ENDANGERED SPECIES ACT
STATUS REVIEW OF THE SPINY ANGEL SHARK
(*Squatina guggenheim*)

Grace A. Casselberry[1] and John K. Carlson[2]

[1]Contractor with Riverside Technology, Inc. in support of NOAA Fisheries Service, Southeast Fisheries Science Center
[2]NOAA Fisheries Service, Southeast Fisheries Science Center-Panama City Laboratory

Acknowledgements
We would like to thank David Ebert (Moss Landing Marine Laboratory) for providing various unpublished Dwayne Meadows and Marta Nammack provided comments on an earlier version of this document documents referenced in this text. We would also like to thank the following peer reviewers: Ivy E. Baremore and Luis O. Lucifora. Dwayne Meadows and Marta Nammack provided comments on an earlier version of this document

This document should be cited as:

Casselberry, G.A. and J.K. Carlson. 2015. Endangered Species Act Status Review of the spiny angel shark (*Squatina guggenheim*). Report to the National Marine Fisheries Service, Office of Protected Resources. SFD Contribution PCB-15-10.

Executive Summary

This status review report was conducted in response to a petition received from WildEarth Guardians on July 8, 2013 to list 81 marine species as endangered or threatened under the Endangered Species Act (ESA). NMFS evaluated the petition to determine whether the petitioner provided substantial information indicating that the petitioned action may be warranted, as required by the ESA. In a *Federal Register* notice on November 19, 2013 (79 FR 69376), NMFS determined that the petition did present substantial scientific and commercial information, or cited such information in other sources, that the petitioned action may be warranted for 19 species and 3 subpopulations of sharks, and thus NMFS initiated a status review of those species. This status review report considers the biology, distribution, and abundance of and threats to a shark species from the Southwestern Atlantic, *Squatina guggenheim* (spiny angel shark).

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INTRODUCTION

Scope and Intent of the Present Document

On July 8, 2013, the National Marine Fisheries Service (NMFS) received a petition from WildEarth Guardians to list 81 species of marine organisms as endangered or threatened species under the Endangered Species Act (ESA) and to designate critical habitat. NMFS evaluated the information in the petition to determine whether the petitioner provided "substantial information" indicating that the petitioned action may be warranted, as required by the 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)). NMFS decided that the petition presented substantial scientific information indicating that listing may be warranted and that a status review was necessary for spiny angel shark, *Squatina guggenheim*; (79 FR 69376, 19 November 2013). Experts and members of the public were requested to submit information to NMFS to assist in the status review process from November 19 through January 21, 2014.

The ESA stipulates that listing determinations should be made on the basis of the best scientific and commercial information available. This document is a compilation of the best available scientific and commercial information on the biology, distribution, and abundance of and threats to the spiny angel shark in response to the petition and 90-day finding. Where available, we provide literature citations to review articles that provide even more extensive citations for each topic. Data and information were reviewed through 30-June 2014.

LIFE HISTORY

Taxonomy and Anatomy

The spiny angel shark (*Squatina guggenheim*) is a chondrichthyan member of the family Squatinidae that can be found in the southwestern Atlantic Ocean from southern Brazil to Argentina (Chiaramonte and Vooren 2007). In English, it is also called the angular angel shark (Colonello et al. 2007, Chiaramonte and Vooren 2007, Awruch et al. 2008). Portuguese common names include *tubarão-anjo-oculto* and *caçao-anjo-espinhoso* (Soto 2001, Silva 2004), and the Spanish common names are *pez ángel, escuadro,* and *angelote* (Awruch et al. 2008, Perier et al. 2011).

The taxonomy of angel sharks of the southwestern Atlantic Ocean has been a source of ongoing controversy (Chiaramonte and Vooren 2007). Due to similar morphological characteristics, *S. argentina, S. guggenheim, S. occulta*, and *S. punctata* have been variously synonymized with each other (Compagno 2005, Chiaramonte and Vooren 2007, de Carvalho 2012). Currently, *S. punctata* is considered a junior synonym of *S. guggenheim* (Vooren and da Silva 1991, de Carvalho et al. 2012, Vaz and Carvalho 2013). Extensive studies of the morphotypes that occur in southern Brazil and the southwestern Atlantic, concluded *S. argentina, S. guggenheim,* and *S. occulta* are three different species that can be distinguished by morphological differences as well as life history characteristics, such as differences in reproductive patterns, overall size, and depth and temperature preference (Vooren and da Silva 1991, Vaz and Carvalho 2013). An analysis of molecular systematics of angel sharks confirms the validity of *S. guggenheim* and *S. occulta* as separate species (Stelbrink et al. 2010).

The spiny angel shark can most easily be distinguished from its sympatric species by the presence of a median row of spines or tubercles on its dorsal side (Figure 1; Vooren and da Silva 1991, Milessi et al. 2001, Schäfer et al. 2012, Vaz and Carvalho 2013). There are 30-35 spines, which are short, conical, and slightly recurved, between the head and the first dorsal fin. In females less than 50 cm total length (TL) and in all males, 2-7 spines continue beyond the first dorsal fin, ending at the second dorsal fin. As females mature, their dorsal spines become less distinct and take the form of flattened tubercles, while juveniles less than 35 cm TL of both sexes have spines flanked on each side by a diffuse row of smaller spines (Vooren and da Silva 1991). Adult males have small spines on the outermost tips of the dorsal surface of their pectoral fins, that are inclined towards the shark's midline. These spines are likely used by males to maintain their position during mating (Colonello et al. 2007). The distance between the eye and the spiracle is 1.5 times the horizontal diameter of the eye and is approximately 1/3 of the distance between the eyes. The tooth formula varies from 10-10/10-10 to 11-11/11-11 (Vooren and da Silva 1991). The nasal capsules are at the same level as the rostral projections and the width of the nasal region between the preorbital processes was 84% of the neurocranial length (Carvalho et al. 2012). The pectoral fin diameter ranges between 29 to 32 % TL. The outer edges of the pectoral fins are straight and the posterior corners are located nearer to the origin of the pelvic fin than to the outer corner of the pelvic fins (Vooren and da Silva 1991). The ampullae of Lorenzini run along the lateral region of the body almost to the origin of the caudal fin (Schäfer et al. 2012). The dorsal skin is light to dark brown with several white or creamy-white to yellowish large, rounded blotches that are variable in size and symmetrically distributed on the entire dorsal surface (Vaz and Carvalho 2013).

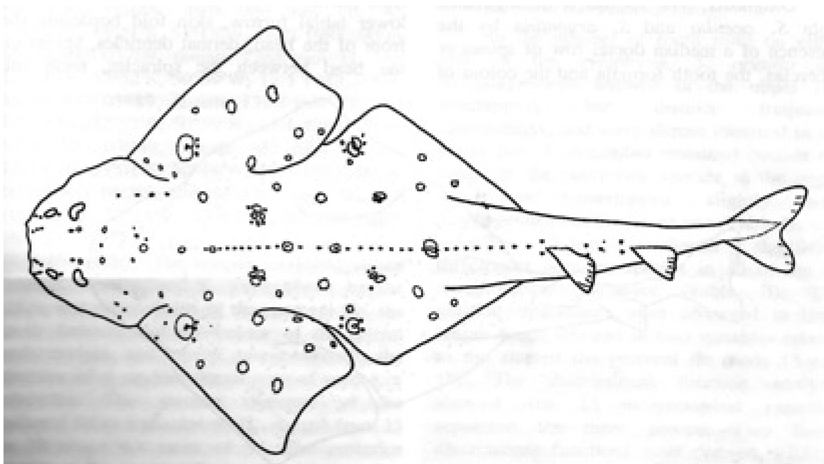

Fig. 5. *Squatina guggenheim* Marini, 1936, MOFURG 05189, female 874 mm TL.

Figure 1. The spiny angel shark based on its re-description by Vooren and da Silva (1991).

Range and Habitat Use

The spiny angel shark is found in the southwestern Atlantic Ocean from Espírito Santo, Brazil, to Rawson, Argentina (Milessi et al. 2001, Vögler et al. 2003, Awruch et al. 2008). It is a primarily coastal, bottom dwelling angel shark (Chiaramonte and Vooren 2007, Crespi-Abril 2013). They prefer depths between 10 and 80 m and temperatures between 10 and 22^{o}C (Vooren and da Silva 1991). They have been reported as deep as 150 m off Argentina (Cousseau 1973, Chiaramonte and Vooren 2007). They live in muddy or sandy bottom substrates are relatively inactive during the day. This nocturnal activity makes them more vulnerable to gillnet fisheries which operate at night (Vooren and Klippel 2005).

In southern Brazil, spiny angel sharks are considered a resident species (Vooren 1997). From 1980-1984 spiny angel sharks were common year round on the southern shelf from Solidão to Chuí at depths between 10 and 100m with some areas recording CPUE densities as high as 50 kg/h (Vooren and Klippel 2005). During the autumn and winter (April-August) adults are found in waters between 40 and 100 m. An inshore migration to depths between 10 and 40 m occurs in the spring and summer (September-March) (Miranda and Vooren 2003). Pupping occurs during this time at depths less than 20 m (Vooren 1997, Miranda and Vooren 2003). Juveniles remain in the shallows for their first year of life (Vooren and da Silva 1991, Vooren 1997, Vooren et al. 2005). The area of Rio Grande do Sul between 31^{o}50'S and 33^{o}30'S at depths less than 20 m is considered a nursery area for spiny angel sharks (Vooren and Klippel 2005). Research surveys off of Ubatuba, São Paulo, Brazil caught spiny angel sharks in shallow sampling stations around 20 m deep and found that they were most abundant near 50 m deep (Rocha et al. 1998).

In northern Argentina, spiny angel sharks are considered to be a eurythermic coastal shelf species with highest abundances on the outer coastal shelf between 28.9 and 49.6 m deep (Jaureguizar et al. 2006). In the Rio de la Plata estuary, Argentina, they were present most frequently in the deepest estuarine zone (12.6-16 m) with salinities between 25 and 34 psu. They are not considered a permanent resident of the estuary, with abundances higher in the summer than during the spring and fall (Jaureguizar et al. 2003).

In the Argentine-Uruguayan Common Fishing Zone, spiny angel shark distribution was influenced by temperature with clear avoidance of water temperatures below 5^{o} and above 20^{o}C. In the spring, animals were concentrated in waters between 13.2 and 18.5^{o}C, and the highest concentrations in the fall were seen between 7.0 and 15.0^{o}C. They prefer salinities between 33.4 and 33.5, with avoidance of salinities below 33.0 and above 34.0. Adult sharks showed stronger temperature and salinity preferences than juveniles. A strong association was found between spiny angel shark presence and thermal horizontal fronts, which indicates that temperature is the principal environmental variable that influences distribution. Spiny angel sharks may also use frontal convergence zones as feeding areas (Vögler et al. 2008).

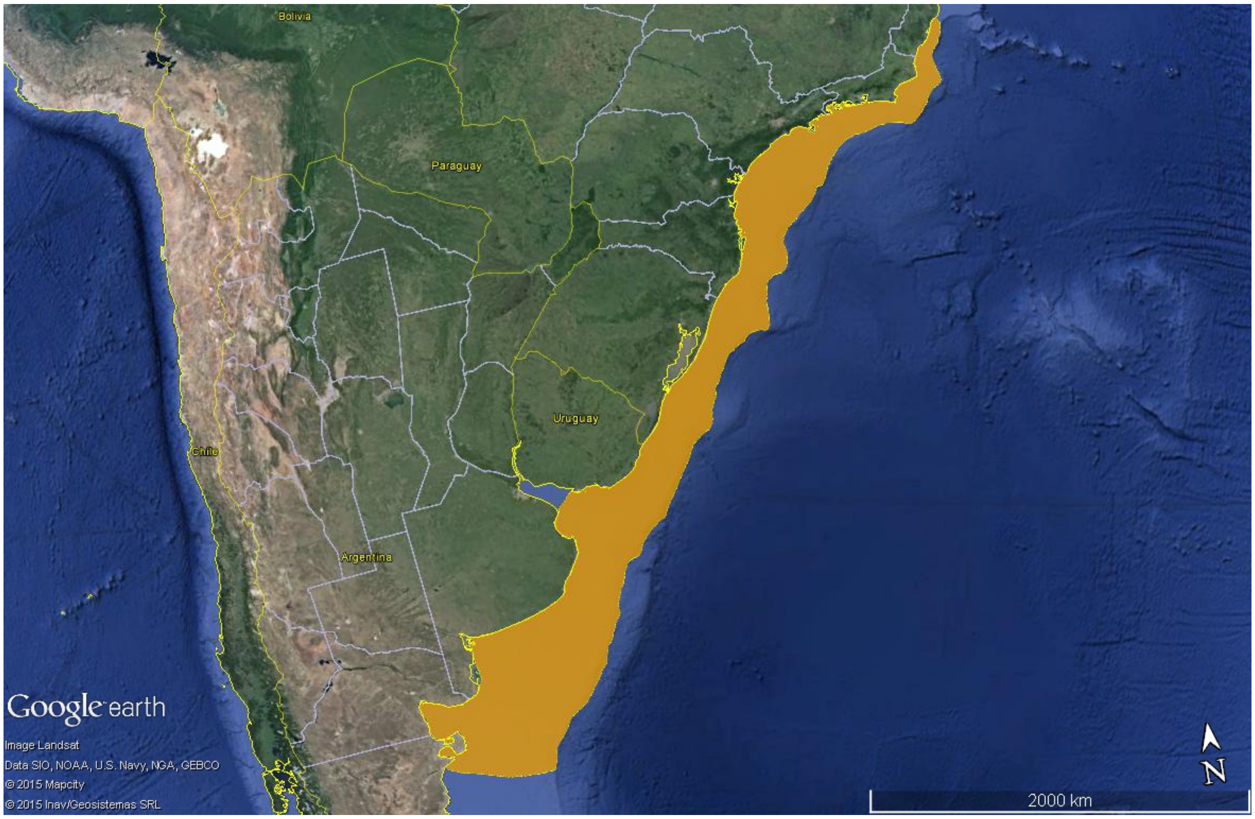

Figure 2. The range of the spiny angel shark from Espírito Santo, Brazil to Rawson, Argentina based on the information gathered in this review.

Diet and Feeding

The spiny angel shark is a mesopredator in southern Brazil's food web (Bornatowski et al. 2014). A study of spiny angel shark trophic ecology has been conducted on individuals living in the Argentine-Uruguayan Common Fishing Zone. Numerically, bony fish made up the vast majority of the diet, at 89.7%. Crustaceans (4.8%), molluscs (4.4%), and polychaetes (0.46%) made up the remaining portions (Vögler et al. 2003). Spiny angel sharks consumed both pelagic and demersal fishes including *Engraulis anchoita*, *Cynoscion guatucupa*, *Patagonotothen ramsayi*, *Notothenia longipes*, and *Merluccius hubbsi*. The crustaceans consumed were primarily shrimps (Penaeidae), while the squid, *Illex argentinus*, was the mollusc species consumed (Vögler et al. 2003, 2009).

Ontogenetic differences in diet were seen. Bony fish were the primary prey item for all size classes (Vögler et al. 2003). Small individuals, less than 60 cm TL, ate mainly small pelagic fishes, and a transition to medium sized benthopelagic fish was seen with increasing size. The size range of fish prey eaten by angel sharks increased with increasing size (Vögler et al. 2009). In fish less than 74 cm TL, the second most consumed prey group was crustaceans, while molluscs were the second most consumed prey group for individuals larger than 75 cm. Large males showed a low incidence of cannibalism (0.7%). Angel sharks less than 45 cm TL specialized more on bony fishes, and the proportions of crustaceans and molluscs in the diet increased with increasing size (Vögler et al. 2003). Overall, as size increased so did the trophic level of the spiny angel shark. The trophic level for the whole population was 3.90 (Vögler et al. 2009). There is also seasonal variation in the diet. In the spring, sharks caught in shallow depths had greater diet diversity, while in the fall sharks caught at deeper depths had greater diet diversity (Vögler et al. 2003).

Another study in the same area found that based on the index of relative importance the fishes *Cynoscion guatucupa*, *Prionotus nudigula, Engraulis anchoita,* and *Raneya brasiliensis* were the most consumed prey items. Over 98% of the diet of both adults and juveniles in all seasons was made up of teleosts. Juveniles were also found to eat other chondrichthyans, decapod crustaceans, and cephalopods, while adults ate other chondrichthyans and cephalopods but did not consume decapods. Overall, the number of prey consumed increased with increasing angel shark size. Seasonal variation in the diet was also documented in this study. In autumn/winter juveniles reduced their consumption of teleosts and started feeding heavily on chondrichthyans. They also consumed low levels of decapods (Colonello 2005).

Spiny angel sharks are thought to be sit-and-wait predators, lying motionless on sandy or muddy bottom until prey passes closely overhead. The prey is then grasped by an upward bite (Vooren and da Silva 1991).

Growth and Reproduction

No age and growth studies on the spiny angel shark could be found. Length frequency distributions of spiny angel sharks caught in the San Matías Gulf, Argentina showed a modal peak of 75-90 cm TL for males and 80-95 cm TL for females (Awruch et al. 2008). The largest recorded animals are 95 cm TL for both sexes (Awruch et al. 2008). Size dimorphism was not seen in the San Matías Gulf (Awruch et al. 2008).

Studies of spiny angel sharks in Rio de la Plata and El Rincón, Argentina, found that males from El Rincón at a given length were significantly heavier than males from Rio de la Plata, while females showed no significant differences in the length-weight relationship (Colonello et al. 2007). Both sexes grew larger in El Rincón than in Rio de la Plata (Colonello et al. 2007). Length at 50% maturity in males was not significantly different between El Rincón and Rio de la Plata and was 75 cm TL and 72.45 cm TL, respectively. Length at 50% maturity was significantly different between study areas for females measuring 71.34 cm TL in Rio de la Plata and 77.01 cm TL in El Rincón (Colonello et al. 2007).

In males in the San Matías Gulf, Argentina, clasper length began to increase rapidly at 75-80 cm TL, and length at 50% maturity was reached at 76 cm TL. Length at 50% maturity in females was reached at 73 cm TL. All females smaller than 71 cm TL were juveniles and all females larger than 83 cm TL were adults (Awruch et al. 2008).

Unlike *S. argentina*, the spiny angel shark has only one functional ovary (Vooren and da Silva 1991). Based on the gonadosomatic index and the maximum diameter of ovarian follicles, the maturation of ovarian follicles lasts about two years before ovulation, followed by gestation (Colonello et al. 2007). Pregnant females occurred simultaneously with adult, non-pregnant females with low gonadosomatic indices and small ovarian follicles and adult, non-pregnant females with high gonadosomatic indices and large ovarian follicles, indicating that the female reproductive cycle is triennial (Colonello et al. 2007).

Ovulating females were found in December as were the smallest free swimming pups and largest embryos, indicating that gestation likely lasts 12 months (Colonello et al. 2007). Gestation begins in the summer (January-February) and pupping occurs the following spring (November-December). Gestation is divided into two stages, uterine gestation and cloacal gestation. Early gestation (January-April) occurs only in the uteri, which contains recently ovulated eggs to embryos up to 25 mm TL. During this stage, the uteri occupy almost the entire length of the abdominal cavity, the cloaca does not extend beyond the pelvic girdle, and externally, the vent appears as a narrow longitudinal slit. During mid-term gestation and parturition (June-November) the uteri contract longitudinally until they are shaped like domes and the cloaca distends longitudinally and transversally until it extends to the midpoint of the body cavity. This reconfiguration causes the uteri and cloaca to form a heart-shaped chamber where the embryos develop. The embryos at this point are similar to adults in body proportions and external characters. The transition between uterine and cloacal gestation occurs in May, or the 5th month of gestation (Sunye and Vooren 1997). Gestation is lecithotrophic and litter mass is 5-7% of maternal mass (Sunye and Vooren 1997, Vooren 1997).

Litter size ranged between 2 and 8 pups with an average of 4.07 pups/litter. Litter size increased with increasing female length (Colonello et al. 2007). The maximum embryo size was 26.5 cm TL and the minimum size of free swimming pups was 27.0 cm TL (Colonello et al. 2007). These values are similar to those found by Vooren and da Silva (1991) with litter size ranging from 3 to 8 pups with 5 or 6 pups being the most common and a size at birth of 25 cm TL and 140 g. The three-year reproductive cycle results in an annual fecundity between 0.67 and 2.33 pups per year (Colonello et al. 2007). Spiny angel sharks have been known to easily abort their pups upon capture, which could be explained by the cloacal gestation phase (Sunye and Vooren 1997).

Population structure

Recently, the population structure of the spiny angel shark has been examined in the middle of its range, in and around the Rio de la Plata Estuary (Garcia et al. 2015). Individuals from the outer estuary, surrounding coastal sites, and the outer shelf of the southwestern Atlantic showed no evidence of population genetic structuring in the mitochondrial cytochrome b gene, but the internal transcribed spacer 2 of recombinant DNA genes indicated that there was a remarkably high level of population genetic structure when the outer shelf spiny angel sharks were considered as a separate group from the coastal and outer estuarine angel sharks. The cytochrome b marker indicates that the number of immigrant females per generation for each population is high (between 12.8 – 46.9 individuals) except for immigrants from the outer shelf to the Atlantic coast, which is much lower (2.8 individuals per generation). All analyses revealed very low values of haplotype and nucleotide diversity from the recombinant DNA genes. Nucleotide diversity in the cytochrome b gene was high. This combination of low haplotype and high nucleotide diversity can be indicative of a transient bottleneck in the ancestral population, or an admixture of samples from small geographically subdivided populations (Garcia et al. 2015). The genetic patterns of exchanged seen in spiny angel sharks could be explained by sex-biased behavior or long term shifts in spatial and temporal environmental variables leading to current displacements. More studies of unlinked mitochondrial and nuclear loci are needed to better understand these patterns (Garcia et al. 2015). Overall, the low levels of genetic diversity in spiny angel shark populations suggest a vulnerability to overexploitation in the southwestern Atlantic Ocean (Garcia et al. 2015).

Demography

No information is available on natural mortality rates or the intrinsic rate of population increase (r) of the spiny angel shark.

DISTRIBUTION AND ABUNDANCE

To provide a better understanding of the spiny angel shark's current distribution and abundance, an extensive search of scientific publications, technical reports, fishery bulletins, and museum specimen records was conducted. We also searched the Global Biodiversity Information Facility Database (GBIF) for museum specimen records. However, there is question on the validity of some records and the website does not guarantee the accuracy of the biodiversity data. Thus, while we do provide a summary of these records the accuracy of the records is not completely reliable

Based on the literature gathered for this review and records from the GBIF database, the spiny angel shark can be found from Espírito Santo, Brazil to Rawson, Argentina in waters with salinities between 25.0 and 34.0 psu and temperatures between 7 and 18.5^{o}C (Table 1). Angel sharks have a low dispersal capacity, resulting in specimens from nearby areas having almost no mixing (Colonello et al. 2007). According to the IUCN Red List Assessment, the range of the spiny angel shark is large, and it is likely composed of smaller, more localized populations that can be easily extirpated through intense fishing (Chiaramonte and Vooren 2007). In Rio de la Plata, in the Argentine-Uruguayan Common Fishing Zone, spiny angel shark densities are particularly high along the Uruguayan coast in the spring. This may be related to the presence of higher salinity waters on the Uruguayan coast than the Argentine coast during this season (Colonello et al. 2007).

According to the IUCN Red List Assessment, spiny angel shark populations are declining (Chiaramonte and Vooren 2007). Fisheries data from Argentina and Brazil indicate that significant declines in angel shark CPUE were seen in the 1990s (Massa and Hozbor 2003, Miranda and Vooren 2003; See Commercial Fishing section below for more details). The abundance of spiny angel sharks in the San Matías Gulf, Argentina, in 1993, was estimated to be 192.53 t (NPOA – Argentina). The San Matías Gulf makes up a very small portion of the spiny angel shark's range (Figure 3). The spiny angel shark's range covers approximately 4,625 km of coastline with about 9.6% of that coastline along the San Matías Gulf (Distances calculated in Google Earth for the purposes of this review). The estimated biomass of spiny angel sharks for all of coastal Argentina was 23,600 t in the spring of 2003 (Massa et al. 2004). No information about effort was provided with this biomass estimate. Surveys of the continental shelf in northern Argentina found a mean biomass of 0.518 t/nm^2 in 1981, which increased to 1.305 t/nm^2 in 1995 before falling to 0.394 t/nm^2 in 1999 (Jaureguizar et al. 2006). More recent abundance and biomass estimates could not be found.

Table 1. Records of the spiny angel shark based on an extensive search of scientific publications, technical reports, museum specimen records, and the Global Biodiversity Information Facility Database (GBIF).

Year	Total Number	Area	Country	Source
1961	1	La Paloma	Uruguay	GBIF Database
1980-1987	1703	Rio Grande do Sul	Brazil	Vooren and Silva 1991
1980-1992	49	Rio Grande do Sul	Brazil	Sunye and Vooren 1997
1981	1	Rawson, Chubut	Argentina	GBIF Database
1982	1	Rio Grande do Sul	Brazil	GBIF Database
1982	1	Rio Grande do Sul	Brazil	GBIF Database
1982	1	Rio Grande do Sul	Brazil	GBIF Database
1985-1986	29	Ubatuba	Brazil	Rocha et al. 1998
1986-1987	40	Ubatuba	Brazil	Rocha et al. 1998
1992	1	Tramandai, Rio Grande do Sul	Brazil	GBIF Database
1992	1	Tramandai, Rio Grande do Sul	Brazil	GBIF Database
1993	1	Bajo de los Huesos	Argentina	GBIF Database
1994	1	Santa Catarina	Brazil	GBIF Database
1994	1	Santa Catarina	Brazil	GBIF Database
1995	1	Santa Catarina	Brazil	GBIF Database
1995-1996	602	Argentine-Uruguayan Common Fishing Zone	Uruguay	Milessi et al. 2001
1995-1998	1280	Argentine-Uruguayan Common Fishing Zone	Argentina/Uruguay	Vogler et al. 2003
1996	584	San Matias Gulf	Argentina	Awruch et al. 2008
1997	457	Argentine-Uruguayan Common Fishing Zone	Argentina/Uruguay	Vogler et al. 2008
1998	1	Ilha do Arvoredo, Santa Catarina	Brazil	GBIF Database
1998	543	Argentine-Uruguayan Common Fishing Zone	Argentina/Uruguay	Vogler et al. 2008
1999	1	Rio de Janeiro	Brazil	GBIF Database
2000-2003	233	Rio de la Plata	Argentina	Colonello et al. 2007
2000-2003	119	El Rincon	Argentina	Colonello et al. 2007
2002	1	Rio Grande do Sul	Brazil	GBIF Database
2007	1	Buenos Aires Province	Argentina	GBIF Database
2007	1	Buenos Aires Province	Argentina	GBIF Database
2007	1	Buenos Aires Province	Argentina	GBIF Database
2007	1	Buenos Aires Province	Argentina	GBIF Database
2007	1	Buenos Aires Province	Argentina	GBIF Database
2007	1	Buenos Aires Province	Argentina	GBIF Database
2006-2008	82	Rio de la Plata Estuary	Argentina	Garcia et al. 2015
2011	1	Paraná	Brazil	Bornatowski et al.

				2011
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Bajo de los Huesos	Argentina	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Necochea, Buenos Aires	Argentina	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Bahia de Guaratiba	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Playa Union, Bahia Engano	Argentina	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Playa Union, Bahia Engano	Argentina	GBIF Database
N/A	1	Playa Union, Bahia Engano	Argentina	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	--	Uruguay	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Playa Union, Bahia Engano	Argentina	GBIF Database
N/A	1	Isla Escondida, Chubut	Argentina	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Bajo de los Huesos	Argentina	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
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N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database

N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Imbai, Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	2	Rio Grande do Sul	Brazil	GBIF Database

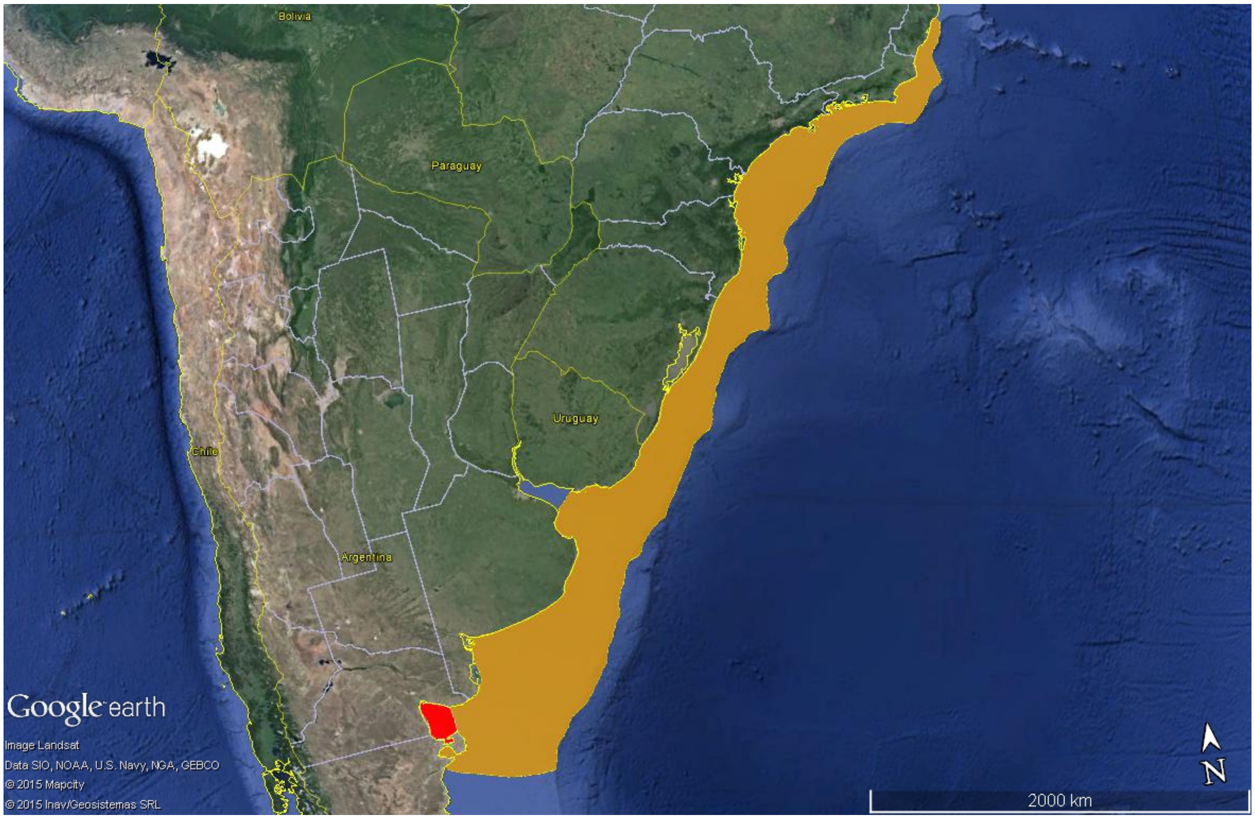

Figure 3. This spiny angel shark's range with the San Matías Gulf highlighted in red.

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

NMFS is required to assess whether this candidate species is threatened or endangered because of one or a combination of the following five threats listed under section 4(a)(1) of the ESA: (A) destruction, modification or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) inadequacy of existing regulatory mechanisms; or (E) other natural or human factors affecting its continued existence. Below we consider the best available information on each of the threat factors in turn.

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

Trawl fisheries occur throughout the spiny angel shark's range. Studies show that the interaction of bottom trawling gears with bottom substrate can have negative effects on benthic fish habitat (Valdemarsen et al. 2007). These impacts are often the most serious on hard substrates with organisms that grow up from the bottom such as corals and sponges, but alterations to soft substrates have also been seen. The trawl doors on bottom otter trawls often cause the most damage to the ocean bottom, but other parts of trawling gear, such as weights, sweeps, and bridles that contact the bottom can also be damaging. Intense fishing disturbance from trawling has reduced the abundance of several benthic species (Valdemarsen et al. 2007). Though there is no specific information available on how trawling has affected the spiny angel shark's habitat, the existence of trawl fisheries within its range makes it likely that damage to bottom substrate has occurred.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Commercial Fishing

The vast majority of fisheries information available on angel sharks from Argentina, Uruguay, and Brazil comes in the form of *Squatina* spp., which includes *S. guggenheim*, *S. argentina*, and *S. occulta*. All information in this section that refers to angel sharks includes multiple angel shark species, while information specific to *S. guggenheim* will specifically reference spiny angel sharks. There is some evidence that spiny angel sharks are the most abundant angel shark species from southern Brazil to Argentina and could make up the majority of angel shark landings data (Vooren and da Silva 1991, Cousseau and Figueroa 2001, Vooren and Klippel 2005).

There is no directed fishery for angel sharks in Argentina, but they are captured in multispecies artisanal shark fisheries and are considered a valuable bycatch species (Chiaramonte 1998, Bornatowski et al. 2011). In 2007, angel shark export revenue in Argentina was $2,732,274 U.S. dollars (NPOA – Argentina). Angel sharks are widely consumed as fresh product called *pollo de mar* (chicken of the sea) and as dried and salted product called *bacalao argentino* (Argentine cod) (Chiaramonte 1998). The spiny angel shark is commercially exploited in the local fisheries that occur in the San Matías Gulf, Argentina (Perier et al. 2011). In the 1990s angel sharks were considered commercially important bycatch, particularly in the Necochea school shark (*Galeorhinus galeus*) gillnet fishery. In the spring, the majority of angel sharks caught in this fishery were gravid females (Chiaramonte 1998). Angel shark landings between 1992 and 1998 remained stable, but 58% declines in CPUEs were recorded (Massa and Hozbor 2003, Vooren and Klippel 2005). Incorrect species identification of angel sharks is a problem that persists in the Argentine-Uruguayan Common Fishing Zone in the Argentine landings (Milessi et al. 2001).

Research surveys in Argentina took place in 2001 through 2003 between 41 and 47^{o}S at 60 to 120 m depths to explore which species are caught as bycatch in the common-hake (*Merluccius hubbsi*) bottom trawl fishery. Spiny angel sharks were caught at a rate of 1.38 individuals/km^2 and 100% of the individuals caught were mature (Crespi-Abril 2013). They occurred in only 2% of the trawl surveys, which could be because for the most part the surveys took place below the spiny angel shark's preferred depth range (Crespi-Abril 2013). Information on the species biology of bycatch in Argentine fisheries is scarce, particularly for elasmobranchs, because those fishes discarded at sea are not recorded in fishery statistics and those landed are often only generally recorded as sharks or skates (Crespi-Abril 2013).

In Uruguay, spiny angel sharks are captured by industrial trawling fleets in coastal and offshore waters (Vögler et al. 2008). They are bycatch species in bottom longline, estuarine gillnet, and some trawl fisheries, but they are also targeted in oceanic gillnet and bottom trawl fisheries (Domingo et al. 2008). Uruguayan artisanal and industrial trawling fleets operate at depths between 10 and 200 m, but incorrect interspecific separation, due to past taxonomic controversy, makes it difficult to determine which species of angel shark, the spiny angel shark (*S. guggenheim*), *S. argentina*, or *S. occulta*, is the most vulnerable to fishing pressure within the Argentine-Uruguayan Common Fishing Zone (Milessi et al. 2001). Annual catches of angel sharks in Uruguay were less than 100 t from 1977 to 1996 and ranged between 200 and 400 t between 1997 and 2005. It is likely that the majority of reported angel shark landings are spiny angel sharks (Domingo et al. 2008).

Spiny angel sharks have been heavily fished in Brazil by double rig trawlers and the industrial gillnet fleet since the 1980s (Haimovici 1998, Vögler et al. 2008). Double rig trawlers fish for angel sharks on the outer shelf down to 140 m, and spiny angel sharks make up the majority of the catch (Haimovici 1998). Mean annual landings of angel sharks were over 2000 t from 1985 to 1994 (Figure 4). All life stages of spiny angel sharks are captured during their reproductive migrations and year round at depths between 50 and 100 m in this fishery (Vooren and Klippel 2005). Although landings were still high between 1990 and 1994, falling CPUEs signaled the approach of a sharp decline in landings (Haimovici 1998).

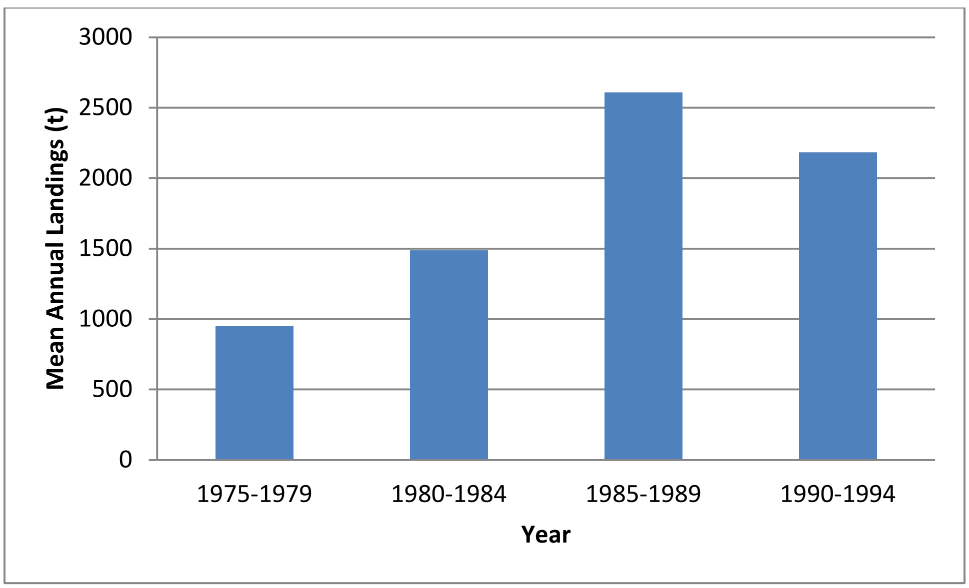

Figure 4. Mean annual landings of angel sharks in southern Brazil between 35^{o}S and 28^{o}S (Haimovici 1998).

In southern Brazil, angel shark landings were recorded in single trawl, pair trawls, oceanic drift nets, and coastal artisanal fisheries. In the early 1990s, single trawls recorded up to 53% of angel shark landings, but since 1993, oceanic drift nets have reported between 41 and 65% of annual landings. Total annual landings increased from 1,648 t in 1986 to 2,296 t in 1993. Landings then fell in 1997 to 607 t. Declines in CPUE were seen in single and pair trawls. CPUE for single trawls peaked in 1984 at 3 t/trip and then declined rapidly to 0.5 t/trip from 1995-1997, an 83% decline. Declines of 85% were seen in pair trawls where CPUE fell from 1 t/trip in 1986 to 0.15 t/trip from 1994-1997. It is estimated that the angel shark population has declined by 85% since 1985. CPUEs remained high in the oceanic drift net fishery, between

1.93 t/trip to 5.20 t/trip, despite the decline in abundance seen with other fishing gear (Miranda and Vooren 2003).

Landings of angel sharks in Argentina, Uruguay, and Brazil have been reported to the FAO. The FAO Aquatic Species Fact Sheets consider *S. guggenheim* (the spiny angel shark) and *S. punctata* to be synonyms for *S. argentina* (www.fao.org). These FAO reported landings are presumably a combination of two valid species, *S. guggenheim* and *S. argentina* (Figure 5).

At this time, more detailed information could not be provided regarding changing fishing effort or fishing grounds for spiny angel sharks over time throughout their range. As noted above, there has been a shift in gear usage, with angel shark catches coming more frequently in oceanic drift nets than in single trawls since 1993 in southern Brazil (Miranda and Vooren 2003).

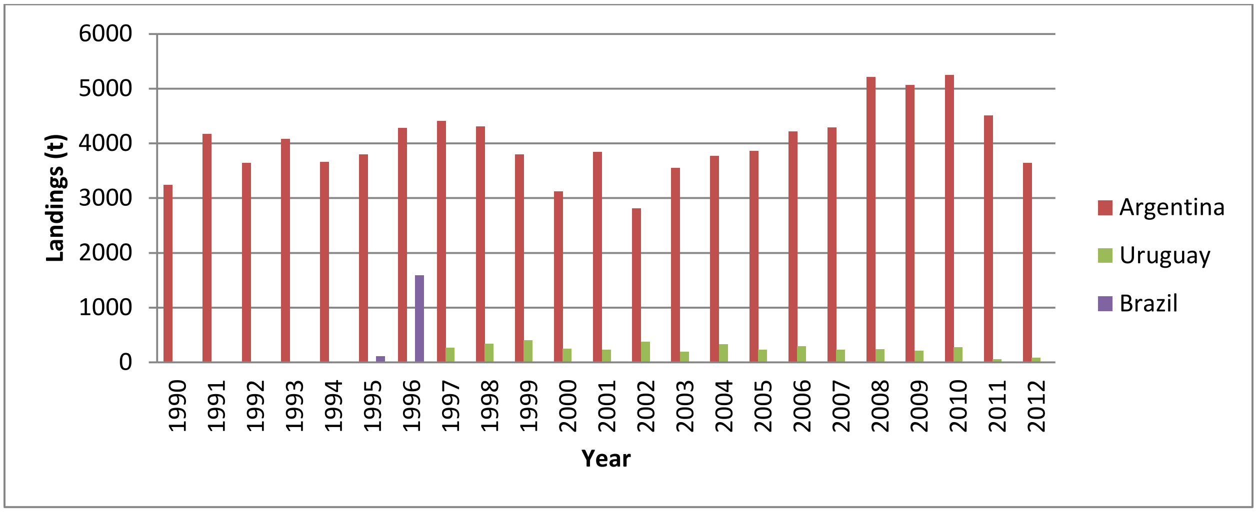

Figure 5. FAO reported landings for angel sharks from Argentina, Uruguay, and Brazil (www.fao.org). Landings for Brazil were only reported in 1995 and 1996.

<u>Competition, Disease, or Predation</u>

Predation

The spiny angel shark has been documented in low frequencies in the stomachs of sand tiger sharks (*Carcharias taurus*), copper sharks (*Carcharhinus brachyurus*), and broadnose sevengill sharks (*Notorynchus cepedianus*). In all three species, the frequency of spiny angel sharks in the diet increased with increasing predator size (Lucifora et al. 2005, Lucifora et al. 2009a, b).

<u>Adequacy of Existing Regulatory Mechanisms</u>

In December 2014, the Brazilian Ministry of the Environment approved a new version of the Brazilian Endangered Species List, which listed the spiny angel shark as critically endangered in Annex I (Directive N^{o} 445). Spiny angel sharks were first listed in Annex I as endangeres in 2004 (Silva 2004). An Annex I Listing forbids the capture, transport, storage, and handling of Argentine angel sharks, except for conservation research purposes that are authorized by the Instituto Chico Mendes de Conservação da Biodiversidade. Additionally in December, 2014, the Instituto Chico Mendes de Conservação da Biodiversidade approved the

National Action Plan for the Conservation and Management of the Elasmobranchs of Brazil (N^{o} 125, Lessa et al. 2005). The spiny angel shark is listed as one of the twelve species of concern. The plan calls for a fishing moratorium and marketing ban until there is scientific evidence that supports population recovery. It also suggests that a fishing exclusion area be established in the coastal zone to protect nursery areas. The plan also includes general short term, mid-term, and long term goals for elasmobranch conservation. The plan sets short term goals for improved data collection on landings and discards, improved compliance and monitoring by the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), supervision of elasmobranch landings to ensure fins are landed with carcasses, the creation of a national port sampler program, and intensified on board observer monitoring programs. Mid-term goals include increased monitoring and enforcement within protected areas as well as the creation of new protected areas based on essential fish habitat for the 12 species of concern. They also call for improved monitoring of fishing from beaches in coastal and estuarine environments. Long term goals call for improved ecological data and stock assessments for key species as well as mapping of elasmobranch spatiotemporal distributions. This data will be used to better inform the creation of protected areas and seasonal fishing closures.

Since 2012, the Comisión Técnica Mixta del Frente Marítimo has set a catch limit of 2,600 t for *Squatina* spp. within the Argentine-Uruguayan Common Fishing Zone (Res. N^{o}8/14, Res. N^{o}10/13, Res. N^{o}10/12). In November, 2012, this limit was met and landings of *Squatina* were banned for the month of December (Res. N^{o} 13/12). In 2013, an additional reserve of 400 t was proposed to be allowed if the 2,600 t limit was reached, and in 2014 a 10% increase in total allowable catch may be added if the commission sees fit (Res. N^{o}10/13, Res. N^{o}8/14).

Uruguay's FAO National Plan of Action for the conservation of chondrichthyans lists the spiny angel shark as a species of high priority (Domingo et al. 2008). It sets a short-term goal of 12-18 months to investigate distribution and habitat use, mid-term goals of 24-30 months to generate a times series of effort and catch, conduct an abundance assessment, and conduct age, growth, reproduction, and diet studies, and a long term goal of 36-48 months to determine maximum sustainable catch limits. Uruguay made it a priority to review current fishing licenses that allow for the catch of spiny angel sharks, possibly modify them, and grant no new fishing licenses. No updated results from the goals and priorities of this plan could be found. Argentina's FAO National Plan of Action for the conservation of chondrichthyans does not consider the spiny angel shark to be a species of high priority (NPOA-Argentina 2009).

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