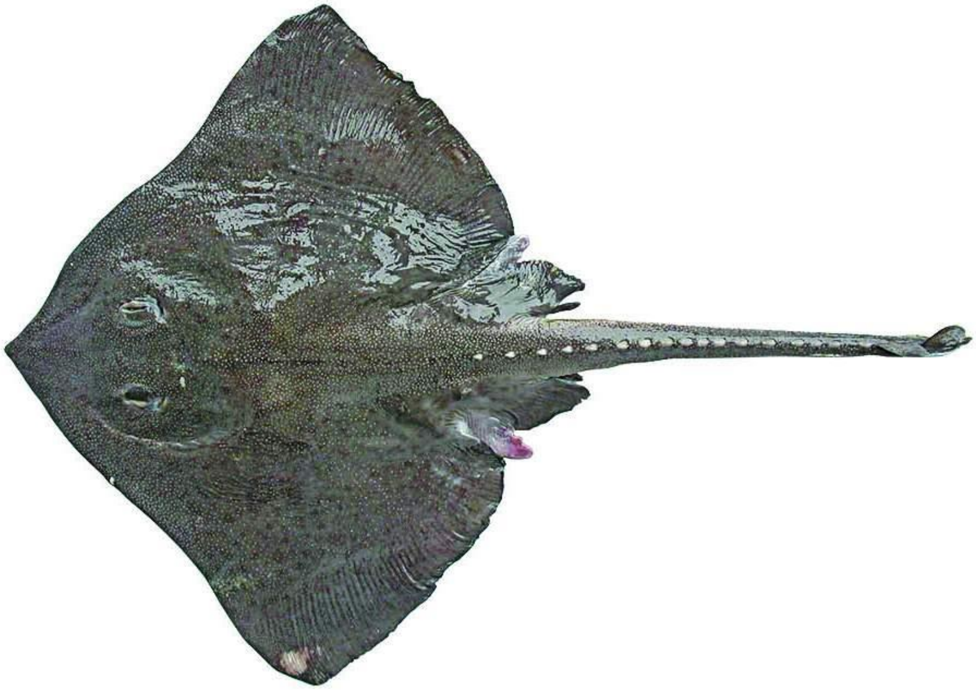
ENDANGERED SPECIES ACT
STATUS REVIEW OF THE GRAYTAIL SKATE
(*Bathyraja griseocauda*)



INIDEP

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 the following peer reviewers; Charles F. Cotton and Alexander Arkhipkin. 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 Graytail Skate (*Bathyraja griseocauda*). Report to the National Marine Fisheries Service, Office of Protected Resources. SFD Contribution PCB-15-04.

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 that the petitioned action may be warranted, as required by the ESA. In a *Federal Register* notice on February 24, 2014 (79 FR 10104), 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 10 species of skates and rays and 15 species of bony fishes, and thus NMFS initiated a status review of those species. This status review report considers the biology, distribution, and abundance of and threats to one skate species from the Southwestern Atlantic, *Bathyraja griseocauda* (graytail skate).

TABLE OF CONTENTS

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 habitats. 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 indicating 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 graytail skate (*Bathyraja griseocauda)* (79 FR 10104). Experts and members of the public were requested to submit information to NMFS to assist in the status review process from February 24 through April 25, 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 graytail skate, 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-May 2014.

LIFE HISTORY AND ECOLOGY

Taxonomy and Anatomy

The graytail skate, *Bathyraja griseocauda*, is a member of the genus *Bathyraja*, the most speciose genus of the family Arhynchobatidae (McCormack et al. 2007). The graytail skate was described by Norman (1937) and was originally classified as *Raja griseocauda*. The graytail skate was later reclassified as *Breviraja griseocauda* (Bigelow and Schroeder 1965). After Ishiyama and Hubbs (1968) established the genus *Bathyraja*, which is distinguished from *Breviraja* based on a number of internal characteristics, particularly the finer structure of the claspers and rostral cartilage, the graytail skate was reclassified into the *Bathyraja* genus by Springer (1971). The currently accepted scientific name of the graytail skate is *Bathyraja griseocauda* [Norman, 1937]. In Spanish-speaking countries, the graytail skate is referred to as *raya gris* and *raya lija* (McCormack et al. 2013).

The graytail skate's disc is rhomboidal (Bizikov et al. 2004). The dorsal surface is brownish with traces of darker spots or rings, with white or yellow coloring on the ventral side (Norman 1937, Bigelow and Schroeder 1965). The whole tail, or at least the lateral parts of the lower surface, is grayish brown in color (Norman 1937). The dorsal surface is covered in numerous small spinules, and there are no enlarged median spines on the disc (Norman 1937). The tip of the snout and axils of the pectoral fins lack spinules (Bigelow and Schroeder 1965). The posterior margins of the pelvic and pectoral fins are dusky. The underside of the tail is covered in dark spots (Bizikov et al. 2004). Eighteen to twenty strong median spines on the tail begin above the origin of the pelvic fins and extend to the first dorsal fin (Norman 1937, Springer 1971, Bizikov et al. 2004). Males have alar thorns, curved spines on the outer part of their pectoral fins, arranged in 21-24 radial rows with 5-7 thorns per row (Bizikov et al. 2004). The teeth of the graytail skate are small with 30 to 36 rows of teeth in the upper jaw (Norman 1937). Graytail skate males and females display sexual homodonty in their dentition (Sáez and Lamilla 2004).

As noted by Norman (1937), the graytail skate is similar in appearance to *Bathyraja brachyurops*, the broadnose skate. The graytail skate has a shorter pre-oral distance (snout tip to the mouth) (12.0-12.5% of the total length (TL)) and a smaller distance between the first pair of gill openings (12.0-14.3% of the TL) than *B. brachyurops* (Bigelow and Schroeder 1965). Additionally, in graytail skate, the vent is located nearer to the tip of the snout than the end of the tail when compared to *B. brachyurops* (Norman 1937).

Range and Habitat Use

The graytail skate is historically found in the waters of the Southwest Atlantic off the coasts of Argentina, Uruguay, Chile, and the Falkland Islands (Norman, 1937, Stehmann 1986, Pequeño and Lamilla 1993, Agnew et al. 1999, Agnew et al. 2000, Bizikov et al. 2004, Massa et al. 2004, Wakeford et al. 2005, Arkhipkin et al. 2008, Arkhipkin et al. 2012) and in the Southeast Pacific off of Chile (Sáez and Lamilla 2004). They have been caught at latitudes as far north as 39^{o}S in the Pacific Ocean and 34^{o}S in the Atlantic Ocean, and as far south as 60°S in the Southern Ocean on the Antarctic shelf (Figure 1; Bigelow and Schroeder 1965, Figueroa et al. 1999, Sáez and Lamilla 2004). A few individuals have been captured on the Antarctic continental shelf, around the Antarctic Peninsula (Bigelow and Schroeder 1965, Springer 1971, and Global Biodiversity Information Facility (BGIF) Database). There are also records of graytail skate in the Southern Ocean in Prydz Bay, Antarctica that was found in the GBIF database. If these records were valid, this would extend the range beyond the southwest Atlantic Ocean and eastern Pacific. However, we could not ascertain the validity of these records.

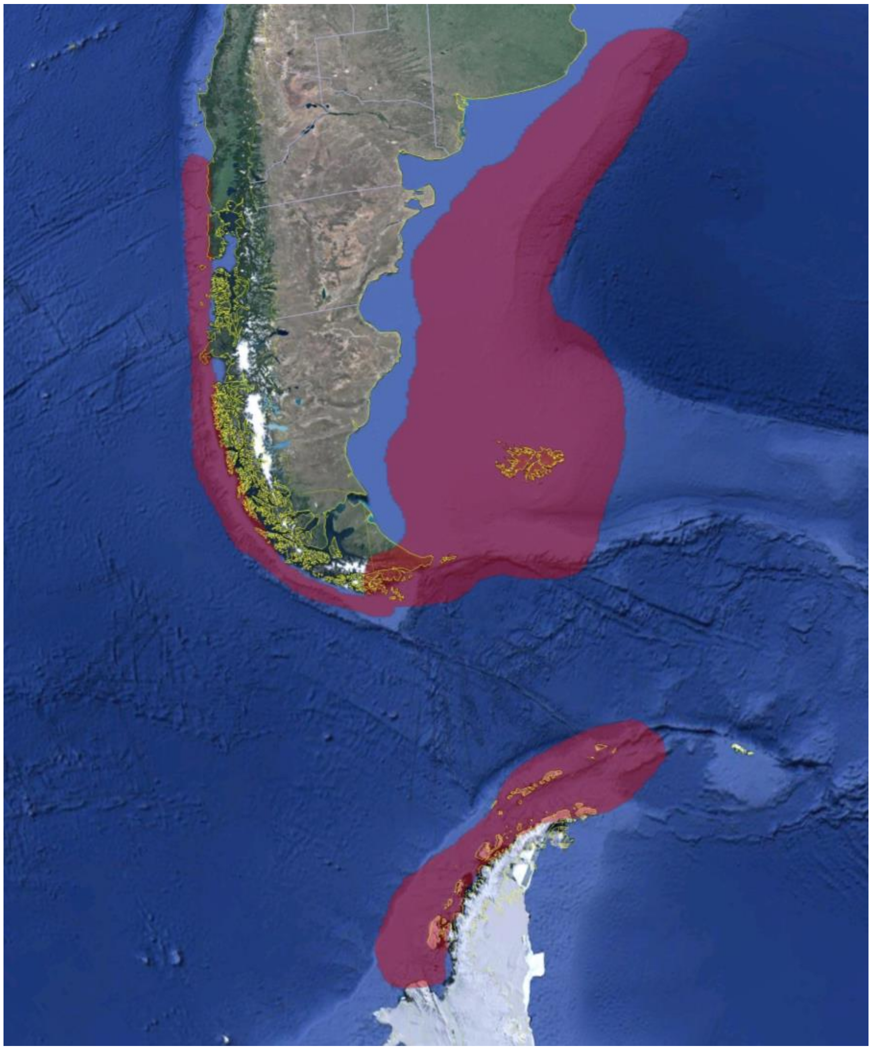


Figure 1. Distribution of the graytail skate in the southwest Atlantic, southeastern Pacific and Southern Ocean.

In the Falkland Islands, graytail skate are caught in the cool, deep waters on the slopes of the continental shelf break, making them more common to the west of the islands (Agnew et al. 1999, Arkhipkin et al. 2008, and Arkhipkin et al. 2012). Graytail skate were particularly abundant south of the islands and were a dominant part of the fauna before the southern skate fishery was closed in the mid-1990s (see Adequacy of Existing Regulatory Mechanisms section below for details; Agnew et al. 1999, Agnew et al. 2000, and Wakeford et al. 2005). Outside the Falkland Islands, on the Patagonian shelf, they are more commonly found on the northwestern outer shelf and northern shelf and slope (Figueroa et al. 1999 and Arkhipkin et al. 2012).

Graytail skates are found at depths between 106 and 1010 m, but are most common at depths below 300m (Bigelow and Schroeder 1965, Menni and Lopez 1984, Brickle et al. 2003, Laptikhovsky et al. 2005, Wakeford et al. 2005, Arkhipkin et al. 2008, and Arkhipkin et al. 2012), but Colonello and Massa (2004) reported the highest density of graytail skate catches at depths of 120m. They have been caught as shallow as 77m in Argentine waters (Bücker 2006).

Graytail skates display an ontogenetic shift in depth preference as they mature (Arkhipkin et al. 2008). In Falkland Islands waters, hatchlings occupy nursery grounds of approximately 300-350m depth, but transition to deeper waters of 400-600m as juveniles. At 20-30cm disc width (DW), some migrate up to shallower depths of 200-400m, while others move into water deeper than 600m. Skates 80-90cm DW or larger occur most commonly at depths of 400-600m (Arkhipkin et al. 2008). Despite these depth changes, studies around the Falkland Islands have shown little evidence of large spatial or temporal movements, which could indicate that graytail skates carry out their entire life cycle within the waters where they hatch (Agnew et al. 2000 and Wakeford et al. 2005).

Studies of catch data around the Falkland Islands show conflicting results about the co-occurrence of different life stages. Arkhipkin et al. (2008) state that hatchlings often co-occur with skates of medium size, while early juveniles are often found with larger, sexually mature skates. Laptikhovsky et al. (2005) state that hatchlings and large skates are commonly caught together at depths greater than 400m, indicating that the graytail skate may spawn in deep water (Laptikhovsky et al. 2005).

Graytail skates exhibit strict stenothermic and stenohaline behavior on the Argentinean shelf, suggesting they tolerate very narrow ranges of temperature and salinity (Figueroa et al. 1999). Catch data suggest that they are found at water temperatures below 6^{o}C (Menni and Lopez 1984 and Colonello and Massa 2004) and salinity above 33.9 PSU (Colonello and Massa 2004).

Diet and Feeding

Various studies on graytail skate diet indicate they are opportunistic predators that are euryphagous, eating a variety of prey items, but favoring piscivory. Brickle et al. (2003) conducted the most extensive study of the diet and feeding habits of the graytail skate caught around the Falkland Islands. Skates smaller than 50 cm (DW) preyed mostly upon benthic gammarid amphipods and isopods, such as *Serolis* spp. *Serolis* remained important in the graytail skate diet for skates as large as 70 cm DW. Skates larger than 50 cm DW preyed increasingly on fishes, including the nototheniid *Patagonotothen ramsayi*, and the squid *Loligo gahi*. Subsequent studies off the Falkland Islands have confirmed this ontogenetic diet shift (Laptikhovsky et al. 2005). In adult graytail skate, fish can make up more than 40% of the diet (Sánchez and Mabragaña 2002). Off the coast of Argentina, the graytail skate did not consume crustaceans

(Sánchez and Mabragaña 2002), which contrasts with data from the Falkland Islands. A study of the environmental impact of fisheries discards around the Falkland Islands found that 1.1 to 7.1% of the food items found in graytail skate stomachs could be classified as being from discarded fisheries bycatch (Laptikhovsky et al. 2006).

Growth and Reproduction

Age and growth studies have been conducted on the graytail skate. Based on vertebral band counts from samples collected from along the coast of Argentina, Bücker (2006) calculated the relative growth rate (k) from the von Bertalanffy growth equation to be 0.064 year^{-1} with a theoretical maximum size (L_∞) of 169.9 cm total length and the estimated size-at-birth (L_0) of 6.1 cm. Arkhipkin et al. (2008), using samples collected only off the Falkland Islands, reported a lower growth rate (k) of 0.02 year^{-1}, with a maximum theoretical size (L_∞) of 313.4 cm total length. Growth rates of graytail skate begin around 5.6 cm/year for the first nine years of life and decline to 4.3 cm/year between fourteen and twenty years old (Arkhipkin et al. 2008). The oldest skate was aged to 28 years (Arkhipkin et al. 2008). In comparison, a study of caudal thorn band counts and vertebral centra ring counts found that the most accurate von Bertalanffy growth parameters came from the vertebral centra with the relative growth rate (k) based on vertebrae centra to be 0.033 year^{-1} with a theoretical maximum size (L_∞) of 219.7 cm total length (Gallagher 2000). Based on observed size data, these parameters are still a slight underestimate of growth (Gallagher 2000).

Commercial fishery catch data around the Falkland Islands between 1993 and 2001 indicates the maximum observed disc width for the graytail skate is 130 cm with a maximum weight of 30.4 kg (Wakeford et al. 2005). The average observed disc width at 50% maturity is 76-77 cm with 101 cm total length (Agnew et al. 2000, Wakeford et al. 2005). This corresponds to approximately 8 kg based on the length weight relationship of graytail skate catches in the Falkland Islands in 2011 (Figure 2; Falkland Islands Government, 2012). On research cruises, the largest male caught had a disc width of 98 cm and the largest female had a disc width of 110 cm (Arkhipkin et al. 2008). Based on catches of the smallest skates, it is thought that hatchlings have disc widths between 9 and 12 cm (Brickle et al. 2003 and Arkhipkin et al. 2008).

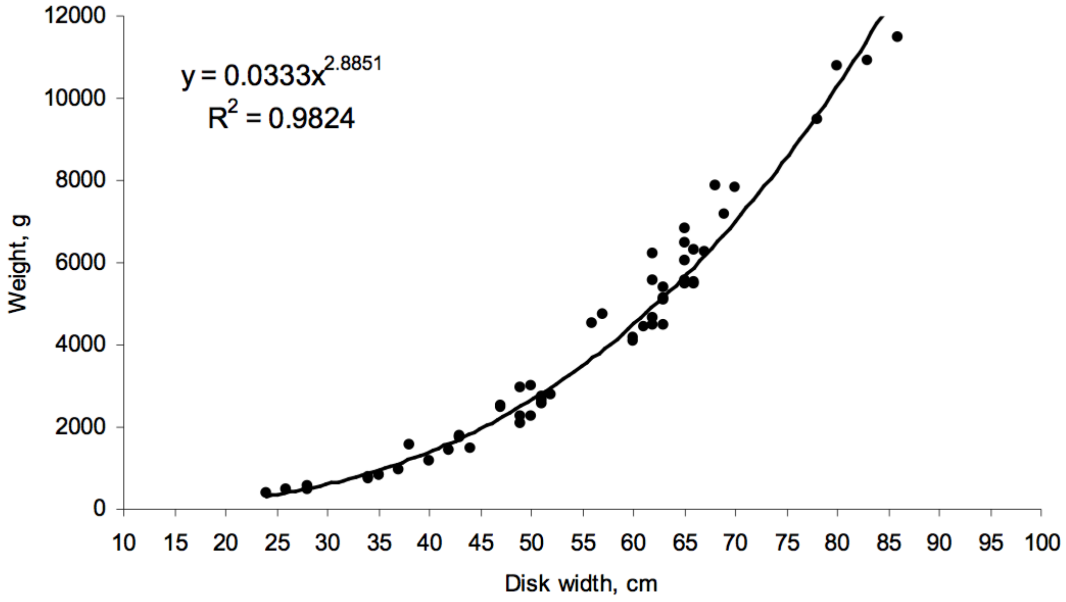


Figure 2. Length-weight relationship of graytail skate caught in Falkland Islands fisheries in 2011 (Falkland Islands Government 2012).

Little is known about the reproduction of the graytail skate (Sánchez and Mabragaña 2002). Based on commercial fleet observer and research cruise data collected around the Falkland Islands, males reached 50% maturity at a disc width of 76-77 cm (Agnew et al. 2000 and Wakeford et al. 2005). Age and growth studies from skates in the same region provide conflicting estimates for length and age at maturity. Gallagher (2000) estimated a total length at 50% maturity of 120.7 cm for both sexes, with males and females maturing after 17.6 and 24.8 years respectively. Arkhipkin et al. (2008) estimated a total length at 50% maturity to be 108.2 cm for females and 94.5 cm for males. Age at maturity in this study was 14 years for males and 17.8 years for females.

A Falkland Islands study of graytail skate biology found that oviparous females caught between 155 and 416 m depth had fully formed egg capsules in every month except January, suggesting that the skate may spawn year round (Arkhipkin et al. 2008). No information was provided on the number of eggs found in each female. A weak spawning peak in the spring and summer months was observed (Arkhipkin et al. 2008). Hatchlings and post-hatchlings with 10-12 cm disc width were caught most frequently in May and between August and November at depths of 208-365 m (Arkhipkin et al. 2008). Most hatchlings and egg capsules were found north of 50^o S latitude (Arkhipkin et al. 2008 and Arkhipkin et al. 2012). Around the Falkland Islands, the spawning grounds of the graytail skate can be found northwest of the islands in deep waters, close to the edge of the continental shelf between 200 and 300 m deep (Arkhipkin et al. 2008).

Demography

Little is known about the population growth and natural mortality of the graytail skate. Age and growth studies indicate that, like most other elasmobranchs, they are a *K*-

selected species with slow growth rates and late age at maturity (Gallagher 2000, Bücker 2006, Arkhipkin et al. 2008).

DISTRIBUTION AND ABUNDANCE

In general, graytail skate is found on the continental shelf and slope in the southwestern Atlantic Ocean, south of 34°S and in the southeastern Pacific Ocean, south of 39°S (Figueroa et al. 1999, Sáez and Lamilla 2004). There are some catch records from the continental shelf surrounding Antarctica (Bigelow and Schroeder 1965, Springer 1971, GBIF Database). The majority of the information available on the distribution of graytail skate comes from catch records from research cruises and observer data from the Falklands Islands and Argentina.

To provide a better understanding of the graytail skate'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 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. While this information may not provide a clear record on trends of abundance, it can provide documentation of the presence or absence of the graytail skate over time. The information available is summarized below, divided by country.

Falkland Islands

The graytail skate can be found throughout Falkland Islands waters, in both the Falkland Islands Inner Conservation and Management Zone (FICZ) and the Falkland Islands Outer Conservation and Management Zone (FOCZ) (Agnew et al. 1999, Gallagher 2000, Brickle et al. 2003, Laptikhovsky 2004, Laptikhovsky et al. 2005, Wakeford et al. 2005, Arkhipkin et al. 2008, Arkhipkin et al. 2012, and GBIF Database). These areas are from 47°S – 57°S and 64°W – 52°W (Agnew et al. 1999). The earliest record of the graytail skate in the Falkland Islands was 1927, which is the holotype specimen for the species (Norman 1937). Since its description as a species, the graytail skate has been caught consistently throughout the Falkland Islands on research cruises and in the commercial fishery (Figure 3; Table 1).

A study of commercial catch data from the Falkland Islands incorporated Argentine catch data in an attempt to determine if their skate assemblages were two separate stocks. The addition of Argentine data did not improve the fit of the model and increased confidence intervals, leading to the conclusion that the two fishing stocks are somewhat distinct (Wakeford et al. 2005). This can be supported by the life history data available which indicates that graytail skate have limited spatial and temporal movements (Wakeford et al. 2005). Catch data from the Falkland Islands commercial fisheries in 2010 was used to estimate a biomass of 7,232 t of graytail skate in Falklands waters, which is consistent with estimates from the 1990s (Falkland Islands Government 2011).

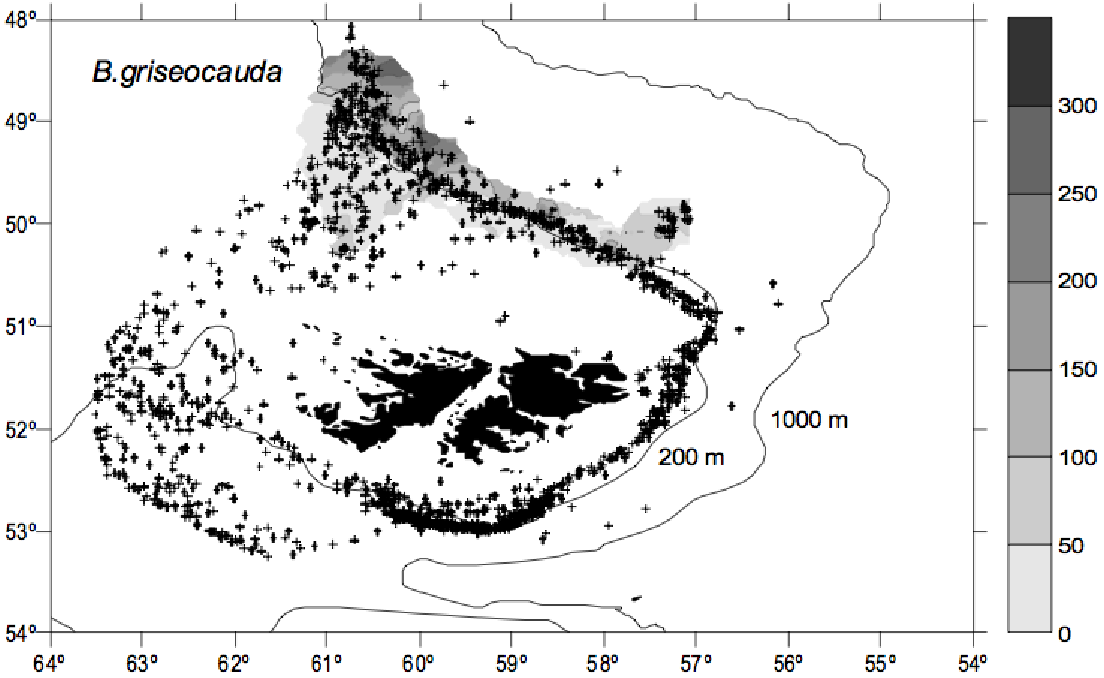


Figure 3. Map of the Falkland Islands showing distributions of commercial and research catch of the graytail skate from 1992-2004 (Bizikov et al. 2004).

Table 1. Records of the graytail skate caught in Falkland Islands waters 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	Source
1927-1928 and 1931-1932	2	Falkland Islands (Malvinas)	Norman 1937
1927-1928 and 1931-1932	8	Argentina/Falkland Islands	Hart 1946
1966	5	Falkland Islands (Malvinas)	GBIF Database
1969	8	Falkland Islands (Malvinas)	GBIF Database
1970	3	Falkland Islands (Malvinas)	GBIF Database
1971	2	Falkland Islands (Malvinas)	GBIF Database
1976	20	Falkland Islands (Malvinas)	GBIF Database
1978	21	Falkland Islands (Malvinas)	GBIF Database
1987	1	Falkland Islands (Malvinas)	GBIF Database
1993-2005	9,332	Falkland Islands (Malvinas)	Laptikhovsky et al. 2005
1994-1996	143	Falkland Islands (Malvinas)	Gallagher 2000
1996-2006	21450	Falkland Islands (Malvinas)	Arkhipkin et al. 2008
1999-2000	158	Falkland Islands (Malvinas)	Brickle et al. 2003
2000-2001	>5712	Falkland Islands (Malvinas)	Wakeford et al. 2005
2000-2010	461	Falkland Islands (Malvinas)	Arkhipkin et al. 2012
N/A	1	Falkland Islands (Malvinas)	GBIF Database
N/A	3	Falkland Islands (Malvinas)	Laptikhovsky 2004

Argentina

Graytail skate are found on the continental shelf and slope around Argentina south of 37^{o}S and 41^{o}S respectively (McCormack et al. 2007). The first recorded catch of the graytail skate in Argentine waters was on the Argentine shelf in 1927 (Norman 1937). Most records for graytail skate in Argentina are from research cruises (Menni and Lopez 1984, Sánchez and Mabragaña 2002, Bücker 2006, and GBIF Database; Table 2). Sánchez and Mabragaña (2002) estimated that the population abundance of the graytail skate on the Argentine shelf between 48^{o}S and 55^{o}S, which includes the Falkland Islands, was 259,210 individuals, or 2,431.98 t. Between 45^{o}S and 41^{o}S, the biomass of graytail skate is estimated to be 503 t ± 2,237 t with an average density of 0.05 t/nm^{2} (Colonello and Massa 2004).

Table 2. Records of the graytail skate caught in Argentine waters 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	Source
1927-1928 and 1931-1932	4	Argentine Shelf	Norman 1937
1927-1928 and 1931-1932	8	Argentina/Falkland Islands	Hart 1946
1966	6	Argentine Shelf	GBIF Database
1970	2	Argentine Shelf	GBIF Database
1971	2	Argentine Shelf	GBIF Database
1976	4	Argentine Shelf	GBIF Database
1978	24	Argentine Shelf	GBIF Database
1978	22	Argentine Shelf	Menni and Lopez 1984
1983	16	Argentine Shelf	GBIF Database
1987	1	Argentine Shelf	GBIF Database
1993-1999	--	Argentina/Uruguay	Figueroa et al. 1999
2000	--	Argentina/Chile	Sanchez and Mabragana 2002
2003	503 tons	Argentine Shelf	Colonello and Massa 2004
2003-2005	40	Argentina/Falkland Islands	Bucker 2006
N/A	7	Argentine Shelf	GBIF Database

Uruguay

There is limited information about the occurrence of graytail skate off Uruguay. Pequeño and Lamilla (1993) note that graytail skate are in Uruguayan waters. Figueroa et al. (1999) stated that *Bathyraja* spp. can be found as far north as the Buenos Aires shelf, but specific species are not listed. At this time, no information on commercial, recreational, or research catches of graytail skate in Uruguay is available, and there is no population abundance estimate from this area.

Chile

Very little information was found pertaining to the presence of the graytail skate in Chilean waters. According to the IUCN Red List, graytail skate are found in the Southeast Pacific off Chile south of 41^{o}S and at depths of 137 to 595 m (McCormack et al. 2007). Saez and Lamilla (2004) caught 42 graytail skate between March 1995 and December 1995 at 350 m depth approximately 20 miles from Punta Galera (Table 3). At this time, there is no other information available on scientific or commercial catch distribution or population abundance from this area.

Table 3. Records of the graytail skate caught in Chilean waters. 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	Source
1995	42	Valdivia, Chile	Saez and Lamilla 2004

Antarctica

There is no documentation of an active fishery for graytail skate on the continental shelf surrounding Antarctica, but they have been caught sporadically by research cruises in the area (Table 4; Bigelow and Schroeder 1965, Springer 1971, and GBIF Database). The majority of graytail skate captures on the Antarctic shelf are in the western hemisphere around the Antarctic Peninsula, south of their range in South American waters (Bigelow and Schroeder 1965, Springer 1971, and GBIF Database). The earliest record of the graytail skate in Antarctica was caught on the *R/V Hero* on February 9, 1969 off Brabant Island, north of the Antarctic Peninsula at a depth of 94 m (Springer 1971). Records are also available in similar areas from the *USNS Eltanin* and the American Marine Living Resources (AMLR) bottom trawl survey of the Antarctic Peninsula (Bigelow and Schroeder 1965 and GBIF Database). Three graytail skate were caught in the eastern hemisphere in Prydz Bay, Antarctica in January 1991 by the Australian Antarctic Data Centre (GBIF Database). If validated, these records would expand the known range of the graytail skate from being a species that lives only in the Southwestern Atlantic and Southeastern Pacific to being circumpolar on the Antarctic shelf. However, we could not ascertain the validity of these records. Given the low number of records from Prydz Bay and the vast distance between this area and the Antarctic Peninsula, with no records between, these records may be mis-identifications and therefore remain suspect.

Table 4. Records of the graytail skate caught in Antarctic waters based on an extensive search of scientific publications, technical reports, museum specimen records, and the Global Biodiversity Information Facility Database (GBIF). Some reviewers have questioned the data in the GBIF Database. In addition, GBIF does not guarantee the accuracy of the biodiversity data served through its portal and web services. Thus, while we do provide a summary of these records the accuracy of the records is not completely reliable.

Year	Total Number	Area	Source
1969	1	Brabant Island, Antarctica	Springer, 1971
1972	1	Antarctic Peninsula, Antarctica	GBIF Database
1991	3	Prydz Bay, Antarctica	GBIF Database
2006	4	Antarctic Peninsula, Antarctica	GBIF Database
N/A	1	South Shetland Islands, Antarctica	Bigelow and Schroeder 1965
N/A	1	Clarence Island, Antarctica	Bigelow and Schroeder 1965

Summary of Distribution and Abundance

Our review of the current literature, surveys, and museum collection specimens on the distribution and abundance of graytail skate indicates that historically the graytail skate occurred in the Southwest Atlantic on the Argentine shelf as far north as 36.8^{o}S. Their range extends southward to the Antarctic shelf surrounding the Antarctic Peninsula to 67.27^{o}S. Records are concentrated towards the edge of the shelf and slope with the easternmost record at 55.45^{o}W. In 1991, three graytail skate were caught on an Australian research cruise in Prydz Bay, Antarctica (GBIF Database). These individuals are the only records of graytail skate caught in the eastern hemisphere, which call into question the validity of those records. The skate is said to be present in the Southeast Pacific along the Chilean shelf (Pequeño and Lamilla 1993, McCormack et al. 2007), but reports of graytail skate in this area are limited (Sáez and Lamilla 2004).

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

Studies show that the interaction of bottom trawling gears with bottom substrate can have negative effects on benthic fish habitat (Valdemarsen at 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 (Valdemarsen et al. 2007). 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 graytail skate's habitat, trawl fisheries exist within its range, and it is likely that damage to bottom substrate has occurred because of these fisheries.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Information available on the harvest of the graytail skate indicates that they are most heavily exploited in the Falkland Islands multispecies skate and ray (batoid) fishery by foreign fleets (Falkland Islands Government 2005-2013; Agnew et al. 1999). Skates are caught primarily for the sale of their wings (Agnew et al. 1999 and Massa and Hozbor 2003). There is also a skate fishery in Argentina, in which graytail skate are likely caught as bycatch (Massa and Hozbor 2003). Skates and rays are also taken as bycatch in other fisheries operating in both countries as well as in Chile and Uruguay (Agnew et al. 1999, Colonello and Massa 2004 and Massa et al. 2004).

Directed Fisheries

Falkland Islands

The graytail skate was the most important batoid caught in the Falkland Islands multispecies rajid fishery in the 1990s based on catch weight, and was estimated to make up 58.14% of the catch south of the islands and 38.81% of the catch north of the islands between 1993 and 1995 (Agnew et al. 1999 and Bizikov et al. 2004). In 1989, Korean vessels began to specifically target rajids in this fishery using demersal trawls, and by 1991 catch of skates and rays rose from less than 1500 t/year to more than 7000 t/year (Figure 4). After the Korean fleets started targeting skates, the proportional catches of graytail skate declined in all areas that were fished, particularly in the southern batoid aggregation area where graytail skate were the majority of the catch (Agnew et al. 1999). From 1992 to 2001 a significant decline in the CPUE for graytail skate was found (Figure 5; Wakeford et al. 2005). Catches of graytail skate showed a reduction in average disc width from 1993-1995, which is likely due to the high exploitation levels that were seen in the fishery during this time (Agnew et al. 2000). Based on observer data, the majority of graytail skate catches in the commercial fishery were small skates with modal disc widths between 25 and 40 cm between 1997 and 2006 (Figure 6; Arkhipkin et al. 2008). This data was collected from commercial trawl fisheries in the FICZ (Arkhipkin et al. 2008). About 54% of catches were female skates with disc widths between 10 and 80 cm, with the majority under size at 50% maturity (Arkhipkin et al. 2008). While the long-lived, slow growing graytail skate became less prevalent, short-lived, faster growing species, such as *Bathyraja albomaculata*, became more prevalent in the commercial catch (Agnew et al. 1999)0. Recent data from the Falkland Islands Government (2012) indicates that the modal disc width of graytail skate catches has increased to 63 cm, which could be indicative of population recovery.

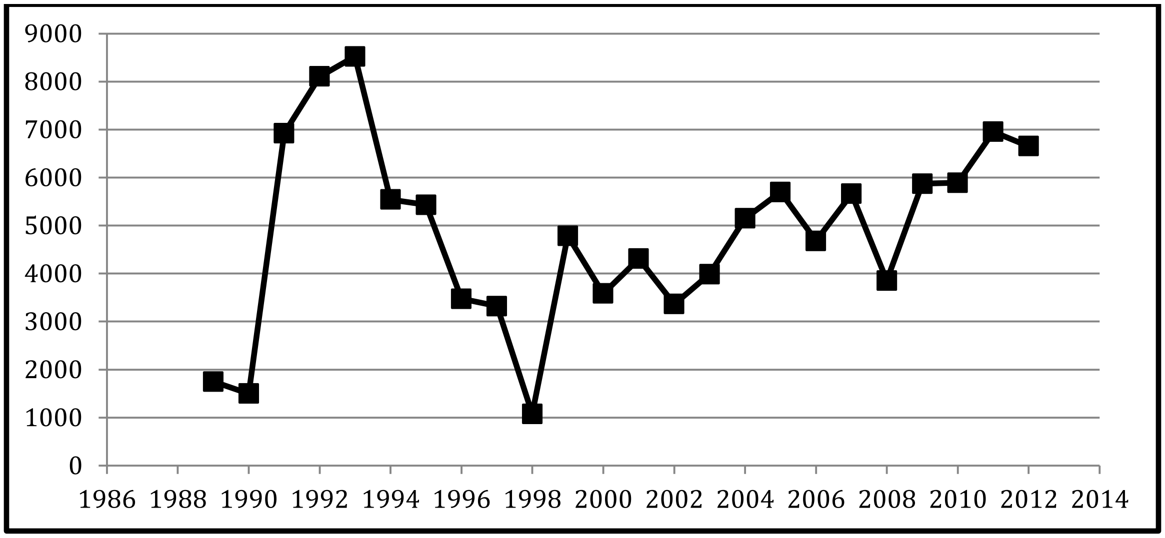


Figure 4. Total catch in tonnes of skates and rays in Falkland Islands waters by year (Falkland Islands Government 2013).

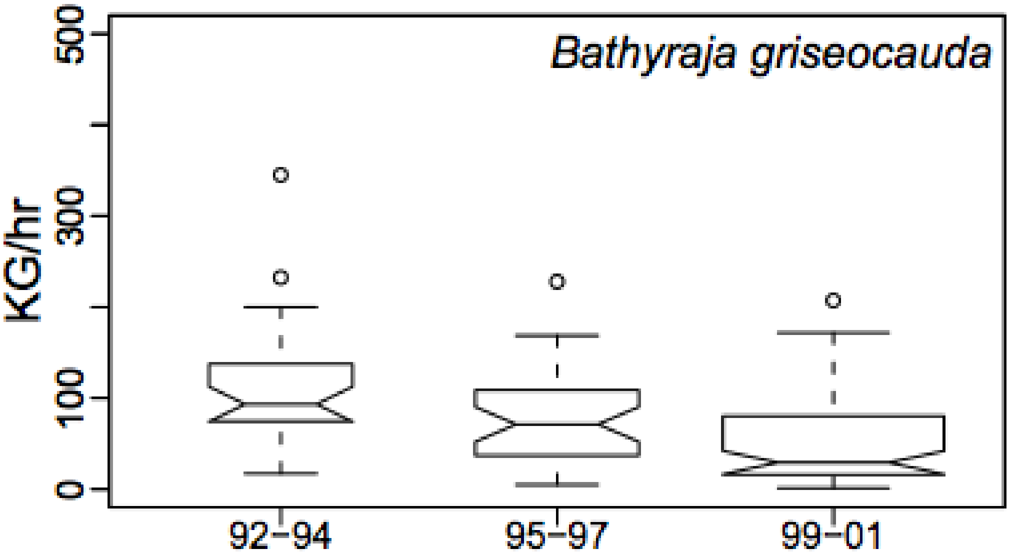


Figure 5. CPUE of graytail skate from Falkland Islands observer data using trawl data between 200 and 300 m deep (Wakeford et al. 2005). Open circles represent outliers.

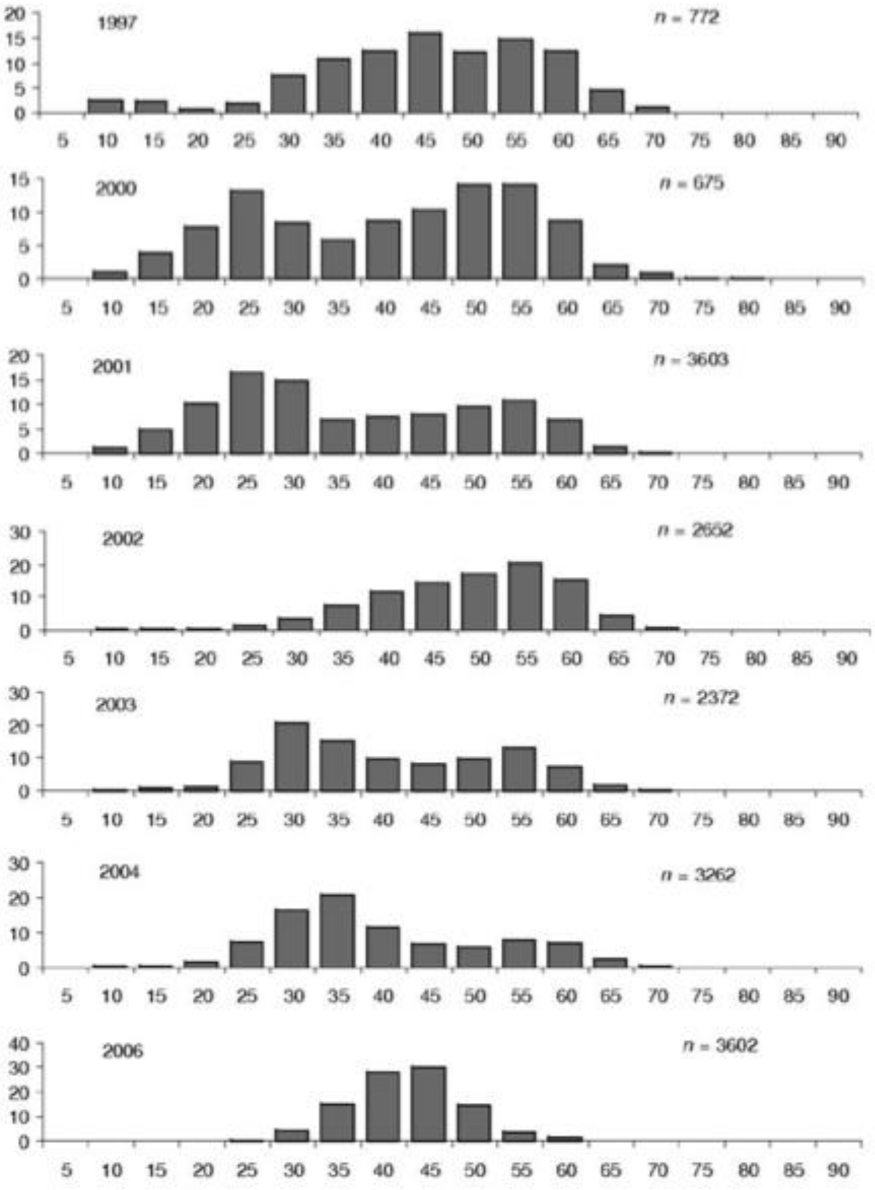


Figure 6. Size frequency distribution of graytail skate between 1997 and 2006 in years where more than 500 individuals from the Falkland Islands commercial catch were measured by observers. Disc width (cm) is reported on the x-axis and frequency (%) on the y-axis (from Arkhipkin et al. 2008).

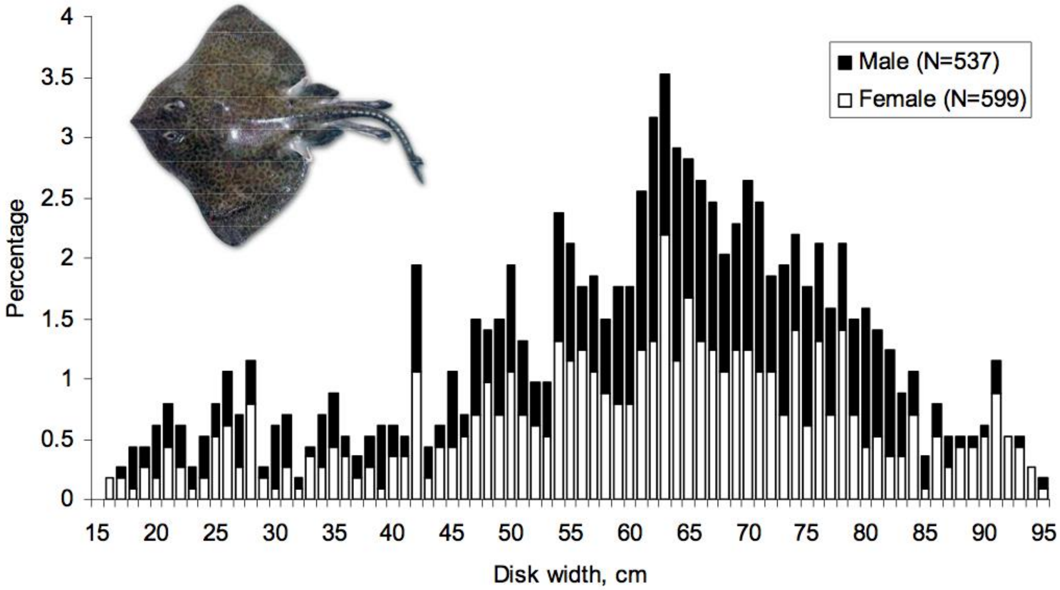


Figure 7. Length frequency distribution of graytail skate caught in Falkland Islands fisheries in 2011 (Falkland Islands Government 2012). Size at reproduction occurs at 75 cm disc width.

Despite the reported reductions in CPUE, the graytail skate remains one of the most abundant species caught in the Falkland Islands multispecies skate fishery (Agnew et al. 1999, Arkhipkin et al. 2008, and Falkland Islands Government 2005, 2006, 2007, 2008, 2010, 2011, 2012). Presently, the graytail skate makes up between 13% and 21.8% of the catch identified to species by observers (Agnew et al. 2000 and Falkland Islands Government 2010, 2011, 2012). No specific published information could be found on how many boats receive observer coverage in the Falkland Islands, but scientific observers are regularly placed on vessels with rajid licenses and on vessels that are under suspicion for misreporting skate and ray bycatch (Agnew et al. 1999). In 2009 and 2011, Falkland Islands observers identified 2.73% and 2.85% of the skate catch by weight to species, respectively (Falkland Islands Government 2010, 2012; calculations performed for this document).

In comparison to data from the other countries within the graytail skate's range, fishery information from the Falkland Islands is very reliable. Based on the information found for this review, it is the only country within the graytail skate's range with a managed rajid fishery that includes observer coverage. Since the closure of the southern ray fishery, fishing effort has been distributed throughout the same general area north of the Falkland Islands (Figure 9; Wakeford et al. 2005). Trends in effort remained relatively stable between 1996, when the southern fishery was closed, and 2001. A subset of effort and catch was used to determine that effort remained between 7,000 and 10,500 tuned fishing hours with tuned catch between 2,000 and 4,000 tonnes, excluding 1998 when effort and catch were drastically lower (Table 5; Wakeford et al. 2005). Catch and effort were standardized using a generalized linear model to account for the effects of year, season, fishing area, and vessel class (Agnew et al. 2000). Wakeford et al. (2005) extended the existing standardized data series for catch and effort by Agnew et al.

(2000) to include data up to 2001. Generally increased effort led to increased catch in the multispecies rajid fishery (Wakeford et al. 2005). Agnew et al. (2000) reported that catch limits around 3000 t in the northern ray fishery appear to be sustainable.

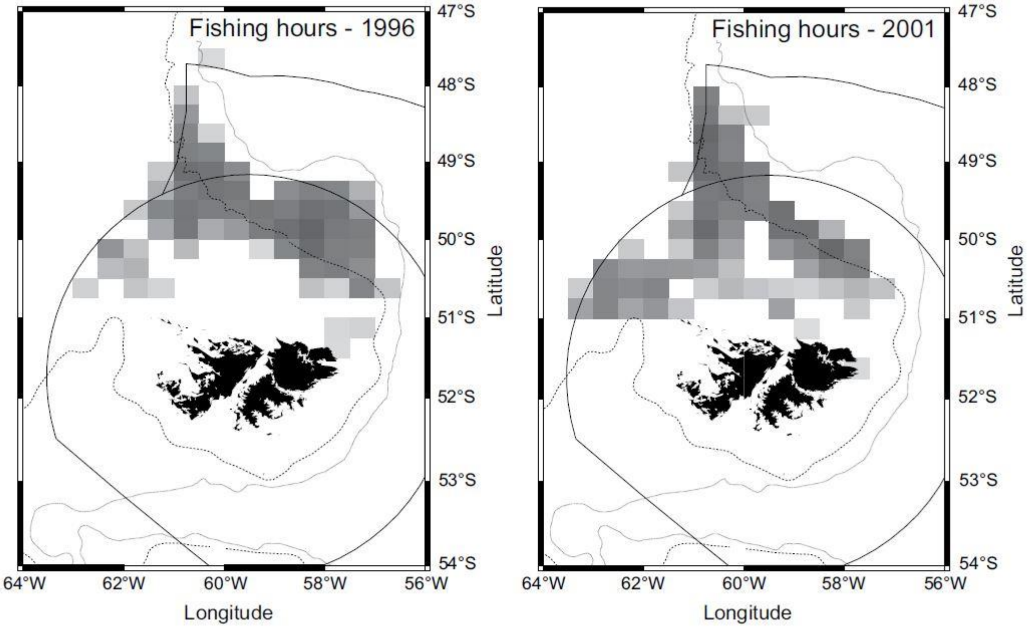


Figure 9. Distribution of fishing hours in the Falkland Islands multispecies rajid fishery in 1996 and 2001 (Wakeford et al. 2005).

Table 5. Tuning catch and tuning effort of batoids for licensed vessels operating north of 52°S from 1991-2001 (Wakeford et al. 2005).

Year	Tuning catch (tonnes)	Tuning effort (hours)
1991	5583	14655
1992	2565	11186
1993	5676	21990
1994	4098	11930
1995	4003	15159
1996	2411	9678
1997	2362	7913
1998	232	612
1999	3890	10413
2000	2643	7891
2001	3280	8493

Argentina

There is an active commercial elasmobranch fishery in Argentine waters, which exploits sharks, skates, and rays (Massa et al. 2004). Initially, skates and rays were mainly discarded as fisheries bycatch, but they are now a source of both target and non-target catch for their wings (Chiaramonte 1998, Massa and Hozbor 2003). Catch of skates and rays in Argentina showed an increasing trend from 183 t in 1991 to 13,265 t in 2000 (Figure 10) (Sánchez and Mabragaña 2002). The total number of vessels reporting skate and ray landings increased from 69 in 1992 to 377 in 1998 (Massa and Hozbor 2003). Deep-water skates, like the graytail skate, are generally not monitored in Argentina, despite the fact that they are under high fishing pressure (Massa et al. 2004). Recently, 36% declines in CPUE for skates and rays have been seen on the Argentine shelf between 34 and 48^{o}S (Massa and Hozbor 2003). However, the data are not species-specific.

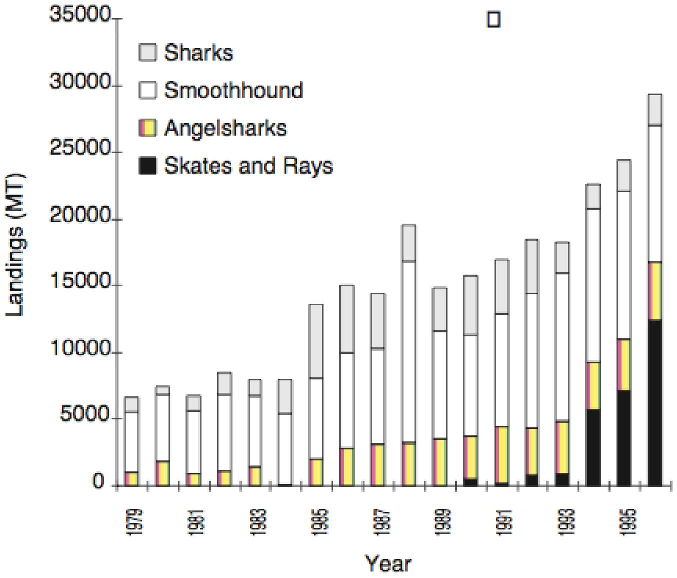


Figure 10. Declared elasmobranch landings in Argentine ports from 1979 to 1996 (Chiaramonte 1998).

Uruguay

There is no information available on the catch of the graytail skate in a directed fishery in Uruguay. However, the reported catch of skates and rays has risen dramatically since it was first reported in 1993 (Figure 11; Domingo et al. 2008). No further information on skate and ray catches in Uruguay could be found at this time.

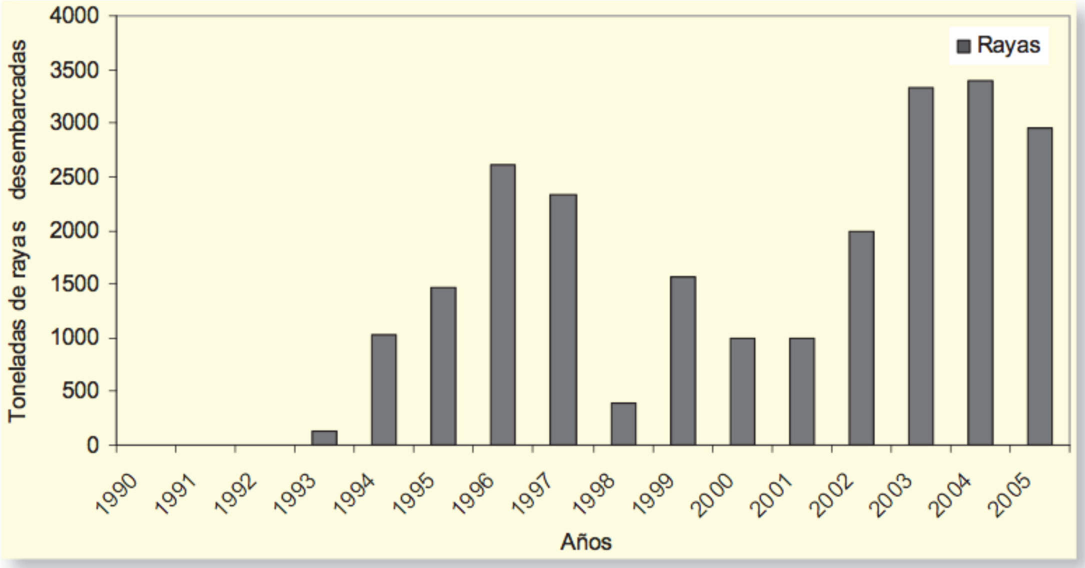


Figure 11. The annual catch of skates and rays in Uruguay in tons from 1990-2005 (Domingo et al. 2008).

Chile

Little information is available on the exploitation of the graytail skate in Chilean waters. There is a directed skate fishery off Chile that primarily targets *Zearaja chilensis*. Information on the depth at which the fishery operates could not be found, but *D. chilensis* lives at depths between 28 and 435 m, overlapping the shallower half of the graytail skate's range (Kyne et al. 2007). Less than 5% of the skate landings in this fishery are graytail skate (McCormack et al. 2007). Declines in *D. chilensis* catches have been reported since 1979 and it is suspected that other skate species, including the graytail skate, have also been affected (McCormack et al. 2007).

Fisheries Bycatch

Skates and rays, including the graytail skate, are known to be taken as bycatch in fisheries in the Falkland Islands, Argentina, Uruguay and Chile. In the Falkland Islands, skates are taken as bycatch under finfish licenses, as well as in the *Loligo* fishery, longline fishery, *Illex* squid fishery, and under experimental licenses (Falkland Islands Government 2011). In addition, a small number of skates are taken as bycatch in the Patagonian toothfish fishery which occurs in the FOCZ (Agnew et al. 1999). In 2011, 57% of the total skate catch was taken as bycatch under finfish licenses (Falkland Islands Government 2012). This was the highest proportion of skate taken as bycatch since the inception of the rajid fishery license. The actual batoid bycatch in Falkland waters could be significantly higher than the reported numbers because only large batoids are processed and reported onboard trawlers (Laptikhovsky 2004). A study of batoids taken as bycatch in bottom trawls in Falkland waters found that the overall survival rate of batoids caught and discarded was 67.0%, but none of the three graytail skate caught in the study survived (Laptikhovsky 2004).

Little information is available on graytail skate bycatch in Argentina, Uruguay, and Chile. In Argentina, graytail skate are often caught in bottom trawl fisheries for bony fish, and fishery independent research on hake *Merluccius hubbsi* (McCormack et al. 2007). The IUCN Red List assessment states that a 59% decline in the biomass of graytail skate caught as bycatch was seen in 1999 between 45 and 55^{o}S when compared to data from 1998, but this may be influenced by an unspecified change in fishing gear that could have reduced the capture of batoids (McCormack et al. 2007). Graytail skate are taken in the Argentine directed fishery for *D. chilensis* and can comprise up to 18% of the catch (McCormack et al. 2007). Other studies of skate bycatch on the Argentine shelf have found that graytail skate are found in only 5.5% of sets, most commonly between 41 and 44^{o}S at depths greater than 100m (Colonello and Massa 2004). In sets with graytail skate, the species with the highest frequency of occurrence were Argentine hake (*Merluccius hubbsi)*, Patagonian toothfish (*Dissostichus eleginoides)*, and pink cusk-eel (*Genypterus blacodes)* (Colonello and Massa 2004). In 2003, Argentina reported that ~9,450 t of deep-water skates, including graytail skates, were caught as bycatch (Massa et al. 2004). Graytail skate are taken with *M. hubbsi*, Angular Volute (sea snail) (*Zidona dufresnei)*, and flounder (*Paralichthys* spp.) in Uruguayan waters (Domingo et al. 2008). In Chile, graytail skate are taken as bycatch in the artisanal Patagonian toothfish longline fishery, which operates between 20 and 49^{o}S in the Pacific Ocean (McCormack et al. 2007).

Competition, Disease, or Predation

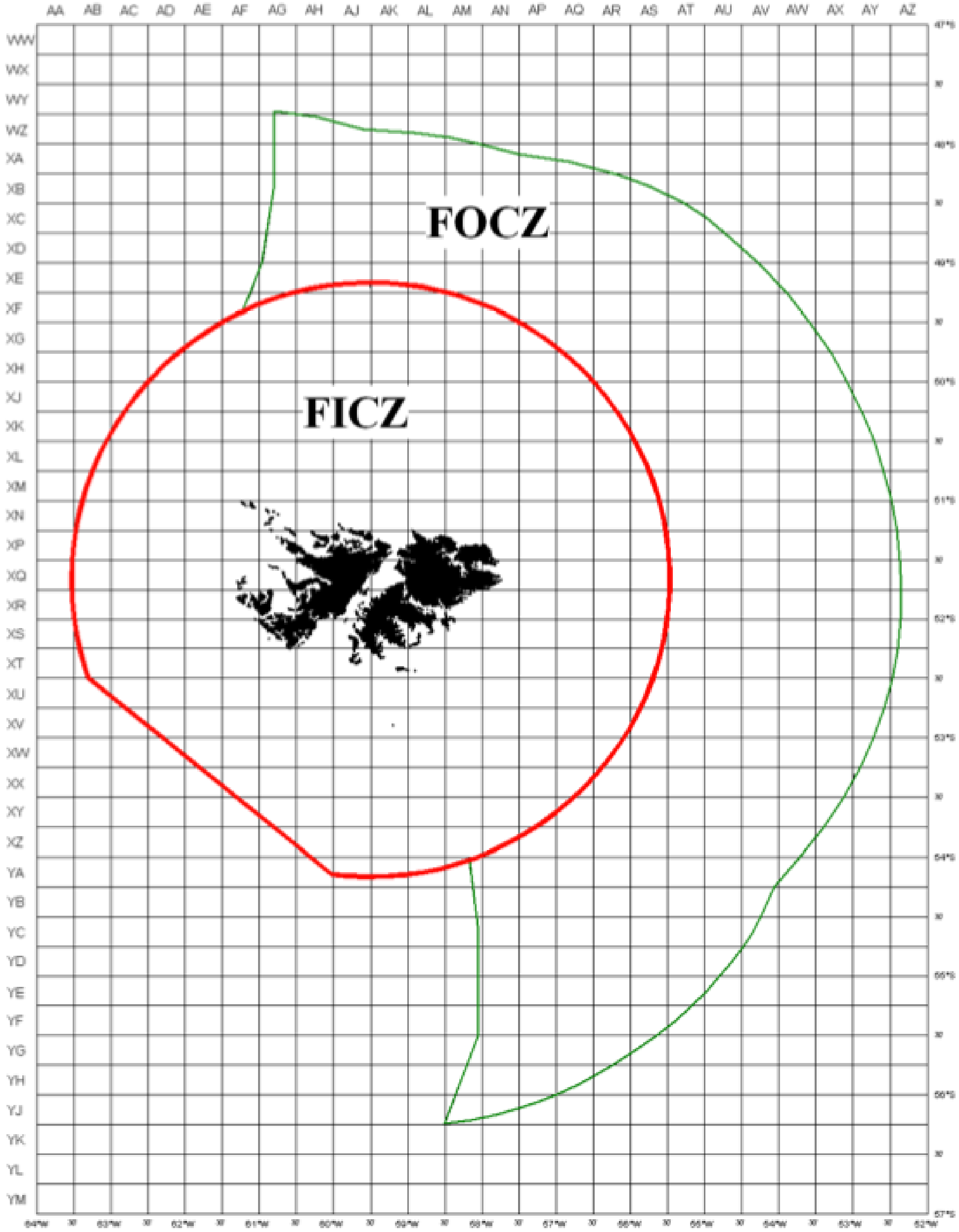
At this time, no information is available regarding competitors, diseases, or predators that pose a threat to the graytail skate.

Adequacy of Existing Regulatory Mechanisms

Falkland Islands

In comparison to most skate and ray fisheries, the Falkland Islands multispecies fishery is rigorously managed by limiting fishing effort (Agnew et al. 1999). The waters surrounding the Falkland Islands are divided into the FICZ, which was established in 1987, and the FOCZ, which was established in 1990 (Figure 12; Agnew et al. 1999). The fishery was initially part of a mixed demersal fishery fished by Spanish vessels, but the take of rajids as a group has been recorded since 1987, when the FICZ was established. In 1991, observers were placed on vessels to identify batoids to species and collect other biological data (Agnew et al. 1999). In 1994, the Falkland Islands developed a specific skate and ray fishery license with two seasons, from January 1 to June 30 and July 1 to December 31, to better regulate the catch of rajids (Agnew et al. 1999). In 1996, trawling for skates and rays was prohibited south of 51^{o}S, to protect a batoid aggregation area that displayed marked declines in CPUE (Agnew et al. 1999). The graytail skate made up a significant portion of the catch in this area prior to the closure, and this measure protects further depletion of graytail skate populations in the area (Agnew et al. 2000). The ultimate goal of the Falkland Islands Fisheries Department was to limit fishing effort to a level that will maintain the long-term sustainability of the rajid fishery (Agnew et al. 1999, Wakeford et al. 2005). Since catch limits were imposed in 1996, the northern stock has seen a gradual increase in CPUE (Agnew et al. 2000) and updated stock assessments suggest that the northern batoid assemblage has recovered to levels similar to the estimated initial biomass after declines of up to 30% in the early to mid-1990s (Wakeford et al. 2005). Currently the majority of commercial catches of graytail skate occur to the west of the Falkland Islands in deeper waters (Arkhipkin et al. 2008).

A portion of the graytail skate population in the Falkland Islands is found within the area closure south of 51^{o}S. The closed area helps to protect the Falkland Islands population, but likely does not provide protection to skate populations found outside of Falkland waters because they are assumed to be separate stocks (Wakeford et al. 2005). Licensed vessels must report their daily catch and effort, but are not required to report species-specific information (Agnew et al. 1999). All of these efforts help to maintain what appears to be a sustainable multispecies fishery, but it has been noted that careful management is needed for the multispecies skate stock to maintain a stable population (Wakeford et al. 2005). Species-specific management may be more beneficial to the survival of graytail skate populations in Falkland waters as differences in life history may occur among various skate species.



This chart is illustrative NOT definitive

Figure 12. A map of the Falkland Islands Interim and Outer Conservation and Management Zones (Falkland Islands Government 2013).

Argentina

Under voluntary compliance with the Food and Agriculture Organization of the United Nations' (FAO) International Plan of Action for the Conservation and Management of Sharks (IPOA – SHARKS), Argentina has enacted its own national plan for elasmobranch conservation and management, the Plan de Acción Nacional para la

Conservación y el Manejo de Condrictios (tiburones, rayas, y quimeras) en la República Argentina (2009). The action plan maps out the following goals:

- Assign priority to elasmobranchs in scientific research plans
- Increase the knowledge of chondrichthyan fisheries and other factors affecting these species within the ecosystem
- Contribute to the conservation of biodiversity and the structure and function of ecosystems
- Promote the implementation of management measures to ensure the conservation, recovery, and/or sustainability of chondrichthyans
- Raise community awareness about the role of chondrichthyans in the ecosystem and their vulnerability to exploitation and changes in the environment.

The graytail skate is acknowledged as one of the many elasmobranch species of Argentina, and thus is covered under this plan.

Several sources have noted that Argentina does little to actively protect elasmobranchs, particularly skates and rays, in their waters (Massa and Hozbor 2003, Massa et al. 2004, McCormack et al. 2007). Though total allowable catch, minimum sizes, and annual quotas are in place for many elasmobranchs in Argentina, they are largely ignored and poorly enforced (McCormack et al. 2007). In 2013, El Insituto Nacional de Investigación y Desarrollo Pesquero (INIDEP) set the recommended total allowable catch for skates and rays to 9,000 tons in the Common Fishing Zone and a landing limit for skates and rays was set to be no more than 30% of the catch (http://www.inidep.edu.ar/pesquerias/marco-legal-3/marco-legal-2013/). INIDEP is a decentralized research agency that falls under the Argentine Ministry of Agriculture, Livestock, and Fisheries. Their research is used to provide guidelines for the sustainable use of marine resources to the Undersecretary of Fisheries and Aquaculture of the Nation (SSPyA), the Federal Fisheries Council (CFP), and the Argentina Chancellery (www.inidep.edu.ar). More detailed information on these new regulations could not be found.

Uruguay

Like Argentina, Uruguay has also developed a national action plan for shark conservation in conjunction with the IPOA – SHARKS. The Plan de Acción Nacional para la Conservación de los Condrictios en las Pesquerías Uruguayas lays out goals for the conservation and sustainable management of chondrichthyan populations in Uruguayan waters, with a particular focus on increasing research data, improving fisheries information by identifying catch to species, and identifying and protecting those species that are particularly vulnerable or threatened (Domingo et al. 2008). Because of its endangered classification on the IUCN Red List, the graytail skate was considered a species of high priority and plans were made to investigate its age, growth, reproduction, diet, distribution, and habitat use in Uruguayan waters. A time series will be generated for effort and catch of the skate in fisheries and an assessment of abundance will be conducted. The Administration and Management group formed by the plan will establish measures to review the current fishing licenses for graytail skate and determine possible modifications to the licenses. Further, no new fishing permits will be granted.

Preliminary research for the action plan showed that the only information available on the graytail skate in Uruguayan waters is that they exist there and information on the whole genus *Bathyraja* in Uruguay is negligible (Domingo et al. 2008). No updated information on the results of the action plan could be found.

Chile

There are few to no regulations in place to protect the graytail skate in Chile. Chile has enforced catch quotas south of $41^{o}28'$ S for the *Dipturus* spp. fishery, and the fishery is closed between December 1 and February 28 for the *Dipturus* spp. reproductive season (McCormack et al. 2007). Though these regulations take place within the graytail skate's range, it is unknown how these regulations affect the graytail skate.

LITERATURE CITED

Agnew, D.J., C.P. Nolan, and J. Pompert. 1999. Management of the Falkland Islands skate and ray fishery. In: Case studies of the management of elasmobranch fisheries. Edited by R. Shotton. FAO Fisheries Technical Paper. 378: 268-284.

Agnew, D.J., C.P. Nolan, J.R. Beddington, and R. Baranowski. 2000. Approaches to the assessment and management of multispecies skate and ray fisheries using the Falkland Islands fishery as an example. Canadian Journal of Fisheries and Aquatic Sciences. 57: 429-440.

Arkhipkin, A.I., N. Baumgartner, P. Brickle, V. Laptikhovsky, J. Pompert, and Z.N. Shcherbich. 2008. Biology of the skates *Bathyraja brachyurops* and *B. griseocauda* in waters around the Falkland Islands, Southwest Atlantic. ICES Journal of Marine Science. 65: 560-570.

Arkhipkin, A., P. Brickle, V. Laptikhovsky, J. Pompert, and A. Winter. 2012. Skate assemblage on the eastern Patagonian Shelf and Slope: structure, diversity, and abundance. Journal of Fish Biology. 80: 1704-1726.

Bigelow, H.B. and W. C. Schroeder. 1965. Notes on a Small Collection of Rajids from the Sub-Antarctic Region. Limnology and Oceanography. 10: 38-49.

Bizikov, V.A., A.I. Arkhipkin, V.V. Laptikhovsky, and J. Pompert. 2004. Identification guide and biology of the Falkland Islands skates. Fisheries Department. Falkland Islands Government. Stanley, Falkland Islands.

Brickle, P., V. Laptikhovsky, J. Pompert, and A. Bishop. 2003. Ontogenetic changes in the feeding habits and dietary overlap between three abundant rajid species on the Falkland Islands' shelf. Journal of the Marine Biological Association of the United Kingdom. 83: 1119-1125.

Brook, B.W., N.S. Sodhi, and C.J.A. Bradshaw. 2008. Synergies among extinction drivers under global change. Trends in Ecology and Evolution. 23: 453-460.

Bücker, A. 2006. Age and growth of skates of the genus *Bathyraja* in Argentina. M.Sc. Thesis, International Studies in Aquatic Tropical Ecology, University of Bremen. Germany.

Chiaramonte, G.E. 1998. Shark fisheries in Argentina. Marine and Freshwater Research. 49: 601-609.

Colonello, J.H. and A.M. Massa. 2004. Abundancias y patornes de distribución de las especies del género *Bathyraja* capturadas durante la primera y segunda etapa de la campaña de evaluación global de *Merluccius hubbsi* de año 2003. Informe Tecnico Interno INIDEP. 39:1-19.

Domingo, A., R. Forselledo, P. Miller, and C. Passadore. 2008. Plan de Acción Nacional para la Conservación de los Condrictios en las Pesquerías Uruguayas. Montevideo: DINARA. 88 p.

Falkland Islands Government. 2005. Fisheries Department Fisheries Statistics, Volume 9, 2004. 70 pp. Stanley, FIG Fisheries Department.

Falkland Islands Government. 2006. Fisheries Department Fisheries Statistics, Volume 10, 2005. 70 pp. Stanley, FIG Fisheries Department.

Falkland Islands Government. 2007. Fisheries Department Fisheries Statistics, Volume 11, 2006. 70 pp. Stanley, FIG Fisheries Department.

Falkland Islands Government. 2008. Fisheries Department Fisheries Statistics, Volume 12, 2007. 70 pp. Stanley, FIG Fisheries Department.

Falkland Islands Government. 2009. Fisheries Department Fisheries Statistics, Volume 13, 2008. 72 pp. Stanley, FIG Fisheries Department.

Falkland Islands Government. 2010. Fisheries Department Fisheries Statistics, Volume 14, 2009. 72 pp. Stanley, FIG Fisheries Department.

Falkland Islands Government. 2011. Fisheries Department Fisheries Statistics, Volume 15, 2009. 72 pp. Stanley, FIG Fisheries Department.

Falkland Islands Government. 2012. Fisheries Department Fisheries Statistics, Volume 16, 2010. 72 pp. Stanley, FIG Fisheries Department.

Falkland Islands Government. 2013. Fisheries Department Fisheries Statistics, Volume 17, 2012. 72 pp. Stanley, FIG Fisheries Department.

Figueroa, D.E., P. Martos, R. Reta, M.B. Cousseau, and J.M. De Astarloa. 1999. Distribución de las rayas de Argentina y Uruguay y su relación con las masas de agua. In: A.E. Tresierra Aguilar and Z.G. Culquichicón (eds), *Libro de resúmenes ampliados, tomo 1. VIII Congreso Latinoamericano sobre Ciencias del Mar,* pp: 148-149. Empresa editora Nuevo Norte S.A., Trujillo, Perú.

Gallagher, M.J. 2000. The fisheries biology of commercial ray species from two geographically distinct regions. Ph.D. Thesis, Department of Zoology, University of Dublin, Trinity College. Ireland.

Gallagher, M. and C.P. Nolan. 1999. A novel method for the estimation of age and growth in rajids using caudal thorns. Canadian Journal of Fisheries and Aquatic Sciences. 56: 1590-1599.

Gallagher, M., C.P. Nolan, and F. Jeal. 2005. The structure and growth processes of caudal thorns. Journal of Northwest Atlantic Fishery Science. 35: 125-129.

Ishiyama, R. and C.L. Hubbs. 1968. *Bathyraja*, a Genus of Pacific Skates (Rajidae) Regarded as Phyletically Distinct from the Atlantic Genus *Breviraja*. Copeia. 2: 407-410.

Kyne, P.M., J. Lamilla, R.R. Licandea, M. Jimena San Martín, M.F.W. Stehmann, and C. McCormack. 2007. *Zearaja chilensis*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 25 July 2014.

Laptikhovsky, V.V. 2004. Survival rates for rays discarded by the bottom trawl squid fishery off the Falkland Islands. Fishery Bulletin. 102: 757-759.

Laptikhovsky, V., A. Arkhipkin, P. Brickle, and J. Pompert. 2005. Biology and fishery of rays, *Bathyraja brachiurops* and *B. griseocauda* around the Falkland Islands. ICES Conference and Meeting Documen. N: 14.

Laptikhovsky, V., J. Pompert, and P. Brickle. 2006. Fishery discards management and environmental impact in Falkland Islands Fisheries. ICES Conference and Meeting Document. K: 05

Massa, A.M. and N.M. Hozbor. 2003. Peces cartilaginosos de la plataforma Argentina: explotacion, situacion y necesidades para un manejo pesquero adecuado. Frente Marítimo. 19: 199-206.

Massa, A., N. Hozbor, and J. Colonello. 2004. Situación actual y avances en el estudio de los peces cartilaginosos. Informe Technico Interno INIDEP. 57: 1-18.

McCormack, C., J. Lamilla, M.J. San Martín, and M.F.W. Stehmann. 2007. *Bathyraja griseocauda.* In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 30 January 2014.

Menni, R.C. and H.L. Lopez. 1984. Distributional patterns of Argentine marine fishes. Physis (Buenos Aires). 42: 71-85.

Norman, J.R. 1937. Coast Fishes. Part II. The Patagonian Region. Discovery Reports. 16: 1-150.

NPOA – Argentina – Plan de Acción Nacional para la Conservación y el Manejo de Condrictios (tiburones, rayas, y quimeras) en la República Argentina. 2009. Anexo Resolucion CFP. 6: 1-57.

Pequeño, G.R. and J.G. Lamilla. 1993. Batoideos comunes a las costas de Chile y Argentina-Uruguay (Pisces: Chondrichthyes). Revista de Biología Marina. 28: 203-217.

Sáez, S. and J. Lamilla. 2004. Sexual homodonty in *Bathyraja griseocauda* (Norman 1937) from the Southern Eastern Pacific (Chile) (Chondrichthyes, Rajidae: Arhynchobatinae). Journal of Applied Ichthyology. 20: 189-193.

Sánchez, M.F. and E. Mabragaña. 2002. Características biológicas de algunas rayas de la región sudpatagónica. INIDEP Informe Técnico. 48: 1-15.

Scenna, L.B., S.B. García de la Rosa, and J.M. Díaz de Astarloa. 2006. Trophic ecology of the Patagonian skate, *Bathyraja macloviana*, on the Argentine continental shelf. ICES Journal of Marine Sciences. 63: 867-874.

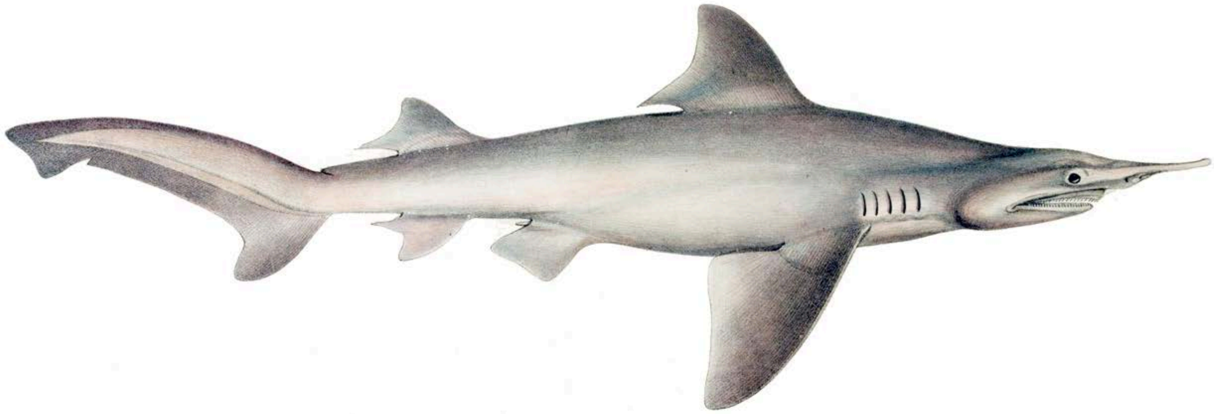
Springer, S. 1971. Three species of skates (Rajidae) from the continental waters of Antarctica. Biology of the Antarctic Seas IV. Antarctic Research Series. 17: 1-10.

Stehmann, M. 1986. Notes on the Systematics of the Rajid Genus *Bathyraja* and its Distribution in the World Oceans. Indo-Pacific Fish Biology: Proceedings of the Second International Conference on Indo Pacific Fishes.

Valdemarsen, J.W., T. Jørgensen, A. Engas. 2007. Options to mitigate bottom habitat impact of dragged gears. FAO Fisheries Technical Paper. 506: 1-29.

Wakeford, R.C., D.J. Agnew, D.A.J. Middleton, J.H.W. Pompert, and V.V. Laptikhovsky. 2005. Management of the Falkland Islands multispecies ray fishery: is species specific management required? Journal of Northwest Atlantic Fisheries Science. 35: 309-324.

ENDANGERED SPECIES ACT
STATUS REVIEW OF THE DAGGERNOSE SHARK
(*Isogomphodon oxyrhynchus*)



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
The authors would like to acknowledge Felipe Carvalho for assistance in locating Brazilian landings data. We would also like to thank the following peer reviewers; André S. Afonso, Riguel F. Contente, and Camila Marion. 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 Review of the Daggernose Shark (*Isogomphodon oxyrhynchus*). Report to the National Marine Fisheries Service, Office of Protected Resources. SFD Contribution PCB-15-05.

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 and Caribbean Sea, *Isogomphodon oxyrhynchus* (daggernose shark).

TABLE OF CONTENTS

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 daggernose shark, *Isogomphodon oxyrhynchus*; (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 daggernose 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 AND ECOLOGY

Taxonomy and Anatomy

The daggernose shark (*Isogomphodon oxyrhynchus*) is the only species in the genus *Isogomphodon*, in the family Carcharhinidae (Compagno 1988). The species was first described in 1839 based on an 18-inch long type specimen caught in Surinam (Springer 1950). The daggernose shark has common names in several languages other than English. It is called *requin bécune* in French and *cazón picudo* in Spanish (Compagno 1984). It also has a number of different common names in Portuguese including: *cação pato*, *cação bicudo*, *cação quati*, *quati*, and *bico-de-pato* (Lessa et al. 1999b, Silva 2004, Rosa and Lima 2005, Rodrigues-Filho et al. 2009).

The most prominent feature of a daggernose shark's anatomy is its elongated snout. Compagno (1984) describes the snout as extremely long and flattened, but not trowel-shaped, ending at an acutely triangular point (Figures 1 and 2). Its eyes are very small and circular with nictitating "eyelids," and its teeth are narrow and serrated with over 45 rows of teeth in each jaw (Compagno 1984, Grace 2001). Sexual heterodonty (tooth dimorphism) appears to be absent, but there is weak ontogenetic heterodonty with stouter tooth cusps on adults (Compagno 1988). It is generally accepted that daggernose sharks lack spiracles (Compagno 1984, 1988), although one specimen was found to have a small spiracle on the left side of its head (Uyeno et al. 1983). The pectoral fins are very large and paddle-shaped (Compagno 1984, Compagno 1988, Grace 2001). The origin of the first dorsal occurs over the midbase or second third of the pectoral fins (Compagno 1984, 1988). The second dorsal is about half the size of the first dorsal with the pelvic fin slightly smaller than the second dorsal (Compagno 1984, 1988). The anal fin is approximately 0.8 of the second dorsal height, with its insertion below or slightly anterior to the second dorsal and a deeply notched posterior margin (Compagno 1988). Daggernose sharks lack an interdorsal ridge (Bigelow and Schroeder 1948, Compagno 1988, Grace 2001). The dorsal side of the body is a uniform gray or gray-brown color (Compagno 1984, Compagno 1988, Grace 2001). The ventral side of the body is white (Compagno 1984, Grace 2001).

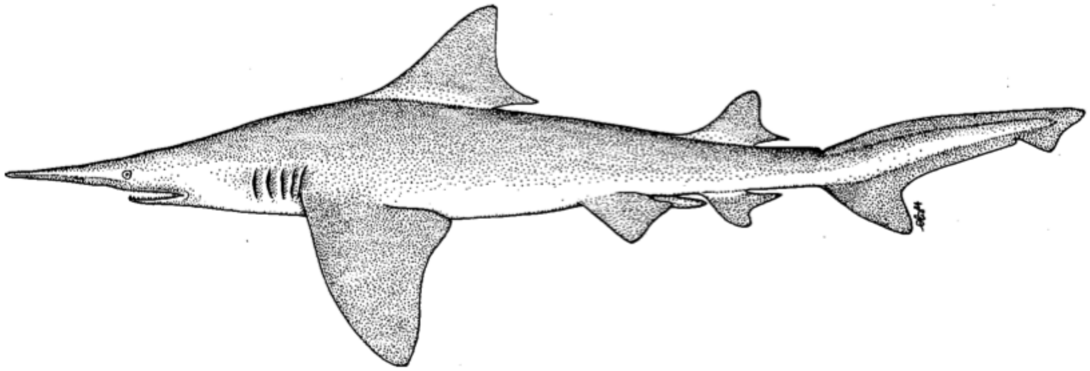


Figure 1. A side view of daggernose shark external anatomy (Compagno 1984).

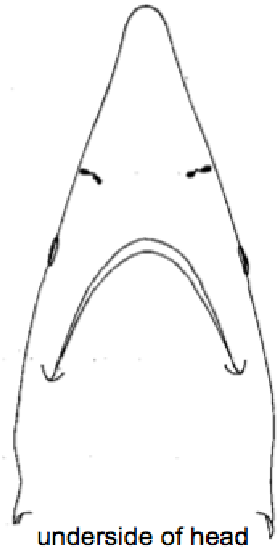


Figure 2. The underside view of the head of a daggernose shark (Compagno 1984).

Range and Habitat Use

The daggernose shark occurs in the central western Atlantic Ocean and Caribbean Sea. It has been reported along the coasts of Venezuela, Trinidad, Guyana, Suriname, French Guiana, and northern Brazil (Figure 3) (Lessa et al. 2006a). Compagno (1984, 1988) reported that the daggernose shark occurred on the eastern, central Brazilian coast in Bahia state. These claims have been unsubstantiated as the species is unknown to local fishermen and has never been caught in fisheries surveys in the area (Lessa et al. 1999a). Currently, the daggernose shark's Brazilian range includes the states of Amapá, Pará, and Maranhão, with Tubarão Bay in Maranhão as its easternmost limit (Silva 2004, Lessa et al. 1999a). The range of the daggernose shark is one of the smallest of any elasmobranch species (Lessa et al. 2000).

The daggernose shark is a coastal species that is commonly found in estuaries and river mouths in tropical climates (Compagno 1984, Compagno 1988, Lessa et al. 1999a, Lessa et al. 1999b, Grace 2001). Different maturity stages occur together in shallow waters between 8 and 40 m deep (Lessa et al. 1999a, Lessa et al. 1999b). Daggernose sharks are most abundant in estuarine and river mouth areas during the Amazonian summer, the rainy season, with males arriving in shallow waters from deeper seamount habitat earlier than females (Lessa 1997, Lessa et al. 1999a, Lessa et al. 2006b). There is no documentation on specific winter habitats of the daggernose shark.

Conflicting reports exist on the preferred substrate type of the daggernose shark. Compagno (1984) states that the species occurs in association with rocky bottoms, but Lessa et al. (1999a) asserts that they are strongly associated with muddy bottoms. They are often found in association with mangrove coastlines, and prefer highly turbid waters (Lessa et al. 1999a). Daggernose sharks seem to prefer low lying and indented coastlines that can have tide changes that vary as much as 7 m (Martins-Juras et al. 1987, Lessa et al. 1999a). They are found in waters ranging from 21.5°C to 31.5°C and salinities between 13.96 and 33.60 ppt (Lessa 1997). Salinity is considered a determining factor for the distribution of the species, but does not prevent the capture of daggernose sharks in shallow waters during the rainy season when waters are less saline (Lessa 1997).

Figure 3. Range of daggernose shark based on the information gathered in this review.

Diet and Feeding

Little is known about the diet and feeding of the daggernose shark. Bigelow and Schroeder (1948) and Compagno (1984) suggest that they feed on schooling fishes, such as clupeids, sciaenids, herring, anchovies, and croakers. It is speculated that their small eyes and elongated snout emphasize the use of their rostral sense organs over eyesight when hunting in turbid waters (Compagno 1984). In Marajó Bay in Brazil, daggernose sharks were found eating catfish (Family Ariidae) (Barthem 1985).

Growth and Reproduction

Growth is similar between males and females. A von Bertalanffy growth model fit to band counts on vertebrae resulted in growth rate parameters (K) between 0.11 and 0.12/year, with a maximum theoretical size (L_∞) between 171.4 and 173.8 cm total length (TL) (Lessa et al. 2000). A growth rate from birth to age one was calculated to be approximately 14 cm/year (Lessa et al. 2000). This rate then slows to approximately 10 cm/year from age 1 to 5-6 for males and age 1 to 6-7 for females (Lessa et al. 2000). The estimated ages at maturity are 5-6 years for males and 6-7 years for females. After maturity is reached, growth rates decrease to less than 10 cm/year (Lessa et al. 2000).

Maximum age was estimated at 20 years based on converting the length of a 160 cm TL female with parameters from the von Bertalanffy growth equation. The largest male caught was 144 cm TL, corresponding to an age of 13 years old (Lessa et al. 2000). However, the oldest aged individuals from vertebrae were a 7 year old male and a 12 year old female (Lessa et al. 2000).

Male daggernose sharks begin maturing between 90 and 110 cm TL (Lessa et al. 1999a). During this time the claspers grow from 4 cm to 10.5 cm long (Lessa et al. 1999a). In the field, fully adult males were observed at sizes larger than 119 cm TL, with claspers 9 cm or longer (Lessa et al. 1999a). According to von Bertalanffy growth parameters, size at maturity for males is 103 cm TL, and size at maturity for females is about 115 cm TL (Lessa et al. 2000). The smallest pregnant female recorded was 118 cm long (Lessa et al. 1999a).

The reproductive cycle of daggernose sharks in Brazil is synchronized with the rain cycle. The rainy season runs from January to June and the dry season runs from July to December. Ovary weight in non-pregnant adults suggests that follicles develop through the latter part of the year, resulting in heavy ovaries during the rainy season (Lessa et al. 1999a). Vitellogenesis begins in females between 105 and 112 cm TL when ovarian follicles reach 1.3 cm in diameter (Lessa et al. 1999a). Seventy percent of the pregnant females collected in the rainy season were carrying a recently fertilized egg or very small embryo, suggesting that the ovulation period takes place at the end of the dry season or at the beginning of the rainy season (Lessa et al. 1999a, Barthem 1985). Pregnant females are found in deeper waters, but there are no specifics on the exact depth range (Lessa et al. 1999a).

Female fecundity is low, commonly ranging between 3 to 7 embryos per female, although there has been one report of a female with 8 embryos (Bigelow and Schroeder 1948, Lessa et al. 1999a, Barthem 1985). Lessa et al. (1999a) reported that the largest litter from a dissected female contained 7 embryos. There is no significant relationship between female size and litter size in daggernose sharks (Lessa et al. 1999a). The largest full term embryo recorded was 43.2 cm (Lessa et al. 2000). The average back calculated length for size at birth was 42.3 cm TL for both males and females (Lessa et al. 2000), and Compagno (1984) stated actual birth length was thought to be between 38 and 41 cm TL.

The gestation period is approximately 12 months, with a protracted birthing period throughout the six-month rainy season (Lessa et al. 1999a, Lessa et al. 2006b). Mature females captured with flaccid uteri and white follicles indicate that there is a break in follicle development between two successive pregnancies, which indicates a 2-year reproductive cycle (Lessa et al. 1999a). Mating and gestation periods can be postponed to compensate for climate variability and changing environmental conditions across years (Lessa et al. 1999a).

Demography

The daggernose shark gives birth to 3-7 pups with a year of gestation and a year of resting between pregnancies (Lessa et al. 1999a). Males mature between 5 and 6 years of age, and females mature between 6 and 7 years of age (Lessa et al. 2000). Using these life history parameters and following methods in Cortes (2002) for estimating survivorship, productivity (as intrinsic rate of population increase, r) was estimated at 0.004 year^{-1} (median) within a range of -0.040-0.038 (5% and 95% percentiles) (Carlson unpublished). Median generation time (T) was estimated at 10.6 years, the mean age of parents of offspring of a cohort (μ_1) is 10.7 years and the expected number of replacements (R_0) is 1.05.

These demographic parameters place daggernose sharks towards the slow growing end of the "fast-slow" continuum of population parameters calculated for 38 species of sharks by Cortés (2002, Appendix 2). These species generally have low potential to recover from exploitation.

DISTRIBUTION AND ABUNDANCE

Records of the daggernose shark have occurred in Trinidad and Tobago, Guyana, Suriname, French Guiana, and the Brazilian states of Amapá, Pará, and Maranhão (Figure 3; Tables 1 and 2). There is no quantitative or qualitative abundance or trend information for daggernose sharks anywhere in their range, though the IUCN Red List Assessment states that the population is declining (Lessa et al. 2006a). The only data available are species catch records and museum collection records, most commonly reported in the GBIF Database. The majority of these records are undated, making it difficult to infer a historical abundance estimate or any current trend in population abundance from our records directly. In addition, there is question on the validity of some records from the GBIF database 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. Most information available on the distribution and abundance of the daggernose shark comes from Brazil. Daggernose shark specimens are housed in several different museums around the world.

Brazil

In Brazil, the daggernose shark can be found in the states of Amapá, Pará, and Maranhão (Barthem 1985, Lessa 1986, Martins-Juras et al. 1987, Lessa 1997, Lessa et al. 1999a, b, Lessa et al. 2000, Sotto and Mincarone 2004, Silva 2004, Lessa et al. 2006b). Daggernose sharks were first formally recorded in Brazil in surveys from the 1960s in the state of Maranhão (Lessa 1986). Recently, they have been caught in two Marine Conservation Areas in northern Brazil, the Parque Nacional Cabo Orange in Amapá, and the Reentrâncias Maranhenses in Maranhão (Lessa et al. 1999b).

Reviews of the species biology state that the population abundance declined by 18.4% per year for ten years from the mid-1990s to mid-2000, resulting in a total population decline of 90% (Rosa and Lima 2005, Kyne et al. 2012), but we were unable to find explicit statistics and studies with data that could support or contradict these statements. In recent years, the absence of daggernose sharks in Brazil in places where they were previously common has been noted. A genetic analysis of sharks being sold in fish markets in northern Brazil, where daggernose sharks were once sold in abundance, found no daggernose sharks in the market between October 2005 and December 2006 (Rodrigues-Filho et al. 2009). Although their absence in fish markets could indicate that artisanal fishermen are following Brazilian law, which prohibits the catch of daggernose sharks without special research permits, it has been noted that these laws are poorly enforced and frequently ignored (Lessa et al. 1999b, Silva 2004, Amaral and Jablonski 2005, Almeida et al. 2011, Rodrigues-Filho 2012). Additionally, daggernose sharks have been absent in research surveys in Maranhão between November 2006 and December 2007, where they were once caught abundantly prior to 1992 (Almeida et al. 2011).

Table 1. Records of the daggernose shark caught in Brazilian waters 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
1969 and 1976	--	Ilha de Santana and Baia de Lencois	Brazil	Lessa 1986
1982	--	Marajo Bay	Brazil	Barthem 1985
1982	1	Foz do Rio Pará, Cabo Maguari, Baía de Marajó	Brazil	GBIF Database
1982	1	Rio Amazonas, Cabo Maguari, Baía de Marajó	Brazil	GBIF Database
1982-1986	--	Ilha de Sao Luis, Maranhao	Brazil	Martins-Juras et al. 1987
1984-1986	--	Maranhao coast	Brazil	Lessa 1997
1984-1987; 1990-1991; 1998	105	between Turiacu and Tubarao Bays, Maranhao coast	Brazil	Lessa et al. 2000
1984-1987; 1990-1991; 1999	1135	between Turiacu and Tubarao Bays, Maranhao coast	Brazil	Lessa et al. 2000
1984-1987; 1998	--	Maranhao coast	Brazil	Lessa et al. 2006
1985-1987; 1989-1990	201	between Turiacu and Tubarao Bays, Maranhao coast	Brazil	Lessa et al. 1999
N/A	1	--	Brazil	GBIF Database
N/A	1	Ilha de Mangunca	Brazil	GBIF Database
N/A	1	Amazonas River, Marajo Bay	Brazil	Soto and Mincarone 2004
N/A	1	Para River, Marajo Bay	Brazil	Soto and Mincarone 2004

Other Countries

There is very little information available on the distribution and abundance of the daggernose shark outside of Brazil. Undated catch records exist across the entire coastline of French Guiana, but records are few throughout Suriname, Guyana, and Trinidad and Tobago (Table 2; GBIF Database, Bigelow and Schroeder 1948, Springer 1950, Compagno 1988). No information could be found on the existence of the daggernose shark in Venezuela. However, the IUCN red list assessment indicates Venezuela is part of their range (Lessa et al. 2006b). Increased levels of artisanal fishing pressure are likely to have caused dramatic population declines in the last decade, similar to the levels documented in Brazil, but scientific data on population trends is severely lacking for this region (Kyne et al. 2012).

Table 2. Records of the daggernose shark caught in Trinidad and Tobago, Guyana, Suriname, and French Guiana based on an extensive search of scientific publication, technical reports, museum specimen records, and the Global Biodiversity Information Facility Database (GBIF).

Year	Total Number	Area	Country	Source
1830	1	--	French Guiana	GBIF Database
1908	1	Georgetown market	Guyana	GBIF Database
1949	1	--	Trinidad	Springer 1950
1959	1	Georgetown	Guyana	GBIF Database
1961	1	Kitty Jetty	Guyana	GBIF Database
1968	1	--	Suriname	GBIF Database
1968	1	--	Suriname	GBIF Database
1968	1	Cayenne	French Guiana	GBIF Database
1968	1	Paramaribo	Suriname	GBIF Database
1981	1	--	Suriname	GBIF Database
1986	1	Port of Spain fish market	Trinidad and Tobago	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database

N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	Cayenne	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	Cayenne	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	Cayenne	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	British Guyana	Guyana	GBIF Database
N/A	1	--	French Guiana	GBIF Database

N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	1	--	French Guiana	GBIF Database
N/A	2	Georgetown	Guyana	Compagno 1988
N/A	1	Paramaribo	Suriname	Compagno 1988
N/A	1	--	French Guiana	Compagno 1988
N/A	1	--	Suriname	Bigelow and Schroeder 1948

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

Daggernose sharks are frequently found in shallow waters along mangrove-lined coasts from Trinidad and Tobago to northern Brazil. There has been a dramatic decline in mangrove forests around the world for decades. It is estimated that between 1980 and 2000 there was a 20-35% decline in global mangrove forest area (FAO 2007, Giri et al. 2011). The current estimate for mangrove forest area in the world is less than half of what it once was, and the forests that still exist are degraded (Giri et al. 2011). Of the countries where daggernose sharks are found, all but French Guiana showed declines in mangrove forest areas between 1980 and 2005 (FAO 2007). However, the available data on mangrove forest area in both French Guiana and Guyana were poor, and it is likely that forest loss occurred in French Guiana and was more severe than estimated in Guyana (FAO 2007).

The main cause of mangrove forest decline thus far has been anthropogenic disturbance (FAO 2007, Gilman et al. 2008, Giri et al. 2011). Coastal areas are under high population pressure and this has led to the clearing of mangrove forests for infrastructure, aquaculture, agriculture, and tourism (FAO 2007). Historically mangroves were harvested for the use of their wood, but that is rarely the main cause of contemporary permanent mangrove loss (FAO 2007). Improper shrimp farming practices pose a huge threat to the survival of mangroves and the surrounding ecosystems (FAO 2007). When done incorrectly, shrimp aquaculture can lead to significant eutrophication and ultimately dead zones in the surrounding waters (FAO 2007). Pollution in developed coastal zones also poses a threat to mangrove survival. This is particularly a problem in

Suriname, where the flow of pesticides into coastal zones threatens mangrove survival (FAO 2007).

Climate change and human's response to climate change pose a major threat to the future survival of the remaining mangrove forests (Gilman et al. 2008). It is thought that the biggest threat to mangroves will be sea level rise (Gilman et al. 2008, Giri et al. 2011). As sea level rises, mangrove's seaward margins will retreat (Gilman et al. 2008). The survival of mangrove forests will depend on the mangrove species' ability to colonize the newly submerged habitat at a rate equal to or greater than sea level rise (Gilman et al. 2008). The slope of the land farther inland could create a natural barrier to the landward expansion of mangrove forests, and manmade obstacles such as sea walls and roads could also inhibit landward expansion (Gilman et al. 2008). Rising sea levels due to climate change are likely to increase the number of manmade seawalls used to protect existing coastal structures (Gilman et al. 2008). Not only will this act as a barrier to landward mangrove expansion, it will also cause erosion and scouring of the mangroves immediately adjacent to the wall (Gilman et al. 2008). There are many other uncertain variables that could arise with changing climate (including increased rainfall, temperature, and CO_2 levels). There is uncertainty about how mangroves will handle these stressors, how human responses to these changes could affect mangrove growth, and how mangroves will respond to the synergistic effects of climate change and anthropogenic disturbances (Gilman et al. 2008).

Many countries now have conservation efforts in place in response to the decline in the world's mangroves. Of the countries where daggernose sharks are found, Brazil is the only one that has laws in place to protect mangrove forests (FAO 2007). Additionally, Brazil has established new coastal protected areas to preserve existing mangrove forests (FAO 2007). According to the FAO (2007), between 2000 and 2005, there was no mangrove loss in Brazil. The majority of mangrove loss in Brazil before 2000 took place in the South, outside of the daggernose shark's range. The low human population in northern Brazil has minimized mangrove loss in that area, but shrimp farming in the region still poses a risk (FAO 2007).

Despite the FAO's findings, a socio-economic survey of mangrove use in northern Brazil found trends of expanding tourism, intensified fishing, and increased urban growth in coastal Pará threatened the mangrove forest (Saint-Paul 2006). Though laws protect the mangroves in the area, extensive deforestation occurred during the study for both subsistence and industrial purposes. It is unclear whether the level of usage of the mangrove forest resources is currently a sustainable practice (Saint-Paul 2006).

Aside from mangrove loss, general coastal development and population increase could negatively affect all of the daggernose shark's habitat. Because coastal areas are so productive, nearshore waters have high economic value, which leads to heavy colonization (Bates et al. 2008). It is estimated that by 2020, 75% of the world's population will live within 60 km of the coast (Knip et al. 2010). Increased human populations and coastal development near the shore will lead to habitat degradation, increased pollution from terrestrial runoff, and increased fisheries exploitation (Knip et al. 2010). Shoreline degradation has already led to some coastlines being less productive and unable to support the nutritional demands of the shark species that utilize them (Knip et al. 2010). Increased runoff and pollution has led to eutrophication and dead zones due to low oxygen levels, thus reducing the health of the ecosystem. This in turn decreases productivity and lowers prey levels, reducing shark foraging success (Knip et al. 2010). As human populations increase in South America, increasing coastal development could pose a large threat to daggernose shark habitat.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

According to Nascimento and Asno (1999), directed fisheries for daggernose sharks have been developing off the northern coast of Brazil during the dry season. These fisheries use 6000 m long gillnets with 18 cm mesh size. These landings are common in Baía do Marajó, Pará (Isaac and Barthem 1995). However, we could find no information on daggernose shark landings or effort for these fisheries.

Daggernose sharks are caught as bycatch in Brazilian artisanal gillnet fisheries for Spanish mackerel (*Scomberomorus brasiliensis*) and king weakfish (*Cynoscion acoupa*) inside or near estuary mouths (Lessa et al. 1999a, Lessa et al. 2000). This incidental catch occurs primarily during the dry season, when daggernose sharks are more abundant in shallow coastal waters (Lessa et al. 1999a). Harvest begins in October and peaks in January when the highest catch per unit effort (CPUE) for daggernose sharks is recorded (71 $kgkm^{-1}h^{-1}$ prior to 1999; Lessa et al. 1999a). On the Maranhão coast, 96,500 tonnes of elasmobranchs were landed each year in artisanal fisheries in the 1990s, while the estimated sustainable total catch is estimated at 23,450 tonnes/year (Lessa 1997). Demographic analyses suggest that mortality as a result of these fisheries is causing the daggernose shark population to decrease at 18.4% per year with declines >90% observed in the 1990s (Lessa et al. 2006a citing Santana and Lessa 2002, which could not be found during the course of this review). We could not locate any recent information on landings of daggernose shark for these fisheries.

Daggernose sharks make up about 7-10% of the elasmobranch incidental catch in artisanal gillnet fisheries on the Maranhão coast in Brazil during the dry season (Lessa et al. 1999b; Lessa et al. 2000). The total elasmobranch incidental catch could not be found. Presumably these fishing practices are similar in Venezuela, Trinidad and Tobago, Guyana, Suriname, and French Guiana, but there is virtually no information available on the artisanal fishing practices, and the daggernose shark in general, in these countries (Lessa et al. 2006a). The value of daggernose shark fins is low, but its meat has been sold in markets from artisanal fisheries for decades (Lessa et al. 2006a). Bigelow and Schroeder (1948) also noted that, though daggernose shark meat was not considered a desirable food, it was sold in markets in Trinidad and was likely sold in the Guyanas.

Information on the catch of daggernose sharks in fisheries is very limited. At this time, we are unable to provide any further information on potential changes in fishing effort, fishing methods, and fishing grounds over time.

Competition, Disease, or Predation

At this time, there is no information available regarding diseases or predators that pose a risk to the survival of the daggernose shark.

Adequacy of Existing Regulatory Mechanisms

Throughout the species' range, species-specific protection for daggernose sharks is only found in Brazil. In 2004, the daggernose shark was first listed in Annex 1 on Brazil's endangered species list (Silva 2004). An Annex 1 listing prohibits the catch of the species except for scientific purposes, which requires a special license from the Brazilian Institute of Environment and Renewable Resources (Silva 2004). This protection was renewed in December, 2014, when the daggernose shark was listed as critically endangered on the most recent version of the Brazilian Endangered Species List approved by the Ministry of the Environment (Directive N^{o} 445). Brazil also has an extensive system of state and federal marine protected areas (Lessa et al. 1999b). Of these, the daggernose shark is found in the Parque Nacional Cabo Orange and the Reentrâncias Maranhenses (Lessa et al. 1999b). The expansion of both of these areas was proposed by Lessa et al. (1999b) in a Brazilian Ministry of the Environment document in order to improve the protection of daggernose shark habitat.

Though Brazil has some regulations in place to protect endangered or threatened species but they are poorly enforced, particularly with artisanal fishermen (Lessa et al. 1999b, Amaral and Jablonski 2005, Almeida et al. 2011, Rodrigues-Filho et al. 2012). Though protective legislation and marine protected areas exist, effective conservation is lacking in Brazil (Lessa et al. 1999b, Amaral and Jablonski 2005). Poverty, lack of education for artisanal fishermen, and increased artisanal fishing effort in Maranhão, Brazil, have contributed to the decline of many elasmobranch populations, potentially including the daggernose shark (Lessa et al. 1999b).

In December, 2014, the Brazilian Government's Chico Mendes Institute for Biodiversity Conservation approved the National Plan of Action for the Conservation of Elasmobranchs of Brazil (N^{o} 125). The plan considers the daggernose shark to be one of the country's 12 species of concern and recommends a moratorium on fishing with the prohibition of sales until there is scientific evidence in support of recovery (N^{o} 125, Lessa et al. 2005). Additionally it proposes the expansion of the Reentrâncias Maranhenses to include the marine coastal zone and banks. The plan recommends increased effort monitoring of vessels using nets in the area and increased education to encourage the release of live daggernose sharks and prevent the landing of the species. In general 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.

There is limited information on shark fishing regulations within the daggernose shark's range outside of Brazil. Both Trinidad and Tobago and Guyana reported shark landings to the FAO in the 1990s, but daggernose sharks were not specifically included in the catches (Shing 1999). Artisanal gillnet fisheries operate in both countries and have been known to partially target sharks while fishing for *Scomberomorus* spp. (Shing 1999). Gillnet fisheries in Guyana and Trinidad and Tobago are restricted to using nets of 900 ft or less with no more than a 15-foot depth (Shing 1999). Currently there are no minimum size restrictions or catch quotas for sharks in both countries (Shing 1999). In the late 1990s a fisheries management plan was drafted for Trinidad and Tobago. This plan prohibited the use of monofilament gillnets less than 4.75" stretch mesh and developed a licensing system (Shing 1999). No further details about the plan could be found. In the summer of 2013, Guyana's Fisheries Department within the Ministry of Agriculture passed a five-year Fisheries Management Plan for Guyana to run from 2013 to 2018 (gina.gov.gy/wp/?p=12293). One aspect of this plan is meant to address shark fishing, but no further details could be found at this time. No pertinent information could be found on shark fishing regulations in Venezuela, Suriname, and French Guiana. There is no information available on daggernose shark conservation efforts in Venezuela, Trinidad and Tobago, Guyana, Suriname, and French Guyana.

LITERATURE CITED

de Almeida, Z.d.S., V.J. Isaac, A.C. Paz, G.C. Marais, H.L.R. Porto. 2011. Avaliação do potencial de produção pesqueira do sistema da pescada-amarela (*Cynoscion acoupa*) capturada pela fronta commercial do Araçagi, Raposa, Maranhão. Boletim do Laboratório de Hidrobiologia. 24: 35-42.

Amaral, A.C.Z. and S. Jablonski. 2005. Conservation of Marine and Coastal Biodiversity in Brazil. Conservation Biology. 19: 625-631.

Barthem, R.B. 1985. Ocorrência, distribuição e biologia dos peixes da Baía de Marajó, Estuário Amazônico. Boletim do Museu Paranese Emilio Goeldi Zoologia. 2: 49-69.

Bates, B.C., Z.W. Kundzewicz, S. Wu, and J.P. Palutikof (Eds.). 2008. Intergovernmental Panel on Climate Change Technical Paper VI: Climate Change and Water. IPCC Secretariate, Geneva. 210 pp.

Bigelow, H.B. and W.C. Schroeder. 1948. Fishes of the Western North Atlantic. Part 1. Lancelets, Cyclostomes, Sharks. Memoirs of Sears Foundation for Marine Research.

Compagno, L.J.V. 1984. FAO species catalogue. Vol. 4. Sharks of the world. An annotated and illustrated catalogue of shark species known to date. FAO Fish. Synop. No. 125, vol. 4.

Compagno, L.J.V. 1988. Sharks of the order Carcharhiniformes. Princeton University Press, Princeton, New Jersey. 486 pp.

Cortés, E. 2002. Incorporating uncertainty into demographic modeling: Application to shark populations and their conservation. Conservation Biology. 16: 1048-1062.

FAO. 2007. The world's mangroves 1980-2005. FAO Forestry Paper 153. Rome, Italy. pp. 89.

Gilman, E.L., J. Ellison, N.C. Duke, and C. Field. 2008. Threats to mangroves from climate change and adaptation options: A review. Aquatic Botany. 89: 237-250.

Giri, C., E. Ochieng, L.L. Tieszen, Z. Zhu, A. Singh, T. Loveland, J. Masek, and N. Duke. 2011. Global Ecology and Biogeography. 20: 154-159.

Grace, M. 2001. Field Guide to Requiem Sharks (Elasmobranchiomorphi: Carcharhinidae) of the Western North Atlantic. Fishery Bulletin. NOAA Technical Report NMFS 153.

Isaac, V.J. and R.B. Barthem. 1995. Os recursos pesqueiros da Amazônia Brasileira. Boletim Museu Paraense Emílio Goeldi. Ciências Humanas. 11(2): 295-339.

IUCN SSG. 2007. Background paper on the conservation status of migratory sharks and possible options for international cooperation under the convention on migratory species. Meeting to identify and elaborate an option for international cooperation on migratory sharks under the Convention on Migratory Species. Mahe, Seychelles. Decmber 11-13, 2007. Agenda Items 4.0, 5.0, and 6.0.

Knip, D.M., M.R. Heupel, and C.A. Simpfendorfer. 2010. Sharks in nearshore environments: models, importance, and consequences. Marine Ecology Progress Series. 402: 1-11.

Kyne, P.M., J.K. Carlson, D.A. Ebert, S.V. Fordham, J.J. Bizzarro, R.T. Graham, D.W. Kulka, E.E. Tewes, L.R. Harrison, and N.K. Dulvy. 2012. Conservation status of North American, Central American, and Caribbean Chondrichthyans. IUCN Species Survival Commission Shark Specialist Group, Vancouver, Canada. pp. 156.

Lessa, R.P. 1986. Levantamento faunístico dos elasmobrânquios (Pisces, Chondrichthyes) do litoral ocidental do estado do Maranhão, Brazil. Boletim do Laboratório de Hidrobiologia, Universidade Federal do Maranhão, São Luis. 7: 27-42

Lessa, R.P. 1997. Sinopse dos estudos sobre elasmobrânquios da costa do Maranhão. Boletim do Laboratório de Hidrobiologia, Universidade Federal do Maranhão, São Luis. 10: 19-36.

Lessa, R., V. Batista, and Z. Almeida. 1999a. Occurrence and biology of the daggernose shark *Isogomphodon oxyrhynchus* (Chondrichthyes: Carcharhinidae) off the Maranhão coast (Brazil). Bulletin of Marine Science. 64: 115-128.

Lessa, R., P. Charvet-Almeida, F.M. Santana, and Z. Almeida. 2006a. *Isogomphodon oxyrhynchus*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 29 January 2014.

Lessa, R.P. and R.C. Menni. 1994. The chondrichthyan community off Maranhão (Northeastern Brazil). In: Proceedings of the Fourth Indo-Pacific Fish Conference, Systematics and Evolution of Indo-Pacific Fishes. pp: 138-172. Bangkok, Thailand.

Lessa, R., F.M. Santana, V. Batista, and Z. Almeida. 2000. Age and growth of the daggernose shark, *Isogomphodon oxyrhynchus*, from northern Brazil. Marine and Freshwater Research. 51: 339-347.

Lessa, R., F.M. Santana, P. Duarte-Neto. 2006b. A critical appraisal of marginal increment analysis for assessing temporal periodicity in band formation among tropical sharks. Environmental Biology of Fishes. 77:309-315.

Lessa, R., F.M. Santana, G. Rincón, O.B.F. Gadig, A.C.A. El-Deir. 1999b. Ministério do Meio Ambiente (MMA) Projecto de Conservação e Utilização Sustentável da Diversidade Biológica Brasileira (PROBIO): Biodiversidade de elasmobrânquios de Brasil. pp.154

Lessa, R., C.M. Vooren, M.L. Goes de Araújo, J.E. Kotas, P.C. Almeida, G.R. Filho, F.M. Santana, O.B. Gadig, C. Sampaio, Z. Almeida, M. Almeida, R.S. Rosa. 2005. Plano Nacional de Ação para a Conservação e o Manejo do Estoques de Peixes Elasmobrânquios no Brasil.

Martins-Juras, I.A.G., A.A. Juras, and N.A. Menezes. 1987. Relação preliminar dos peixes da Ilha de São Luís, Maranhão, Brasil. Revista Brasileira de Zoologia. 4: 105-113.

Nascimento, R.C. and M.F. Asano. 1999. Descrição e caracterização da pescaria artesanal de cação pato *Isogomphodon oxyrhynchus* (Muller et Henle, 1841) na região norte do Brasil. Anais do I Congresso Latinoamericano de Engenharia de Pesca, Recife, 17-21/10/99, Vol. I, 996-1002.

Rosa, R.S. and F.C.T. Lima. 2005. Os Peixes Brasileiros Ameaçados de Extinção. pp. 278

Rodrigues-Filho, L.F.d.S., T.C. da Rocha, P.S. do Rêgo, H. Schneider, I. Sampaio, and M. Vallinoto. 2009. Identification and phylogenetic inferences on stocks of sharks affected by the fishing industry off the Northern coast of Brazil. Genetics and Molecular Biology. 32:405-413.

Rodrigues-Filho, L.F., D. Pinhal, D. Sodré, and M. Vallinoto. 2012. Shark DNA forensics: Applications and impacts on genetic diversity. Analysis of Genetic Variation in Animals. pp. 269-286.

Saint-Paul, U. 2006. Interrelations among mangroves, the local economy, and social sustainability: a review from a case study in north Brazil. In: Environment and Livelihoods in Tropical Coastal Zones. Hoanh, C.T., T.P. Tuong, J.W. Gowing, and B. Hardy (eds.). CAB International. pp. 154-162.

Shing, C.C.A. 1999. Shark fisheries in the Caribbean: The status of their management including issues of concern in Trinidad and Tobago, Guyana, and Dominica. In: Case studies of the management of elasmobranch fisheries. R. Shotton (ed.). FAO Fisheries Technical Paper. 378, part 1. Rome, FAO.

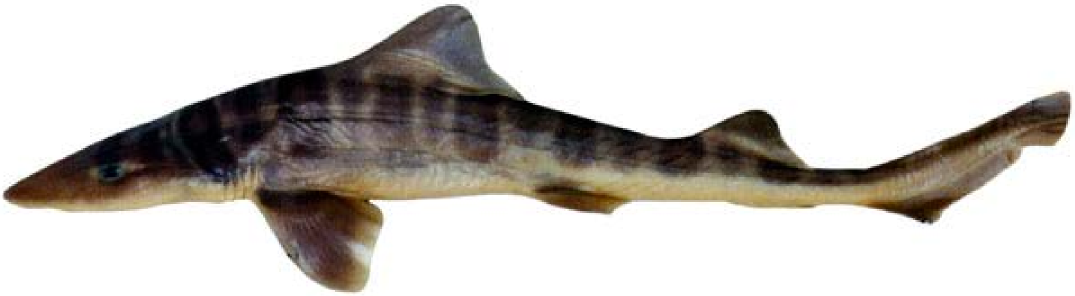
Silva, M. 2004. Ministério do Meio Ambiente. Instrução Normativa N^{o}5. May 21, 2004.

Soto, J.M.R. and M.M. Mincarone. 2004. Collections of the Museu Oceanográfico do Vale do Itajaí. I. Catalog of cartilaginous fishes (Myxini, Cephalaspidomorphi, Elasmobranchii, Holocephali). Museu Oceanográfico do Vale do Itajaí, Universidade do Vale do Itajaí. Itajaí, SC, Brazil.

Springer, S. 1950. An outline for a Trinidad shark fishery. In: Proceedings of the Third Annual Gulf and Caribbean Fisheries Session. Coral Gables, Florida, USA. Pp. 17-27.

Uyeno, T., K. Matsuura, and E. Fujii (eds). 1983. Fishes trawled off Suriname and French Guiana. Japan Marine Fishery Resource Research Center, Tokyo, Japan.

ENDANGERED SPECIES ACT STATUS REVIEW OF THE STRIPED SMOOTHHOUND(*Mustelus fasciatus*)



(Fishbase)

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 the following peer reviewers; Charles F. Cotton, Mauro Belleggia, and Melissa Giresi. 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 Review of the Striped Smoothhound (*Mustelus fasciatus*). Report to the National Marine Fisheries Service, Office of Protected Resources. Contribution PCB-15-06

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, *Mustelus fasciatus* (striped smoothhound).

TABLE OF CONTENTS

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 striped smoothhound, *Mustelus fasciatus* (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 striped smoothhound 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 31-July 2014.

LIFE HISTORY AND ECOLOGY

Taxonomy and Anatomy

The striped smoothhound (*Mustelus fasciatus* (Garman, 1913)) is a member of the family Triakidae, and was first described based on a juvenile specimen (Compagno 1984, Lorenz et al. 2010). It is a senior synonym of *Mustelus striatus* (Devincenzi, 1920) (Menni et al. 1984, Compagno 1984, Compagno 1988). The striped smoothhound has several different common names in Spanish and Portuguese. Spanish speaking countries refer to it as *recorrecostas, gatuzo, gatuso,* and *tiburón* (Menni et al. 1984, Menni and Lucifora 2007, Domingo et al. 2008, Ruarte et al. 2009), and in Portuguese it is called *cola fina, cação sebastião, cação-malhado, cação-listrado,* and *cação-papa-sirí* (Mazzoleni and Schwingel 1999, Biedzicki de Marques et al. 2002, Vooren and Klippel 2005, Haimovici and Fischer 2007).

There are at least four other species of the genus *Mustelus* that occur in the southwestern Atlantic with ranges overlapping the striped smoothhound: *M. canis, M. higmani, M. norrisi*, and *M. schmitti* (Rosa and Gadig 2010). *Mustelus* species are often difficult to distinguish due to their conserved morphology and highly variable intraspecific meteristic characteristics. This problem is compounded in the southwestern Atlantic due to the presence of few scientific collection specimens, particularly of larger individuals, which leads to a lack of comparative ontogenetic observations that can be used for species diagnosis (Rosa and Gadig 2010). Our reviewers have stressed that more genetic and morphological work is need to distinguish the smoothhounds in this area. We have provided the distinguishing taxonomic characters that are currently accepted below.

The striped smoothhound's head is large with a pre-pectoral distance of 19.5-24.5% total length (TL) (Rosa and Gadig 2010). The snout has a pre-oral distance between 8.9 and 12.6% TL and is acutely pointed (Compagno 1984, Rosa and Gadig 2010). The eyes are very small, with an orbital diameter of 1.3-3.3% TL (Compagno 1984, Rosa and Gadig 2010). Labial folds are present. The labial folds on the upper jaw (1.6-2.3% TL) are longer than the labial folds on the lower jaw (1.3-1.8% TL) (Heemstra 1997, Rosa and Gadig 2010). The striped smoothhound's teeth are small and uniform in size and are similar in adults and juveniles (Heemstra 1997, Vooren and Klippel 2005, Rosa and Gadig 2010). The crowns of the teeth are very low, rounded, and asymmetric (Compagno 1984, Heemstra 1997, Rosa and Gadig 2010). The upper jaw has 64-66 teeth while the lower jaw has 55-58 teeth (Heemstra 1997, Rosa and Gadig 2010).

The first dorsal fin is short, broad, and triangular with a large base and is located closer to the pelvic fins than the pectoral fins (Compagno 1984, Rosa and Gadig 2010). The second dorsal fin base is generally slightly smaller than the first dorsal fin base, and a dermal ridge is present between the two fins (Vooren and Klippel 2005). The interdorsal space is 16-19% of the TL (Compagno 1984). The pectoral and pelvic fins have posterior margins that are nearly straight, and the caudal fin is not well developed, with a small and rounded ventral lobe (Rosa and Gadig 2010).

Like many sharks, the striped smoothhound is grey or grey-brown on its dorsal side and white on its ventral side (Compagno 1984). Newborns and juveniles have dark bars of irregular widths running across the dorsal surface of their head and body (Heemstra 1997). Typically, there are 15 bars present, with 3 on the head, 6 on the body, and 6 on the tail (Vooren and Klippel 2005). The distinguishing vertical bars are still present in adults, but are not nearly as defined as they are in juveniles (Sadowski 1977, Heemstra 1997, Lorenz et al. 2010, Rosa and Gadig 2010). The maximum observed size is 162 cm TL (17.5 kg) for males, and 177 cm TL (29.7 kg) for females (Lorenz et al. 2010).

The striped smoothhound is one of the most distinctive *Mustelus* species, but it does bear similarities to *M. mento*, however the latter species is only reported from the Pacific and any Atlantic records are likely misidentified *M. schmitti* (Romero et al. 2007). Striped smoothhound can be distinguished from *M. mento* by the number of precaudal vertebrae (58-63 in striped smoothhound) (Heemstra 1997). The striped smoothhound stands out from the other *Mustelus* species in the southwestern Atlantic because of its triangular dorsal and pectoral fins, underdeveloped caudal fin, unique tooth morphology, wide head, and small eyes (Rosa and Gadig 2010).

Range and Habitat Use

Striped smoothhound are demersal sharks and can be found at depths between 1 and 250 m along the continental shelf and slope of the Southwestern Atlantic in Brazil, Uruguay, and Argentina (Soto 2001). Their distribution is coastal and restricted between Santa Catarina in southern Brazil and Bahía Blanca, Buenos Aires Province, Argentina (Figure 1), covering about 15,000 km of coastline (Lopez Cazorla and Menni 1983, Vooren and Klippel 2005, Lorenz et al. 2010). Adult biomass is concentrated between Rio Grande and Chuí in Rio Grande do Sul, Brazil during the winter (Vooren 1997, Vooren and Klippel 2005). A portion of the population migrates from Brazil to Uruguayan and Argentine waters in summer, while the rest of the population remains as residents in Rio Grande do Sul year round (Vooren 1997, Vooren and Klippel 2005). They occur only occasionally in Mar del Plata, Argentina, near the southern boundary of their range (Lopez Cazorla and Menni 1983).

In Rio Grande do Sul, Brazil, striped smoothhound display clear ontogenetic depth distributions. Neonates, which range between 35 and 48 cm TL, are common in inshore areas between Cassino Beach, just South of the city of Rio Grande, and Chuí in Rio Grande do Sul in depths less than 20 m, with the greatest frequencies between 2-5 meters depth from November to January (Vooren and Klippel 2005). These shallow areas may function as nurseries (Vasconcellos and Vooren 1991, Soto 2001, Vooren and Klippel 2005). Adults are found mainly in water depths between 50-100 m in autumn and winter but move to shallower depths (≤50 m) in spring and summer (Vooren and Klippel 2005). Males are only rarely caught in waters less than 20 m deep in the summer, and are much more common at depths between 20 and 50 m (Vooren and Klippel 2005). Females can be found in waters less than 20 m deep in the summer when they move into coastal waters for pupping (Vooren and Klippel 2005).

Striped smoothhound are generally found in cooler water temperatures. In Brazil, adult striped smoothhound occur in waters between 18-21^{o}C (Vooren and Klippel 2005) and in Argentina, at the southernmost point of its range, in temperatures around 15^{o}C (Lopez Cazorla and Menni 1983). Juveniles are found in temperatures of 11-15^{o}C during the Brazilian winter (Vooren and Klippel 2005). Adult striped smoothhound are rarely caught in waters less than 16°C, and are much more common in waters greater than 18°C (Vooren and Klippel 2005). The return migration to Brazilian waters from Argentina and Uruguay is related to temperature preferences of greater than 18°C (Vooren and Klippel 2005). Striped smoothhound prefer water salinities between 33.3 and 33.6 ppt (Lopez Cazorla and Menni 1983).

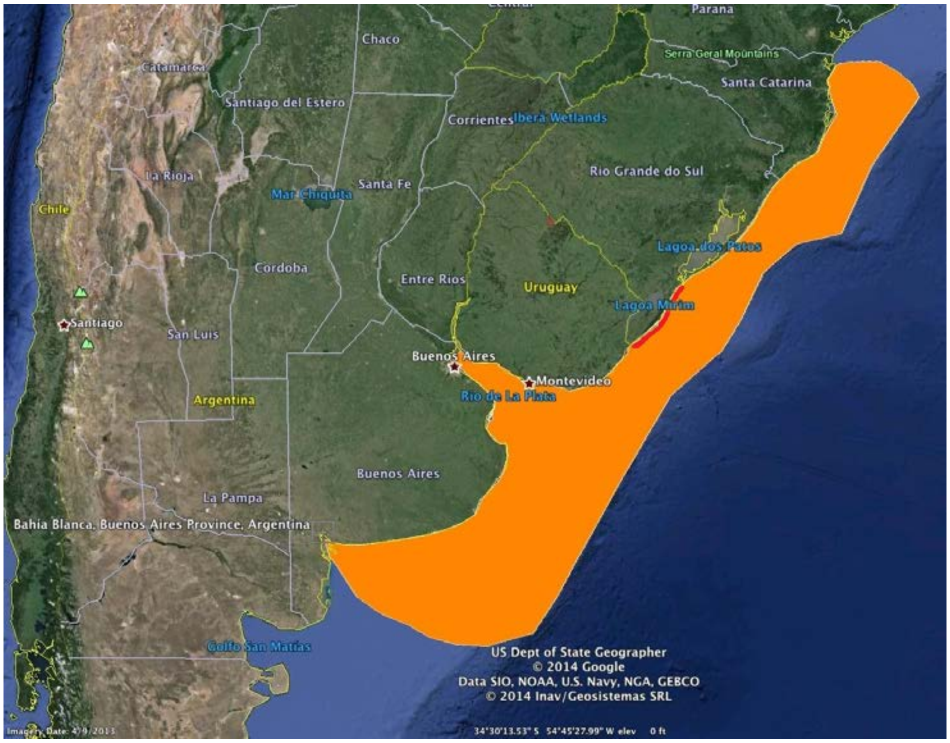


Figure 1. The range of the striped smoothhound based on information collected in this review. The coastline between Rio Grande and Chuí in Rio Grande do Sul, where species biomass is concentrated, is highlighted in red.

Diet and Feeding

Knowledge of the striped smoothhound's diet is limited. Soto (2001) studied the stomach contents of 17 specimens captured off Parcel da Solidão in Rio Grande do Sul, Brazil. Crustaceans were the most abundant prey group, making up 82.4% of the diet, while fishes and mollusks were present in lower numbers, 11.8% and 5.9%, respectively. Box crabs (*Heptus pudibundus*) were the most prevalent crustacean, occurring in 52.9% of the stomachs examined (Soto 2001).

Growth and Reproduction

Very little information is available on striped smoothhound life history. Age and growth studies are not available and conflicting data exist for size at birth and size at maturity in Rio Grande do Sul, Brazil. Vasconcellos and Vooren (1991) reported that size at birth is between 39 and 43 cm TL, and that sexual maturity is reached at 130 and 135 cm TL for males and females, respectively. Vooren and Klippel (2005) report size at birth between 35 and 38 cm TL and size at maturity of 119 cm TL for males (Soto 2001) and 121 cm TL for females. Our reviewers noted that this smaller size at maturity could be a compensatory response to fishing mortality.

Striped smoothhound have placental viviparous reproduction (Vooren 1997). Pregnant females migrate into shallow waters (<20 m) along the Rio Grande do Sul coast to give birth from October to December (Vasconcellos and Vooren 1991, Vooren 1997, Lorenz et al. 2010). Vooren and Klippel (2005) report that pupping takes place from November to January, however Soto (2001) reports that it occurs from September to November. Newborns are seen in high frequency in November, along with females with mature follicles of 2.2 cm and postpartum uteri, suggesting an annual reproductive cycle (Vasconcellos and Vooren 1991). After pupping, females move to deeper waters to mate (Soto 2001, Vooren and Klippel 2005, Lorenz et al. 2010).

Striped smoothhound have 4-14 pups per litter, with an average of 8 pups (Vasconcellos and Vooren 1991). Litter mass is about 11% of maternal body mass (Vooren 1997). One study found a positive relationship of litter size and maternal size (Soto 2001); however, two other studies found no correlation (Vasconcellos and Vooren 1991, Heemstra 1997). Size frequency distributions of embryos are generally normally distributed with a modal length of 18 cm in May and 36 cm in September (Vasconcellos and Vooren 1991). Gestation lasts 11-12 months (Soto 2001, Lorenz et al. 2010).

Demography

No information is available on natural mortality rates or the intrinsic rate of population increase (*r*) of the striped smoothhound.

DISTRIBUTION AND ABUNDANCE

To provide a better understanding of the striped smoothhound’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 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.

The striped smoothhound is distributed from Santa Catarina in southern Brazil to the Bahia Blanca in Buenos Aires Province, Argentina (Table 1). Striped smoothhound were once considered a dominant permanent resident in Rio Grande do Sul, Brazil, and displayed predictable abundance changes throughout the year (Vooren 1997). Though striped smoothhound were common in Brazil in the early 1970s and 1980s, they are currently rare within their range, and caught only sporadically in areas where they were once found (Soto 2001). On the southern Brazilian shelf in depths of 10-100 m, catch per unit effort (CPUE) varied between 2 kg/hr and 7 kg/hr from January 1982 to August 1983 in areas of low density, and 8 kg/hr to 33 kg/hr from January 1983 to August 1983 in concentrated areas (Vooren and Klippel 2005). It is thought that the striped smoothhound naturally occurred at low abundance before they were exploited in fisheries (Vooren and Klippel 2005). They occurred at a frequency of only 10% in research trawl surveys from 10-100 m deep between 1972 and 2005 and making up only 2-4% of the total elasmobranch CPUE from 1980-1984. In Rio Grande do Sul in the 1980s, neonates were relatively abundant in the summer along 10,688 km of coastline, but by the 2000s they were only abundant along 395 km of coastline (Vooren and Klippel 2005). This corresponds to an estimated 95% decline in neonate production between 1981 and 2005 (Vooren and Klippel 2005). Current catches by Uruguayan fishermen are infrequent, and trawl surveys in Argentina and Uruguay indicate a 96% decline in biomass between 1994 and 1999 (Lorenz et al. 2010). During the 1990s, striped smoothhound were absent from Argentine research surveys and are currently rarely caught by the commercial fleet, suggesting that the Argentine sea represents the periphery of its distribution (Massa 2013).

Table 1. Records of the striped smoothhound 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
1859	1	Rio Grande	Brazil	GBIF Database
1865	1	Rio Grande do Sul	Brazil	GBIF Database
1887	1	Montevideo	Uruguay	GBIF Database
1944	2	Barra, Rio Grande do Sul	Brazil	GBIF Database
1978	2	--	Argentina	GBIF Database
1980s	11	Rio Grande do Sul	Brazil	Soto and Mincarone 2004
1980	1	Rio Grande do Sul	Brazil	Soto and Mincarone 2004
1980	1	Rio Grande do Sul	Brazil	GBIF Database
1980-1984	215	Rio Grande do Sul	Brazil	Vasconcellos and Vooren 1991
1981-1999	6	Mar del Plata	Argentina	Massa 2013
1986	1	Rio Grande do Sul	Brazil	GBIF Database
1986	1	Torres, Rio Grande do Sul	Brazil	Soto and Mincarone 2004
1986	2	Rio Grande do Sul	Brazil	Soto and Mincarone 2004
1988-1992	109	Imbe Harbor	Brazil	Soto 2001
1990	2	Mostardas, Rio Grande do Sul	Brazil	Soto and Mincarone 2004
1992	1	Tramandi, Rio Grande do Sul	Brazil	Soto and Mincarone 2004
1995	1	Cassino, Rio Grande do Sul	Brazil	GBIF Database
1995	7	Santa Vitoria do Palmar, Rio Grande do Sul	Brazil	Soto and Mincarone 2004
1995	1	Santa Vitoria do Palmar	Brazil	GBIF Database

1996	2	Tavares, Rio Grande do Sul	Brazil	Soto and Mincarone 2004
1996	1	Farol de Conceiao	Brazil	GBIF Database
1997	1	Rio Grande do Sul	Brazil	Soto and Mincarone 2004
1997	1	--	Brazil	GBIF Database
2007	1	SE Punta del Diablo, Rocha	Uruguay	Lorenz et al. 2010
2009	1	Pozo de Fango off La Paloma, Rocha	Uruguay	Lorenz et al. 2011
N/A	9	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Tramandai	Brazil	GBIF Database
N/A	1	Montevideo	Uruguay	GBIF Database
N/A	1	Torres	Brazil	GBIF Database
N/A	1	Santa Vitoria do Palmar	Brazil	GBIF Database
N/A	1	Tramandai	Brazil	GBIF Database
N/A	1	--	--	GBIF Database
N/A	1	Montevideo	Uruguay	GBIF Database
N/A	1	Montevideo	Uruguay	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	Compagno 1984
N/A	1	Rio Grande do Sul	Brazil	Compagno 1988
N/A	2	Montevideo	Uruguay	Compagno 1988
N/A	1	Montevideo	Uruguay	Heemstra 1997
N/A	2	--	Uruguay	Sadowski 1977
N/A	1	Bahía Blanca	Argentina	Cazola and Menni 1983

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.

<u>Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range</u>

Various trawl fisheries occur throughout the striped smoothhound's range. Studies show that the interaction of bottom trawling gears with bottom substrate can have negative effects on benthic fish habitat (Valdemarsen at 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 (Valdemarsen et al. 2007). 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 (Vademarsen et al. 2007).

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 striped smoothhound'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

Overutilization in commercial fisheries poses the greatest threat to striped smoothhound. Because of their (presumed) natural low abundance, directed fisheries for striped smoothhound alone were never viable but striped smoothhound are caught as part multispecies smoothhound fisheries within their range and as bycatch in fisheries for other species such as drums, flounders, and mullets (Haimovici and Mendonça 1996; Vooren and Klippel 2005). As mentioned by a reviewer, since there has been no formal stock assessment for this species, the claims of naturally low abundance could be because portions of the population reside in waters that have been unsampled or undersampled over the years.

Striped smoothhound were once commonly caught as bycatch, although in low numbers, in the 1970s and 1980s in Brazil (Soto 2001, Vooren and Klippel 2005). Adult striped smoothhound are currently rare in commercial catches in Brazil (Vooren and Klippel 2005). According to the IUCN Red List assessment, the current threat to striped smoothhound is intensive fishing by pair trawl, shrimp trawl, gillnet and beach seine in the habitat of this shark (Hozbor et al. 2004). Striped smoothhound landings, although numbers are not available, have also been reported in double rig trawls, pair trawls, bottom longlines, and bottom gillnets in Itajaí Harbor, Santa Catarina (Mazzoleni and Schwingel 1999). An analysis of fisheries discards in shrimp trawls and flounder fisheries found striped smoothhound were occasionally caught and some were retained, while some were discarded (Haimovici and Mendonça 1996). Generally, large striped smoothhound weighing more than 4 kg are retained, while those less than 4 kg are discarded (Haimovici and Maceira 1981). The rate of discard mortality is unknown.

Intense coastal commercial fishing in Brazil affects the recruitment of juvenile sharks into the population (Vooren 1997). Gillnet and trawl fisheries operate along the Brazilian coast, close to shore, where striped smoothhound neonates and juveniles are found year round (Soto 2001, Vooren and Klippel 2005). This puts constant fishing pressure on the species before they reach maturity (Vooren and Klippel 2005). The female spring migration also interacts with these fisheries, affecting the reproductive capacity of the population (Vooren and Klippel 2005). According to the IUCN Red List assessment, gillnets set in inshore areas used to capture neonate striped smoothhound in large numbers (10-100 per set) in the 1980s, but in 2003, they were caught only sporadically and in much smaller numbers (Hozbor et al. 2004). Neonates were also common in waters off Rio Grande do Sul in the early 1980s, but sampling in 2005 yielded only one neonate (Vooren and Klippel 2005). A 95% decline in neonate abundance has been seen since 1981 in the Rio Grande do Sul nursery area based on similar research trawl surveys from the 1980s and early 2000s (Vooren and Klippel 2005).

Striped smoothhound are caught sporadically as bycatch in gillnets, bottom longlines, and trawls in fisheries off Uruguay and Argentina (Domingo et al. 2008, Lorenz et al. 2010). Striped smoothhound are caught in fisheries for Brazilian flathead (*Percophis brasiliensis*), Argentinian sandperch (*Pseudopercis semifasciata*), and apron rays (*Discopyge tschudii*), at depths between 14 and 48 m (Chiaramonte 1998; Lasta et al. 1998). Striped smoothhound are also found in trawls targeting striped weakfish (*Cynoscion guatucupa*) and whitemouth croaker (*Micropogonias funieri*) (Domingo et al. 2008). Landings of smoothhounds (primarily *M. schmitti*, but also *M. fasciatus* and *M. canis*) in Uruguay increased dramatically in the early 2000s (Figure 2; Domingo et al. 2008). No explanation was provided for the cause of the increase in landings. Bycatch in these fisheries has resulted in marked declines. According to unpublished data cited in the IUCN Red List assessment, in the coastal region of the Bonaerensean District of northern Argentina and Uruguay the biomass of striped smoothhound decreased by 96% between 1994 and 1999 in trawl surveys (Hozbor et al. 2004). No further information on survey design was provided in the Red List assessment. As emphasized by one of our reviewers, currently, striped smoothhound occur only rarely in Argentina.

Based on the information gathered for this review, fisheries data available for the striped smoothhound are inconsistent and sporadic at best. Numbers quantifying catch of striped smoothhound are rarely reported in papers and many of those papers only mention qualitative information, such as the presence or absence of smoothhound within the catch. Research on catch composition in Cassino Beach, Rio Grande do Sul, Brazil, shows that the number of neonates caught has declined from 1980-1983 to 2002-2003 (Figure 3; Vooren and Klippel 2005). Data compiled from separate Brazilian research surveys from the 1980s and early 2000s show declines in CPUE over time (Table 2 and 3; Vooren and Klippel 2005). Since striped smoothhound are not a target species in fisheries, no information was available on the distribution or potential changes in fishing effort and fishing grounds over time.

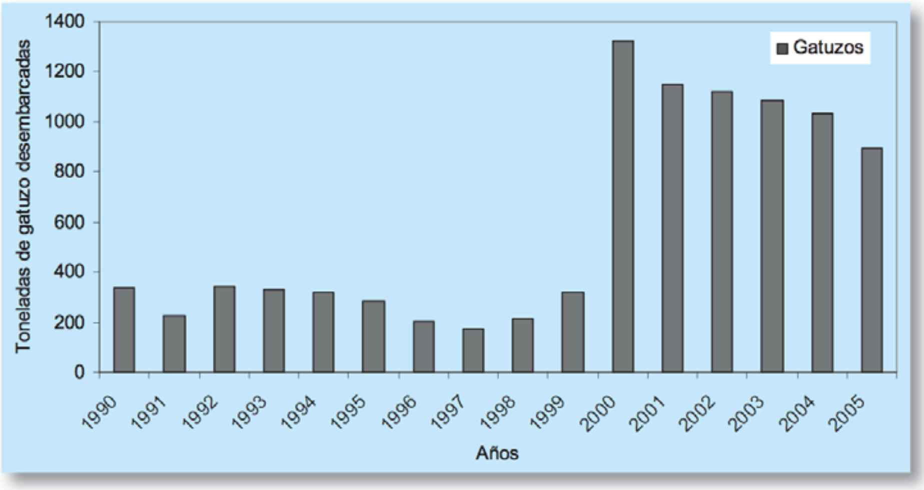


Figure 2. Landings of smoothhounds (*M. schmitti, M. fasciatus,* and *M. canis*) in Uruguay from 1990 to 2005 (Domingo et al. 2008).

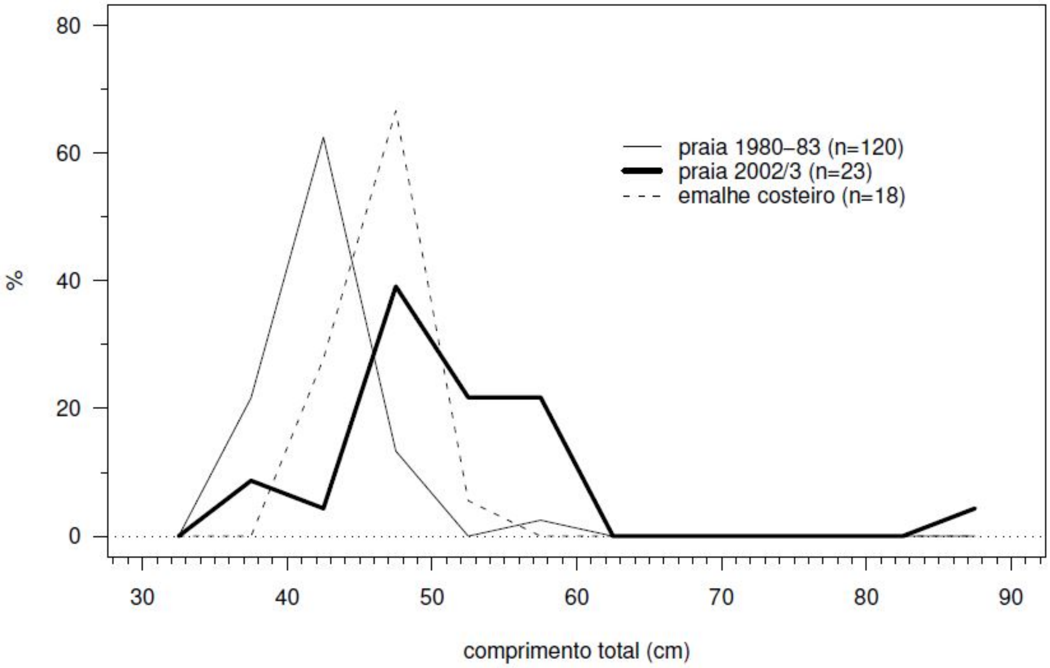


Figure 3. The length frequency of the catch of neonates (35-48 cm TL) and juvenile striped smoothhound from artisanal fishing in Cassino Beach, Rio Grande do Sul, Brazil in 1980-1983 ("praia 1980-83 (n=120)"; November-February) and in 2002-2003 ("praia 2002/3 (n=23)"; December to February), and from industrial gillnet fishing on the continental shelf between 15 and 20 m deep in December 2002 ("emalhe costeiro (n=18)") (Vooren and Klippel 2005).

Table 2. Catches of neonate striped dogfish in summer (December to February) in artisanal fisheries in Cassino Beach, Rio Grande do Sul, Brazil (Vooren and Klippel 2005).

	Beach Seine		Driftnet	
Years	1981-1985	2002-2003	1981-1985	2002-2003
Number of Sets	14	20	4	15
Frequency of occurrence	36%	40%	75%	13%
Number caught	27	23	74	3
CPUE (number per set)	1.9	1.2	18.5	0.2

Table 3. Catches of juvenile striped dogfish in trawl surveys at depths less than 20 m on the Rio Grande do Sul coast. Data from 1981 and 1982 were from depths of 10-20 m between Solidão and Chuí, and data from 2005 were from depths of 7-20 m between Torres and Chuí.

Date	Number of Sets	Frequency of Occurrence (%)	CPUE (kg/hr)
Feb. 1981	7	86	2.55
Jan. 1982	13	54	3.95
Feb. 2005	62	2	0.02

Competition, Disease, or Predation

Currently, no information is available regarding threats to the striped smoothhound population via competition, disease, or predation.

Adequacy of Existing Regulatory Mechanisms

In December, 2014, the Brazilian Ministry of the Environment approved a new version of the Brazilian Endangered Species List, which listed the striped smoothhound as critically endangered in Annex I (Directive N^{o} 445). An Annex I Listing forbids the capture, transport, storage, and handling of striped smoothhounds, 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 striped smoothhound is not listed as one of the twelve species of concern, but the plan does call for fishing closures in coastal waters, up to 20 m deep, in Rio Grande do Sul, to protect striped smoothhound nursery areas (Lessa et al. 2005). This suggestion is similar to that made by Vooren and Klippel (2005), which suggested that the coastal nursery between Cassino Beach and Chuí in Rio Grande do Sul be closed to fishing at depths less than 20 m. They also proposed a closure between 32 and 34^{o}S, where adults now seem to be found in greatest abundance (Vooren and Klippel 2005). 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 (Lessa et al. 2005).

Uruguay's FAO National Plan of Action for the conservation of chondrichthyans lists the striped smoothhound as a species of high priority (Domingo et al. 2008). It sets short-term goals of 12-18 months to investigate distribution and habitat use, mid-term goals of 24-30 months to generate time series of effort and catch, and long-term goals of 36-48 months to research reproduction, age and growth, and diet, and conduct an abundance assessment. They made it a priority to review current fishing licenses that allow for the catch of striped smoothhound and possibly modify them, grant no new fishing licenses, forbid processing and marketing of striped smoothhound, and promote public awareness to release captured individuals. The results gleaned from the goals and priorities of this plan could not be found. Argentina's FAO National Plan of Action for the conservation of chondrichthyans does not consider the striped smoothhound to be a species of high priority (NPOA-Argentina 2009).

Some general fishing regulations could also help protect the striped smoothhound throughout its range. In Brazil, trawling in waters less than 10 m deep is banned, but enforcement is poor (Hozbor et al. 2004). An area fishing ban for whitemouth croaker (*Micropogonias furnieri*) within the Argentine and Uruguayan Common Fishing Zone became effective August 31, 2014. This area is part of the striped smoothhound's range during the spring and summer, and a fishing ban for other species could help prevent their capture as bycatch.

LITERATURE CITED

Biedzicki de Marques, A.A., C.S. Fontana, E. Vélez, G.A. Bencke, M. Schneider, and R. Esser dos Reis. 2002. Lista das Espécies da Fauna Ameaçadas de Extinção no Rio Grande do Sul. Decreto N^{o} 41.672. Porto Alegre.

Chiaramonte, G.E. 1998. Shark fisheries in Argentina. Marine and Freshwater Resources. 49: 601-609.

Compagno, L.J.V. 1984. FAO Species Catalogue. Sharks of the World: an annotated illustrated catalogue of the shark species known to date. Part 2 – Carcharhiniformes. FAO Fisheries Synopsis No. 125, Vol. 4(2). FAO, Rome.

Compagno, L.J.V. 1988. Sharks of the Order Carcharhiniformes. Princeton University Press, Princeton, New Jersey.

Domingo, A., R. Forselledo, P. Miller, and C. Passadore. 2008. Plan de Acción Nacional para la Conservación de los Condrictios en las Pesquerías Uruguayas. Montevideo: DINARA. 88 p.

Haimovici, M. and L.G. Fischer. 2007. Avaliação de descartes na pesca de arrasto. In: *A prospecção pesqueira e abundância de estoques marinhos no Brasil nas décadas de 1960 a 1990: Levantamento de dados e Avaliação Crítica*. Brasília: MMA/SMCQA. pp. 330.

Haimovici, M. and R.P. Maceira. 1981. Observações sobre seleção na pesca de arrasto de fundo no Rio Grande do Sul. *Anais do Segundo Congresso Brasileiro de Engenharia de Pesca*. pp. 401-411.

Haimovici, M. and J.T. Mendonça. 1996. Descartes da fauna acompanhante na pesca de arrasto e tangones dirigida a linguados e camarões na plataforma continental do sul do Brasil. Atlântida, Rio Grande. 18: 161-177.

Heemstra, P.C. 1997. A review of the smooth-hound sharks (genus *Mustelus*, family Triakidae) of the Western Atlantic Ocean, with descriptions of two new species and a new subspecies. Bulletin of Marine Science. 60(3): 894-928.

Hozbor, N., C.M. Vooren, and A.F. Lamónaca. 2004. *Mustelus fasciatus*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 29 January 2014.

Lasta, C.A., C. Bremec, and H. Mianzan. 1998. Areas icticas costeras en la zona comun de pesca Argentino-Uruguaya (ZCPAU) y en el litoral de la Provincia de Buenos Aires. Noviembre, 1994. INIDEP Inf. Tec. 21: 91-101.

Lessa, R., C.M. Vooren, M.L. Goes de Araújo, J.E. Kotas, P.C. Almeida, G.R. Filho, F.M. Santana, O.B. Gadig, C. Sampaio, Z. Almeida, M. Almeida, R.S. Rosa. 2005. Plano Nacional de Ação para a Conservação e o Manejo do Estoques de Peixes Elasmobrânquios no Brasil.

Lopez Cazorla, A. and R.C. Menni. 1983. Presencia de *Mustelus fasciatus* (Garman, 1913) en Bahia Blanca, Argentina (Chondrichthyes, Triakidae). Historia Natural. 3(13): 137-140.

Lorenz, H.R., G. Polizzi, B. Zava, F. Fiorentino. 2010. New maximum lengths for the striped smooth-hound *Mustelus fasciatus* (Garman, 1913) (Carcharhiniformes, Triakidae). Biol. Mar. Mediterr. 17(1): 258-259.

Massa, A.M. 2013. Peces cartilaginosos (clase Chondrichthyes) de la región costera bonaerense y uruguaya: Situación, imacto y grado de vulnerabilidad de las distintas especies frente a la presión pesquera. PhD Thesis. Facultad de Ciencieas Naturales y Exactas. Universidad Nacional de Mar del Plata.

Mazzoleni, R.C. and P.R. Schwingel. 1999. Elasmobranch species landed in Itajaí Harbor, Southern Brazil. Notas Téc. Facimar. 3: 111-118.

Menni, R.C., R.A. Ringuelet, and R.H. Aramburu. 1984. Peces Marinos de la Argentina y Uruguay. Hemisferio Sur S.A., Buenos Aires, Argentina.

Menni, R.C. and L.O. Lucifora. 2007. Condrictios de la Argentina y Uruguay. Lista de Trabajo. ProBiota.

NPOA – Argentina – Plan de Acción Nacional para la Conservación y el Manejo de Condrictios (tiburones, rayas, y quimeras) en la República Argentina. 2009. Anexo Resolucion CFP. 6: 1-57.

Romero, M., L. Leandro, and J. Lamilla. 2007. *Mustelus mento*. The IUCN Red List of Threatened Species. Version 2014.3. <www.icunredlist.org>. Downloaded on 11 February 2015.

Rosa, M.R and O.B.F. Gadig. 2010. Taxonomic comments and an identification key to species for the Smooth-hound sharks genus *Mustelus* Link, 1790 (Chondrichthyes: Triakidae) from the Western South Atlantic. Pan-American Journal of Aquatic Sciences. 5(3): 401-413.

Ruarte, C.O., M.R. Rico, and L. Lucifora. 2009. Inventario Íctico del litoral costero Bonaerense y Uruguayo. INIDEP Inf. Téc. 69.

Sadowski, V. Primeiro registro de ocorrência de espécimens adultos de cação-malhado *Mustelus fasciatus* (Garmin, 1913). Ciencia e Cultura.

Soto, J.M.R. 2001. Distribution and reproductive biology of the striped smoothhound *Mustelus fasciatus* (Garman, 1913) (Carcharhiniformes, Triakidae). Mare Magnum. 1(2): 129-134.

Soto, J.M.R. and M.M. Mincarone. 2004. Collections of the Museu Oceanográfico do Vale do Itajaí. I. Catalog of cartilaginous fishes (Myxini, Cephalaspidomorphi, Elasmobranchii, Holocephali). Mare Magnum. 2(1-2): 1-125.

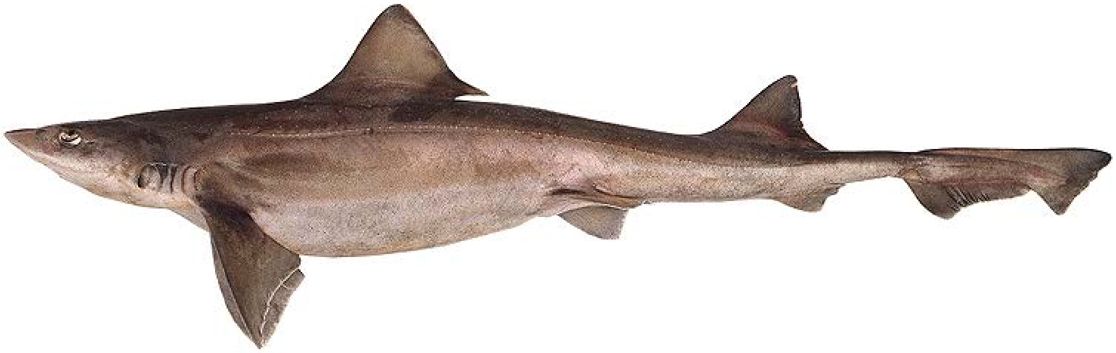
Valdemarsen, J.W., T. Jørgensen, A. Engas. 2007. Options to mitigate bottom habitat impact of dragged gears. FAO Fisheries Technical Paper. 506: 1-29.

Vasconcellos, M.C. and C.M. Vooren. 1991. Desenvolvimento sexual, ciclo reproductivo e fecundidade de *Mustelus fasciatus* no sul do Brasil. X Encontro Brasileiro de Ictiologia, Maringá-PR, p. 44 (abstract).

Vooren, C.M. 1997. Demersal elasmobranchs. In: *Subtropical Convergence Environments: The Coast and Sea in the Southwestern Atlatntic*. U. Speeliger, C. Odebrecht, and J.P. Castello (Eds.). pp. 141-145.

Vooren, C.M. and S. Klippel. 2005. Biologia e status de conservação do cação-listrado *Mustelus fasciatus*. In: *Ações para a conservação de tubarões e raias no sul do Brasil*. C.M. Vooren and S. Klippel (eds.). Porto Alegre: Igaré. pp. 262.

ENDANGERED SPECIES ACT STATUS REVIEW OF THE NARROWNOSE SMOOTHHOUND (*Mustelus schmitti*)



(INIDEP)

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 the following peer reviewers; Charles F. Cotton, Mauro Belleggia, and Melissa Giresi. 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 Review of the Narrownose Smoothhound (*Mustelus schmitti*). Report to the National Marine Fisheries Service, Office of Protected Resources. SFD Contribution PCB-15-07.

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, *Mustelus schmitti* (narrownose smoothhound).

TABLE OF CONTENTS

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 narrownose smoothhound, *Mustelus schmitti* (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 narrownose smoothhound 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 31-July 2014.

LIFE HISTORY AND ECOLOGY

Taxonomy and Anatomy

The narrownose smoothhound (*Mustelus schmitti*, Springer 1939), also called the Patagonian smoothhound (Oddone et al. 2005, Segura and Milessi 2009), is a member of the family Triakidae (Massa et al. 2006). The narrownose smoothhound is called *gatuzo* in Spanish and *cação-cola-fina* and *caçonete* in Portuguese (Silva 2004, Massa et al. 2006).

There are at least four other species of the genus *Mustelus* that occur in the southwestern Atlantic with ranges overlapping the narrownose smoothhound: *M. canis*, *M. higmani*, *M. norrisi*, and *M. fasciatus* (Rosa and Gadig 2010). *Mustelus* species are often difficult to distinguish due to their conserved morphology and highly variable intraspecific meteristic characteristics. This problem is compounded in the southwestern Atlantic due to the presence of few scientific collection specimens, particularly of larger individuals, which leads to a lack of comparative ontogenetic observations that can be used for species diagnosis (Rosa and Gadig 2010). Our reviewers have stressed that more genetic and morphological work is need to distinguish the smoothhounds in this area. We have provided the distinguishing taxonomic characters that are currently accepted below.

Narrownose smoothhound have a slender body (body depth 7.1-10.9% total length (TL) and body width 9.9-11.3% TL) and a short head, with a prepectoral length that is 17-21% of the TL (Compagno 1984, Rosa and Gadig 2010). Their snout is bluntly angular (Compagno 1984) with a narrow internostril distance, 1.7-3.2% of the TL (Rosa and Gadig 2010). Mouth width is 4.4-6.3% TL and mouth dept is 1.5-3.5 % TL (Rosa and Gadig 2010). The narrownose smoothhound's eyes are large, fitting 2-3.1 times in the preorbital snout (Compagno 1984) and making up 2.1-3.8% of TL (Rosa and Gadig 2010). Labial folds are present and are longer on the upper jaw than on the lower jaw (Compagno 1984, Heemstra 1997, Rosa and Gadig 2010). Narrownose smoothounds are grey with numerous small white spots on their dorsal side and white on their ventral side (Compagno 1984, Heemstra 1997).

Narrownose smoothhound have a body form similar to other Triakids. The space between the first and second dorsal fin makes up 17-23% of the total length (Compagno 1984). The trailing edges of both dorsal fins have exposed ceratotrichia, a distinctive characteristic for the species (Rosa and Gadig 2010). The midbase of the first dorsal fin is closer to the bases of the pelvic fins than the bases of the pectoral fins (Compagno 1984). The pectoral fins are relatively small with the anterior margins being 12-16% of the TL (Compagno 1984). The anterior margins of the pelvic fins are 6.7-8.7% of the TL, making them relatively small (Compagno 1984). The pectoral and pelvic fins are broad and slightly concave on the rear edge (Heemstra 1997, Rosa and Gadig 2010). The height of the anal fin is 2.5-3.4% of the TL (Compagno 1984). The ventral lobe of the caudal fin is poorly developed (Heemstra 1997).

Narrownose smoothhound have a semi-pavement homodont dentition, with short tooth crowns and reduced cusps. In adults, the lower jaw has two more tooth rows than the upper jaw. In juveniles, differences in tooth row counts were not seen between the sexes and in the upper and lower jaws. For juveniles, the dental formula was 47-63/50-63, and it was 40-77/50-69 for adults. The total number of tooth rows increases with growth. Teeth in the upper jaw were longer than teeth in the lower jaw, while teeth in the lower jaw were wider than teeth in the upper jaw. Across all life stages narrownose smoothhound have an average tooth replacement rate of 4 days/series. Juveniles replace their teeth at a rate that is significantly slower than adults (Belleggia et al. 2014).

Narrownose smoothhound are most similar to *M. canis* within its range. Often it is adult narrownose smoothhound that are confused with juvenile *M. canis* (Rosa and Gadig 2010). *M. canis* tends to have larger eyes and browner coloration than the narrownose smoothhound. *M. canis* also lacks the exposed ceratotrichia on the dorsal fin margins and the small white spots on the dorsal flanks as seen with narrownose smoothhound (Rosa and Gadig 2010).

Range and Habitat Use

The narrownose smoothhound is found in the southwestern Atlantic from southern Brazil to southern Argentina between 22^{o}S and 47^{o}45'S (Figure 1; Belleggia et al. 2012). Rio de Janeiro is the northernmost limit in Brazil (Oddone et al. 2007). The southern limit of the narrownose smoothhound's distribution is Ría Deseado, a protected area (Chiaramonte and Pettovello 2000). Narrownose smoothhound juveniles, adults, and gravid females migrate north into Brazilian waters in the winter and remain there from April to November (Haimovici 1997, Vooren 1997, Oddone et al. 2005, Massa et al. 2006). The migration is associated with cold water moving north into their Argentine range (Haimovici 1997). They are most common in waters off Uruguay in spring, summer, and autumn (December to April) (Vooren 1997, Oddone et al. 2005). In Argentina, abundance is highest in waters off Buenos Aires Province and northern Patagonia (Molina and Cazorla 2011). They are found at depths up to 120 m in Argentina, but in Brazil they have been captured as deep as 195 m (Belleggia et al. 2012). Narrownose smoothhound are found in waters with surface temperatures between 8-11.7^{o}C and bottom temperatures between 5.5 and 11^{o}C in Argentina (Menni 1985, Chiaramonte and Pettovello 2000). Wintering grounds in Brazil have water temperatures between 12 and 20^{o}C (Massa et al. 2006). Narrownose smoothhound have been reported in waters with salinities of 22.4 practical salinity units (psu) and higher (Molina and Cazorla 2011).

There are several known nursery areas for the narrownose smoothhound in Argentina: Bahía de Samborombón, Bahía Blanca/El Rincón, and inshore areas of Río de la Plata in Buenos Aires; and Bahía Engaño in Chubut (Oddone et al. 2005, Galíndez et al. 2010, Cortés et al. 2011, Molina and Cazorla 2011). All life stages are found in nursery areas in the spring but adult presence declines in the summer, while young-of-the-year and juveniles remain until autumn (Colautti et al. 2010). This residency pattern has also been seen in Ría Deseado, Argentina (Chiaramonte and Pettovello 2000). In Bahía Engaño, all life stages are present from spring through autumn (September-May), but juveniles are more abundant in spring (Van der Molen and Caille 2001). A small population of the Brazilian migrants was known to give birth in south Brazil in November and remain through February, but The IUCN Red List suggests that this population may have been extirpated (Massa et al. 2006).

There is a shift in the size and sex of narrownose smoothounds with their distribution. In Río de la Plata and El Rincón, Argentina, smoothhound size generally increases with depth, with smoothhounds less than 40 cm TL occurring more often in water less than 25 m. Larger individuals are also found in cooler waters with lower salinities (Cortés et al. 2011). In Uruguay, adult females were only found north of 35^{o}30'S, which could be where mating takes place (Oddone et al. 2007). Females were also more common on the inner continental shelf at depths less than 50 m during spring and summer, while males were more common on the outer continental shelf (Pereyra et al. 2008). In the autumn and winter, both sexes are found on the outer continental shelf (Pereyra et al. 2008).

Figure 1. The range of the narrownose smoothhound from Rio de Janeiro, Brazil to Ría Deseado, Argentina based on the information collected in this review.

Diet and Feeding

Olivier et al. (1968) first characterized the diet of the narrownose smoothhound as carcinophagous, benthic infaunal, and ichthiophagous. The narrownose smoothhound is an opportunistic predator that generally feeds on epifaunal benthic organisms and the diet varies geographically and ontogenetically (Capitoli et al. 1995).

In Río de la Plata and El Rincón, Argentina, the diet is generally dominated by crustaceans, fishes, and polychaetes. Crustaceans were most important based on the index of relative importance (IRI), but polychaetes were the most abundant in number, while fish were dominant by weight. The most abundant crustaceans in the diet were decapods *Peltarion spinosulum*, *Leucippa pentagona*, and polychaetes in the Maldanidae and Sabellidae families. Coastal narrownose smoothhound consumed fewer fish than those in deeper areas. Crustaceans were more abundant in the diet in the northern part of Argentina than the southern part. As smoothhounds increase in body size, the consumption of polychaetes declined and was replaced by more fishes and crustaceans. The shift to crustaceans occurred around 60 cm TL, while smoothhounds about 85 cm TL fed primarily on fish. Based on diet information from this area, the trophic level calculated for narrownose smoothhound was 3.57 (Belleggia et al. 2012).

Temporal and ontogenetic variations in diet were also found for narrownose smoothhound in Anegada Bay, Argentina. In general, neonate smoothhounds were the more specialized feeders, with diet becoming more generalized as the species grew in size and age. In summer, decapods, particularly *Neohelice granulata*, had the highest index of relative importance (95% IRI) of the neonate diet (Molina and Cazorla 2011). Isopods were found consistently throughout the diet of all life stages, but polychaetes, decapods and bivalves were more common in juveniles and adults. Amphipods were fed on more by juveniles, while cephalopods were only preyed upon by adults. However, in the winter, amphipods, cephalopods, and stomatopods were absent from the diet of all life stages and the importance of decapods decreased. Neonates still fed primarily on *N. granulata* (Molina and Cazorla 2011). Based on diet information from this area, the trophic level was calculated at 3.51(Molina and Cazorla 2011), which is similar to that calculated by Belleggia et al. (2012).

Smaller scale diet studies in Argentina also found the diet to be dominated by epifaunal benthic organisms. In Ría Deseado, Chiaramonte and Pettovello (2000) found that the main prey item in adults was decapod crabs, *Cyrtograpsus angulatus,* followed by fishes, isopods (Family Serolidae), and polychaetes. Young of the year from this area ate mainly krill from the order Euphausiacea, along with *C. angulatus* and Serolidae (Chiaramonte and Pettovello 2000). In Bahía Engaño, crustaceans were found to be the most abundant prey group, primarily *Artemesia longinaris*. Polychaetes, teleosts, and cephalopods were present, but less numerous (Van der Molen and Caille 2001).

Growth and Reproduction

In general, narrownose smoothhound females grow faster and grow to a larger size than males (Chiaramonte and Pettovello 2000, Sidders et al. 2005, Segura and Milessi 2009). The maximum recorded size is 110 cm TL (Molina and Cazorla 2011). According to the IUCN Red List Assessment, maximum total length in Argentina is 90 cm for males and 108.5 cm for females. In Brazil, the maximum total length it is 78 cm for males and 96 cm for females. The model total length of narrownose smoothhound in Brazil is 60 cm for males and 72 cm for females (Massa et al. 2006).

Narrownose smoothhound are non-placental and reported to be yolk-sac viviparous (Hamlett et al. 2005, Galíndez et al. 2010), however other congeneric species examined are either placental or mucoid histotrophic viviparous (Musick and Ellis, 2005). Their reproductive cycle is annual with a gestation of 11 months followed by immediate ovulation and mating (Chiaramonte and Pettovello 2000). Pregnant females migrate offshore in late summer to early autumn, after mating in inshore areas. They return inshore to pup and mate again in the spring (Colautti et al. 2010). Reproduction occurs at different times, ranging from late November in northern Argentina to mid-December at the southern extent of its range (Molina and Cazorla 2011). Litter size varies between 2 and 14 pups with a mode of 8 pups per litter (Massa et al. 2006). Mean litter size varies between 4 and 5.73 pups per litter throughout its range (Sidders et al. 2005, Galíndez et al. 2010). Litter size increases significantly with maternal length (Oddone et al. 2005, Cortés 2007), but larger females do not produce larger offspring (Sidders et al. 2005). According to the IUCN Red List, the average individual annual fecundity is 8 (Massa et al. 2006). Size at birth is estimated at 24.4 ± 4.25 cm (Colautti et al. 2010), with the smallest free swimming neonate recorded at 25.2 cm TL (Chiaramonte and Pettovello 2000). Samborombón Bay, Bahía Blanca, Anegada Bay, Río de la Plata, and El Rincón are considered to be nursery areas for the narrownose smoothhound (Molina and Cazorla 2011).

Size at maturity varies throughout the narrownose smoothhound's range. In southern Patagonia, Argentina, claspers begin to elongate in males at 62 cm TL and are fully calcified by 76 cm TL, indicating maturity has occurred. Females begin maturing at about 45 cm and are mature by 79 cm TL (Chiaramonte and Pettovello 2000). In Anegada Bay, Argentina, 50% of the population is mature at about 55 cm TL in males and 56 cm TL in females, which is about 2.4 years of age for both sexes. All males are sexually mature by 61 cm and females at 64 cm, about 3.4 years of age (Colautti et al. 2010). The estimated size at which 50% of the males and females were mature was 59 cm TL and 72 cm TL, respectively, in Rio de la Plata, Argentina (Oddone et al. 2005). Off the coast of Punta del Diablo, Uruguay, the estimated size at 50% maturity was 59 cm for females and 56 cm for males (Segura and Milessi 2009). In the Argentine-Uruguayan Common Fishing Zone (AUCFZ), the estimated size at maturity was 57.6 cm for males and 59.9 cm for females (Cousseau et al. 1998). This is lower than estimates of 60 cm and 62 cm TL for males and females made by Menni et al. (1986) in the same area in the 1980s. Size at first breeding and mean total length have also decreased in Argentina (Diaz de Astarloa et al. 1997). In Brazil, Hiamovici (1997) estimated the age at maturity of narrownose smoothhound was 6 years, with a longevity of 11 years. Hiamovici (1997) did not specify if the age at maturity listed was age at 50% maturity or age at 100% maturity. The IUCN Red List Assessment lists length at 50% maturity in Brazil as 57 cm for females and 55 cm for males, in northern Argentina between 50.5 and 62.6 cm for females and 54.9 and 60 cm for males, and in Patagonia between 79.1 and 79.5 cm for females and 70.5 and 75.9 cm for males. Age at first breeding in Brazil is 4 years for females and 3 years for males, while it is 6.5 years for females and 5.7 years for males in Argentina. Longevity is listed as 9 years for males and 16 years for females in Brazil (Massa et al. 2006). More recently, Hozbor et al. (2010) estimated an age at maturity of 4 years for both sexes with a longevity of 20.8 years for males and 24.7 years for females.

Population Structure

The genetic structure of the narrownose smoothhound population was examined using one mitochondrial DNA marker to test if multiple stocks occur throughout its range (Pereyra et al. 2010). No distinct population structure was found among all of the sampling sites, and gene flow out of Mar del Plata was estimated to be less than one migrant per generation. The dominant haplotype was found to be widely distributed and present at all collection sites. However, nucleotide diversity was lower than that reported for other elasmobranchs and this may indicate that narrownose smoothhound experienced a genetic bottleneck or recent expansion which potentially occurred during the Pleistocene Era (Pereyra et al. 2010). Our reviewers have noted that more research is needed using other genetic markers to better determine the population structure of the narrownose smoothhound.

Demography

Using a stage-structured Lefkovitch matrix and life history parameters from animals collected off Mar del Plata, Argentina, Cortés (2007) determined the intrinsic rate of increase (*r*) for narrownose smoothhound is 0.175 per year (lower 95% confidence limit=0.030; upper 95% confidence limit=0.314) when the population is not subject to exploitation. Because of this higher intrinsic rate of increase, Cortés (2007) concluded that narrownose smoothhound could withstand higher levels of exploitation than other coastal sharks in the Buenos Aires Coastal Ecosystem. Exploitation was found to be sustainable when fishing mortality levels are close to 0.1, equivalent to an annual removal rate of about 10% of the population.

These demographic parameters place narrownose smoothhound toward the faster growing end of the “fast-slow” continuum of population parameters calculated for 38 species of sharks by Cortés (2002, Appendix 2). These species generally have higher potential to recover from exploitation.

In Brazil, the annual rate of population increase was calculated to be 1.058 between 1980 and 1994 (Massa et al. 2006).

DISTRIBUTION AND ABUNDANCE

To provide a better understanding of narrownose smoothhound’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 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.

The narrownose smoothhound is distributed throughout the southwestern Atlantic Ocean from Rio de Janeiro, Brazil to Ría Deseado, Argentina (Table 1; Oddone et al. 2007, Belleggia et al. 2012). Higher abundances of juveniles and neonates have been found in nursery areas throughout Argentina in Samborombón Bay, Bahía Blanca, Anegada Bay, Río de la Plata, El Rincón, and Ría Deseado (Chiaramonte and Pettovello 2000, Molina and Cazorla 2011). Adults are mostly found in offshore areas, migrating inshore in the spring to give birth and mate (Colautti et al. 2010).

Sexual segregation of males and females has been seen in both Argentina and Uruguay. Females showed a preference for shallower and cooler water than males (Menni 1985; Pereyra et al. 2008). Females also tend to be found in more northern areas off Uruguay in the summer, while males are found to the south (Oddone et al. 2007).

The narrownose smoothhound is the most abundant and widely distributed Triakid in the Argentine Sea (Van der Molen and Caille 2001). In 1994, narrownose smoothhound densities off Rio de la Plata were as high as 44 t/nm^2. The rest of the

Argentine-Uruguayan Common Fishing Zone had densities between 1 and 10 t/nm^2, but some areas had densities as high as 22 t/nm^2 (Cousseau et al. 1998). Based on research surveys and commercial fishing data, the abundance of the narrownose smoothhound in Argentina and Uruguay was estimated to be 156,065 t from November to December of 1999 (Figure 2; Massa et al. 2004a, b). Updated abundance estimates could not be found. The IUCN Red List assessment cites unpublished data from Massa and Hozbor stating that biomass in the main fishing areas, along the coast of Buenos Aires Province, Argentina, and Uruguay, has declined by 22% and national landings in Argentina decreased by 30% between 1998 and 2002 (Massa et al. 2006). Declines in abundance continued to be seen in Argentine waters through 2005 (Massa and Hozbor 2008). The IUCN Red List assessment also states that it is likely that Brazil's locally breeding population has been extirpated due to the Brazilian smoothhound fishery, contributing to the 85% population decline seen in the area (Massa et al. 2006, Molina and Cazorla 2011).

Table 1. Records of the narrownose smoothhound 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
1700	1	Maldonado	Uruguay	GBIF Database
1700	1	Maldonado	Uruguay	GBIF Database
1901	1	Bahía Blanca	Brazil	GBIF Database
1925	2	--	Brazil	GBIF Database
1925	2	--	Uruguay	GBIF Database
1944	1	Ribeirao, Santa Catarina	Brazil	GBIF Database
1944	1	Ribeirao, Santa Catarina	Brazil	GBIF Database
1950	1	--	--	GBIF Database
1961	2	--	Brazil	GBIF Database
1961	1	Mar del Plata	Argentina	GBIF Database
1964	1	Point Medanos	Argentina	GBIF Database
1966	1	--	Uruguay	GBIF Database
1966	5	--	Argentina	GBIF Database
1966	2	--	Brazil	GBIF Database
1970	4	--	Argentina	GBIF Database
1976	4	--	Argentina	GBIF Database
1978	31	--	Argentina	GBIF Database
1979	2	Lagoa dos Patos, Costa de Sao Jose do Norte, Rio Grande do Sul	Brazil	GBIF Database
1980	1	--	Brazil	GBIF Database
1980	1	Lagoa dos Patos, Canal Acesso, Rio Grande do Sul	Brazil	GBIF Database
1981	1	Rawson	Argentina	GBIF Database
1983	1	--	Brazil	GBIF Database
1983	8	--	Argentina	GBIF Database
1985-	570	Bahía Blanca	Argentina	Marcovecchio et

1986				al. 1991
1987	1	Argentine Sea	Argentina	GBIF Database
1988	1	Argentine Sea	Argentina	GBIF Database
1988	1	Tramandai	Brazil	GBIF Database
1991	2	Barra de Santos	Brazil	GBIF Database
1991	2	Imbai	Brazil	GBIF Database
1992	1	Golfo San Jose	Argentina	GBIF Database
1992	20	Bahía Blanca	Argentina	Galindez and Aggio 2002
1993	2	Necochea	Argentina	GBIF Database
1993, 1995, 2000	52	La Paloma, Mar del Plata, and Puerto Quequen	Uruguay and Argentina	Ivanov and Brooks 2002
1993-2006	--	Rio de la Plata and El Rincon	Argentina	Cortes et al. 2011
1994	1	Puerto Lobos	Argentina	GBIF Database
1994-1995	2255	Rio de la Plata	Argentina	Oddone et al. 2005
1994-1995	4824	Rio de la Plata	Argentina	Oddone et al. 2007
1994-1998	88	Argentine Sea	Argentina	Chiaramonte and Pettovello 2000
1995	1	Cassino Beach	Brazil	GBIF Database
1995	1	Santa Cruz	Argentina	GBIF Database
1995-1996	65	Bahía Engano	Argentina	Van der Molen and Caille 2001
1996	7	Rio Grande do Sul	Brazil	GBIF Database
1996-1997	95	Santos, Sao Paulo	Brazil	Gonzalez 1999
1997	2	--	Brazil	GBIF Database
1997	1	Torres	Brazil	GBIF Database
1997	1	Necochea	Argentina	GBIF Database
1998	1	Rawson	Argentina	GBIF Database
2001-2003	20	Mar del Plata	Argentina	Alarcos et al. 2006
2003-2004	637	Necochea, Buenos Aires	Argentina	Sidders et al. 2005
2003-2008	2290	Anegada Bay	Argentina	Colautti et al. 2010
2004	--	--	Uruguay	Pereyra et al. 2008
2004-2005	3429	Mar del Plata	Argentina	Cortes 2007
2004-2007	41	Bahía Blanca	Argentina	Rojas 2013
2005-2006	696	Punta del Diablo	Uruguay	Segura and Milessi 2009
2005-2008	99	Rio de la Plata	Argentina	Pereyra et al. 2010
2007-	103		Argentina	Belleggia et al.

2008				2014
2008	1577	Anegada Bay, Buenos Aires	Argentina	Molina and Cazorla 2011
2008-2009	525	Argentine Shelf	Argentina	Belleggia et al. 2012
2012	1	--	Brazil	GBIF Database
N/A	13	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Golfo San Matias	Argentina	GBIF Database
N/A	3	--	Uruguay	GBIF Database
N/A	1	Costa de Laguna	Brazil	GBIF Database
N/A	1	Argentine Shelf	Argentina	GBIF Database
N/A	4	Golfo Nuevo	Argentina	GBIF Database
N/A	1	Buenos Aires	Argentina	GBIF Database
N/A	1	Barra de Santos	Brazil	GBIF Database
N/A	1	Golfo San Jose	Argentina	GBIF Database
N/A	1	Puerto Rawson	Argentina	GBIF Database
N/A	1	Playa Union	Argentina	GBIF Database
N/A	3	Tramandai	Brazil	GBIF Database
N/A	3	Buenos Aires	Argentina	GBIF Database
N/A	1	--	Uruguay	GBIF Database
N/A	3	Playa Union, Bahía Engano	Argentina	GBIF Database
N/A	1	Golfo San Jose	Argentina	GBIF Database
N/A	1	Barra de Santos	Brazil	GBIF Database
N/A	1	Canal Villarino Viejo, Bahía Blanca	Argentina	GBIF Database
N/A	1	Mar del Plata	Argentina	GBIF Database
N/A	1	Squarema	Brazil	GBIF Database
N/A	1	--	Brazil	GBIF Database
N/A	2	Maldonado. Rio de la Plata	Uruguay	GBIF Database

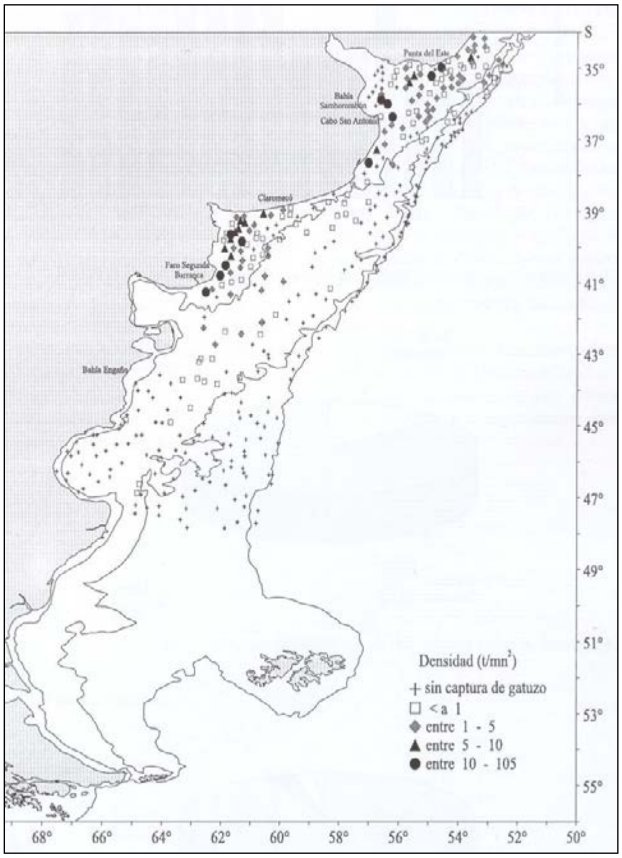


Figure 2. The distribution and density of the narrownose smoothhound from November-December, 1999 (Massa et al. 2004b).

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

Various trawl fisheries occur throughout the species 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 (Valdemarsen et al. 2007). Studies on the effects of trawling within the narrownose smoothhound's range have shown that large gastropods are frequently injured when caught as bycatch in hake trawls and discarded (Carranza 2006, Carranza and Horta 2008). Though the animals studied are not part of the narrownose smoothhound diet, damaged habitat and relocated animals could have indirect effects on the smoothhound by attracting scavengers, altering trophic relationships and potentially increasing competitive interactions (Carranza 2006). It is also likely that the animals that the narrownose smoothhound eats are similarly affected by trawling activities.

<u>Overutilization for commercial, recreational, scientific, or educational purposes</u>

Commercial Fishing

Narrownose smoothhound are intensely fished throughout their entire range, including several of their nursery grounds (Belleggia et al. 2012). Both industrial and artisanal fleets harvest the species. Landings have been reported to the Food and Agriculture Organization of the United Nations (FAO) from Argentina since 1960 and from Uruguay since 1993. Argentinian landings peaked in 1988 at 13,597 t and have fluctuated from about 6,000 to 12,000 tonnes since (Figure 3). Landings reported by Uruguay peaked in 1999 at 3,212 tonnes and have steadily declined to 2012.

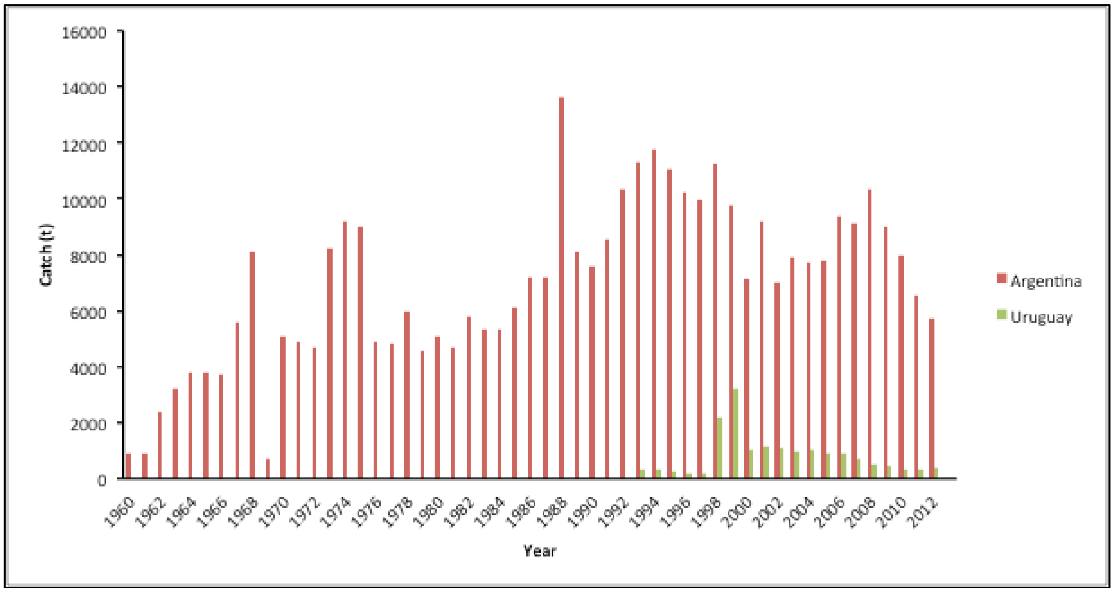


Figure 3. Annual landings of narrownose smoothhound reported to Food and Agriculture Organization of the United Nations by Argentina and Uruguay (source, FAO.org).

Narrownose smoothhound are targeted in artisanal fisheries in Uruguay using bottom fixed gill nets (Paesch and Domingo 2003, Segura and Milessi 2009). Artisanal fishermen targeting narrownose smoothhound in Uruguay mainly operate out of Punta de Diablo, Barra de Valizas, and La Paloma (Segura and Milessi 2009). Narrownose smoothhound are also caught as bycatch in Uruguay in inshore and offshore trawl fisheries, as well as inshore and offshore gillnet fisheries (Paesch and Domingo 2003, Domingo et al. 2008). Landings of smoothhounds in Uruguay (primarily *M. schmitti*, but also *M. fasciatus* and *M. canis*) increased dramatically between 1999 and 2000, reaching 1300 tons and then began to steadily decline, reaching approximately 850 tons by 2005 (Domingo et al. 2008). This is contradictory to the landings reported to the FAO that are referenced in Figure 2. Identifying the true species composition of shark catches in Uruguay can be difficult because catch is often reported by common name and the same common name is used for multiple species (Nion 1999). In 2009, the narrownose smoothhound was cataloged as overfished in the coastal regions of Uruguay (Defeo et al. 2009).

Narrownose smoothhound make up 9-12% of the total landings from coastal fleets in Argentina, making it the most important elasmobranch for Argentine fisheries (Galíndez et al. 2010). In the 1990s, the narrownose smoothhound was the main shark caught in the Argentine Sea based on an extracted biomass of 10,200 t for that time period and was the second most consumed domestic fish (Van der Molen et al. 1998, Chiaramonte 1998). Landings of narrownose smoothhound in Buenos Aires, Argentina were around 6,000 t per year from 1994-2002 (Molina and Cazorla 2011). Landings steadily increased after 2002, until they reached 9,000 t in 2008 (Molina and Cazorla 2011). We could not find any reports of updates on landings, but data reported to FAO indicate a decline since 2008.

The narrownose smoothhound is the most heavily exploited shark in artisanal fisheries in Argentina, especially in areas between 36°S and 41°S. The smoothhound artisanal fishing season in Argentina is from October 15 to December 15 and exclusively uses bottom gill nets. Narrownose smoothhound make up 96% of artisanal landings and range in size from 52-75 cm TL. Narrownose smoothhound are also caught in directed industrial shark fisheries in Argentina (Massa et al. 2004). In these fisheries, fishing effort for narrownose smoothhound steadily increased from 1991to 1998, while the total catch in the mid-1990s leveled out and slightly declined until significantly increasing in 1998 (Figure 4; Massa et al. 2004). Both effort and catch declined in 1999. Narrownose smoothhound are also caught as bycatch in commercial bottom trawls in Argentina, making up about 20% of the coastal harvest from these fisheries (Colautti et al. 2010). Pérez et al. (2011) found that CPUE for narrownose smoothhound has been increasing or maintaining a stable trend from 2000-2007 (Table 2). However, decreasing abundance, mean TL, and size at maturity indicates that the narrownose smoothhound was over exploited in Argentina (Massa 2013).

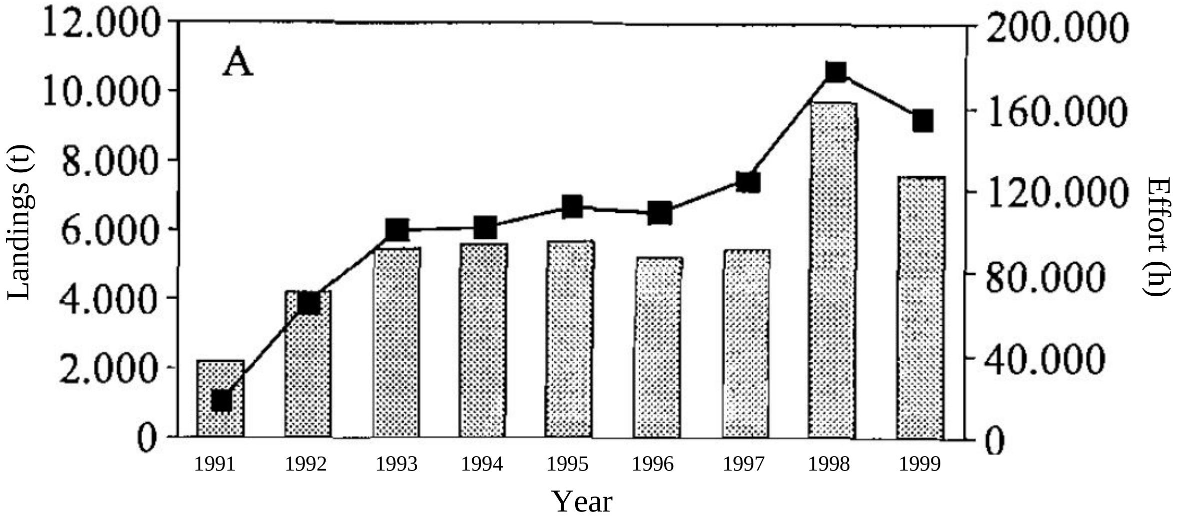


Figure 4. Trends in catch (grey bars) and effort (black line) for the narrownose smoothhound between 1991 and 1999 along the coast of Buenos Aires, Argentina and Uruguay (Massa et al. 2004).

Table 2. Mean values of CPUE (kg/h) between 34 and 42^{o}S in Argentina from 1992-2007 (Pérez et al. 2011).

Year	Average CPUE (kg/h)
1992	31.32
1993	26.40
1994	32.19
1995	29.67
1996	28.18
1997	29.00
1998	37.18
1999	35.91
2000	25.00
2001	25.76
2002	36.30
2003	37.72
2004	35.09
2005	37.87
2006	42.36
2007	42.30

In the Argentine-Uruguayan Common Fishing Zone, narrownose smoothhound are the most heavily exploited shark, with Uruguay landing 1,000 t and Argentina landing 10,000 t per year (Segura and Milessi 2009). Though maximum permitted catch limits are set by both countries, population declines have been seen throughout the narrownose smoothhound's range, mostly due to increased fishing effort (Colautti et al. 2010, Molina and Cazorla 2011). Market demand for narrownose smoothhound is increasing, and continued intense fishing pressure has caused a chronological reduction in both maximum total length and total length at maturity (Cortés 2007, Molina and Cazorla 2011).

The majority of shark landings in Brazil between 1975 and 1997 were narrownose smoothhound and *Galeorhinus galeus* (Miranda and Vooren 2003). Narrownose smoothhound were landed in the Rio Grande Port from trawl and oceanic drift net fisheries from April to October (Miranda and Vooren 2003). The highest reported CPUE for a single trawl was 7 t/trip in 1985 (Miranda and Vooren 2003). Migratory narrownose smoothhound are fished intensely without regulation in Brazil, which has been reported to cause an 85% decline in population size (Molina and Cazorla 2011).

More detailed information on changes in fishing grounds, effort, and fishing methods over time could not be found for this review.

Competition, Disease, or Predation

Predation

Narrownose smoothhound are an important prey item for large sharks, including the broadnose sevengill shark (*Notorynchus cepedianus*), the copper shark (*Carcharhinus brachyurus*), and the sand tiger shark (*Carcharias taurus*) (Cortés et al. 2011). Predation levels on narrownose smoothhound are unknown.

Parasites

Some research has been done on the parasite load in the spiral intestine of the narrownose smoothhound. Cestodes were first recorded in narrownose smoothhound from Argentina by Ivanov (1997). In subsequent studies, the species *Echinobothrium notoguidoi, Calliobothrium australis, C. barbarae, C. lunae*, *Orygmatobothrium schmitti*, and *Eutetrarhynchus vooremi* were recorded in the spiral intestine (Ivanov 1997, Ivanov and Brooks 2002, Alarcos et al. 2006). The number of cestodes per host varied between 4-143 tapeworms, and there was no significant correlation between smoothhound size and parasite load (Alarcos et al. 2006). The number of species and total number of cestodes within the narrownose smoothhound is consistent with studies of parasites in other shark species (Alarcos et al. 2006) and thus does not suggest an unusual threat.

Disease

No diseases have been noted for narrownose smoothhound but some evidence of fungal infections has been reported. A survey of 95 individuals caught on the coast of Santos, Sao Paulo, Brazil, between March 1996 and May 1997 found 4 individuals with

Hifalomicose. Hifalomicose is a fungal infection that causes muscle necrosis with hyphal penetration into the cartilage. All infected individuals displayed necrosis on their snout and an additional infection from the yeast, *Fusarium solani*. The ulcers from the necrosis turn greenish and result in major bleeding, which leads to death. This infection can cause widespread infestations because the fungus is easily transmitted and has a fast life cycle (Gonzalez 1999).

One case of albinism has been reported in narrownose smoothhounds (Teixeira and Góes de Araújo 2002). The individual was caught in the winter of 1993 off of the coast of Rio Grande do Sul, Brazil. It was a completely white juvenile male, measuring 58.5 cm TL, with pink irises. Albinism is a rare genetic abnormality in elasmobranchs and has only been reporting in a handful of species (Teixeira and Góes de Araújo 2002).

Adequacy of Existing Regulatory Mechanisms

In 2004, the narrownose smoothhound was listed in Annex 1 on Brazil's endangered species list. This listing was renewed in 2014, when the narrownose smoothhound was listed on Annex 1as critically endangered (Directive N^{o} 445). An Annex 1 listing prohibits the catch of the species except for scientific purposes, which requires a special license from the Brazilian Institute of Environment and Renewable Resources.

The Comisión Técnica Mixta del Frente Marítimo, which sets fishing regulations for the Argentine-Uruguayan Common Fishing Zone, set the species-specific total permissible catch of narrownose smoothhound in 2014 at 4,500 t (Res. N^{o} 7/14). This is the same level that has been set since 2012 (Res. N^{o} 11/13, Res. N^{o} 9/12). In 2011, the total permissible catch was set for *Mustelus spp*., as opposed to narrownose smoothhound alone, at 4,000 t, which was lowered from the 4,850 t limit set from 2002 to 2010 (Res. N^{o} 5/11, Res. N^{o} 5/02).

Some regulations are in place to protect narrownose smoothhound nursery habitat. Ría Deseado, the southernmost limit of the narrownose smoothhound's range, is designated as a protected area, which protects the local population from being exposed to fishing (Chiaramonte and Pettovello 2000). Anegada Bay, Argentina, a known narrownose smoothhound nursery area, was designated as a multiple use zone reserve in 2001 (Colautti et al. 2010). The smoothhound fishery in Anegada Bay has been closed since 2008 in order to protect the local population (Colautti et al. 2010). In the Argentine-Uruguayan Common Fishing Zone, trawling is banned within five nautical miles of the coast (Pereyra et al. 2008). This coincides with the area where narrownose smoothhound pupping and breeding take place (Pereyra et al. 2008).

A trawling ban is in place in Uruguay between La Paloma and Chuy between 25 and 50 m deep in the summer to protect juvenile *Cynoscion guatucupa*, but this ban could also protect some of the narrownose smoothhound population (Pereyra et al. 2008). Additionally, Uruguay's area closure at depths of 50 m to protect juvenile hake (*Merluccius hubbsi*) in the spring, summer, and autumn corresponds with high use areas of the narrownose smoothhound population and could protect a portion of the population (Pereyra et al. 2008).

Uruguay's FAO National Plan of Action for the conservation of chondrichthyans lists the narrownose smoothhound as a species of high priority (Domingo et al. 2008). It sets short-term goals of 12-18 months to investigate distribution and habitat use, generate times series of effort and catch, and conduct an abundance assessment and mid-term goals of 24-30 months to determine maximum sustainable catch limits and conduct age, growth, reproduction, and diet studies. They made it a priority to review current fishing licenses that allow for the catch of narrownose smoothhound and possibly modify them and grant no new fishing licenses. The results gleaned from the goals and priorities of this plan could not be found. Argentina's FAO National Plan of Action for the conservation of chondrichthyans includes the narrownose smoothhound as one of its eleven species of priority (NPOA-Argentina 2009). Similar to Uruguay's plan, a priority listing calls for compiling the scientific information available on the species and makes goals for increased research and improved management. There are some general fishing regulations listed in Argentina's Plan that may provide some protection to narrownose smoothhound (Table 3).

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 narrownose smoothhound is listed as one of the twelve species of concern in the plan (Lessa et al. 2005). The plan includes 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 (Lessa et al. 2005).

Table 3. Legislations from national and provincial governments in Argentina for the conservation and sustainable use of fisheries resources that may afford some protection to the narrownose smoothhound (NPOA-Argentina 2009).

GENERAL REGULATIONS		
Res. SAGPyA N° 265/2000	Establishes a large area in the central Patagonian continental shelf where bottom trawlers are banned (180,000 km^2)	Effective from 09-06-2000
Res. CFP N^o 7/2000	Establishes a closed area to protect juvenile fish in the Rincón region.	Effective from 1st November to 28 February of each year.
Res. CFP N^o 1/2008	National Plan of Action to prevent and eliminate illegal, unreported and unregulated fisheries.	Effective from January 2008
Res. CTMFM N° 10/2000	Establishes fishing effort restrictions.	Effective from 13-12-2000

Res. CTMFM N° 09/2007, 02/2008 y 05/2008.	Establishes seasonal closed areas in order to protect juvenile hake.	Effective seasonally
Disp Direction of Fisheries Development (Bs. As.) N° 217/07	Regulates recreational fishing in Buenos Aires Province.	Effective from December 2007

Other Natural or Manmade Factors Affecting the Species

A 1991 study of metal bioaccumulation in sharks in Bahía Blanca, Argentina, found that narrownose smoothhound presented higher metal levels than sharks of the same species collected in other areas (Marcovecchi et al. 1991). Mercury concentrations in the muscle and liver tissues were higher than sharks living in the Argentine Sea. Additionally, narrownose smoothhound had abnormally high muscular cadmium levels when compared to other shark species from Bahía Blanca. Diet tends to be the most important source of trace metals in sharks, with fish providing a significant source of mercury and crustaceans providing a significant source of cadmium (Marcovecchio et al. 1991). High cadmium levels in narrownose smoothhound could be explained by the predominance of crustaceans in their diet (as discussed in the Diet and Feeding section above). No information was provided on the impact these metals could have on the survival of individuals in Bahía Blanca.

LITERATURE CITED

Alarcos, A.J., V.A. Ivanov, and N.H. Sardella. 2006. Distribution patterns and interactions of cestodes in the spiral intestine of the narrownose smoothhound shark, *Mustelus schmitti* Springer, 1939 (Chondrichthyes, Carcharhiniformes). Acta Parasitológica. 51(2): 100-106.

Belleggia, M., D.E. Figueroa, F. Sánchez, and C. Bremec. 2012. The feeding ecology of *Mustelus schmitti* in the southwestern Atlantic: geographic variations and dietary shifts. Environmental Biology of Fishes. 95: 99-114.

Belleggia, M., D.E. Figueroa, and C. Bremec. 2014. The dentition of the narrownose smooth-hound shark, *Mustelus schmitti*. Marine and Freshwater Research. 65: 688-696.

Capitoli, R.R., M.L. Ruffino, and C.M. Vooren. 1995. Alimentação do tubarão Mustelus schmitti Springer na plataforma costeira do Estado de Rio Grande do Sul, Brasil. Atlântica 17: 109–122.

Chiaramonte, G.E. 1998. Shark fisheries in Argentina. Marine and Freshwater Research. 49: 601-609.

Chiaramonte, G.E. and A.D. Pettovello. 2000. The biology of *Mustelus schmitti* in southern Patagonia, Argentina. Journal of Fish Biology. 57: 930-942.

Colautti, D., C. Baigun, A.L. Cazorla, F. Llompart, J.M. Molina, P. Suquele, and S. Calvo. 2010. Population biology and fishery characteristics of the smooth-hound *Mustelus schmitti* in Anegada Bay, Argentina. Fisheries Research. 106: 351-357.

Compagno, L.J.V. 1984. FAO Species Catalogue. Sharks of the World: an annotated illustrated catalogue of the shark species known to date. Part 2 – Carcharhiniformes. FAO Fisheries Synopsis No. 125, Vol. 4(2). FAO, Rome.

Cortés, E. 2002. Incorporating uncertainty into demographic modeling: Application to shark populations and their conservation. Conservation Biology. 16(4): 1048-1062.

Cortés, R. 2007. Sustentabilidad de la explotación del gatuzo, *Mustelus schmitti*, en el ecosistema costero bonaerense (34-42°S). Universidad Nacional de Mar del Plata. Licenciatura en Ciencias Biológicas Master's Thesis.

Cortés, F., A.J. Jaureguizar, R.C. Menni, R.A. Guerrero. 2011. Ontogenetic habitat preferences of the narrownose smooth-hound shark, *Mustelus schmitti*, in two Southwestern Atlantic coastal areas. Hydrobiologia. 661: 445-456.

Cousseau, M.B., C.R. Carozza, G.J. Macchi. 1998. Abundancia, reproduccion, y distribucion de tallas del gatuzo (*Mustelus schmitti*) en la Zona Comun de Pesca Argentino-Uruguaya y en El Rincón Noviembre, 1994. INIDEP Inf. Tec. 21: 103-115.

Defeo, O., S. Horta, A. Carranza, D. Lecari, A. De Álava, J. Gómez, G. Martínez, J. Lozoya, and E. Celentano. 2009. Hacia un manejo ecosistémico de pesquerías. Áreas Marinas Protegidas en Uruguay. Facultad de Ciencies – DINARA. Montevideo, Uruguay. 129 pp.

Diaz de Astarloa, J.M., Carozza, C.R., Guerrero, R.A. Baldoni, A.G.and Cousseau, M.B. 1997. Algunas características biológicas de peces capturados en una campaña costera invernal en 1993, en el área comprendida entre 34°S y 42°S (Atlántico Sudoccidental) y su relación con las condiciones ambientales. Informe Técnico INIDEP No. 14.

Domingo, A., R. Forselledo, P. Miller, and C. Passadore. 2008. Plan de Acción Nacional para la Conservación de los Condrictios en las Pesquerías Uruguayas. Montevideo: DINARA. 88 p.

Figueiredo, J.L. 1977. Manual de Peixes Marinhos do Sudeste do Brasil I. Introdução, Cações, raias e quimeras. São Paulo: Museu de Zoologia Universidade de São Paulo.

Fischer, J., K. Erikstein, B. D'Offay, S. Guggisberg, and M. Barone. 2012. Review of the Implementation of the International Plan of Action for the Conservation and Management of Sharks. FAO Fisheries and Aquaculture Circular No. 1076. FAO, Rome.

Galíndez, E.J., M.C. Díaz Andrade, A.C. Moya, S. Estecondo. 2010. Morphological changes in the pregnant uterus of the smooth hound dogfish *Mustelus schmitti* Springer, 1939 (Gatuzo) (Condrichthyes, Triakidae). Microscopic study and phylogenetic reproductive implications. Internal Journal of Morphology. 28: 1003-1010.

Gonzalez, M.M.B. 1999. Hifalomicose em *Mustelus schmitti* (Springer) (Chondrichthyes, Triakidae). Revista Brasileira de Zoologia. 16(2): 293-298.

Hamlett, W.C., G. Kormanik, M. Storrie, B. Stevens, and T.I. Walker (2005). Chondrichthyan parity, lecithotrophy and matrotrophy. In: Hamlett, W.C. (ed.) Reproductive biology and phylogeny of chondrichthyes: sharks, rays, and chimaeras, Vol. 3. Endfield, USA: Science Publishers. pp. 395-434.

Haimovici, M. 1997. Recursos pesqueiros demersais de região sul: subsídios para o levantamento do estado da arte dos recursos vivos marinhos do Brasil – Programa REVIZEE.

Heemstra, P.C. 1997. A review of the smooth-hound sharks (genus *Mustelus*, family Triakidae) of the Western Atlantic Ocean, with descriptions of two new species and a new subspecies. Bulletin of Marine Science. 60(3): 894-928.

Hozbor, N.M, M.B. Saez, and A.M. Massa. Edad y crecimiento de *Musteluz schmitti* (gatuzo), en la región costera bonaerense y uruguaya. Informe de Investigación. INIDEP N^{o} 49. 15 pp.

Ivanov, V.A. 1997. *Echinobothrium notoguidoi* n. sp. (Cestoda: Diphyllidea) from *Mustelus schmitti* (Chondrichthyes: Carcharhiniformes) in the Argentine Sea. The Journal of Parasitology. 83(5): 913-916.

Ivanov, V.A. and D.R. Brooks. 2002. *Calliobothrium spp*. (Eucestoda: Tetraphyllidea: Onchobothriidae) in *Mustelus schmitti* (Chondrichthyes: Carcharhiniformes) from Argentina and Uruguay. The Journal of Parasitology. 88(6): 1200-1213.

Lessa, R., C.M. Vooren, M.L. Goes de Araújo, J.E. Kotas, P.C. Almeida, G.R. Filho, F.M. Santana, O.B. Gadig, C. Sampaio, Z. Almeida, M. Almeida, R.S. Rosa. 2005. Plano Nacional de Ação para a Conservação e o Manejo do Estoques de Peixes Elasmobrânquios no Brasil.

Marcovecchio, J.E., V.J. Moreno, A. Perez. 1991. Metal accumulation in tissues of sharks from Bahia Blanca estuary, Argentina. Marine Environmental Research. 31(4): 263-274

Massa, A.M., L.O. Lucifora, and N. Hozbor. 2004a. Condrictios de las regiones costeras bonaerense y Uruguay. In: El Mar Argentino y sus recursos pesqueros. Tomo 4. Biología y evaluación del estado de explotación. R. Sanchez and S. Veis. (Eds.). INIDEP, pp. 85–99.

Massa, A.M., C. Lasta, and C. Carozza. 2004b. Estado actual y explotación del gatuzo (*Mustelus schmitti*). In: R. Sanchez and S. Bezzi (Eds.). El Mar Argentino y sus recursos pesqueros. Vol. 4. Biología y evaluación del estado de explotación. INIDEP Special Publications. Mar del Plata, Argentina. pp. 67-83.

Massa, A., N. Hozbor, G.E. Chiaramonte, A.D. Balestra, and C.M. Vooren. 2006. *Mustelus schmitti*. In: IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 29 January 2014.

Massa, A.M. and N. Hozbor. 2008. Estimación de abundancia de peces cartilagionosos en el Atalntico Sudoccidental entre 34^{o} y 41^{o} S, a profundidades menores a 50 m. Periodo 1993-2005. Informe de Investigación INIDEP. N^{o} 47. pp. 11.

Menni, R.C. 1985. Distribución y biología de *Squalus acanthias, Mustelus schmitti* y *Galeorhinus vitaminicus* en el mar argentino en agosto-septiembre de 1978 (Chondrichthyes). Revista del Museo de la Plata (nueva serie). Sección Zoología. Tomo XIII Nº 138: 151–182.

Menni, R.C., M.B. Cousseau, and A.R. Gosztonyi. 1986. Sobre la biologia de los tiburones costeros de la Provincia de Buenos Aires. Anales de la Sociedad Cientifica Argentina. 123: 3-26.

Miranda L.V. and C.M. Vooren. 2003. Captura e esforço da pesca de elasmobrânquios demersais no sul do Brasil nos anos de 1975 a 1997. Frente Marítimo 19B: 217–231.

Molina, J.M. and A.L. Cazorla. 2011. Trophic ecology of *Mustelus schmitti* (Springer, 1939) in a nursery area of northern Patagonia. Journal of Sea Research. 65: 381-389.

Musick, J. A., and J. K. Ellis. 2005. Reproductive evolution of chondrichthyans. Pages 45-79 *in* W. C. Hamlett, editor. Reproductive Biology and Phylogeny of Chondrichthyes: Sharks, Batoids, and Chimaeras. Science Publishers, Inc., Enfield, New Hampshire.

Nion, H. 1999. La pesuería de tiburones en Uruguay con especial referencia al cazón (*Galeorhinus galeus*, Linnaeus 1758). In: *Case Studies of the Management of 387 Elasmobranch Fisheries*. R. Shotton, Ed. pp. 218-267. FAO Fisheries Technical Paper 378.

NPOA – Argentina – Plan de Acción Nacional para la Conservación y el Manejo de Condrictios (tiburones, rayas, y quimeras) en la República Argentina. 2009. Anexo Resolucion CFP. 6: 1-57.

Oddone, M.C., L. Paesch, and W. Norbis. 2005. Reproductive biology and seasonal distribution of *Mustelus schmitti* (Elasmobranchii: Triakidae) in the Rio de la Plata oceanic front, south-western Atlantic. Journal of the Marine Biological Association of the United Kingdom. 85: 1193-1198.

Oddone, M.C., L. Paesch, W. Norbis, and G. Velasco. 2007. Population structure, distribution, and abundance patterns of the Patagonian smoothhound *Mustelus schmitti* Springer, 1939 (Chondrichthyes, Elasmobranchii, Triakidae) in the Rio de la Plata and inner continental shelf, SW Atlantic Ocean (34^{o}30'-39^{o}30'S). Brazilian Journal of Oceanography. 55(3): 167-177.

Olivier, R.S., R. Bastida, and M.R. Torti. 1968. Sobre el ecosistema de las aguas litorales de Mar del Plata. Niveles tróficos y cadenas alimentarias pelágicos demersales y bentónicos-demersales. Servicio de Hidrografía Naval. H 1025: 1-45.

Paesch, L. and A. Domingo. 2003. La pesca de condrictios en el Uruguay. Comisión Técnica Mixta del Frente Marítimo. 19: 207–216.

Pereyra, I., L. Orlando, W. Norbis, and L. Paesch. 2008. Variación especial y temporal de la composición por tallas y sexos del gatuso *Mustelus schmitti* Springer, 1939 capturado por la pesca de arrastre en la costa oceánica uruguaya durante 2004. Revista de Biología Marina y Oceanografía. 43(1): 159-166.

Pereyra, S., G. García, P. Miller, S. Oviedo, and A. Domingo. 2010. Low genetic diversity and population structure of the narrownose shark (*Mustelus schmitti*). Fisheries Research. 106: 468-473.

Pérez, M., A. Massa, and H.D. Cordo. 2011. Estimación de un índice de abundancia annual de gatuzo (*Mustelus schmitti*) a partir de datos de la flota commercial Argentina. Período 1992-2008.

Rosa, M.R and O.B.F. Gadig. 2010. Taxonomic comments and an identification key to species for the Smooth-hound sharks genus *Mustelus* Link, 1790 (Chondrichthyes: Triakidae) from the Western South Atlantic. Pan-American Journal of Aquatic Sciences. 5(3): 401-413. INIDEP Informe Técnico No. 79.

Rojas, F.O. 2013. Testicular histology of *Mustelus schmitti* Springer, 1939 (Elasmobranchii, Triakidae). BioScriba. 6: 16-32.

Segura, A.M. and A.C. Milessi. 2008. Biological and reproductive characteristics of the Patagonian smoothhound *Mustelus schmitti* (Chondrichthyes, Triakidae) as documented from an artisanal fishery in Uruguay. Journal of Applied Ichthyology. 25: 78-82.

Sidders, M.A., L.L. Tamini, J.E. Perez, and G.E. Chiaramonte. 2005. Biología reproductive del gatuzo *Mustelus schmitti* Springer, 1939 (Chondrichthyes, Triakidae) en el área de Puerto Quequén, Provincia de Buenos Aires. Revista del Museo Argentino de Ciencias Naturales. 7: 89-101.

Silva, M. 2004. Ministério do Meio Ambiente. Instrução Normativa N^{o}5. May 21, 2004.

Teixeira, S.F. and M.L. Góes de Araújo. 2002. First record of albinism in the smooth dogfish *Mustelus schmitti* Springer, 1939 (Carcharhiniformes – Triakidae) from Southern Brazil. Brazilian Archives of Biology and Technology. 45(2): 241-243.

Valdemarsen, J.W., T. JØrgensen, A. Engas. 2007. Options to mitigate bottom habitat impact of dragged gears. FAO Fisheries Technical Paper. 506: 1-29.

Van der Molen, S. and G. Caille. 2001. Bahía Engaño: a north Patagonian nursery area for the smoothhound shark *Mustelus schmitti* (Carcharhiniformes: Triakidae). Journal of the Marine Biological Association of the United Kingdom. 81: 851-855.

Vooren, C.M. 1997. Demersal elasmobranchs. In: *Subtropical Convergence Environments: The Coast and Sea in the Southwestern Atlatntic*. U. Speeliger, C. Odebrecht, and J.P. Castello (Eds.). pp. 141-145.

ENDANGERED SPECIES ACT
STATUS REVIEW OF THE BRAZILIAN GUITARFISH
(*Rhinobatos horkelii*)


(costanorte.com.br)

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 the following peer reviewers: Andre Afonso, Riguel F. Contente, and Camila Marion. 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 Brazilian guitarfish (*Rhinobatos horkelii*). Report to the National Marine Fisheries Service, Office of Protected Resources. SFD Contribution PCB-15-08.

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 that the petitioned action may be warranted, as required by the ESA. In a *Federal Register* notice on February 24, 2014 (79 FR 10104), 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 10 species of skates and rays and 15 species of bony fishes, and thus NMFS initiated a status review of those species. This status review report considers the biology, distribution, and abundance of and threats to one guitarfish species from the Southwestern Atlantic, *Rhinobatos horkelii* (Brazilian guitarfish).

TABLE OF CONTENTS

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 indicating 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 Brazilian guitarfish (*Rhinobatos horkelii)* (79 FR 10104). Experts and members of the public were requested to submit information to NMFS to assist in the status review process from February 24 through April 25, 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 Brazilian guitarfish, 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-May 2014.

LIFE HISTORY AND ECOLOGY

Taxonomy and Anatomy

The Brazilian guitarfish (*Rhinobatos horkelii*) is a member of the order Rajiformes and the family Rhinobatidae (Lessa and Vooren 2007). In Portuguese, it is called *viola* or *raia-viola* (Figueiredo 1977, Rosa and Lima 2005). In Spanish, it is called *pez guitarra*, *guitarra grande, mandolin*, and *melgacho* (NPOA-Argentina 2009). The Brazilian guitarfish has long nostrils with transversely flat or a slightly convex crown (Lessa and Vooren 2007). The interorbital distance is 3.7 times the preorbital distance. The spiracles have two distinct peaks with the outer peak nearly two times as large as the inner (Refi 1973). There are 56-68 teeth in the upper jaw and 62-74 teeth in the lower jaw, with teeth getting larger towards the center of both jaws (Bigelow and Schroeder 1953, Refi 1973). The disc width is about 5/6 of the body length (Bigelow and Schroeder 1953). The insertion of the first dorsal fin is behind the tips of the pelvic fins, and the median row of tubercles on the dorsal surface are large and thorn-like (Lessa and Vooren 2005). The dorsal midline has a row of tubercles with 62-73 in front of the first dorsal, 9-11 between the two dorsal fins, and 4-10 after the second dorsal (Refi 1973). The dorsal fins are triangular and similar in size with straight or slightly convex margins. Near the orbits, there are 4-7 larger tubercles and 2-6 along the inner margin of each orbit. The tip of the snout also has 2-4 small rounded tubercles on juvenile specimens (Bigelow and Schroeder 1953). The dorsal side is olive grey or chocolate brown and lacks light or dark markings. Additionally, the snout has a “sooty” oval patch (Lessa and Vooren 2005). The ventral side is a lighter version of the dorsal color or the same color as the dorsal side (Bigelow and Schroeder 1953).

The species within the family Rhinobatidae are very similar morphologically, which can make them difficult to distinguish from each other (De-Franco et al. 2010). *Rhinobatos horkelii* and *Rhinobatos percellens* are particularly similar and co-occur in Brazil (Lessa and Vooren 2005, De-Franco et al. 2010). Published records of *Rhinobatos percellens* in southern Brazil (Chao et al. 1982 in Lessa and Vooren 2007) are not accurate due to problems with one of the criteria originally used for separating *R. horkelii* and *R. percellens.* According to Figueiredo (1977), the Brazilian guitarfish’s mouth is proportionally smaller than *R. percellens*. From measurements of only four specimens (two juveniles of *R. percellens* and two juveniles of *R. horkelii*, all from Rio de Janeiro), Bigelow and Schroeder (1953) used the relative size of the nasal groove as a diagnostic criterion for separating *R. horkelii* and *R. percellens*. However, according to Lessa and Vooren (2007), the value of this morphometric measurement does not permit the correct identification of specimens of all sizes and from all areas where they co-occur. Over 9,000 specimens of *Rhinobatos spp*, have been examined since 1972 from southern Brazil by Lessa (1982) and Sadowsky (1973) (reported in Lessa and Vooren (2007)) using the criterion of Bigelow and Schroeder (1953) and all were correctly identified as *R. horkelii*. Recently, a multiplex-PCR protocol has been developed to accurately distinguish between the two species (De-Franco et al. 2010; this technique is discussed further in the Adequacy of Regulatory Mechanisms section below).

Range and Habitat Use

The Brazilian guitarfish is distributed along the coast of South America in the southwestern Atlantic from Bahia, Brazil to Mar del Plata, Argentina (Figure 1; Figueiredo 1977, Lessa and Vooren 2005, 2007, GBIF Database). The majority of the population is concentrated between 28^{o} and 34^{o}S. Newborns and juveniles live year round in coastal waters less than 20 m deep. Adults coexist with immature individuals in shallow waters between November and March, when pupping and mating occurs, but spend the rest of the year offshore in waters greater than 40 m depth. In the winter, individuals can be found in water temperatures as low as to 9^{o}C, while the average summer water temperature individuals are found in is 26^{o}C (Lessa and Vooren 2005). Brazilian guitarfish are commonly found in salinities ranging from 24-28 ppt in northern Argentina (Jaureguizar et al. 2006).

Figure 1. The range of the Brazilian guitarfish from Bahia, Brazil, to Mar del Plata, Argentina, based on information gathered in this review.

Diet and Feeding

Refi (1973) recorded the stomach contents of six individuals caught in Mar de la Plata, Argentina. Stomachs contained octopus, *Octopus tehuelchus*, shrimp, *Hymenopeneus muelleri*, decapods, isopods, and polychaetes.

Growth and Reproduction

Based on a yearly vertebral annulus formation in September, Lessa and Vooren (2005) found that the theoretical maximum size and growth rate based on the von Bertalanffy growth equation were 135.5 cm TL (L_{∞}) and 0.194 (K), respectively, with age at maturity is between 7 and 9 years for females and 5 and 6 years for males. Caltabellota (2014) found similar results with L_{∞} equal to 121.71 cm and K equal to 0.21. No significant differences were found in growth between the sexes. The Fabens theoretical longevity was estimated to be 18.24 years for females and 13.86 years for males, while the Taylor theoretical longevity was estimated to be 14.17 years for females and 10.90 years for males (Caltabellota 2014). Lessa and Vorren (2007) estimated female longevity to be 28 years and male longevity to be 15 years. The Brazilian guitarfish can reach up to 1.5 m total length (TL) and weigh up to 12 kg (Martins and Schwingel 2003).

The size at maturity for Brazilian guitarfish is between 90 and 120 cm TL for both sexes (Lessa et al. 2005a, Lessa and Vooren 2005). The reproductive cycle is annual. Gravid females live at depths greater than 20 m for most of the year, but migrate into the shallows in the spring and summer to give birth. Females mate after giving birth (Vooren 1997, Lessa and Vooren 2005). The smallest pregnant females recorded were between 91-92 cm TL, and all captured females 119 cm TL and larger were pregnant. Gestation time is 11-12 months. Females have 4-12 pups/litter, and litter size increases with female size (Lessa and Vooren 2005). Development is lecithotrophic, and litter mass ranges between 5 and 7% of female body mass (Vooren 1997). Pregnancy has two phases. The dormant stage is from April to November, while females are in relatively deep, cold waters between 40 and 100 m (Lessa et al. 2005a). The fertilized eggs are enclosed in a common shell, and do not continue to develop until summer. Warm summer temperatures in November initiate the shell to open and embryo development progresses rapidly, with embryos growing from 1 cm to 29 cm TL (Lessa and Vooren 2005).

Demography

The Brazilian guitarfish gives birth to 4-12 pups annually. Females mature between 7 and 9 years of age (Lessa and Vooren 2005). However, Caltabellota (2014) assumed an age at maturity of 5 years, and found the estimated total natural mortality from catch curves to be 0.692 for males and 0.751 for females. Modeling of various exploitation scenarios found that under natural conditions with no fishing mortality, the population would increase by 9% each year, doubling every 7.41 years. In the presence of fishing mortality with an age at first capture of two years, the Brazilian guitarfish population will decline by 25% every 2.73 years, however if the age at first capture was after the age at first maturity, assumed to be 5 years for these models, the population would increase by 4% each year (Catabellota 2014).

DISTRIBUTION AND ABUNDANCE

To provide a better understanding of the Brazilian guitarfish'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 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

The Brazilian guitarfish is found from Bahia, Brazil to Mar del Plata, Argentina, but most of the population is concentrated between 28° and 34°S in Brazil. Neonates and juveniles are present in shallow waters, less than 20 m, year round while adults migrate inshore from waters greater than 40 m to give birth and mate (Lessa and Vooren 2005). Brazilian guitarfish have been captured in the Río de la Plata estuary at depths between 12.6-16 m (Jaureguizar et al. 2003).

Few abundance estimates are available for the Brazilian guitarfish throughout its range. The mean biomass of Brazilian guitarfish in northern Argentina (34-43°S) was 0.1240 t/nm^2 between 1981 and 1999, making up 0.44% of the biomass of demersal fish on the northern

Argentine continental shelf (Jaureguizar et al. 2006). In northern Argentina, in 1981, Brazilian guitarfish biomass was calculated to be 0.010 t/nm^2. Biomass peaked in 1994 at 0.441 t/nm^2 before falling steadily to 0.007 t/nm^2 in 1999 (Jaureguizar et al. 2006). Biomass estimates from Argentina's FAO National Plan of Action for the Conservation of Chondrichthyans for the coast of Buenos Aires province and Uruguay were 2,597 t in 1994, 661 t in 1998, and 91 t in 1999 (NPOA-Argentina 2009). Research surveys conducted between Chuí and Solidão, Brazil in February 2005 found an average CPUE of 1.68 kg/hr, or 0.00168 t/hr, (Vooren et al. 2005) but this survey was only for one year.

Few records of Brazilian guitarfish were found in the literature review and in the GBIF Database (Table 1). Two records from the GBIF Database report individuals of Brazilian guitarfish in Peru and Trinidad. Both of these specimens come from old records and are housed in Natural History Museums in Denmark and Sweden. It is likely that these specimens were misidentified upon capture. As noted in the Taxonomy and Anatomy section of this report, it is difficult to distinguish between the different species of guitarfish that occur in the waters off of South America using solely morphological characteristics. The specimen from Trinidad may be *R. percellens*, a species commonly confused with the Brazilian guitarfish (Casper and Burgess 2009).

Table 1. Records of the Brazilian guitarfish 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
1700	1	Rio de Janeiro	Brazil	GBIF Database
1833	1	--	Peru	GBIF Database
1843	1	Bahia	Brazil	GBIF Database
1862	1	Rio de Janeiro	Brazil	GBIF Database
1866	1	Camamu	Brazil	GBIF Database
1867	1	Pernambuco	Brazil	GBIF Database
1918	1	--	Trinidad	GBIF Database
1966	1	Chuy	Brazil	GBIF Database
1978	1	Buenos Aires Province	Argentina	GBIF Database
1979	1	Lagoa das Patos, Rio Grande	Brazil	GBIF Database
1983	1	Rio Grande do Sul	Brazil	GBIF Database
2000	1	Barra do Rio Ararangui, Santa Catarina	Brazil	GBIF Database
2000s	18	Rio de Janeiro	Brazil	De-Franco et al. 2010
2000s	15	Sao Paulo	Brazil	De-Franco et al. 2010
2000s	7	Rio Grande do Sul	Brazil	De-Franco et al. 2010
2008-2009	149	Bahia to Rio Grande do Sul	Brazil	De-Franco et al. 2012
N/A	1	--	Brazil	GBIF Database
N/A	1	Pernambuco	Brazil	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Tramandai	Brazil	GBIF Database
N/A	1	--	Brazil	GBIF Database

N/A	1	--	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	Bahia	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	Torres, Rio Grande do Sul	Brazil	GBIF Database
N/A	1	--	Brazil	GBIF Database

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: (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 range of Brazilian guitarfish. Studies show that the interaction of bottom trawling gears with bottom substrate can have negative effects on benthic fish habitat. 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 (Valdemarsen et al. 2007). 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 Brazilian guitarfish'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

Some of the fisheries information provided in the following section refers to the genus *Rhinobatos*, not specifically to the Brazilian guitarfish, *R. horkelii*. Information about landings of *Rhinobatos spp.* within the Brazilian guitarfish's range will refer only to guitarfish while landings data specific to *R. horkelii* will specifically reference Brazilian guitarfish.

Commercial landings data for the Brazilian guitarfish could be inaccurate due to the common fishing practice of heading and gutting sharks and rays before they are brought into port. It has been noted that this makes identification of guitarfish to species particularly difficult (De-Franco et al. 2010). Genetic samples from guitarfish landed in 2008 and 2009 indicate that the species composition of the catch was different from what was reported in the ports, as according to the genetic samples Brazilian guitarfish remained part of the catch even after landings were prohibited by Brazilian law (De-Franco et al. 2012; see Adequacy of Existing Regulatory Mechanisms for more details).

Before landings were prohibited, the Brazilian guitarfish was considered to be the only economically important species of the order Rajiformes in southern Brazil, where they were fished in industrial and artisanal fisheries (Lessa and Vooren 2005). Brazilian guitarfish were caught in otter trawls, pair trawls, shrimp trawls, beach seines, and bottom gillnets (Haimovici 1997, Mazzoleni and Schwingel 1999, Martins and Schwingel 2003). Commercial catches of the Brazilian guitarfish occurred from 28^{o}-34^{o}S in Brazil, where the species is most heavily concentrated (Martins and Schwingel 2003, Lessa and Vooren 2005). Catches of guitarfish were high between Imbituba and Rio Grande, Brazil from autumn to spring (Martins and Schwingel 2003). Over 70% of the Brazilian guitarfish were caught in paired trawls or the artisanal fishery. Catches from trawling peaked annually from December to March, when adults are concentrated in shallow waters for mating (Miranda and Vooren 2003).

Artisanal landings of Brazilian guitarfish came mainly from the beach seine fishery, which captured pregnant females and adult males on their inshore pupping migration (Miranda and Vooren 2003, Lessa and Vooren 2005). It has been reported that up to 98% of the artisanal fishery catch were pregnant females (Lessa and Vooren 2005). Miranda and Vooren (2003) reported artisanal landings declined from about 330 t in 1992 to 125 t in 1997.

Declines in total catch and catch-per-unit effort (CPUE) were seen in ports throughout southern Brazil (Figure 2, 3; Haimovici 1997, Haimovici et al. 1998). Landings of guitarfish in Rio Grande do Sul fell from 1,253 t in 1984 to 460 t in 1994, and CPUE declined from 0.76 t/trip in 1984 to 0.05 t/trip in 1992 (Martins and Schwingel 2003). The catch of Brazilian guitarfish in commercial elasmobranch fisheries in southern Brazil increased from 842 t in 1975 to 1,804 t in 1984 but then precipitously declined to 115 and 276 t between 1992 and 1997 (Miranda and Vooren 2003). In southern Brazil, CPUE declined from 1.46 t/trip in 1975 to 0.2 t/trip in 1993 for paired trawls, from 0.53 t/trip in 1975-1977 to 0.1 t/trip in 1988 for single trawls, and from 3.1 t/trip in 1996 to 0.22 t/trip in 1999 for the gillnet fishery (Miranda and Vooren 2003). These dramatic CPUE declines point to an estimated 85% decline in abundance from 1975-1990 (Miranda and Vooren 2003). Increases in CPUE have been recorded off Santa Catarina in paired trawls (0.11 t/trip in 2000 to 0.15 t/trip in 2002) and in single trawls (0.63 t/trip in 2001 to 1.0 t/trip in 2002). However, this increase is likely a reflection of changes in operational strategy as opposed to an increase in guitarfish abundance (Martins and Schwingel 2003). It is thought that high fishing pressure from both artisanal and industrial fisheries has caused stock biomass to decrease by about 90%, based on declines in annual CPUE from otter trawls and pair trawls and total landings in Rio Grande, Brazil (Lessa and Vooren 2005). Otter trawl CPUE declined from 0.76 t/trip in 1984 to 0.10 t/trip in 1997, and pair trawl CPUE declined from 2.03 t/trip in 1984 to 0.14 t/trip in 1997. Total landings from all fishery methods increased from 850 t in 1975 to 1,927 t in 1984 before falling to 216 t in 1997 (Lessa and Vooren 2005).

In July 2010, the state of São Paulo, Brazil, declared the stock of Brazilian guitarfish collapsed. This was due to intense exploitation that reduced biomass and reproductive potential to a level that severely compromised recovery (Act N^{o} 56.031).

Little information is available on catches of Brazilian guitarfish outside of Brazil. In Uruguay, Brazilian guitarfish are caught as bycatch in bottom longline, oceanic gillnet, pelagic trawls, and bottom trawls (Domingo et al. 2008). From 1994 to 2001, Brazilian guitarfish were caught exclusively in coastal fisheries, and the catch did not exceed 4 t/year (Paesch and Domingo 2003). No other information is available on landings data.

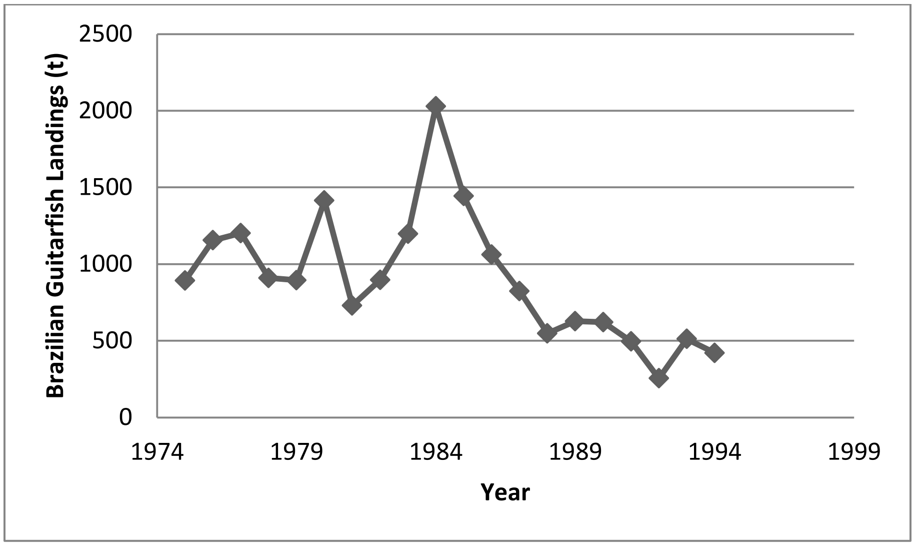


Figure 2. Landings of Brazilian guitarfish in tons from industrial fisheries in Santa Catarina, Rio Grande, and São Paulo, Brazil (Haimovici 1997).

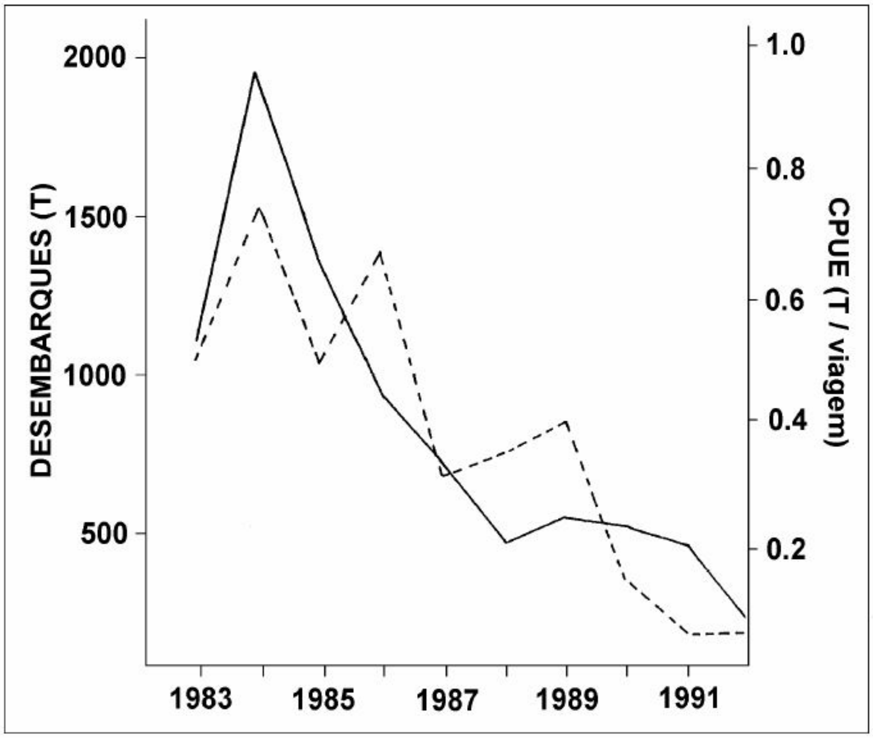


Figure 3. Landings of Brazilian guitarfish from the port of Rio Grande in tons (solid line) and the average annual CPUE from trawls in tons/trip (dashed line) (Haimovici et al. 1998).

Competition, Disease, or Predation

At this time no information is available about competition, disease, or predation that threatens the survival of the Brazilian guitarfish.

Adequacy of Existing Regulatory Mechanisms

In December 2014, the Brazilian guitarfish was listed in Annex 1 on Brazil's endangered species list as critically endangered (Brazilian Ministry of the Environment Directive N^{o} 445). An Annex 1 listing prohibits the catch of the species except for scientific purposes, which requires a special license from the Brazilian Institute of Environment and Renewable Resources. Permits for directed fishing of the species are no longer issued, transport and sale of the species are prohibited, and incidental catches of the species must be discarded at sea. The Brazilian guitarfish was originally listed in Annex 1 in 2004 (Silva 2004). This original listing did not distinguish between endangered and critically endangered species, but carried with it the same fishing ban. According to Lessa and Vooren (2007), this law was gradually becoming more effectively enforced, but De-Franco et al.'s (2012) genetic studies indicate that by 2009 enforcement was still poor. There is also a prohibition of trawl fishing within three nautical miles from the coast of southern Brazil which is being enforced satisfactorily (Lessa and Vooren 2007). However, the species is still caught as bycatch in the legally permitted coastal gillnet fisheries and offshore trawl and gillnet fisheries (Lessa and Vooren 2007).

A genetic study of guitarfish landings in Brazil has found that although landings of Brazilian guitarfish are prohibited, they continue to be brought into ports throughout southeastern and southern Brazil. Of the 267 guitarfish samples collected between 2008 and 2009, 55.8% were identified as Brazilian guitarfish. Of the 85 samples from boats in Santa Catarina, 100% were Brazilian guitarfish, as opposed to *R. percellens* or *Zapteryx brevirostris*. Fishers commonly remove the head and gut any guitarfish before arriving in port, which makes it difficult to distinguish the Brazilian guitarfish from the other two species in the area, *R. percellens* and *Zapteryx brevirostris*. Surveys of fishermen indicate that they are aware of the Brazilian guitarfish capture prohibition, but it was concluded that lack of adequate government inspections may be encouraging them to disregard the law (De-Franco et al. 2012).

Brazilian guitarfish are found in several marine protected areas in Brazil. In São Paulo, they are found in APA de Cananéia-Iguape-Peruíbe, which is 234,000 hectares. In Parana, they are in PARNA do Superagui, which is 33,988 hectares, and in Santa Catarina, they are in REBIO do Arvoredo and RESEX Marinha do Pirjubaé, which are 17,600 and 1,712 hectares, respectively (Rosa and Lima 2005).

In December, 2014, the Brazilian Government's Chico Mendes Institute for Biodiversity Conservation approved the National Plan of Action for the Conservation of Elasmobranchs of Brazil (N^{o} 125). The plan considers the Brazilian guitarfish to be one of the country's 12 species of concern and recommends a moratorium on fishing with the prohibition of sales until there is scientific evidence in support of recovery (N^{o} 125, Lessa et al. 2005b). Additionally it proposes a fishing exclusion area over a large region of the coast of Rio Grande do Sul at depths of 20m to protect nursery areas. In general 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.

Uruguay's FAO National Plan of Action for the conservation of chondrichthyans lists the Brazilian guitarfish as a species of high priority (Domingo et al. 2008). It sets short-term goals of 12-18 months to investigate distribution and habitat use and generate time series of effort and catch, mid-term goals of 24-30 months to conduct an abundance assessment and determine maximum sustainable catch limits, and a long term goal of 36-48 months to conduct age, growth, reproduction, and diet studies. Uruguay made it a priority to review current fishing licenses that allow for the catch of Brazilian guitarfish and possibly modify them, grant no new fishing licenses, forbid processing and marketing, and promote safe release if possible. 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 Brazilian guitarfish to be a species of high priority (NPOA-Argentina 2009).

LITERATURE CITED

Bigelow, H.B. and W.C. Schroeder. 1953. Fishes of the Western North Atlantic. Part 2: Sawfishes, Guitarfishes, Skates and Rays. Chimaeroids. Yale University. New Haven, Connecticut.

Caltabellotta, F.P. 2014. Dinâmica populacional das raisa-violas, *Rhinobatos horkelii, Rhinobatos percellens* e *Zapteryx brevirostris* (Chondrichthyes, Rhinobatidae) da Plataforma Continental de São Paulo. Graduate Thesis: Universidade Estadual Paulista. Botucatu, São Paulo.

Casper, B.M. and G.H. Burgess. 2009. *Rhinobatos percellens*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlis.org>. Downloaded on 05 September 2014.

Cortés, E. 2002. Incorporating uncertainty into demographic modeling: Application to shark populations and their conservation. Conservation Biology. 16: 1048-1062.

De-Franco, B., F.F. Mendonça, D.T. Hashimoto, F. Porto-Foresti, C. Oliveira, and F. Foresti. 2010. Forensic identification of the guitarfish species *Rhinobatos horkelii, R. percellens* and *Zapteryx brevirostris* using multiplex-PCR. Molecular Ecology Resources. 10: 197-199.

De-Franco, B.A., F.F. Mendonça, C. Oliveira, and F. Foresti. 2012. Illegal trade of the guitarfish *Rhinobatos horkelii* on the coasts of central and southern Brazil: genetic identification to aid conservation. Aquatic Conservation: Marine and Freshwater Ecosystems. 22: 272-276.

Domingo, A., R. Forselledo, P. Miller, and C. Passadore. 2008. Plan de Acción Nacional para la Conservación de los Condrictios en las Pesquerías Uruguayas. Montevideo: DINARA. 88 p.

Figueiredo, J.L. 1977. Manual de Peixes Marinhos do Sudeste do Brasil I. Introdução, Cações, raias e quimeras. São Paulo: Museu de Zoologia Universidade de São Paulo.

Haimovici, M. 1997. Recursos pesqueiros demersais da região sul. Subsídios para o levantamento do estado da arte dos recursos vivos marinhos do Brasil – Programa REVIZEE. pp. 54.

Haimovici, M., J.P. Castello, and C.M. Vooren. 1998. Pescarias. In: *Os Ecossistemas Costeiro e Marinho do Extremo Sul do Brasil*. U. Seeliger, C. Odebrecht, and J.P. Castello (Eds.). Editoria Ecoscientia. Rio Grande, Brazil. pp. 205-218.

Jaureguizar, A.J., R. Menni, C. Bremec, H. Mianzan, and C. Lasta. 2003. Fish assemblage and environmental patterns in the Río de la Plata estuary. Estuarine, Coastal and Shelf Science. 56: 921-933.

Jaureguizar, A.J., R. Menni, C. Lasta, and R. Guerrero. 2006. Fish assemblages of the northern Argentine coastal system: spatial patterns and their temporal variations. Fisheries Oceanography. 15: 326-344.

Lessa, R.P. and C.M. Vooren. 2005. Brazilian guitarfish *Rhinobatos horkelii*. In *Sharks, Rays and Chimaeras: The Status of the Chondrichthyan Fishes*. S.L. Fowler, M. Camhi, G.H. Burgess, G.M. Cailliet, S.V. Fordham, R.D. Cavanagh, C.A. Simpfendorfer and J.A. Musick (eds). pp. 329-331. IUCN SSC Shark Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

Lessa, R., C.M. Vooren, M.L. Goes de Araújo, J.E. Kotas, P.C. Almeida, G.R. Filho, F.M. Santana, O.B. Gadig, C. Sampaio, Z. Almeida, M. Almeida, R.S. Rosa. 2005b. Plano Nacional de Ação para a Conservação e o Manejo do Estoques de Peixes Elasmobrânquios no Brasil.

Lessa, R.C., C.M. Vooren, J. Lahaye. 2005a. Desenvolvimento e ciclo sexual das femeas migracoes e fecundidade da viola *Rhinobatos horkelii* (Müller and Henle, 1841) do sul do Brasil. Fundação Universidade Federal do Rio Grande. Atlântica. 8: 5-34.

Lessa, R. and C.M. Vooren. 2007. *Rhinobatos horkelii*. In: IUCN Red List of Threatened Species. Version 2013.2. <www.icunredlist.com>. Downloaded on 30 January 2014.

Mazzoleni, R.C. and P.R. Schwingel. 1999. Elasmobranch species landed in Itajaí Harbor, Southern Brazil. Notas Téc. Facimar. 3: 111-118.

Martins, R.R. and P.R. Schwingel. 2003. Variação espaço-temporal da CPUE para o gênero *Rhinobatos* (Rajiformes, Rhinobatidae) na costa sudeste e sul do Brasil. Notas Téc. Facimar. 7: 119-129.

Miranda L.V. and C.M. Vooren. 2003. Captura e esforço da pesca de elasmobrânquios demersais no sul do Brasil nos anos de 1975 a 1997. Frente Marítimo. 19B: 217–231.

NPOA – Argentina – Plan de Acción Nacional para la Conservación y el Manejo de Condrictios (tiburones, rayas, y quimeras) en la República Argentina. 2009. Anexo Resolucion CFP. 6: 1-57.

Paesch, L. and A. Domingo. 2003. La pesca de condrictios en el Uruguay. Publication Comisión Técnica Mixta del Frente Marítimo. 19: 207–216.

Refi, S.M. 1973. *Rhinobatos horkelii* Müller and Henle, 1841 en aguas de la plataforma continental Argentina (Rajiformes, Rhinobatidae). Neotropica. 19(58): 1-4.

Rosa, R.S. and F.C.T. Lima. 2005. Os Peixes Brasileiros Ameaçados de Extinção. pp. 278.
Silva, M. 2004. Ministério do Meio Ambiente. Instrução Normativa N^{o}5. May 21, 2004.

Valdemarsen, J.W., T. Jørgensen, A. Engas. 2007. Options to mitigate bottom habitat impact of dragged gears. FAO Fisheries Technical Paper. 506: 1-29.

Vooren, C.M. 1997. Demersal elasmobranchs. In: *Subtropical Convergence Environments: The Coast and Sea in the Southwestern Atlatntic*. U. Speeliger, C. Odebrecht, and J.P. Castello (Eds.). pp. 141-145.

Vooren, C.M., S. Klippel, and A.B. Galina. 2005. Os elasmobrânquios das aguas costeiras da Platforma Sul. In: *Ações para a conservação d e tubarões e raias no sul do Brasil*. C.M. Vooren and S. Klippel (eds). Porto Alegre, Igaré. pp. 113-120.

ENDANGERED SPECIES ACT
STATUS REVIEW OF THE ARGENTINE ANGEL SHARK
(*Squatina argentina*)

(www.fishbase.org)

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 Eric Ebert (Moss Landing Marine Laboratory), as well as Diego Vaz (University of Sao Paulo) and María Cristina Oddone (Universidade Federal de Rio Grande), for providing us with some of the 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 Argentine angel shark (*Squatina argentina*). Report to the National Marine Fisheries Service, Office of Protected Resources. SFD Contribution PCB-15-09.

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 argentina* (Argentine angel shark).

TABLE OF CONTENTS

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 Argentine angel shark, *Squatina argentina*; (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 Argentine 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 Argentine angel shark (*Squatina argentina*) is a chondrichthyan member of the family Squatinidae that can be found in the Southwestern Atlantic Ocean from Southern Brazil to Argentina. In English it is called the Argentine angel shark and the longfin angel shark (Vooren and Chiaramonte 2006). They are called *cação-anjo* in Portuguese (Miranda and Vooren 2003) and *angelito, angelote,* and *pez ángel* in Spanish (Vooren and Chiaramonte 2006, Domingo et al. 2008).

The taxonomy of angel sharks of the southwestern Atlantic Ocean has been a source of ongoing controversy (Vooren and Chiaramonte 2006). Due to similar morphological characteristics, *S. argentina*, *S. guggenheim*, *S. occulta*, and *S. punctata* have been variously synonymized with each other (Compagno 2005, Vooren and Chiaramonte 2006, 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). Isoenzymatic studies concluded that the nominal species *Squatina argentina* was at least two different species based on esterase patterns from heart extracts as well as morphological features (Solé-Cava et al. 1983). 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 Argentine angel shark can be distinguished from *S. guggenheim* and *S. occulta* by its coloration, dental formula, some neurocranial features, dorsal surface denticle pattern, and pectoral fin shape. Unlike *S. guggenheim*, the Argentine angel shark lacks a dorsal midline of morphologically distinct denticles (Vaz and Carvalho 2013). Dermal denticles densely cover the entire dorsal surface, except for the posterior margins of unpaired fins and the anterior apex of the pectoral fins. No sexual dimorphism in the morphology and distribution of dermal denticles was seen. They have 24 vertical tooth rows in both jaws with a dental formula of 12-12/12-12 (Vaz and Carvalho 2013). Upper jaw teeth are smaller than lower jaw teeth and are spaced more widely apart. There was no sexual dimorphism in teeth. In the neurocrania, the distal portion of the upper postorbital process has a lanceolate shape and the projection of the external canal is in a laterally diagonal position on the octic capsule (de Carvalho et al. 2012). The pectoral fins are large, twice as long as they are wide, with a length 32.4 - 36.7% of the total length (TL). The anterior margins of the pectoral fins are strongly convex, creating a visible "shoulder" area at the base of the head (Figure 1; Vaz and Carvalho 2013). The dorsal coloration is dark to purplish brown with small, round, white spots symmetrically distributed across the entire dorsal surface (Vooren and da Silva 1991, Milessi et al. 2001, Vaz and Carvalho 2013). Spot size ranges, but it is always at least half of the eye length (2.3 – 2.9% TL; Vaz and Carvalho 2013). Small individuals are creamy white over the entire ventral surface, while larger animals develop dark beige on the central region of the head, margins of the pectoral fins, origin of the pelvic fins, and the posterior region of the trunk (Vaz and Carvalho 2013). Unlike *S. guggenheim and S. occulta*, female Argentine angel sharks have two functional ovaries, which can also serve as an identifying feature (Vooren and da Silva 1991).

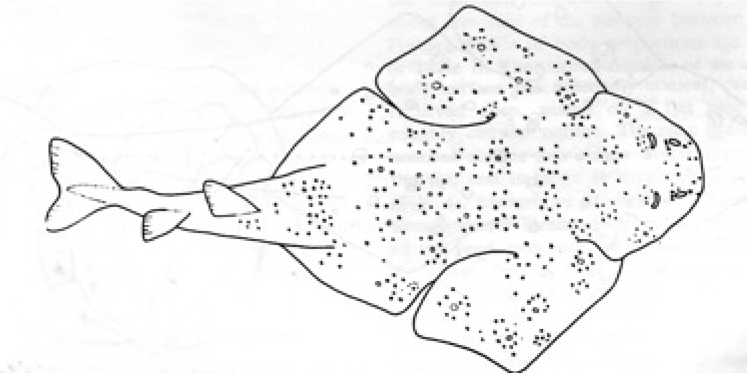


Figure 1. The Argentine angel shark based on its re-description by Vooren and da Silva (1991).

Range and Habitat Use

Conflicting information is available on the exact range of the Argentine angel shark. The IUCN Red List states that they are found from Rio Grande do Sul in southern Brazil to Patagonia, Argentina, but their distribution map indicates that they range from Rio de Janeiro, Brazil to Chubut, Argentina (Vooren and Chiaramonte 2006). Vaz and de Carvalho (2013) state that the Argentine angel shark is distributed from Santa Catarina, Brazil to southern Uruguay, while Milessi et al. (2001) say they range from São Paulo, Brazil, south to Patagonia, Argentina. Records from the GBIF Database, which may be unreliable, indicate that Argentine angel sharks have been found as far south as Chubut, Argentina and as far north as Santa Catarina, Brazil (Table 1). For the purposes of this review and based on peer reviewer recommendations, we have chosen to accept Vaz and Carvalho's (2013) range from the most recent taxonomic review.

Argentine angel sharks live at depths between 100 and 400 m, with a principal depth range of 120-320 m (Cousseau 1973, Vooren and da Silva 1991, Vooren and Klippel 2005). Both sexes and all life stages are found between Rio Grande and Chuí in Brazil (Vooren and Klippel 2005). They live on muddy or sandy bottom substrates on the continental shelf and slope. Angel sharks are active mostly at night, and show limited movement and dispersal migration between neighboring populations, with migrants having no impact on the short term abundance of a population (Vooren and Klippel 2005).

Figure 2. The range of the Argentine angel shark from Santa Catarina, Brazil to Buenos Aires, Argentina based on the most recent taxonomic confirmation by Vaz and Carvalho (2013).

Diet and Feeding

Little information is available regarding the Argenitne angle sharks's diet. The stomach contents of 53 individuals showed that fish made up 68.33% of the diet, crustaceans made up 15% of the diet, and molluscs made up 1.6% of the diet. The rest of the diet contained unidentifiable remains. The most common fish species was *Cynoscion striatus*, while the shrimp *Artemesia longinaris* and *Hymenopenaeus mulleri* where the most common crustaceans, and *Loligo brasiliensis* was the most common mollusc (Cousseau 1973). A study of the foodweb of the short-finned squid (*Illex argentinus*) indicates that they are occasionally preyed upon by Argentine angel sharks (dos Santos and Haimovici 2000). In general, 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

Little is known about the growth and reproduction of the Argentine angel shark. Their maximum total length is 138 cm with a size at sexual maturity of 120 cm TL (Vooren and da Silva 1991, Vooren and Klippel 2005). Age at first maturity and size at birth are unknown (Vooren and da Silva 1991, Vooren and Klippel 2005).

Gravid females and neonates are rarely found, so little is known about the gestation and birth of this species (Vooren 1997). Vooren and Klippel (2005) indicate that like *S. occulta* and *S. guggenheim*, the Argentine angel shark may have cloacal gestation during the latter half of pregnancy. In May of 1987, at 29°S, in Santa Catarina, Brazil, two neonates, 35 and 37 cm TL, were caught. This could indicate that Argentine angel sharks reproduce on the slope of the southern Brazilian continental shelf (Vooren and Klippel 2005). Gestation is lecithotrophic (Vooren 1997). Litter size ranges from 7-11 pups, most commonly 9 or 10 pups, and litter size is not related to maternal size (Vooren and da Silva 1991, Vooren and Klippel 2005).

Demography

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

DISTRIBUTION AND ABUNDANCE

To provide a better understanding of the Argentine 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

The geographic distribution of the Argentine angel shark is poorly defined, but it is clear that they are present in southern Brazil, Uruguay, and at least the northern part of Argentina (Table 1; see Range and Habitat Use section above). Argentine angel sharks have been documented year round in southern Brazil (Vooren 1997). In the Argentine-Uruguayan Common Fishing Zone, Argentine angel sharks are distributed in the highest densities (from 1 to 11.4 t/nm^2) along the Uruguayan coast, where salinities are higher than the Argentine coast (Díaz de Astarloa et al. 1997). This paper refers to all *Squatina* species as Argentine angel sharks. However, it is likely more applicable to *S. guggenheim*, which is more common than Argentine angel sharks in the Argentine-Uruguayan Common Fishing Zone.

No specific population abundance estimates could be found for Argentine angel sharks. They are considered to be the least common species of angel shark found in the southwestern Atlantic, when compared to *S. guggenheim* and *S. occulta*, particularly in Argentina (Vooren and Klippel 2005). In Brazil, they are most abundant between Rio Grande and Chuí in Rio Grande do Sul, Brazil, and there is no evidence of the existence of abundant populations outside of this region (Vooren and Klippel 2005, Vooren and Chiaramonte 2006). Based on fishery independent research surveys, from 1986-2002, the abundance of both the Argentine angel shark and *S. occulta* has declined by approximately 80% on the outer shelf and upper slope of the southern Brazilian continental shelf (Vooren and Klippel 2005).

According to the GBIF database, there are two records of Argentine angel sharks that were caught in Namibia, well outside of their range in the southwestern Atlantic. Both of these records are from the early 1930s and are from specimens that are now housed in the Zoological Museum at the Natural History Museum of Denmark. It is likely, given the taxonomic controversy over angel shark species and the age of the specimens, that these specimens are misidentified as Argentine angel sharks and are really another angel shark species. It is hypothesized that that these records are actually *S. guggenheim* from the La Plata estuary and the town of Médanos, Argentina. Additionally, there is one undated record from Chile, which is also likely the result of a species misidentification.

Table 1. Records of the Argentine 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
1925	1		Uruguay	GBIF Database
1933	1	La Plata River	Namibia	GBIF Database
1934	1	Medano	Namibia	GBIF Database
1954	1	--	Brazil	GBIF Database
1966	1	La Paloma	Uruguay	GBIF Database
1966	1	Rio Grande do Sul	Brazil	GBIF Database
1966	1	--	Uruguay	GBIF Database
1966	1	--	Uruguay	GBIF Database
1966	1	Chubut	Argentina	GBIF Database
1966	1	Buenos Aires	Argentina	GBIF Database
1968	1	Paraná	Brazil	GBIF Database
1970	1	Rio Negro	Argentina	GBIF Database
1971	1	Punta del Diablo	Uruguay	GBIF Database
1971	1	Punta del Diablo	Uruguay	GBIF Database
1973	1	Buenos Aires	Argentina	GBIF Database
1973	1	Buenos Aires	Argentina	GBIF Database
1973	1	Chubut	Argentina	GBIF Database
1973	1	Chubut	Argentina	GBIF Database
1973	1	Chubut	Argentina	GBIF Database
1973	1	Chubut	Argentina	GBIF Database
1973	1	Rio Negro	Argentina	GBIF Database
1973	1	Chubut	Argentina	GBIF Database
1976	1	Rawson, Chubut	Argentina	GBIF Database
1976	1	Chubut	Argentina	GBIF Database
1976	1	Rio Negro	Argentina	GBIF Database
1976	1	Buenos Aires	Argentina	GBIF Database
1976	1	Buenos Aires	Argentina	GBIF Database
1976	1	Buenos Aires	Argentina	GBIF Database
1976	1	Buenos Aires	Argentina	GBIF Database
1976	1	Rio Negro	Argentina	GBIF Database
1976	1	Buenos Aires	Argentina	GBIF Database
1976	1	Buenos Aires	Argentina	GBIF Database
1976	1	Buenos Aires	Argentina	GBIF Database
1976	1	Buenos Aires	Argentina	GBIF Database
1976	1	Buenos Aires	Argentina	GBIF Database
1978	1	Buenos Aires	Argentina	GBIF Database

1978	1	Chubut	Argentina	GBIF Database
1978	1	Bahia Blanca, Buenos Aires	Argentina	GBIF Database
1978	1	Chubut	Argentina	GBIF Database
1978	1	Bahia Blanca, Buenos Aires	Argentina	GBIF Database
1978	1	Buenos Aires	Argentina	GBIF Database
1978	1	Buenos Aires	Argentina	GBIF Database
1978	1	Buenos Aires	Argentina	GBIF Database
1978	1	Buenos Aires	Argentina	GBIF Database
1978	1	Golfo San Matias, Rio Negro	Argentina	GBIF Database
1978	1	Buenos Aires	Argentina	GBIF Database
1978	1	Rio Negro	Argentina	GBIF Database
1978	1	Chubut	Argentina	GBIF Database
1978	1	Buenos Aires	Argentina	GBIF Database
1978	1	Neochea, Buenos Aires	Argentina	GBIF Database
1980-1987	160	Rio Grande do Sul	Brazil	Vooren and da Silva 1991
1982	1	Rio Grande do Sul	Brazil	GBIF Database
1982	1	Rio Grande do Sul	Brazil	GBIF Database
1983	1	Buenos Aires	Argentina	GBIF Database
1983	1	Buenos Aires	Argentina	GBIF Database
1983	1	Rawson, Chubut	Argentina	GBIF Database
1983	1	Chubut	Argentina	GBIF Database
1983	1	Chubut	Argentina	GBIF Database
1995-1996	8	Argentine-Uruguayan Common Fishing Zone	Argentina/Uruguay	Milessi et al. 2001
2001	1	Rio Grande do Sul	Brazil	GBIF Database
2002	1	Rio Grande do Sul	Brazil	GBIF Database
2003-2005	2	Rio Grande do Sul	Brazil	Kütter et al. 2009
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	--	Chile	GBIF Database
N/A	1	--	Brazil	GBIF Database
N/A	1	--	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	Buenos Aires	Argentina	GBIF Database
N/A	1	--	Uruguay	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	Coquimba	Chile	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	La Paloma	Uruguay	GBIF Database
N/A	1	Buenos Aires	Argentina	GBIF Database
N/A	1	--	Uruguay	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	1	Bahia Blanca, Buenos Aires	Argentina	GBIF Database
N/A	1	Rio Grande do Sul	Brazil	GBIF Database
N/A	8	--	Argentina, Uruguay, and Brazil	Vaz and de Carvalho 2013
N/A	1	--	Uruguay	Bigelow and Schroeder 1948
N/A	2	Rio Grande do Sul	Brazil	de Carvalho et al. 2012

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 Argentine 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 Argentine 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 simply to angel sharks includes multiple angel shark species, while information specific to *S. argentina* will specifically reference Argentine angel sharks. There is some evidence that *S. guggenheim* is the most abundant angel shark species from southern Brazil to Argentina and could make up the majority of angel shark landings data, while the Argentine angel shark is much less common (Vooren and da Silva 1991, Cousseau and Figueroa 2001, Vooren and Klippel 2005).

There is no directed fishery for angel sharks in Argentina, but historically they were captured in multispecies artisanal shark fisheries and were considered a valuable bycatch species (Chiaramonte 1998). In the early 2000s, angel sharks were one of the main cartilaginous fish landed in Argentine ports and were mostly caught along the coasts of Buenos Aires and Uruguay (Massa et al. 2004). In 2007, angel shark export revenue in Argentina was $2,732,274 U.S. dollars (NPOA – Argentina). Angel sharks were 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). Historically, in Mar del Plata, they were caught for the sale of their liver oil (Cousseau 1973). 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). Argentine angel shark landings between 1992 and 1998 remained stable, but declines in CPUEs were recorded (Massa and Hozbor 2003). A decline in landings has been seen since 1998 (Massa et al. 2004). Though *S. guggenheim* was the most commonly landed species of angel shark in Argentina, captures of Argentine angel sharks were also frequently reported (Massa et al. 2004). Incorrect species identification of angel sharks is a problem that persists in the Argentine-Uruguayan Common Fishing Zone, particularly in the Argentine landings (Milessi et al. 2001).

In Uruguay, Argentine angel sharks are targeted in the Atlantic gillnet fishery and bottom trawl fisheries. They are also caught as bycatch in bottom long line, estuarine 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 species identification, due to the aforementioned taxonomic controversy, makes it difficult to determine which species of angel shark, the Argentine angel shark (*S. argentina*), *S. guggenheim*, or *S. occulta*, is the most vulnerable to fishing pressure within the Argentine-Uruguayan Common Fishing Zone (Milessi et al. 2001). 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 *S. guggenheim* (Domingo et al. 2008).

Historically, in Brazil, double rig trawlers fished for angel sharks on the outer shelf down to 140 m, and *S. guggenheim* maked up the majority of the catch (Haimovici 1998). Mean annual landings of angel sharks have been over 2000 t since 1985 (Figure 3). Although landings were still high between 1990 and 1994, falling CPUEs signaled the approach of a decline in landings (Haimovici 1998). Argentine angel sharks have been reported to be the least captured angel shark species in Brazilian fisheries (Perez and Wahlrich 2005).

Argentine angel sharks are caught as bycatch in the monkfish (*Lophius gastrophysus*) fishery off southern Brazil. For every 100 nets set 1.052 Argentine angel sharks are caught and 49.3% of them are retained and processed. This makes them the second most retained bycatch species in this fishery, second to Geryonid crabs (Perez and Wahrlich 2005). It is estimated that 8,698 Argentine angel sharks were caught in the monkfish fishery in 2001 (Perez and Wahrlich 2005).

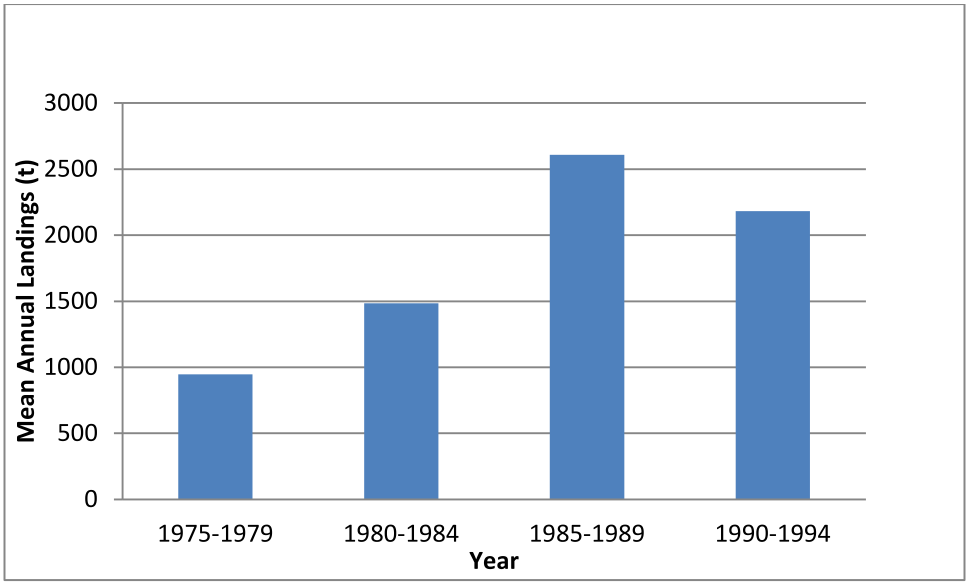


Figure 3. Mean annual landings of angel sharks in southern Brazil between 35°S and 28°S (Haimovici 1998).

In southern Brazil, angel shark landings are 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 overall the angel shark population has declined by 85% since 1985. CPUEs have 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). Miranda and Vooren (2003) state that the angel shark species included in the reported landings are only *S. guggenheim* and *S. occulta*, not the Argentine angel shark. However, the IUCN Red List assessment for the Argentine angel shark includes these data in their report (Vooren and Chiaramonte 2006), implying that Argentine angel sharks were part of these landings. Due to the above mentioned taxonomic controversy, Argentine angel sharks may also make up a portion of the landings mentioned by 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* and *S. punctata* to be synonyms for the Argentine angel shark (*S. argentina*) (www.fao.org). These FAO reported landings are presumably a combination of two valid species, *S. guggenheim* and the Argentine angel shark, and may also include landings of *S. occulta* (Figure 4).

At this time, more detailed information could not be provided regarding changing fishing effort or fishing grounds for Argentine 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 (Miranda and Vooren 2003).

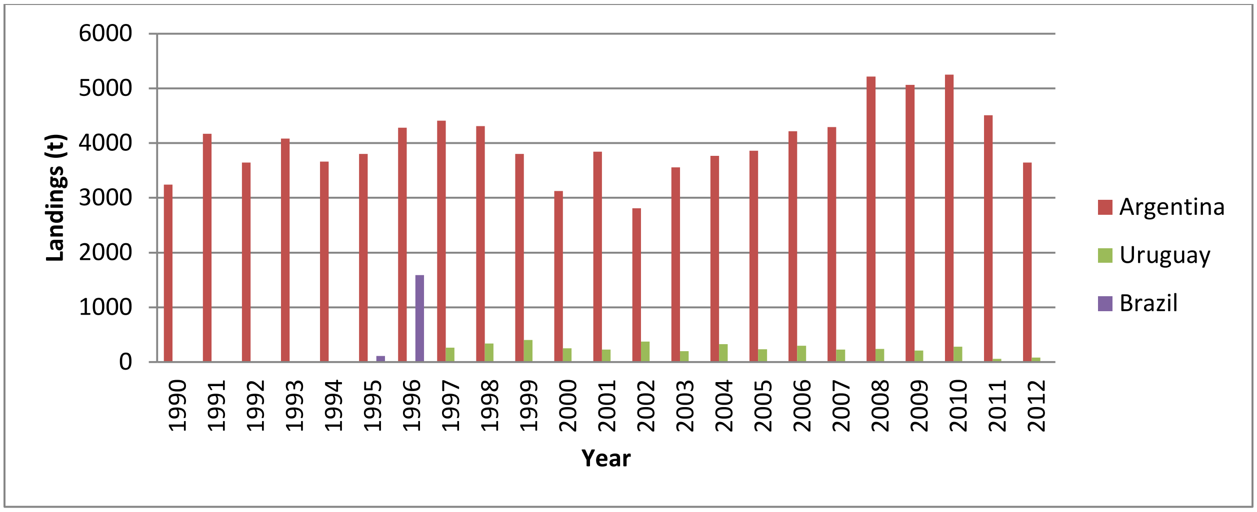


Figure 4. FAO reported landings for angel sharks from Argentina, Uruguay, and Brazil (www.fao.org).

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

Predation

Studies of South American sea lion (*Otaria flavescens*) diet in Uruguay found that they consume Argentine angel sharks, particularly in Cabo Polonio (Szteren 2006). No other publications could be found that specifically indicate other animals as Argentine angel shark predators.

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

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 for 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).

In Brazil, the gillnet monkfish fishery, which is the source of significant Argentine angel shark bycatch, is being monitored in several ways, including 100% observer coverage and the implementation of two “no take” zones, which could help lower bycatch numbers (Vooren and Chiaramonte 2006). The IUCN Red List listing notes that successful conservation of the Argentine angel shark will be highly dependent upon the successful management of the gillnet monkfish fishery (Vooren and Chiaramonte 2006).

In December 2014, the Brazilian Ministry of the Environment approved a new version of the Brazilian Endangered Species List, which listed the Argentine angel shark as critically endangered in Annex I (Directive N^{o} 445). 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 Argentine angel shark is not listed as one of the twelve species of concern, but the plan 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.

Uruguay's FAO National Plan of Action for the conservation of chondrichthyans lists the Argentine 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 time 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 Argentine angel sharks and 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 Argentine angel shark to be a species of high priority (NPOA-Argentina 2009). Brazil's National Plan of Action could not be found, but as of 2012 an unapproved draft version did exist (Fischer et al. 2012). The contents of the unapproved draft could not be found.

Other Natural or Manmade Factors Affecting the Species

Two Argentine angel sharks sampled from fish markets in southern Brazil between October 2003 and June 2005 had an average mercury concentration of 30.4 ng/g. This is below the World Health Organization's recommended limits for consumption, but these levels of mercury could be harmful to angel sharks living in the environment, continuously consuming contaminated fish (Kütter et al. 2009). Major sources of mercury contamination in the area come from industries and domestic effluents as well as atmospheric emissions (Kütter et al. 2009).

LITERATURE CITED

Compagno, L., M. Dando, and S. Fowler. 2005. Sharks of the World. Princeton University Press. Princeton, New Jersey.

de Carvalho, M.R., C. Faro, and U.L. Gomes. 2012. Comparative neurocranial morphology of angelsharks from the south-western Atlantic Ocean (Chondrichthyes, Elasmobranchii, Squatinidae): implications for taxonomy and phylogeny. Acta Zoologica. 93: 171-183.

Chiaramonte, G.E. 1998. Shark fisheries in Argentina. Marine and Freshwater Research. 49: 601-609.

Cousseau, M.B. 1973. Taxonomia y biologia del pez angel, *Squatina argentina* Marini (Pisces, *Squatinidae*). Physis A. 32(84): 175-195.

Cousseau, M.B. and D.E. Figueroa. 2001. Las especies del géro *Squatina* en aguas de Argentina (Pisces: Elasmobranchii: Squatinidae). Neotrópica. 47: 85-86.

Díaz de Astarloa, J.M., C.R. Carozza, R.A. Guerrero, A.G. Baldoni, and M.B. Cousseau. 1997. Algunas caracteristicas biologicas de peces capturados en una campaña costera invernal en 1993, en el area comprendida enter 34° y 42°S (Atlantico sudoccidental) y su relacion con las condiciones abientales. INIDEP Informe Técnico. 14: 1-14.

Domingo, A., R. Forselledo, P. Miller, and C. Passadore. 2008. Plan de Acción Nacional para la Conservación de los Condrictios en las Pesquerías Uruguayas. Montevideo: DINARA. 88 p.

dos Santos, R.A. and M. Haimovici. 2000. The Argentine short-finned squid *Illex argentinus* in the food webs of southern Brazil. Sarsia. 85: 49-60.

Fischer, J., K. Erikstein, B. D'Offay, S. Guggisberg, and M. Barone. 2012. Review of the Implementation of the International Plan of Action for the Conservation and Management of Sharks. FAO Fisheries and Aquaculture Circular No. 1076. FAO, Rome.

Hiamovici, M. 1998. Present state and perspectives for the southern Brazil shelf demersal fisheries. Fisheries Management and Ecology. 5: 277-289.

Kütter, V.T., N. Mirlean, P.R.M. Baisch, M.T. Kütter, E.V. Silva-Filho. 2009. Mercury in freshwater, estuarine, and marine fishes from Southern Brazil and its ecological implication. Environmental Monitoring and Assessment. 159: 35-42.

Lessa, R., C.M. Vooren, M.L. Goes de Araújo, J.E. Kotas, P.C. Almeida, G.R. Filho, F.M. Santana, O.B. Gadig, C. Sampaio, Z. Almeida, M. Almeida, R.S. Rosa. 2005. Plano Nacional de Ação para a Conservação e o Manejo do Estoques de Peixes Elasmobrânquios no Brasil.

Massa, A.M. and N.M. Hozbor. 2003. Peces cartilaginosos de la plataforma Argentina: explotacion, situacion, y necesidades para un manejo pesquero adecuado. Frente Marítimo. 19: 199-206.

Massa, A., N. Hozbor, and J. Colonello. 2004. Situación actual y avances en el studio de los peces cartilaginosos. Informe Tecnico Inerno INIDEP. 57: 1-18.

Milessi, A., R. Vögler, and G. Bazzino. 2001. Indentificación de tres especies del genero *Squatina* (Elasmobranchii, Squatinidae) en la Zona Común de Pesca. Gayana (Concepción). 65(2): 167-172.

Miranda L.V. and C.M. Vooren. 2003. Captura e esforço da pesca de elasmobrânquios demersais no sul do Brasil nos anos de 1975 a 1997. Frente Marítimo 19B: 217–231.

NPOA – Argentina – Plan de Acción Nacional para la Conservación y el Manejo de Condrictios (tiburones, rayas, y quimeras) en la República Argentina. 2009. Anexo Resolucion CFP. 6: 1-57.

Perez, J.A.A. and R. Wahrlich. 2005. A bycatch assessment of the gillnet monkfish *Lophius gastrophysus* fishery off southern Brazil. Fisheries Research. 72: 81-95.

Solé-Cava, A.M., C.M. Vooren, and J.A. Levy. 1983. Isozymic differentiation of two sibling species of *Squatina* (Chondrichthyes) in south Brazil. Comparative Biochemistry and Physiology. 75(B2): 355-358.

Szteren, D. Predation of *Otaria flavescens* over artisanal fisheries in Uruguay: Opportunism or prey selectivity? Latan American Journal of Aquatic Mammals. 5(1): 29-38.

Valdemarsen, J.W., T. Jørgensen, A. Engas. 2007. Options to mitigate bottom habitat impact of dragged gears. FAO Fisheries Technical Paper. 506: 1-29.

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

Vooren, C.M. 1997. Demersal elasmobranchs. In: *Subtropical Convergence Environments: The Coast and Sea in the Southwestern Atlatntic*. U. Speeliger, C. Odebrecht, and J.P. Castello (Eds.). pp. 141-145.

Vooren, C.M. and K.G. da Silva. 1991. On the taxonomy of the angel sharks from southern Brazil, with the description of *Squatina occulta* sp. n. Revista Brasileira de Biologia. 51(3): 589-602.

Vooren, C.M. and S. Klippel. 2005. Biologia e status de conservação dos cações-anjo *Squatina guggenheim, S. occulta* and *S. argentina*. In: C.M. Vooren and S. Klippel (eds.). Ações para a conservação de tubarões e raias no sul do Brasil. Porto Alegre: Igaré, 2005. pp. 262.

Vooren, C.M. and G.E. Chiaramonte. 2006. *Squatina argentina*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 29 January 2014.

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).

TABLE OF CONTENTS

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).

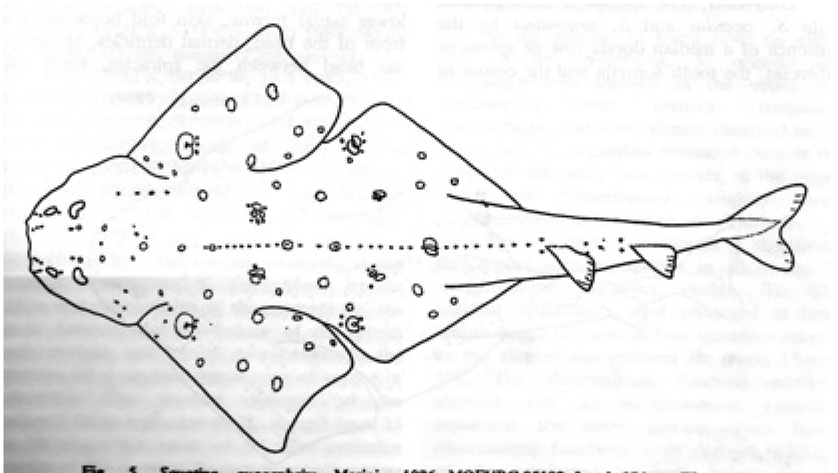


Fig. 5. *Squatina guggenheim* Marini, 1936, MOFURG 05189, female 874 mm TL.

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).

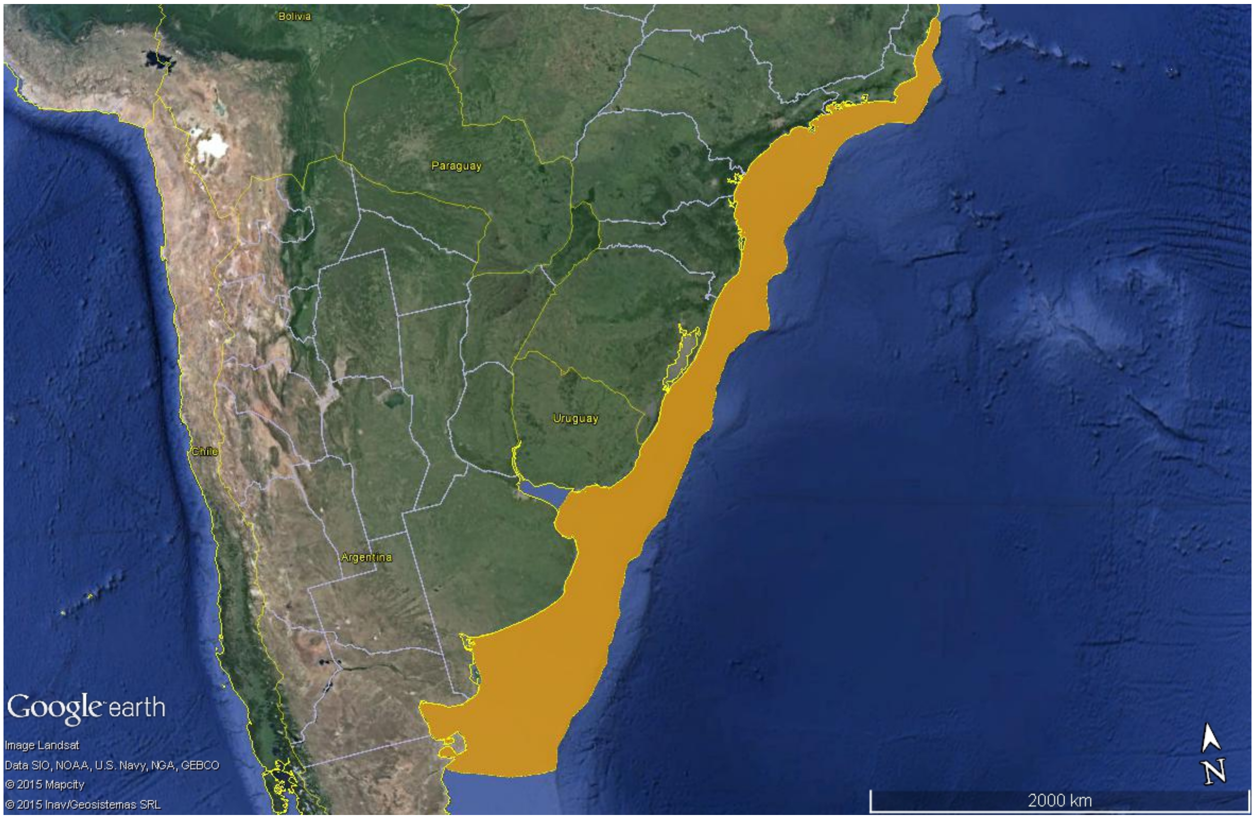


Figure 2. The range of the spiny angel shark from Espírito Santo, Brazil to Rawson, Argentina based on the information gathered in this review.

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
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	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

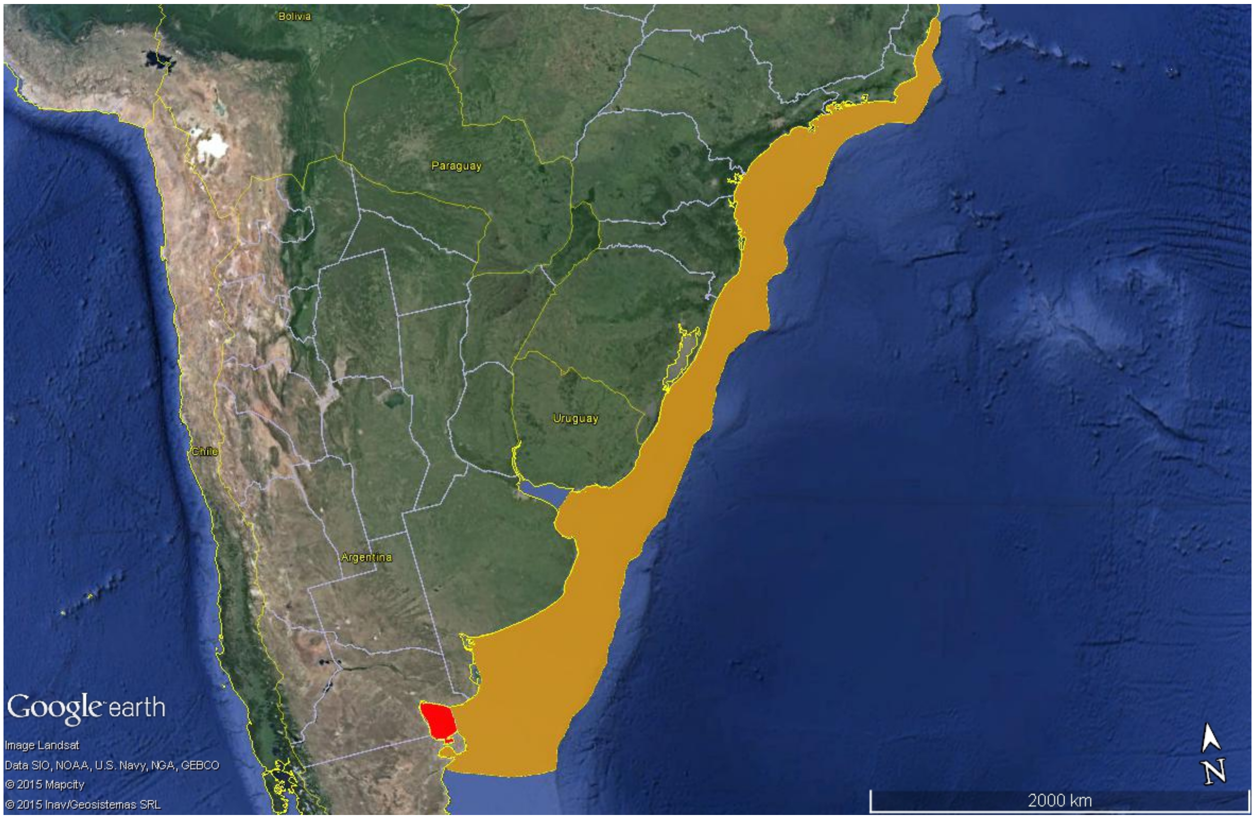


Figure 3. This spiny angel shark's range with the San Matías Gulf highlighted in red.

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.

<u>Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range</u>

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°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).

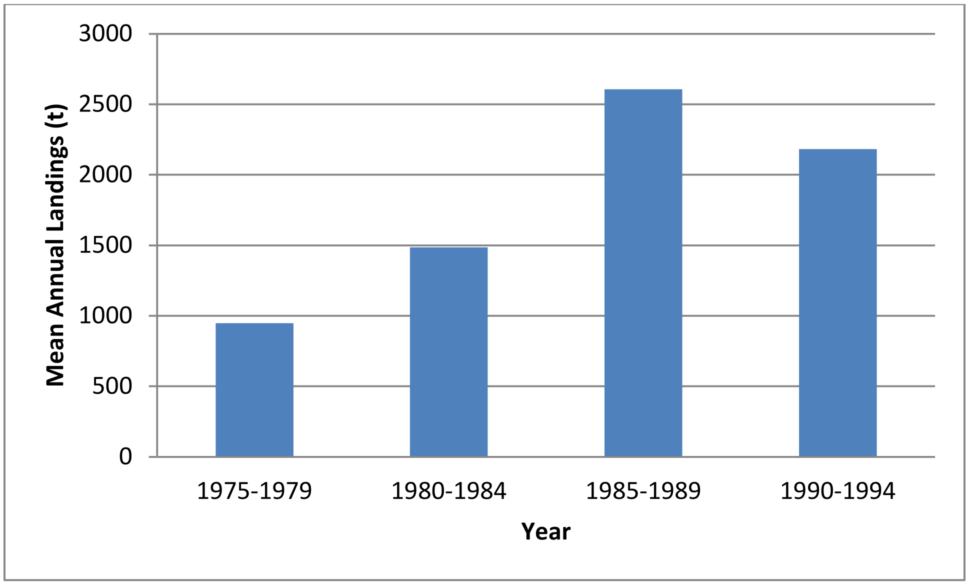


Figure 4. Mean annual landings of angel sharks in southern Brazil between 35°S and 28°S (Haimovici 1998).

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).

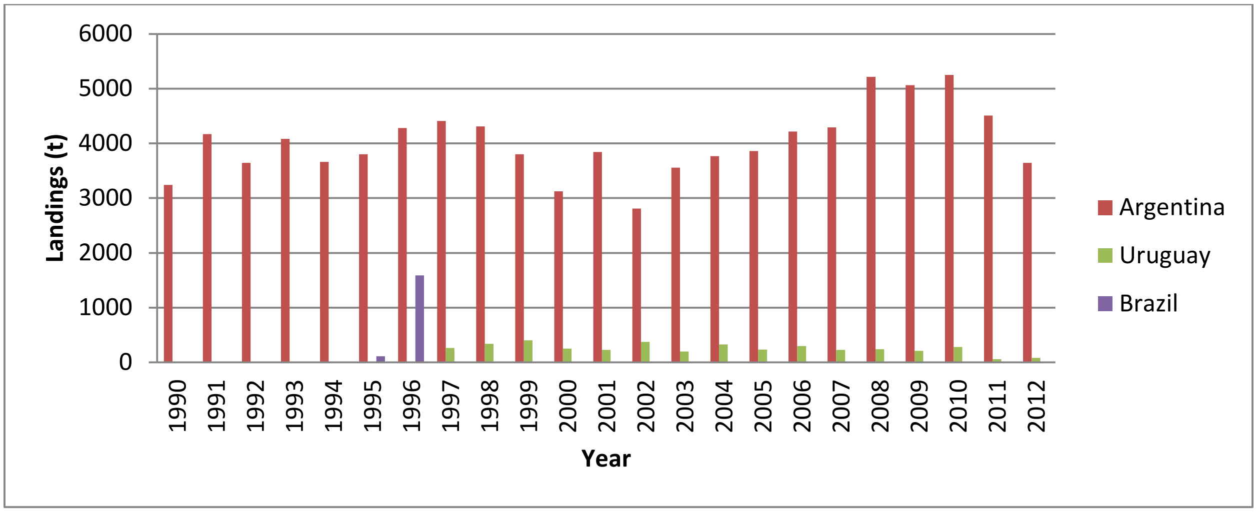


Figure 5. FAO reported landings for angel sharks from Argentina, Uruguay, and Brazil (www.fao.org). Landings for Brazil were only reported in 1995 and 1996.

Competition, Disease, or Predation

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).

Adequacy of Existing Regulatory Mechanisms

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).

LITERATURE CITED

Awruch, C.A., F.L. Lo Nostro, G.M. Somoza, and E. Di Giácomo. 2008. Reproductive biology of the angular angel shark *Squatina guggenheim* (Chondrichthyes: Squatinidae) off Patagonia (Argentina, southwestern Atlantic. Ciencias Marinas. 34(1): 17-28.

Bornatowski, H., A.F. Navia, R.R. Braga, V. Abilhoa, and M.F.M. Corrêa. 2014. Ecological importance of sharks and rays in a structural foodweb analysis in southern Brazil. ICES Journal of Marine Science. 71(3): 713-724.

Bornatowski, H., J.R. Simões Vitule, V. Abilhoa, and M.F. Maia Corrêa. 2011. Unconventional fishing for large sharks in the State of Paraná, southern Barzil: a note of concern. Journal of Applied Ichthyology. 27: 1108-1111.

Chiaramonte, G.E. 1998. Shark fisheries in Argentina. Marine and Freshwater Research. 49: 601-609.

Chiaramonte, G. and C.M. Vooren. 2007. *Squatina guggenheim*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <iucnredlist.org>. Downloaded on 29 January 2014.

Colonello, J.H. 2005. Ecología reproductive y hábitos alimentarios del pez ángel, *Squatina guggenheim* (Chondrichthyes: Squatinidae), en el Distrito Biogeográfico Bonaerense, entre 34° y 42°S. Tesis de Licenciatura. Universidad Nacional de Mar del Plata.

Colonello, J.H., L.O. Lucifora, and A.M. Massa. 2007. Reproduction of the angular angel shark (*Squatina guggenheim*): geographic differences, reproductive cycle, and sexual dimorphism. ICES Journal of Marine Science. 64: 131-140.

Compagno, L., M. Dando, and S. Fowler. 2005. Sharks of the World. Princeton University Press. Princeton, New Jersey.

Cousseau, M.B. 1973. Taxonomia y biologia del pez angel, *Squatina argentina* Marini (Pisces, *Squatinidae*). Physis A. 32(84): 175-195.

Cousseau, M.B. and D.E. Figueroa. 2001. Las especies del género *Squatina* en aguas de Argentina (Pisces: Elasmobranchii: Squatinidae). Neotrópica. 47: 85-86.

Crespi-Abril, A.C., S.N. Pedraza, N.A. García, and E.A. Crespo. 2013. Species biology of elasmobranch by-catch in bottom-trawl fishery on the northern Patagonian shelf, Argentina. Aquatic Biology. 19: 239-251.

de Carvalho, M.R., C. Faro, and U.L. Gomes. 2012. Comparative neurocranial morphology of angelsharks from the south-western Atlantic Ocean (Chondrichthyes, Elasmobranchii, Squatinidae): implications for taxonomy and phylogeny. Acta Zoologica. 93: 171-183.

Domingo, A., R. Forselledo, P. Miller, and C. Passadore. 2008. Plan de Acción Nacional para la Conservación de los Condrictios en las Pesquerías Uruguayas. Montevideo: DINARA. 88 p.

Garcia, G., S. Pereyra, V. Gutierrez, S. Oviedo, P. Miller, and A. Domingo. 2015. Population structure of *Squatina guggenheim* (Squatiniformes, Squatinidae) from the south-western Atlantic Ocean. Journal of Fish Biology. 86: 186-202.

Hiamovici, M. 1998. Present state and perspectives for the southern Brazil shelf demersal fisheries. Fisheries Management and Ecology. 5: 277-289.

Jaureguizar, A.J., R. Menni, C. Bremec, H. Mianzan, and C. Lasta. 2003. Fish assemblage and environmental patterns in the Río de la Plata estuary. Estuarine, Coastal and Shelf Science. 56: 921-933.

Jaureguizar, A.J., R. Menni, C. Lasta, and R. Guerrero. 2006. Fish assemblages of the northern Argentine coastal system: spatial patterns and their temporal variations. Fisheries Oceanography. 15(4): 326-344.

Lessa, R., C.M. Vooren, M.L. Goes de Araújo, J.E. Kotas, P.C. Almeida, G.R. Filho, F.M. Santana, O.B. Gadig, C. Sampaio, Z. Almeida, M. Almeida, R.S. Rosa. 2005. Plano Nacional de Ação para a Conservação e o Manejo do Estoques de Peixes Elasmobrânquios no Brasil.

Lucifora, L.O., V.B. García, and A.H. Escalante. 2009a. How can the feeding habits of the sand tiger shark influence the success of conservation programs? Animal Conservation. 12: 291-301.

Lucifora, L.O., V.B. García, R.C. Menni, A.H. Escalante, N.M. Hozbor. 2009b. Effects of body size, age and maturity stage on diet in a large shark: ecological and applied implications. Ecological Research. 24: 109-118.

Lucifora, L.O., R.C. Menni, and A.H. Escalante. 2005. Reproduction, abundance and feeding habits of the broadnose sevengill shark *Notorynchus cepedianus* in north Patagonia, Argentina. Marine Ecology Progress Series. 289: 237-244.

Massa, A.M. and N.M. Hozbor. 2003. Peces cartilaginosos de la plataforma Argentina: explotacion, situacion, y necesidades para un manejo pesquero adecuado. Frente Marítimo. 19: 199-206.

Massa, A., N. Hozbor, and J. Colonello. 2004. Situación actual y avances en el studio de los peces cartilaginosos. Informe Tecnico Inerno INIDEP. 57: 1-18.

Milessi, A., R. Vögler, and G. Bazzino. 2001. Indentificación de tres especies del genero *Squatina* (Elasmobranchii, Squatinidae) en la Zona Común de Pesca. Gayana (Concepción). 65(2): 167-172.

Miranda L.V. and C.M. Vooren. 2003. Captura e esforço da pesca de elasmobrânquios demersais no sul do Brasil nos anos de 1975 a 1997. Frente Marítimo 19B: 217–231.

NPOA – Argentina – Plan de Acción Nacional para la Conservación y el Manejo de Condrictios (tiburones, rayas, y quimeras) en la República Argentina. 2009. Anexo Resolucion CFP. 6: 1-57.

Perier, M.R., M. Estalles, N.M. Coller, M.N. Suarez, G.J. Mora, and E.E. Di Giácomo. 2011. Chondrichthyans of the San Matías Gulf, Patagonia, Argentina. Revista del Museo Argentino de Ciencias Naturales. 13(2): 213-220.

Rocha, G.R.A. and C.L.D.B. Rossi-Wongtshowski. 1998. Demersal fish community on the inner shelf of Ubatuba, southeastern Brazil. Revista Brasileira de Oceanografia.

Schäfer, B.T., C.E. Malavasi, P.O. Favaron, C.E. Ambrósio, M.A. Miglino, A.F. de Amorim, R.E.G. Rici. 2012. Morphological observations of the ampullae of Lorenzini in *Squatina guggenheim* and *S. occulta* (Chondrichthyes, Elasmobranchii, Squatinidae). Microscopy Research and Technique. 75: 1213-1217.

Silva, M. 2004. Ministério do Meio Ambiente. Instrução Normativa N^{o}5. May 21, 2004.

Stelbrink, B., T. von Rintelen, G. Cliff, and J. Kriwet. 2010. Molecular systematics and global phylogeny of angel sharks (genus *Squatina*). Molecular Phylogenetics and Evolution. 54: 395-404.

Soto, J.M. 2001. Annotated systematic checklist and bibliography of the coastal and oceanic fauna of Brazil. I. Sharks. Mare Magnum. 1(1): 51-120.

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

Valdemarsen, J.W., T. Jørgensen, A. Engas. 2007. Options to mitigate bottom habitat impact of dragged gears. FAO Fisheries Technical Paper. 506: 1-29.

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

Vögler, R., A.C. Milessi, and R.A. Quiñones. 2003. Trophic ecology of *Squatina guggenheim* on the continental shelf off Uruguay and northern Argentina. Journal of Fish Biology. 62: 1254-1267.

Vögler, R., A.C. Milessi, and R.A. Quiñones. 2008. Influence of environmental variables on the distribution of *Squatina guggenheim* (Chondrichthyes, Squatinidae) in the Argentine-Uruguayan Common Fishing Zone. Fisheries Research. 91: 212-221.

Vögler, R., A.C. Milessi, and R.A. Quiñones. 2009. Changes in trophic level of *Squatina guggenheim* with increasing body length: relationships with type, size, and trophic level of its prey. Environmental Biology of Fishes. 84: 41-52.

Vooren, C.M. 1997. Demersal elasmobranchs. In: *Subtropical Convergence Environments: The Coast and Sea in the Southwestern Atlatntic*. U. Speeliger, C. Odebrecht, and J.P. Castello (Eds.). pp. 141-145.

Vooren, C.M. and K.G. da Silva. 1991. On the taxonomy of the angel sharks from southern Brazil, with the description of *Squatina occulta* sp. n. Revista Brasileira de Biologia. 51(3): 589-602.

Vooren, C.M. and S. Klippel. 2005. Biologia e status de conservação dos cações-anjo *Squatina guggenheim, S. occulta* and *S. argentina*. In: C.M. Vooren and S. Klippel (eds.). Ações para a conservação de tubarões e raias no sul do Brasil. Porto Alegre: Igaré, 2005. pp. 262.

Vooren, C.M., S. Klippel, and A.B. Galina. 2005. Os elasmobrânquios das aguas costeiras da Platforma Sul. In: *Ações para a conservação d e tubarões e raias no sul do Brasil*. C.M. Vooren and S. Klippel (eds). Porto Alegre, Igaré. pp. 113-120.