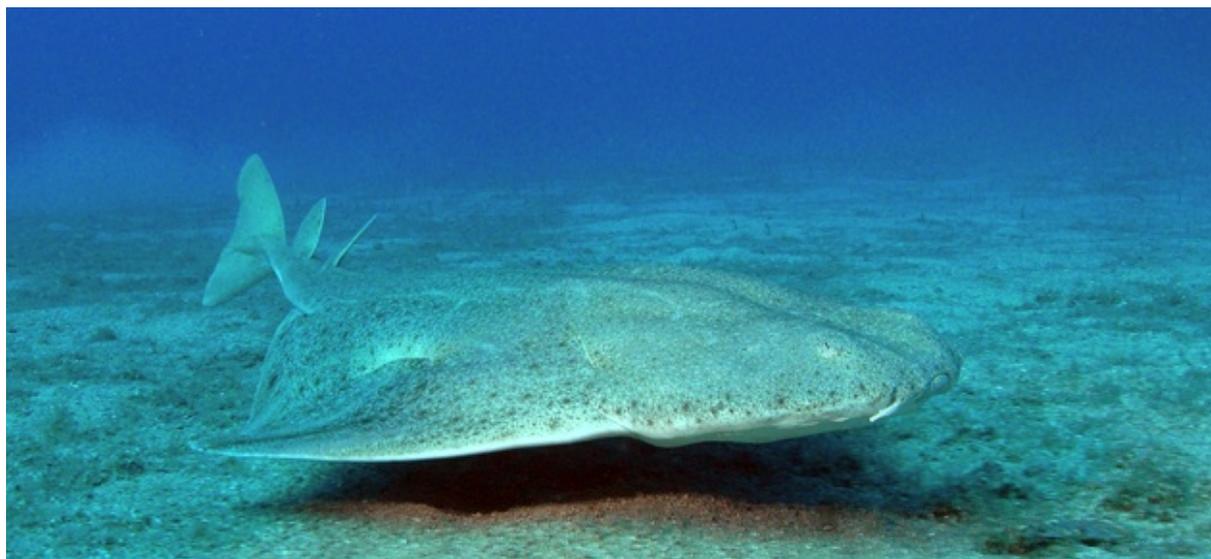


Draft Status Review Report of 3 Species of Angelsharks: *Squatina aculeata*, *S. oculata*, and *S. squatina*



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



Margaret H. Miller
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National Marine Fisheries Service
National Oceanic and Atmospheric Administration
Silver Spring, MD

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EXECUTIVE SUMMARY

This draft 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 draft report is the status review for three of the five angelshark species, namely, *Squatina aculeata*, *Squatina oculata*, and *Squatina squatina*. This draft 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 and off the Balearic Islands. 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, and off the Balearic Islands. 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, Adriatic Sea and Black 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 compensatory 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 petition¹ 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 May 2015.

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).

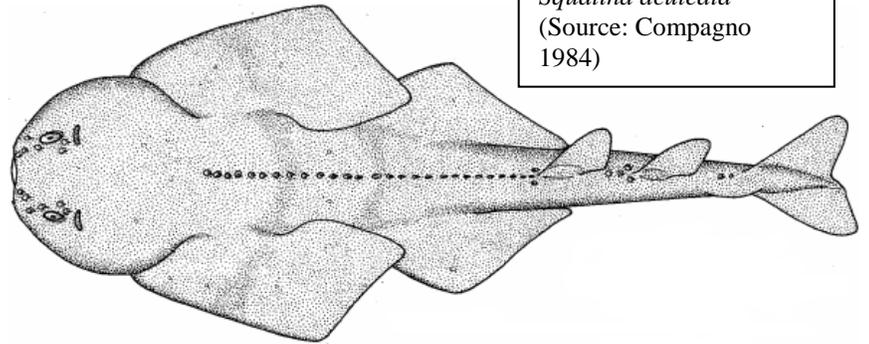


Figure 1. Dorsal view of *Squatina aculeata* (Source: Compagno 1984)

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).

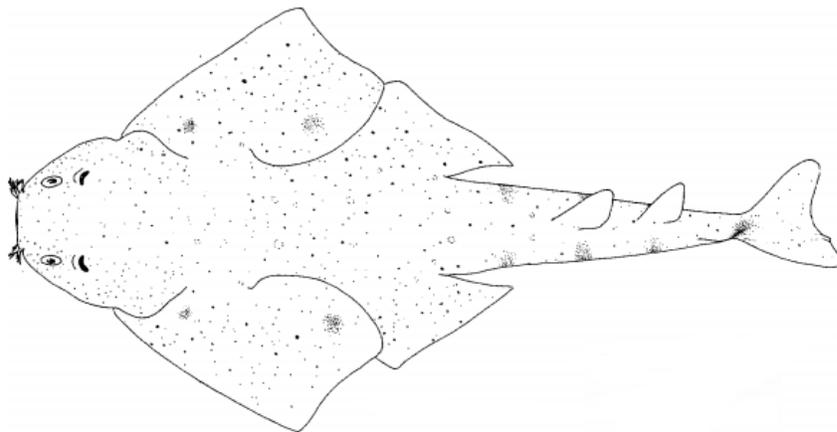


Figure 2. Dorsal view of *Squatina oculata* (Source: Compagno 1984)

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).

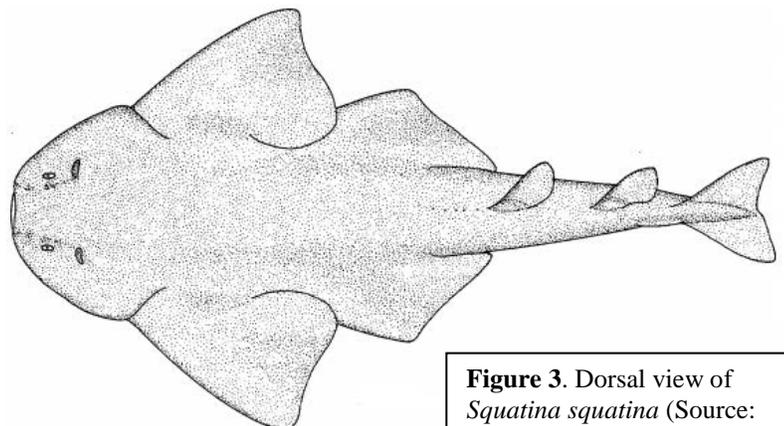


Figure 3. Dorsal view of *Squatina squatina* (Source: Compagno 1984)

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).



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). 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).

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

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.

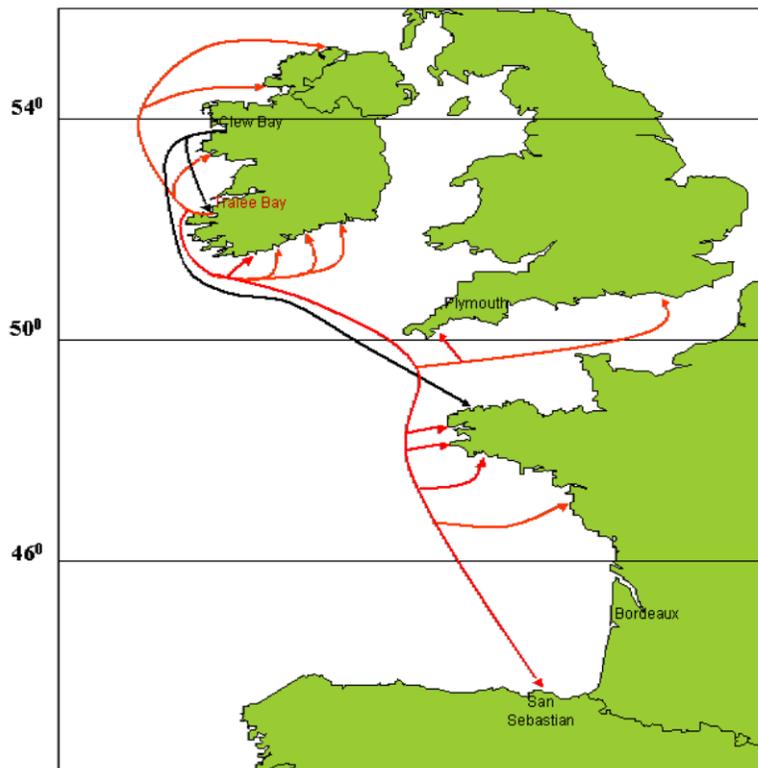


Figure 8. Migration patterns based on locations of recaptured tagged *S. squatina* sharks (n=190) from 1970 to 2006. Black lines represent recapture locations of sharks released in Clew Bay and red lines represent recapture locations of sharks released in Tralee Bay. (Source: OSPAR Commission 2010)

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 environment 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 at 160 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, with size at birth from 24 cm to 30 cm (Osaer 2009; Tonachella 2010). 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 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, which is a bit smaller than the values estimated elsewhere. Weight has been recorded up to 80 kg (Quigley 2006). In the Mediterranean, birthing occurs 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).

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* based on observations of female aggregations. Additionally, 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 several years (Alianza Tiburones Canarias 2014).

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)).

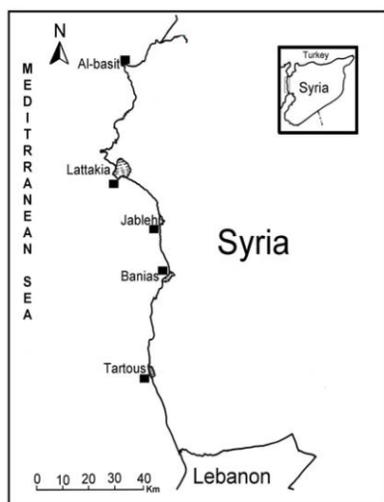


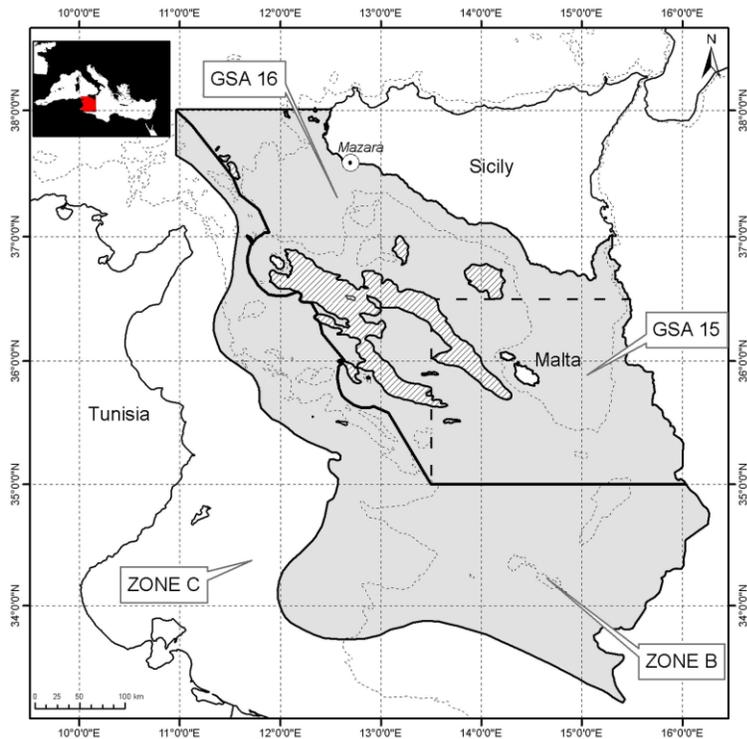
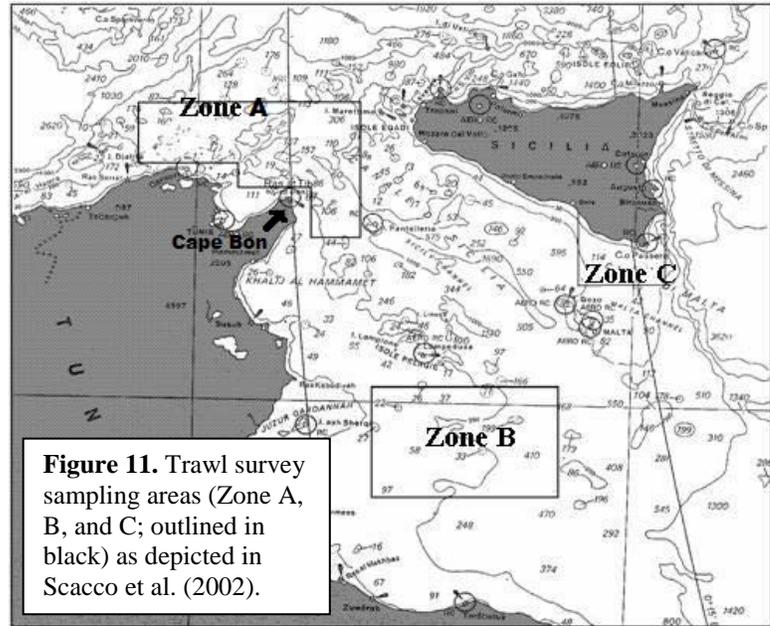
Figure 10. Sampling locations depicted in Saad et al. (2006).

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. 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).

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.



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, and I was unable to find information on the present abundance of the species in these waters.

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, extensive bottom trawl surveys conducted from 1994-2005 throughout the Adriatic Sea have also failed to locate the species in these waters (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) and 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). 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. Additional and more expansive surveys in this area are needed to confirm this conclusion.

Eastern Atlantic

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 the 1970s 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 squatid 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.

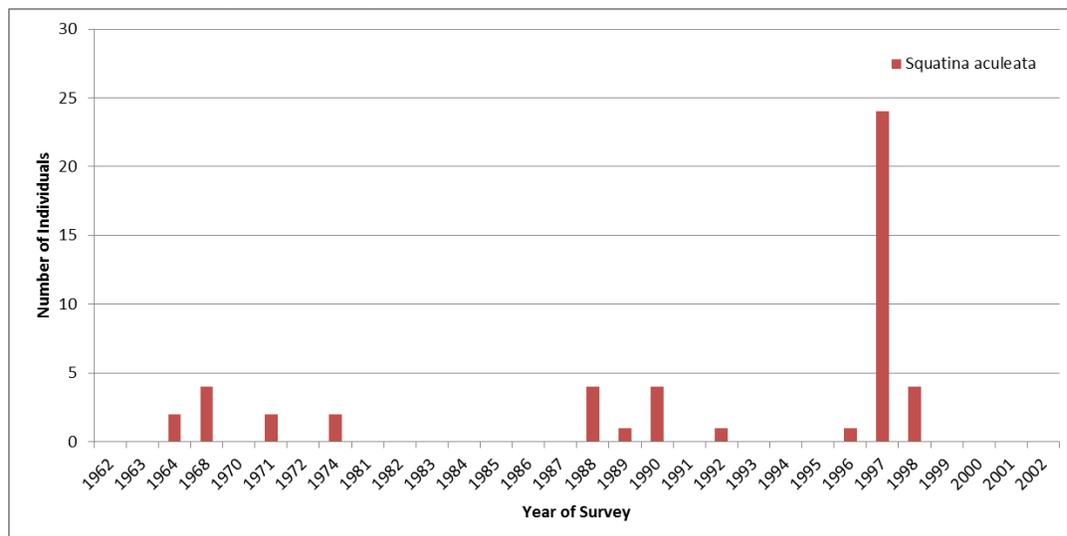


Figure 13. Number of *Squatina aculeata* individuals observed in trawl surveys conducted off the coast of West Africa from 1962 to 2002. (Source: SIAP project database)

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 northern Tyrrhenian Sea and off the Balearic Islands. 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 (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. 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).

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).

Eastern Atlantic

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 squatiniid 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).

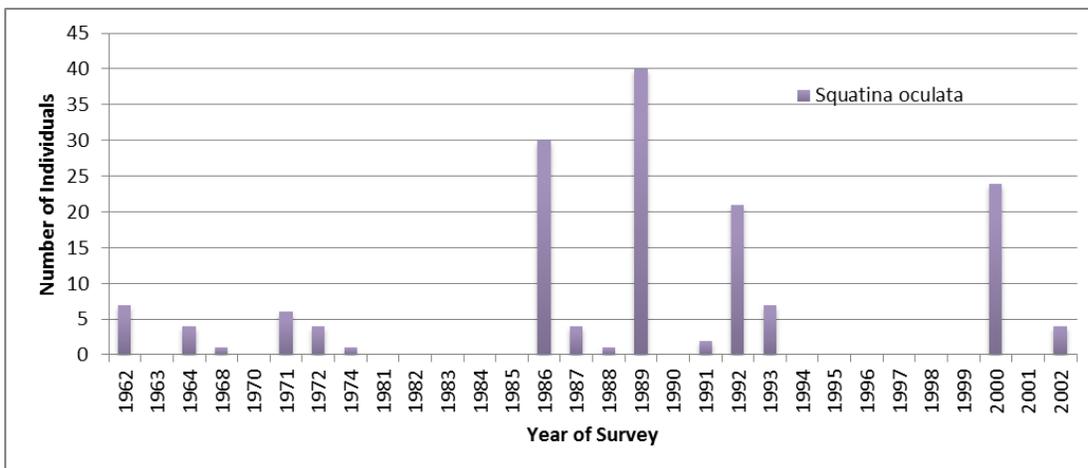


Figure 14. Number of *Squatina oculata* individuals observed in trawl surveys conducted off the coast of West Africa from 1962 to 2002. (Source: SIAP project database)

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, northern Tyrrhenian Sea, and off the Balearic Islands, 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).

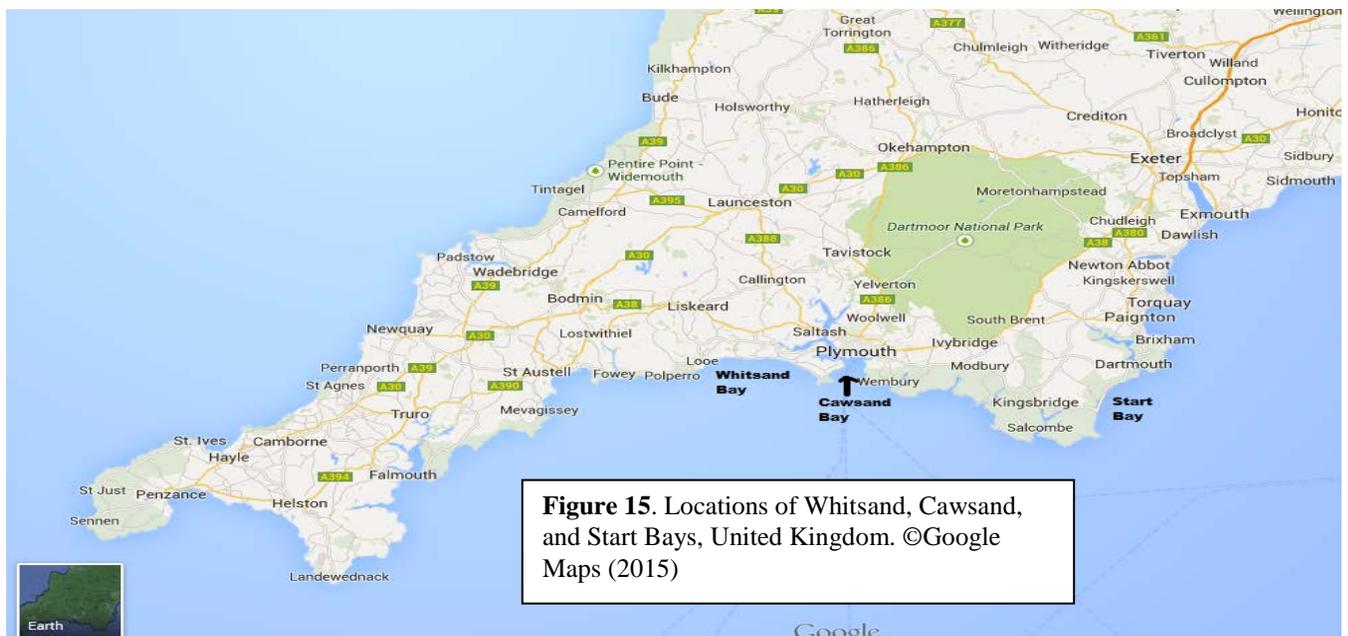


Figure 15. Locations of Whitsand, Cawsand, and Start Bays, United Kingdom. ©Google Maps (2015)

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.

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

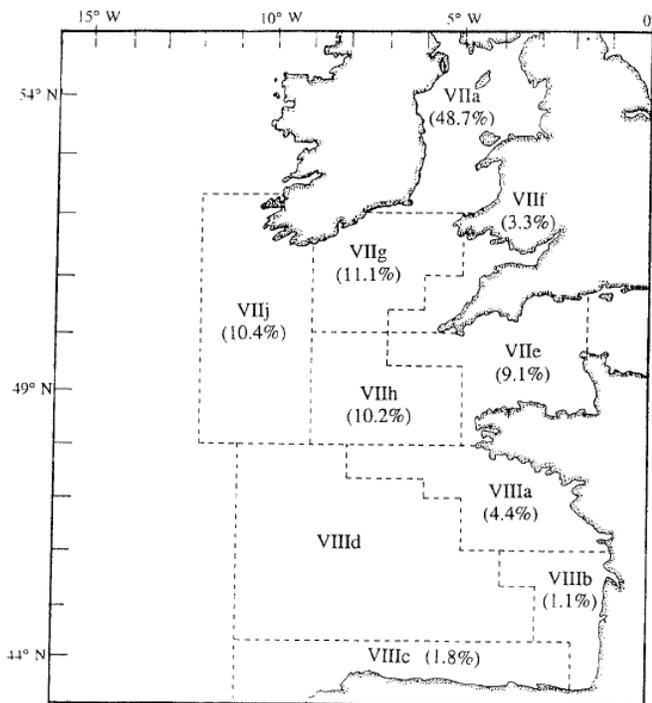


Figure 16. Map showing the ICES areas where groundfish surveys were conducted between 1981 and 1983. The number of trawls conducted in a certain area is given as the percentage of the total number of trawls

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.

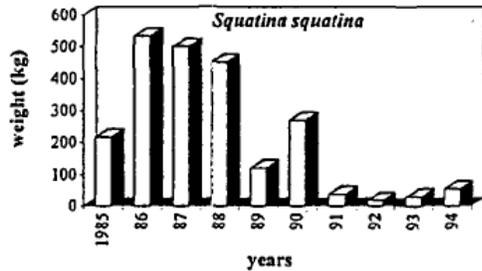
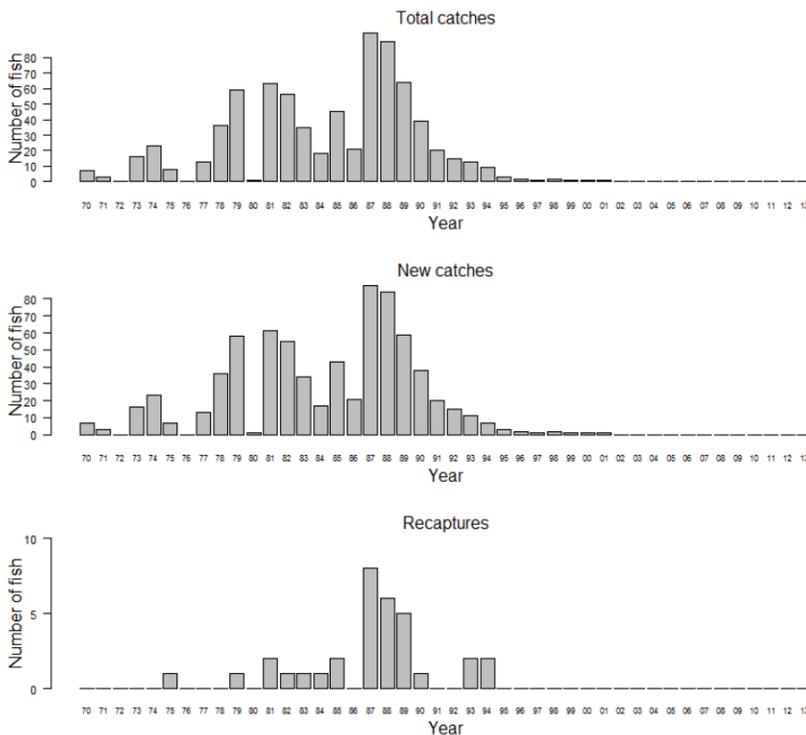


Figure 17. Landings (kg) of *S. squatina* at Arcachon, France from 1985 to 1994. (Source Quéro 1998)

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 the 1960s, *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

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)

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.

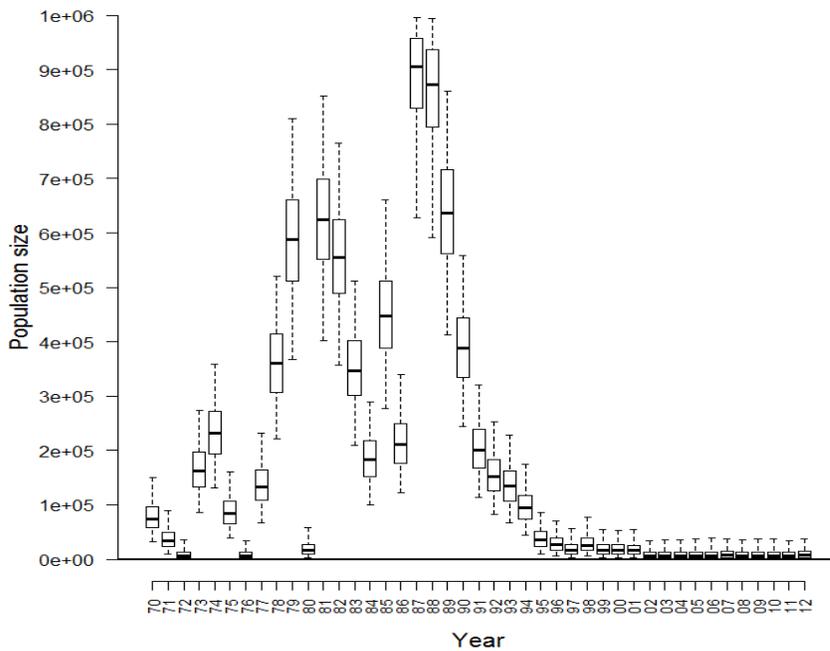


Figure 19. Boxplots of the annual population sizes posteriors for *S. squatina* in Tralee Bay (Source: ICES 2014).

Mediterranean Sea

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, Adriatic Sea, and northern Tyrrhenian Sea (Jukic-Peladic et al. 2001; Ferretti et al. 2005; Morey et al. 2006; OSPAR Commission 2010; 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) and in the Adriatic Sea (Tortonese 1956). However, Ferretti et al. (2005) noted the disappearance of the entire *Squatina* genus from the northern Tyrrhenian Sea in the early 1970s. Trawl surveys conducted from 1995-1999 in the Strait of Sicily recorded *S. squatina* near Cape Bon, Tunisia with a biomass that comprised 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). 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). 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).

Eastern Atlantic

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). 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 (www.programaposeidon.eu) (J. Barker, pers. comm. 2014). Since the launch of the Poseidon portal in April 2014, there have been 624 validated records (sightings of angelsharks), covering areas with no previous records such as El Hierro and La Palma (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, a few dive centers have been collecting observational data even prior to the creation of the Poseidon portal. For example, 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. 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 and were highest in January and February, with the majority of sightings occurring in relatively shallow waters (of depths around 9 m) and less than 50 m from the coastline.

The Davy Jones Diving dive center continues to log sightings of angelsharks and other species on its website (available at: <http://www.davyjonesdiving.com/diving/p50-diving-conditions-log.shtml>). 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).

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, northern Tyrrhenian Sea, Adriatic Sea, and Black Sea. 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), the Adriatic Sea (Jukic-Peladic et al. 2001; Dulvy et al. 2003), northern Tyrrhenian Sea (Ferretti et al. 2005), and Black Sea (OSPAR Commission 2010). 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, 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 northern Tyrrhenian Sea (where it was part of commercial landings in the 1970s), and off the Balearic Islands (where angelsharks were historically common). For *S. oculata*, the species may no longer be found in the Aegean Sea, northern Tyrrhenian Sea, and off the Balearic Islands, 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.

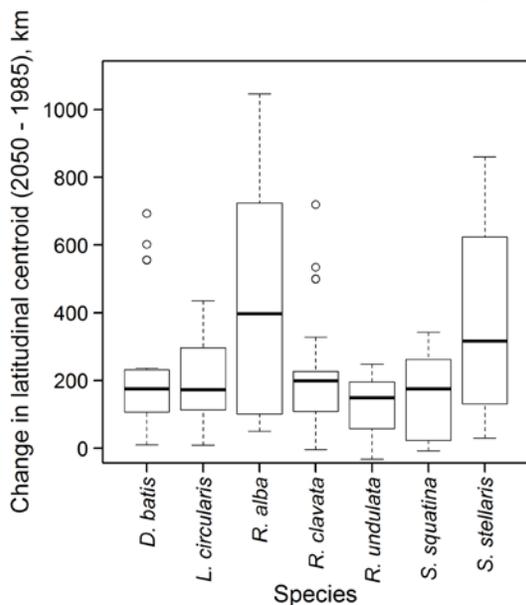


Figure 20. Predicted change in latitudinal centroid distribution (km) by 2050 relative to 1985 for 7 species in the North Sea. The box whiskers represent the extreme data points within 1.5 times the inter-quartile range from the lower and upper quartiles. Circles represent data points outside of these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

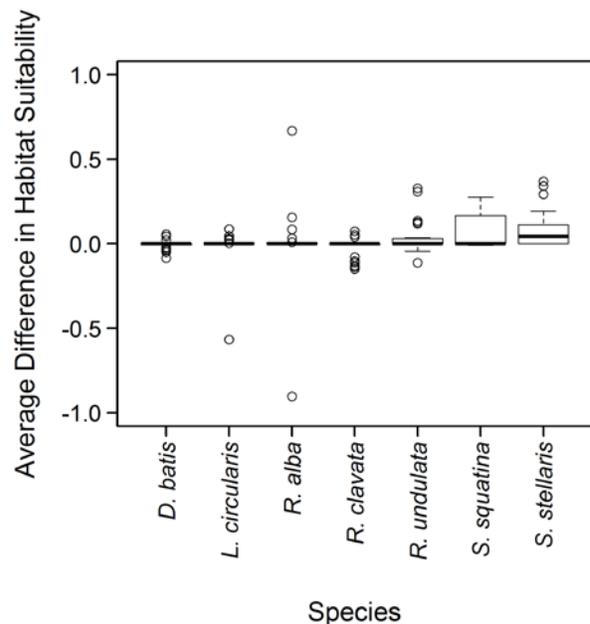


Figure 21. Predicted change in relative habitat suitability between 1985 and 2050 for 7 species in the North Sea. The box whiskers represent the extreme data points within 1.5 times the inter-quartile range from the lower and upper quartiles. Circles represent data points outside of these extremes (Source: 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, historical fishing gear called “squaenara” or “squadra” were purposely built to catch angelsharks (EVOMED 2011), suggesting a level of abundance that would warrant specialized gear and targeting of the species. 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 Quérou 1998). This exploitation continued for much of the 19th and early 20th centuries, with *S. squatina* sold 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; D. Quigley, pers. comm. 2015 citing Rutton (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, with no recent updates on the status or presence of these species from those areas. 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 absent based on recent 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 km²), 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 trawl 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). 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).

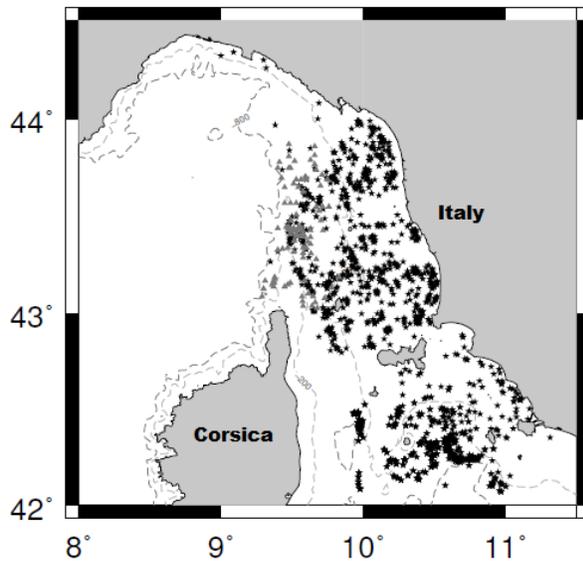


Figure 22. Map of the tows covering the continental shelf and upper slope of the Tuscan coast conducted from 1972-1974 and between 1985 and 2004 as depicted in Ferretti et al. (2005).

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). In addition, the *Squatina* species are 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].

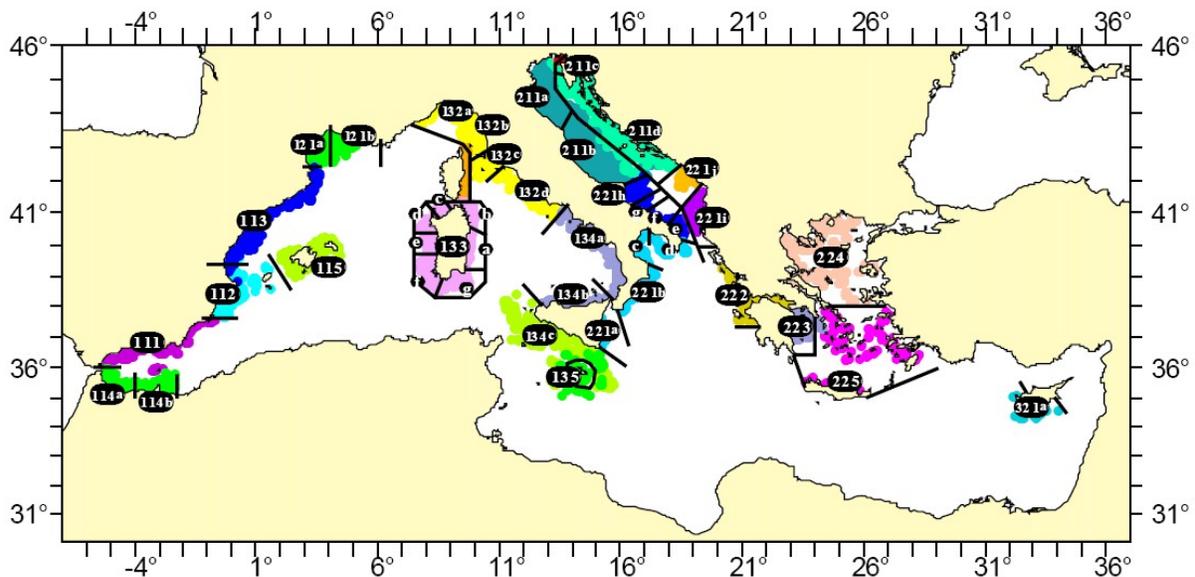


Figure 23. MEDITS survey coverage (sampling areas identified by various colors) (Source: © S.I.B.M. 2013-2014; www.sibm.it).

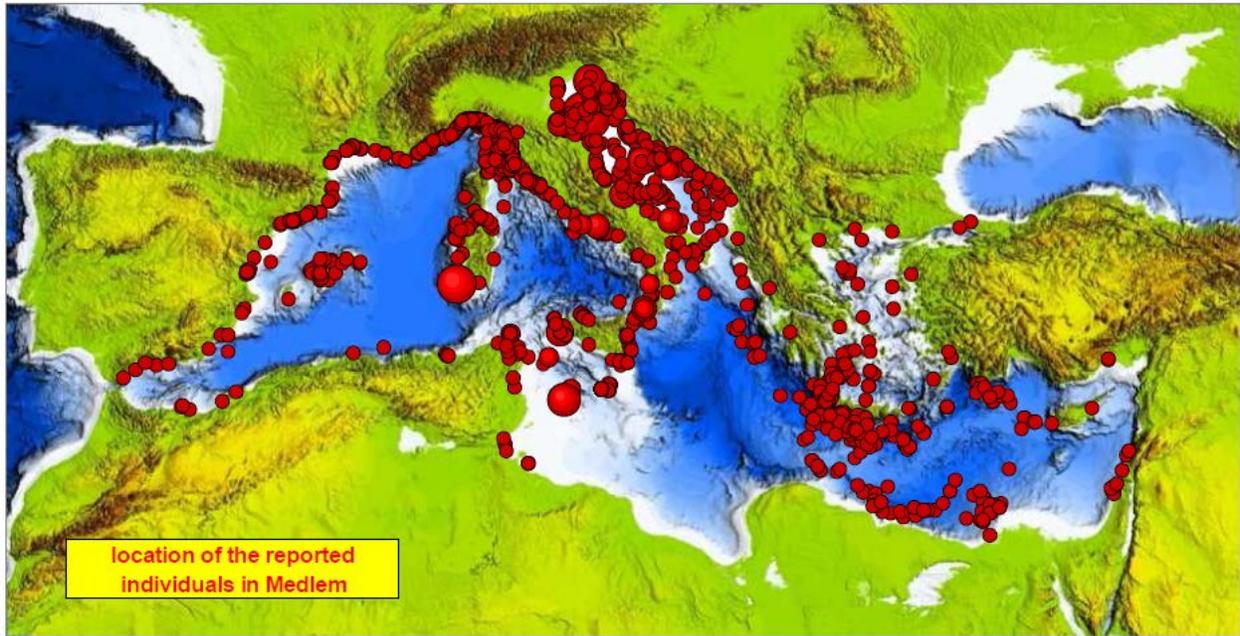


Figure 24. MEDLAM program reported locations of individual elasmobranchs. (Source: Baino et al. 2012)

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).

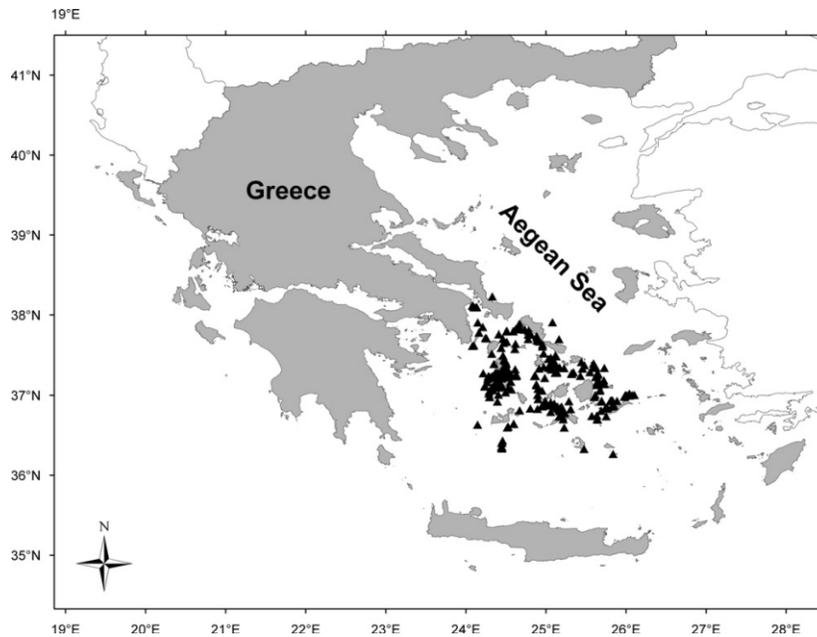


Figure 25. Map of the trawl sampling stations conducted from 1995 to 2006 as depicted in Damalas and Vassilopoulou (2011).

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; Ferretti 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-Peladic 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).

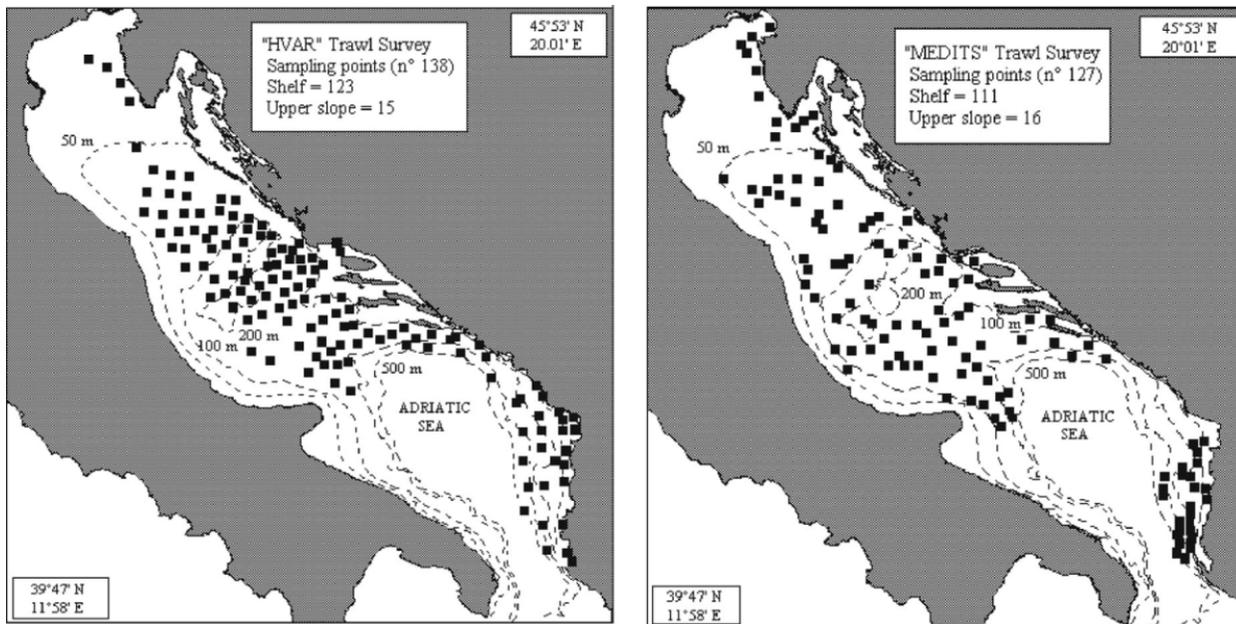


Figure 26. Trawl survey sampling points from the 1948 “HVAR” survey (on left) and 1998 MEDITS survey (on right). (Source: Jukic-Peladic et al. 2001)

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).

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

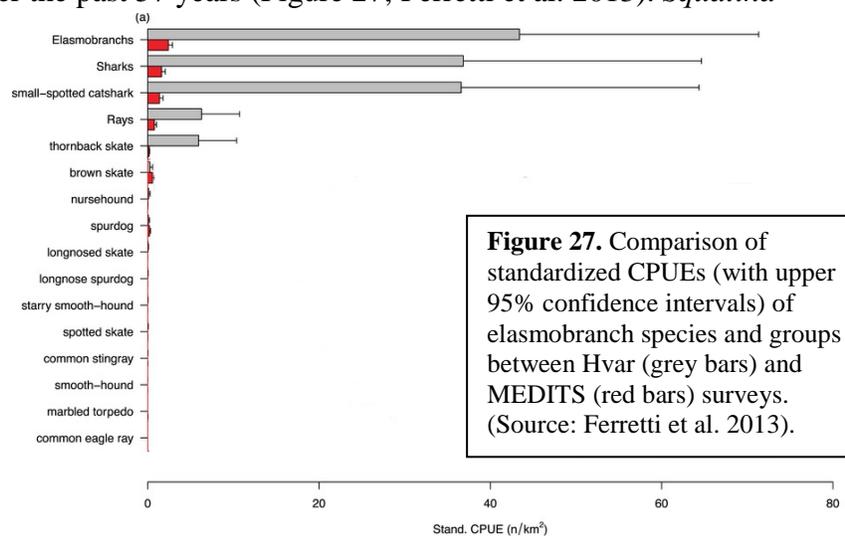


Figure 27. Comparison of standardized CPUEs (with upper 95% confidence intervals) of elasmobranch species and groups between Hvar (grey bars) and MEDITS (red bars) surveys. (Source: Ferretti et al. 2013).

species and likely caused the apparent extirpation of *Squatina* species within the Adriatic Sea.

In addition to these fishery-independent survey data, analyses of commercial landings 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 $10,583 \pm 2,599$ t compared to $2,014 \pm 1681$ 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.

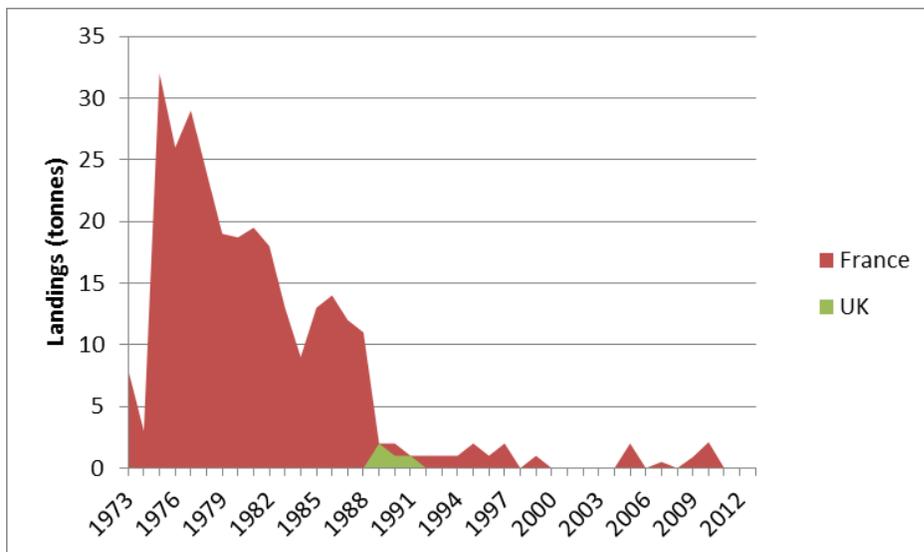


Figure 28. Total landings (tonnes) of *S. squatina* by French (FRA) and UK vessels from 1973 to 2013 in the Celtic Sea (Source: ICES 2014).

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). 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. Coelho, 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 the 1960s, *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 1964² 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 1965³ 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, 1967⁴, 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*

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/>

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 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 al. 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

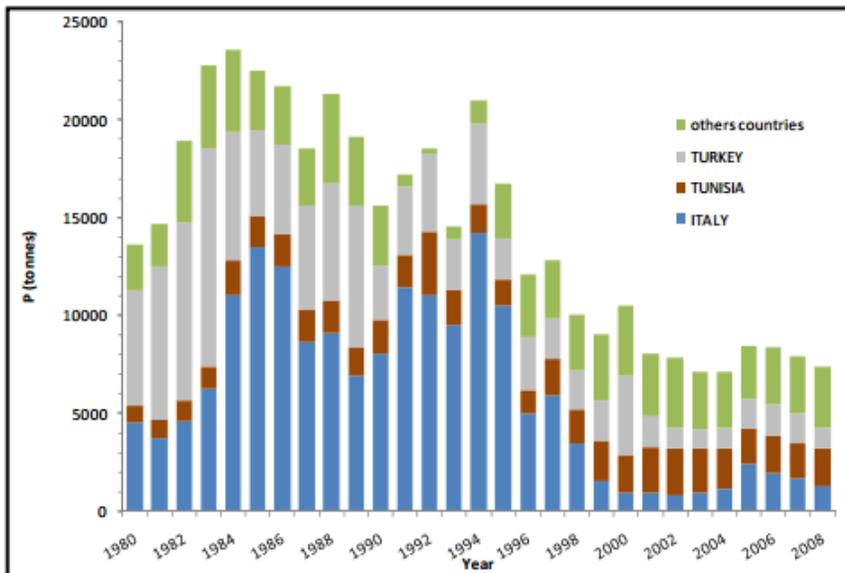


Figure 29. Elasmobranch catch (mt) in the Mediterranean and Black Sea, highlighting the contribution of Turkey, Tunisia, and Italy. (Source: Bradai et al. 2012)

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.

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 (Echwikihi 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.

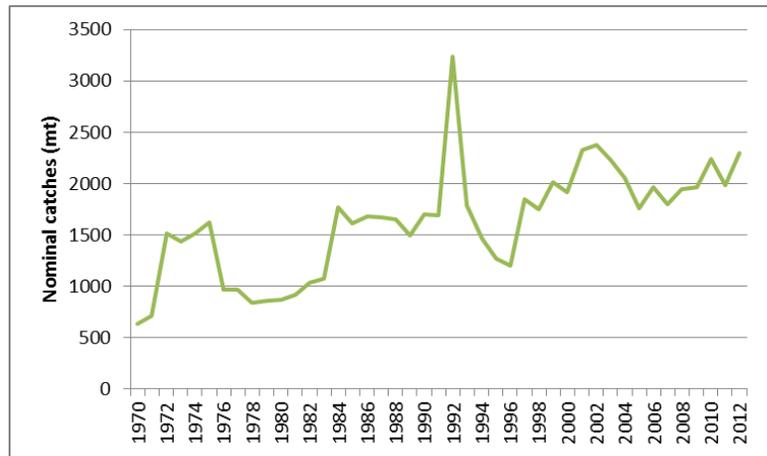


Figure 30. Nominal catches (mt) of elasmobranchs landed by Tunisia from 1970 to 2012. (Source: FAO Global Capture Production Database)

In terms of current species-specific information, I could only find data on *S. squatina* catches in

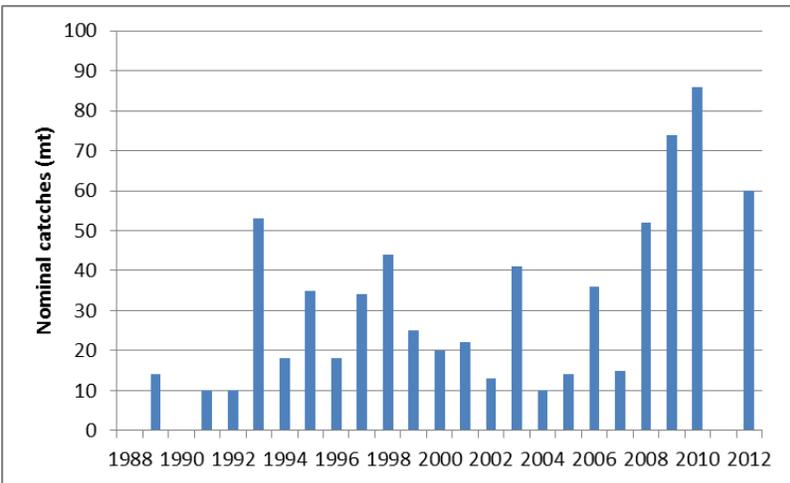


Figure 31. Nominal catches (mt) of *S. squatina* landed by Tunisia from 1988 to 2012. (Source: FAO Global Capture Production Database)

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; 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 (Ragonese et al. 2013; Bradai et al. 2006), 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. Ferretti 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. aculeata* shark from Gökova Bay by a fisherman using a trammel net (V. Ünal, personal communication 2015). This individual (a

female *S. aculeata*) is the largest specimen ever recorded from Turkish waters (V. Ünal, pers. comm. 2015).



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

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

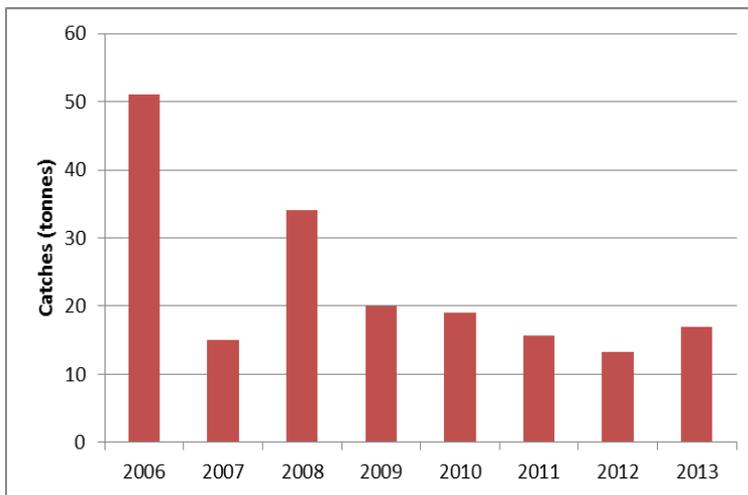


Figure 33. Catches (tonnes) of angelsharks in Turkey (Source: Fishery Statistics Publications; Turkish Statistical Institute; <http://www.turkstat.gov.tr/>)

Catches of angelsharks in Turkey declined over the past 8 years after a peak of 51 tonnes was reported in 2006 (Figure 32). 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.

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. 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 angelsharks⁵ 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). Although *S. squatina* are assumed to be fairly common around the Canary Islands, very little is known about this population or the associated risks of this level of utilization (by sport fishermen and artisanal fishermen) on the local population. Research is presently being conducted to examine species distribution and habitat use throughout the Canary Islands, with preliminary findings expected in the spring/summer of 2015 (E. Meyers and J. Barker, pers. comm. 2014).

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 squatid species (C.

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>

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). Although not as common anymore, this information suggests that *S. oculata*, and *S. aculeata*, were and potentially still are susceptible to being caught in artisanal fishing gear. 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; however, 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

All three species are listed on Annex II of 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.” Additionally, 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. 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*..

In 2009, *S. squatina* received full protection in EU waters from the European Council (Council Regulation (EC) 43/2009). European Union vessels are currently prohibited from fishing for, retaining on board, transshipping, or landing *S. squatina* in all EU waters (including EU waters within the Mediterranean Sea) (EC 23/2010, 57/2011, 43/2012, 39/2013, 43/2014). This retention prohibition may decrease, to some extent, fisheries-related mortality of the species, especially in those parts of its range where the species was previously landed. However, for the most part, it appears that the species is normally discarded due to its low commercial value. Therefore, without further information on the survival rate of the species when bycaught by the trawl and demersal line fisheries throughout its range, it is unknown whether this regulatory mechanism will decrease *S. squatina*’s risk of extinction.

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.

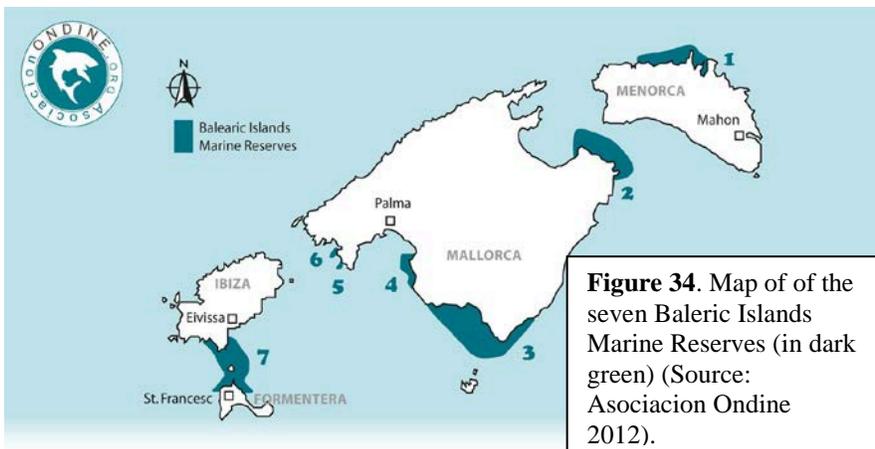
In terms of commercial fishing, a major threat identified for the angelsharks in Irish waters was the overutilization (in the form of bycatch) of the species by commercial fishermen using trammel nets. In 2002, a regulation (SI – Statutory Instrument) was implemented prohibiting the use of trammel nets 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 prohibitions 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.



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 Turkish waters, created to protect certain species; however, none have been designated with the intention of sustaining fisheries (Begun et al. 2012). Additionally, according to Begun et al. (2012), the designation objectives as well as protection measures vary greatly by MPA 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).

Within the Canary Islands, the EU prohibited bottom trawling throughout the EEZ in 2005 ((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. squatina*, contributing to its past decline, this prohibition will provide 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 Asociación 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

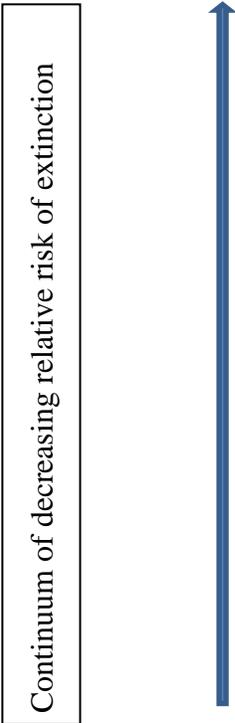
The SCUBA diving industry is a significant contributor to the local economy in the Canary Islands. In a study on the economic benefits of diving with sharks and rays in the area, Modino (2011) estimated that this tourism activity brings in more than 10 million Euros annually to the economy. In fact, 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:

Qualitative ‘Reference Levels’ of Relative Extinction Risk

 <p>Continuum of decreasing relative risk of extinction</p>	<p><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.</p> <p><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.</p> <p><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.</p>
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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.

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; 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, and off the Balearic Islands. 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; 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 central Mediterranean (i.e., Libya) and 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 compensatory 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, Adriatic Sea, and Black Sea, and 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; 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 3-year 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. 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. Although it is unknown if *S. squatina* 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 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 unknown, may be confined to this small geographic area. With limited inter-population exchange, its susceptibility to natural environmental and demographic fluctuations 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* 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. 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 (Lanzarote, 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).

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 Aquarium 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.

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