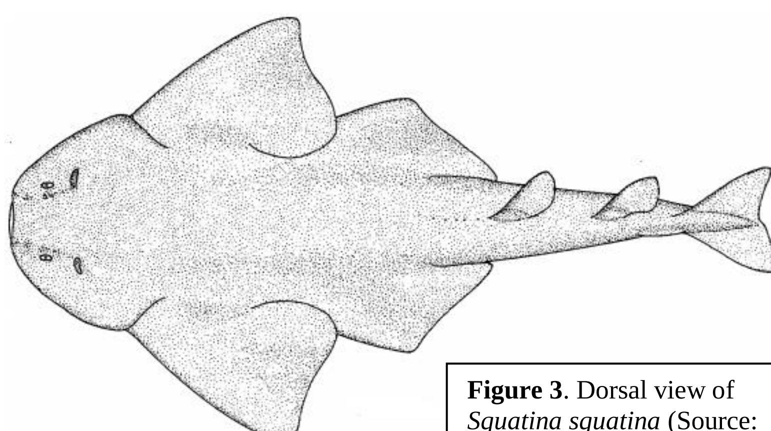

Figure 3. Dorsal view of *Squatina squatina* (Source: Compagno 1984)

Historical Range and Habitat Use

Angelsharks can be found worldwide in temperate and tropical waters. The three species under review are found in coastal and outer continental shelf sediment habitats in the Mediterranean Sea and eastern Atlantic. These species are bottom dwellers and prefer to spend most of their time buried in the sand or mud (Compagno 1984). More information on the individual species' respective ranges is provided below.

Squatina aculeata was historically found in central and western Mediterranean waters and in the eastern Atlantic, from Morocco to Angola (Figure 4). According to Capapé *et al.* (2005), it has never been recorded in Atlantic waters north of the Strait of Gibraltar. *Squatina aculeata* occurs in depths of 30 m to 500 m on the continental shelf and upper slope (Compagno 1984). It was historically assumed to be very rare or absent from the eastern Mediterranean (Capapé *et al.* 2005; Psomadakis *et al.* 2009); however, a number of studies have documented its presence in this region (see **Distribution and Historical and Current Abundance** section below), suggesting possible misidentification of the species in historical records.

Figure 4. Likely historical range of *S. aculeata* (Source: Morey *et al.* 2007b range map of *S. oculata*).

Figure 5. Historical range of *S. oculata* (Source: Morey *et al.* 2007b)

Squatina oculata was historically found throughout the Mediterranean Sea and in the Eastern Atlantic from Morocco to Angola (Figure 5). The species occurs in depths of 20 m to 560 m on the continental shelf and upper slopes, but is more commonly found in depths between 50 and 100 m (Compagno 1984; Serena 2005).

Figure 6. Historical range of *Squatina squatina*. (Source: Morey *et al*. 2006)

Squatina squatina is the most northerly distributed of the three angelshark species. The historical range of *S. squatina* extended along the eastern Atlantic, from Scandinavia (rarely) to Mauritania, including the Canary Islands, and in the English Channel, Mediterranean Sea and Black Sea (Figure 6). Recent survey and industrial fisheries data also indicate the presence of the species off the coast of Sierra Leone (Sierra Leone Ministry of Fisheries and Marine Resources personal communication 2016), suggesting that the species' range may extend farther south than previously thought (or, perhaps more likely, represents a misidentification of the species). It is found from inshore areas out to the continental shelf in depths of 5 m to 150 m (OSPAR Commission 2010). It may also be observed in estuaries and brackish waters (OSPAR Commission 2010). The species is nocturnal and can be found swimming strongly off the sea bottom at night, and spends the day time buried in the mud or sand, with only its eyes protruding (Day 1880; Tonachella 2010).

In the northern part of its range, *S. squatina* appears to undertake seasonal migrations, with northerly movements coinciding with warming water temperatures (Day 1880; OSPAR Commission 2010). It is suspected that the fish move inshore for the summer, to areas such as Tralee Bay in Ireland and Cardigan Bay in the United Kingdom, and out to deeper water in the winter, with overwintering spots thought to include waters off Pembrokeshire (Wales) (Figure 7; ICES 2014).

Figure 7. Yellow line depicts a suspected over-wintering spot for *S. squatina* and red locations depict suspected summer areas (Source: Adapted from ICES 2014).

Since 1970, the Central Fisheries Board of Ireland has been tagging and releasing rod-caught *S. squatina* in Irish waters, specifically in Tralee Bay and Clew Bay (Figure 8). The results from this tagging program show that the species occasionally moves far, possibly during seasonal migrations, with almost 20% of recaptured fish caught outside of Tralee and Clew Bays. Locations of recaptures even included areas off England, France, and Spain (Figure 8). Since 2006, the longest time at liberty for a tagged *S. squatina* has been 4,532 days (almost 12 years), with three other tagged fish at liberty for over 10 years (Quigley 2006). In addition, the longest distance travelled by a tagged fish has been 1,160 km; however, Quigley (2006) notes that, for the most part, these tagged fish remained in Irish waters and close to their initial tagging location, indicating potentially high site fidelity.

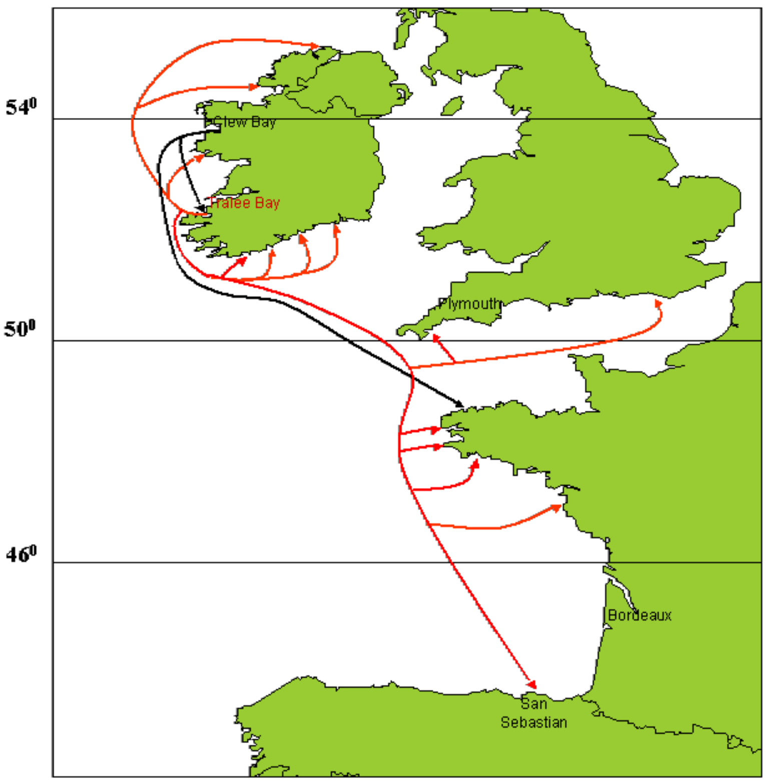

Figure 8. Migration patterns based on locations of recaptured tagged *S. squatina* sharks (n=190) from 1970 to 2006. Black lines represent recapture locations of sharks released in Clew Bay and red lines represent recapture locations of sharks released in Tralee Bay. (Source: OSPAR Commission 2010)

In Mediterranean waters, *S. squatina* do not appear to travel as far, but data are extremely limited. For example, in the Gulf of Tunis, 15 *S. squatina* individuals were tagged and released between 1969 and 1971, with two of these sharks recaptured (Quignard and Capapé 1971). One shark was caught 10 km from the release site after 12 days at liberty and the other was caught 25 km from its release spot after 186 days at liberty (Quignard and Capapé 1971). Similarly, Capapé *et al.* (1990) tagged and released 23 *S. squatina* individuals in 1989, also in the Gulf of Tunis, and reported 4 recaptures 10 - 44 km from their release spot, with a time at liberty ranging from 12 to 231 days.

Feeding and Diet

All three species are ambush predators, meaning they lie in wait for prey to approach before attacking. Based on their diet, they are considered to be high trophic level predators (trophic level = 4.0; Cortés 1999). According to Compagno (1984), *S. aculeata* feeds on small sharks and jacks and *S. oculata* prefers small fishes, including goatfishes. Corsini and Zava (2007) also reported benthic invertebrates, including cephalopods and crustaceans, in the stomachs of *S. aculeata*. *Squatina squatina* has a diet that consists mostly of bony fishes, especially flatfishes, and other demersal animals (skates, crustaceans, molluscs), with the occasional eelgrass and seabird (Day 1880; Compagno 1984; Ellis *et al.* 1996; Agri-Food & Biosciences Institute 2009). In the Canary Islands, Narváez (2012) found that teleosts were the most important prey item for *S. squatina* (89.8% Index of Relative Importance (IIR)) followed by cephalopods (9.4% IIR).

Reproduction and Growth

The three angelshark species are ovoviviparous, meaning embryos develop inside eggs that hatch within the female's body, with young born live. However, according to Sunye and Vooren (1997), *Squatina* species also have a uterine–cloacal chamber (the chamber where embryos complete their final development stage) that is open to the external environmental through a cloacal vent. This anatomical configuration is thought to be the reason why *Squatina* species are found to easily abort embryos during capture or handling (Sunye and Vooren 1997; Capapé *et al.* 2005) and should be taken into consideration when evaluating reproductive capacity and threats to *Squatina* species. Additional species-specific information regarding reproduction and growth is provided below.

For ***S. aculeata***, gestation likely lasts around a year, with parturition occurring between May and July (Capapé *et al.* 2005). Litter sizes range from 8 to 12 pups, and size at birth is around 30 cm to 35 cm total length (TL) (Capapé *et al.* 2005). *Squatina aculeata* displays sexual dimorphism, with males maturing at around 120 cm - 124 cm TL and reaching maximum sizes of around 152 cm TL, and females maturing at larger sizes, around 137 cm – 143 cm TL, and attaining larger maximum sizes (175 cm - 180 cm TL) (Capapé *et al.* 2005; Serena 2005). I could not find any information on specific geographic areas that may be important for reproduction or growth.

For ***S. oculata***, gestation also likely lasts, at a minimum, around a year (Capapé *et al.* 1990, 2002). Litter sizes range from 5 to 8 pups with size at birth around 23 cm to 27 cm TL (Capapé *et al.* 1990, 2002). Males mature around 71 cm TL and reach sizes of at least 145 cm TL, and females mature around 90 cm TL, with maximum size estimated at160 cm TL (Compagno 1984; Capapé *et al.* 1990, 2002). Based on 1989 trawl data, which showed gravid females and young-of-the-year *S. oculata* individuals caught in the shallow (10 m - 40 m depths) waters of the Gulf of Tunis, Capapé *et al.* (1990) suggested that the Gulf of Tunis was a nursery area for *S. oculata*.

For ***S. squatina***, the gestation period for individuals in the Canary Islands is estimated to be ±6 months with a three-year reproductive cycle (Osaer 2009). Elsewhere, gestation period is unknown but possibly lasts from 8 to 12 months, with potentially a two-year reproductive cycle (Tonachella 2010; ICES 2014). Litter sizes range from 7 to 25 pups for *S. squatina* in the Mediterranean (Tortonese 1956), with size at birth estimates ranging from 24 cm to 30 cm (Osaer 2009; Tonachella 2010). Based on *S. squatina* from the Tunisian Plateau, males mature between 80 cm and 132 cm TL, with maximum sizes attained at 183 cm TL, and females mature between 126 cm and 169 cm TL and attain maximum sizes of up to 244 cm TL (Compagno 1984; Capapé *et al.* 1990; Quigley 2006; Tonachella 2010). In contrast, in the Canary Islands, Osaer (2009) found length at first maturity (Lm50) for males to be 100.9 cm TL and for females to be 102.1 cm TL. The maximum observed estimates of size from the Canary Islands range from 120.8 cm TL (Osaer *et al.* 2015) to 122 cm (from *in situ* measurements; Narváez 2012; Osaer and Narváez 2015), sizes that are smaller than even the smallest mature female reported by Capapé *et al.* (1990) in Tunisian waters (at 126 cm TL). These findings suggest that maturity and maximum sizes attained by *S. squatina* may significantly differ by region. Additionally, parturition also differs by region, with birthing occurring in the Mediterranean from December to February, but in the more northern parts of its range, birthing occurs later in the year (for example, in England, birthing is thought to occur in July) (Morey *et al.* 2006). Weight of the species has been recorded up to 80 kg (Quigley 2006).

In the 1980s, fishermen reported catching juvenile *S. squatina* in Cardigan Bay, Wales, potentially indicating that this area once served as a nursery ground for the species. Within the Canary Islands, shark biologist Eva Meyers (Principal Investigator of Angel Shark Project, personal communication 2015) identified nursery grounds off Puerto del Carmen, Lanzarote and Narváez *et al.* (2006) suggest that the Bay of Sardina, off the northern coast of Gran Canaria Island, also currently serves as a nursery area and possible mating ground for *S. squatina*. Additionally, Narváez (2012) identified Sardina del Norte off Gran Canaria Island as another nursery ground based on the prevalence of females with total lengths above Lm50 and the total lengths of the observed neonates. Teresitas beach, in Tenerife (Canary Islands), is also thought to be a nursery ground based on the accounts of Teresitas beachgoers who have reported being bitten by small angelsharks over the past decade (El Dia Digital 2000; Alianza Tiburones Canarias 2014).

Population Structure

No studies have examined the population structure or genetic population dynamics of either *S. aculeata* or *S. oculata*. For *S. squatina*, only preliminary information is available from the Canary Islands portion of its range. Based on information in an abstract, between 2009 and 2016, Fitzpatrick *et al.* (2016) collected 509 tissue samples from *S. squatina* individuals off the Gran Canaria, Tenerife, and Lanzarote islands within the Canary Islands archipelago. Analysis of the deoxyribonucleic acid (DNA) sequences from four mitochondrial loci showed almost no genetic variation, with identical haplotypes found in almost all of the sampled individuals (Fitzpatrick *et al.* 2016).

Distribution and Historical and Current Abundance

S. aculeata

Mediterranean Sea

In terms of distribution, *S. aculeata* was historically thought to be rare or absent in the eastern Mediterranean. There are a few records of *S. aculeata* in the Adriatic Sea (from 1975; Capapé *et al.* 2005) and Ligurian Sea (Tortonese 1956), and in the eastern Mediterranean from the Ionian Sea (from 1987; Papaconstantinou 1988) and Greek Seas (from 1971; Papaconstantinou 1988; and from 1973; Capapé *et al.* 2005), although the specific location was not identified. In 2007, Corsini and Zava (2007) reported the first record of the species in Hellenic waters of the Southeast Aegean Sea (around Rhodes and the Dodecanese Islands). One male individual (143.5 cm TL; likely mature) was caught between Kalymnos and Kos Islands (Greece) in 64 m depth in May 2004 and another male (104.5 cm TL; 8.7 kg; likely immature) was caught by trawl in 65 m - 75 m depth in March 2006 off Pardisi (northwest coast of Rhodes, Greece) (Figure 9; Corsini and Zava 2007). Damalas and Vassilopolou (2011) also recorded the species in trawl catches from the central Aegean Sea between 1995 and 2000, but noted it was absent in the more recent hauls from 2003-2006. Catch of *S. aculeata* has also been reported from the Çanakkale Strait off Turkey (Ünal *et al.* 2010) and from Gökova Bay in the southern Aegean Sea (Figure 9; Filiz *et al.* 2005).

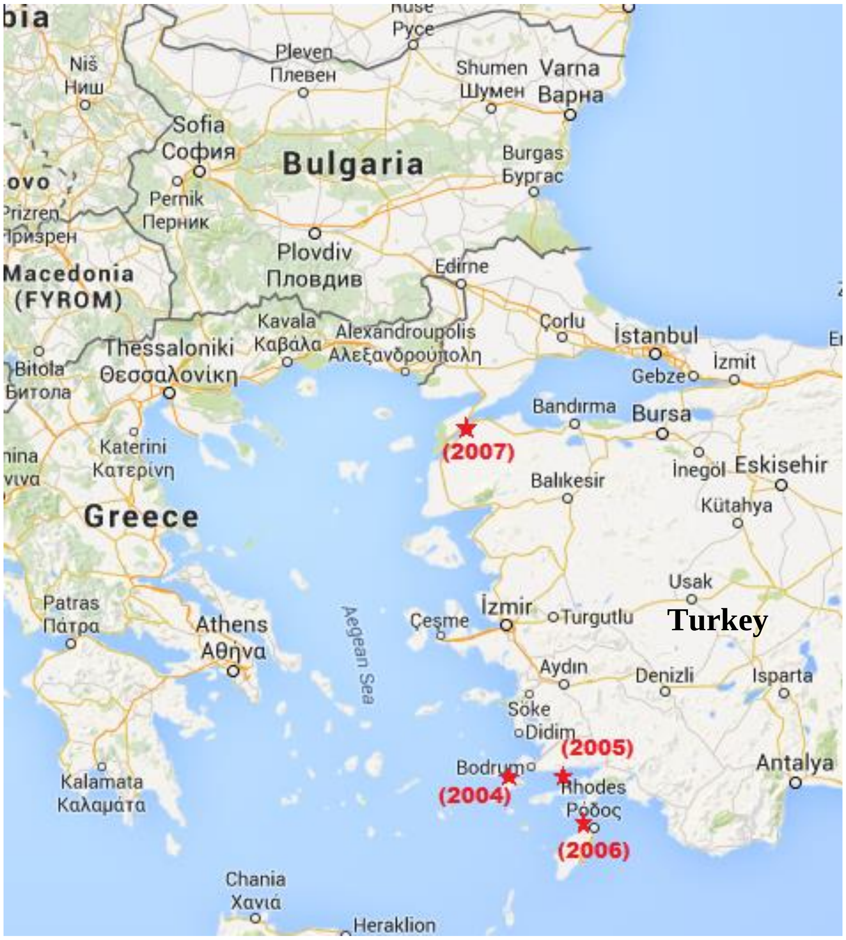

Figure 9. Recent observations (2004-2007) of *S. aculeata* individuals in areas where previously the species was considered to be absent or rare.

The species was also listed as occurring in the Levantine Sea by Golani (1996) (as reported in Capapé *et al.* (2005)), with the first actual description of a specimen caught in this area from Iskenderun Bay in 1997 (Basusta 2002); however, by 2004, Golani noted that the species was no longer reported in the area (Golani personal communication cited in Capapé *et al.* (2005)). In their updated checklist of marine fishes of Turkey, Bilecenoğlu *et al.* (2014) recorded *S. aculeata* as occurring in the Aegean Sea and Levantine Sea. There is also evidence of its occurrence along the Syrian coast as Saad *et al.* (2006) captured the species during longline, trawl, and beach seine surveys conducted from 2001-2004 (see Figure 10 for sampling coverage).

The species is currently reported as "doubtful" or rare in many areas in the central and western Mediterranean Sea, such as off the Spanish and French coasts, within Italian waters, and off Algeria (Barrull *et al.* 1999; Capapé *et al.*

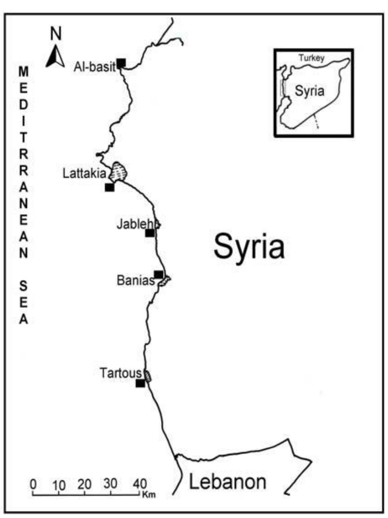

Figure 10. Sampling locations depicted in Saad *et al.* (2006).

2005). In the central Mediterranean, specifically the Gulf of Gabès (Tunisia), the species was noted as being abundant in 1978 (Quignard and Ben Othman 1978) and “regularly observed” in 2006 (Bradai *et al.* 2006). While I could not find information on the present abundance of the species in the Gulf of Gabès, other reports, including a more recent study, suggest the species has significantly declined in the region and is now a rare occurrence in Mediterranean Tunisian waters (Scacco *et al.* 2002; Capapé *et al.* 2005; Ragonese *et al.* 2013). Trawl surveys, conducted from 1995-1999 in the Strait of Sicily, recorded *S. aculeata* near Cape Bon (Tunisia) with a reported biomass of < 10 kg, comprising < 1% of the total elasmobranch biomass (see Figure 11 for sampling coverage; Scacco *et al.* 2002).

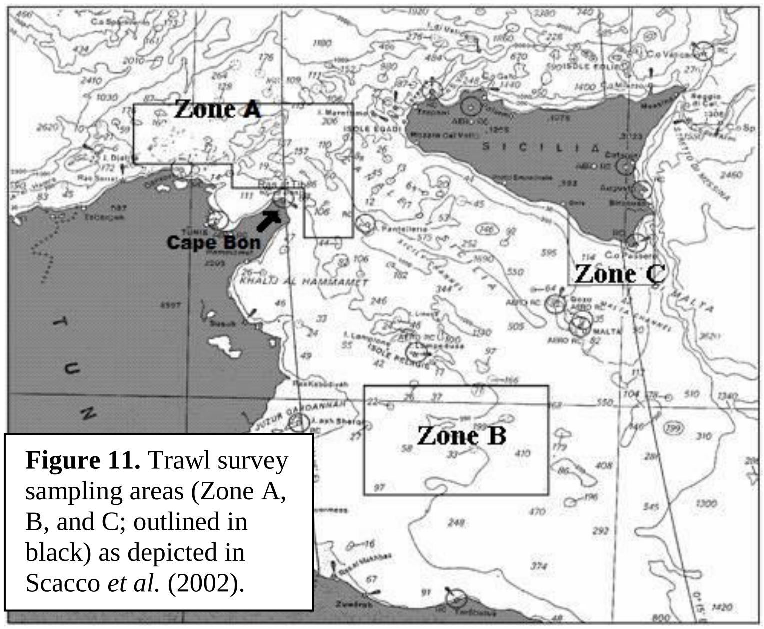

Figure 11. Trawl survey sampling areas (Zone A, B, and C; outlined in black) as depicted in Scacco *et al.* (2002).

In a more recent analysis of extensive trawl survey data collected off the southern coasts of Sicily from 1994 to 2009 (see Figure 12 for sampling coverage), Ragonese *et al.* (2013) found only one report of a captured *S. aculeata* individual. This shark was caught during a shelf haul in 86 m depth close to the Gulf of Gabès (Tunisia) in 2000. Although the species had been previously included in inventories of sharks and ray species from the Maltese Islands (based on unconfirmed records; Schembri *et al.* 2003), neither the Scacco *et al.* (2002) study nor the Ragonese *et al.* (2013) study provided evidence that it is still found in the area.

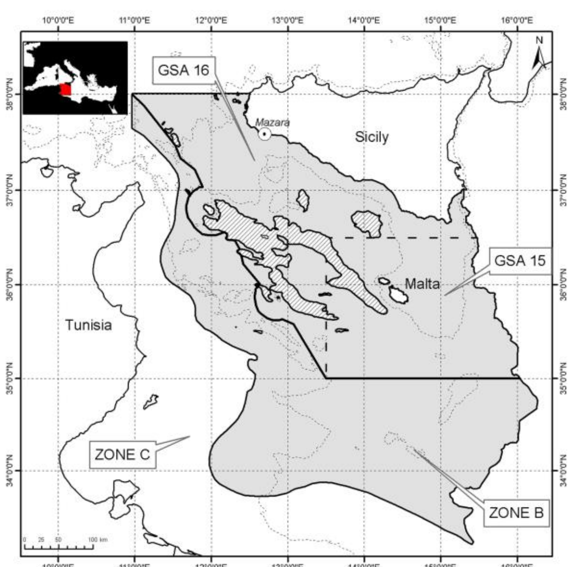

Figure 12. Trawl survey area (colored in light grey) as depicted in Ragonese *et al.* (2013).

In contrast, in waters off Libya, the species was described as relatively common by the United National Environment Programme (UNEP) in 2005 (UNEP-Mediterranean Action Plan Regional Activity Centre For Specially Protected Areas (UNEP-MAP RAC/SPA) 2005); however, no corresponding citation or data accompanied this statement. Furthermore, in 2016, Dr. Ramadan, head of the Marine Biology Branch at Omar Al-Mukhtar University in Libya, remarked that the three angelsharks are not common in the catches of Libyan fishermen (Dr. Ramadan personal communication 2016), suggesting abundance of the species may have declined in the past 10 years.

Due to taxonomic confusions regarding angelsharks in the 19th and 20th centuries, it is also unclear whether reports of *S. aculeata* in the Gulf of Naples (Italy) from 1909 and 1942 are accurate (Psomadakis *et al.* 2009). Psomadakis *et al.* (2009) suggest that these records are likely *S. oculata* individuals since this species is found throughout the Tyrrhenian Sea, whereas *S. aculeata* specimens are rare in the Mediterranean Sea. However, Ferretti *et al.* (2005) notes the former presence of *S. aculeata* in commercial landings data from off the Tuscan coast, Capapé *et al.* (2005) points to a few records of *S. aculeata* in the Adriatic Sea (from 1975); and, as mentioned previously, *S. aculeata* has recently been documented from the Southern Aegean Sea and from the Çanakkale Strait off Turkey (Filiz *et al.* 2005; Corsini and Zava 2007; Ünal *et al.* 2010), indicating either a recent range extension of the species or, more likely accurate identifications of *S. aculeata* in the historical records. Ferretti *et al.* (2005) also conclude, though, that the species has been extirpated from the northern Tyrrhenian Sea since the early 1970s, based on survey data from trawls conducted between 1972 and 2004. Similarly, based on interview data from Maynou *et al.* (2011), retired small scale and trawl fishermen that once operated in the Ligurian and Tyrrhenian Seas indicate that angelsharks (*Squatina* spp) disappeared from waters off the western Italian coast by the early 1980s and from waters off Sardinia by the mid-1980s.In the Adriatic Sea, extensive bottom trawl surveys conducted from 1994-2005 also failed to locate the species (Jukic-Peladic *et al.* 2001; Ferretti *et al.* 2013).

In the western Mediterranean, the only information that I could find concerning the distribution and abundance of the species is the mention of a few specimens held in Spanish and French museums (The Global Biodiversity Information Facility (GBIF) 2013),the discussion in the International Union for Conservation of Nature (IUCN) Red List assessment of the species by Morey *et al.* (2007a), which relates to the populations off the Balearic Islands (Spain), and interview responses from retired fishermen that trawled in the Catalan Sea (Maynou *et al.* 2011). Specifically, Morey *et al.* (2007a) suggest that *Squatina* species (presumably *S. aculeata* or *S. oculata* based on fishing depths) were historically common in the Balearic Islands, pointing to evidence of a special type of fishing net that was used for catching angelsharks in this area. According to Morey *et al.* (2007a), these species were frequently caught in coastal artisanal fisheries, trawls, and bottom longline fisheries until the 1970s, after which captures became sporadic. Citing personal communication with G. Morey, Morey *et al.* (2007a) note that records from a lobster gillnet fishery operating in the Balearic Islands caught angelsharks on a daily basis until the mid-1980s. Since the mid-1990s, the species has been notably absent in the records (Morey *et al.* 2007a). In a study that aimed to characterize the demersal elasmobranch assemblage off the Balearic Islands using trawl survey data from 1996, 1998, and 2001, the authors also found no evidence of any *Squatina* species in the area (Massuit and Moranta 2003). Specifically, four bottom trawl surveys were conducted along the continental shelf and upper slope as well as unexploited deeper water of the middle and lower slope. The surveys were done during the spring and autumn, around Mallorca and Menorca (Spain) in 2001 (between 40 m and 800 m depth) and south of Eivissa and Formentera (Spain) in 1996 and 1998 (between 200 m and 1800 m depth) (Massuit and Moranta 2003). No *Squatina* species were collected in the 131 hauls from these trawl surveys, despite the overlap of the surveyed area with the observed depth range of the species, suggesting potential extirpation from these areas. Similarly, Maynou *et al.* (2011) interviewed 23 fishermen in 2009, with ages ranging from 49-88, who started trawl fishing in the Catalan Sea between 1932 and 1974. Only 14% of the fishermen were able to recognize an angelshark (*Squatina* spp.), with the authors interpreting the survey information as evidence that angelsharks were likely extirpated from the Catalan Sea by 1959 (or earlier) (Maynou *et al.* 2011). Additional and more expansive surveys in this area are needed to confirm these conclusions.

<u>Eastern Atlantic</u>

In the eastern Atlantic, observed population declines appear to have occurred within the past 40 years, particularly in waters off West Africa. According to a personal communication in the Morey *et al.* (2007a) assessment (from F. Litvinov in 2006), *S. aculeata* was commonly reported in Russian surveys off the coast of West Africa during the1970s and 1980s. Similarly, in their 1973 check-list of marine fishes, Hureau and Monod (1973) also referred to the species as common in these waters. By the early 1980s, however, there were signs of decline based on observations of the species. In fact, by 1985, Muñoz-Chapuli (1985) considered the species to be rare in the eastern Atlantic. This characterization was based on data from 181 commercial trawls conducted in 0 m - 550 m depths from 1980-1982 along the northwestern African coast (27°N – 37°N) and Alboran Sea. Only 28 *S. aculeata* sharks were captured, with 25 of them caught off the coast of Morocco (between 31°N and 34°N). In waters farther south, Morey *et al.* (2007a) indicate that the species was frequently caught by artisanal Senegalese fishermen 30 years ago (mid-1970s), with catches now very rare according to artisanal fishermen and observers of the industrial demersal trawl fleets (Morey *et al.* (2007a) citing a personal communication from M. Ducrocq). Similarly, Capapé *et al.* (2005) noted that the species was relatively abundant off the coast of Senegal and was landed throughout the year; but, in recent years, Senegalese fishermen have reported fewer observations of all squatinid species (Dr. Christian Capapé, Professor at Université Montpellier 2, personal communication 2015). In their revision of Irvine's *Marine Fishes of Tropical West Africa*, Edwards *et al.* (2001) note the occurrence of *S. aculeata* off the coast of Ghana but provide no information as to its frequency or abundance. In Sierra Leone, Morey *et al.* (2007a), citing a personal communication from M. Seisay, state that the species was "periodically caught by demersal trawlers in the 1980s, but are now caught very infrequently." These observations tend to support the available survey data, although data are only available through the year 2002. From 1962 to 2002, species recorded from 246 surveys conducted along the west coast of Africa were reported in two databases: Trawlbase and Statbase, as part of the Système d'Information et d'Analyse des Pêches (SIAP) project (Mika Diop, Program Officer at Sub-Regional Fisheries Commission, personal communication 2015). Based on the information from the databases, *S. aculeata* was recorded rather sporadically in the surveys since the 1970s and in low abundance (Figure 13), the exception being a 1997 survey conducted off Senegal, which recorded 24 individuals. However, in the surveys that followed (conducted from 1999-2002; with surveys off Senegal conducted in 1999 and 2000), no *S. aculeata* individuals were caught.

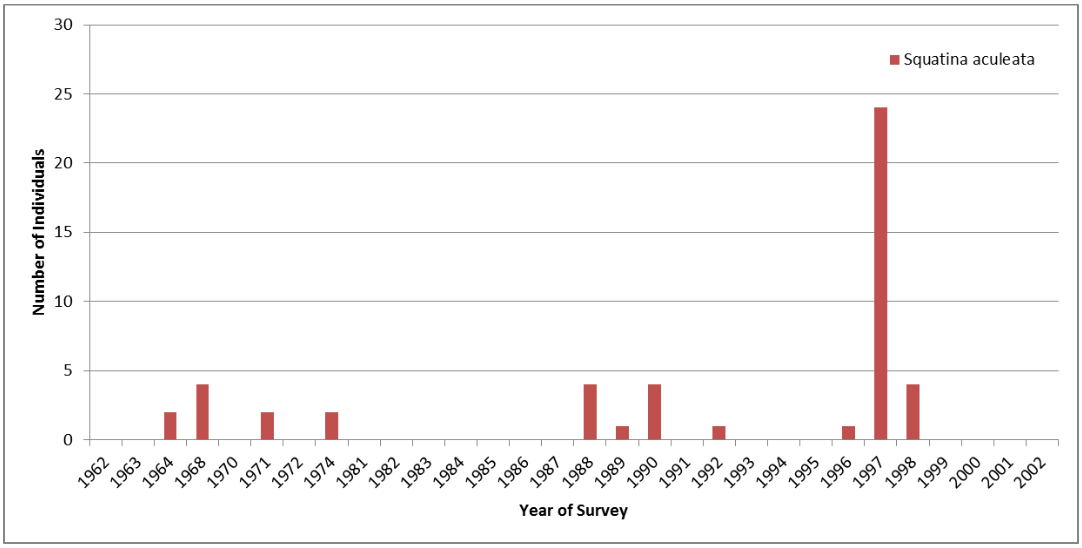

Figure 13. Number of *Squatina aculeata* individuals observed in trawl surveys conducted off the coast of West Africa from 1962 to 2002. (Source: SIAP project database)

Historical versus Current Range

Based on the above information regarding present distribution and abundance, it appears the species may no longer be found in the Adriatic Sea or central Aegean Sea. Although once present in commercial landings and characterized as abundant in certain Mediterranean waters in the 1970s (e.g., within the Tyrrhenian Sea and Tunisian waters), the available information suggests the species is presently a rare occurrence throughout its historical Mediterranean range, with evidence of potential extirpations in the Tyrrhenian Sea, off the Balearic Islands and in the Catalan Sea. Similarly, in the eastern Atlantic, the available information suggests the species was abundant off the west coast of Africa in the 1970s but has since undergone declines to the point where it is now a rare occurrence in these waters (with the last observation of the species from the available data dating back to 1998). It is unknown if the species is still found throughout its eastern Atlantic range.

S. oculata

Mediterranean Sea

The current distribution and abundance of *S. oculata* is not well known. In the western Mediterranean, it is possible that the species has been extirpated from the Balearic Islands and Catalan Sea (see discussion for *S. aculeata* above); however, further surveys are required to confirm this conclusion. In the central Mediterranean, Ferretti *et al.* (2005) noted the disappearance of the entire *Squatina* genus from the northern Tyrrhenian Sea in the early 1970s, and interviews of retired small scale and trawl fishermen, who once operated in the Tyrrhenian and Ligurian Seas, suggest angelsharks had disappeared from waters off the western Italian coast by the early 1980s and from waters off Sardinia by the mid-1980s (Maynou *et al.* 2011). Between the Maltese Islands and Tunisia, Ragonese *et al.* (2013) noted *S. oculata'*s sporadic occurrence based on data from both shelf and slope trawls conducted in 1997, 1998, and 2006 (see Figure 12 for sampling coverage), whereas Bradai *et al.* (2006) "regularly observed" the species in the Gulf of Gabès. Prior to these surveys, Capapé *et al.* (1990) had suggested that the Gulf of Tunis (Tunisia) was likely a nursery area for *S. oculata* based on trawl catch data. I have no information to indicate whether the Gulf of Tunis is still used by juvenile *S. oculata* or to estimate the present abundance of the species in the Gulf of Gabès. In 2005, UNEP reported the species as being relatively common in Libyan waters but provided no corresponding citation or data to support this statement or further information regarding abundance in the Mediterranean

Sea (UNEP-MAP RAC/SPA 2005). Furthermore, in 2016, Dr. Ramadan, head of the Marine Biology Branch at Omar Al-Mukhtar University in Libya, remarked that the three angelsharks are not common in the catches of Libyan fishermen (Dr. Ramadan pers. comm. 2016), suggesting abundance of the species may have declined in the past 10 years.

In the eastern Mediterranean, in December 2004, one female *S. oculata* individual (79.5 cm TL; 3.75 kg) that was likely immature was caught by a trawl net in depths of 60 m - 70 m in Trianda Gulf off the northwest coast of Rhodes, Greece. This marked the first record of the species in Hellenic waters of the Southeastern Aegean Sea (Corsini and Zava 2007). The species also appears to be rare in the central Aegean Sea as Damalas and Vassilopolou (2011) recorded only one individual during their analysis of 335 records of bottom trawl hauls conducted between 1995 and 2006. On the other hand, the species is characterized as "prevalent" by Golani (2006) along the Mediterranean coast of Israel. In their updated checklist of marine fishes of Turkey, Bilecenoğlu *et al.* (2014) recorded *S. oculata* as occurring in the Sea of Marmara, Aegean Sea, and Levantine Sea. In 2015, an individual was landed near Akyaka (Turkey) by local fishermen (Joanna Barker, UK & Europe Project Manager Conservation Programmes, ZSL, personal communication 2015). There is also evidence of its occurrence along the Mediterranean Syrian coast as Saad *et al.* (2006) captured the species during longline, trawl, and beach seine surveys conducted from 2001-2004 (see Figure 10 for sampling coverage). The species has also been reported in the Adriatic Sea (Arapi *et al.* 2006; Soldo 2006), where 4,082 kg of the species were caught in 2004 by Albanian fishing vessels; although, extensive bottom trawl surveys conducted from 1994-2005 throughout the Adriatic Sea failed to locate the species in these waters (Jukic-Peladic *et al.* 2001; Ferretti *et al.* 2013).

<u>Eastern Atlantic</u>

In the eastern Atlantic, there is very little available information on the abundance of this species. The IUCN Red List assessment of the species by Morey *et al.* (2007b) also cites to the same personal communication from M. Ducrocq and F. Litvinov found in the assessment of *S. aculeata* (Morey *et al.* 2007a) that indicates the species was frequently caught by artisanal Senegalese fishermen as well as commonly reported in Russian surveys off the coast of West Africa 30 years ago. Hureau and Monod (1973) also referred to the species as "rather common" in the eastern Atlantic, from Morocco to Angola. During 1981-1982, a Norwegian research vessel conducted trawl surveys off West Africa from Aghadir to Ghana to examine the composition and biomass of fish resources in this region. *Squatina oculata* was the only *Squatina* species caught during these surveys, with catch rates of 45.6 kg/hour off the coast of Gambia, 13.4 kg/hour off Sierra Leone, and 12.4 kg/hour off Liberia (Strømme 1984). In 2001, *S. oculata* was also reported as occurring off the coast of Ghana, with individuals usually caught between November and December but rarely landed (Edwards *et al.* 2001). No other data on abundance or frequency of occurrence were provided. Based on personal communication, Morey *et al.* (2007b) report that catches of the species in this region are now very rare and Senegalese fishermen have noted a decrease in observations of all squatinid species over the years (C. Capapé, pers. comm. 2015). Based on the information from the SIAP databases, *S. oculata* was recorded rather sporadically in the surveys, with a few years with reports > 20 individuals, primarily from surveys conducted off the coast of Senegal (Figure 14).

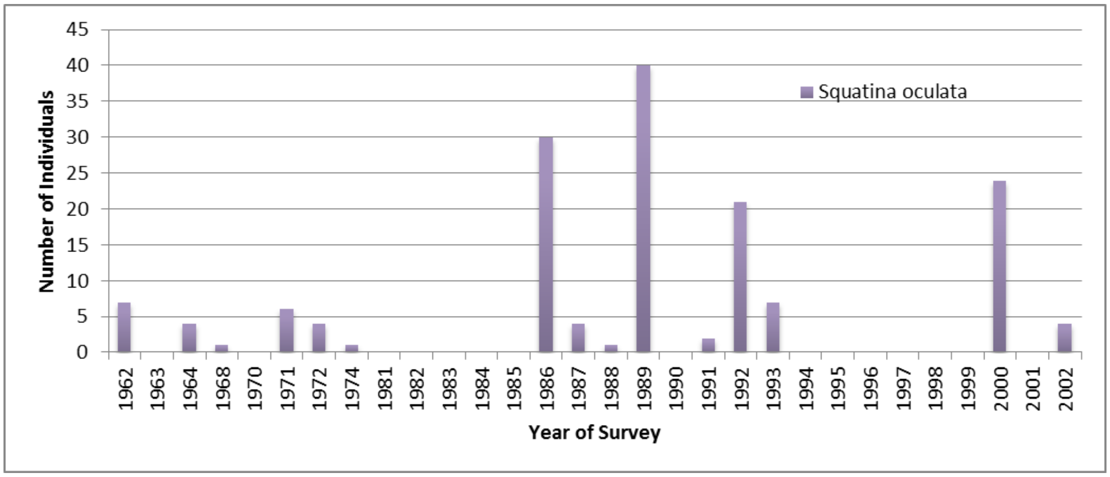

Figure 14. Number of *Squatina oculata* individuals observed in trawl surveys conducted off the coast of West Africa from 1962 to 2002. (Source: SIAP project database)

Historical versus Current Range

Based on the above information regarding current distribution and abundance, it is difficult to draw conclusions regarding the species present distribution and abundance. While the species appears to be rare and possibly extirpated in the Aegean Sea, Tyrrhenian Sea, off the Balearic Islands and in the Catalan Sea, the literature suggests it may also be relatively common in portions of the central Mediterranean and the Levantine Sea; however, these characterizations were made almost 10 years ago. In the eastern Atlantic, the available data indicate the species may have been common off the west coast of Africa back in the 1970s and 1980s, but according to fishermen, are now rarely seen (with the last observation of the species dating back to 2002).

S. squatina

Northeastern Atlantic

Throughout most of the northeastern Atlantic, *S. squatina* was historically relatively common. As Day (1880) reported, the species was common within the North Sea and English Channel, especially along the southern coasts of Kent, Sussex, and Hampshire. It was also frequently observed in the Firth of Clyde after gales (Day 1880). Hureau and Monod (1973) noted its occurrence from the western and southern North Sea, and in Scandinavian waters in the Skagerrak and Kattegat. The authors characterized the species as common over 40 years ago, except in the most northern and eastern parts of its range. Pethon (1979) also documented the presence of the species in waters off Norway (first record in 1929; second record in 1979), describing the species as rare in Scandinavian waters but common in the southern part of the North Sea and around the British Isles. However, comparisons of historical and current catch and survey data on *S. squatina* suggest significant declines in abundance of the species throughout its range in the northeastern Atlantic, with possible extirpations of the species from the western English Channel (near Plymouth), North Sea, and Baltic Sea (although adult *S. squatina* were always considered to be rare in these waters; HELCOM 2013) (Morey *et al*. 2006; OSPAR Commission 2010; McHugh *et al.* 2011; ICES 2014).

Within the western English Channel, near Plymouth, UK, historical trawl surveys were conducted between 1913 and 1922 in Cawsand Bay and Whitsand Bay (Figure 15) in depths less than 20 m (McHugh *et al*. 2011). A total of 23 trawls were made in Cawsand Bay, conducted in various months, with a mean trawl duration ranging from 18 to 60 minutes. In Whitsand Bay, a total of 24 trawls were conducted, also in various months, with a mean trawl duration ranging from 25 to 77 minutes. Based on results from the surveys, CPUE (number of individuals ≥ 15 cm TL per hour) of *S. squatina* in Cawsand Bay was estimated to be 3.07 and in Whitsand Bay 1.61. When the Whitsand Bay waters were surveyed again between 2008 and 2009 (Cawsand Bay was not re-sampled), using similar methods as the historical surveys and over various months (with a total of 36 trawls and a mean trawl duration of 20 minutes), the species was absent. In fact, 1969-1972 research vessel logbooks provide the last reported capture of the species from these waters (McHugh *et al.* 2011).

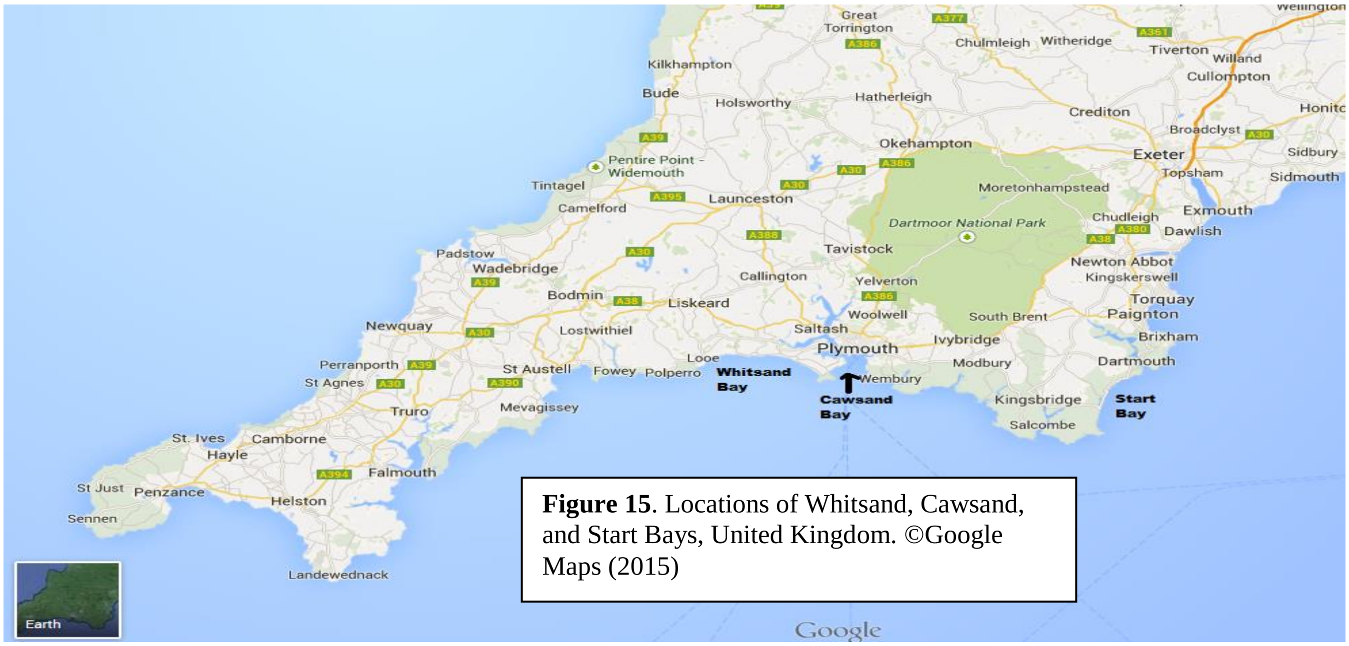

Figure 15. Locations of Whitsand, Cawsand, and Start Bays, United Kingdom. ©Google Maps (2015)

Comparison of anecdotal information and trawl data from historical and more recent surveys in Start Bay (Devon) also suggest a decline and potential extirpation of the species from these waters. For example, in the autumn of 1879, Day (1880) reported encountering 26 *S. squatina* sharks that had been pulled in by seine net from Start Bay onto the shores of Teignmouth (Devon, UK). From August 1901 to October 1902, exploratory trawl surveys were conducted in these waters on a monthly basis. Over the course of the 14 months, 111 hauls were made with a total tow duration of 208 hours. *Squatina squatina* comprised 2% of the demersal species in the trawl catch, with an estimate of 0.8 sharks caught per hour over the course of the study period (Rogers and Ellis 2000). However, when these waters were surveyed again from 1989 to 1997, no angelsharks were present in the hauls (Rogers and Ellis 2000). Given the Day (1880) observation and CPUE from the historical survey, as well as the McHugh *et al.* (2011) data from the nearby Whitsand Bay, it seems likely that the absence of the species in recent trawl surveys indicates low and/or patchy abundance, or potential extirpation, in these waters.

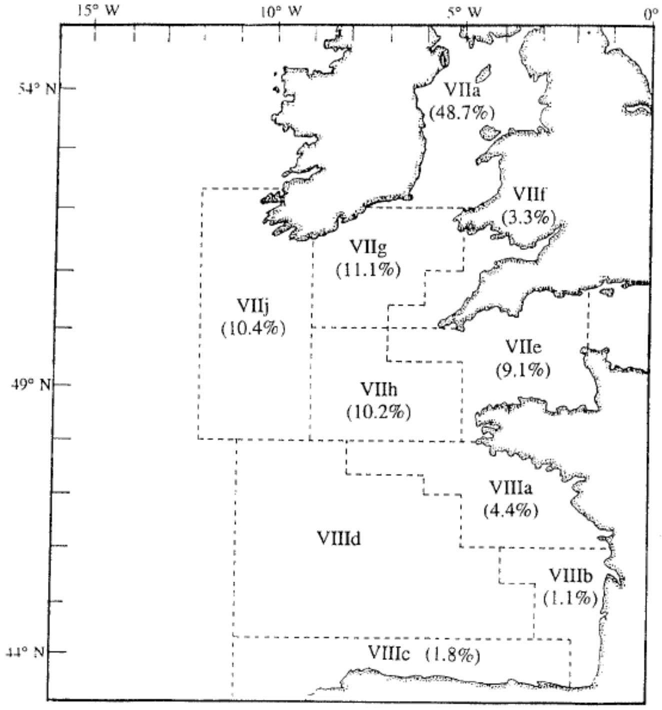

Figure 16. Map showing the ICES areas where groundfish surveys were conducted between 1981 and 1983. The number of trawls conducted in a certain area is given as the percentage of the total number of trawls

Similarly, in other areas of the northeastern Atlantic, survey data on *S. squatina* catch suggest very low abundance. Ellis *et al.* (1996) analyzed data from 550 bottom trawls conducted throughout the northeastern Atlantic (with survey focus in the Irish Sea; Figure 16) between 1981 and 1983 and found only 19 *S. squatina* sharks, comprising 0.6% of the total elasmobranch catch.

Analysis of more extensive bottom-trawl survey datasets, covering the period of 1967-2002 and with sampling in the North Sea (1967-1990; 2001-2002), Celtic Sea (1982-2002), Eastern English Channel (1989-2002), Irish Sea (1988-2001), and Western English Channel (1990-2001), failed to record any *S. squatina* (Ellis *et al.* 2004). However, in 2009, one *S. squatina* was captured in Cardigan Bay during a UK beam trawl survey, four sharks were collected off Pembrokeshire (Wales) near the entrance to St. George's Channel (two in 2007 and two in 2010), and recent (2015) reports on social media networks of *S. squatina* catches provide some evidence of the contemporary presence of the species in the Irish Sea and nearby waters (Figure 7; ICES 2013; ICES 2014; J. Barker pers. comm. 2015).

Comparisons of historical and more recent landings data from the northeastern Atlantic also provide some insight into the abundance trends of the species within this region. For example, in the mid-19th century, *S. squatina* was commonly fished off the western coast of France, in Arcachon Bay and the Bay of Biscay, with landings from Arcachon totaling around 25,000 kg per year (Laporte 1853 cited by Quéro and Cendrero 1996 and Quéro 1998). In contrast, annual landings from this area from 1985 – 1994 were below 600 kg per year and appear to have declined (Figure 17). In 1996, only 291 kg of the species were caught in Arcachon Bay and the Bay of Biscay (Quéro 1998). Although fishing effort and gears have changed over the past century, the significant decrease in annual landings from historical estimates may indicate a decline in the relative abundance of the species in these waters, especially considering the species' susceptibility to overexploitation due to its life history traits (e.g., low fecundity, long gestation time) and accessibility to fishermen as an inshore, shallow water species.

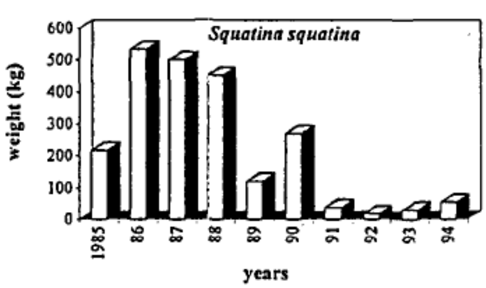

Figure 17. Landings (kg) of S. squatina at Arcachon, France from 1985 to 1994. (Source Quéro 1998)

In Irish waters, historical records (dating back to 1772), suggest the species was rare off northern and eastern Ireland but regularly observed off the southern and western coasts (Dr. Declan Quigley, Sea Fisheries Protection Authority, personal communication 2015). For the angelshark population found off the west coast of Ireland, the only area where data are available, their decline appears to have occurred much more recently than in the Irish Sea, English Channel, and Bay of Biscay. In fact, in the1960s, *S. squatina* were regularly caught in large numbers in Tralee Bay (County Kerry) by recreational anglers competing in fishing tournaments. Data from a marine sport fish tagging program in Ireland also suggests the species was rather common in these waters, with 320 angelsharks caught, tagged, and released in Tralee and Clew Bays (Ireland) from 1987-1991. However, by the late 1990s, data from angler catches and the tagging program indicate that abundance started to decline. Specifically, annual numbers of *S. squatina* (weighing > 22.68kg) caught by rod and line gear significantly decreased when compared to the previous 50 years, and from 1997-2001, only 16 angelsharks were caught by the tagging program, despite no change in tagging effort (Figure 18; Quigley 2006; ICES 2014). Since 2006, only one individual has been caught and tagged (with the fish tagged by commercial fishermen in 2011; ICES 2014). The species is now extremely rare off the west coast of Ireland, with no reported recaptures of tagged sharks since 2004. Using the tagging program data (Figure 18), the International Council for the Exploration of the Sea (ICES) (2014) provided results from an exploratory state-space stock assessment model of the Tralee Bay population that was presented in Bal *et al.* (2014). These preliminary results show that the population of *S. squatina* in the bay is, as expected, extremely small (Figure 19), yet ICES (2014) cautions that the actual population size is uncertain, with further work and additional data required to produce more reliable models and estimates. In October 2013, an angler reported catching (and releasing) an angelshark in Tralee Bay, confirming that the species still exists in these waters.

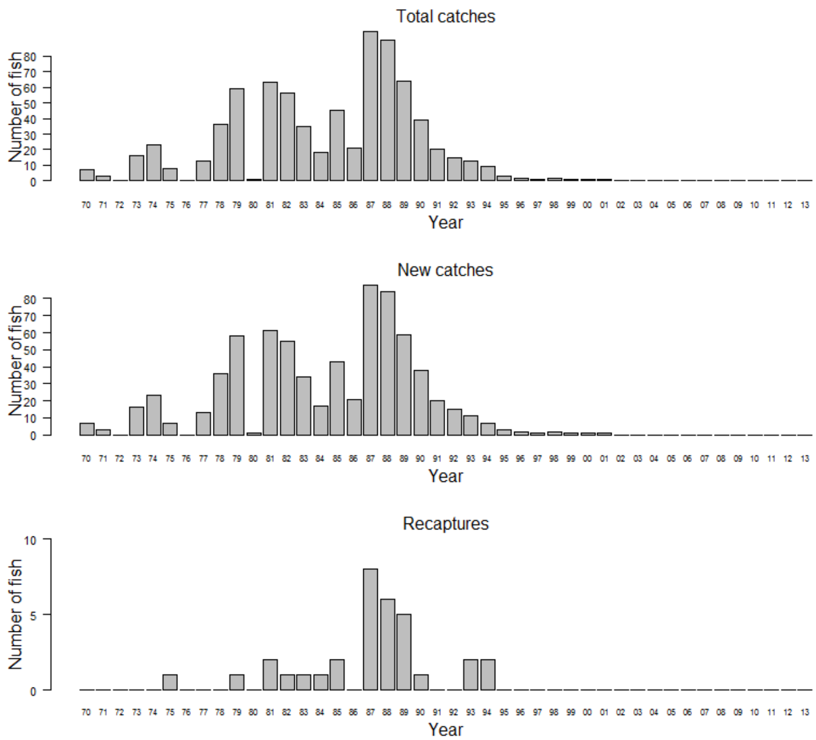

Figure 18. Number of *S. squatina* caught and recaptured in Tralee Bay: a) total number of sharks caught by year (includes newly caught and recaptured sharks); b) new captures of *S. squatina* by year; and c) recaptures of tagged *S. squatina* by year. (Source: ICES 2014)

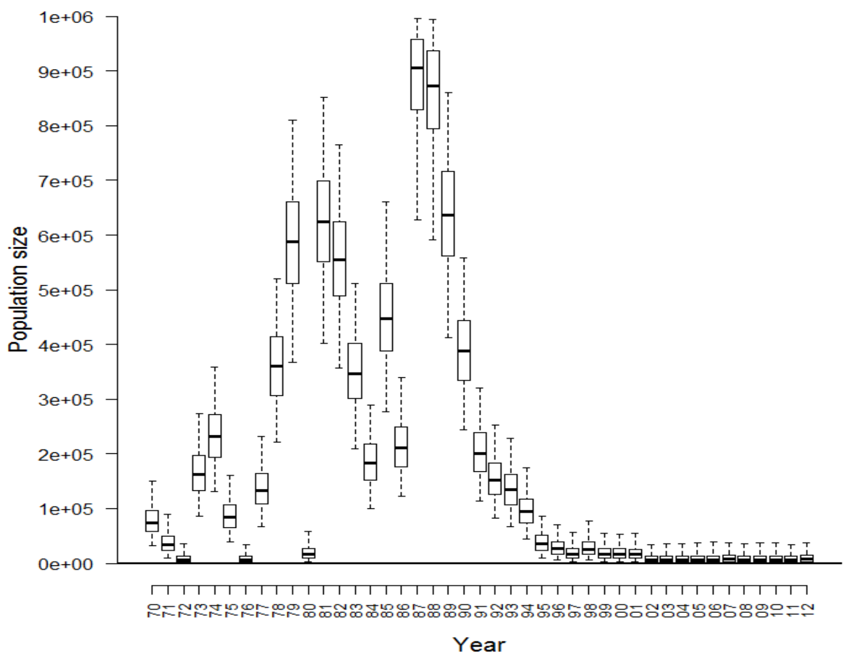

Figure 19. Boxplots of the annual population sizes posteriors for *S. squatina* in Tralee Bay (Source: ICES 2014).

<u>Mediterranean Sea</u>

Similar to the trend in the northeastern Atlantic, *S. squatina* populations have declined throughout the Mediterranean Sea, with possible local extirpations in the Black Sea, Catalan Sea, and Tyrrhenian Sea (Jukic-Peladic *et al.* 2001; Ferretti *et al.* 2005; Morey *et al.* 2006; OSPAR Commission 2010; Maynou *et al.* 2011; Ferretti *et al.* 2013). In the central Mediterranean, *S. squatina* was commonly recorded in historical faunistic lists (Giusto and Ragonese 2014). The species was reported in the Gulf of Naples in historical records dating back to 1871 through at least 1956 (Tortonese 1956; Psomadakis *et al.* 2009). In the Northern Adriatic Sea, Fortibuoni *et al.* (2016) report the species as common in the nineteenth and early twentieth centuries, with sizes ranging from 150-200cm based on naturalists' accounts and historical documents. However, by the 1960s, the species had essentially collapsed, with its absence noted from 3,685 scientific trawl tows, 4,347 logbook trawl tows, and 444 gill net samples conducted between 1948 and 2014 in the Northern Adriatic Sea (Fortibuoni *et al.* 2016). Despite the notable absence in the fisheries data, surveys of fishermen indicate that the species may still be present in the Adriatic Sea (with sightings as recently as 2013), but the population is likely highly fragmented and significantly depleted (Fortibuoni *et al.* 2016).

Ferretti *et al.* (2005) noted the disappearance of the entire *Squatina* genus from the northern Tyrrhenian Sea in the early 1970s. Similarly, Maynou *et al.* (2011) interviewed 45 retired fishermen in 2009, with ages ranging from 49-98, who started fishing in the small scale and trawl fisheries in the Ligurian and Tyrrhenian Seas between 1922 and 1982. The fishermen indicated that angelsharks had disappeared from waters off the western Italian coast by the early 1980s and from waters off Sardinia by the mid-1980s (Maynou *et al.* 2011).

Trawl surveys conducted from 1995-1999 in the Strait of Sicily recorded *S. squatina* near Cape Bon, Tunisia with a biomass that comprised only 1% of the total elasmobranch catch (Scacco *et* *al.* 2002). Ragonese *et al.* (2013) confirmed the rarity of this species, reporting only one captured individual from their analysis of survey data from 1994 to 2009. The fish was caught at a depth of 128 m in 2005, close to the Maltese Islands. More recently, in 2011, an artisanal fishing vessel caught an *S. squatina* shark in a trammel net set at 85 m depth, 11 nautical miles off the coast of Mazara del Vallo (Giusto and Ragonese 2014). The authors expressed concern regarding the recovery capability of the species, noting that despite the extensive and continuous survey monitoring programs covering this region (i.e., GRUND and MEDITS; see **Overutilization for Commercial, Recreational, Scientific, or Educational Purposes** section for more information), this is the first documented occurrence of *S. squatina* in over 30 years (Giusto and Ragonese 2014).

In contrast, Bradai *et al.* (2006) reported that the species was "regularly observed" in the Gulf of Gabès; however, I have no information on the present abundance of the species in this area. In 2005, UNEP reported the species as being relatively common in Libyan waters, but provided no corresponding citation or data to support this statement or further information regarding abundance in the Mediterranean Sea (UNEP-MAP RAC/SPA 2005). Furthermore, in 2016, Dr. Ramadan, head of the Marine Biology Branch at Omar Al-Mukhtar University in Libya, remarked that the three angelsharks are not common in the catches of Libyan fishermen (Dr. Ramadan pers. comm. 2016), suggesting abundance of the species may have declined in the past 10 years.

In 2008, three *S. squatina* individuals were recorded in Egypt from commercial landings in western Alexandrian waters (Moftah 2011). According to Kabasakal and Kabasakal (2014), *S. squatina* is rare but present off the coasts of Turkey. In previous surveys conducted and cited by the authors, Kabasakal and Kabasakal (2014) report that *S. squatina* comprised 1.1% of the total number of elasmobranchs (n=4632) caught in Turkish seas between 1995 and 1999, and 0.46% of the total shark catches (n=1068) between 1995 and 2004 in the northern Aegean Sea. In their updated checklist of marine fishes of Turkey, Bilecenoğlu *et al.* (2014) record *S. squatina* as occurring in the Black Sea (although the reference dates back to 1999), Sea of Marmara, Aegean Sea, and Levantine Sea. Kabasakal and Kabasakal (2014) also confirmed the presence of *S. squatina* in the Sea of Marmara but remark on its rarity in these waters. In the Levantine Sea, Bulguroğlu *et al.* (2014) reported the capture of an *S. squatina* individual in 2013 by a commercial trawl vessel from a depth of 50 m in Antalya Bay (southern Turkey), In 2015, an individual was caught in Gokova Bay near Akyaka (Turkey) by a local fisherman (Gelbalder 2015). Hadjichristophorou (2006) characterized the species as occasionally occurring in Cyprus fishery records, and Saad *et al.* (2006) captured the species along the Syrian coast during longline, trawl, and beach seine surveys conducted from 2001-2004 (see Figure 10 for sampling coverage). Additionally, Soldo (2006) notes the presence of the species in the Adriatic Sea but the information used to support this assertion is unclear as the species has not been reported in survey data from these waters since 1958 (Ferretti *et al.* 2013).

<u>Eastern Atlantic</u>

Presently, the only part of its range where *S. squatina* is still relatively common is in the Canary Islands (Muñoz-Chapuli 1985; OSPAR Commission 2010). Within the Canary Islands, *S. squatina* has been reported in fisheries catch from the islands of El Hierro, La Palma, Tenerife, Gran Canaria, Fuerteventura and Lanzarote (Brava de Laguna and Escánez 1975, cited by

Narváez 2012). However, much of the information on *S. squatina* presence and abundance from this area comes from diver observational data. In 2013, the Zoological Society of London (ZSL), Universidad de Las Palmas de Gran Canaria (ULPGC) and Zoological Research Museum Alexander König (ZFMK) created the "Angel Shark Project" (ASP) with the overall goal of securing the future of the angelshark in Europe. The first phase of the ASP was to raise awareness of the importance of the Canary Islands for angelshark conservation and to gather public sighting data of angelsharks through the creation of a citizen science sighting scheme called Poseidon (J. Barker, pers. comm. 2014). [The Canarian Government REDPromar also created a sightings portal in 2013, Red de Observadores del Medio Marino en Canarias (*http://www.redpromar.com/*), and officially declared it as a network of marine observers in the Canary Islands in a June 2015 Resolution (ElasmoCan pers. comm. 2016).**]**

Since the launch of the Poseidon portal in April 2014, there have been 624 validated records (sightings of angelsharks) (Meyers *et al.* 2014; Meyers pers. comm. 2015; also see reported sightings on the ASP website, available at http://angelsharkproject.com/). Currently, 22 dive centers are actively reporting angelsharks (J. Barker, pers. comm. 2014); however, the "Davy Jones Diving" dive center, in Gran Canaria, has collected data on angelshark sightings in the "El Cabron" or Arinaga Marine Reserve since 2006 (prior to creation of the sightings portals). Narváez *et al.* (2008) analyzed these dive data for the period of May 2006 through August 2008 and found that 271 angelsharks were sighted over the course of 1,709 dives. The sex of the shark could only be determined in 41% of the sightings, with an overall sex distribution of 1: 1.6 (female: male). In addition, 9% of the sightings were determined to be juveniles. The sightings of angelsharks peaked when water temperature dropped below 21°C, with around 72% of the sightings occurring in temperatures between 19 ˚C and 21˚C, and were highest in January 2007 and February 2008 (Narváez 2012). The sighting depth oscillated between 3m and 29m, with 82% of sightings occurring in relatively shallow waters, between 5m and 15m in depth and less than 50 m from the coastline (Narváez 2012). Narváez (2012) also analysed and described the population structure and habitat use of angelsharks through visual census conducted between July 2006 and June 2008 in the locations of Sardina del Norte and Caleta (Gran Canaria Island). In Sardina del Norte, 219 individuals were observed in 226 sightings, and 152 individuals were observed in 169 sightings in Caleta. Five individuals were re-sighted in Sardina del Norte and 13 in Caleta (Narváez 2012).

The Davy Jones Diving dive center continues to publish elasmobranch species sightings on its web (available at: *http://www.davyjonesdiving.com/diving/p50-diving-conditions-log.shtml*). Using more recent data from the center, Narváez *et al.* (2014) analyzed a 6-year data set (2006-2013, excluding 2011) for elasmobranch sightings in the area of El Cabrón (Gran Canaria). The authors found that *S. squatina* was the only observed shark species and the most frequently observed elasmobranch out of 9 species, comprising 43.5% of the total elasmobranch sightings. Similar to the findings from Narváez (2012), trends in the sighting probability of *S. squatina* show a clear seasonal pattern, with a low probability of sightings (2%) in the summer until mid-autumn (in water temperatures above 22˚C) and maximum average probability (of 27.5%) in temperatures between 18˚ to 21˚C (Narváez *et al.* 2014). Analysis of the log data from January 1, 2011 through December 29, 2014 shows that angelsharks are still frequently observed in the Arinaga Marine Reserve, with sightings recorded on 35% of the dive trips off Gran Canaria over the past 3 years (n = 1,253 total trips).

Elsewhere in the Eastern Atlantic, current distribution and abundance data is lacking. Based on information provided by the Sierra Leone Ministry of Fisheries and Marine Resources, industrial fisheries and research survey data collected from 2008-2010 indicate the recent presence of the species off the coast of Sierra Leone (personal communication 2016). Prior to these findings, the range of the species in the Eastern Atlantic was thought to extend only as far south as Mauritania. It is unclear if these findings indicate a range expansion for the species, new migratory routes, a reflection of the true range of the species that was previously unknown due poor sampling of the region, or, perhaps more likely, misidentification of the species as the species has yet to be identified from any other countries south of Mauritania. Regardless, in terms of distribution and abundance, the Sierra Leone Ministry of Fisheries and Marine Resources notes that *Squatina* species are sparsely distributed and seldom caught within Sierra Leone waters (pers. comm. 2016).

Historical versus Current Range

Based on the above information regarding present distribution and abundance, it appears that the species' historical range has been significantly curtailed, with evidence of potential extirpations in the North Sea, western English Channel, Baltic Sea, Catalan Sea, Tyrrhenian Sea, Black Sea, and portions of the Adriatic Sea based on data from spatially expansive surveys. Although once common, the species is presently rare throughout the rest of its historical range, with the exception of the Canary Islands.

ANALYSIS OF THE ESA SECTION 4(A)(1) FACTORS

The ESA requires NMFS to determine whether a species is endangered or threatened because of any of the factors specified in section 4(a)(1) of the ESA. The following provides information on each of these five factors as they relate to the status of these three angelshark species. Since the ranges and life history of these three species overlap, many of the threat issues overlap as well and are discussed generally for the three species. When species-specific information is available, it is noted within the discussion.

Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

As mentioned previously, there has been a curtailment of the historical range of *S. squatina*, with evidence of local extirpations in many parts of the range where the species used to be present and, in some cases, rather common. This includes areas within the North Sea (OSPAR Commission 2010; ICES 2013), the Baltic Sea (OSPAR Commission 2010), western English Channel (Rogers and Ellis 2000; Dulvy *et al.* 2003), Tyrrhenian Sea (Ferretti *et al.* 2005; EVOMED 2011; Maynou *et al.* 2011), Black Sea (OSPAR Commission 2010), and potentially the Catalan Sea (Maynou *et al.* 2011) and portions of the Adriatic Sea (Jukic-Peladic *et al.* 2001; Dulvy *et al.* 2003). A curtailment of historical range is much less evident for the other two species, where data are severely limited. The IUCN Red List reviews of *S. aculeata* and *S. oculata* suggest these two species are now rare or even absent from most of the northern Mediterranean coastline (Morey *et al.* 2007a, b). Many historical records simply document the presence of these species in certain locations, with no corresponding information on abundance or distribution. Only a few references provided subjective descriptions of historical abundance, and only from select areas (i.e., Balearic Islands, Catalan Sea, Gulf of Gabès, Libya, Israel, and Senegal; see **Distribution and Historical and Current Abundance** section). However, based on the absence of the species in relatively recent and repeated surveys in areas where they were once historically documented, it is possible that both species may have experienced a curtailment of their historical range. For *S. aculeata*, the available information suggests it may no longer be found in the Adriatic Sea or central Aegean Sea (where the species was likely historically rare), and is also missing from the Tyrrhenian Sea (where it was part of commercial landings in the 1970s), and off the Balearic Islands and in the Catalan Sea (where angelsharks were historically common). For *S. oculata*, the species may no longer be found in the Aegean Sea, Tyrrhenian Sea, off the Balearic Islands and in the Catalan Sea, where its historical abundance in these areas mirrors that of *S. aculeata*.

The significant demersal trawling that occurred and continues to occur throughout the range of the *Squatina* species (Sacchi 2008; FAO 2013) has likely altered seafloor morphology (Puig *et al.* 2012), but I found no information that this habitat modification has had a direct effect on the abundance of these three species, or is specifically responsible for the curtailment of range of any of the *Squatina* species.

In 2012, there was concern regarding the *S. squatina* habitat around the Canary Islands as the Spanish government had approved a deep-water oil exploration project off the coasts of

Fuerteventura and Lanzarote (Navío 2013). However, based on the 2014 exploratory drilling in the region, Repsol (the Spanish oil company in charge of the project) determined that the area "lacked the necessary volume and quality [of methane and hexane gases] to consider future extraction" and abandoned drilling off the Canary Islands in January 2015 (Bjork 2015).

I also investigated the predicted impacts to angelshark habitat from climate change to evaluate whether this may be a threat that could increase the species' risks of extinction. In 2013, Jones *et al.* published a study that specifically projected distribution shifts of *S. squatina* and a number of other species in the North Sea under "high" emissions climate change scenarios, representative of a "heterogenous world with a continuously increasing global population and regionally oriented economic development" (see SRES A2 scenario in IPCC 2000; Jones *et al.* 2013). Using a number of environmental oceanographic variables for predicting distribution (including bathymetry, sea surface temperature, sea bottom temperature, salinity, sea ice concentration, primary productivity, and distance to coast) the authors ran three species distribution models to predict shifts in range, change in range area, and change in habitat suitability based on climate change impacts through 2050. Results from the models indicate that *S. squatina* in the North Sea will not likely be significantly impacted by climate change. Although the species is predicted to have a northward shift in its distribution (median projected change of 200 km northwards; Figure 20) and relatively small reduction in overall range, it was also projected to have an average increase in habitat suitability (Figure 21) across protected areas (i.e., Dogger Bank) and a decrease in overlap with commercially exploited species (assuming *S. squatina* can re-establish itself in the North Sea). Therefore, it appears that any negative impacts from a range shift due to climate change will potentially be offset by the increase in availability of protected habitat areas for the species and decrease in bycatch occurrence during commercial fishery operations. Although there are many uncertainties associated with these modeling efforts, including the species' dispersal ability and biological and physiological responses to climate change impacts, at this time the best available information does not suggest that climate change contributes significantly to the extinction risk of the species.

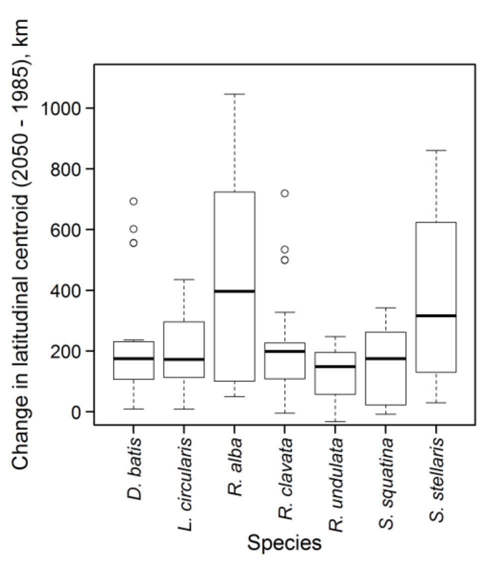

Figure 20. Predicted change in latitudinal centroid distribution (km) by 2050 relative to 1985 for 7 species in the North Sea. The box whiskers represent the extreme data points within 1.5 times the inter-quartile range from the lower and upper quartiles. Circles represent data points outside of these extremes (Source: Jones *et al.* 2013).

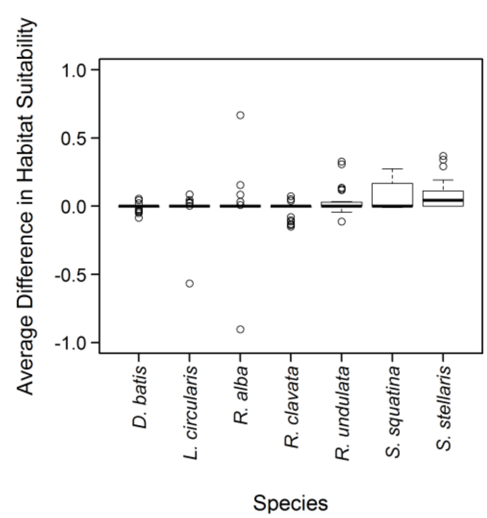

Figure 21. Predicted change in relative habitat suitability between 1985 and 2050 for 7 species in the North Sea. The box whiskers represent the extreme data points within 1.5 times the inter-quartile range from the lower and upper quartiles. Circles represent data points outside of these extremes (Source: Jones *et al.* 2013).

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The ESA contains no guidance on how to assess overutilization. For the purposes of this status review, evidence of overutilization as a threat to the species was analyzed using available historical and current catch and survey data, trends, fishing effort information, and anecdotal reports.

Historical overutilization

Although there are no abundance estimates for any of the *Squatina* species, historical records and anecdotal reports indicate that they were regularly caught within certain areas of their respective ranges. For example, *S. squatina* (which was historically called "monkfish" before anglerfish entered the market) was commonly recorded on the southern and eastern English coasts, western and southern coasts of Ireland, within the North Sea, on the Dogger Bank, in the Bristol Channel, in the Firth of Clyde, and in the Mediterranean Sea during the 19th and early 20th centuries (Day 1880; Ferretti *et al.* 2005; Morey *et al.* 2006; D. Quigley, pers. comm. 2015). In Italy and Croatia, historical fishing gear called "squaenara" or "squadrara" (in Italian) and "sklatara" (in Croatian) were purposely built to catch angelsharks (EVOMED 2011; Fortibuoni *et al.* 2016), suggesting a level of abundance that would warrant specialized gear and targeting of the species. In fact, along the Adriatic coast of the Austro-Hungarian empire, "squaenera" fishing gear was widely used at the end of the nineteenth century, and was the second most common fishing net set along the Austrian littoral (Fortibuoni *et al.* 2016). Similarly, in French waters, angelsharks were so common that Arcachon fishermen would use a special net designed specifically for catching them. These fishermen, who fished on the continental shelf in the southern Bay of Biscay, would rope the tails of the species with a string that was attached to a type of wooden buoy and bring the live shark back to shore, with annual catches of *S. squatina* totaling around 25,000 kg per year by the mid-19th century (Laporte 1853 cited by Quéro 1998). In 1905, data from the Venice fish market indicate that 15,760 kg of *S. squatina* were sold, and from 1919-1925, the annual average increased to 57,540 (±10,589) kg (Fortibuoni *et al.* 2016).This heavy exploitation continued for much of the 19th and early 20th centuries, with *S. squatina* marketed for its flesh (which was consumed or used for a variety of purposes, including: medicine, polish for wood and ivory, cover for hilts of swords, and sheaths for knives) (Edwards *et al.* 2001; Saad *et al.* 2006; ICES 2014; Vallejo and Gonzalez 2014; D. Quigley, pers. comm. 2015 citing Rutty (1772)), liver (for oil; ICES 2014), and carcass (for fishmeal; Shark Trust 2010). However, over the last 50 years, significant reductions in *S. squatina* have been observed, with the decline in abundance coinciding with the start of trawling activities in the northeast Atlantic and Mediterranean (Ferretti *et al.* 2005; Morey *et al.* 2006; Psomadakis *et al.* 2009; McHugh *et al.* 2011; Dell'Apa *et al.* 2012). Because angelsharks are sedentary, bottom-dwelling species, they are highly susceptible to being caught in demersal and trawl fisheries. Consequently, as the demersal fisheries expanded with the use of steam-powered trawlers in the 1890s, *S. squatina* began to experience significant population declines, with evidence of local extirpations in a number of areas (Barrull *et al.* 1999; Ferretti *et al.* 2005; Morey *et al.* 2006; Psomadakis *et al.* 2009; McHugh *et al.* 2011; Dell'Apa *et al.* 2012).

It is likely that *S. aculeata* and *S. oculata* were also negatively impacted by these demersal fisheries, given their similar behavior and overlapping ranges; however, information regarding their relative historical abundance and/or frequency throughout their respective ranges, which could provide insight into population trends and impacts of this utilization, is less certain. Instead, much of the historical information from Mediterranean waters is primarily in the form of presence/absence on shark inventory lists for different countries, with no corresponding information on abundance or frequency of occurrence. A few exceptions are the Rey (1928) inventory of Iberian fishes, which characterized *S. oculata* as “common” along the southern and eastern Iberian coasts, and the Quignard and Ben Othman (1978) inventory of Gulf of Gabès fishes, which reported *S. aculeata* as abundant in these waters and was further supported by Bradai *et al.* (2006) who “regularly observed” *S. aculeata* and *S. oculata* in the Gulf. More recently, Golani (2006) characterized the abundance of *S. oculata* as “prevalent” in Mediterranean waters off Israel and UNEP-MAP RAC/SPA (2005) noted both species as being “relatively common” in Libyan waters; however, in all cases, no further information on abundance, the rationale behind the characterization, or specific data were provided. In addition, these characterizations are almost 10 years old and may no longer accurately describe the abundance of these species. In fact. based on the recent comments from Dr. Ramadan (head of the Marine Biology Branch at Omar Al-Mukhtar University in Libya), these *Squatina* species are not common in the traditional Libyan fisheries catch, despite the use of fishing gear aimed at catching demersal fish species (pers. comm. 2016), with *S. squatina* previously documented as bycatch, particularly in fixed gillnets, back in 2000 (Lamboeuf *et al.* 2000). No recent updates on the status or presence of these species from the other areas mentioned above could be found. Therefore, although it is unclear if *S. oculata* and *S. aculeata* were ever truly common throughout their range in the Mediterranean, there is evidence that they were at least present (and perhaps abundant) at one point and may now be rare or absent based on recent observational and survey data. In the eastern Atlantic portion of their range, anecdotal reports and some survey data indicate that these species may have been quite common off the coast of West Africa in the 1970s and 1980s but now are rarely observed.

Examining the extent of coverage of the recent surveys and evaluating the potential impact of historical fishing effort can allow for reasonable conclusions to be drawn regarding the impact of utilization on these species. For example, for *S. aculeata*, Ferretti *et al.* (2005) concluded that this species has been extirpated from off the Tuscan coast since the early 1970s. This conclusion was based on the fact that the species was formerly present in commercial landings data (although of unknown magnitude) and absent in recent trawl surveys. The trawl surveys were extensive, covering the continental shelf and upper slope of the Tuscan coast, from 0 to 800 meters depth, with 88 tows conducted from 1972-1974 and 1,614 tows between 1985 and 2004 (Figure 22; Ferretti *et al.* 2005). In terms of historical fishing effort, the Tuscan fishery had been active for many years prior to the 20th century; however, it wasn’t until the beginning of the 20th century when fishermen began focusing on exploiting demersal resources (Ferretti *et al.* 2005). As technology advanced in the 1930s, the fishery improved, and by 1960, Ferretti *et al.* (2005) estimated that the fleet was exploiting approximately 90% of the Tuscan Archipelago (~ 13,000 km^2), with the majority of trawl effort concentrated in depths less than 400 m. Although it is unclear if *S. aculeata* was formerly abundant in this region (which could provide insight into the likelihood of the species in landings and survey data), given the history of the fishery, area of operation of the Tuscan fleets, and coverage of the recent trawl surveys, it is likely that historical overutilization of the species has occurred as a result of the expansion of the trawl fishery and has led to its possible extirpation from the region. The decline and subsequent extirpation is further corroborated by interviews with fishermen who used to participate in the small scale and trawl fisheries in the Ligurian and Tyrrhenian Seas. According to their personal observations, the *Squatina spp* were already reduced in numbers by the 1960s and 1970s (during the surge in fishing effort and capacity), with the last catches of the species from these seas remembered as occurring in the early 1980s (EVOMED 2011; Maynou *et al.* 2011). Fishermen that trawled off the Sardinian coast also noted the progressive decline in abundance of the *Squatina spp* during these years of fishery expansion, with the disappearance of the species from Sardinian waters occurring in the mid-1980s (EVOMED 2011; Maynou *et al.* 2011).

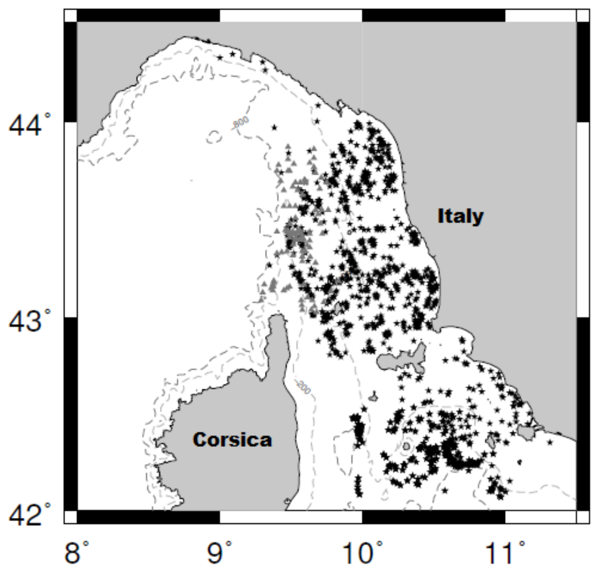

Figure 22. Map of the tows covering the continental shelf and upper slope of the Tuscan coast conducted from 1972-1974 and between 1985 and 2004 as depicted in Ferretti *et al.* (2005).

Similar conclusions can be made regarding the present status of the *Squatina* species off the Balearic Islands by comparing historical characterizations of these species and fishing effort to recent fishery-independent survey data. Historically, Morey *et al.* (2007a) suggested that *Squatina* species (presumably *S. aculeata* or *S. oculata* based on fishing depths) were commonly caught in the Balearic Islands, pointing to evidence of a special type of fishing net that was used for catching angelsharks in this area. These species were frequently caught in the coastal artisanal fisheries and also by the trawl and bottom longline fisheries until the 1970s, after which captures became more sporadic (Morey *et al.* 2007a). Morey et al (2007a) also reference records from a lobster gillnet fishery operating in the Balearic Islands that showed it was common to catch angelsharks on a daily basis until the mid-1980s. The timing of the observed depletion in the *Squatina* populations coincides with the fast growth in bottom trawling fishing effort in the Balearic Islands, where growth (estimated in terms of vessel engine power (HP)) exponentially increased from around 5,000 HP in the mid-1960s to over 20,000 HP by the early 1980s (Coll *et al.* 2014). The depths at which these trawlers fished also got progressively deeper over this time period due to increases in ship technology and gear. From 1940-1959, around 85 percent were trawling in shallow grounds of 40 – 150 m depths, and 15 percent in 40-800 m depths (EVOMED 2011). Between 1960-1979, more fishermen were exploiting deeper waters, with 44 percent strictly fishing in the shallow grounds, 30 percent fishing in depths of 40-800 m, and 17 percent in 200-800 m depths (EVOMED 2011). Although *S. aculeata* and *S. oculata* could have potentially used deeper waters as a refuge from fishing mortality during the 1940s and 1950s (as their depth distribution extends from 20-30 m to over 500 m), by the 1960s and 1970s, these deeper waters were no longer safe from exploitation. *Squatina squatina* likely experienced the highest level of fishing mortality as this species is found in much shallower depths, from 5 – 150 m, and therefore was accessible to the trawl fishermen during this entire time period. Since the mid-1990s, these species have not been recorded in fishery records (Morey *et al.* 2007a; EVOMED 2011), with Maynou *et al.* (2011) suggesting angelsharks were likely extirpated from the Catalan Sea prior to 1959. Further confirming this observation is the fact that the *Squatina* species are also notably absent in recent data from multiple fishery-independent studies that aimed to characterize the demersal elasmobranch assemblage off the Balearic Islands. These studies analyzed bottom trawl survey data collected from the continental shelf and slope of the Balearic Islands in depths of 41 m down to 1713 m, and covering the years of 1996, 1998, and 2001 (Massutí and Moranta 2003; Massutí and Reñones 2005). No *Squatina* species were recorded from the trawl hauls despite the overlap of the surveyed area with the observed depth range of the species. Therefore, given the historical fishing effort in this area, the timing of the observed declines in the angelshark populations, and the recent absence of the *Squatina* species from both fishery records and fishery-independent survey data, it seems reasonable to conclude that historical overutilization of these angelshark species has led to the observed extirpation of these species from this area.

Recent absence of the *Squatina* species has also been observed in survey data throughout many other areas of the northeast Atlantic and Mediterranean. For example, in the Italian Gruppo Nazionale Risorse Demersal (GRUND) surveys, which were demersal trawl surveys conducted in all Italian seas, Morey *et al.* (2007a,b) noted the absence of *S. aculeata* and *S. oculata* in the haul records covering the period of 1985 to 1998 (9,281 hauls over 22 surveys; citing Relini *et al.* 2001). More expansive surveys conducted along the Mediterranean coastline in 10 m to 800 m depths and covering waters from Alboran to the Aegean (part of the Mediterranean International Trawl Survey (MEDITS) program – see Figure 23 for MEDITS sampling coverage) also failed to find *S. oculata* and had very few observances of the other *Squatina* species (Baino *et al.* 2001). Out of the 6,336 tows conducted from 1995-1999, *S. aculeata* appeared in only one tow (from Aegean Sea) and *S. squatina* appeared in two (from western Mediterranean: defined as coasts of Morocco, Spain and France) (Baino *et al.* 2001). Similarly, the Mediterranean Large Elasmobranchs Monitoring (MEDLAM) program, which was designed to monitor the captures and sightings of large cartilaginous fishes occurring in the Mediterranean Sea, also has very few records of the *Squatina* species in their database. Since its inception in 1985, the program has collected around 1,866 records (including historical records) of more than 2,000 specimens from 20 participating countries. Figure 24 shows the locations of the reported 2,048 individuals, providing a depiction of the extent of coverage of this program. Out of the 2,048 elasmobranchs documented in the database through 2012, there are records identifying only 6 individuals of *S. oculata*, 4 of *S. squatina*, and 1 of *S. aculeata* [note: without access to the database, the dates of these observations are unknown].

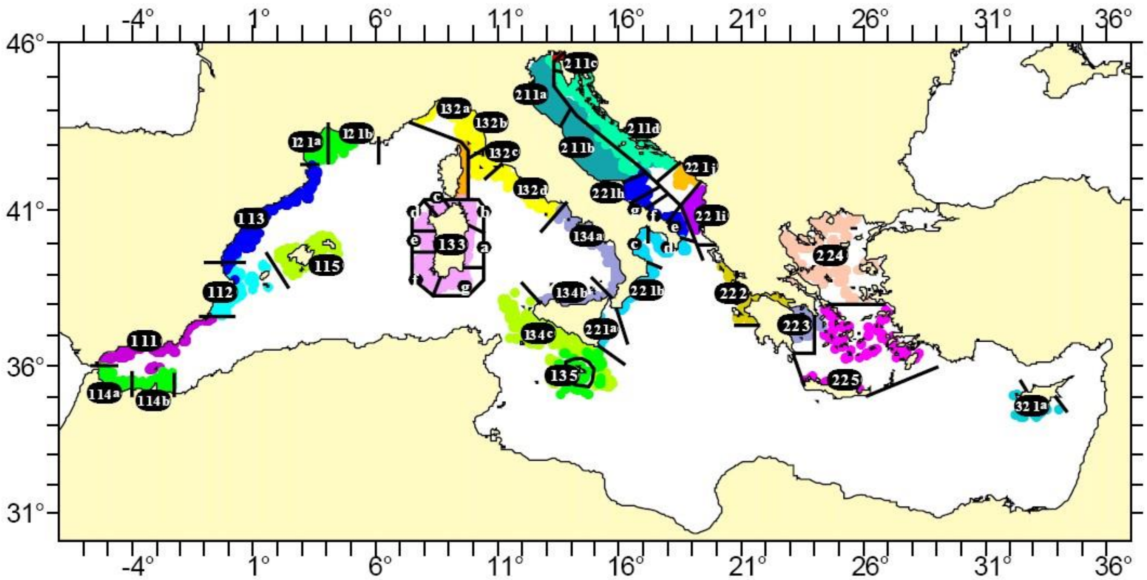

Figure 23. MEDITS survey coverage (sampling areas identified by various colors) (Source: © S.I.B.M. 2013-2014: www.sibm.it).

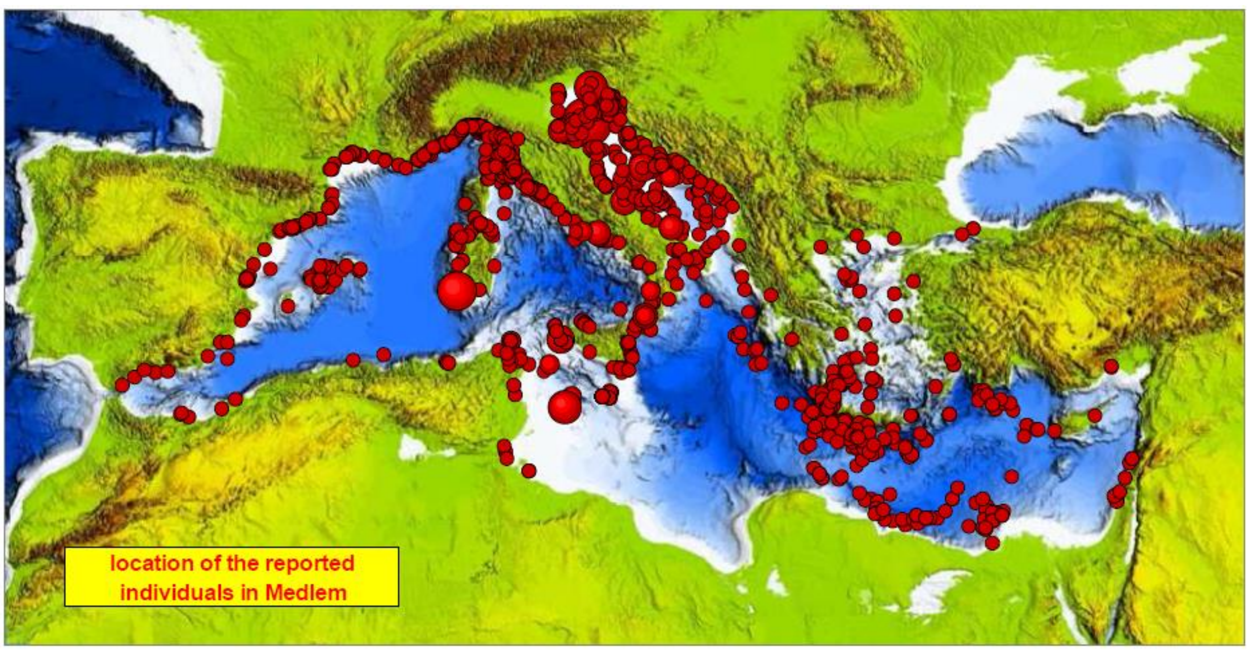

Figure 24. MEDLAM program reported locations of individual elasmobranchs. (Source: Baino *et al.* 2012)

These areas have also seen a shift in species composition and richness since the expansion of the trawl fisheries. Historically abundant larger elasmobranch species, including angelsharks, have seemingly been replaced by smaller, more opportunistic species, a strong indicator of overutilization of these larger elasmobranchs by commercial fisheries (Rogers and Ellis 2000; Damalas and Vassilopoulou 2011; McHugh *et al.* 2011). For instance, in the central Aegean Sea, a major fishing ground for the Greek bottom trawl fishery fleet, Damalas and Vassilopoulou

(2011) noted a significant decrease in chondrichthyan species richness along with a decline in their abundance from 1995 to 2006. Specifically, the authors analyzed data collected from 335 commercial bottom trawl hauls conducted in depths between 50 m and 339 m from 1995 to 2006 (2001-2002 was excluded) (Figure 25). A total of 217 species (141 bony fishes, 24 mollusks, 22 crustaceans, and 30 chondrichthyan species, including *S. aculeata* (n=3) and *S. oculata* (n=1)) were recorded from these hauls. However, in the last four years of the study (2003-2006), *S. aculeata* and *S. oculata* were absent from trawl catches, along with 9 other chondrichthyan species (over a third of the total). The authors estimated that species richness declined by an average of 0.66 species per year during the study period (with a more rapid decline exhibited from 1995-2000 compared to 2003-2006). They attributed the decline in part to the intense fishing pressure by the Greek bottom trawl fishery and the vulnerability of certain species, such as angelsharks, to exploitation (Damalas and Vassilopoulou 2011).

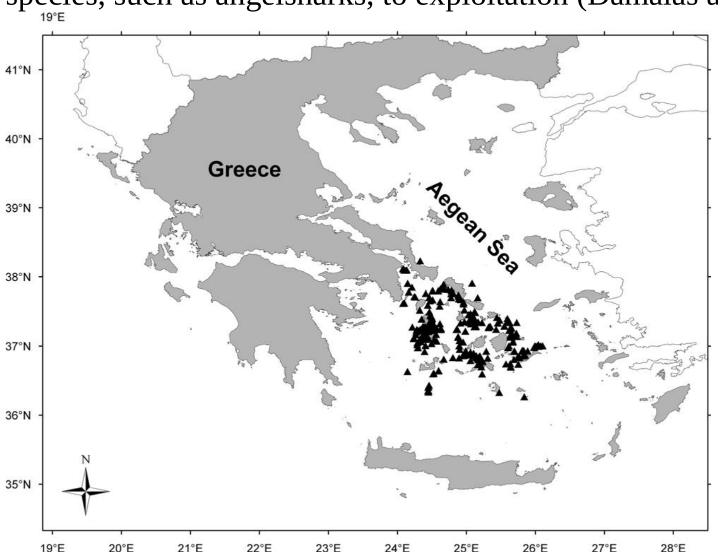

Figure 25. Map of the trawl sampling stations conducted from 1995 to 2006 as depicted in Damalas and Vassilopoulou (2011).

In the western English Channel, comparison of species assemblage in historical (1911 and 1922) and contemporary (2008 – 2009) inshore trawl surveys also showed a significant decline in elasmobranch size distribution and abundance (after removal of the now abundant lesser-spotted catshark, *S. canicula*, from the dataset) (McHugh *et al.* 2011). *S. squatina* was notably absent in the contemporary trawl data but had been present in the historical catch (McHugh *et al.* 2011).

In the Adriatic Sea, where a number of surveys covering the entire basin have been conducted since 1948 (Table 1), similar changes in species composition and richness have also been observed. These surveys, and resultant data, have allowed for examinations of the impact of historical exploitation on the Adriatic Sea demersal fish assemblage (Ungaro *et al.* 1998; Jukic-Peladic *et al.* 2001; Feretti *et al.* 2013).

Table 1. Summary of trawl surveys conducted in the Adriatic Sea since 1948 (Source: Ferretti *et al.* 2013).

Survey	Time range	Sampling design	Depth range	Tows	Stations	Species	Index of abundance
Hvar	1948–1949	ASBS	20–433.5	278	167	23	n/tow
Zupanovic	1957–1958	RA	29.5–104	126	10	17	n/tow
Jukic	1963–1971	Hvar stations	38–262	197	24	15	n/tow
GRUND	1994–1995	Transect SRS	13–421	307	75	13	n/hour
MEDITS	1994–2005	SRS	9.5–840	1667	144	27	n/tow

Using the Hvar and MEDITS surveys, Jukic-Pealdic *et al.* (2001) compared trawl catch from 1948 (Hvar survey) to catch in 1998 (MEDITS) (see Figure 26 for comparison of sampling points) and found a decrease in overall elasmobranch diversity and occurrence. Larger shark and ray species that were present in 1948, including *S. squatina*, were rare or, in the case of *S. squatina*, completely absent in 1998 (Jukic-Peladic *et al.* 2001). The authors attribute the extirpation of many species, including *S. squatina*, and the displacement of the larger elasmobranchs by smaller sized species to the overutilization of the Adriatic Sea demersal resources (Jukic-Peladic *et al.* 2001).

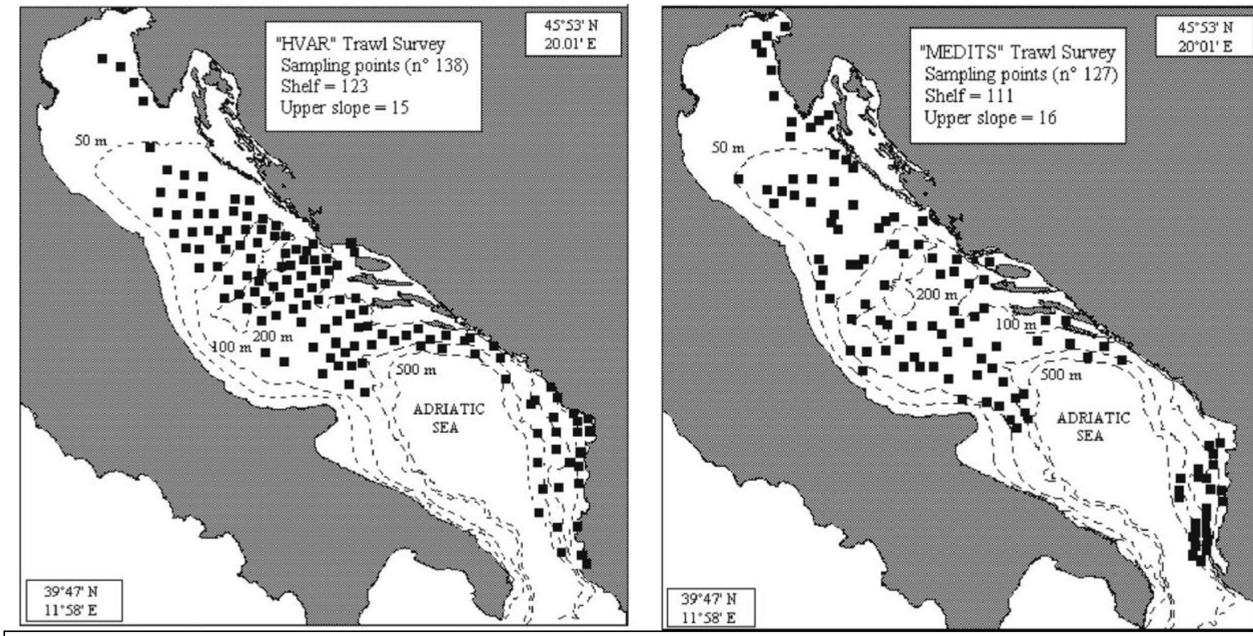

Figure 26. Trawl survey sampling points from the 1948 "HVAR" survey (on left) and 1998 MEDITS survey (on right). (Source: Jukic-Peladic *et al.* 2001)

A comparison of more recent bottom trawl survey data from the MEDITS surveys (from 1994-2005) to the Hvar survey data (1948-1949) indicate that the abundance of sharks in the Adriatic Sea has declined by 95.6% over the past 57 years (Figure 27; Ferretti *et al.* 2013). *Squatina squatina* was still absent from the more recent MEDITS survey data, with the last survey record of the species from the Zupanovic survey in 1958 (Ferretti *et al.* 2013).

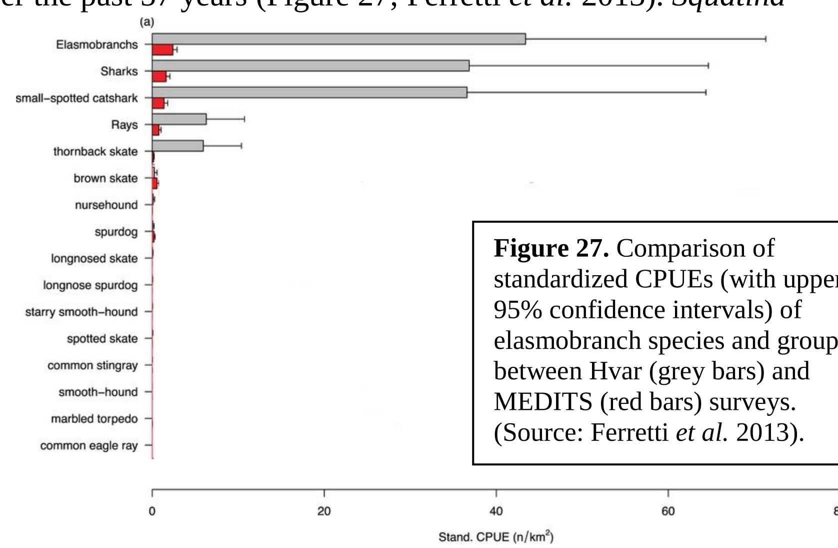

Figure 27. Comparison of standardized CPUEs (with upper 95% confidence intervals) of elasmobranch species and groups between Hvar (grey bars) and MEDITS (red bars) surveys. (Source: Ferretti *et al.* 2013).

The survey data (Table 1) also allow for comparisons to be made between basins within the Adriatic Sea because these basins have experienced differing levels of exploitation throughout the years. Historically, the western basin experienced much higher fishing pressure than the eastern basin, primarily due to the development and expansion of the high-capacity and efficient Italian fishing fleets beginning in the late 19th century. The eastern basin saw mainly subsistence fishing by former Yugoslavian fishing sectors prior to World War I, and, in general, experienced much less fishing pressure until recently (Ferretti *et al.* 2013). When basins were compared using the survey data (Table 1), the less exploited eastern basin had higher CPUE and species richness, which is what would be expected if fishing pressure were the main driver of species decline (Ferretti *et al.* 2013). In other words, the interbasin comparison data lend further support to the conclusion that historical overutilization of demersal fish has led to the decline in many shark species, including the *Squatina* species within the Adriatic Sea.

Additionally, surveys of fishermen who have operated in the northern Adriatic Sea over the past few decades also confirm the rarity of angelsharks, particularly *S. squatina*. Between December 2013 and September 2014, Fortibuoni *et al.* (2016) interviewed 52 fishermen (mostly between 50 and 60 years of age) from 12 harbors in the northern Adriatic (covering Italy, Slovenia, and Croatia) and found that 50% of them had never caught or even heard of the common angelshark. Of the ones that had caught the species at least once, 69% claimed that the species has since disappeared from the Northern Adriatic Sea. However, while recent sightings of the species by fishermen in 2013 indicate that it has not completely been extirpated from the Adriatic Sea, Fortibuoni *et al.* (2016) found a significant decline in the size of *S. squatina* individuals caught over time, providing further evidence of the overutilization of the species in this part of its range.

In addition to these survey data, analyses of commercial landings and market data also indicate that historical overutilization throughout the northeast Atlantic and Mediterranean has led to the general decline in the abundance of demersal shark and ray species. For example, in an analysis of Italian landings data, Dell'Apa *et al.* (2001) noted that elasmobranch landings were fairly steady until the 1970s, at which point they began to increase, reaching peaks in 1985 and 1994 and then sharply declining, which the authors attribute to overharvesting. Between 1983 and 1994, mean annual elasmobranch landings were 10,583 ± 2,599 t compared to 2,014 ± 1681 t between 1996 and 2004, a time period that also showed a consistent annual decrease in CPUE. Similarly, in the English Channel, landings of elasmobranchs have declined steadily since the 1950s, with an overall decrease in high trophic level species (such as gadoid fishes and elasmobranchs) and an increase in low trophic level species (such as invertebrates), indicative of unsustainable fisheries that are "fishing down marine food webs" (Molfese *et al.* 2014). For areas where landings of *Squatina* species have been recorded (down to species level), the data show a similar trend. For example, in the Celtic Sea, French landings of *S. squatina* appear to have declined after peaking in the 1970s, falling to less than 1 t per year by the late 1990s (Figure 28, ICES 2013). UK landings, however, were minimal, with 2 mt reported in 1989, and 1 mt in 1990 and 1991 (Figure 28). Data on corresponding fishing effort are unavailable.

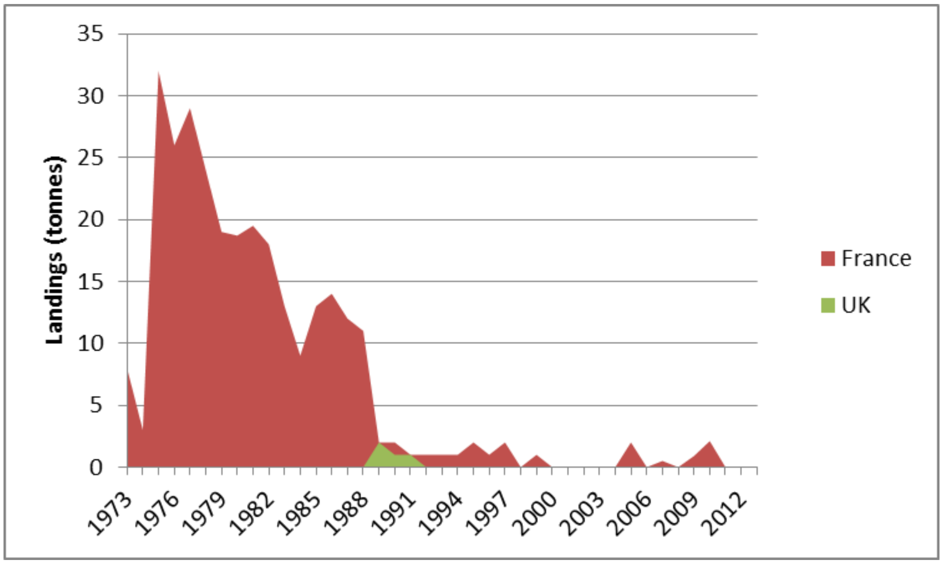

Figure 28. Total landings (tonnes) of *S. squatina* by French (FRA) and UK vessels from 1973 to 2013 in the Celtic Sea (Source: ICES 2014).

Similarly, in the Bay of Biscay and Iberian waters, where *S. squatina* was once common (see **Distribution and Historical and Current Abundance)**, landings of the species have substantially declined from the mid-19th century estimates of 25,000 kg per year. Only negligible amounts have been reported in the Bay of Biscay since 1996 (Table 2). In the Venice fish market, where an average of over 57,500 kg of *S. squatina* were sold on an annual basis in the 1920s, landings have declined significantly and have since never reached those peak levels (Fortibuoni *et al.* 2016). Specifically, official landing numbers show a decrease from 1,400 kg in the 1950s to less than 20 kg in the 1980s (Fortibuoni *et al.* 2016). Additionally, between 1986 and 2002, no angelshark was recorded sold in the market, with the last record dating back to 2005, when a 3.5 kg individual was sold (Fortibuoni *et al.* 2016). Aggregated landings data of the genus *Squatina* from the Portuguese fisheries statistics also show a decreasing trend over the last 20 years (personal communication from R. Coelho to Morey *et al.* (2006)); however, no information is known regarding the corresponding effort or other factors such as changes in retention/discarding practices (R. Coehlo, personal communication, 2014), which confounds interpretation of these trends.

Table 2. Landings (tonnes) of *S. squatina* by French and UK vessels from 1996 to 2012 in the Bay of Biscay and Iberian waters. (Source: ICES 2013).

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
France	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.1		0.1	0.1	0.04	0.02	0.9			
UK (E&W)																0.6	
Total	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.04	0.02	0.9	0	0.6	0

Off the west coast of Ireland, recreational fishermen observed a decline in rod-caught *S. squatina* beginning in the late 1990s. In fact, since 2006, only two individuals have been caught in these waters (one in 2006 and one in 2013 in Tralee Bay). The decline in this *S. squatina* population, to the point where the species is now extremely rare, has been attributed to both the historical recreational angling of the species as well as the operations of the commercial trammel net fishermen in this area (D. Quigley, pers. comm. 2015). In the1960s, *S. squatina* were regularly caught in Tralee Bay by recreational anglers competing in fishing tournaments. Pictures from some of these competitions, found online in the Kennelly Archive (http://www.kennellyarchive.com/), depict the extensive catch of *S. squatina* during these tournaments and highlight the especially large individuals that were caught (with all fish brought ashore). For example, pictures from a June 1964[2] sea angling competition show a "record catch," when 37 *S. squatina* were caught in less than 3 hours off the coast of Fenit Pier (Ireland). Another record catch was caught in June 1965[3] during a boat-angling competition in Tralee Bay, where four trophy *S. squatina* individuals, weighing 60, 59, 50, and 30 lbs (27.2, 26.8, 22.7, 13.6 kgs), respectively, were caught in addition to numerous smaller individuals. On May 28, 1967[4], the award for the "heaviest fish of the day" from the All-Ireland Open Boat Angling Championship was for a 60 lb (27.2 kg) angelshark with photos from this competition also depicting numerous caught fish, including *S. squatina* sharks. Given the life history characteristics of the species, this level of essentially unregulated utilization and removal of larger and, hence, probably mature individuals likely contributed to the observed decline in the *S. squatina* population from this area.

Although catch-and-release became increasingly more common practice in Ireland over the years (Fahy and Carroll 2009), decreasing the threat of overutilization by recreational anglers, a new threat emerged in the 1970s in the form of trammel net usage by commercial fishermen. Trammel nets, which are a type of gill net consisting of three layers of netting tied together on a common floatline and leadline, were introduced off the coast of Kerry (Ireland) in the early 1970s (Quigley and MacGabhann 2014). They were primarily used to catch crawfish (*Palinurus elephas*), but given the non-specificity of the fishing gear, these nets also by-caught spider crab (*Maja brachydactyla*), another commercially important species in the area, as well as many other elasmobranchs and non-target species (Quigley and MacGabhann 2014). The prevalent use of these nets led to significant decreases in crawfish landings (from 300 t in 1971 to 34 t in 2006) as well as startling declines in the bycatch species, with Fahy and Carroll (2009) characterizing the angelsharks as having been fished "almost to elimination" by the use of these trammel nets. Given the above information, it is likely that the historical overutilization by both recreational anglers as well as commercial fishermen led to the significant decline in the *S. squatina* population off the west coast of Ireland to the point where observations of the species are presently extremely rare (see **Distribution and Historical and Current Abundance**).

Farther south, in waters off West Africa, *S. oculata* and *S. aculeata* were commonly observed in the 1970s and 1980s. However, it was also during this time period that shark fishing in the region really started to expand and intensify (Diop and Dossa 2011). In a review of shark fishing in the Sub Regional Fisheries Commission (SRFC) member countries: Cape-Verde, Gambia, Guinea, Guinea-Bissau, Mauritania, Senegal, and Sierra Leone, Diop and Dossa (2011) state that the shark fisheries and trade in this region spread throughout the region in the 1980s and 1990s with the development of a market and increasing worldwide demand for shark fins. The number of boats and people entering the fishery, as well as improvements to fishing gear, steadily increased from 1994 to 2005, especially in the artisanal fishing sector where catches rose substantially. For example, before 1989, artisanal catch was less than 4,000 mt. However, from 1990 to 2005, fishing effort and catch increased dramatically, with catch estimates of over 26,000 mt by 2005 (Diop and Dossa 2011). Including bycatch estimates from the industrial fishing fleet increases this number to over 30,000 mt in 2005 (note that discards of shark

2 http://www.kennellyarchive.com/search-all/640161/
3 http://www.kennellyarchive.com/licence/NRB008/
4 http://www.kennellyarchive.com/id/FVC004/ ; http://www.kennellyarchive.com/id/EVP001/

carcasses at sea were not included in bycatch estimates, suggesting bycatch may be underestimated) (Diop and Dossa 2011). By 2008, shark landings had dropped by more than 50% to 12, 000 mt (Diop and Dossa 2011). Although landings were not identified to the species level, it is likely that this intense and relatively unregulated fishing pressure on sharks significantly contributed to the observed decline of the *Squatina* species in this region, to the point where these sharks are now only rarely observed.

Current exploitation

Overutilization of these angelshark species is still a threat as the shark, trawl, and other demersal fisheries that historically contributed to the *Squatina* species' declines remain active throughout their respective ranges. In fact, in the Mediterranean Sea, trawling still provides one of the highest economic returns in the fishery sector operating in these waters (Sacchi 2008; STECF 2013). In 2008, Sacchi reported a Mediterranean fleet of approximately 84,000 fishing entities, with around 10% using trawl gear and contributing more than half of the catch. By 2012, the fleet size had decreased to around 76,023 vessels, but had a total fishing capacity of 1,578,015 gross tonnage and 5,807,827 kilowatt power (European Commission 2014). In April 2015, the General Fisheries Commission for the Mediterranean (GFCM) identified 9,171 large fishing vessels (i.e., larger than 15 meters) as authorized to fish in the GFCM convention area (which includes Mediterranean waters and the Black Sea). Of these vessels, 46 percent identified as trawlers, although 28 percent did not report their class of fishing gear (GFCM 2015). The trawlers operate in depths of up to 800 m but normally conduct hauls in less than 300 m (Sacchi 2008), which overlaps with the depth range of the *Squatina* species. In addition, the trawlers tend to participate in multi-species fisheries, meaning they are not just targeting one species but rather catching hundreds of different species during operations.

Because of the low selectivity of the trawl gear and the intensity of fishing effort, a significant portion of the trawl catch tends to be discarded at sea (Sacchi 2008). For example, in Greece, the bottom trawl fishery provides around 20% of the total marine production; however, 45% of the catch is usually discarded at sea (Damalas and Vassilopoulou 2010). In a study that examined discard practices of trawlers operating in the Aegean and western Ionian Sea over the course of 3 years, it was estimated that around 44% of the total catch (13,500 – 22,000 t per year) was discarded (Machias *et al.* 2001). Damalas and Vassilopoulou (2011) note that chondrichthyans, especially, tend to be discarded at sea due to their low commercial value. Based on their observations of 335 commercial bottom trawl hauls in the Aegean Sea between 1995 and 2006, they calculated that over 90% of chondrichthyans (by number) were discarded. However, data are limited on the discard rates of *Squatina* species. In the Damalas and Vassilopoulou (2011) study, only 4 *Squatina* sharks were observed caught (3 *S. aculeata* and 1 *S. oculata*), with two individuals discarded. In the Machias *et al.* (2001) study, both *S. aculeata* and *S. oculata* were always discarded from the commercial trawl haul. Observer data from the French discard observer program from 2003-2013 recorded two discarded *S. squatina* individuals (both in 2012) (ICES 2014). Although there is some evidence that cartilage from *S. oculata* may be used in dietary supplements (Jo *et al.* 2005; Sim *et al.* 2007), most of the information I found suggest that *Squatina* species are generally bycaught (Edwards *et al.* 2001; Morey *et al.* 2007a, b; OSPAR Commission 2010; ICES 2014) and would more likely than not be discarded with the other chondrichthyan species. This is especially true for *S. squatina* which is currently prohibited from being retained in European Union (EU) waters (see **Inadequacy of existing regulatory**

measures). In fact, ICES (2014) reports that *S. squatina* is now only landed as a “curio” for fish stalls. As such, the impact of the continued operation of these demersal fleets on the threat of overutilization really depends on the survival rate of these *Squatina* species after being discarded.

At this time, the discard survival rate of the *Squatina* species is unknown; however, ICES (2014) assumes it to be high based on rates reported for the African angelshark (*S. africana*) (at-vessel mortality rate of 60% in prawn trawlers (Fennessy 1994) and 67% in protective shark gillnets (Shelmerdine and Cliff 2006)) and Australian angelshark (*S. australis*) (mortality rate estimates of 25% and 34% in gillnets (Reid and Krogh 1992; Braccini *et al.* 2012). These two angelsharks have similar life history traits to the *Squatina* species under review. Both sharks are found in warm temperate and tropical waters, occurring on the continental shelf and upper slope from inshore to depths of 256 m (*S. australis*) and 494 m (*S. Africana*), similar to the depth ranges of *S. aculeata, S. oculata, and S. squatina*. They bury themselves in mud and sandy bottoms and feed mainly on teleosts, cephalopods (*S. africana*; Shelmerddine and Cliff 2006), and crustaceans (Rowling *et al.* 2010). In addition, both angelsharks are ovoviviparous and similarly produce small litters (7-11 pups for *S. africana*; 10-13 pups for *S. australis*) (Compagno 1984; Rowling *et al.* 2010). Although *S. africana* is a smaller angelshark compared to the other four (with observed maximum sizes of 80 cm TL for males and 108 cm TL females; Compagno 1984), size at maturity for all five angelsharks are quite similar. *Squatina africana* males mature between 75-78 cm TL and females between 90-93 cm TL (Compagno 1984), and *S. australis* males mature between 80-90 cm TL and females between 90-100 cm TL (Rowling *et al.* 2010). Given these similarities, I do not find issue with inferring discard survival rates for the three *Squatina* species under review from those rates estimated for *S. africana* and *S. australis*. However, given the sensitive life history traits of the three *Squatina* species to exploitation, their present demographic risks, as well as the evidence of population declines and potential local extirpations to the point where all three species are rarely observed throughout their respective ranges, I would argue that an assumed 60% at-vessel mortality rate in trawl fisheries significantly contributes to the extinction risk of these species at this time, and is the primary factor presently contributing to the threat of overutilization of the species.

I would similarly argue that a 25 – 67% mortality rate in gillnets also significantly contributes to the threat of overutilization of the species, as many of the artisanal fisheries, and even some commercial fisheries, throughout the range of these *Squatina* species primarily employ the use of trammel and gillnets during fishing operations. For example, in a review of artisanal fisheries in the western-central Mediterranean (covering Morocco, Algeria, Tunisia, Libya, Italy, France, and Spain), Coppola (2001) found that the most important gear used in artisanal fisheries were gillnets and entangling nets (comprising 53% of the total gear utilized). In Turkey, the majority of fishermen work in the small-scale fishery (comprising around 83% of the total fleet; Turkish Institute). The small-scale fishery operations consist of daily trips, generally in the Aegean and Black Seas, to target fish species using gill nets, trammel nets, entangled nets, and demersal and pelagic longlines in 5-12 m long boats with 10-70 horsepower engines (Tokac et all. 2012). And, as mentioned previously, artisanal fishing effort is also significant off the west coast of Africa, with fishermen employing a variety of nets to capture species, with some nets that are even specially designed for catching shark species (Diop and Dossa 2011). Additionally, off the west coast of Ireland, there is evidence that commercial fishermen use trammel nets year-round in the inshore fisheries (Fahy and Carroll 2009). Therefore, given the level of artisanal fishing effort and use of fishing nets throughout the range of these *Squatina* species, particularly in areas where these species have been noted as historically or presently abundant, I conclude that the inferred estimates of mortality rates in nets indicates that discard mortality significantly contributes to the threat of overutilization of *S. aculeata*, *S. oculata*, and *S. squatina*. Additionally, for those fish that may survive after discard, the evidence that gravid females tend to abort embryos during capture and handling will contribute to reductions in reproductive capacity and likely translate to further declines in populations.

In addition to discard mortality, there is also evidence that these species are still being landed in certain parts of their ranges. In Egypt, for example, which has the 2nd largest fishing fleet (of vessels > 15 m) operating in the GFCM convention area, Moftah (2011) documented three *S. squatina* individuals for sale in a major fish market in western Alexandria. According to Bradai *et al.* (2012), the top elasmobranch fishing countries presently operating in the Mediterranean are Tunisia, Turkey, and Italy. From 1980 to 2008, these three countries were responsible for 76% of the total catch of elasmobranchs in the Mediterranean and Black Seas (Figure 29). Currently (as of April 2015), Italy has the largest fishing fleet (of vessels > 15m) operating in the GFCM convention area, with 84 percent of its vessels (n= 1,421) identified as trawlers. Turkey has the third largest fishing fleet, with 54 percent identified as trawlers, and Tunisia has the fifth largest, with around 50 percent of its vessels considered to be trawlers. Although Italian vessels are currently prohibited from landing *S. squatina* in EU waters (see **Inadequacy of existing regulatory measures**), Tunisia and Turkey do not have the same prohibitions for their respective waters. Additionally, there are no prohibitions from landing the other two species of angelsharks throughout their range.

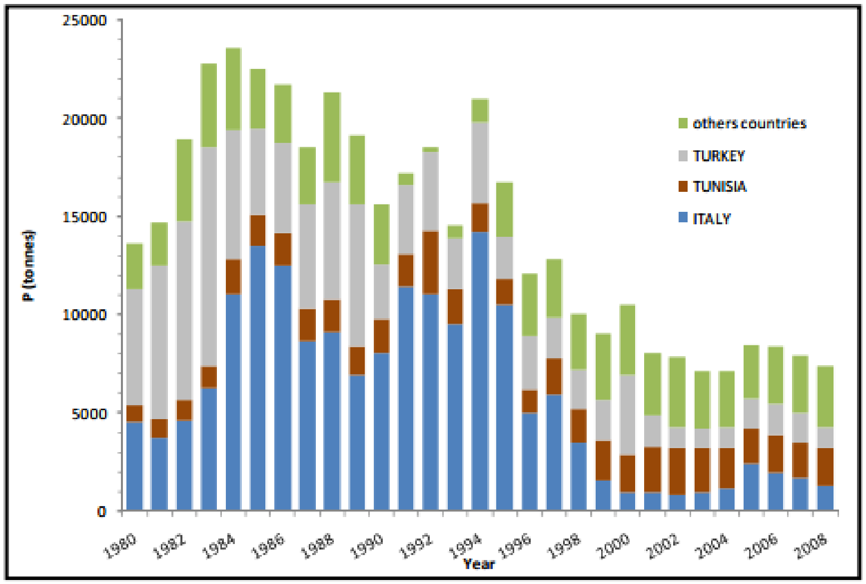

Figure 29. Elasmobranch catch (mt) in the Mediterranean and Black Sea, highlighting the contribution of Turkey, Tunisia, and Italy. (Source: Bradai *et al.* 2012)

In waters off Tunisia, the present level of fishing effort by trawlers as well as artisanal fishermen is a concern for any remaining populations of the three angelshark species. Tunisia is centrally located in the Mediterranean Sea, with a coastline of over 1,300 km long and 41 fishing ports (Haddad 2011). The Gulf of Gabès and Gulf of Tunis, which historically supported populations of the *Squatina* species (Capapé *et al.* 1990; Quignard and Ben Othman 1978), are two of the most important fishing grounds of the Tunisian coast (Echwikhi *et al.* 2013; Cherif *et al.* 2008). In 2011, the Tunisian fishing fleet consisted of 11,393 units, which included 10,500 coastal boats (artisanal fishermen), 430 trawlers, 400 sardine seiners, 38 tuna seiners, and 25 coral-fisher boats (Haddad 2011). Elasmobranchs, in particular, constitute an important catch component in Tunisian fisheries, especially artisanal fisheries (Echwikihi *et al.* 2013), and since 1970, annual catches of elasmobranchs have steadily increased (Figure 30). Recent catches of elasmobranchs average around 2,000 mt per year.

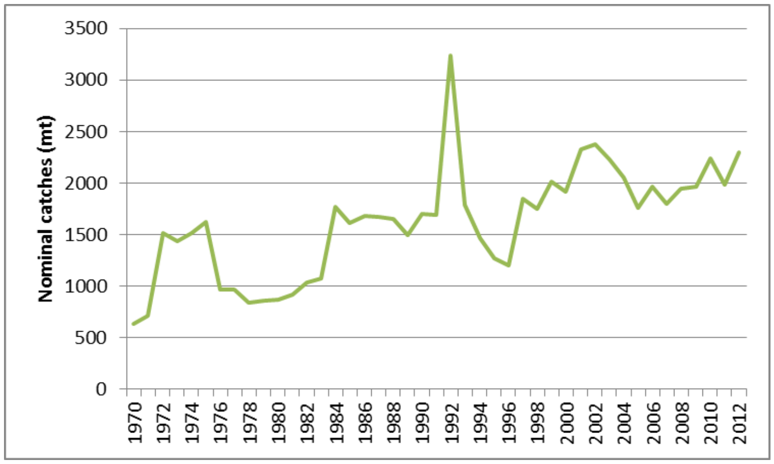

Figure 30. Nominal catches (mt) of elasmobranchs landed by Tunisia from 1970 to 2012. (Source: FAO Global Capture Production Database)

In terms of current species-specific information, I could only find data on *S. squatina* catches in these waters, which also appear to show an increase in recent years, with a peak of 86 mt in 2010 (Figure 31). Capapé *et al.* (1990) observed that *S. squatina* was fished throughout the year in Tunisian waters (in depths of 10 m – 50 m), and recorded a total of 61 males and 65 female angelsharks for sale in the fish market of Tunis (date of this observation was not given but assumed to be prior to 1990). Based on the recent catch data (Figure 31), it appears that *S. squatina* is still being exploited by Tunisian fisheries. It is unknown if this exploitation is sustainable; however, based on the species' life history traits as well as the observed decline of the species and potential extirpations in areas where reported catches and landings have been of lesser magnitude (e.g., Bay of Biscay;

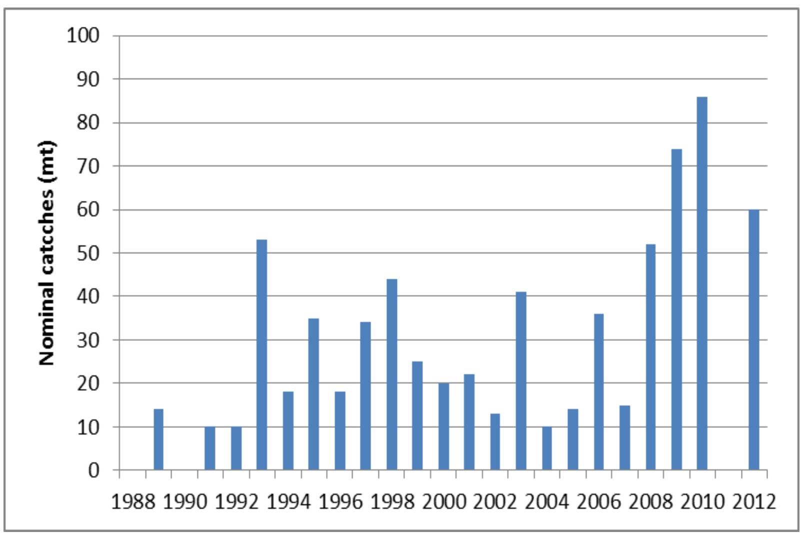

Figure 31. Nominal catches (mt) of *S. squatina* landed by Tunisia from 1988 to 2012. (Source: FAO Global Capture Production Database)

Celtic Seas; Figure 28), this present level of exploitation is likely to cause declines in the *S. squatina* population from this area through the foreseeable future.

The absence of data for the other two *Squatina* species is also telling, especially since in 1978, *S. aculeata* was noted as abundant, and as recently as 2006, both species were "regularly observed" in the Gulf of Gabès (Quignard and Ben Othman 1978; Bradai *et al.* 2006). Additionally, in 1990, the Gulf of Tunis was posited as a nursery ground for *S. oculata* based on young-of-the-year individuals captured during trawling operations (Capapé *et al.* 1990). The fact that observations of these species are now rare, with the most recent ones within the region occurring almost a decade ago (Bradai *et al.* 2006; Ragonese *et al.* 2013), suggests that the remaining populations of *S. aculeata* and *S. oculata* are likely small, potentially isolated, and at risk from stochastic and demographic fluctuations. These risks will only increase in the future as more individuals are removed from the populations as a result of the continued fishing pressure by trawlers and artisanal fishermen within this region.

Another area of the Mediterranean where present levels of exploitation of demersal resources are likely a threat to these species is in the Tyrrhenian Sea. According to Ferretti *et al.* (2005), 90% of the Tuscan Archipelago is currently being exploited by the Tuscan fleet. The fleet is approximately 700 boats; however, trawlers, which comprise 24% of the fleet, account for 65% of the total gross tonnage off the Tuscan coast. Feretti *et al.* (2005) also note that although the trawlers have the ability to fish further offshore (due to technological advances), they continue to focus their fishing effort in depths of less than 400 m. Although *Squatina* spp. have not been observed in this area since the early 1970s (Ferretti *et al.* 2005), the continued fishing pressure by these trawlers in depths where the *Squatina* spp. would commonly be found will likely prevent any potential re-establishment of these species to this area in the foreseeable future.

I also found information that suggested at least one angelshark species, *S. aculeata*, was a recent target of recreational fishermen in Turkey. Based on field survey data collected between January and September 2007, boat-based recreational fishermen operating in Çanakkale Strait caught an estimated 23,820 kg of *S. aculeata* (Ünal *et al.* 2010). The number of surveyed fishermen represented only 2.7% of the estimated recreational fishery population. In addition, the results from the surveys indicated that the marine recreational fishery in Turkey is essentially unmonitored and hence potentially unsustainable (Ünal *et al.* 2010). In fact, almost half of the recreational activity can be considered commercial activity as many of the recreational fishermen are selling their catches (even though marine recreationally caught fish are not legally allowed to be traded; Ünal *et al.* 2010). Given the high level of marine recreational harvest (around 30% of the commercial fishing harvest; Ünal *et al.* 2010), evidence of *S. aculeata* as a potentially targeted and traded species, and lack of monitoring or controls regarding fishing practices, this marine recreational fishery is a threat contributing to the direct overutilization of the species. In 2015, one of the co-authors of the above study noted that the species is presently rare in Turkish waters, but mentioned the recent capture of an *S. squatina* shark from Gökova Bay by a fisherman using a trammel net (V. Ünal, personal communication 2015).

In addition to the marine recreational fisheries, the commercial fisheries of Turkey are harvesting angelsharks; however, the information on catch is not species-specific. According to Turkey's "Fisheries Statistics" publication, 17 tonnes of angelsharks were harvested in 2013, with 68% of

Figure 32. Map showing the different regions associated with the commercial fishery harvest of Turkey. (Source: Turkish Statistical Institute 2014)

the catch coming from the Aegean region, 26% from the Mediterranean region, and 6% from the Marmara region (Figures 32 and 33).

Catches of angelsharks in Turkey declined over the past 8 years after a peak of 51 tonnes was reported in 2006 (Figure 33). Although there is no accompanying information on fishing effort, the bottom trawl fishery is highly active in Turkish waters. In fact, this fishery is responsible for around 90% of the total demersal fish catch from the Aegean Sea (Tokaç *et al.* 2012). As such, the decline in angelshark catch may likely be a result of decreasing abundance of these sharks in the region.

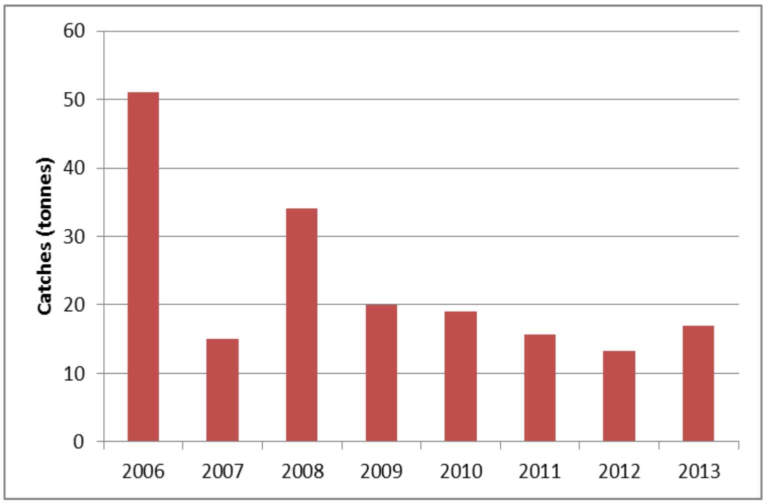

Figure 33. Catches (tonnes) of angelsharks in Turkey (Source: Fishery Statistics Publications; Turkish Statistical Institute; http://www.turkstat.gov.tr/)

In the northeastern Atlantic, in Irish waters, angling for *S. squatina* is now essentially prohibited (see **Inadequacy of Existing Regulatory Measures** section); however, the species is still at risk of being bycaught by commercial inshore fisheries. Despite the prohibition on trammel nets in certain areas off the Kerry and Galway coasts, these nets are still widely used and deployed year-round in the inshore fisheries (Fahy and Carroll 2009). Given that the use of trammel nets for crawfish fishing and associated level of angelshark bycatch historically contributed to the decline and present rarity of the *S. squatina* population in this area, the continued widespread use of these nets by commercial fishermen may lead to extirpation of the species from the area and can be considered a threat of overutilization that significantly contributes to the species' risk of extinction.

Additionally, in the northeastern Atlantic, Spanish and French fleets have reported landings of *S. squatina* to ICES since the species' retention prohibition by the EU in 2009 (see **Inadequacy of existing regulatory mechanisms**). In 2010, Spanish reported landings amounted to 9 tonnes (live weight), increased to 10 tonnes in 2011, and significantly increased to 63 tonnes in 2012. All of these landings occurred in FAO Fishing Area IXa, off the coast of Portugal and Spain (ICES 2014). The ICES (2014) notes that there are also nominal records of *S. squatina* in French national landings for 2012 and 2013 but does not report the figures due to the unreliability of the data. There was no corresponding information on fishing effort and, in addition, it is unclear why this EU prohibited species is still being landed by EU vessels.

Similarly, in the Canary Islands, where *S. squatina* retains its EU prohibited designation, individuals continue to be captured by local and sport fishermen. Couce-Montero *et al.* (2015) also report that angelsharks (*S. squatina*) are the main species caught, presumably as bycatch, by longlines and gillnet off Gran Canaria. Although *S. squatina* is not a targeted species in the Canary Islands, nor is there large demand for the species, fishermen in the area do eat angelsharks and may illegally land the species (E. Meyers, pers. comm. 2014). Additionally, in browsing websites of a number of sport fishing companies that operate in the Canary Islands, I found pictures of sport fishermen posing with hooked angelsharks[5] despite their prohibited status. There is evidence that angelsharks caught by sportfishermen are returned to the water after a photo has been taken; however, the post-release survival rates are unknown (J. Barker, pers. comm. 2015). This has become a concern in recent years due to the increasing number of sport fishermen in the area. According to Barker *et al.* (2014), from 2005 to 2010 there has been a nearly 3-fold increase in the number of recreational angler licenses (from 40,000 to 116,000), with over 830 registered charter fishing boats in operation. As the number of recreational anglers increases, so does the risk of hooking (and potentially killing) one of these prohibited sharks. Additionally, illegal fishing of the species by artisanal fishermen for personal consumption is also a concern in these waters (E. Meyers, pers. comm. 2014). In a broad-scale study of the impacts of artisanal, recreational and industrial fleets on the Gran Canaria marine ecosystem, Couce-Montero *et al.* (2015) found overall fishing pressure by these fleets to be high, similar to rates in the Gulf of Cádiz, and higher than rates in the Catalan Sea, Aegean Sea, and Adriatic Sea. Benthic sharks, as a functional group, were considered to be overexploited (Couce-Montero *et al.* 2015). Although *S. squatina* are assumed to be fairly common around the Canary Islands, the population may not be able to sustain this intensive rate of exploitation. Additional information regarding the Canary Island *S. squatina* population is needed, with research presently being conducted to examine the species distribution and habitat use throughout the Canary Islands (E. Meyers and J. Barker pers. comm. 2014; http://elasmocan.org/research/).

In waters off West Africa, artisanal fishing pressure on sharks remains high and relatively unregulated. In 2010, the number of artisanal fishing vessels that landed elasmobranchs in the SRFC zone was estimated to be around 2,500 vessels, with 1,300 of those specializing in catching sharks (Diop and Dossa 2011). Morey *et al.* (2007a, b) note that although there are no directed fisheries for *Squatina* species, it is taken as bycatch in the international industrial demersal trawl fisheries and artisanal fisheries. In a personal communication to Morey *et al.* (2007b), M. Ducrocq states *S. oculata* were common and frequently caught by artisanal Senegalese fishermen in line and gillnet gear around 30 years ago and Capapé *et al.* (2005) noted that *S. aculeata* was relatively abundant off the coast of Senegal and landed throughout the year. However, since 2005, fishermen have reported fewer observations of all squatinid species (C. Capapé, pers. comm. 2015),with no observed landings in recent years in the artisanal fishery (Mathieu Ducrocq, Programme Arc d'Emeraude, Agence Nationale des Parcs Nationaux, personal communication 2014). In Sierra Leone, recent data from an artisanal landing site in

5 http://www.marlincanariasportfishing.com/, http://www.bluemarlin3.com/photoalbums/boatrecords_thumbs.php?album_id=134, http://www.white-marlin.com/Angelshark_foto1693_photos_en, http://www.marlinfishingcanaria.com/gallery

Bonthe recorded the occurrence of *S. oculata* but information on its frequency at this site, or actual landing amounts, were unavailable (Sierra Leone Ministry of Fisheries and Marine Resources pers. comm. 2016). Presently, the *Squatina* species are described as sparsely distributed and seldom caught in Sierra Leone (Sierra Leone Ministry of Fisheries and Marine Resources pers. comm. 2016). Although evidently not as common anymore, the above information suggests that *S. oculata*, and *S. aculeata*, were and potentially still are susceptible to being caught in artisanal fishing gear throughout this region. Taking into account this susceptibility, as well as the fact that fishing for sharks occurs year-round in this region, and fishery management plans are still in the early implementation phase for this region (Diop and Dossa 2011), the continued operations of the artisanal fisheries may prevent any potential re-establishment of these *Squatina* species to this area (if already extirpated) or lead to further declines in existing local populations in the foreseeable future.

In addition, the significant amounts of illegal fishing in the waters off West Africa are also likely contributing to the observed declines of the species. Illegal fishing activities off West Africa are thought to account for around 37% of the region's catch, the highest regional estimate of illegal fishing worldwide (Agnew *et al.* 2009, EJF 2012). From January 2010 to July 2012, the UK-based non-governmental organization Environmental Justice Foundation (EJF) conducted a surveillance project in southern Sierra Leone to determine the extent of illegal fishing in waters off West Africa (EJF, 2012). The EJF staff received 252 reports of illegal fishing by industrial vessels in inshore areas, 90% of which were bottom trawlers (EJF 2012). The EJF (2012) surveillance also found these pirate industrial fishing vessels operating inside exclusion zones, using prohibited fishing gear, refusing to stop for patrols, attacking local fishers and destroying their gear, and fleeing to neighboring countries to avoid sanctions. Due to a lack of resources, many West African countries are unable to provide effective or, for that matter, any enforcement, with some countries even lacking basic monitoring systems.

In waters off Senegal, which may have historically supported larger populations of *S. aculeata* and *S. oculata* (see **Distribution and Historical and Current Abundance** section), fishery resources have been severely depleted both due to foreign and illegal fishing activities. According to Vidal (2012a), after Senegal cancelled its licensing agreement with the subsidized EU fleet in 2006, dozens of large (10,000-tonne factory ships) foreign trawling vessels were granted new licenses by the government and were reportedly catching hundreds of tonnes of fish a day (and up to 300,000 tonnes a year; Vidal 2012b) in Senegalese waters. Although these trawlers are prohibited from trawling within 12-miles of the coast, due to the lack of monitoring and policing capabilities, many move closer inshore at night to fish (Vidal 2012b). Quoting the manager of the largest fishing port in Senegal, Vidal (2012b) reports that fish catches have decreased 75% compared to 10 years ago. Based on the level of fishing activity, reported landings and trends, fishing gear, and area of operation, it is likely that these foreign and illegal trawling activities have significantly contributed to the observed decline of the *Squatina* species within these areas. Although many of the foreign vessel licenses were cancelled in 2012 (see **Inadequacy of Existing Regulatory Mechanisms** section), due to the lack of enforcement resources, illegal trawling is still considered to be a threat.

Disease or Predation

I found very little information to indicate that disease or predation is a threat to the *Squatina* species. Bulguroğlu *et al.* (2014) reported the first occurrence of a parasitic marine leech (*Stibarobdella moorei*) on *S. squatina* captured from Antalya Bay, Turkey. Narváez and Osaer (2016) also identified the parasitic marine leech (*Stibarobdella macrothela*) on *S. squatina* in the Canary Islands, and Osaer and Narváez (2015) found *Aegapheles deshaysiana* to be a common micropredator on *S. squatina,* also in the Canary Islands. Despite presence data, I could find no further information on rates of parasitism in the *Squatina* species or data to suggest they are affecting the abundance of angelsharks.

In an abstract by Narváez *et al.* (2006), there is reference to a sighting of a sea anemone (*Telmatactis cricoides*) preying upon a juvenile S. *squatina*, but the authors suggest that this was an incident of opportunistic feeding by the sea anemone rather than an indication that *S. squatina* is a common dietary item for the sea anemone.

Inadequacy of Existing Regulatory Mechanisms

In 2009, all three *Squatina* species were listed on Annex II of the Specially Protected Areas and Biological Diversity (SPA/BD) Protocol to the Barcelona Convention, "which requires Mediterranean countries to undertake maximum, cooperative efforts for their protection and recovery, including controlling or prohibiting their capture and sale, prohibiting damage to their habitat, and adopting measures for their conservation and recovery." In 2012, the GFCM adopted recommendation GFCM/36/2012/3, which prohibits those sharks on Annex II of the SPA/BD Protocol from being retained on board, transhipped, landed, transferred, stored, sold or displayed, or offered for sale by Contracting Parties and Cooperating non-contracting Parties (CPCs) of the GFCM. It also requires CPCs to release the species unharmed and alive. In 2012, Spain published Order AAA/75/2012 which announced the inclusion of the Mediterranean populations of these three angelshark species (*S. squatina, S. oculata, and S. acuelata*) on Spain's List of Wild Species under Special Protection. Species on the list are protected from capture, injury, trade, import and export, and require periodic evaluations of their conservation status. These regulations and retention prohibitions may decrease, to some extent, fisheries-related mortality of the *Squatina* species in the Mediterranean. However, for the most part, it appears that these *Squatina* species are normally discarded due to their low commercial value. Therefore, without further information on the survival rate of the species when bycaught by the trawl and demersal line fisheries throughout their range, it is unknown whether these regulatory mechanisms will decrease the *Squatina* species' risks of extinction.

Elsewhere, specific regulations prohibiting the capture or trade of these angelshark species, or other efforts to protect and recover these species, have only been applied to *S. squatina*.. For example, in 2009, *S. squatina* received full protection in EU waters from the European Council (Council Regulation (EC) 43/2009). It is prohibited for EU fishing vessels to fish for, retain, transship, or land *S. squatina* in EU waters (EU 2016/72). Similarly, in 2008, *S. squatina* was listed under Schedule 5, Section 9(1) of the UK Wildlife and Countryside Act (1981), which protects the species from being killed, injured or taken on land and up to 6 nautical miles from English coastal baselines. In 2011, these protections were extended out to 12 nautical miles and the species was also added under section 9(2) and 9(5), protecting it from being possessed or traded. In 2010 and 2012, ICES advised that *S. squatina* remain on its list of Prohibited Species and that any incidental bycatch be returned to the sea (ICES 2014).

In 2006, the Irish Specimen Fish Committee, which verifies and publicizes the capture of specimen (trophy) fish caught by Irish anglers using rod and reel methods, removed *S. squatina* from its list of eligible "specimen status" species due to concern over its status. Prior to this removal, if an angler caught an angelshark that exceeded 22.68 kg, the angler could send in a claim form and potentially receive a "specimen fish" award. This suspension from specimen status was in effect for three years. In 2009, the committee reviewed data on angler catches of angelsharks and found a decline in the number being caught and released, and decided to continue excluding *S. squatina* from specimen status until 2012. In 2013, the committee once again decided to keep the exclusion in place until the next review period in 2015. As long as this exclusion from the specimen status list is in place, it should provide some benefit to the local populations as it will decrease potential fisheries-related mortality of the larger (and likely mature individuals) that may occur during handling and processing of the fish to meet the claim requirements. However, these benefits may be minimal as claims for a new record (which is different from a specimen fish) are still considered, with the requirement that the fish be weighed on shore, photographed and returned alive. The current angling record is a 33 kg *S. squatina* caught in 1980 off Fenit, in County Kerry, Ireland.

In terms of commercial fishing, a major threat identified for the angelsharks in Irish waters was the overutilization (in the form of bycatch) of the species by commercial fishermen using trammel nets. In 2002, a regulation (SI – Statutory Instrument) was implemented prohibiting the use of trammel nets to catch crawfish in specific areas off the coasts of Kerry and Galway (SI No. 179). This regulation was renewed in 2006 (SI No. 233); however the use of trammel nets to catch other species is still allowed (Fahy and Carroll 2009), decreasing the level of protection that this prohibition affords angelsharks. In addition, enforcement of inshore fishery regulations is lacking, and, as a consequence, Fahy and Carroll (2009) note that trammel nets are set year-round in Brandon and Tralee Bays (south-west Ireland – areas once known for large *S. squatina* populations) with the majority of landed crawfish caught by this method. Due to the deficiencies in the legislation (Bord Iascaigh Mhara (BIM) 2012) and enforcement of the SI, commercial trammel net fishing in the inshore areas off western Ireland still poses a significant risk to any remaining *S. squatina* individuals, and, as such, this regulatory measure is inadequate in decreasing the threat of overutilization by commercial fisheries in this area.

In terms of controlling general fishing effort in the Mediterranean, the Common Fisheries Policy (CFP; the fisheries policy of the EU) requires Member States to achieve a sustainable balance between fishing capacity and fishing opportunities. However, due to criticisms that the CFP has failed to control the problem of fleet overcapacity (European Commission 2009; 2010) and consequently prevent further declines in fish stocks (Khalilian *et al.* 2010), it was reformed in 2014. It is too soon to tell if the new policies identified in the CFP, such as a complete "discard ban" and managing stocks according to maximum sustainable yield, will be adequate in controlling fishing effort by the European fishing fleet to the point where they no longer pose a threat to the remaining *Squatina* species populations.

In non-EU countries, regulations to protect these *Squatina* species from overutilization are lacking. As mentioned above, there are no species-specific management measures and current regulations are likely inadequate to prevent further declines in the three *Squatina* species. In Turkey, for example, there are very few landing quotas for species, due to a lack of stock assessments, even though evidence suggests that many of the species found in Turkish seas are presently overexploited (OECD 2003; Tokaç *et al.* 2012; Ulman *et al.* 2013). The number of registered fishing boats continues to increase, with previous attempts to control the fishing effort deemed unsuccessful. Based on an analysis of catch data, Ulman *et al.* (2013) note that the optimal fleet capacity has been exceeded by over 350% for all of Turkey's seas, suggesting that fishing effort and stocks will continue to decline. Although there are some seasonal prohbitions to protect spawning stocks in certain areas, minimum size regulations, and gear restrictions, including a bottom trawl ban in the Sea of Marmara, there is little enforcement of existing regulations, with current management measures and prohibitions likely insufficient to protect fish resources from further declines (OECD 2003; Ulman *et al.* 2013).

Off the coast of west Africa, fishing occurs year-round, including during shark breeding season (Diop and Dossa 2011). Many of the state-level management measures in this region lack standardization at the regional level (Diop and Dossa 2011), which weakens some of their effectiveness. For example, Sierra Leone and Guinea both require shark fishing licenses; however, these licenses are much cheaper in Sierra Leone, and, as a result, fishers from Guinea fish for sharks in Sierra Leone (Diop and Dossa 2011). Also, although many of these countries have recently adopted FAO recommended National Plans of Action – Sharks, their shark fishery management plans are still in the early implementation phase, and with few resources for monitoring and managing shark fisheries, the benefits to sharks, including *Squatina* species, from these regulatory mechanisms have yet to be realized (Diop and Dossa 2011). Additionally, many of these countries also lack the resources and capabilities to effectively enforce presently implemented fishing regulations, making this region a hotbed for illegal fishing activities (Agnew *et al.* 2009, EJF 2012). For example, although the Senegalese government took a significant step in controlling the exploitation of its fisheries when it cancelled the licenses of 29 foreign fishing trawlers in 2012, Senegal's director of Ministry of Fisheries and Maritime Affairs, Mr. Cheikh Sarr, recognizes that the country still lacks the enforcement resources and capabilities to combat illegal fishing activities. Mr. Sarr, quoted in Lazuta (2013), remarks: "Revoking these licenses has been helpful in the general sense . . . But the reality is, whether or not a boat is authorized to enter our waters, if they decide to engage in IUU [fishing], they will come . . . And often, we have very little power to stop them." [Note: These licenses were cancelled in response to the growing anger of artisanal fishermen at the level overfishing by these trawlers and the alleged corruption of the previous government's licensing system (Vidal 2012a). It is unclear if these licenses will remain cancelled in the future under different government regimes.] As such, the present regulatory mechanisms in this region, as well as means to enforce these mechanisms, appear inadequate to control the exploitation by illegal fishing vessels and thus pose a threat to the *Squatina* populations that may still be found in these waters.

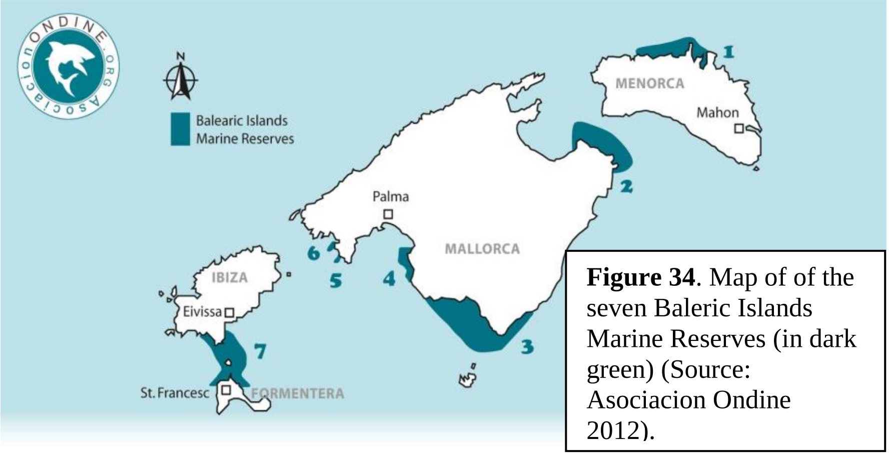

Figure 34. Map of of the seven Baleric Islands Marine Reserves (in dark green) (Source: Asociacion Ondine 2012).

In terms of habitat protection for the *Squatina* species, there are currently a number of marine reserves around the Balearic Islands with restrictions that range from the use of certain fishing gear in specific locations to complete "no-take" areas (Figure 34). Additionally, throughout the reserves, trawling, purse seining, longlining, collecting shellfish, coral fishing and catching certain fish and invertebrates, including *Squatina spp.*,is prohibited (Asociación Ondine 2012). Although *S. squatina* is thought to be extirpated from this area, *S. oculata* and *S. aculeata* may still occur (although there are no recent observations to verify this) and could benefit from these protections. However, given that these reserves cover only a very small portion of the species' ranges, it is likely that any benefit received (e.g., fewer fisheries-related mortalities) would be inadequate to significantly decrease the extinction risk of these species throughout their ranges.

There are also a few marine protected areas (MPAs) in Libyan and Turkish waters; however, the presence and distribution of the *Squatina* species within these MPAs is unknown. Additionally, according to Begun *et al.* (2012), the designation objectives as well as protection measures vary greatly by MPA in Turkey, and these areas still face threats of fishing and pollution. They also only cover around 6.57% of Turkey's territorial waters and, as such, would likely be inadequate to significantly decrease the extinction risk of the *Squatina* species (Begun *et al.* 2012).

In the Canary Islands, by Royal Decree 2200/1986, trawling was prohibited in 1986 within the territorial seas of the Canary Islands and Spanish EEZ, which was further reinforced by the 2005 EU prohibition of bottom trawling throughout the Canary Islands EEZ ((EC) No 1568/2005) in an effort to protect deep-water coral reefs from fishing activities. As demersal trawling is identified as a significant threat to *S.* s*quatina*, contributing to its past decline, this prohibition provides needed protection to *S. squatina* in an area where the species is still commonly observed.

There are also three marine reserves designated in the Canary Islands (Figure 35). These marine reserves, which provide protection from fishing activities, are relatively small, constituting only 0.15% of the EEZ around the islands. However, in 2009, 27 Special Areas of Conservation (SAC) for inclusion in the Natura 2000 network were established in the Canary Islands (Figure 36).

Figure 35. Location of the three marine reserves in the Canary Islands (Source: © Canary Fishing)

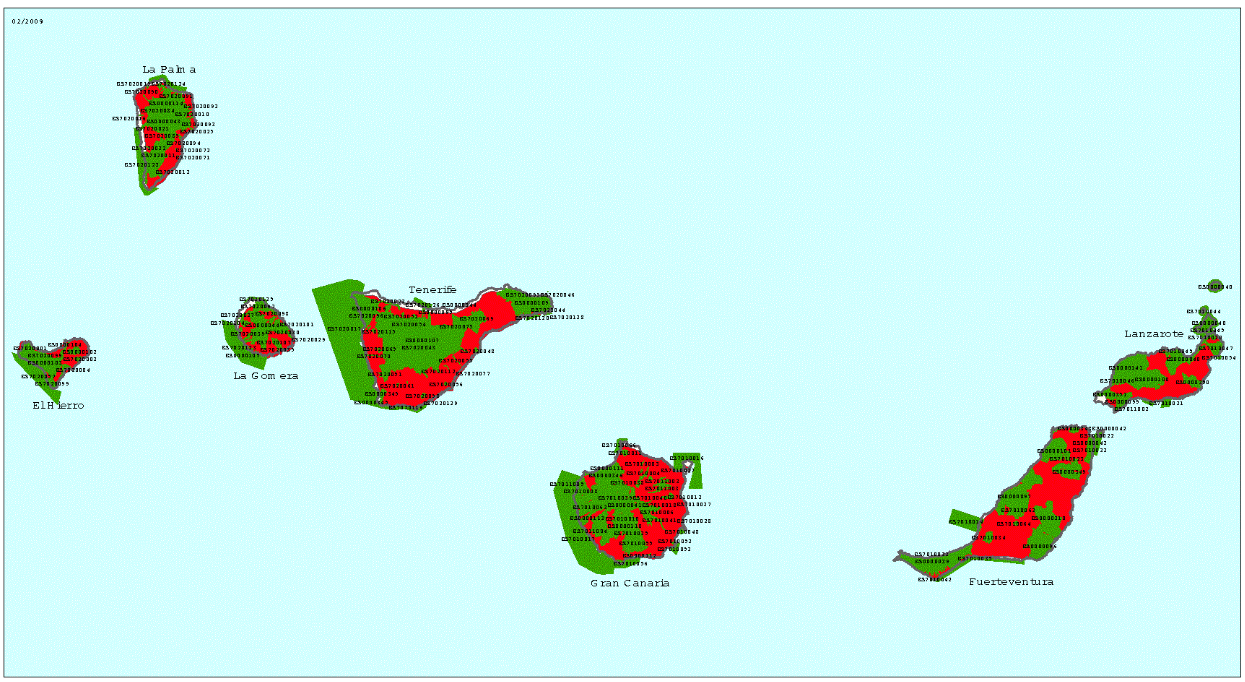

Figure 36. Location of the SACs in the Canary Islands (depicted in green). (Source: Natura 2000)

Natura 2000 is a European Union network of protected areas designated to conserve natural habitats and the animal and plant species within those habitats. It consists of SACs designated under EU's Habitats Directive and Special Protection Areas for Birds (SPAs) established under EU's Birds Directive. According to European Communities (2009), below are the obligations of EU Member States within Natura 2000 sites:

"Member states must ensure that:

- activities are avoided that could significantly disturb the species or deteriorate the

habitats for which the site is designated.
- positive measures are taken, where necessary, to maintain and restore the habitats and species to a 'favourable conservation state'

In addition, Natura 2000 sites should be protected from any new development projects or major changes in land-use that could seriously damage their nature values, unless these developments are of over-riding public interest and adequate compensation measures are taken. How these conditions are respected is for each Member State to decide. Nevertheless, all conservation measures must take into account the economic, social and cultural as well as regional and local characteristics of the sites in question."

To determine success, every six years the Member states must report to the European Commission on the conservation status of their respective species and habitats and the measures that they have implemented to help protect them (European Communities 2009).

The SACs in the Canary Islands cover around 3.6% of the EEZ. Because information on the specific distribution of *S. squatina* around the Canary Islands is currently unavailable, I was unable to determine whether and to what extent the designated SACs overlap with important *S. squatina* habitat. In addition, it is unclear how effective these SAC designations will be in decreasing threats to *S. squatina*. The only prohibited activities within these SACs are: dumping from a boat or platform into the sea, anchoring on seagrass, capturing or collecting protected species, feeding species, and harassing or harming cetaceans and sea turtles (Ministerio de Agricultura, Alimentación y Medio Ambiente 2014). I could not find any information on how or if these prohibitions are being enforced.

In addition, based on the main potential threats to the species in the Canary Islands, which include sport fishing practices and illegal fishing by artisanal fishermen for personal consumption (E. Meyers, pers. comm. 2015) , it does not appear that the current regulatory mechanisms in place are adequate to address these threats. In August 2014, due to the concern over sport fishing of prohibited shark species, the Canarian Government required that anyone obtaining a sport fishing license prominently display a poster of prohibited shark species (including *S. squatina*) on board their boat. Although this new requirement may help deter sport fishermen from keeping the sharks, it does nothing to address the stress of capture and lethal handling techniques used by these fishermen (e.g., gaffing and long periods out of water; ZSL 2014). Additionally, those boats that had a sport fishing license prior to August 2014 are not required to have or display this poster (E. Meyers, pers. comm. 2015).Thus, the species may continue to suffer mortality at the hands of sport fishermen. Similarly, I found no information to suggest that the current regulatory mechanisms will be adequate to curb the illegal fishing of the species by artisanal fishermen in the area. Although the species is protected in EU waters, the local Canarian government does not reinforce this law, nor is there legal prosecution of violators (E. Meyers, pers. comm. 2015).
In terms of habitat protection in the Canary Islands, I found no current regulatory mechanisms in place to protect the only identified nursery habitats for the species in the Canary Islands (Teresitas beach, Puerto del Carmen, and Bay of Sardina). However, a campaign has been initiated to promote the importance of Teresitas beach, the most popular beach in Tenerife, and educate beachgoers on the species (Alianza Tiburones Canarias 2014) and Asociacion Tonina, a

non-profit organization dedicated to the research of the marine environment and outreach, is working on a project to study the distribution and abundance of angelsharks in the Teresitas nursery area (http://asociaciontonina.com/portfolio/conocenos/).

Other Natural or Manmade Factors

The SCUBA diving industry is a significant contributor to the local economy in the Canary Islands. In a study on the economic benefits of diving with sharks and rays in the area, Modino (2011) estimated that this tourism activity brings in more than 10 million Euros annually to the economy. In fact, many diving companies in the Canary Islands advertise the experience of encountering the rare angelshark during their diving expeditions (see http://www.davyjonesdiving.com/diving/P78-Angel-sharks-Gran-canaria.shtml , http://www.elasmodiver.com/CanaryIslands.htm). Meyers (pers. comm. 2015) notes that divers have recently observed female angelsharks straying from their usual birthing areas (in areas frequented by divers) to more remote coastal areas (where divers tend to be absent) to give birth. Although these observations indicate that the increased diver disturbance may be affecting angelshark behavior, at this time, there is not enough information to determine if diver disturbance is a threat negatively affecting the abundance of the *S. squatina* population in the Canary Islands.

EXTINCTION RISK ANALYSIS

According to section 4 of the ESA and our implementing regulations, the Secretary (of Commerce or the Interior) determines whether a species is threatened or endangered as a result of any (or a combination) of the following five section 4(a)(1) factors: (A) destruction or modification of habitat, (B) overutilization, (C) disease or predation, (D) inadequacy of existing regulatory mechanisms, or (E) other natural or man-made factors. Collectively, the Services simply refer to these factors as “threats.” As part of this status review, I was asked to evaluate the impact of the above threats on the extinction risk of the species. To do this, I conducted a threats assessment whereby I identified the present threats currently operating on the species and their likely impact on the biological status of the species. I also looked for future threats (where the impact on the species has yet to be manifested) and considered the reliability to which I could forecast the effects of these threats and future events on the status of the three *Squatina* species. To further inform my extinction risk determination, I conducted demographic risk analyses for the three species, evaluating population viability characteristics and their trends, such as abundance, growth rate/productivity, spatial structure and connectivity, and diversity, to determine the potential risks they pose to the species. These analyses provide an assessment of the biological response or manifestation of past factors for decline and present threats. Using this information, I evaluated the overall extinction risk of the three *Squatina* species. Because species-specific information (such as current abundance) is sparse, qualitative ‘reference levels’ of relative extinction risk were used to describe the assessment of extinction risk. The definitions of the qualitative ‘reference levels’ of relative extinction risk are provided below:

<table>
<tr><th colspan="2">Qualitative ‘Reference Levels’ of Relative Extinction Risk</th></tr>
<tr><td>Continuum of decreasing relative risk of extinction</td><td><u>Low Risk</u>: A species is at a low risk of extinction if it exhibits a trajectory indicating that it is unlikely to be at a moderate level of extinction risk in the foreseeable future (see description of “Moderate Risk” below). A species may be at low risk of extinction due to its present demographics (i.e., stable or increasing trends in abundance/population growth, spatial structure and connectivity, and/or diversity) with projected threats likely to have insignificant impacts on these demographic trends.

<u>Moderate Risk</u>: A species is at moderate risk of extinction if it exhibits a trajectory indicating that it will more likely than not be at a high level of extinction risk in the foreseeable future (see description of “High Risk” below). A species may be at moderate risk of extinction due to its present demographics (i.e., declining trends in abundance/population growth, spatial structure and connectivity, and/or diversity and resilience) and/or projected threats and its likely response to those threats.

<u>High Risk</u>: A species is at high risk of extinction when it is at or near a level of abundance, spatial structure and connectivity, and/or diversity that place its persistence in question. The demographics of the species may be strongly influenced by stochastic or depensatory processes. Similarly, a species may be at high risk of extinction if it faces clear and present threats (e.g., confinement to a small geographic area; imminent destruction, modification, or curtailment of its habitat; or disease epidemic) that are likely to create such imminent demographic risks.</td></tr>
</table>

Recommendations as to whether the species should be listed as threatened or endangered were not part of this analysis. Rather, scientific conclusions about the overall risk of extinction faced by the species were based on an evaluation of the species’ demographic risks and threats. Determination of the ESA listing status of each species is a decision that includes the above analyses as well as consideration of the certainty of implementation of future conservation efforts, the certainty of effectiveness of existing conservation efforts, as well as other management considerations.

Squatina aculeata

Demographic Risk Analysis

Abundance

There are no quantitative historical or current abundance estimates for *S. aculeata*. In the Mediterranean, the best available information suggests that the species was likely naturally historically rare, with possible exceptions off the coasts of Libya, Tunisia, and the Balearic Islands. However, recent and spatially expansive trawl data indicate the species is currently rare in those areas as well and notably absent throughout most of its historical Mediterranean range (Baino *et al.* 2001; Massuit and Moranta 2003; Ferretti *et al.* 2005; Morey *et al.* 2007; Damalas and Vassilopoulou 2011; Maynou *et al.* 2011; Ragonese *et al.* 2013), indicating a decline in abundance that has subsequently led to possible extirpation of the species from the Adriatic Sea, central Aegean Sea, Ligurian and Tyrrhenian Seas, off the Balearic Islands and in the Catalan Sea. In the northeast Atlantic, the species was once common in waters off West Africa, from Mauritania to Sierra Leone (Hureau and Monod 1973; Capapé *et al.* 2005; Morey *et al.* 2007a). However, it appears to have undergone declines from its population size in the 1970s, to the point where individuals of the species are rarely observed or caught, with the last record of the species from the available data dating back to 1998.

Given the lack of quantitative data, historical and current abundance estimates of the species cannot be determined. However, based on the best available information (including anecdotal accounts as well as survey data), it appears that the species has likely undergone declines throughout its range, with no evidence to suggest a reversal of these trends. Their rare occurrence and absence in recent survey data, despite sampling effort in areas and depths where *S. aculeata* would potentially or previously be found, suggest current populations are likely small and fragmented, making them particularly sensitive to stochastic and demographic fluctuations.

Growth Rate/Productivity

The growth rate and longevity of *S. aculeata* is unknown. The species is thought to have a 2-year reproductive cycle, with a long gestation period (~ one year) and low fecundity (litter sizes range from 8 to 12 pups). This reproductive output may be further reduced as gravid *Squatina* females have been found to easily abort embryos during capture and handling. In addition, based on the data, it appears that both males and females of the species do not reach reproductive maturity until they have grown to around 80% of their maximum size. These reproductive characteristics suggest the species has relatively low productivity, similar to other elasmobranch species, which has likely hindered its ability to quickly rebound from threats that decrease its abundance (such as overutilization). The available data on abundance and growth rate/productivity indicate that the species is likely to continue to decline throughout its range, with no information to suggest this trend is reversing.

Spatial Structure/Connectivity

Information on the connectivity among *S. aculeata* populations is not available. Data from tracking studies of the closely related *S. squatina* indicate limited dispersal in the Mediterranean Sea (10 – 45 km), although results are based on only six recaptured individuals. There is no genetic, morphological or behavioral information available that could provide insight into natural rates of dispersal and genetic exchange among populations. However, based on information that *S. aculeata* are ovoviviparous (lacking a dispersive larval phase) and likely have a patchy distribution due to local extirpations and population declines, I conclude that connectivity of *S. aculeata* populations has been affected and is likely low. Limited inter-population exchange would reduce the recovery potential for the depleted and small local populations and may increase the risk of extirpations, possibly leading to complete extinction.

Diversity
The loss of diversity can increase a species' extinction risk through decreasing a species' capability of responding to episodic or changing environmental conditions. This can occur through a significant change or loss of variation in life history characteristics (such as reproductive fitness and fecundity), morphology, behavior, or other genetic characteristics. Although it is unknown if *S. aculeata* has experienced a loss of diversity, the likely small, fragmented, and possibly isolated remaining populations suggest the species may be at an increased risk of random genetic drift and could experience the fixing of recessive detrimental alleles, reducing the overall fitness of the species.

Threats Assessment

As discussed in the **Analysis of the ESA Section 4(a)(1) factors** section above, present threats to the species include overutilization by fisheries and inadequate regulatory mechanisms. The demersal fisheries that historically contributed to the decline in *S. aculeata* are still active throughout the species' range and primarily operate in depths where *S. aculeata* would occur. The available information suggests heavy exploitation of demersal resources by these fisheries, including high levels of chondrichthyan discards and associated mortality due to the low gear selectivity and intensity of fishing effort throughout the Mediterranean and eastern Atlantic. There is also species-specific data that show it is currently landed by recreational fishermen operating in Turkish waters in the eastern part of its range, in what is described as a rarely monitored fishery. If not adequately regulated, this recreational fishing pressure will likely contribute to further population declines in the only area where the species has been identified in fisheries statistics in recent years (2010). Off the west coast of Africa, the data suggests that the artisanal fishery and industrial trawl operations, as well as illegal fishing operations, have contributed to the decline in the population in this area. As current regulatory measures appear inadequate to protect *S. aculeata* from further fishery-related mortality, with the species already considered to be rare in this region, these fishing operations are likely to continue to pose a threat to *S. aculeata*. Overall, given the present demographic risks of the species and inherent vulnerability to overexploitation, the additional fishing mortality sustained by the species, as a result of continued commercial, artisanal, and recreational fishing, is a threat that is significantly contributing to the species' risk of extinction throughout its range.

Risk of Extinction

Although there is significant uncertainty regarding the current abundance of the species, the best available information indicates that the species has suffered substantial declines in portions of its range where it once was common, and is considered to be rare throughout its entire range. The species likely consists of small, fragmented, isolated, and declining populations that are likely to be strongly influenced by stochastic or depensatory processes and have little rebound potential or resilience. This vulnerability is further exacerbated by the present threats of overutilization and inadequacy of existing regulatory measures that continue to contribute to the decline of the existing populations, compromising the species' long-term viability. Therefore, based on the best available information and the above analysis, I conclude that the *S. aculeata* is presently at a high risk of extinction throughout its range.

Squatina oculata

Demographic Risk Analysis

Abundance
There are no quantitative historical or current abundance estimates for *S. oculata*. In the Mediterranean, the data suggest that the species may have been historically abundant off the southern and eastern Iberian coasts, off the Balearic Islands, and in Tunisian waters, with a potential nursery ground identified in the Gulf of Tunis. However, recent and spatially expansive trawl data indicate the species is now rare in those areas and notably absent throughout most of its historical Mediterranean range, with the last quantitative record of the species from the available literature dating back to 2006 (Baino *et al.* 2001; Massuit and Moranta 2003; Damalas and Vassilopoulou 2011; Maynou *et al.* 2011; Ragonese *et al.* 2013). Exceptions to this characterization are qualitative descriptions of the abundance of the species from literature dated almost 10 years ago, which suggest the species may be relatively common in portions of the Levantine Sea (i.e., Israel, Syria). In the northeast Atlantic, the species was common in waters off West Africa in the 1970s and 1980s, from Mauritania to Liberia (Strømme 1984; Edwards *et al.* 2001; Morey *et al.* 2007b; Diop and Dossa 2011). However, according to mainly anecdotal observations by fishermen, the species is now rarely seen in this area, with the last record of the species from the available data dating back to 2002.

Given the lack of quantitative data, historical and current abundance estimates of the species cannot be determined, and trends in abundance are also difficult to decipher. However, the species' rare occurrence and absence in recent survey data, despite sampling effort in areas and depths where *S. oculata* would potentially or previously be found, suggest current populations may be in decline. Although the species was described as "prevalent" and "regularly observed" almost a decade ago in some parts of its range, the absence of updated data or information on the species within these areas in recent years is worrisome. Regardless, remaining populations may be small but are likely fragmented, making them particularly sensitive to stochastic and demographic fluctuations.

Growth Rate/Productivity
The growth rate and longevity of *S. oculata* is unknown. The species is thought to have a 2-year reproductive cycle, with a long gestation period (~ one year) and low fecundity (litter sizes range from 5 to 8 pups). This reproductive output may be further reduced as gravid *Squatina* females have been found to easily abort embryos during capture and handling. In addition, based on the data, it appears that both males and females of the species do not reach reproductive maturity until they have grown to around half of their maximum size. These reproductive characteristics suggest the species has relatively low productivity, similar to other elasmobranch species, which

has likely hindered its ability to quickly recover from threats that decrease its abundance (such as overutilization). The available data on abundance and growth rate/productivity indicate that the species is likely to continue to decline throughout its range, with no information to suggest this trend is reversing.

Spatial Structure/Connectivity
Information on the connectivity among *S. oculata* populations is not available. As mentioned above, data from tracking studies of the closely related *S. squatina* indicate limited dispersal in the Mediterranean Sea (10 – 45 km), although results are based on only six recaptured individuals. There is no genetic information available that could provide insight into natural rates of dispersal and genetic exchange among populations. However, based on information that *S. oculata* are ovoviviparous (lacking a dispersive larval phase) with a patchy distribution due to local extirpations and population declines, I conclude that connectivity of *S. oculata* populations is likely low. Limited inter-population exchange would reduce the recovery potential for the depleted and small local populations and may increase the risk of extirpations, possibly leading to complete extinction.

Diversity
The loss of diversity can increase a species' extinction risk through decreasing a species' capability of responding to episodic or changing environmental conditions. This can occur through a significant change or loss of variation in life history characteristics (such as reproductive fitness and fecundity), morphology, behavior, or other genetic characteristics. Although it is unknown if *S. oculata* has experienced a loss of diversity, the likely small, fragmented, and possibly isolated remaining populations suggest the species may be at an increased risk of random genetic drift and could experience the fixing of recessive detrimental alleles, reducing the overall fitness of the species.

Threats Assessment

As discussed in the **Analysis of the ESA Section 4(a)(1) factors** section above, present threats to the species include overutilization by fisheries and inadequate regulatory mechanisms. The demersal fisheries that historically contributed to the decline of the *Squatina* species are still active throughout the species' range and primarily operate in depths where *S. oculata* would occur. The available information suggests heavy exploitation of demersal resources by these fisheries, including high levels of chondrichthyan discards and associated mortality due to the low gear selectivity and intensity of fishing effort, throughout the Mediterranean and eastern Atlantic. Off the west coast of Africa, the data suggests that the artisanal fishery and industrial trawl operations, as well as illegal fishing operations, have contributed to the decline in the population in this area. As current regulatory measures appear inadequate to protect *S. oculata* from further fishery-related mortality, with the species already considered to be rare in this region, these fishing operations are likely to continue to pose a threat to *S. oculata*. Overall, given the present demographic risks of the species and inherent vulnerability to overexploitation, the additional fishing mortality sustained by the species, as a result of continued commercial and artisanal fishing, is a threat that is significantly contributing to the species' risk of extinction throughout its range.

Risk of Extinction

Although there is significant uncertainty regarding the current abundance of the species, the best available information indicates that the species is rare throughout most of its range, likely consisting of fragmented, isolated, and declining populations that are likely to be strongly influenced by stochastic or depensatory processes. This vulnerability is further exacerbated by the present threats of overutilization and inadequacy of existing regulatory measures that continue to contribute to the decline of the existing populations, compromising the species' long-term viability. Therefore, based on the best available information and the above analysis, I conclude that the *S. oculata* is presently at a high risk of extinction throughout its range.

Squatina squatina

Abundance

Based on historical and current catches and survey data, *S. squatina* has undergone significant declines in abundance throughout most of its historical range. Although once considered to be fairly common, the species is now considered to be extirpated from the western English Channel, North Sea, Ligurian and Tyrrhenian Seas, and Black Sea, and potentially the Catalan Sea and portions of the Adriatic Sea, and is considered rare throughout the rest of its range in the northeast Atlantic and Mediterranean (Jukic-Peladic *et al.* 2001; Morey *et al.* 2006; OSPAR Commission 2010; EVOMED 2011; Maynou *et al.* 2011; McHugh *et al.* 2011; Ferretti *et al.* 2013; ICES 2014), with one exception. The *S. squatina* population off the Canary Islands may be fairly stable (although there is no trend data to confirm this) (E. Meyers, pers. comm. 2014; J. Barker, pers. comm. 2015); however, this area only constitutes an extremely small portion of the species' range and its present abundance in this portion remains uncertain.

Although the lack of quantitative data creates significant uncertainty regarding historical and current abundance estimates of the species, the best available information suggests that *S. squatina* has undergone significant declines and is likely still in decline throughout most of its range, with evidence of local extirpations and a significant curtailment of its historical range. Current populations are likely small and fragmented, making them particularly sensitive to stochastic and demographic fluctuations.

Growth Rate/Productivity

The growth rate and longevity of *S. squatina* is unknown. The species is thought to have a 2 or 3year reproductive cycle, with a long gestation period (8-12 months) and relatively low fecundity (litter sizes range from 7 to 25 pups). This reproductive output may be further reduced as gravid *Squatina* females have been found to easily abort embryos during capture and handling. In addition, based on the data, it appears that both males and females of the species do not reach reproductive maturity until they have grown to around 44-72% of their maximum size. These reproductive characteristics suggest the species has relatively low productivity, similar to other elasmobranch species, which has likely hindered its ability to quickly rebound from threats that decrease its abundance (such as overutilization). The available data on abundance and growth rate/productivity indicate that the species is likely to continue to decline throughout its range, with no information to suggest this trend is reversing.

Spatial Structure/Connectivity

Information on the connectivity among *S. squatina* populations is not available. Tagging data of *S. squatina* released off the west coast of Ireland suggest the species makes seasonal migrations, with the capability of traveling quite far (longest distance was 1,160 km). However, for the most part, the majority of these tagged fish tended to remain in Irish waters and close to their initial tagging location (Quigley 2006). According to ICES (2014), *S. squatina* likely has a localized and patchy distribution within the Celtic Seas. This is probably true of the species throughout the rest of its range as data from another tracking study of *S. squatina* indicate limited dispersal in the Mediterranean Sea (10 – 25 km), suggesting possible high site fidelity (although results are based on only two recaptured individuals). There is no genetic information available that could provide insight into natural rates of dispersal and genetic exchange among populations throughout the species' range. However, based on information that *S. squatina* are ovoviviparous (lacking a dispersive larval phase) and likely have a patchy distribution due to local extirpations and population declines, I assume that connectivity of *S. squatina* populations is likely low. Limited inter-population exchange would reduce the recovery potential for the depleted and small local populations and may increase the risk of extirpations, possibly leading to complete extinction.

Diversity

The loss of diversity can increase a species' extinction risk through decreasing a species' capability of responding to episodic or changing environmental conditions. This can occur through a significant change or loss of variation in life history characteristics (such as reproductive fitness and fecundity), morphology, behavior, or other genetic characteristics. Currently, preliminary genetic information for the species is only available from the population off the Canary Islands, and indicates exceptionally low genetic diversity, with identical haplotypes found in *S. squatina* individuals across the archipelago (Fitzpatrick *et al.* 2016). Although it is unknown if *S. squatina* has experienced a loss of diversity throughout its range, the likely small, fragmented, and possibly isolated remaining populations, with evidence of low genetic diversity within its "stronghold" (*i.e*., the Canary Islands), suggest the species may be at an increased risk of random genetic drift and could experience the fixing of recessive detrimental alleles, reducing the overall fitness of the species.

Threats Assessment

As discussed in the **Analysis of the ESA Section 4(a)(1) factors** section above, present threats to the species include a curtailment of range, overutilization by fisheries and inadequate regulatory mechanisms. The demersal fisheries that historically contributed to the decline in *S. squatina* are still active throughout the species' range and primarily operate in depths where *S. squatina* would occur. Although the species is protected in EU waters, the available information suggests heavy exploitation of demersal resources by fisheries operating throughout the Mediterranean and eastern Atlantic, resulting in high levels of chondrichthyan discards and associated mortality. The species is also being landed, both legally and illegally, at levels that historically led to population declines. In the Canary Islands, which are thought to be the last stronghold for the species, *S. squatina* is presently at risk of mortality at the hands of artisanal fishermen as well as a growing number of sport fishermen, despite the prohibition on capturing the species. Although trawling is banned within the Canary Islands, and a number of marine reserves and SACs have been established here, it is unclear to what extent these regulations will be effective in protecting important *S. squatina* habitat or decreasing fishing mortality rates.

Risk of Extinction

Although there is significant uncertainty regarding the current abundance of the species, the best available information indicates that the species has undergone a substantial decline in abundance. Once noted as common in historical records, the species is presently rare throughout most of its range (and considered extirpated in certain portions), with evidence suggesting it currently consists of small, fragmented, isolated, and declining populations that are likely to be strongly influenced by stochastic or depensatory processes. Based on tagging data, the Canary Island population, whose present abundance and population structure remains largely unknown, may be confined to this small geographic area. With limited inter-population exchange, its susceptibility to natural environmental and demographic fluctuations significantly increases its risk of extirpation. The vulnerabilities of the species (small population sizes, declining trends, potential isolation) are further exacerbated by the present threats of curtailment of range, overutilization and inadequacy of existing regulatory measures that will either contribute or continue to contribute to the decline of the existing populations, compromising the species' long-term viability. Therefore, based on the best available information and the above analysis, I conclude that the *S. squatina* is presently at a high risk of extinction throughout its range.

CONSERVATION EFFORTS

In response to the alarming decline of *S. squatina* throughout its range over the years, a number of conservation efforts have developed with the goal of learning more about these sharks in order to understand how better to protect them. Most of these efforts have been concentrated in the Canary Islands. One such effort, which was previously mentioned, is the ASP. It was created in November 2013 with the overall goal of securing the future of the angelshark (*S. squatina*) in Europe. Part of this effort included creating the "ePoseidon" network which is a database that the public can access in order to log their sightings of the species around the Canary Islands. This information will help researchers better understand the distribution of the species throughout the islands. Scientists from ULPGC have also been doing validation dives in angelshark hotspots to collect information on the spatial and temporal distribution patterns, assess population abundance, and identify residency and movement patterns to identify potential nursery areas or important habitat (ASP 2014). In addition to this network, the ASP has also recently received funding to work with the sportfishing community and pilot an angelshark tagging project in the region that will start in April 2015 (E. Meyers, pers. comm. 2015). Goals for this collaboration include reducing angelshark mortality by developing a best practice guide for catch and release of the species with the sportfishing community, raising awareness of the importance of the Canary Islands for angelshark conservation, and expanding the network of citizen scientists that report angelshark sightings to ePoseidon (J. Barker, pers. comm. 2014). The aim of the pilot tagging program is to find the best methodology to tag angelsharks to be used in future tagging programs. The ASP has also received funding from the Save our Seas Foundation for a tagging project covering the three main Islands (Lanazarote, Gran Canaria and Tenerife), including the nursery grounds in each island and collaborating with Asociacion Tonina in "las Teresitas" nursery ground. The best tagging methodology identified in the pilot tagging will be used to gather data on angelshark movements and migratory behavior (E. Meyers pers. comm. 2015). Future plans include projects to reduce morality and/or disturbance of the angelshark in the Canary Islands, data collection to inform conservation (including genetic and tagging research), and awareness raising campaigns, but are dependent on future funding (J. Barker, pers. comm. 2015).

Similarly, ElasmoCan (http://elasmocan.org/home/) is another conservation initiative aimed at developing and conducting innovative research to obtain the required knowledge for elasmobranch conservation (and in particular *S. squatina*) and help define effective criteria for their sustainable use. Some of their main research topics for *S. squatina* in the Canary Islands includes: genetic assessments, reproduction, habitat use (includes population structure and nursery area assessments), photo-identification (development of non-invasive techniques to identify individuals), citizen science projects (e.g., promoting the use of public portals for reporting of diver sightings), predators (identifying parasites and micropredators and assessing impacts), and diet (analyzing stomach contents) (ElasmoCan pers. comm. 2016).

As mentioned previously, Asociacion Tonina is also working on a project to study the distribution and abundance of angelsharks in the Teresitas nursery area in the Canary Islands (http://asociaciontonina.com/portfolio/conocenos/) and Alianza Tiburones Canarias started a campaign to promote the importance of Teresitas beach and educate beachgoers on the species (http://alianzatiburonescanarias.blogspot.com/2014/08/comunicado-la-guarderia-de-angelotes-de.html).

Another conservation endeavor that is ongoing is a collaborative project between Deep Sea World (Scotland's National Aquarium) and Hastings Blue Reef Aquarium whose aim is to breed angelsharks in captivity. There are only 4 adult *S. squatina* sharks held by these UK aquaria (3 males; 1 female) (Deep Sea World 2015; Bluereef Aqariuam 2015). In 2004, the female angelshark, held by Hastings Blue Reef Aquarium, was transported to Deep Sea World and introduced to their two male angelsharks. In 2007, after what appeared to be a successful mating, the female produced 3 stillborn pups. In 2011, the female became pregnant once again, and this time successfully delivered 19 pups. This marked the first time that an angelshark has successfully bred in captivity (Deep Sea World 2015), which may be an important first step in the conservation of the species.

REFERENCES

Agnew, D.J., Pearce, J., Pramod, G., Peatman, T., Watson, R., Beddington, J.R. and T. J. Pitcher. 2009. Estimating the worldwide extent of illegal fishing. PLoS ONE 4 (2).

Agri-Food & Biosciences Institute. 2009. Position statement on sharks, skates and rays in Northern Ireland waters. *Northern Ireland Environment Agency Research and Development Series* No. 09/03

Alianza Tiburones Canarias. 2014. Comunicado: La guardería de angelotes de la playa de las Teresitas en Tenerife. Blogpost, Friday, August 22, 2014. Available at: http://alianzatiburonescanarias.blogspot.com/2014/08/comunicado-la-guarderia-de-angelotes-de.html

Arapi, D., Sadikaj, R. and E. Nelaj. 2006. Fishing and cartilaginous fishes on the Adriatic and Ionian Seas of Albania. Proceedings of the International Workshop on Mediterranean Cartilaginous Fish with Emphasis on Southern and Eastern Mediterranean, Turkish Marine Research Foundation, Istanbul. Pp. 209-214.

Angel Shark Conservation Project (ASP). 2014. Angel Shark Project. Webpage available at: http://angelsharkproject.com/

Asociacion Ondine. 2012. Marine Reserves. Webpage available at http://asociaciondine.org/marine-reserves/

Baino, R., Serena, F., Ragonese, S., Rey, J. and P. Rinelli. 2001. Catch composition and abundance of elasmobranchs based on the MEDITS program. *Rapp Comm Int Mer Medit* 36: 234.

Baino, R., Mancusi, C., Barone, M., Morey, G., Vacchi, M., Gil de Sola, L., Bradai, M.N., Sperone, E., Kallianotis, A., Hemida, F., Saad, A. A., Dimech, M., Peristeraki, P., Bariche, M.,Cavlan, G., Clò, S., De Sabata, E., Castellano, L., Garibaldi, F., Tinti, F., Pais, A., Follesa, C., Micarelli, P., Poisson, F., Carlucci, R., Soldo, A., Bottaro, M., Cebrian, D., Fortuna, C., Seret, B., Ferretti, F., El-Far, A., Saygu, I., Shakman, E.A., Bartolí, A., Guallart, J., Damalas, D., Megalofonou, P., Notarbartolo di Sciara, G., Cannas, R. and F. Serena. 2012. The data collection on large cartilaginous fishes in the Mediterranean basin: an update of the MEDLEM database. Presentation at the 16th annual conference of European Elasmobranchs Association. 23-24th November 2012. Milan, Italy

Bal, G., White, J., Johnston, G., Roche, W., O'Reilly, S., Green, P. and P. Fitzmaurice. 2014. Estimates of yearly population size of Angel Sharks from Tralee Bay. Working Document to the ICES Working Group on Elasmobranch Fishes. 8 pp.

Barker, J., Piper, R., Meyers, E., Fernández-Palacios and R. Haroun. 2014. Protecting the last angel shark stronghold in the Canary Islands. Abstract in Proceedings of the European

Elasmobranch Association Annual Scientific Conference, The Netherlands, 7-9 November 2014.

Barrull, J., Mate, I. and M. Bueno. 1999. Observaciones de tiburones (*Chondrichtyes euselachii*) en aguas de Cataluña (Mediterráneo no), con algunos aspectos generals de su ecología. *Scientia gerundensis* 24: 127-151.

Başusta, N. 2002. Occurrence of a sawback angelshark (*Squatina aculeata* Cuvier, 1829) off the Eastern Mediterranean Coast of Turkey. *Turk J Vet Anim Sci* 26: 1177-1179.

Begun, T., Muresan, M., Zaharia, T., Dencheva, K., Sezgin, M., Bat, L. and V. Velikova. 2012. Conservation and Protection of the Black Sea Biodiversity. Review of the existing and planned protected areas in the Black Sea (Bulgaria, Romania, Turkey) with a special focus on possible deficiencies regarding law enforcement and implementation of management plans. EC DG Env. MISIS Project Deliverables. www.misisproject.eu

Bilecenoğlu, M., Kaya, M., Cihangir, B., and E. Çiçek. 2014. An updated checklist of the marine fishes of Turkey. *Turk J Zool* 38: 1-29.

Bjork, C. 2015. Repsol abandons drilling off Canary Islands. The Wall Street Journal Online. January 16th. Retrieved April 18, 2015 at: http://www.wsj.com/articles/repsol-abandons-drilling-off-canary-islands-1421422659.

Bord Iascaigh Mhara (BIM). 2012. Review of Crawfish Technical Conservation Measures. Final Report. February 2012.

Braccini, M., Van Rijn, J. and L. Frick. 2012. High post-capture survival for sharks, rays, and chimaeras discarded in the main shark fishery of Australia? PLoS ONE 7(2): e32547. doi:10.1371/journal.pone.0032547.

Bradai, M.N., Saidi, B., Enajjar, S. and A. Bouain. 2006. The Gulf of Gabès: a spot for the Mediterranean elasmobranchs. Proceedings of the International Workshop on Mediterranean Cartilaginous Fish with Emphasis on Southern and Eastern Mediterranean, Turkish Marine Research Foundation, Istanbul. Pp. 209-214.

Bradai, M.N., Saidi, B. and S. Enajjar. 2012. Elasmobranchs of the Mediterranean and Black sea: status, ecology and biology. Bibliographic analysis. *Studies and Reviews. General Fisheries Commission for the Mediterranean.* No. 91. Rome, FAO. 103 pp.

Bulguroğlu, S.Y., Korun, J., Gökoğlu, Y., and Y. Özvarol. 2014. The marine leech Stibarobdella moorei (Oka, 1910) (Hirudinea, Piscicolidae) parasitic on the thornback ray Raja clavata Linnaeus, 1758 and angelshark Squatina squatina (Linnaeus, 1758) in Antalya Bay, Mediterranean Sea of Turkey. Helminthologia 51(3): 250-252.

Capapé, C., Quignard, J.P. and J. Mellinger. 1990. Reproduction and development of two angel sharks, *Squatina squatina* and *S. oculata* (Pisces: Squatinidae), of Tunisian coasts: semidelayed vitellogenesis, lack of egg capsules, and lecithotrophy. *J Fish Biol* 37: 347–356.

Capapé, C., Seck, A.A., Gueye–Ndiaye, A., Diatta, Y. and M. Diop. 2002. Reproductive biology of the smoothback angel shark, *Squatina oculata* (Elasmobranchii, Squatinidae), from the coast of Senegal (eastern tropical Atlantic). *J Mar Biol Assoc UK* 82: 635-640.

Capapé, C., Diatta, Y., Seck, A.A., Guélorget, O., Ben Souissi, J. and J. Zaouali. 2005. Reproduction of the sawback angelshark *Squatina aculeata* (Chondrichthyes: Squatinidae) off Senegal and Tunisia. *Cybium* 29(2): 147-157.

Cherif, M., Zarrad, R., Gharbi, H., Missaoui, H. and O. Jarboui. 2008. Length-weight relationships for 11 fish species from the Gulf of Tunis (SW Mediterranean Sea, Tunisia). *Pan-Am J Aquat Sci* 3(1): 1-5.

Compagno, L. 1984. FAO species catalogue. Vol. 4. Sharks of the world. An annotated and illustrated catalogue of sharks species known to date. Part 1. Hexanchiformes to Lamniformes. *FAO Fish Synop* (125)Vol.4, Pt.1: 249 p.

Coppola, S.R. 2001. Inventory of artisanal fishery communities in the Western-Central Mediterranean. FAO-COPEMED Project. FAO-FIRM, Rome.

Corsini, M. and B. Zava. 2007. Recent capture of *Squatina oculata* and *Squatina aculeata* from Dodecanese Islands (SE Aegean Sea, Eastern Mediterranean). *Biol Mar Mediterr* 14(2): 352-353.

Cortés, E. 1999. Standardized diet compositions and trophic levels of sharks. *ICES J Mar Sci* 56: 707–717.

Couce-Montero, L., Christensen, V. and J.J. Castro. 2015. Effects of small-scale and recreational fisheries on the Gran Canaria ecosystem. Ecological Modelling 312: 61-76.

Damalas, D. and V. Vassilopoulou. 2010. Demersal ichthyofauna of the central Aegean Sea: Declining trends in species richness. *Rapp Comm Int Mer Medit* 39: 485.

Damalas, D. and V. Vassilopoulou. 2011. Chondrichthyan by-catch and discards in the demersal trawl fishery of the central Aegean Sea (Eastern Mediterranean). *Fisheries Research* 108: 142-152.

Day, F. 1880. The Fishes of Great Britain and Ireland. Volume II. Williams and Norgate; London; Edinburgh. 388 pp.

Deep Sea World. 2015. Education: Conservation - Angel Shark Breeding Project. Available online at: http://www.deepseaworld.com/education/conservation

Dell'Apa, A., Kimmel, D.G. and S. Clò. 2012. Trends of fish and elasmobranch landings in Italy: associated management implications. *ICES J Mar Sci* 69(6): 1045–1052.

Diop, M. and J. Dossa. 2011. 30 years of shark fishing in West Africa. A joint initiative by FIBA, PRCM, and CSRP. Corlet/Condé-sur-Noireau, France. Available at: http://www.iucnssg.org/tl_files/Assets/Regional%20files/West%20Africa/30years_eng.pdf

Dulvy, N.K., Sadovy, Y. and J.D. Reynolds. 2003. Extinction vulnerability in marine populations. *Fish and Fisheries* 4: 25-64.

Echwikhi, K., Saidi, B., Bradai, M.N. and A. Bouain. 2013. Preliminary data on elasmobranch gillnet fishery in the Gulf of Gabès, Tunisia. *J Appl Ichthyol* 29: 1080-1085.

Edwards, A.J., Gill, A.C. and P.O. Abohweyere. 2001. A revision of Irvine's Marine Fishes of Tropical West Africa. Darwin Initiative Project. 178 p.

Environmental Justice Foundation (EJF). 2012. Pirate Fishing Exposed: The Fight Against Illegal Fishing in West Africa and the EU. Available at: http://ejfoundation.org/sites/default/files/public/Pirate%20Fishing%20Exposed.pdf

El Día Digital. 2000. Dos personas sufren mordeduras en los pies mientras se bañaban en Las Teresitas. Available at http://eldia.es/2000-06-14/tenerife/tenerife22.htm

Ellis, J.R., Pawson, M.G. and S.E. Shackley. 1996. The comparative feeding ecology of six species of shark and four species of ray (Elasmobranchii) in the North-East Atlantic. *J Mar Biol Assoc UK* 76: 89–106.

Ellis, J.R., Cruz-Martínez, A. Rackham, B.D. and S.I. Rogers. 2004. The distribution of chondrichthyan fishes around the British Isles and implications for conservation. *J Northw Atl Fish Sci* 35: 195-213.

European Commission. 2009. Green Paper: Reform of the Common Fisheries Policy. COM 163 final. Brussels.

European Commission. 2010. Commission Staff Working Document: Synthesis of the Consultation on the Reform of the Common Fisheries Policy. SEC 428, final. Brussels.

European Commission. 2014. Report from the Commission to the European Parliament and the Council on Member States' efforts during 2012 to achieve a sustainable balance between fishing capacity and fishing opportunities. COM 233, final. Brussels.

EVOMED. 2011. The 20th century evolution of Mediterranean exploited demersal resources under increasing fishing disturbance and environmental change. Draft Final Report. Contract. N°SI2 539097

European Communities. 2009. Natura 2000 Europe's nature for you across the 27 EU countries. Luxembourg: Office of Official Publications of the European Communities.

Fahy, E. and J. Carroll. 2009. Vulnerability of male spider crab *Maja brachydactyla* (Brachyura: Majidae) to a pot fishery in south-west Ireland. *J. Mar. Biol. Assoc. U.K.* 89 (7): 1353-1366.

FAO. 2013. GFCM Task 1 Statistical Bulletin 2010. Released May 2013. FAO. Available at: http://www.faosipam.org/Task1_Bulletin_2013_GSAs/GFCM-Task1-Statistical-Bulletin-2013.pdf

Fennessy, S.T. 1994. Incidental capture of elasmobranchs by commercial prawn trawlers on the Tugela Bank, Natal, South Africa. *S Afr J Mar Sci* 14: 287-296.

Ferretti, F., Myers, R.A., Sartor, P. and F. Serena. 2005. Long term dynamics of the chondrichthyan fish community in the upper Tyrrhenian Sea. *ICES CM* 2005/N:25.

Ferretti, F., Osio, G.C., Jenkins, C.J., Rosenberg, A.A. and H.K. Lotze. 2013. Long-term change in a meso-predator community in response to prolonged and heterogeneous human impact. *Scientific Reports* 3: 1057.

Filiz, H., Irmak, E. and S. Mater. 2005. Occurrence of *Squatina aculeata* Cuvier, 1829 (Elasmobranchii, Squatinidae) from the Aegean Sea, Turkey. E.U. *J Fish & Aquat Sci* 22(3-4): 451-452.

Fitzpatrick, C.K., Bernard, A., Osaer, F., Narváez, K. and S. Mahmood. 2016. A Genetic Exploration in a Last Refuge: The Common Angelshark (*Squatina squatina*) in the Canary Islands. Abstract Submission to the July 2016 Joint Meeting of Ichthyologists and Herpetologists. American Elasmobranch Society Session.

Fortibuoni, T., Borme, D., Franceschini, G., Giovanardi, O. and S. Raicevich. 2016. Common, rare or extirpated? Shifting baselines for common angelshark, Squatina squatina (Elasmobranchii: Squatinidae), in the Northern Adriatic Sea (Mediterranean Sea). *Hydrobiologia* 772(1): 247-259.

Froese, R. and D. Pauly. Editors. 2014. FishBase. World Wide Web electronic publication. www.fishbase.org, version (11/2014).

The Global Biodiversity Information Facility (GBIF). 2013. GBIF Backbone Taxonomy, 2013-07-01. Accessed via http://www.gbif.org/

Gelbalder. 2015. Gökova'da Melek Köpek Balığı (*Squatina squatina*). Survival of Artisanal Fisheries Society Blog Post from February 26, 2015; available at http://www.gelbalder.org/akd/7036-gokovada-melek-kopek-baligi-squatina-squatina.html

General Fisheries Commission for the Mediterranean (GFCM). 2015. GFCM AVL – Authorized Vessel List (>15M). Last updated: 17 Apr 2015. Available at: http://www.gfcmonline.org/data/avl/

Giusto, G.B. and S. Ragonese. 2014. Finding of the almost disappeared angel shark (*Squatina*

squatina, Linnaeus, 1758) (*Chondrichthyes Squatinidae*), off the south coasts of Sicily (Mediterranean Sea). Short Notes. *Nautralista sicil*, S. IV, XXXVIII (1): 113-114.

Golani, D. 2006. Cartilaginous fishes of the Mediterranean coast of Israel. Proceedings of the International Workshop on Mediterranean Cartilaginous Fish with Emphasis on Southern and Eastern Mediterranean, Turkish Marine Research Foundation, Istanbul. Pp. 209-214.

Haddad, N. 2011. VMS/SSN The Tunisian Vessel Monitoring System. Presentation given at the Workshop on the Implementation of a Vessel Monitoring System (VMS) in the Mediterranean and the Black Sea. Zagreb, Croatia 28-30 November 2011.

Hadjichristophorou, M. 2006. Chondrichthyes in Cyprus. Proceedings of the International Workshop on Mediterranean Cartilaginous Fish with Emphasis on Southern and Eastern Mediterranean, Turkish Marine Research Foundation, Istanbul. Pp. 209-214.

HELCOM. 2013. Species Information Sheet: *Squatina squatina*. HELCOM Red List Fish and Lamprey Species Expert Group.

Hureau, J.C. and T. Monod (eds.). 1973. Check-list of the fishes of the north-eastern Atlantic and of the Mediterranean. UNESCO, Paris, 683 pp.

ICES. 2013. Report of the Working Group on Elasmobranch Fishes (WGEF), 17–21 June 2013, Lisbon, Portugal. *ICES CM* 2013/ACOM:19. 680 pp.

ICES. 2014. Report of the Working Group on Elasmobranch Fishes (WGEF), 17–26 June 2014, Lisbon, Portugal. *ICES CM* 2014/ACOM:19. 671 pp.

Jo, J-H., Do, J-R., Kim, Y-M., Kim, D-S., Lee, T-K., Kim, S-B., Cho, S-M., Kang, S-N. and D.C. Park. 2005. Optimization of shark (Squatina oculata) cartilage hydrolysis for the preparation of chondroitin sulfate. *Food Sci Biotechnol* 14(5): 651-655.

Jones, M.C., Dye, S.R., Fernandes, J.A., Frölicher, T.L., Pinnegar, J.K., Warren, R. and W.W.L. Cheung. 2013. Predicting the impact of climate change on threatened species in UK waters. *PLOS ONE* 8(1).

Jukic-Peladic S., Vrgoc N., Krstulovic-Sifner S., Piccinetti C., Piccinetti-Manfrin G., Marano, G. and N. Ungaro. 2001. Long-term changes in demersal resources of the Adriatic Sea: comparison between trawl surveys carried out in 1948 and 1998. *Fish Res* 53: 95–104.

Kabasakal, H. and O. Kabasakal. 2014. Status of angelshark, *Squatina squatina* (Elasmobranchii: Squatiniformes: Squatinidae) in the Sea of Marmara. *Annales Ser Hist Nat* 24(1): 41- 46.

Khalilian, S., Froese, R., Proelss, A. and T. Requate. 2010. Designed for failure: A critique of the Common Fisheries Policy of the European Union. *Mar Pol* 34: 1178-1182.

Lamboeuf, M., Abdallah, A.B., Coppola, R., Germoni, A. and M. Spinelli. 2000. Artisanal fisheries in Libya: census of fishing vessels and inventory of artisanal fishery metiers. No. 33-39.

Lazuta, J. 2013. Senegal: new government tries to combat overfishing. Good Governance Africa Online. July 1st. Accessed April 28, 2015 at: http://gga.org/stories/editions/aif-13-out-of-water/senegal-new-government-tries-to-combat-overfishing

Machias, A., Vassilopoulou, V., Vatsos, D., Bekas, P., Kallianiotis, A., Papaconstantinou, C. and N. Tsimenides. 2001. Bottom trawl discards in the northeastern Mediterranean Sea. *Fisheries Research* 53(2):181-195

Massutí, E. and J. Moranta. 2003. Demersal assemblages and depth distribution of elasmobranches from the continental shelf and slope off the Balearic Islands (western Mediterranean). *ICES J Mar Sci* 60: 753–766.

Massutí, E. and O. Reñones. 2005. Demersal resource assemblages in the trawl fishing grounds off the Balearic Islands (western Mediterranean)*. *Sci Mar* 69(1): 167-181.

Maynou, F., Sbrana, M., Sartor, P., Maravelias, C., Kavadas, S., Damalas, D., Cartes, J.E. and G. Osio. 2011. Estimating Trends of Population Decline in Long-Lived Marine Species in the Mediterranean Sea Based on Fishers' Perceptions. PLoS ONE 6 (7).

McHugh, M., Sims, D.W., Partridge, J.C. and M.J. Genner. 2011. A century later: Long-term change of an inshore temperate marine fish assemblage. *J Sea Research* 65: 187-194.

Meyers, E., Barker, J., Haroun, R., Rödder, D. 2014. Patterns in the abundance, distribution and behavior of the Angel Shark (*Squatina squatina*) in the Canary Islands. Oral presentation with abstract in Proceedings of the European Elasmobranch Association Annual Scientific Conference, The Netherlands, 7-9 November 2014

Ministerio de Agricultura, Alimentación y Medio Ambiente. 2014. Zona especial de conservación ES7010016. Área Marina de la Isleta. Demarcación marina canaria.

Modino, R. 2011. Las investigaciones sobre turismo de observación de tiburones y rayas en España. PASOS. *Revista de Turismo y Patrimonio Cultural* 9(2): 467-476.

Moftah, M., Abdel Aziz, S.H., Elramah, S. and A. Favereaux. 2011. Classification of sharks in the Egyptian Mediterranean waters using morphological and DNA barcoding approaches. *PLoS ONE* 6(11): e27001. doi:10.1371/journal.pone.0027001

Molfese, C., Beare, D. and J.M. Hall-Spencer. 2014.Overfishing and the replacement of demersal finfish by shellfish: an example from the English Channel. *PLoS ONE* 9(7): e101506. doi:10.1371/journal.pone.0101506

Morey, G., Serena, F., Mancusi, C., Fowler, S.L., Dipper, F. and J. Ellis. 2006. *Squatina squatina*. The IUCN Red List of Threatened Species. Version 2014.3.

<www.iucnredlist.org>.

Morey, G., Serena, F., Mancusi, C., Coelho, R., Seisay, M., Litvinov, F. and N. Dulvy. 2007a. *Squatina aculeata*. The IUCN Red List of Threatened Species. Version 2014.3. <www.iucnredlist.org>.

Morey, G., Serena, F., Mancusi, C., Coelho, R., Seisay, M., Litvinov, F. and N. Dulvy. 2007b. *Squatina oculata*. The IUCN Red List of Threatened Species. Version 2014.3. <www.iucnredlist.org>.

Muñoz-Chapuli, R. 1985. Análisis de las capturas de escualos demersales en el Atlántico NE (27°N - 37°N) y mar de Alborán (Mediterráneo occidental). *Inv Pesq* 49(1): 121-136.

Narváez, K. 2012. Aspectos biológicos y ecológicos del tiburón ángel "*Squatina squatina*" (Linnaeus 1758) en la isla de Gran Canaria. Ph.D. dissertation. Universidad de Las Palmas de Gran Canaria, Spain. pp. 271.

Narváez, K., Osaer, F. and R. Haroun. 2006. Preliminary results of habitat use of the angel shark *Squatina squatina* and other elasmobranches on the northern coast of Gran Canaria In: Programme & Abstracts from the 10th European Elasmobranch Association Science Conference, 11th-12th November 2005, Zoological Institute & Museume, University of Hamburg.

Narváez, K., Osaer, F., Goldthorpe, B., Vera, E. and R. Haroun. 2008. Results of a 2 year angel shark survey by "Davy Jones Diving" in the island of Gran Canaria. Davy Jones Diving, Playa de Arinaga, Gran Canaria, Spain. Available at: http://www.davyjonesdiving.com/diving/P79-Angel-shark-diving-survey-2008.shtml

Narváez, K., Osaer, F., Goldthorpe, B. and E. Vera. 2014. Long-term sightings of elasmobranchs by recreational divers in the island of Gran Canaria, Central-East Atlantic. Resumenes IV CCM. Available at http://elasmocan.org/long-term-sightings-shark-ray-davy-jones-diving-2014/

Narváez, K. and F. Osaer. 2016. The marine leech *Stibarobdella macrothela* parasitic on the angel shark *Squatina squatina*. Marine Biodiversity 1–2. doi: 10.1007/s12526-016-0444-y

Natura. 2000. Natura 2000: Habitats Directive Sites according to biogeographical regions. European Commission. Webpage available at: http://ec.europa.eu/environment/nature/natura2000/sites_hab/biogeog_regions/maps/canarias.pdf

Navío. 2013. Oil drilling off the coasts of Lanzarote and Fuerteventura. Press release. Canary Islands, Island Connections.eu. Available at: http://www.islandconnections.eu/1000003/1000003/0/40033/canary-islands-article.html

Oceana. 2012. Areas marinas de Canarias afectadas por la exploración petrolífera. Canal de

Canarias y costas orientales del archipiélago. 80 p. Available at: http://oceana.org/sites/default/files/reports/OCEANA_REPSOL_Canarias_Jul2012_0.pdf

Organisation for Economic Co-operation and Development (OECD). 2003. Country note on national fisheries management systems – Turkey. In: OECD, Fisheries Management Systems in OECD Countries. Country Notes. Paris, OECD. Available at: http://www.oecd.org/turkey/34431494.pdf

Osaer, F. 2009. Morfometría y reproducción del angelote "*Squatina squatina*" (Linnaeus, 1758) en la isla de Gran Canaria. Ph.D. dissertation. Universidad de Las Palmas de Gran Canaria, Spain. pp. 173.

Osaer, F. and K. Narváez. 2015. The angel shark *Squatina squatina* prey of the isopod *Aegapheles deshaysiana*. Marine Biodiversity, 1-2. DOI 10.1007/s12526-015-0358-0.

Osaer, F., Narváez, K, Pajuelo, J.G. and J.M. Lorenzo. 2015. Sexual development and maturity scale for the angel shark *Squatina squatina* (Elasmobranchii: Squatinidae), with comments on the adequacy of general maturity scales. Sex Early Dev Aquat Org 1:117-132. doi:10.3354/sedao00012.

OSPAR Commission. 2010. Background document for angel shark *Squatina squatina*. OSPAR Commission, UK. Publication Number: 471/2010.

Papaconstantinou, C. 1988. Check-list of marine fishes of Greece. Fauna Graeciae IV, Hellenic Zoological Society, Athens, 257 pp.

Penthon, P. 1979. Sjeldne saltvannsfisker fra sydostnorske farvann I arene 1970-78. *Fauna* 12: 145-151.

Popescu, I. and J.J. Ortega-Gras. 2013. Fisheries in the Canary Islands. Document prepared for the European Parliament's Committee on Fisheries, IP/B/PECH/NT/2013-02, March 2013, 53 pp.

Psomadakis, P.N., Maio, N. and M. Vacchi. 2009. The chondrichthyan biodiversity in the Gulf of Naples (SW Italy, Tyrrhenian Sea): An historical overview. *Cybium* 33(3): 199-209.

Puig, P, Canals, M., Company, J.B., Martín, J., Amblas, D., Lastras, G., Palanques, A. and A.M. Calafat. 2012. Ploughing the deep sea floor. Letter. *Nature* 489: 286-290.

Quéro, J-C. 1998. Changes in the Euro-Atlantic fish species composition resulting from fishing and ocean warming. *Italian J Zool* 65. *Suppl*: 493-499.

Quéro, J-C. and O. Cendrero. 1996. Incidence de la pêche sur la biodiversité ichthyologiques marine: le basin d'Arachon et le plateau continental sud Gascogne. *Cybium* 20(4): 325-356.

Quigley, D.T. 2006. Angelshark (*Squatina squatina*) in Irish Waters. Sherkin Comment 41: 5.

Quigley, D.T.G. and D. MacGabhann. 2014. Exceptionally large Crawfish *Palinurus elephas* (Fabricius, 1787) from Irish, UK and French Atlantic waters. *Bulletin of the Porcupine Marine Natural History Society* 2 (Autumn 2014): 42-44.

Quignard, J-P. and C. Capapé. 1971. Note preliminarie sur le marquage des selaciens des cotes de Tunisie. *Bull Inst Océanogr Pêche, Salammbô* 2(2): 143-155.

Quignard, J-P. and S. Ben Othman. 1978. Les poisons du golfe de Gabès: situation actuelle et future. *Bull Inst Océanogr Pêche, Salammbô* 5(1-4): 43–52.

Ragonese, S., Vitale, S., Dimech, M. and S. Mazzola. 2013. Abundances of demersal sharks and chimaera from 1994-2009 scientific surveys in the central Mediterranean Sea. *PLOS ONE* 8(9).

Reid, D. and M. Krogh. 1992. Assessment of catches from protective shark meshing off NSW beaches between 1950 and 1990. *Aust J Mar Freshwater Res* 43: 283–296.

Rey, L. 1928. *Ictiología Ibérica (Fauna Ibérica). Peces (Generalidades, Ciclóstomos y Elasmobranquios)*. Museo Nacional de Ciencias Naturales, Madrid.

Rogers, S.I. and J.R. Ellis. 2000. Changes in the demersal fish assemblages of British coastal waters during the 20th century. *ICES J Mar Sci* 57: 866–881.

Rowling, K., Hegarty, A. and M. Ives, Eds. 2010. Angel Shark, pp 1-4. In Status of Fisheries Resources in NSW 2008/09. Industry & Investment NSW, Cronulla.

Saad, A., Ali, M. and B. Seret. 2006. Shark exploitation and conservation in Syria. Proceedings of the International Workshop on Mediterranean Cartilaginous Fish with Emphasis on Southern and Eastern Mediterranean, Turkish Marine Research Foundation, Istanbul. Pp. 209-214.

Sacchi, J. 2008. The use of trawling nets in the Mediterranean. Problems and selectivity options. In: Basurco B. (ed.). The Mediterranean fisheries sector. A reference publication for the VII meeting of Ministers of agriculture and fisheries of CIHEAM member countries (Zaragoza, Spain, 4 february 2008).Zaragoza : CIHEAM / FAO / GFCM, 2008. pp. 87-96 (Options Méditerranéennes : Série B. Etudes et Recherches; n. 62)

Scacco, U., Andaloro, F., Campagnuolo, S., Castriota, L. and M. Vacchi. 2002. Cartilaginous fishes as a component of trawl discard in the strait of Sicily. Northwest Atlantic Fisheries Organization. Scientific Council Meeting – September 2002. NAFO SCR Doc. 02/87. Serial No. N4708.

Schembri, T., Fergusson, I.K. and P.J. Schembri. 2003. Revision of the records of shark and ray species from the Maltese Islands (Chordata: Chondrichthyes). *The Central Mediterranean Naturalist* 4(1): 71-104.

Serena, F. 2005. *Field identification guide to the sharks and rays of the Mediterranean and Black Sea*. FAO Species Identification Guide for Fishery Purposes. FAO, Rome.

Shark Trust. 2010. An Illustrated Compendium of Sharks, Skates, Rays and Chimaera. Chapter 1: The British Isles and Northeast Atlantic. Part 2: Sharks.

Shelmerdine, R.L. and G. Cliff. 2006. Sharks caught in the protective gill nets off KwaZulu-Natal, South Africa. 12. The African angel shark *Squatina africana* (Regan). *Afr J of Mar Sci* 28 (3-4): 581-588.

Sim, J-S., Im, A-R., Cho, S.M. and H.J. Jang. 2007. Evaluation of chondroitin sulfate in shark cartilage powder as a dietary supplement: Raw materials and finish products. *Food Chem* 101: 532-539

Soldo, A. 2006. Status of the sharks in the Adriatic. Proceedings of the International Workshop on Mediterranean Cartilaginous Fish with Emphasis on Southern and Eastern Mediterranean, Turkish Marine Research Foundation, Istanbul. Pp. 209-214.

Scientific, Technical and Economic Committee for Fisheries (STECF). 2013. The 2013 Annual Economic Report on the EU Fishing Fleet (STECF-13-15). Publications Office of the European Union, Luxembourg, EUR 26158 EN, JRC 84745, 302 pp.

Stelbrink, B., von Rintelen, T., Cliff, G. and J. Kriwet. 2010. Molecular systematics and global phylogeography of angel sharks (genus *Squatina*). *Mol Phylogenet Evol* 54(2): 395-404.

Strømme, T. 1984. Report on the R/V DR FRIDTJOF NANSEN fish resource survey off West Africa: Morocco to Ghana and Cape Verde Islands May 1981-March 1982. CECAF/ECAF Series 84/29, FAO, Rome. Available at: http://www.fao.org/docrep/003/q8364e/Q8364E00.htm

Sunye, P.S. and C.M. Vooren. 1997. On cloacal gestation in angel sharks from southern Brazil. *J Fish Biol* 50: 86-94

Tokaç, A., Gücü, A.C. and B. Öztürk. (Eds.). 2012. The State of the Turkish Fisheries. Publication Number: 34, Published by Turkish Marine Research Foundation, Istanbul, Turkey.

Tonachella, N. 2010. 2010 focus on GFCM-SAC Priority Species status, 2010. FAO/GFCM. Rome, Italy. 44 p.

Tortonese, E. 1956. Leptocardia, Cyclostomata, Selachii. Fauna d'Italia. Edizioni Calderini, Bologna, 545 pp.

Turkish Statistical Institute. 2014. Fishery Statistics 2013. Agricultural Production Statistics Group. Publication Number 4349.

Ulman, A. Bekişoğlu, Ş., Zengin, M., Knudsen, S., Ünal, V., Mathews, C., Harper, S., Zeller, D. and D. Pauly. 2013. Supplementary Data "From bonito to anchovy: a reconstruction of Turkey's marine fisheries catches (1950-2010)." *Med Mar Sci* 14(2): 309-342.

Ünal, V., Acarli, D. and A. Gordoa. 2010. Characteristics of marine recreational fishing in the Çanakkale Strait (Turkey). *Medit Mar Sci* 11(2): 315-330.

UNEP-MAP RAC/SPA. 2005. Chondrichthyan fishes of Libya: Proposal for a research programme. By Seret, B. Ed. RAC/SPA, Tunis. 31pp

Ungaro, N., Marano, G., Marsan, R. and K. Osmani. 1998. Demersal fish assemblage biodiversity as an index of fishery resources exploitation. *Italian J Zool* 65. Suppl: 511-516.

Vallejo, J.R. and J.A. González. 2014. Fish-based remedies in Spanish ethnomedicine: a review from a historical perspective. *Journal of Ethnobiology and Ethnomedicine* 10:37. http://www.ethnobiomed.com/content/10/1/37

Vaz, D.F.B. and M.R. De Carvalho. 2013. Morphological and taxonomic revision of species of *Squatina* from the Southwestern Atlantic Ocean (Chondrichthyes: Squatiniformes: Squatinidae). *Zootaxa* 3695: 1-81.

Vidal, J. 2012a. Senegal revokes licences of foreign fishing trawlers. The Guardian.Com Online, Guardian Global development. May 4th. Accessed April 28, 2015 at: http://www.theguardian.com/environment/2012/may/04/senegal-revokes-licences-foreign-fishing-vessels

Vidal, J. 2012b. Senegal's fishing community will act on foreign fleets if government doesn't. The Guardian.Com Online, Guardian Global development. April 2nd. Accessed April 28, 2015 at: http://www.theguardian.com/global-development/2012/apr/02/senegal-fishing-community-act-foreign-fleets

Zoological Society of London (ZSL). 2014. Angel Shark Conservation Project. Webpage available at: http://www.zsl.org/conservation/regions/uk-europe/angel-shark-conservation-project