

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Parts 223 and 224

[Docket No. 150909839–5839–01]

RIN 0648–XE184

Endangered and Threatened Wildlife and Plants; 12-Month Finding for 7 Foreign Species of Elasmobranchs Under the Endangered Species Act

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Proposed rule; 12-month petition finding; request for comments.

SUMMARY: We, NMFS, have completed comprehensive status reviews under the Endangered Species Act (ESA) for seven foreign marine elasmobranch species in response to a petition to list those species. These seven species are the daggernose shark (*Isogomphodon oxyrinchus*), Brazilian guitarfish (*Rhinobatos horkelii*), striped smoothhound shark (*Mustelus fasciatus*), narrownose smoothhound shark (*Mustelus schmitti*), spiny angel shark (*Squatina guggenheim*), Argentine angel shark (*Squatina argentina*), and graytail skate (*Bathyraxa griseocauda*). Based on the best scientific and commercial information available, and after taking into account efforts being made to protect these species, we have determined that the daggernose shark (*I. oxyrinchus*), Brazilian guitarfish (*R. horkelii*), striped smoothhound shark (*M. fasciatus*), and Argentine angel shark (*S. argentina*) meet the definition of an endangered species under the ESA. We have determined that the narrownose smoothhound shark (*M. schmitti*) and spiny angel shark (*S. guggenheim*) meet the definition of a threatened species under the ESA. Therefore, we propose to list these six species under the ESA. Additionally, we have determined that the graytail skate (*B. griseocauda*) does not warrant listing under the ESA at this time. We are not proposing to designate critical habitat for any of the species proposed for listing because the geographical areas occupied by these species are entirely outside U.S. jurisdiction, and we have not identified any unoccupied areas within U.S. jurisdiction that are currently essential to the conservation of any of these species. We are soliciting comments on our proposal to list these six foreign marine elasmobranch species.

DATES: Comments on this proposed rule must be received by February 5, 2016. Public hearing requests must be made by January 21, 2016.

ADDRESSES: You may submit comments on this document, identified by NOAA–NMFS–2015–0161, by either of the following methods:

- **Electronic Submissions:** Submit all electronic public comments via the Federal eRulemaking Portal. Go to www.regulations.gov/ #/docketDetail;D=NOAA-NMFS-2015-0161. Click the “Comment Now” icon, complete the required fields, and enter or attach your comments.
- **Mail:** Submit written comments to NMFS Office of Protected Resources (F/PR3), 1315 East West Highway, Silver Spring, MD 20910, USA.

Instructions: Comments sent by any other method, to any other address or individual, or received after the end of the comment period, may not be considered by NMFS. All comments received are a part of the public record and will generally be posted for public viewing on www.regulations.gov without change. All personally identifying information (e.g., name, address, etc.), confidential business information, or otherwise sensitive information submitted voluntarily by the sender will be publicly accessible. NMFS will accept anonymous comments (enter “N/A” in the required fields if you wish to remain anonymous).

You can find the petition, status review report, **Federal Register** notices, and the list of references electronically on our Web site at <http://www.nmfs.noaa.gov/pr/species/petition81.htm>.

FOR FURTHER INFORMATION CONTACT:

Maggie Miller, NMFS, Office of Protected Resources (OPR), (301) 427–8403 or Chelsey Young, NMFS, OPR, (301) 427–8491.

SUPPLEMENTARY INFORMATION:**Background**

On July 15, 2013, we received a petition from WildEarth Guardians to list 81 marine species as threatened or endangered under the Endangered Species Act (ESA). This petition included species from many different taxonomic groups, and we prepared our 90-day findings in batches by taxonomic group. We found that the petitioned actions may be warranted for 27 of the 81 species and announced the initiation of status reviews for each of the 27 species (78 FR 63941, October 25, 2013; 78 FR 66675, November 6, 2013; 78 FR 69376, November 19, 2013; 79 FR 9880, February 21, 2014; and 79 FR 10104, February 24, 2014). This document

addresses the findings for 7 of those 27 species: daggernose shark (*Isogomphodon oxyrinchus*), Brazilian guitarfish (*Rhinobatos horkelii*), striped smoothhound shark (*Mustelus fasciatus*), narrownose smoothhound shark (*Mustelus schmitti*), spiny angel shark (*Squatina guggenheim*), Argentine angel shark (*Squatina argentina*), and graytail skate (*Bathyraxa griseocauda*). The status of, and relevant **Federal Register** notices for, the other 20 species can be found on our Web site at <http://www.nmfs.noaa.gov/pr/species/petition81.htm>.

We are responsible for determining whether species are threatened or endangered under the ESA (16 U.S.C. 1531 *et seq.*). To make this determination, we consider first whether a group of organisms constitutes a “species” under the ESA, then whether the status of the species qualifies it for listing as either threatened or endangered. Section 3 of the ESA defines a “species” to include “any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature.” On February 7, 1996, NMFS and the U.S. Fish and Wildlife Service (USFWS; together, the Services) adopted a policy describing what constitutes a distinct population segment (DPS) of a taxonomic species (the DPS Policy; 61 FR 4722). The DPS Policy identified two elements that must be considered when identifying a DPS: (1) The discreteness of the population segment in relation to the remainder of the species (or subspecies) to which it belongs; and (2) the significance of the population segment to the remainder of the species (or subspecies) to which it belongs. As stated in the DPS Policy, Congress expressed its expectation that the Services would exercise authority with regard to DPSs sparingly and only when the biological evidence indicates such action is warranted. Based on the scientific information available we determined that the daggernose shark (*I. oxyrinchus*), Brazilian guitarfish (*R. horkelii*), striped smoothhound shark (*M. fasciatus*), narrownose smoothhound shark (*M. schmitti*), spiny angel shark (*S. guggenheim*), Argentine angel shark (*S. argentina*), and graytail skate (*B. griseocauda*) are “species” under the ESA. There is nothing in the scientific literature indicating that any of these species should be further divided into subspecies or DPSs.

Section 3 of the ESA defines an endangered species as “any species which is in danger of extinction throughout all or a significant portion of its range” and a threatened species as

one “which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” We interpret an “endangered species” to be one that is presently in danger of extinction. A “threatened species,” on the other hand, is not presently in danger of extinction, but is likely to become so in the foreseeable future (that is, at a later time). In other words, the primary statutory difference between a threatened and endangered species is the timing of when a species may be in danger of extinction, either presently (endangered) or in the foreseeable future (threatened).

When we consider whether a species might qualify as threatened under the ESA, we must consider the meaning of the term “foreseeable future.” It is appropriate to interpret “foreseeable future” as the horizon over which predictions about the conservation status of the species can be reasonably relied upon. The foreseeable future considers the life history of the species, habitat characteristics, availability of data, particular threats, ability to predict threats, and the reliability to forecast the effects of these threats and future events on the status of the species under consideration. Because a species may be susceptible to a variety of threats for which different data are available, or which operate across different time scales, the foreseeable future is not necessarily reducible to a particular number of years.

Section 4(a)(1) of the ESA requires us to determine whether any species is endangered or threatened due to any of the following factors: the present or threatened destruction, modification, or curtailment of its habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; the inadequacy of existing regulatory mechanisms; or other natural or manmade factors affecting its continued existence. Under section (4)(b)(1)(A), we are also required to make listing determinations based solely on the best scientific and commercial data available, after conducting a review of the species’ status and after taking into account efforts being made by any state or foreign nation to protect the species.

Status Reviews

Status reviews for the petitioned species addressed in this finding were conducted by a contractor for the NMFS Southeast Fisheries Science Center and are available at <http://www.nmfs.noaa.gov/pr/species/petition81.htm> or on the respective species pages found on the Office of

Protected Resources Web site (<http://www.nmfs.noaa.gov/pr/species/index.htm>). These status reviews compiled information on each species’ biology, ecology, life history, and threats from information contained in the petition, our files, a comprehensive literature search, and consultation with experts. The draft status review reports (Casselberry and Carlson 2015 a–g) were submitted to independent peer reviewers and comments and information received from peer reviewers were addressed and incorporated as appropriate before finalizing the draft report. The peer review report is available at http://www.cio.noaa.gov/services_programs/prplans/PRsummaries.html. These status reviews did not include extinction risk analyses for the species; thus, the extinction risk analyses for the seven species are included in this 12-month finding. In addition to the status review reports, we considered information submitted by the public in response to our petition finding as well as information we compiled to assess the extinction risk of the species to make our determinations.

Extinction Risk Analyses

We considered the best available information and applied professional judgment in evaluating the level of risk faced by each of the seven species. For each extinction risk analysis, we evaluated the species’ demographic risks (*demographic risk analysis*), such as low abundance and productivity, and threats to the species including those related to the factors specified by the ESA section 4(a)(1)(A)–(E) (*threats assessment*), and then synthesized this information to estimate the extinction risk of the species (*risk of extinction*).

The demographic risk analysis, mentioned above, is an assessment of the manifestation of past threats that have contributed to the species’ current status and informs the consideration of the biological response of the species to present and future threats. For this analysis, we considered the demographic viability factors developed by McElhany *et al.* (2000). The approach of considering demographic risk factors to help frame the consideration of extinction risk has been used in many of our status reviews, including for Pacific salmonids, Pacific hake, walleye pollock, Pacific cod, Puget Sound rockfishes, Pacific herring, scalloped and great hammerhead sharks, and black abalone (see <http://www.nmfs.noaa.gov/pr/species/> for links to these reviews). In this approach, the collective condition of individual populations is considered at the species

level according to four demographic viability factors: Abundance, growth rate/productivity, spatial structure/connectivity, and diversity. These viability factors reflect concepts that are well-founded in conservation biology and that individually and collectively provide strong indicators of extinction risk.

In conducting the threats assessment, we identified and summarized the section 4(a)(1) factors that are currently operating on the species and their likely impact on the biological status of the species. We also looked for future threats (where the impact on the species has yet to be manifested) and considered the reliability to which we could forecast the effects of these threats and future events on the status of these species.

Using the findings from the demographic risk analysis and threats assessment, we evaluated the overall extinction risk of the species. Because species-specific information (such as current abundance) is sparse, qualitative “reference levels” of risk were used to describe extinction risk. The definitions of the qualitative “reference levels” of extinction risk were as follows: “Low Risk”—a species is at a low risk of extinction if it exhibits a trajectory indicating that it is unlikely to be at a moderate level of extinction risk in the foreseeable future (see description of “Moderate Risk” below). A species may be at low risk of extinction due to its present demographics (*i.e.*, stable or increasing trends in abundance/population growth, spatial structure and connectivity, and/or diversity) with projected threats likely to have insignificant impacts on these demographic trends; “Moderate Risk”—a species is at moderate risk of extinction if it exhibits a trajectory indicating that it will more likely than not be at a high level of extinction risk in the foreseeable future (see description of “High Risk” below). A species may be at moderate risk of extinction due to its present demographics (*i.e.*, declining trends in abundance/population growth, spatial structure and connectivity, and/or diversity and resilience) and/or projected threats and its likely response to those threats; “High Risk”—a species is at high risk of extinction when it is at or near a level of abundance, spatial structure and connectivity, and/or diversity that place its persistence in question. The demographics of the species may be strongly influenced by stochastic or compensatory processes. Similarly, a species may be at high risk of extinction if it faces clear and present threats (*e.g.*, confinement to a small geographic area; imminent destruction,

modification, or curtailment of its habitat; or disease epidemic) that are likely to create such imminent demographic risks.

Below we summarize information from the status review reports and information we compiled on the seven foreign marine elasmobranch species, analyze extinction risk of each species, assess protective efforts to determine if they are adequate to mitigate existing threats to each species, and propose determinations based on the status of each of the seven foreign marine elasmobranch species.

Daggernose Shark (*Isogomphodon oxyrinchus*)

Species Description

The daggernose shark (*Isogomphodon oxyrinchus*) is the only species in the genus *Isogomphodon*, in the family Carcharhinidae (Compagno 1988). It has a uniform gray or gray-brown color and white underside (Compagno 1984; Compagno 1988; Grace 2001), and is identified by its prominent, elongated snout. The pectoral fins of the species are very large and paddle-shaped (Compagno 1984; Compagno 1988; Grace 2001).

Range and Habitat Use

The daggernose shark occurs in the central western Atlantic Ocean and Caribbean Sea and has been reported along the coasts of Venezuela, Trinidad, Guyana, Suriname, French Guiana, and northern Brazil (Lessa *et al.* 2006a). The 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 daggernose shark has one of the smallest ranges of any elasmobranch species (Lessa *et al.* 2000). It is a coastal species that is commonly found in estuaries and river mouths in tropical climates and is most abundant in these areas during the Amazonian summer (*i.e.*, the rainy season) (Compagno 1984; Compagno 1988; Lessa 1997; Lessa *et al.* 1999a; Lessa *et al.* 2006b; Grace 2001). These sharks are often found in association with mangrove coastlines, occur in highly turbid waters and in low lying and indented coastlines that can have tide changes that vary as much as 7 meters (m) (Martins-Juras *et al.* 1987; Lessa *et al.* 1999a). Daggernose sharks occur in water depths between 8 m and 40 m, temperatures ranging from 21.5 °C to 31.5 °C and salinities between 13.96 and 33.60 ppt (Lessa 1997; Lessa *et al.* 1999a, b). 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). Specific winter habitats of the daggernose shark are unknown.

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 rates of daggernose sharks are similar between males and females, with an estimated growth rate from birth to age 1 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). Thus, estimated ages at maturity are 5–6 years for males and 6–7 years for females. In terms of size, male daggernose sharks begin maturing between 90 cm and 110 cm total length (TL), with fully adult males observed at sizes larger than 119 cm TL in the field (Lessa *et al.* 1999a). According to von Bertalanffy growth parameters, size at maturity is 103 cm TL for males and about 115 cm TL for females (Lessa *et al.* 2000), although the smallest pregnant female recorded was 118 cm long (Lessa *et al.* 1999a). After maturity is reached, growth rates decrease to less than 10 cm/year (Lessa *et al.* 2000). Maximum age is estimated to be approximately 20 years based on converting the length of a 160 cm TL female with parameters from the von Bertalanffy growth equation, although the largest male caught was 144 cm TL, corresponding to an age of 13 years old, and the oldest aged individuals from vertebrae analyses were of a 7 year old male and a 12 year old female (Lessa *et al.* 2000).

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. A study by Lessa *et al.* (1999a) found that 70 percent of the pregnant females collected during the study 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 (Barthem 1985). The gestation period is approximately 12 months, with a protracted birthing period throughout the 6-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 also be postponed to compensate for climate variability and changing environmental conditions across years (Lessa *et al.* 1999a). Female fecundity is low, commonly ranging between 3 to 7 embryos per female, with the largest litter observed containing 7 embryos, and one report of a female with 8 embryos (Bigelow and Schroeder 1948; Barthem 1985; Lessa *et al.* 1999a). There is no significant relationship between female size and litter size in daggernose sharks (Lessa *et al.* 1999a).

Genetics and Population Structure

Studies examining the genetics of the species or information on its population structure could not be found.

Demography

Based on the above life history parameters, and following methods in Cortés (2002) for estimating survivorship, Casselberry and Carlson (2015a) estimated productivity (as intrinsic rate of population increase, “*r*”) at 0.004 year⁻¹ (median) within a range of –0.040–0.038 (5 percent and 95 percent percentiles) (Carlson unpublished). Median generation time was estimated at 10.6 years, the mean age of parents of offspring of a cohort (μ_1) was 10.7 years and the expected number of replacements (R_0) was 1.05. Lessa *et al.* (2010) estimated annual population growth to be $r = -0.048$ under natural mortality rates (of 0.28 using the Hoenig (1984) method and 0.378 using the Pauly (1980) method), and a generation time of 9 years. If fishing mortality rates were incorporated, the annual population growth was estimated to be $r = -0.074$, with a generation time of 8.4 years (Lessa *et al.* 2010). 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), which means this species generally has a low potential to recover from exploitation.

Historical and Current Distribution and Population Abundance

In Brazil, daggernose sharks were historically found in the states of Amapá, Pará, and Maranhão, and were first formally recorded in surveys from the 1960s in the state of Maranhão (Lessa 1986). In 1999, daggernose sharks were documented as occurring 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). However, in recent years, the absence of daggernose sharks in areas where they were previously common has been noted. For example, in the Bragança fish market in northern Brazil (State of Pará), daggernose sharks were once among the most common shark species sold in the market. However, a genetic analysis of shark carcasses collected from this fish market between 2005 and 2006 found no evidence of daggernose sharks being sold in the market (Rodrigues-Filho *et al.* 2009). Although the species' absence in fish markets could indicate obedience of Brazilian law, which prohibited the catch of daggernose sharks in 2004, it has been noted that these laws are poorly enforced and frequently ignored (see discussion of *Inadequacy of Existing Regulatory Mechanisms* below). Additionally, while daggernose sharks were once caught abundantly in Maranhão prior to 1992, they were notably absent in research surveys conducted from November 2006 to December 2007 (Almeida *et al.* 2011). Based on the species' life history parameters and rates of fishing mortality, population abundance was estimated to have declined by 18.4 percent per year for 10 years from the mid-1990s to mid-2000, resulting in a total population decline of over 90 percent (Santana and Lessa 2002; Rosa and Lima 2005; Kyne *et al.* 2012).

Very little information is available on the distribution and abundance of the daggernose shark outside of Brazil. While undated catch records exist across the entire coastline of French Guiana, records are scarce throughout Suriname, Guyana, and Trinidad and Tobago (Bigelow and Schroeder 1948; Springer 1950; Compagno 1988; Global Biodiversity Information Facility (GBIF) 2013). Additionally, although Lessa *et al.* (1999a) includes Venezuela as part of the daggernose shark range (citing Cervigón 1968), no other information could be found regarding the present existence of the daggernose shark in Venezuela. Given the species' sensitive biological traits to exploitation and evidence of high artisanal fishing

pressure, it is assumed that dramatic population declines have occurred in the last decade throughout this part of the species' range, similar to the levels documented in Brazil, but scientific data on population trends are severely lacking for this region (Kyne *et al.* 2012).

Summary of Factors Affecting the Daggernose Shark

We reviewed the best available information regarding historical, current, and potential threats to the daggernose shark species. We find that the main threat to this species is overutilization for commercial purposes. We consider the severity of this threat to be exacerbated by the species' natural biological vulnerability to overexploitation, which has led to significant declines in abundance and subsequent extirpations from areas where the species was once commonly found. We find current regulatory measures inadequate to protect the species from further overutilization. Hence, we identify these factors as additional threats contributing to the species' risk of extinction. We summarize information regarding these threats and their interactions below according to the factors specified in section 4(a)(1) of the ESA. Available information does not indicate that habitat destruction or modification, disease, predation or other natural or manmade factors are operative threats on these species; therefore, we do not discuss these factors further in this finding. See Casselbury and Carlson (2015a) for discussion of these ESA section 4(a)(1) threat categories.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Based on historical catch data and trends, the primary threat to daggernose sharks is overutilization in artisanal fisheries. Given its rather shallow depth distribution, in Brazil, the species is bycaught in the artisanal gillnet fisheries for Spanish mackerel (*Scomberomorus brasiliensis*) and king weakfish (*Cynoscion acoupa*), which operate inside or near estuary mouths. Historically, the species was caught in large numbers along the northern Brazilian coastline and represented a significant component of the artisanal gillnet bycatch. For example, in the State of Pará, daggernose sharks represented close to 70 percent of the artisanal catch in the 1980s during the Amazonian summer (Lessa *et al.* 2010). Farther south, off the Maranhão coast, harvest of daggernose sharks would begin in October and peak in January, with the catch per unit effort (CPUE) of

these sharks in gillnets ranging from 6.04 kilogram (kg)/km/hour up to 71 kg/km/hour (during the peak in the rainy season) in the early 1990s. However, due to the species' sensitive life history traits, this high level of fishing mortality was found to be unsustainable, causing the daggernose shark population to decrease by 18.4 percent per year in the 1990s. By 1999, the percentage of daggernose sharks in the artisanal gillnet bycatch along the Brazilian coast had significantly decreased, with daggernose sharks comprising only around 7–10 percent of the elasmobranch incidental catch (Lessa *et al.* 1999b; Lessa *et al.* 2000). By 2004 and 2006 the species was no longer observed or recorded in the states of Pará (Lessa *et al.* 2010) or Maranhão (Almeida *et al.* 2011), respectively, based on data from research surveys conducted in these regions.

Artisanal fisheries operating off Brazil continue to exert significant fishing pressure on the daggernose shark, which is likely contributing to fishing mortality rates that historically resulted in the substantial decline of the species. As such, overutilization continues to be a threat to the species as these fisheries are still highly active throughout its range. In fact, in the North region of Brazil (which includes the States of Amapá and Pará), the artisanal sector accounts for more than 80 percent of the total landings from this region and represents around 40 percent of the total artisanal landings for the entire country. These fisheries tend to be concentrated in areas where the daggernose shark would most likely occur, including the Amazon River estuary, small estuaries and bays, and shallow coastal waters within the extensive mangrove area that covers the northern coast of Brazil (Vasconcello *et al.* 2011). In the Northwest region of Brazil (which includes the States of Maranhão south to Bahia), the artisanal sector is also the dominant fishing sector, accounting for more than 60 percent of the total landings from this region. The king weakfish fishery, which was noted as one of the main artisanal gillnet fisheries responsible for bycatching daggernose sharks, remains one of the most important fisheries in Brazil as evidenced by the fact that the species was the 4th most landed marine fish in terms of volume in 2011 (21,074.2 t; Ministério da Pesca e Aquicultura (MPA) 2011). Together, the artisanal landings from these regions represent over 80 percent of the total artisanal landings for the entire country (Ministério do Meio Ambiente/Instituto Brasileiro do Meio Ambiente e dos

Recursos Naturais Renováveis (MMA/IBAMA) 2007).

These artisanal fishing practices and effort levels, which caused declines in daggnose shark populations off Brazil, are likely similar in Venezuela, Trinidad and Tobago, Guyana, Suriname, and French Guiana (which comprises the other half of the species' range). These countries have a substantial artisanal fishing sector presence, with catches from artisanal fishing comprising up to 80 percent of the total fish landings. In French Guiana, sharks alone comprised 40.4 percent of the annual artisanal landings for the local market (Harper *et al.* 2015). However, as noted in the *Inadequacy of existing regulatory mechanisms* section, due to minimal controls of these artisanal fisheries, including lack of enforcement capabilities of existing regulations, the available data indicate that many of these country's coastal marine resources are fully to overexploited (Food and Agriculture Organization of the United Nations (FAO) 2005a, 2005b, 2006, 2008). In Trinidad and Tobago, for example, it is estimated that the artisanal fleet catches between 75 and 80 percent of the total landings from these islands (FAO 2006). Of concern, as it relates to overutilization of the daggnose shark, is the fact that Trinidad and Tobago have an open access fishery for the artisanal sector, which means there are no restrictions on the numbers and types of vessels, fishing gear, or trips (FAO 2006; Mohammed and Lindop 2015). In other words, any local vessel is allowed to enter the fishery and catch as much they can handle, with no restriction on fishing effort (FAO 2006). Similarly, Guyana also operates an open access fishery for its artisanal gillnet sector. Given that artisanal fishing for groundfish in Guyana, which comprises one of the country's two main fishing activities (the other being direct exploitation of shrimp by trawlers), is predominantly conducted using gillnets, open access fisheries cover a significant portion of the fishery sector for the country (FAO 2005a).

As noted above, this essentially unregulated artisanal fishing throughout the Atlantic Caribbean, employing unselective net gear and concentrated in inshore coastal waters where daggnose sharks would primarily occur, has led to the overexploitation of many marine species, including sharks. However, there is virtually no information available on daggnose shark catches from the Caribbean countries in the daggnose shark range. These countries report general shark landings to the FAO but, in addition to these catches

being significantly underestimated (on the order of 2.6 times for Trinidad and Tobago (Mohammed and Lindop 2015); 1.6 times for Guyana (Macdonald *et al.* 2015); 3.4 times for Suriname (Hornby *et al.* 2015); and 4 times for French Guiana (Harper *et al.* 2015)), daggnose sharks are not specifically identified in the catches (Shing 1999). However, historical and more recent information suggests daggnose sharks were and may still be utilized. Although the value of daggnose shark fins is low, its meat has been sold in markets from artisanal fisheries for decades (Lessa *et al.* 2006a), with Bigelow and Schroeder (1948) recording daggnose shark meat in markets in Trinidad and Tobago and noting its likelihood in markets in Guyana. Therefore, given the evidence of utilization of the species, as well as the significant fishing effort by artisanal fishing fleets throughout the daggnose shark range, including unregulated access to fishing grounds where the shark occurs, the observed absence of the daggnose shark in recent years can likely be attributed to overutilization of the species to the point where overutilization is significantly contributing to its risk of extinction.

Inadequacy of Existing Regulatory Mechanisms

Throughout the species' range, species-specific protection for daggnose sharks is only found in Brazil. In 2004, the daggnose shark was first listed in Annex I of Brazil's endangered species list: "Lista Nacional Oficial de Espécies da Fauna Ameaçadas de Extinção—Peixes e Invertebrados Aquáticos" (Silva 2004). An Annex I 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 (IBAMA) (Silva 2004). This protection was renewed in December 2014, when the daggnose 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 No 445). "Critically endangered" on this list is defined as a species that presents an extremely high risk of extinction in the wild in the near future due to profound environmental changes or high reduction in population, or significant decrease in the taxon's range. In addition to the landing prohibition, daggnose sharks also receive protection when they occur within two of Brazil's marine protected areas (MPAs): The Parque Nacional Cabo Orange and the Reentrâncias Maranhenses (Lessa *et al.* 1999b);

however, the last time they were reported in these areas was in 1999.

Although Brazil has a number of regulations in place to protect endangered or threatened species, like the ones described above for daggnose sharks, it is generally recognized that these regulations are poorly enforced, particularly within artisanal fisheries (Lessa *et al.* 1999b; Amaral and Jablonski 2005; Almeida *et al.* 2011; Rodrigues-Filho *et al.* 2012). Poverty, lack of education within the artisanal fisheries sector, and increased artisanal fishing effort, especially in the State of Maranhão, have already contributed to the decline of many elasmobranch populations, including the daggnose shark (Lessa *et al.* 1999b), despite the existence of protective legislation and marine protected areas. As such, effective conservation appears to be lacking in Brazil (Lessa *et al.* 1999b; Amaral and Jablonski 2005), with existing regulatory mechanisms likely inadequate to protect the daggnose shark from further fishery-related mortality.

In December 2014, the Brazilian Government's Chico Mendes Institute for Biodiversity Conservation approved an FAO National Plan of Action (NPOA) for the conservation of sharks (hereafter referred to as FAO NPOA-sharks) for Brazil (No. 125). The plan considers the daggnose 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 (Lessa *et al.* 2005). Additionally, it proposes the expansion of the Reentrâncias Maranhenses (where daggnose sharks were observed in 1999) to include the marine coastal zone and banks, providing additional protection to the sharks from potential fishery-related mortality. The plan recommends increased effort monitoring of vessels using nets in the area and increased education to encourage the release of live daggnose 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 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. It also calls 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. However, as stated above, the plan was only just approved as of December 2014, and will not be fully implemented for another 5 years. Even if the recommendations outlined in the plan are implemented in the future, it remains uncertain if they will be effective as the best available information suggests that current regulatory measures in Brazil to protect vulnerable species are poorly enforced, particularly within artisanal fisheries.

Outside of Brazil, there is limited information on shark fishing regulations or their adequacy for protecting daggnose sharks from overutilization. In Guyana and Trinidad and Tobago, gillnet fisheries are restricted to using nets of 900 ft or less with no more than a 15-foot depth; however, currently, there are no minimum size restrictions or catch quotas for sharks in either country (Shing 1999). As mentioned previously, both countries have open access fisheries (however, in Guyana the open access fishery only applies to the artisanal gillnet fishery) (FAO 2005a, 2006). In the late 1990s a fisheries management plan was drafted for Trinidad and Tobago, which prohibited the use of monofilament gillnets less than 4.75" stretch mesh and developed a licensing system (Shing 1999); however, no further details about the plan, including effectiveness or enforcement of these regulations, could be found. According to Casselberry and Carlson (2015a), in the summer of 2013, Guyana's Fisheries Department within the Ministry of Agriculture passed a 5-year Fisheries Management Plan for Guyana to run from 2013 to 2018, with one aspect of this plan meant to address shark fishing, but no further details could be found at this time. Enforcement of existing fishery regulations is also lacking due to insufficient resources, with minimal control over the fisheries resulting in increasing competition and conflicts among fishermen and between fishing fleets and, consequently, overfishing of marine resources (FAO 2005a, 2005b, 2006, 2008). No other pertinent information could be found on shark fishing regulations or their adequacy in controlling the exploitation of sharks, and more specifically daggnose sharks.

Extinction Risk

Although accurate and precise population abundance and trend data for the daggnose shark are lacking, best available information provides multiple lines of evidence indicating that this species currently faces a high risk of extinction. Below, we present the demographic risk analysis, threats assessment, and overall risk of extinction for the daggnose shark.

Demographic Risk Analysis

Abundance

There is a significant lack of abundance information for *I. oxyrinchus* throughout its range. In northern Brazil, the relatively recent (2004–2009) absence of the species in fish markets where they were once abundantly sold, in addition to their absence in fishery-independent research surveys in areas where they were commonly caught prior to 1992, suggests the species has suffered significant declines in population abundance. Based on the daggnose shark's life history parameters and rates of fishing mortality, the population abundance in northern Brazil is estimated to have declined by 18.4 percent per year from the mid-1990s to mid-2000, resulting in a total population decline of at least 90 percent in approximately half of the species' known range. Although abundance information from the other parts of the species' range, including off Venezuela, Trinidad, Guyana, Suriname and French Guiana, is presently unavailable, it is thought that these populations have suffered similar declines based on the species' biological vulnerability and susceptibility to artisanal fisheries operating in these areas. Given the continued artisanal fishing pressure throughout the species' range, coupled with the species' present rarity and its potential extirpation in areas where it was previously abundant, it is likely that the species is still in decline, with current abundance trends and levels contributing significantly to its risk of extinction.

Growth Rate/Productivity

The daggnose shark has extremely low productivity. Litter sizes range from 2–8 pups, with a 1-year gestation period and a year of resting between pregnancies. In other words, annual fecundity averages only 1–4 pups because of the species' biennial reproductive periodicity. Using these life history parameters, Casselberry and Carlson (2015a) estimated a productivity (as the intrinsic rate of population increase) of $r = 0.004 \text{ year}^{-1}$ (median)

within a range of -0.040 – 0.038 (Carlson unpublished). Under natural mortality rates, Lessa *et al.* (2010) estimated annual population growth to be negative, with an $r = -0.048$ and a generation time of 9 years. When fishing mortality was considered, the estimate of r decreased even further, to -0.074 , with a generation time of 8.4 years. Considering the daggnose shark has already undergone substantial population declines, and is still susceptible to fishing mortality in the active artisanal fisheries throughout its range, the species' extremely low productivity (with estimates of negative annual population growth rates) is likely significantly contributing to its risk of extinction.

Spatial Structure/Connectivity

Very limited information is available regarding spatial structure and connectivity of the daggnose shark populations. The best available information suggests the daggnose shark has a very restricted range, one of the smallest of any elasmobranch species, and, as such, an increased vulnerability to extinction from environmental or anthropogenic perturbations. In addition, the substantial declines in the Brazilian population and subsequent absence of the species in areas it was previously known to occur, as well as its rarity throughout the rest of its range, suggest the species likely exists as patchy and small populations, which may limit connectivity. However, there is not enough information to identify critically important populations to the taxon as a whole, or determine whether the rates of dispersal among populations, metapopulations, or habitat patches are presently posing a risk of extinction.

Diversity

The loss of diversity can increase a species' extinction risk through decreasing a species' capability of responding to episodic or changing environmental conditions. This can occur through a significant change or loss of variation in life history characteristics (such as reproductive fitness and fecundity), morphology, behavior, or other genetic characteristics. Although it is unknown if *I. oxyrinchus* has experienced a loss of diversity, the significant decline estimated for the population in northern Brazil (comprising approximately half of its known range), as well as the likely small populations elsewhere throughout its range, suggest the species may be at an increased risk of random genetic drift and could experience the fixing of

recessive detrimental genes, reducing the overall fitness of the species.

Threats Assessment

The primary threat to the daggenose shark is overutilization in artisanal fisheries. In Brazil, the species is bycaught in the artisanal gillnet fisheries for Spanish mackerel and king weakfish. Historically, the species comprised up to around 70 percent of the artisanal catch during the Amazonian summer in the State of Pará, and was caught in large numbers by the artisanal gillnet fisheries operating on the Maranhão coast in Brazil. However, given the extremely low productivity of the species and vulnerability to depletion, this level of exploitation resulted in substantial declines (estimated at over 90 percent) to the point where the species is no longer found in fish markets or observed in trawl and research survey data. The artisanal gillnet fisheries that were responsible for this decline are still active throughout the species' range and likely exerting similar fishing pressure that historically resulted in the substantial decline of the daggenose shark populations. In fact, together, the artisanal landings from the North region of Brazil (which includes the States of Amapá and Pará) and Northwest region (which includes the States of Maranhão south to Bahia), the areas where daggenose sharks were once historically abundant, represent over 80 percent of the total artisanal landings for the entire country, indicating the importance and, hence, likely continuation of this type of fishing in these regions. Notably, the king weakfish fishery, which was reported as one of the two main artisanal gillnet fisheries responsible for bycatching daggenose sharks, remains one of the most important fisheries in Brazil.

Artisanal gillnet fisheries are also active in the other parts of the species' range, including Venezuela, Trinidad and Tobago, Guyana, Suriname, and French Guiana, with likely similar fishing practices. Although landings data from these countries are unknown, the available information suggests that artisanal fishing pressure is high and that the species has been taken in small numbers by local fishermen in these countries, with daggenose sharks historically sold in markets in Trinidad and likely Guyana. Given the species' susceptibility to depletion from even low levels of fishing mortality, it is highly likely that overutilization by artisanal fisheries operating throughout the species' range is a threat that is significantly contributing to its risk of extinction.

In 2004, the daggenose shark was listed on Brazil's endangered species list, and as of 2014, was classified as "critically endangered." Additionally, it is listed as one of 12 species of concern under Brazil's FAO NPOA-sharks. However, the implementation and effectiveness of the recommendations outlined in this plan remain uncertain, with the best available information indicating that current regulatory measures in Brazil to protect vulnerable species are poorly enforced, particularly in artisanal fisheries (the fishery sector that poses the biggest threat of overutilization of the species). In addition, there appears to be a lack of adequate fishing regulations to control the exploitation of the daggenose shark in the other parts of its range, and, as such, the inadequacy of existing regulatory measures is a threat that further contributes to the extinction risk of the species.

Risk of Extinction

Although there is significant uncertainty regarding the current abundance of the species, the species' population growth rate and productivity estimates indicate that the species has likely suffered significant population declines (of up to 90 percent) throughout its range and will continue to decrease without adequate protection from overutilization. The species' restricted coastal range, combined with its recent (2004–2009) absence in areas where it was once commonly found, as well as its present rarity throughout the rest of its range (with the last record of the species from 1999) indicate potential local extirpations and suggest an increased likelihood that the species is strongly influenced by stochastic or compensatory processes. This vulnerability is further exacerbated by the present threats of overutilization and inadequacy of existing regulatory measures that will significantly contribute to the decline of the existing populations (based on its demographic risks) to the future, compromising the species' long-term viability. Therefore, based on the best available information and the above analysis, we conclude that *I. oxyrinchus* is presently at a high risk of extinction throughout its range.

Protective Efforts

With the exception of the recommendations within Brazil's FAO NPOA-sharks (discussed above), we were unable to find any other information on protective efforts for the conservation of daggenose sharks in Brazil, Venezuela, Trinidad and Tobago, Guyana, Suriname, or French Guiana that would potentially alter the

extinction risk for the species. We seek additional information on other conservation efforts in our public comment process (see below).

Proposed Determination

Based on the best available scientific and commercial information as presented in the status review report and this finding, we find that the daggenose shark is presently in danger of extinction throughout its range. We assessed the ESA section 4(a)(1) factors and conclude that the species faces ongoing threats from overutilization and inadequacy of existing regulatory mechanisms throughout its range. The species' natural biological vulnerability to overexploitation and present demographic risks (e.g., low and declining abundance, negative population growth rates, small, fragmented and likely isolated populations, extremely restricted distribution, and very low productivity) are currently exacerbating the negative effects of the aforementioned threats, placing this species in danger of extinction. We also found no evidence of protective efforts for the conservation of daggenose shark that would reduce the level of extinction risk faced by the species. We therefore propose to list the daggenose shark as an endangered species.

Brazilian Guitarfish (*Rhinobatos horkelii*)

Species Description

The Brazilian guitarfish (*Rhinobatos horkelii*) is a member of the order Rajiformes and the family Rhinobatidae (Lessa and Vooren 2007). 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). The Brazilian guitarfish has long nostrils with transversely flat or a slightly convex crown and has a median row of tubercles (nodules) on its dorsal surface that are large and thorn-like (Lessa and Vooren 2005). The disc width is about 5/6 of the body length, with dorsal fins that are triangular and similar in size (Bigelow and Schroeder 1953). The dorsal side of the Brazilian guitarfish is olive grey or chocolate brown in color and lacks light or dark markings. Additionally, its snout has a "sooty" oval patch (Lessa and Vooren 2005).

Range and Habitat Use

The Brazilian guitarfish is found along the coast of South America in the southwestern Atlantic from Bahia, Brazil to Mar del Plata, Argentina (Figueiredo 1977; Lessa and Vooren 2005, 2007; GBIF 2013). 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 occur, 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 9 °C, while in the summer, individuals are found in average water temperatures of 26 °C (Lessa and Vooren 2005). Brazilian guitarfish are commonly found in salinities ranging from 24–28 ppt in northern Argentina (Jaureguizar *et al.* 2006).

Diet and Feeding

There is very little information on the diet or feeding behavior of Brazilian guitarfish. Refi (1973) recorded the stomach contents of six individuals caught in Mar del Plata, Argentina and found that stomachs contained the Patagonian octopus (*Octopus tuelchus*), shrimp (*Hymenopeneus muelleri*), decapods, isopods, and polychaetes. No other information on diet or feeding could be found.

Growth and Reproduction

Based on a yearly vertebral annulus formation in September, Vooren *et al.* (2005a; citing Lessa (1982)) report the von Bertalanffy growth rate (*k*) for Brazilian guitarfish to be 0.0194, with a theoretical maximum size of 135.5 cm TL and age at maturity between 7 and 9 years for females and 5 and 6 years for males. Similar results were estimated by Caltabellota (2014), with a theoretical maximum size of 121.71 cm TL and *k* = 0.21. No significant differences were found in growth between the sexes. Using two different methods, Caltabellota (2014) also estimated theoretical longevity of 18.24 and 14.17 years for females, and 13.86 and 10.90 years for males. Vooren *et al.* (2005a) found longevity to be longer for both females and males, with estimates of 28 years and 15 years, respectively.

Size at maturity for Brazilian guitarfish is between 90 cm and 120 cm TL for both sexes; the smallest pregnant females recorded were between 91–92 cm TL, and all captured females larger than 119 cm TL were pregnant (Lessa *et al.* 2005a; Lessa and Vooren 2005). The Brazilian guitarfish has an annual reproductive cycle, with lecithotrophic development (*i.e.*, larva depend on the egg's yolk reserve supplied by the mother), and a gestation period lasting approximately 11–12 months (Lessa *et al.* 2005a; Lessa and Vooren 2005). 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. Litter sizes range from 4–12 pups and increase with female size (Lessa and Vooren 2005).

Genetics and Population Structure

Studies examining the genetics of the species or information on its population structure could not be found.

Demography

Total natural mortality for Brazilian guitarfish was estimated by Caltabellota (2014) using an age at maturity of 5 years (*i.e.*, an earlier age of maturity than what was reported by Vooren *et al.* (2005a)), 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 percent each year, with a population doubling time of 7.41 years (Caltabellota 2014). In the presence of fishing mortality and an age at first capture of 2 years, the Brazilian guitarfish population would decline by 25 percent 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 percent each year (Caltabellota 2014). Based on the life history parameters discussed previously, these demographic parameters indicate that the Brazilian guitarfish generally has a low potential to recover from exploitation, particularly if the species is experiencing fishing pressure on neonates and juveniles.

Historical and Current Distribution and Population Abundance

The Brazilian guitarfish is distributed along the coast of South America, from Bahia, Brazil to Mar del Plata, Argentina. The species' center of distribution lies between 28° and 34° S. and also corresponds to the area where it is most abundant. This area is known as the Plataforma Sul, which includes the continental shelf of southern Brazil and extends from Cabo de Santa Marta Grande (28°36' S.) to Arroio Chuí (33°45' S.). In historical bottom trawl surveys between latitudes 28°00' S. and 34°30' S., *R. horkelii* was common across the Plataforma Sul south of latitude 29°40' S. (Vooren *et al.* 2005a). Annual catch of Brazilian guitarfish in this area was approximately 636 t–1803 t from 1975–1987 (Miranda and Vooren 2003). Research surveys conducted between Chuí and Solidão (Rio Grande do Sul, Brazil) in February 2005 found an average CPUE of 1.68 kg/hr (Vooren

et al. 2005b), but no follow-up surveys were conducted after 2005.

Throughout the rest of its range, there is little information on the abundance of *R. horkelii*, with the species considered to be a rare occurrence. In northern Argentina (34° S.–43° S.), estimated mean biomass of Brazilian guitarfish was 0.1240 t/nm² between 1981 and 1999, with *R. horkelii* comprising only 0.44 percent of the biomass of demersal fish on the northern Argentine continental shelf (Jaureguizar *et al.* 2006). In 1981, biomass of Brazilian guitarfish was calculated to be 0.010 t/nm² in 1981. Estimated biomass then peaked at 0.441 t/nm² in 1994 before falling steadily to 0.007 t/nm² in 1999 (Jaureguizar *et al.* 2006). Biomass estimates reported in Argentina's FAO NPOA-sharks for the coast of Buenos Aires province and Uruguay were 2,597 t in 1994, 661 t in 1998, and 91 t in 1999 (Argentina FAO NPOA-sharks 2009). Along the oceanic coast of Uruguay, *R. horkelii* occurs with low density, with annual catches around 3 t in 2000 and 2001 (Meneses 1999; Paesch and Sunday 2003).

Summary of Factors Affecting the Brazilian Guitarfish (*Rhinobatos horkelii*)

We reviewed the best available information regarding historical, current, and potential threats to the Brazilian guitarfish species. We find that the main threat to this species is overutilization for commercial purposes. We consider the severity of this threat to be exacerbated by the species' natural biological vulnerability to overexploitation, which has led to significant declines in abundance of all life stages, particularly neonates. We find current regulatory measures inadequate to protect the species from further overutilization. Hence, we identify these factors as additional threats contributing to the species' risk of extinction. We summarize information regarding these threats and their interactions below according to the factors specified in section 4(a)(1) of the ESA. Available information does not indicate that habitat destruction or curtailment, disease, predation or other natural or manmade factors are operative threats on these species; therefore, we do not discuss these factors further in this finding. See Casselbury and Carlson (2015b) for discussion of these ESA section 4(a)(1) threat categories.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Based on historical catch data and trends, the primary threat to Brazilian guitarfish is overutilization in industrial and artisanal fisheries. Before landings were prohibited in Brazil in 2004, the Brazilian guitarfish was considered to be the only economically important species of the order Rajiformes in southern Brazil, where they were fished and caught in otter trawls, pair trawls, shrimp trawls, beach seines, and bottom gillnets (Haimovici 1997; Mazzoleni and Schwingel 1999; Martins and Schwingel 2003; Lessa and Vooren 2005). Commercial catches of the Brazilian guitarfish primarily occurred between 28° S.–34° S. in Brazil, where the species is most heavily concentrated (Martins and Schwingel 2003; Lessa and Vooren 2005). The pair and simple trawl fleets, which operate on the inner continental shelf and outer shelf, respectively, were responsible for the majority of the commercial *R. horkelli* catch in the 1970s and 1980s (Vooren *et al.* 2005a). Based on historical data, CPUE for the pair trawling fleet was highest from December to March, when adults of the species would concentrate in coastal waters during the summer for birthing and reproduction purposes (making them, as well as their young, more susceptible to being caught in large numbers by the trawlers) (Miranda and Vooren 2003; Vooren *et al.* 2005a). In the winter (April to September), the simple trawl fleet saw an increase in CPUE as both juvenile and adult Brazilian guitarfish migrated to the outer shelf; however, as the species was able to spread out more on the outer shelf, the CPUE of the simple trawl fleet tended to be half of what the pair trawling fleet experienced (Miranda and Vooren 2003; Vooren *et al.* 2005a). Regardless, given the effort and complementary spatial and temporal operations of these fleets, the adult population of Brazilian guitarfish was under high fishing pressure year-round. Consequently, this level of exploitation led to significant decreases in the abundance of the species, as evidenced by the substantial declines in landings and CPUE from both of these fleets. From 1975 to 1986, Brazilian guitarfish were common in the landings of these two fleets that were operating from Rio Grande do Sul, averaging more than 100 t annually in the simple trawl fleet and more than 200 t annually in the pair trawl fleet (Klippel *et al.* 2005). The simple trawl fleet saw maximum landings of Brazilian guitarfish in the years 1976 (228 t) and 1984 (219 t) and

the pair trawl fleet landed a Brazilian industrial fishing record amount of 1,014 t of *R. horkelli* in 1984 (Klippel *et al.* 2005). However, both fleets saw a significant drop in landings and CPUE after 1986. After 1987, landings oscillated between 50 t and 200 t annually for the pair trawl fleet, and from 1991–2000, annual landings did not exceed 10 t for the single trawl fleet (Klippel *et al.* 2005). In terms of CPUE, the simple trawl fleet saw an 84 percent decline between 1975–1986 and 1993–1999, with CPUE decreasing from 0.55 t/trip (range: 0.41–0.94) to 0.09 t/trip (range: 0.04–0.15) for the respective time periods (Vooren *et al.* 2005a). Similarly, the pair trawl fleet CPUE decreased from 1.07 t/trip (range: 0.43–2.38) to 0.18 t/trip (range: 0.09–0.30), an 83 percent decline between the two time periods (Vooren *et al.* 2005a). Based on these landings and CPUE data, the Brazilian guitarfish population on the Plataforma Sul is thought to have collapsed after 1986, with the abundance of the species after 1993 estimated to be around 16 percent of its 1986 level (Vooren *et al.* 2005a).

From 2000 to 2002, increases in CPUE of *R. horkelli* were recorded off Santa Catarina, Brazil, in both pair trawls (from 0.11 t/trip in 2000 to 0.15 t/trip in 2002) and single trawls (from 0.63 t/trip in 2001 to 1.0 t/trip in 2002) (Martins and Schwingel 2003). However, these increases were assumed to be a reflection of changes in operational fishing strategy as opposed to an increase in guitarfish abundance (Martins and Schwingel 2003). In 2000, the single and pair trawl fleets operating out of Itajaí (Santa Catarina, Brazil) began fishing in depths of 100 m–200 m on the outer continental shelf and slope between 28° S.–30° S., which was previously unexplored fishing grounds by these trawl fleets (Martins and Schwingel 2003; Vooren *et al.* 2005a). These fleets subsequently caught large amounts of Brazilian guitarfish in the autumn and winter, of which the majority were juveniles (Vooren *et al.* 2005a; Klippel *et al.* 2005). In fact, based on a sample of landings data between 2002 and 2003, juveniles (<90 cm) comprised around 81 to 94 percent of the *R. horkelli* catch from the industrial trawl fleets, and 76 percent in the bottom gillnet fleet (Klippel *et al.* 2005). This increase in *R. horkelli* catch by the industrial fleets was attributed to their fishing in a previously unexplored outer shelf and slope habitat that likely constituted a haven for part of the Plataforma Sul population of Brazilian guitarfish (Martins and Schwingel 2003). Although it was determined that

these fleets were not specifically targeting *R. horkelli* (based on the fact that the species comprised only around 1–2.5 percent of the total catch in 2002 and 2003), decreases in the CPUE of *R. horkelli* between 2002 and 2003 suggest that the population was already being impacted by the increase in fishing pressure in this area (Vooren *et al.* 2005a). Specifically, the *R. horkelli* CPUE of these fleets declined from 663 kg/trip in 2002 to 456 kg/trip in 2003 (Vooren *et al.* 2005a), which equates to a decline of 31 percent and is concerning for a population that has already been fished to such low levels. In fact, in July 2010, the state of São Paulo, Brazil declared the stock of Brazilian guitarfish collapsed due to intense exploitation, with biomass and the stock's reproductive potential at such a level that severely comprises recovery.

In addition to the contribution of the industrial fisheries to the overutilization of the species, artisanal fisheries were also known for catching large quantities of the Brazilian guitarfish in beach seines and fixed nets (Miranda and Vooren 2003; Lessa and Vooren 2005). In fact, before the prohibition of the species, artisanal fisheries, combined with the industrial pair trawl fisheries, caught over 70 percent of the Brazilian guitarfish (Miranda and Vooren 2003). Because these artisanal fisheries operate on the inshore pupping grounds of the species, the guitarfish catch consists primarily of aggregations of pregnant females (around 98 percent of the catch) (Lessa and Vooren 2005). In the 1980s, annual artisanal catches of guitarfish wavered around 600 t–800 t but declined soon after (Lessa, 1982; Miranda and Vooren 2003). In 1992, artisanal landings were estimated at 330 t and by 1997, landings dropped to only 125 t, a decrease that was attributed to a reduction in catches specifically of *R. horkelli* (Miranda and Vooren 2003). Monitoring of 20 artisanal beach seine fishing operations in 2002/2003 documented only a single haul containing *R. horkelli*, and artisanal fishermen now report that catches of Brazilian guitarfish are rare (Vooren *et al.* 2005a). Due to this significant decline in abundance of the species, artisanal fishermen have shifted their focus to fishing for mullet (Vooren *et al.* 2005a). However, they still operate within the *R. horkelli* inshore pupping grounds on the Plataforma Sul, and, as such, the species remains susceptible to incidental capture in beach seines and fixed net fishing gear (Vooren *et al.* 2005a). Recent data also indicate that when Brazilian guitarfish are caught by

artisanal fishermen, the species is not usually released, despite its prohibited status (Vooren *et al.* 2005a; Vieira 2014). For example, from November 2013 to March 2014, Vieira (2014) monitored four artisanal fishing boat operations (off Rio Grande do Sul) that made 50 sets over 20 fishing trips in depths of 5 m to 21 m using primarily gillnets. The Brazilian guitarfish was the second most abundant species caught by gillnets, with 125 individuals captured, representing 17.5 percent of elasmobranch catch. Its frequency of occurrence per fishing trip was 40 percent. The author noted that all of the caught sharks (either as catch or bycatch) were sold, whereas out of all the caught rays, only *R. horkelli* was sold. Additionally, although the CPUE was estimated to be relatively low for the elasmobranchs in the study, given the area where these artisanal fisheries operate, the majority of the *R. horkelli* catch consisted of immature individuals and breeding adults (with observations of pregnant females initiating abortion on the boats) which likely compromises recruitment to the already at risk population (Vieira 2014).

The substantial abundance declines of *R. horkelli* on the Plataforma Sul due to overutilization by fisheries, as indicated by the commercial and artisanal fisheries data, is further confirmed by CPUE data from fishery-independent surveys of the region. On the Plataforma Sul, a number of research cruises dating back to 1972 have surveyed the area using bottom trawl gear (from depths of around 10 m to over 500 m). In an analysis of this time series set, Vooren *et al.* (2005a) note that between the periods of 1975–1986 and 1993–1999, CPUE of *R. horkelli* showed similar declines as those observed in the commercial CPUE over the same period. Based on the CPUE trends, abundance of *R. horkelli* on the Plataforma Sul in depths of 20 m–200 m is estimated to have decreased by about 85 percent between 1975 and 1999 (Vooren *et al.* 2005a).

Overall, based on the above commercial and artisanal fishing data, it is estimated that over the period of 1975–1986, around 100,000 mature *R. horkelli* females and 100,000 mature *R. horkelli* males were caught annually (Vooren *et al.* 2005a). The removal of these reproductively active adults from the population translated to a loss of around 600,000 newborns per year, or 6.7 million newborns over the course of the 11-year period of fishing, and led to recruitment overfishing of the species (Vooren *et al.* 2005a). As a result of this overutilization, abundance of the species on the Plataforma Sul

significantly declined, causing the stock to collapse after 1986.

Overutilization still remains a threat to the species as fishing by the industrial and artisanal fleets continues to occur at high efforts on the Plataforma Sul and especially within important nursery habitats for the species (Vooren *et al.* 2005a; Klippel *et al.* 2005; Vooren and Klippel 2005c). In 2007, the industrial fleets operating off southern Brazil, where *R. horkelli* is most concentrated, and specifically from the States of Parana, Santa Catarina, and Rio Grande do Sul (identified as Brazil's "South Region"), were responsible for landing around 54 percent (151,154 mt) of the total industrial fish catch for all of Brazil (277,364.5 mt). Within Brazil's South Region, the industrial fleet comprised 59.3 percent of the total fish landings from the region (255,080.5 mt). In 2011, the South Region's marine fish landings (not including aquaculture) amounted to 158,515.4 mt, representing 47 percent of the total fish production from that region and 28.6 percent of the national total of marine fish landings. In terms of artisanal fisheries, fishing pressure (and related mortality) on *R. horkelli* is likely high given that the mullet fishery, the target of artisanal fisheries operating within *R. horkelli* nursery habitats, is an important fishery in Brazil. According to Lemos *et al.* (2014), catches of mullets (*Mugil liza*) in Rio Grande do Sul and Santa Catarina between 1997 and 2010 were around 95 percent of the total catch from all other Brazilian states, Uruguay, and Argentina. In 2011, mullets were the 2nd most landed fish (in terms of volume) in the artisanal fisheries in Rio Grande do Sul (IBAMA/Centro de Pesquisa e Gestão dos Recursos Pesqueiros Lagunares e Estuarinos (CEPERG) 2012) and the 5th most landed marine fish species for all of Brazil, with landings totaling 18,045 t (MPA 2011), suggesting that this significant fishing effort by artisanal fisheries in the inshore pupping grounds of Brazilian guitarfish is unlikely to decrease in the foreseeable future. Additionally, the relatively recent expansion and operation of the Rio Grande do Sul and Itajai trawl fleets on the outer shelf and continued operation of the pair trawl fleet on the inner continental shelf suggest overutilization (in the form of bycatch mortality) is still a threat to the species. Areas that previously served as offshore refugia for the Plataforma Sul population from fishing pressure are no longer protected from exploitation, with both juveniles and adults susceptible to

fishery-related mortality over their entire habitat.

Inadequacy of Existing Regulatory Mechanisms

Like the daggernose shark, the Brazilian guitarfish was also listed on Brazil's endangered species list in 2004, and as of 2014, was classified as "critically endangered." In 2007, Lessa and Vooren noted that the 2004 prohibition on catching the species was gradually becoming more effectively enforced, but genetic studies indicate that enforcement was still relatively poor as recently as 2009. Of 267 guitarfish samples that were collected at ports throughout southeastern and southern Brazil between 2008 and 2009, 55.8 percent were genetically identified as Brazilian guitarfish (De-Franco *et al.* 2012). Of the 85 samples from boats operating off Santa Catarina, 100 percent of the guitarfish were Brazilian guitarfish (De-Franco *et al.* 2012). When the fishermen were asked about their landings during sample collection, many of them denied harvest of guitarfish, suggesting that fishermen are aware of the capture prohibition of Brazilian guitarfish (De-Franco *et al.* 2012). However, because fishermen commonly remove the head and gut of any guitarfish before arriving in port, distinguishing the Brazilian guitarfish from the other two guitarfish species in the area (*R. percellens* and *Zapteryx brevirostris*) is difficult, which, when coupled with the lack of adequate government inspections, may be encouraging fishermen to disregard the law for economic gain (De-Franco *et al.* 2012). Similarly, and most recently, a 2013 investigation by Sea Shepherd Brazil into the illegal trade of elasmobranchs by the São Paulo General Warehousing and Centers Company led to the seizure of 700 kg of illegal elasmobranch species by federal police. Included in the illegal haul were Brazilian guitarfish, again suggesting that poor enforcement of present regulations is likely contributing to the continued exploitation and, consequently, overutilization of the species.

Although the Brazilian guitarfish occurs in several MPAs within Brazilian waters, including APA de Cananéia-Iguape-Peruíbe (São Paulo; 234,000 hectares), PARNA do Superagui (Parana; 33,988 hectares), REBIO do Arvoredo (Santa Catarina; 17,600 hectares) and RESEX Marinha do Pirjubaé (Santa Catarina; 1,712 hectares) (Rosa and Lima 2005), these MPAs only protect the species from exploitation when they occur within these areas. In addition, the coverage of these MPAs compared to

the range of the species is very small and also located north of the center of distribution and concentration of the species and, therefore, unlikely to significantly decrease the threat of overutilization to the species.

Another regulation in place in Brazil to control the exploitation of marine resources is a prohibition on trawl fishing within three nautical miles (nm) from the coast of southern Brazil. This prohibition may help decrease fishery-related mortality of *R. horkelli* in the nearshore areas primarily used as nursery habitat by the species; however, according to Chiaramonte and Vooren (2007), enforcement of this prohibition has been noted as difficult. In addition, the species is still susceptible to being caught as bycatch in the legally permitted coastal gillnet fisheries (which also operate in nursery areas) and in the offshore trawl and gillnet fisheries and vulnerable to the associated bycatch mortality (Lessa and Vooren 2007). Therefore, the adequacy of the trawl prohibition in decreasing fishery-related mortality of *R. horkelli* to the point where the extinction risk of the species is significantly lowered is unclear.

Like the daggenose shark, the Brazilian guitarfish is one of Brazil's 12 species of concern identified in their FAO NPOA-sharks. The plan recommends a moratorium on fishing with a prohibition of sales until there is scientific evidence in support of recovery, and proposes a fishing exclusion area over a large region of the coast of Rio Grande do Sul at depths of 20 m to protect nursery areas (No 125, Lessa *et al.* 2005). As noted in the daggenose shark analysis above, this plan will not be fully implemented for another 5 years and it remains uncertain whether the recommendations will be implemented and effective, as the best available information suggests that current regulatory measures in Brazil to protect the Brazilian guitarfish are poorly enforced.

Similar to Brazil, Uruguay also lists the Brazilian guitarfish as a species of high priority in its FAO NPOA-sharks (Domingo *et al.* 2008). The plan sets short-term goals (12–18 months) to investigate distribution and habitat use and generate time-series of effort and catch; mid-term goals (24–30 months) to conduct an abundance assessment and determine maximum sustainable catch limits; and long term goals (36–48 months) to conduct age, growth, reproduction, and diet studies. In its plan, Uruguay made it a priority to: Review current fishing licenses that allow for the catch of Brazilian guitarfish and possibly modify them; no

longer grant new licenses that would allow for such fishing; forbid processing and marketing of the species; and promote safe release if possible. However, updated results from the goals and priorities of this plan could not be found. As such, their implementation and overall effectiveness at decreasing the threats to the species remains highly uncertain.

Extinction Risk

The best available information provides multiple lines of evidence indicating that the *R. horkelli* currently faces a high risk of extinction. Below, we present the demographic risk analysis, threats assessment, and overall risk of extinction for the Brazilian guitarfish.

Demographic Risk Analysis

Abundance

There is very limited information regarding abundance estimates for *R. horkelli* throughout its range. The majority of the Brazilian guitarfish population and center of distribution is concentrated between 28° S. and 34° S. in southern Brazil, and it is scarce elsewhere. On the northern Argentine continental shelf, between 34° S. and 43° S., which appears to be the southern extent of the species' range, mean biomass of *R. horkelli* has fluctuated over the years. In 1981, biomass was estimated to be 0.010 t/nm². Biomass peaked in 1994 at 0.441 t/nm² before falling to 0.007 t/nm² in 1999 (Jaureguizar *et al.* 2006). This represents a 98 percent decrease from peak biomass between 1994–1999, but only a decrease of around 30 percent from estimates in 1981. While mean abundance estimates from the presumed center of the species' distribution are not available, we can infer significant historical population declines from a variety of fishery effort, catch and landings data from this region. Based on both fishery-independent sampling and commercial fleet CPUE data from 1975–1986 and 1993–2002, the population of Brazilian guitarfish along the southern coast of Brazil has significantly decreased in size. Data from the single and pair trawl fleets operating on the Plataforma Sul indicate that CPUE declined by 61 percent and 74 percent, respectively, between the periods of 1975–1986 and 1993–2002 (Klippel *et al.* 2005). The population is assumed to have collapsed after 1986. Since 1993, the population is estimated to be about 16 percent of its 1986 level. Due to species identification issues, there is some level of uncertainty regarding the accuracy of the available data; however,

based on the best available information (including fisheries-independent survey data), it appears that the species has likely undergone significant declines throughout its range. Given the continued high fishing pressure in the species' nursery grounds and presence of the species in recent landings data despite its prohibited status, abundance has likely continued to decline.

Growth Rate/Productivity

Lessa and Vooren (2005) estimated the growth rate of *R. horkelli* as (k) = 0.194, and more recently, Caltabellota (2014) reported similar results, with an estimated k = 0.21 (with no significant difference in growth rates between sexes). The species is thought to reproduce annually, with a long gestation period (~1 year) and low fecundity (litter sizes range from 4 to 12 pups). Females have also been observed aborting embryos upon capture in fishing gear, further decreasing the reproductive output of the species. In addition, based on the data, it appears that both males and females of the species do not reach reproductive maturity until they have grown to approximately 74–89 percent of their maximum size. These reproductive characteristics suggest the species has relatively low productivity, similar to other elasmobranch species, which likely hinders its ability to quickly rebound from threats that decrease its abundance (such as overutilization).

Under natural mortality, Caltabellota (2014) estimated that the population would increase by 9 percent each year, doubling every 7.41 years. However, if individuals of the species are fished before reaching maturity (assumed to be 5 years), the Brazilian guitarfish population will decline by 25 percent every 2.73 years (Caltabellota 2014). Given the historical declines in CPUE and levels of neonate and juvenile landings, the species was likely subject to this exploitation scenario and subsequently experienced a negative population growth rate to the point where the population collapsed after 1986. With the continued fishing pressure by the mullet fisheries operating in the nursery habitats and the industrial fisheries on the Plataforma Sul, the available data on growth rate and productivity of the species indicates that current exploitation levels will likely continue to cause population declines in the species, with no information to suggest this trend is reversing.

Spatial Structure/Connectivity

The species is thought to have a continuous distribution along the

Plataforma Sul (where the species is most abundant) (Vooren *et al.* 2005a); however, there is no information on the connectivity among other *R. horkelii* populations throughout the rest of its range, including the importance of the Plataforma Sul population to the taxon as a whole. Based on the available data, there is not enough information to identify critical populations or determine whether the rates of dispersal among populations, metapopulations, or habitat patches are posing a risk of extinction to the species.

Diversity

The loss of diversity can increase a species' extinction risk through decreasing a species' capability of responding to episodic or changing environmental conditions. This can occur through a significant change or loss of variation in life history characteristics (such as reproductive fitness and fecundity), morphology, behavior, or other genetic characteristics. Although it is unknown if *R. horkelii* has experienced a loss of diversity, the significant reduction in population size on the Plataforma Sul, as well as the likely small populations elsewhere throughout its range, suggest the species may be at an increased risk of random genetic drift and could experience the fixing of recessive detrimental genes, reducing the overall fitness of the species.

Threats Assessment

Present threats to the species include overutilization by fisheries and inadequate regulatory mechanisms. The artisanal and industrial fisheries that historically contributed to the decline in *R. horkelii* are still active throughout the species' range and significantly contribute to national marine fish production. In fact, in Brazil in 2007, the industrial fleets were responsible for landing over half of the marine fish from the country's South Region, where *R. horkelii* is most concentrated, with artisanal fisheries responsible for 10 percent. The most recent statistics from 2011 show that marine fish landings from the South Region represent almost half of the fish production from that region and 28.6 percent of the Brazilian national total of marine fish landings. Because these artisanal and industrial fleets primarily operate in locations where *R. horkelii* would occur, and use rather unselective fishing gear, their operations are likely contributing significantly to the fishery-related mortality rates of the species and impacting the status of the species.

Although trawl fishing in Brazil is prohibited within 3 nm of the coast (<10

m depth), the shallow nursery areas, where neonates are found year-round and where adults are concentrated during the pupping and mating season, are still accessible to and heavily fished by artisanal fisheries using gillnets and beach seines. For example, in the mullet fishery, fishermen use beach seines to trap the mullets; however, due to the low selectivity of the fishing gear, these seines may also catch large numbers of juvenile and pregnant female guitarfish as evidenced by the historical data from beach seine operations on the coast of Rio Grande do Sul (Miranda and Vooren 2003; Lessa and Vooren 2005; Vooren *et al.* 2005a). The mullet fishery remains an important fishery in Brazil and in 2011, mullets were the 2nd most landed fish in the Rio Grande do Sul artisanal fisheries and the 5th most landed marine fish in all of Brazil. Additionally, the artisanal gillnet fisheries operating off Rio Grande do Sul are also known to bycatch and sell pregnant females, mature males, and juvenile Brazilian guitarfish, despite its prohibited status. Based on the modeled exploitation scenarios and resultant population growth rates described in the demographic analysis above, continued fishing pressure by both artisanal fisheries targeting mullet, as well as other gillnet fisheries, and subsequent fishery-related mortality of immature Brazilian guitarfish, is likely contributing to the significant decline of the species and is a threat that places the species at a high risk of extinction.

In addition to the threat from artisanal fishing operations, juveniles and adults of the species are also at risk of bycatch-related mortality by the industrial trawl and gillnet fleets operating off Rio Grande do Sul and Santa Catarina. These fleets focus trawling efforts on the inner and outer continental shelf (between 29° S. and 34° S.), essentially covering the entire seasonal adult migratory corridor. Of concern is the fact that the *R. horkelii* catch from these industrial fleets are predominantly juveniles, with estimates of juveniles comprising around 76 to 94 percent of the landings from these fleets. Again, based on the modeled exploitation scenarios, this level of juvenile catch is likely contributing to significant declines in the population. Additionally, the relatively recent expansion and operation of the Rio Grande do Sul and Itajaí trawl fleets into previously unexplored depths of 100 m–200 m on the outer shelf 28° S.–30° S., and the subsequent large catches of Brazilian guitarfish, also suggest that areas that previously served as offshore refugia for the Rio Grande do Sul

population from fishing pressure are no longer protected from exploitation.

In July 2010, the State of São Paulo, Brazil, declared the stock of Brazilian guitarfish collapsed due to intense exploitation. Despite the species' listing under Brazil's endangered species list since 2004, which effectively prohibits catching this species, *R. horkelii* continues to be brought into ports throughout southeastern and southern Brazil. In both Brazil and Uruguay, *R. horkelii* is considered a species of high priority under the country's respective FAO NPOA-sharks. However, the implementation and effectiveness of the recommendations outlined in these plans remain uncertain, with the best available information indicating that current regulatory measures to protect vulnerable species are poorly enforced, particularly within artisanal fisheries. Overall, the best available information suggests heavy exploitation of *R. horkelii*, particularly in the area where it was historically most abundant, and a significant lack of adequate regulatory mechanisms to protect the species from overutilization throughout its range.

Risk of Extinction

Although there is significant uncertainty regarding the current abundance of the species, the best available information indicates that the species has suffered significant historical population declines, with no indication that these trends have stabilized or reversed. Based on the species' demographic risks, without adequate protection, these severely depleted populations are likely to be strongly influenced by stochastic or compensatory processes. This vulnerability is further exacerbated by the present threats of overutilization and inadequacy of existing regulatory measures that continue to contribute to the decline of the existing populations, compromising the species' long-term viability. Therefore, based on the best available information and the above analysis, we conclude that the *R. horkelii* is presently at a high risk of extinction throughout its range.

Protective Efforts

With the exception of the recommendations within Brazil and Uruguay's FAO NPOA-sharks plans discussed above, we were unable to find any other information on protective efforts for the conservation of Brazilian guitarfish in Brazil, Uruguay, or Argentina that would potentially alter the extinction risk for the species. We seek additional information on other conservation efforts in our public comment process (see below).

Proposed Determination

Based on the best available scientific and commercial information as presented in the status review report and this finding, we find that the Brazilian guitarfish is presently in danger of extinction throughout its range. We assessed the ESA section 4(a)(1) factors and conclude that the species faces ongoing threats from overutilization and inadequacy of existing regulatory mechanisms throughout its range. The species' natural biological vulnerability to overexploitation and present demographic risks (e.g., low and declining abundance, negative population growth rates, and likely small and/or isolated populations at an increased risk of random genetic drift) are currently exacerbating the negative effects of the aforementioned threats, placing this species in danger of extinction. We also found no evidence of protective efforts for the conservation of Brazilian guitarfish that would reduce the level of extinction risk faced by the species. We therefore propose to list the Brazilian guitarfish as an endangered species.

Smoothhound Sharks

Smoothhound sharks are members of the family Triakidae and genus *Mustelus*. The *Mustelus* species are often difficult to distinguish due to their conserved morphology and highly variable intraspecific meristic characteristics. This problem is compounded in the southwestern Atlantic, with very few specimens, particularly of larger individuals, leading to a lack of comparative ontogenetic observations that can be used for species diagnosis (Rosa and Gadig 2010). To date, there are at least five species of the genus *Mustelus* that occur with overlapping ranges in the southwestern Atlantic: *M. canis*, *M. higmani*, *M. norrisi*, *M. fasciatus* and *M. schmitti* (Rosa and Gadig 2010). Two of these species, *M. fasciatus* and *M. schmitti*, are elasmobranchs that are being considered for listing in this finding.

Striped Smoothhound Shark (*Mustelus fasciatus*)

Species Description

The striped smoothhound is one of the most distinctive *Mustelus* species. Its head is large, with very small eyes and a sharply pointed snout (Compagno 1984; Rosa and Gadig 2010). Labial folds are present, and are longer on the upper jaw than on the lower jaw (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 2005b; 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 2005b). 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). 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). 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). Overall, 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

The striped smoothhound is a demersal shark species, found at depths between 1 m and 250 m along the continental shelf and slope of the Southwestern Atlantic in Brazil, Uruguay, and Argentina (Soto 2001). The species has a very restricted coastal distribution, ranging from Santa Catarina in southern Brazil to Bahía Blanca in Buenos Aires Province, Argentina, which covers about 1,500 km of coastline (Lopez Cazorla and Menni 1983; Vooren and Klippel 2005b; Lorenz *et al.* 2010). During the winter, adult biomass is concentrated on the Plataforma Sul between Rio Grande and Chuí off Rio Grande do Sul, Brazil (Vooren 1997; Vooren and Klippel 2005b). During the summer, a portion of the population migrates from Brazil to Uruguay and Argentine waters, while the rest of the population remains on the Plataforma Sul off Rio Grande do Sul as year-round residents (Vooren 1997; Vooren and Klippel 2005b). Outside of Brazil, the striped smoothhound occurs only occasionally, with sporadic observations from the Mar del Plata, Argentina, near the southern boundary of its range (Lopez Cazorla and Menni 1983).

Striped smoothhounds display clear ontogenetic (*i.e.*, life-stage based) depth distributions. In Rio Grande do Sul, neonates are common in inshore areas between Cassino Beach and Chuí in depths less than 20 m, with the greatest frequencies between 2 m–5 m depth from November to January (summer months; Vooren and Klippel 2005b). As such, these shallow areas likely function as important nursery areas for the species (Vasconcellos and Vooren 1991; Soto 2001; Vooren and Klippel 2005b). Adults are found mainly in water depths between 50 m–100 m in autumn and winter but move to shallower depths (≤ 50 m) in spring and summer (Vooren and Klippel 2005b). In the summer, males are much more common at depths between 20 m and 50 m, and are only rarely caught in waters less than 20 m deep, whereas females can be found in waters less than 20 m deep as they move into coastal waters for pupping during the summer months (Vooren and Klippel 2005b). Striped smoothhound are generally found in cooler water temperatures (11 °C–15 °C for juveniles during winter months, and >16 °C for adults; Vooren and Klippel 2005b) and prefer water salinities between 33.3 ppt and 33.6 ppt (Lopez Cazorla and Menni 1983).

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 percent of the diet, while fishes and mollusks were present in lower numbers (11.8 percent and 5.9 percent, respectively). Box crabs (*Heptus pudibundus*) were the most prevalent crustacean, occurring in 52.9 percent of the stomachs examined (Soto 2001).

Growth and Reproduction

There is scant information on striped smoothhound life history. Age and growth studies are not available and conflicting data exist for sizes at birth and maturity in Rio Grande do Sul. For example, one study reported that size at birth is between 39 cm and 43 cm TL, and that sexual maturity is reached at 130 cm and 135 cm TL for males and females, respectively (Vasconcellos and Vooren 1991). More recent studies report smaller sizes, with birth estimated between 35 cm and 38 cm TL and size at maturity estimated at 119 cm TL for males and 121 cm TL for females (Soto 2011; Vooren and Klippel 2005b). The smaller size at maturity seen in the more recent studies could be a

compensatory response to the high levels of fishing mortality the species has experienced since the early 1980s (see *Overutilization for Commercial, Recreational, Scientific or Educational Purposes* section). The maximum observed sizes for striped smoothhound are 162 cm TL (17.5 kg) for males and 177 cm TL (29.7 kg) for females (Lorenz *et al.* 2010).

Striped smoothhound have placental viviparous reproduction (Vooren 1997) and a gestation period that lasts between 11 and 12 months (Soto 2001; Lorenz *et al.* 2010). 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 (2005b) report that pupping takes place from November to January, but Soto (2001) reports that it occurs earlier, from September to November. Striped smoothhounds have 4–14 pups per litter, with an average of 8 pups (Vasconcellos and Vooren 1991). Newborns are seen in high frequency in November, along with females with mature follicles 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 2005b; Lorenz *et al.* 2010). 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).

Genetics and Population Structure

Studies examining the genetics of the species or information on its population structure could not be found.

Demography

The striped smoothhound is generally thought to have low fecundity, with a long gestation time (~1 year), and an average of only eight pups (range = 4–14 pups). Information regarding natural mortality rates or the intrinsic rate of population increase (r) of the striped smoothhound is unavailable; however, based on the life history parameters described previously, the species likely has low productivity, which may hinder its ability to recover from exploitation.

Historical and Current Distribution and Population Abundance

The striped smoothhound is distributed from Santa Catarina in southern Brazil to the Bahía Blanca in Buenos Aires Province, Argentina. While striped smoothhound were once considered a dominant permanent resident in Rio Grande do Sul in the

early 1970s and 1980s, and displayed predictable abundance changes throughout the year (Vooren 1997), they are now considered sporadic in this area and rare in the northern and southern portions of their range (Soto 2001). Prior to fisheries exploitation, it is thought that the striped smoothhound had naturally low abundance based on their relatively low frequency of occurrence in fishery research surveys (Vooren and Klippel 2005b). For example, in research trawl surveys on the Plataforma Sul, conducted from 1972–2005 with over 1,500 hauls, striped smoothhound occurred at a frequency of only 10 percent in the trawl hauls from the 10 m–100 m depth range (Vooren and Klippel 2005b) and comprised only 2 to 4 percent of the total elasmobranch CPUE for the period of 1980–1984. Despite this low frequency of occurrence, Vooren and Klippel (2005b) note that neonates of the species were relatively abundant in the 1980s in the summer and commonly observed along the 10,688 km of the Rio Grande do Sul coastline. In fact, for the period of 1981–1985, estimated CPUE from artisanal fisheries operating off Rio Grande do Sul ranged from 1.9 individuals/haul for beach seines to 18.5 individuals/haul for gillnet fishing gear. In research trawl surveys conducted in shallow waters of 10 m–20 m depths in 1981 and 1982, juvenile *M. fasciatus* occurred at a frequency of 54–86 percent in trawl hauls with a CPUE of 2.55–3.95 kg/hour. However, in follow-up surveys conducted nearly two decades later, juveniles and neonates were mostly absent from hauls, despite significant sampling in habitats where they had been known to occur. In 2005, neonates were noted as abundant along only 395 km of the Rio Grande do Sul coastline, corresponding to an estimated 95 percent decline in occupied area by neonates between 1981 and 2005 (Vooren and Klippel 2005b).

In Uruguay and Argentina, current catches by fishermen are infrequent. Additionally, trawl surveys conducted along the coastal region of the Bonaerensean (Buenos Aires) District of northern Argentina and Uruguay indicate a 96 percent decline in biomass of the species between 1994 and 1999 (Hozbor *et al.* 2004). Striped smoothhounds were also absent from Argentine research surveys conducted in the 1990s and are currently rarely caught by the commercial fleet, suggesting that the Argentine sea represents the periphery of its distribution (Massa 2013).

Summary of Factors Affecting Striped Smoothhound (*Mustelus fasciatus*)

We reviewed the best available information regarding historical, current, and potential threats to the striped smoothhound species. We find that the main threat to this species is overutilization for commercial purposes. We consider the severity of this threat to be exacerbated by the species' natural biological vulnerability to overexploitation, which has led to significant declines in abundance of all life stages, particularly neonates. We find current regulatory measures inadequate to protect the species from further overutilization. Hence, we identify these factors as additional threats contributing to the species' risk of extinction. We summarize information regarding these threats and their interactions below according to the factors specified in section 4(a)(1) of the ESA. Available information does not indicate that habitat destruction, modification or curtailment, disease, predation or other natural or manmade factors are operative threats on these species; therefore, we do not discuss these factors further in this finding. See Casselbury and Carlson (2015c) for discussion of these ESA Section 4(a)(1) threat categories.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The greatest threat to striped smoothhound is overutilization in commercial fisheries, particularly by those fisheries operating on the Plataforma Sul off Rio Grande do Sul. The Plataforma Sul comprises approximately one-third of the species' geographic distribution and is the area where the species was historically most concentrated. In fact, striped smoothhound were commonly caught as bycatch in the 1970s and 1980s on the Plataforma Sul in Brazil, albeit in low numbers (Soto 2001; Vooren and Klippel 2005b). Estimates of CPUE of *M. fasciatus* on the shelf in the early 1980s varied between 2 kg/hr and 7 kg/hr (in areas of low density) and 8 kg/hr to 33 kg/hr (in areas where the species was more highly concentrated) (Vooren and Klippel 2005b). Although the presumed naturally low abundance of striped smoothhound prohibited a directed fishery from developing for this species on the Plataforma Sul, they were and continue to be caught as part of the multispecies smoothhound fisheries and as bycatch in fisheries for other species such as drums, flounders, and mullets (Haimovici and Mendonça 1996; Vooren and Klippel 2005b). Striped

smoothhounds have been reported in landings from the industrial pair and double-rig trawl fleets, bottom longline and gillnet fleets and artisanal fisheries (Mazzoleni and Schwingel 1999). When caught, large striped smoothhound weighing more than 4 kg are generally retained and those less than 4 kg are discarded (Haimovici and Maceira 1981), but the rate of discard mortality is unknown. However, as both industrial and artisanal fishing intensified on the Plataforma Sul in the 1980s and continued through the 1990s, with the heavy use of trawls, gillnets and beach seines within the habitat of the striped smoothhound shark, the rates of fishery-related mortality experienced by the species clearly led to dramatic declines in its abundance (Soto 2001; Hozbor *et al.* 2004).

The intense coastal commercial and artisanal fishing off Rio Grande do Sul that takes place in nearshore waters along the coast (see additional discussion of these fisheries in the Brazilian guitarfish assessment) has likely had, and continues to have, the greatest impact on the species. These coastal fisheries primarily use beach seines, gillnet and trawl gear in the nearshore locations where striped smoothhound neonates and juveniles are found year-round. This level of fishing effort exerts constant pressure on the species before it reaches maturity (Soto 2001; Vooren and Klippel 2005b), and consequently, affects the recruitment of juvenile sharks into the population (Vooren 1997). Significant declines in neonate and juvenile populations have already been observed. Between the areas of Chuí and Torres of Rio Grande do Sul, Brazil, for example, neonates were abundant in the summer in the 1980s, along the coast from depths of 2 m–20 m, representing an area of occupancy of about 10,688 km². According to Hozbor *et al.* (2004), gillnets set off beaches in this area would capture neonate striped smoothhound in large numbers (10–100 per set) in the 1980s; however, by 2003, this level of removal had led to substantial declines in the population, with striped smoothhound currently caught only sporadically and in much smaller numbers. Similarly, off of Cassino Beach (located close to the midpoint between Chuí and Torres) Vooren and Klippel (2005b) estimated that CPUE of neonate striped smoothhound decreased by up to 99 percent in the artisanal fisheries during this time period. Specifically, the CPUE of neonate striped smoothhound and frequency of its occurrence in the artisanal gillnet fishery sets went from

18.5 (individuals/set) and 75 percent, respectively, in 1981–1985 to 0.2 (individuals/set) and 13 percent in 2002–2003. In 2005, neonates remained common only in the inner edge of their former 10,688 km² occupied area, in depths between 2 m–5 m: An area of only 395 km². This significant reduction in occupied area translates to an estimated 95 decline in neonate production and is likely a result of the intense artisanal and industrial fishing pressure and overutilization of the species within this area. Trawl surveys conducted in the same area but in depths of 10 m–20 m showed a similar decline in the CPUE of juvenile striped smoothhounds, from 2.55 kg/hour in 1981 and 3.95 kg/hour in 1982 to 0.02 kg/hour in 2005, an estimated 99 percent decrease in abundance (Vooren and Klippel 2005b).

In addition to the coastal artisanal and industrial fisheries, the intense fishing by the Plataforma Sul trawl fisheries that operate between the coastal waters and inner continental shelf (see description of the pair trawl fleet in the Brazilian guitarfish assessment) also affected and continues to impact the reproductive capacity of the striped smoothhound population in southern Brazil. These trawl fisheries, whose area of operation intersects with the spring migration of female *M. fasciatus*, incidentally catch both pregnant females and adult male striped smoothhounds on the inner shelf (Haimovici and Mendonça 1996; Vooren and Klippel 2005b). As such, all life-stages of the species as well as both sexes are subject to constant fishing pressure year-round, which Vooren and Klippel (2005b) point to as the primary cause for the significant decline and present rarity of the resident striped smooth population on the Plataforma Sul. As discussed in the Brazilian guitarfish assessment, fishing by the industrial and artisanal fleets continues to occur at high efforts on the Plataforma Sul and especially within the important coastal nursery and inner shelf habitats for the species (which overlap with *R. horkelli*). In fact, total marine fish landings from Rio Grande do Sul (where striped smoothhound are most concentrated on the Plataforma Sul) have increased substantially in recent years, from 23,594 t in 2007 to 34,385 t in 2011 (an increase of 46 percent over 4 years) (MMA/IBAMA 2007; IBAMA/CEPERG 2012). Out of the 27 Brazilian States, Rio Grande do Sul reports the 6th highest level of marine fish landings and Santa Catarina (which represents the northern periphery of the species' range in Brazil) reports the

highest level of marine fish landings (121,960 t in 2011) (IBAMA/CEPERG 2012). Based on the trends in the available fishing data, it is unlikely that the industrial and artisanal fishing on the Plataforma Sul, and particularly off the coast of Rio Grande do Sul within striped smoothhound habitat, will decrease in the foreseeable future, indicating that overutilization (in the form of bycatch mortality) is still a threat to the species.

Outside of Brazil, off Uruguay and Argentina, striped smoothhound are caught sporadically as bycatch in gillnets, bottom longlines, and trawls in fisheries targeting Brazilian flathead (*Percophis brasiliensis*), Argentinian sandperch (*Pseudoperca semifasciata*), apron rays (*Discopyge tschudii*), striped weakfish (*Cynoscion guatucupa*) and whitemouth croaker (*Micropogonias furnieri*) (Chiaramonte 1998; Lasta *et al.* 1998; Domingo *et al.* 2008). Bycatch levels and the associated fishery-related mortality of striped smoothhound in these fisheries have resulted in marked declines in the population, with trawl surveys conducted in the coastal region of the Bonaerensean District of northern Argentina and Uruguay indicating a 96 percent decline in the biomass of striped smoothhound between 1994 and 1999 (Hozbor *et al.* 2004). In the early 2000s, annual landings of smoothhounds (primarily *M. schmitti*, but also *M. fasciatus* and *M. canis*) in Uruguay increased dramatically, from fewer than 350 t in the 1990s to a peak of 1,300 t in 2000 and remained above 1,000 t through 2005; however, the cause for this reported increase in landings is unknown and, since 2000, landings have progressively declined (Domingo *et al.* 2008). In Uruguay's latest 2013 Fishery Statistics Bulletin, there were no reported landings of *M. fasciatus* (Dirección Nacional de Recursos Acuáticos (DINARA) 2014). Similarly, in Argentina, striped smoothhounds are also currently a rare occurrence (Casselberry and Carlson 2015c).

Inadequacy of Existing Regulatory Mechanisms

Like the daggernose shark and Brazilian guitarfish, the striped smoothhound is also listed as critically endangered under Annex I of Brazil's endangered species list. Aside from authorized conservation research purposes, the capture, transport, storage, and handling of striped smoothhounds is prohibited. There is also a prohibition of trawl fishing within three nautical miles of the coast of southern Brazil, although the enforcement of this prohibition has been noted as difficult

(Chiaramonte and Vooren 2007). In addition, the species is still susceptible to being caught as bycatch in the legally permitted coastal gillnet fisheries and offshore trawl and gillnet fisheries and vulnerable to the associated bycatch mortality (Lessa and Vooren 2007). While the striped smoothhound is not listed as one of the 12 species of concern under Brazil's FAO NPOA-sharks, the plan does call for a fishing exclusion area over a large region of the coast of Rio Grande do Sul at depths of 20 m to protect nursery areas (which would include the striped smoothhound nursery habitat) (Lessa *et al.* 2005). The plan also proposes a fishing closure between 32° S. and 34° S., where adults of the species now seem to be found in greatest abundance (Vooren and Klippel 2005b). However, as mentioned previously, the plan was only just approved as of December 2014, and will not be fully implemented for another 5 years. Thus, the implementation and effectiveness of the recommendations outlined in the plan remain uncertain, with the best available information indicating that current regulatory measures in Brazil to protect vulnerable species are poorly enforced.

In contrast to Brazil, Uruguay's FAO NPOA-sharks does list the striped smoothhound as a species of high priority (Domingo *et al.* 2008), and, as stated previously, has set goals to collect the necessary information on its priority species in order to conduct abundance assessments, review current fishing licenses, and promote public awareness to release captured individuals. However, no updated results from the goals and priorities of this plan could be found. As such, their implementation and overall effectiveness at decreasing the threats to the striped smoothhound remains highly uncertain. Additionally, in 2013, the National Directorate of Aquatic Resources (DINARA), the state agency responsible for regulating and controlling fishing and aquaculture in Uruguay, passed a resolution authorizing fishing with gillnets and longlines in the Río de la Plata and Atlantic Ocean at a distance less than 300 m from the coast, between March 1 and October 31 of each year. This type of fishing was previously prohibited in 2008; however, due to concerns brought forth by the artisanal fishermen, primarily of the socio-economic nature, DINARA revised the prohibition to allow for this seasonal fishing (Resolution No. 24/04/2013 MGAP). Although this seasonal restriction should provide some protection for the population of migrating pupping females (which moves inshore to pup

primarily from October to December), it does little to decrease fisheries-related mortality of young striped smoothhounds which remain in these coastal waters following birth. In other words, given that the depth distribution of *M. fasciatus* extends from shallow coastal waters out to 100 m depths, and fishery records from Uruguay show that the species is primarily bycaught in the artisanal longline and gillnet fisheries (Domingo *et al.* 2008), this new resolution is unlikely to adequately decrease the threat of overutilization to striped smoothhounds.

Extinction Risk

The best available information provides multiple lines of evidence indicating that the *M. fasciatus* currently faces a high risk of extinction. Below, we present the demographic risk analysis, threats assessment, and overall risk of extinction for the striped smoothhound shark.

Demographic Risk Analysis

Abundance

While there are no quantitative abundance estimates available for *M. fasciatus*, qualitative information and historical catch data can provide some insight into the current abundance of the species. Based on data from research trawl surveys, it is thought that the striped smoothhound naturally occurred at low abundance before they were exploited in fisheries (Vooren and Klippel 2005b), and were once considered a dominant permanent resident species on the Plataforma Sul. However, presently, the species is rarely observed anywhere in its range and caught only sporadically. Historical data from artisanal gillnet and beach seine fisheries suggest neonate production on the Plataforma Sul has decreased by 95 percent since the 1980s. Additionally, research trawl survey data estimate a decline in juvenile striped smoothhounds in these coastal waters of around 99 percent over this same period. Considering adult female striped smoothhounds follow a spring migration into these same coastal areas for pupping purposes, and, thus, are also susceptible to these artisanal fisheries, the significant declines in neonate and juvenile abundance likely correspond to declines in the number of reproductively active females in the population as well, as overutilization of the species through the direct removal of young striped smoothhound shark recruits.

Although CPUE data are lacking from other parts of the species' range, with catches of striped smoothhound

characterized as sporadic and rare in Uruguay and Argentina, respectively, survey data suggest that the migratory population has also experienced similar declines. Based on trawl survey data collected from along the Bonaerensean District of northern Argentina and Uruguay, the population of striped smoothhounds suffered an estimated 96 percent decline in biomass between 1994 and 1999. No other information on abundance or trends was available from this portion of the species' range. However, considering the species was of naturally low abundance prior to exploitation, and fishing pressure has historically been high (particularly on neonates in nursery areas and juvenile and adults on the inner shelf, including on both the resident and migratory populations) with no indications that this pressure has ceased, it is likely that the species has continued to suffer declines throughout its range.

Growth Rate/Productivity

Very little information is known about the life history of *M. fasciatus*. Age and growth studies are unavailable for the species, and there is conflicting information reported from the literature regarding the species' size at birth and size at maturity from Rio Grande do Sul, Brazil. Estimates of size at maturity range from 119 to 130 cm TL for males and 121 to 135 cm TL for females, with the smaller and more recent size estimates a possible compensatory response to fishing mortality. Size at birth ranges from 35 to 48 cm TL. The species is generally thought to have low fecundity, with a long gestation time (~1 year) and an average of only 8 pups per litter. These reproductive characteristics suggest the species has relatively low productivity, similar to other elasmobranch species, which has likely hindered its ability to quickly rebound from threats that decrease its abundance (such as overutilization).

Spatial Structure/Connectivity

The striped smoothhound has a very restricted coastal range of only 1,500 km. On the Plataforma Sul off southern Brazil, there is thought to be a permanent, year-round resident population. Vooren and Klippel (2005b) note that the area occupied by this population represents one third of the species' total range, and that the conservation of this resident population is integral to the conservation of the taxon as a whole, indicating the relative importance of this population to the species' survival. However, there is also thought to be a migratory population that is present on the Plataforma Sul in the winter that returns to Uruguay and

Argentina in the summer concurrent with changes in water temperature. No information exists on the connectivity between the resident and winter migrant *M. fasciatus* populations found on the Plataforma Sul; however, based on the significant decline of the population off the Buenos Aires Province, it seems likely that the increased fishing pressure on the migratory population while they winter on the Plataforma Sul may be negatively impacting the populations found in other parts of the species' range.

Diversity

The loss of diversity can increase a species' extinction risk through decreasing a species' capability of responding to episodic or changing environmental conditions. This can occur through a significant change or loss of variation in life history characteristics (such as reproductive fitness and fecundity), morphology, behavior, or other genetic characteristics. Although it is unknown if *M. fasciatus* has experienced a loss of diversity, high fishing pressure on neonates and reproductively active adults in coastal waters has negatively affected recruitment rates of neonates into the population, resulting in a significant depletion of the resident population on the Plataforma Sul. This reduction of the important resident population in Brazil, combined with the likely small populations elsewhere throughout its range, suggest the species may be at an increased risk of random genetic drift and could experience the fixing of recessive detrimental genes, reducing the overall fitness of the species.

Threats Assessment

The primary threat to striped smoothhounds is overutilization in commercial fisheries. Although not targeted in any fisheries throughout its range, due to its presumed naturally low abundance, striped smoothhounds are caught as part of the multispecies smoothhound fisheries and as bycatch in fisheries for other species such as drums, flounders, and mullets. While adult striped smoothhounds were once commonly caught as bycatch in the 1970s and 1980s in Brazil, albeit in low numbers, they are now considered rare in commercial catches. Additionally, intensive fishing by gillnet and trawl fisheries in shallow coastal areas where juveniles and neonates occur results in constant fishing pressure on the species before it reaches maturity, negatively affecting recruitment of neonates into the population. In fact, the historical data on the abundance of newborns in

coastal waters provide strong evidence that a 95 percent reduction in annual production of neonates occurred from 1984 to 2005 as a result of constant fishing pressure in important coastal nursery areas. Adult striped smoothhounds are also susceptible to these fisheries during their spring migration into these same coastal areas for pupping, and are at risk of being caught as bycatch by the industrial gillnet and trawl fleets operating on the inner shelf throughout the rest of year. In fact, the level of fishing mortality on the migratory wintering population on the Plataforma Sul may have led to the observed declines in the striped smoothhound population found off the coast of northern Argentina. Thus, the intense fishing effort by the commercial and artisanal fisheries on the Plataforma Sul appear to be negatively affecting the reproductive capacity and growth of the population throughout its range.

In 2004, the species was listed on Brazil's endangered species list, which effectively prohibited the capture of this species. As of 2014, the species was classified as "critically endangered" on this list. Although the species is not identified as one of 12 species of concern under Brazil's FAO NPOA-sharks, the plan calls for fishing closures in areas of <20 m deep that would provide protection to neonates and juveniles, as well as other closures to protect adult aggregations. In Uruguay, the striped smoothhound is listed as a species of high priority on its FAO NPOA-sharks (Domingo *et al.* 2008); however, as mentioned previously, the implementation and effectiveness of the recommendations outlined in both the Brazilian and Uruguayan plans remain uncertain, with the best available information indicating that current regulatory measures in both countries are inadequate to protect the species from further overutilization.

Given the continued and significant fishing effort by the industrial trawl fleet and artisanal gillnet on the Plataforma Sul, contributing to the fishing mortality of the resident population as well as the wintering migratory population, and inadequacy of existing regulatory measures to control the exploitation of the marine resources throughout the species' range, the best available information suggests that overutilization of the species by industrial and artisanal fisheries is a threat significantly contributing to its risk of extinction.

Risk of Extinction

Although there is significant uncertainty regarding the current status of the species, the best available

information indicates that the species has suffered significant declines throughout its range due to overutilization in industrial and artisanal fisheries. The species' very restricted coastal range, with data to suggest it has undergone a decline of over 90 percent in one third of this range, combined with its present rarity throughout the rest of its range, make it particularly susceptible to local extirpations and significantly increases its risk of extinction from environmental and anthropogenic perturbations or catastrophic events. With no indication that abundance trends have stabilized or reversed in recent years, nor any indication that regulatory measures have been implemented or are adequately enforced to protect the Plataforma Sul neonates in important nursery areas, the local reproducing adult population, or the migratory population from unsustainable fishing mortality levels, it is likely that the species continues to suffer from population declines. Based on the species' demographic risks, these severely depleted populations are likely to be strongly influenced by stochastic or compensatory processes without adequate protection. This vulnerability is further exacerbated by the present threats of overutilization and inadequacy of existing regulatory measures that continue to contribute to the decline of the existing populations, compromising the species' long-term viability. Therefore, based on the best available information and the above analysis, we conclude that *M. fasciatus* is presently at a high risk of extinction throughout its range.

Protective Efforts

With the exception of the recommendations within Brazil and Uruguay's FAO NPOA-sharks, we were unable to find any other information on protective efforts for the conservation of striped smoothhound sharks in Brazil, Uruguay, or Argentina that would potentially alter the extinction risk for the species. We seek additional information on other conservation efforts in our public comment process (see below).

Proposed Determination

Based on the best available scientific and commercial information as presented in the status review report and this finding, we find that the striped smoothhound is presently in danger of extinction throughout its range. We assessed the ESA section 4(a)(1) factors and conclude that the species faces ongoing threats from overutilization and inadequacy of existing regulatory

mechanisms throughout its range. The species' natural biological vulnerability to overexploitation and present demographic risks (*e.g.*, significantly reduced and declining abundance levels, decreases in neonate production and recruitment, low productivity, restricted range with likely small and/or isolated populations at an increased risk of random genetic drift) are currently exacerbating the negative effects of the aforementioned threats, placing this species in danger of extinction. We also found no evidence of protective efforts for the conservation of striped smoothhound that would reduce the level of extinction risk faced by the species or otherwise alter its current status. We therefore propose to list the striped smoothhound shark as an endangered species.

Narrownose Smoothhound Shark (*Mustelus schmitti*)

Species Description

The narrownose smoothhound shark has a slender body, similar in form to other triakids, and a short head (Compagno 1984; Rosa and Gadig 2010). The species has large eyes and a snout that is bluntly angular (Compagno 1984) with a narrow internostril distance (Rosa and Gadig 2010). Like *M. fasciatus*, labial folds are present on the mouth and are longer on the upper jaw than on the lower jaw (Compagno 1984; Heemstra 1997; Rosa and Gadig 2010). Narrownose smoothhounds are grey with numerous small white spots on their dorsal side and solid white coloration on their ventral side (Compagno 1984; Heemstra 1997). The trailing edges of both dorsal fins have exposed ceratotrichia (slender soft or stiff filaments of an elastic protein that superficially resembles keratin), a distinctive characteristic for the species (Rosa and Gadig 2010). The pectoral and pelvic fins are both relatively small, (Compagno 1984) and the ventral lobe of the caudal fin is poorly developed (Heemstra 1997).

Range and Habitat Use

The narrownose smoothhound is found in the southwestern Atlantic from southern Brazil to southern Argentina between 22° S. and 47°45' S. (Belleggia *et al.* 2012). Rio de Janeiro, Brazil, is the northernmost limit of the species' range (Oddone *et al.* 2007) and Ría Deseado, Argentina is the southernmost limit (Chiaramonte and Pettovello 2000). Narrownose smoothhound occurs at depths up to 120 m in Argentina and has been captured as deep as 195 m in Brazil (Belleggia *et al.* 2012). In Argentinian waters, narrownose

smoothhound is found in waters with surface temperatures of 8 °C–11.7 °C and bottom temperatures of 5.5 °C–11 °C (Menni 1985; Chiaramonte and Pettovello 2000) and salinity that is generally 22.4 practical salinity units (psu) and higher (Molina and Cazorla 2011).

Like striped smoothhounds, a portion of the narrownose smoothhound population is migratory. In the winter, juveniles, adults, and gravid females migrate north into Brazilian waters and remain there from April to November (Haimovici 1997; Vooren 1997; Oddone *et al.* 2005; Massa *et al.* 2006). This migration is thought to be triggered by cold water moving north into their Argentinian range (Haimovici 1997). Water temperatures in the wintering grounds are usually between 12 °C and 20 °C (Massa *et al.* 2006). In the spring, summer, and autumn (December to April) narrownose smoothhounds are most common in waters off Uruguay (Vooren 1997; Oddone *et al.* 2005) and Argentina, with highest abundance in Argentinian waters noted off Buenos Aires Province and northern Patagonia (Molina and Cazorla 2011).

Diet and Feeding

Olivier *et al.* (1968) first characterized the diet of the narrownose smoothhound as carcinophagous (*i.e.*, eats crabs and other crustaceans), benthic infaunal (*i.e.*, eats animals that live in the substrate), and ichthyophagous (*i.e.*, eats fish). The narrownose smoothhound is an opportunistic predator that generally feeds on epifaunal benthic organisms and the diet appears to vary geographically and ontogenetically (Capitoli *et al.* 1995). For example, in Río de la Plata and El Rincón, Argentina, the diet is generally dominated by crustaceans, fishes, and polychaetes; however, as narrownose smoothhounds increase in body size, the consumption of polychaetes declines and is replaced by more fishes and crustaceans. The shift to crustaceans occurs around 60 cm TL, while narrownose smoothhounds around 85 cm TL feed primarily on fish (Belleggia *et al.* 2012). Temporal and ontogenetic variations in diet were also found for *M. schmitti* in Anegada Bay, Argentina, where neonates are more specialized feeders and predominantly consume decapods, and adults more commonly consume polychaetes, decapods, bivalves, and occasionally cephalopods (Molina and Cazorla 2011). Smaller scale diet studies in Argentina also found the diet to be dominated by epifaunal benthic organisms, including decapod crabs,

fishes, isopods, and polychaetes, and, to a lesser extent, some teleosts and cephalopods (Chiaramonte and Pettovello 2000; Van der Molen and Caille 2001).

Growth and Reproduction

The narrownose smoothhound has an estimated lifespan of 20.8 and 24.7 years for males and females, respectively (Hozbor *et al.* 2010). 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). Maximum recorded size for *M. schmitti* is 110 cm TL, with a modal TL in Brazil of 60 cm for males and 72 cm for females (Massa *et al.* 2006; Molina and Cazorla 2011). Size at maturity varies throughout the narrownose smoothhound's range, with estimates for male size at 50 percent maturity ranging from 55 cm TL to 59 cm TL and for females ranging from 56 to 72 cm TL (Chiaramonte and Pettovello 2000; Oddone *et al.* 2005; Segura and Milessi 2009; Colautti *et al.* 2010). 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 (Casselberry and Carlson 2015d).

Narrownose smoothhound sharks are non-placental and reported to be yolk-sac viviparous (Hamlett *et al.* 2005; Galíndez *et al.* 2010). Their reproductive cycle is annual with a gestation of 11 months followed by immediate ovulation and mating (Chiaramonte and Pettovello 2000). In the spring, females move inshore to pup and mate, and then migrate offshore in late summer to early autumn (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 (Massa *et al.* 2006), with an average litter size of around 4 to 5 pups (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). Nursery grounds for the narrownose smoothhound shark in Argentina (based on higher abundance of neonates and juveniles within these areas) are found in the El Rincón area (including Bahía Blanca and Anegada Bay) and the Río de la Plata (including Samborombón Bay) (Chiaramonte and Pettovello 2000; Molina and Cazorla 2011).

Genetics and Population Structure

In terms of population structure, only one genetics study has been conducted to determine if multiple stocks occur throughout the species' range (Pereyra *et al.* 2010). Results of this study indicate that *M. schmitti* comprises a single demographic unit in the Río de la Plata area and its maritime front (area separating Uruguay and Argentina), suggesting high connectivity and genetic homogeneity over this geographic range (Pereyra *et al.* 2010). The authors attribute this genetic homogeneity to the likely high dispersal and migration rates of the species (based on tagging studies of related species *M. antarcticus* and *M. lentiginatus*; Francis 1988) and lack of obvious dispersal barriers in the study area. The study also found that nucleotide diversity in *M. schmitti* was lower than that reported for other elasmobranchs. These results may indicate that narrownose smoothhound experienced a genetic bottleneck, recent expansion, or selection, which potentially occurred during the Pleistocene Era (Pereyra *et al.* 2010).

Demography

The annual population growth rate for narrownose smoothhound in Brazil was calculated to be 1.058 between 1980 and 1994 (Massa *et al.* 2006). More recently, using life history parameters from individuals collected off Mar del Plata, Argentina, Cortés (2007) determined the intrinsic rate of increase (r) for narrownose smoothhound to be 0.175 per year when the population is not subject to exploitation (lower 95 percent confidence limit = 0.030; upper 95 percent confidence limit = 0.314). Because of this relatively high 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 region, with sustainable exploitation rates equivalent to an annual removal rate of about 10 percent of the population. Natural mortality rates of the species ranged from 0.139 to 0.412 (Cortés 2007). These demographic parameters place narrownose smoothhound toward the faster growing end of the "fast-slow" continuum of population parameters calculated by Cortés (2002), which means this species generally has a higher potential to recover from exploitation.

Historical and Current Distribution and Population Abundance

The narrownose smoothhound is the most abundant and widely distributed triakid in the Argentine Sea (Van der Molen and Caille 2001), with densities

off Río de la Plata as high as 44 t/nm² in 1994 (Cousseau *et al.* 1998). Throughout the rest of the Argentine-Uruguayan Common Fishing Zone (AUCFZ) [an area that extends 200 nm off the coast from the border of Uruguay and Brazil to just south of Necochea, Argentina] densities of narrownose smoothhounds ranged between 1 and 10 t/nm², with some areas supporting densities as high as 22 t/nm² (Cousseau *et al.* 1998). Based on data from research surveys conducted in the spring in Argentine maritime waters (covering coastal Buenos Aires and waters off Uruguay from 35° S.–41° S.), abundance of *M. schmitti* in this area increased from 82,000 t in 1978 to 184,302 t in 1994. In 1999, *M. schmitti* abundance on the continental shelf and slope from 34° S.–48° S. was estimated to be 191,722 t (Argentina FAO NPOA-sharks 2009). Although recent abundance estimates could not be found, Massa *et al.* (2006), citing unpublished data, indicate that between 1998 and 2002, biomass of the species declined by 22 percent in main fishing areas along the coast of Buenos Aires Province (Argentina) and the Bonaerensean region (Uruguay) and national landings in Argentina decreased by 30 percent. By 2003, abundance of *M. schmitti* (between 35° S.–41° S.) had fallen to 88,500 t (Argentina FAO NPOA-sharks 2009). Declines in abundance continued to be seen in Argentine waters through 2005 (Massa and Hozbor 2008). Similarly, in Brazil, based on CPUE data, abundance of the winter migrant population of *M. schmitti* is estimated to have declined by 85 percent between 1985 and 1994 (Miranda and Vooren 2003), and Massa *et al.* (2006) note that a small local breeding population that was relatively common in the 1980s in southern Brazil has seemingly been extirpated from the area.

Summary of Factors Affecting Narrownose Smoothhound (*Mustelus schmitti*)

We reviewed the best available information regarding historical, current, and potential threats to the narrownose smoothhound shark. We find that the main threat to this species is overutilization for commercial purposes. We consider the severity of this threat to be reduced by the species' natural biological ability to withstand higher levels of exploitation. However, we find that historical and present levels of utilization have exceeded the species' biological capacity to quickly recover from exploitation, and have subsequently led to significant declines in abundance. We also find that current regulatory measures are inadequate to

protect the species from further overutilization. Hence, we identify these factors as additional threats contributing to the species' risk of extinction. We summarize information regarding these threats and their interactions below according to the factors specified in section 4(a)(1) of the ESA. Available information does not indicate that habitat destruction or modification, disease, predation or other natural or manmade factors are operative threats on these species; therefore, we do not discuss these factors further in this finding. See Casselbury and Carlson (2015d) for discussion of these ESA section 4(a)(1) threat categories.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The primary threat to the narrownose smoothhound is overutilization in commercial and artisanal fisheries as the species is intensely fished throughout its entire range, including within its nursery grounds. In Argentina, *M. schmitti* is considered the most important elasmobranch in Argentine fisheries, making up 9–12 percent of the total landings from coastal fleets (Galíndez *et al.* 2010), and is the most heavily exploited shark species in artisanal fisheries. As bycatch in Argentine commercial bottom trawls, narrownose smoothhounds comprise around 20 percent of the coastal harvest from these fisheries (Colautti *et al.* 2010). In the 1990s, fishing for the species increased in the directed industrial shark fisheries (Massa *et al.* 2004a), with the narrownose smoothhound being the main shark caught in the Argentine Sea (based on an extracted biomass of 10,200 t for that time period), and the second most consumed domestic fish (Van der Molen *et al.* 1998; Chiaramonte 1998). Between 1981 and 1991, commercial catches of *M. schmitti* ranged from 5,000 t–8,000 t, with peak landings of 13,000 t in 1988 (Cousseau and Perrotta 2000 cited in Massa *et al.* 2004a; FAO Global Capture Production Database). From 1992 to 1997, total catch of narrownose smoothhound remained fairly stable, hovering between 6,000 t and 8,000 t (Massa *et al.* 2004a), whereas the number of Argentine fishing vessels catching *M. schmitti* increased from 216 to 298 (Massa and Hozbor 2003). This increase in vessels and associated fishing pressure on the species consequently led to significant declines in the abundance of the species off the Argentine coast over this time period. Specifically, between 1992 and 1998, CPUE declined by 50 percent for the fishing fleet comprised of small-sized

vessels (<20 m) operating on the Argentine shelf, whereas the larger vessels (>20 m) that fished in deeper waters saw a decrease in CPUE of 78 percent (Massa and Hozbor 2003). The larger fishing vessels also reported a decrease in the mean length of landed narrownose smoothhounds, from 59 cm in 1994 to 55 cm in 1999, a size smaller than estimated size at 50 percent maturity (Colautti *et al.* 2010). The decline in biomass and CPUE of the species, as well as the decrease in the average size of narrownose smoothhounds in the landings, all point to evidence of the significant historical overutilization of the species off the Argentine coast. In 2003, reported landings of narrownose smoothhound in Argentine ports reached 7,899 t, which exceeded the recommended maximum catch limit of 7,200 t for that year (Massa *et al.* 2004b), but between 2003 and 2007, mean values of CPUE of the species steadily increased, from 37.72 kg/h in 2003 to 42.3 kg/h in 2007 (Perez *et al.* 2011). However, Perez *et al.* (2011) cautions that the increase in CPUE does not necessarily reflect an increase in abundance of the species. Rather the CPUE increase appears to be influenced by greater accessibility to the species (with the data indicating an increase in directed fishing effort for *M. schmitti* or a greater overlap of the species with other targeted species) (Perez *et al.* 2011).

In the artisanal fisheries in Argentina, the narrownose smoothhound is a highly targeted shark, particularly in the coastal areas between 36° S. and 41° S. latitudes. In Anegada Bay, a known nursery area for the shark, the smoothhound artisanal fishing season used to operate from October 15 to December 15, with fishermen exclusively using bottom gillnets to catch the sharks. In 2004, *M. schmitti* comprised 96 percent of artisanal landings from Anegada Bay; however, due to the selectivity of the artisanal gillnet sizes, only 1.8 percent of the fish captured were juveniles and 36.8 percent corresponded to pre-adults or young adults (Colautti *et al.* 2010). The catches ranged in size from 52–75 cm TL, which is generally below the recommended size for sustainable exploitation of this species (Cortés 2007), although size at maturity in Anegada Bay has been estimated at 61 cm for males and 64 cm for females (Colautti *et al.* 2010). Since 2008, the smoothhound fishery in this bay has been closed as an additional level of protection for the species; however, Colautti *et al.* (2010) note that extensive coastal commercial fishing still occurs

year-round in the surrounding El Rincón area in the southwest Buenos Aires province, which contains a number of nursery habitats for the species in addition to Anegada Bay. Because trawl nets are the predominant commercial gear used throughout the El Rincón area, a high proportion of the narrownose smoothhound catch in the coastal commercial fisheries are juveniles (Cousseau *et al.* 1998; Massa *et al.* 2004a; Pereyra *et al.* 2008; Molina and Cazorla 2011). In addition, catches from this area comprise a significant proportion of the total Argentinian narrownose smoothhound landings, with El Rincón landings making up 37–53 percent of the national total of *M. schmitti* landings from 2003 to 2008 (Colautti *et al.* 2010). Colautti *et al.* (2010) suggests that this heavy coastal commercial fishing pressure on narrownose smoothhounds in the El Rincón area, especially in the nursery areas of the species, is not only leading to overfishing of the sharks in the region but is also contributing to a potential loss of genetic diversity, as individuals with the highest growth rate are preferentially removed from the population during fishing operations. Declines in the biomass of the species have already been reported from the El Rincón area, with estimates of up to 50 percent between 1994 and 2003 (Colautti *et al.* 2010).

In Uruguay, landings of smoothhounds (primarily *M. schmitti*, but also *M. fasciatus* and *M. canis*) increased dramatically between 1999 and 2000, reaching 1,300 t, and then began to steadily decline, reaching approximately 850 t by 2005 (Domingo *et al.* 2008). According to data reported to the FAO, these estimates may be underestimated as the landings from Uruguay show peaks of 2,156 t and 3,212 t of narrownose smoothhound in 1998 and 1999, respectively (FAO Global Capture Production Database). 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). However, similar to the Domingo *et al.* (2008) estimates, the FAO landings also decreased after 2001, with 892 t estimated in 2005. By 2009, the narrownose smoothhound was considered overfished in the coastal regions of Uruguay (Defeo *et al.* 2009).

In the AUCFZ, narrownose smoothhounds are the most heavily exploited shark (Segura and Milessi 2009). Though maximum permitted catch limits in the AUCFZ are set by both countries (Argentina and Uruguay), population declines have been seen

throughout this portion of the narrownose smoothhound's range, mostly due to increased fishing effort on juveniles of the population (Colautti *et al.* 2010; Molina and Cazorla 2011). For example, samples taken in the port of Mar del Plata, where the largest percentage of the species is landed, indicate that in 2001, nearly half of *M. schmitti* landings consisted of juveniles, with the average size of the landings estimated at 61.5 cm TL (Izzo and Rico 2003 cited in Massa *et al.* 2004b). In 2002, the percentage of juveniles landed increased to 81.7 percent, and the average size of the narrownose smoothhound sharks in the landings decreased to 52.5 cm TL (Izzo and Rico 2004 cited in Massa *et al.* 2004b), a value below the size at maturity of the species (*i.e.*, 55 to 60 cm TL). In other words, this level of utilization of the species, including the apparent removal of larger individuals from the population, led to a decrease in the average size of narrownose smoothhound sharks in landings, with the majority of the landings comprised of immature individuals. As litter sizes are correlated with maternal length, this removal of larger individuals from the population may significantly reduce the reproductive output of the species. Additionally, focusing fishing effort on primarily juveniles of the population can also have significant negative effects on recruitment (Vooren 1997) and may lead to further declines in the species. In fact, landings of the species in the AUCFZ have decreased in recent years, from 4,480 t in 2010 to 2,921 t in 2014, a decline in catch of around 35 percent (CTMFM 2015). In addition, the estimated size at maturity of narrownose smoothhounds in the AUCFZ has chronologically decreased since the 1970s, which is also indicative of overutilization of the species in this area. Specifically, in 1978, the size at maturity for males and females was estimated to be 60 cm and 62 cm TL, respectively (Menni *et al.* 1986). In 1997, Diaz de Astarloa *et al.* (1997) calculated size of maturity using data from a 1993 winter coastal fishing cruise to be 54.9 and 60.5 cm TL for males and females, respectively. Similarly, estimates calculated in 1998 determined the size at maturity to be 57.6 cm for males and 59.9 cm for females (Cousseau *et al.* 1998). More recently, Cortés (2007) estimated the total size of maturity of the species to be 56.04 cm TL, which is lower than estimates in previous studies (Menni *et al.* 1986; Diaz de Astarloa *et al.* 1997; Cousseau *et al.* 1998) and is consistent with a declining population trend. Finally,

since 2008, total landings of *M. schmitti* reported by Argentina and Uruguay to the FAO have decreased by over 57 percent and 63 percent, respectively, although no corresponding effort information is available. Despite the multiple indicators of overutilization of the species, in 2013, Argentina landed a total of 4,379 t of *M. schmitti* and Uruguay landed 194 t (FAO Global Capture Production Database), suggesting the species is still considered valuable catch and bycatch in these countries.

In Brazil, *M. schmitti* occurs as winter migrants on the Plataforma Sul off Rio Grande do Sul and, similar to *R. horkelli* and *M. fasciatus*, is caught by the trawl and oceanic gillnet fleets operating on the continental shelf. From 1975 to 1997, *M. schmitti* was one of two species that made up the majority of demersal shark landings in the port of Rio Grande (the other being the school shark, *Galeorhinus galeus*; Miranda and Vooren 2003). Targeted fishing for the species is thought to have increased from the mid 1970s through the 1980s, as evidenced by the near tripling of CPUE values of *M. schmitti* in the single trawl fleet, from 2.48 t/trip in 1975 to 7.31 t/trip in 1987 (Miranda and Vooren 2003). Likewise, the CPUE of *M. schmitti* by pair trawls from 1975 to 1987 reflected a similar trend, increasing from 0.35 t/trip to 2 t/trip (Miranda and Vooren 2003). However, CPUE values for both fleets decreased rapidly after 1987, with values in 1994 (1 t/trip for single trawl and 0.3 t/trip for pair trawl) indicating an approximate 85 percent decline in abundance of *M. schmitti* from 1985 numbers (Miranda and Vooren 2003). Despite the decline, *M. schmitti* was still being landed at the port of Rio Grande from April to October in 1994 and 1995 by single trawl and oceanic gillnet fleets, with peak CPUE from these fleets corresponding with the seasonal occurrence of the species on the Plataforma Sul.

Similar to the trends seen in the striped smoothhound within the coastal waters off southern Brazil, neonates of *M. schmitti* have also declined in abundance, a likely result of the intense coastal commercial and artisanal fishing along the Brazilian coast (see additional discussion of these fisheries in the assessments for Brazilian guitarfish and striped smoothhound). As mentioned previously, these coastal fisheries primarily use beach seines, gillnet and trawl gear in the nearshore locations off Rio Grande do Sul, habitat for narrownose smoothhound neonates and juveniles. Consequently, neonate *M. schmitti* populations that were once

abundant in the 1980s have since seemingly disappeared, with data that show an absence of neonate individuals from artisanal beach net catches in 2003 and coastal trawl surveys conducted in 2005 (Vooren *et al.* 2005b). Further, Massa *et al.* (2006) report that a small local population of narrownose smoothhounds that was known to give birth in south Brazil in November and remain through February may have been extirpated, but additional information to confirm this potential extirpation is unavailable.

As discussed in both the Brazilian guitarfish and striped smoothhound assessments, fishing by the industrial and artisanal fleets continues to occur at high efforts on the Plataforma Sul, and especially within the important coastal nursery and inner shelf habitats for the species (which overlap with both *R. horkelli* and *M. fasciatus*). This heavy fishing pressure may have led to the apparent extirpation of the local breeding population of narrownose smoothhound in southern Brazil (Massa *et al.* 2006 citing Vooren and Lamónaca unpublished data) and is likely contributing to the fishing mortality of the wintering migratory population. Based on the trends from available fisheries data (see *R. horkelli* and *M. fasciatus* assessments), it is unlikely that the industrial and artisanal fishing on the Plataforma Sul, and particularly off the coast of Rio Grande do Sul within narrownose smoothhound habitat, will decrease in the foreseeable future, indicating that overutilization (in the form of bycatch mortality) will continue to be a threat to the species leading to further declines in the wintering migratory population.

Inadequacy of Existing Regulatory Mechanisms

In Argentina, there are few regulations in place to protect narrownose smoothhound nursery habitat. For example, Ría Deseado (~40 km; 47°45' S.; 65°55' W.), the southernmost limit of the narrownose smoothhound's range, is designated as a nature preserve and protects the local population from fishery-related mortality (Chiaramonte and Pettovello 2000). It has been identified as a nursery area, where breeding adults, neonates, and juveniles enter Ría Deseado waters in the late spring and stay until late summer (Chiaramonte and Pettovello 2000). Anegada Bay (39°50'51" S. to 40°43'08" S. and 62°28'44" W. to 62°03'00" W.), Argentina, another known narrownose smoothhound nursery area, is also protected from fishing operations. The bay was previously designated as a multiple use zone reserve in 2000,

which did little to protect the *M. schmitti* population from fishing mortality as a smoothhound fishery operated within the bay waters. However, in 2004 and 2008, fishing was banned in the bay due to concern over the conservation of the bay's natural resources, and since 2008, the smoothhound fishery in Anegada Bay has remained closed (Colautti *et al.* 2010). However, as Anegada Bay is surrounded by the larger El Rincón area, which also includes a number of other nursery habitats for the species and is open to fishing, it is unclear how effective the protections in Anegada Bay will be in decreasing the extinction risk of the species from overutilization. While these specific areas provide important protection for the species during critical life stages, they comprise a very small portion of the species' range and it is unclear to what extent the species relies on these small nursery areas for recruitment to the population.

In Uruguay, regulations that likely contribute to decreasing the fishery-related mortality of the species include a summer trawling ban in 25 m to 50 m depths between La Paloma and Chuy and specific fishery area closures in the spring, summer, and autumn on the Uruguayan continental shelf, designated to protect juvenile hake (*Merluccius hubbsi*) but which also correspond with high use areas of the narrownose smoothhound population (Pereyra *et al.* 2008).

Both Argentina and Uruguay list the narrownose smoothhound as a high priority species within their respective FAO NPOA-sharks (Domingo *et al.* 2008; Argentina FAO NPOA-sharks 2009). These plans, as stated previously, set goals to collect the necessary information on its priority species in order to conduct abundance assessments, increase research and improve management of the species, review current fishing licenses, and promote public awareness to release captured individuals. However, no updated results from the goals and priorities of these plans could be found. As such, the implementation and overall effectiveness of these plans at decreasing the threats to the narrownose smoothhound remains highly uncertain.

In the AUCFZ, the area where current fisheries information indicates narrownose smoothhounds may likely be most abundant and heavily targeted, the Comisión Técnica Mixta del Frente Marítimo (CTMFM) is in charge of managing fish stocks and does so through the implementation of catch limits and fishery closures. For example, every year, the CTMFM implements a prohibition against

demersal trawling in an area that covers a large section of the common fishing zone, extending across the continental shelf, in order to protect vulnerable chondrichthyans from fishery-related mortality. This prohibition, which is usually in place between November and March, helps to decrease fishery-related mortality of the narrownose smoothhound shark during at least part of the year. The CTMFM also establishes additional area closures to trawling gear throughout the year in the AUCFZ, including within the Rio de la Plata (where historical estimates of narrownose smoothhound were as high as 44 t/nm²; Cousseau *et al.* 1998), in order to protect whitemouth croaker (*Micropogonias furnieri*) and juvenile hake from overexploitation by the fisheries. As these areas correspond with high use by the narrownose smoothhound population, the trawling bans will also directly help to protect the narrownose smoothhound from additional fishery-related mortality.

In terms of the direct management of *M. schmitti* sharks, from 2002 to 2010, the CTMFM has set the total permissible catch limit for all *Mustelus spp.* at 4,850 t. In 2011, this limit was lowered to 4,000 t (Res. N° 5/11, Res. N° 5/02), and in 2012, the CTMFM set a species-specific total permissible catch limit for narrownose smoothhound at 4,500 t (Res. N° 11/13, Res. N° 9/12). This catch limit remained at this level until 2015, when it was reduced to 3,500 t (Res. N° 6/15). However, despite these maximum allowable catch levels for *Mustelus spp.* that have been set since 2002, McCormack *et al.* (2007) reports that elasmobranch quotas and size regulations are largely ignored in Argentina and poorly enforced. This may explain why population declines continued to occur in this part of the species' range even after regulations were implemented to sustainably manage the species. Due to a lack of abundance data since 2003, it is unclear whether the catch limits for *Mustelus spp.* have positively affected the population since 2002, though it is worth noting that since 2010, catches of *M. schmitti* in the AUCFZ have been below the total allowable levels and on a decline (CTMFM 2015). However, perhaps the recent decline in *M. schmitti* landings prompted the reduction in catch limits in 2015.

In Brazil, the narrownose smoothhound is listed on Annex 1 of Brazil's endangered species list and classified as critically endangered (Directive N° 445). As described in previous species assessments, an Annex 1 listing prohibits the catch of the species except for scientific purposes,

which requires a special license from IBAMA. There is also a prohibition of trawl fishing within three nautical miles from the coast of southern Brazil, although the enforcement of this prohibition has been noted as difficult (Chiaromonte and Vooren 2007). In addition, the species is still susceptible to being caught as bycatch in the legally permitted coastal gillnet fisheries and offshore trawl and gillnet fisheries and vulnerable to the associated bycatch mortality (Lessa and Vooren 2007). Additionally, unlike the striped smoothhound, the narrownose smoothhound is listed as one of the 12 species of concern under Brazil's FAO NPOA-sharks and would also benefit from the proposed fishing closures and other management measures outlined in the plan. However, as mentioned previously, the plan was only just approved as of December 2014, and will not be fully implemented for another 5 years. Thus, the implementation and effectiveness of the recommendations outlined in the plan remain uncertain, with the best available information indicating that current regulatory measures in Brazil to protect vulnerable species are poorly enforced.

Extinction Risk

The best available information provides multiple lines of evidence indicating that the *M. schmitti* currently faces a moderate risk of extinction. Below, we present the demographic risk analysis, threats assessment, and overall risk of extinction for the narrownose smoothhound shark.

Demographic Risk Analysis

Abundance

There is limited information available regarding quantitative abundance estimates of narrownose smoothhound throughout its range. However, biomass estimates as well as trends in commercial landings and CPUE data can provide some insight into the abundance of the species. The narrownose smoothhound is the most abundant and widely distributed triakid in the Argentine Sea. In Argentina, the narrownose smoothhound is mainly landed by the commercial fleet operating in the Buenos Aires coastal region, and represents up to 14.5 percent of landings (Carozza *et al.* 2001 cited in Massa *et al.* 2004b). Between 1992 and 1997, landings of the species in Argentina were fairly stable, on the order of 6,000–8,000 t; however, CPUE values decreased by upwards of 78 percent during this time period, indicating a likely decline in the abundance of the species. From 1998 to

2002, biomass of *M. schmitti* reportedly declined in the main fishing areas along the coast of Buenos Aires Province and the surrounding region by approximately 22 percent (Massa *et al.* 2006). National landings also decreased in Argentina by 30 percent during this same time period and have continued to decline based on FAO landings data through 2013. It is important to note that the decrease in landings is not due to falling market values as *M. schmitti* continues to fetch a high price in the Argentine domestic market (Massa *et al.* 2004b). In 2003, the spring time abundance of *M. schmitti* from coastal Buenos Aires and Uruguay (between 34° S.–41° S.) was estimated to be 88,500 t, which represents a 50 percent and 39 percent decline from estimated values in 1994 and 1999, respectively (Massa *et al.* 2004a). Additionally, based on estimates calculated in 2007, size at maturity of the species has chronologically decreased since the 1970s, a strong indication of overutilization of the species and declining abundance.

In Uruguay, there is conflicting information regarding the trend in catches of *M. schmitti*. Landings of smoothhounds in Uruguay are aggregated at the genus level because catch is often reported by common name and the same common name is used for multiple species. Thus, identifying the true species composition of shark catches in Uruguay is problematic. According to Domingo *et al.* (2008), landings of smoothhounds in Uruguay (primarily *M. schmitti*) increased dramatically between 1999 and 2000, reaching 1,300 tons, and then steadily declined to approximately 850 tons by 2005. Based on landings data reported to the FAO, catches of *M. schmitti* have continued to decline, with only 194 t reported in 2013. However, without corresponding effort information, it is unclear if the decrease in landings is a result of decreases in abundance in the species.

In Brazil, *M. schmitti* occurs as winter migrants on the Plataforma Sul and is caught by the trawl and oceanic gillnet fleets operating on the continental shelf. Based on CPUE data from these fleets, the wintering population has likely suffered significant declines in abundance. The CPUE values from both the single and pair trawl fisheries showed an increase from the mid 1970s to the late 1980s; however, after 1987, CPUE values for both fleets decreased rapidly, and in 1994, these CPUE values showed an approximate 85 percent abundance decline of *M. schmitti* from 1985 values (Miranda and Vooren 2003). Massa *et al.* (2006) also cites

unpublished data that indicate the likely extirpation of a local breeding population of narrownose smoothhound in Brazil as a result of fishing in inshore pupping and nursery areas. Although no further information was given regarding this population, survey and fisheries data suggest significant declines in newborn *M. schmitti* from a local nursery area off the coast of Rio Grande do Sul. Once abundant in the 1980s in the coastal waters off Casino Beach, Rio Grande do Sul, neonates of this local population have since seemingly disappeared, with data that show an absence of individuals from artisanal beach nets in 2003 and coastal trawl surveys in 2005 (Vooren *et al.* 2005b). This absence of neonates, compared to data from the 1980s, is likely a sign of decline of this population and may even suggest a potential extirpation.

Overall, best available information suggests the species is likely in decline in parts of its Argentine and Uruguayan range, and has experienced a significant decrease in abundance in its winter migrant population in Brazil. Although present abundance estimates are unknown, the significant declines in both CPUE and landings of the species throughout its range, as well as the chronological reduction of the species' average size (based on landings data) and size of maturity, suggest overexploitation of the species and a declining abundance trend. Targeting of the species will continue, given its demand in the market and importance in both the artisanal and commercial fisheries in the region and, combined with the high fishing pressure in the species' nursery areas, the species may continue to experience population declines throughout its range, with abundance levels that will likely contribute significantly to its extinction risk in the foreseeable future.

Growth Rate/Productivity

The narrownose smoothhound has an estimated lifespan of 20.8 years and 24.7 years for males and females, respectively, with a maximum recorded size of 110 cm TL. Information regarding size and age of maturity estimates vary throughout the species' range, but the most recent estimate from Hozbor *et al.* (2010) suggests an age at maturity of 4 years for both sexes. Although *M. schmitti* has an annual reproductive cycle with a lengthy gestation period (11 months) and an average of only 4–5 pups per litter, the species' intrinsic rate of population increase is relatively high, at 0.175 per year. Natural mortality rates ranged from 0.139 to 0.412 (Cortés 2007). These estimates indicate that *M. schmitti* has

a higher potential to recover from exploitation compared to other coastal sharks, and could withstand annual removal rates of up to approximately 10 percent of the population. However, based on confirmed chronological reductions in both average size (from landings data) and total length at maturity in the species, it is apparent that removal rates of the species have been exceeding the 10 percent sustainable removal rate. The reduction in mean size and size at maturity is particularly concerning due to the positive relationship between maternal length and litter size (*i.e.*, litter size increases significantly with maternal length) in which a decrease in maximum size has the potential to reduce the species' reproductive output. As such, these reductions likely compromise the species' growth rate and productivity, and consequently, hinder its ability to recover from exploitation.

Spatial Structure/Connectivity

Very limited information is available regarding spatial structure and connectivity of *M. schmitti* populations. Tagging studies of related species *M. antarcticus* and *M. lenticulatis* found that they have high dispersal capacities (Francis 1988), but no such studies have been conducted specifically for *M. schmitti*. If narrownose smoothhound populations are connected, then the significant fishing pressure on the migratory population while they winter on the Plataforma Sul may be negatively impacting the populations found in other parts of the species' range (perhaps contributing to the observed declines off Argentina and Uruguay). However, based on the available data, there is not enough information to identify critical populations or determine whether the rates of dispersal among populations, metapopulations, or habitat patches are posing a risk of extinction.

Diversity

The loss of diversity can increase a species' extinction risk through decreasing a species' capability of responding to episodic or changing environmental conditions. This can occur through a significant change or loss of variation in life history characteristics (such as reproductive fitness and fecundity), morphology, behavior, or other genetic characteristics. In terms of population structure, only one genetics study has been conducted to determine if multiple stocks occur throughout the species' range (Pereyra *et al.* 2010). Results of this study indicate that *M. schmitti*

comprises a single demographic unit in the Río de la Plata area and its maritime front (area separating Uruguay and Argentina), with no distinct population structure found between or within the Río de la Plata, the Atlantic coast or its outer shelf. These findings indicate high connectivity and suggest genetic homogeneity over this geographic range, which is attributed to the likely high dispersal and migration rates of the species (Pereyra *et al.* 2010). However, a lack of genetic structure can also result from many other factors, including large effective population sizes and/or the presence of shared ancestral polymorphisms due to recent population divergence.

In addition to genetic homogeneity, the study found that nucleotide diversity in *M. schmitti* was lower than that reported for other elasmobranchs. These results may indicate that narrownose smoothhound experienced a genetic bottleneck, recent expansion, or selection, which potentially occurred during the Pleistocene Era (Pereyra *et al.* 2010). However, it is difficult to unambiguously discern between evidence for natural selection and demographic population expansion. Overall, the low genetic diversity values found for the species and evidence that fishing pressure may have already altered the genetic characteristics of the population (*i.e.*, smaller average size and size at maturity, which in turn can alter reproductive fitness and fecundity) raise considerable concern over the species' status. This information indicates that *M. schmitti* may be at an increased risk of inbreeding depression or random genetic drift, and could experience the fixing of recessive detrimental genes, reducing the overall fitness of the species.

Threats Assessment

The primary threat to narrownose smoothhounds is overutilization in commercial and artisanal fisheries, with the species both targeted and bycaught throughout its range. In Argentina, *M. schmitti* is considered the most important elasmobranch for Argentine fisheries; however, data suggest that the majority of narrownose smoothhounds caught by Argentine fishermen are juveniles (*e.g.* up to 81.7 percent of the landings in 2002), indicating significant fishing pressure in important nursery areas. Declines in both CPUE and biomass of *M. schmitti* in Argentina occurred throughout the 1990s and early 2000s; however, mean values of CPUE have shown a slight upward trend from 2003–2007. However, as noted previously, these values should be interpreted with caution as they could

be the result of increased directed fishing pressure on *M. schmitti* or an increase in overlap of fishing vessels in areas where *M. schmitti* has higher concentrations. Further, the chronological reduction in mean size and size of sexual maturity since the 1970s indicates overfishing of the species, suggesting exploitation rates are higher than what the species can presently sustain.

In the AUCFZ, where *M. schmitti* is most heavily exploited, fishing regulations currently set total permissible catch of *M. schmitti* at 3,500 t (which is a reduction from the 4,500 t limit that was in place since 2012). Additionally, trawling is banned within 5 nm of the coast, which coincides with the pupping and breeding areas of the species. While there is no information to indicate whether these regulatory mechanisms are positively affecting the status of the narrownose smoothhound, particularly since species-specific catch limits for *M. schmitti* have only been implemented since 2012, these regulations may help reduce fishing pressure in this important part of the species' range. Since 2010, catches of *M. schmitti* in the AUCFZ have been below the total allowable levels (for *Mustelus spp.* and *M. schmitti*) and on a decline; however, it should be noted that despite total allowable catch, minimum sizes, and annual quotas in place for many elasmobranchs in Argentina, they are largely ignored and poorly enforced (McCormack *et al.* 2007).

In Uruguay, narrownose smoothhounds are both targeted in artisanal fisheries and caught as bycatch. Despite the difficulties in identifying species composition of shark catches and discrepancies in catch information, data indicate landings of *M. schmitti* have declined in Uruguay, and in 2009, the species was classified as overfished in coastal regions of Uruguay and considered a high priority under the country's FAO NPOA-sharks.

In southern Brazil, the intensive fishing effort on the Plataforma Sul has likely led to overutilization, and consequently, significant declines in the winter migrant population of *M. schmitti* and potential extirpation of a local breeding population. Bottom trawl fishery CPUE data provide evidence that abundance of the winter migrant population of *M. schmitti* decreased by 85 percent due to intensive fishing effort from 1985 onwards. The absence of neonates from coastal waters, where they were once abundant in the 1980s, also suggest that intense fishing effort, especially in important nursery areas, has led to significant declines in local populations and potential extirpation of

a small population of Brazilian migrants that was known to give birth in south Brazil in November and remain through February (Massa *et al.* 2006). Since 2004, the species has been listed on Brazil's endangered species list, which prohibits fishers from catching this species. The species is also listed as one of 12 species of concern under Brazil's FAO NPOA-sharks, which calls for fishing closures in areas of <20 m deep that would provide protection to neonates and juveniles, as well as other closures to protect adult aggregations; however, the implementation and effectiveness of the recommendations outlined in the plan remain uncertain, with the best available information indicating that current regulatory measures in Brazil to protect vulnerable species are poorly enforced, particularly in artisanal fisheries.

Based on the best available information, it is evident that *M. schmitti* is heavily exploited and has likely experienced population declines throughout its range as a result of historical and continued overutilization of the species. In limited parts of the species' range, regulatory mechanisms are seemingly adequate to control for overutilization, such as the closures of important nursery areas in Argentina which protect neonates and juveniles from fishing mortality. However, throughout large portions of the species' range, particularly in areas where the species is most heavily exploited, it is evident that regulatory mechanisms are not adequately protecting the species from further decline. For example, in the AUCFZ, continued population declines have been seen in this part of the species' range through 2005 (Massa and Hozbor 2008), despite annual maximum allowable catches for *Mustelus spp.* since 2002. Additionally, while CPUE values in Argentina have shown a slight upward trend from 2003–2007, the cause of this trend is uncertain and may actually reflect increased direct and indirect fishing effort on *M. schmitti*. While species-specific catch limits were implemented for *M. schmitti* in 2012, it is unclear if these levels are adequate to prevent further declines in the species. Although corresponding effort data are unavailable, since 2008, landings of *M. schmitti* reported by Argentina and Uruguay to the FAO have decreased by over 50 percent. Since 2010, catches in the AUCFZ have been below the total allowable catch levels and also on a decline, which may suggest reducing fishing pressure on the species or evidence that catch regulations are potentially being followed. However,

McCormack *et al.* (2007) note that quotas and size regulations are largely ignored and lack enforcement in Argentina. Additionally, since 2006, the total number of vessels in Argentina's fishing fleet has remained fairly stable (OECD 2014), potentially indicating that fishing effort has not decreased substantially in recent years. As such, the decreasing landings, even below total allowable catch limits, may indicate a continued decline in the abundance of the species. Overall, based on the best available information, we find that existing regulatory measures throughout the most heavily exploited areas of the species' range are inadequate to protect the species from overutilization, which is the main threat significantly contributing to the extinction risk of *M. schmitti*.

Risk of Extinction

While there is considerable uncertainty regarding the species' current abundance, the best available information indicates that the species has experienced population declines of significant magnitude throughout its range. Most concerning is the evidence to suggest *M. schmitti* has undergone a chronological decline in average size (based on landings data) and mean size of maturity, as shown in studies from the 1970s through 2007 (Massa *et al.* 2004a; Cortés 2007). Not surprisingly, this decreasing trend corresponds to an increase of fishing operations and provides evidence of the negative impact of historical and current exploitation rates and associated fishing mortality on the biological status of the species. Because of the positive relationship between maternal length and litter size for the species, a decrease in the average size of the population has the potential to reduce the species' reproductive output. Furthermore, a decrease in average size below the species' mean size of maturity can hasten the reduction of biomass and increase the risk of local extinction (Baum and Myers 2004 cited in Massa *et al.* 2004b). Although the species' relatively high intrinsic rate of population increase and ability to withstand moderate levels of exploitation up to 10 percent of the total population provides the narrownose smoothhound shark with some protection from extinction, and is likely the reason why the species remains the most abundant houndshark in the Argentine Sea, the aforementioned decreases in average size and size at maturity as well as population size suggest the species is being exploited at a level exceeding what it can sustain. Thus, based on the best available

information, we conclude that the species is currently at a moderate risk of extinction due to declining trends in abundance and population growth/productivity, which are unlikely to reverse in the foreseeable future because of the continued overutilization of the species in commercial and artisanal fisheries and inadequacy of existing regulatory measures to control this level of exploitation.

Protective Efforts

With the exception of the recommendations within the FAO NPOA-sharks discussed above, we were unable to find any other information on protective efforts for the conservation of narrownose smoothhound in Argentina, Uruguay, or Brazil that would potentially alter the extinction risk for the species. We seek additional information on other conservation efforts in our public comment process (see below).

Proposed Determination

Based on the best available scientific and commercial information as presented in the status review report and this finding, we find that the narrownose smoothhound is not presently in danger of extinction throughout its range, but likely to become so in the foreseeable future. We assessed the ESA section 4(a)(1) factors and conclude that the species faces ongoing threats from overutilization and inadequacy of existing regulatory mechanisms throughout its range. Due to the species' relatively fast population growth rate (for elasmobranchs) and likely high historical abundance, it can withstand moderate rates of exploitation. However, based on the declining trends in the species' abundance, its low genetic diversity, the observed decreases in average size of the species in catches as well as the decreases in size at maturity in areas where it is most heavily exploited, best available data suggest that the fishing mortality rate is higher than what the species can sustain. Although the species' present level of abundance does not appear to be at such a low level to trigger the onset of compensatory processes, the species' observed downward trend is unlikely to reverse in the foreseeable future as a result of continued overutilization. We therefore conclude that the species is on a trajectory indicating that it will more likely than not be at risk of extinction in the foreseeable future. We also found no evidence of protective efforts for the conservation of narrownose smoothhound that would reduce the level of extinction risk faced by the

species. We therefore propose to list the narrownose smoothhound as a threatened species.

Angel Sharks

Angel sharks are members of the family Squatinidae. Both the spiny angel shark (*Squatina guggenheim*) and Argentine angel shark (*Squatina argentina*), two of the elasmobranchs considered for listing in this finding, can be found in the Southwestern Atlantic Ocean from southern Brazil to Argentina. 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 that *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).

Spiny Angel Shark (*Squatina guggenheim*)

Species Description

The spiny angel shark (*S. guggenheim*) can be distinguished from its sympatric species by the presence of a median row of spines or tubercles on its dorsal side (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. As females mature, their dorsal spines become less distinct and take the form of flattened tubercles, whereas 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. 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 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).

Range and Habitat Use

The spiny angel shark is found in the southwestern Atlantic Ocean from Espirito 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-Abriel 2013). Spiny angel sharks prefer depths between 10 m and 80 m, but have been reported as deep as 150 m off Argentina (Cousseau 1973; Chiaramonte and Vooren 2007), and occur in temperatures between 10 °C and 22 °C (Vooren and da Silva 1991). The species lives in muddy or sandy bottom substrates and is relatively inactive during the day. This nocturnal activity makes the spiny angel shark more vulnerable to gillnet fisheries, which tend to operate at night (Vooren and Klippel 2005a).

Diet and Feeding

Spiny angel sharks are thought to be sit-and-wait predators, lying motionless on the bottom until prey passes closely overhead. The prey is then grasped by an upward bite (Vooren and da Silva 1991). Based on diet studies, the spiny angel shark appears to prefer bony fishes but will also feed on crustaceans, molluscs, and polychaetes (Vögler *et al.* 2003; Colonello 2005; Vögler *et al.* 2009). In the AUCFZ, a study of spiny angel shark trophic ecology found that, numerically, bony fish made up the vast majority of the diet, at 89.7 percent (Vögler *et al.* 2003). Crustaceans (4.8 percent), molluscs (4.4 percent), and polychaetes (0.46 percent) 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*, *Nototothenia longipes*, and *Merluccius hubbsi*. The crustaceans consumed were primarily shrimps (Penaeidae), while the squid *Illex argentinus* was the only species of mollusc consumed (Vögler *et al.* 2003, 2009).

Although ontogenetic and seasonal differences in diet have been observed for the species (Vögler *et al.* 2003; Colonello 2005; Vögler *et al.* 2009), bony fish remain the primary prey item for all size classes and during all

seasons, and, generally, as size of the spiny angel shark increases so does its trophic level. Ranging from a minimum trophic level of 3.69 for the smallest length group of spiny angel shark (23–60 cm) to a maximum trophic level of 4.40 for the largest length group (81–91 cm), the entire population of spiny angel sharks in the AUFCZ was estimated to have a trophic level of 3.90 (Vögler *et al.* 2003; 2009). For comparison, in aquatic environments, trophic levels tend to range from 2 (for species that are lower on the food chain, such as herbivores and detritivores) to 5.5 (for predators of marine mammals, such as the polar bear and killer whale) (Pauly *et al.* 2014).

Growth and Reproduction

Very few age and growth studies on the spiny angel shark could be found. In terms of length frequency distributions of spiny angel sharks, individuals 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, with no evidence of size dimorphism (Awruch *et al.* 2008). The largest recorded animals were 95 cm TL for both sexes (Awruch *et al.* 2008). Length at 50 percent maturity for males was reached at 76 cm TL and for females at 73 cm TL (Awruch *et al.* 2008).

Studies of spiny angel sharks farther north, 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); but, length at 50 percent maturity in males was not significantly different between El Rincón and Rio de la Plata (75 cm TL and 72.45 cm TL, respectively). However, length at 50 percent maturity was significantly different between study areas for females, with estimates of 71.34 cm TL in Rio de la Plata and 77.01 cm TL in El Rincón (Colonello *et al.* 2007).

In southern Brazil, spiny angel sharks reach a maximum length of 92 cm TL and age of 12 years (Vooren and Klippel 2005a). According to the characteristics for the *S. guggenheim* population presented in Vooren and Klippel (2005a), the relative growth rate (k) of the species from the von Bertalanffy growth equation is 0.275 year^{-1} with a theoretical maximum size (L_{∞}) of 94.7 cm TL. Length and age at first maturity is estimated to be 72 cm TL and 4 years,

respectively (Vooren and Klippel 2005a).

In terms of reproduction, the spiny angel shark has only one functional ovary (Vooren and da Silva 1991), with the maturation of ovarian follicles lasting about 2 years before ovulation, followed by gestation (Colonello *et al.* 2007). The female reproductive cycle is thought to be triennial (Colonello *et al.* 2007), with a gestation period that likely lasts 12 months (Colonello *et al.* 2007). Gestation begins in the summer (January–February) and pupping occurs the following spring (November–December) (Sunye and Vooren 1997). 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 and embryos up to 25 mm TL (Sunye and Vooren 1997). During mid-term gestation and parturition (June–November) the uteri undergo a physical reconfiguration, causing the uteri and cloaca to form a heart-shaped chamber where the embryos develop (Sunye and Vooren 1997). According to Sunye and Vooren (1997), because this uterine–cloacal chamber is open to the external environment through a cloacal vent, this anatomical configuration is thought to be the reason why *Squatina* species are observed easily aborting embryos during capture or handling.

Pupping occurs during the spring and summer months (September–March) in depths less than 20 m (Vooren 1997; Miranda and Vooren 2003). Litter sizes for the species range between 2 and 8 pups (Colonello *et al.* 2007; Vooren and Klippel 2005a). For spiny angel sharks in Argentina, Colonello *et al.* (2007) estimated an average of 4.07 pups per litter, with fecundity increasing with female length. In contrast, Vooren and Klippel (2005a) note that spiny angel sharks in southern Brazil frequently have 5 or 6 pups per litter, with the number of pups unrelated to female length. However, given the 3-year reproductive cycle, the range in pup estimates for spiny angel sharks results in a very low annual fecundity for the species (*e.g.*, between 0.67 and 2.67 pups per year) (Colonello *et al.* 2007; Vooren and Klippel 2005a). After pupping, juveniles of the species will remain in the shallow waters for one year before migrating out to the continental shelf (Vooren and da Silva 1991; Vooren 1997; Vooren and Klippel 2005a). In terms of known juvenile habitat, the area of Rio Grande do Sul between 31°50′ S. and 33°30′ S. at depths less than 20 m is considered a nursery area for spiny angel sharks (Vooren and Klippel 2005a).

Genetics and Population Structure

Recently, Garcia *et al.* (2015) examined the population structure of the spiny angel shark in the middle of its range, in and around the Rio de la Plata estuary. Using mitochondrial DNA (which is maternally-inherited DNA), the authors found that individuals from the outer estuary, surrounding coastal sites, and the outer shelf of the southwestern Atlantic showed no evidence of population genetic structuring. However, examination of nuclear recombinant DNA genes (which are biparentally-inherited) indicated that there was a remarkably high level of population genetic structure between the outer shelf spiny angel sharks and the coastal and outer estuarine angel sharks. In other words, the samples of spiny angel shark from the outer shelf represent an isolated group from the samples of spiny angel shark from the coastal and outer estuarine sites. Additionally, mitochondrial DNA indicated that the number of immigrant females per generation from the outer shelf to the Atlantic coast was much lower (2.8 individuals per generation) than the number of immigrant females per generation between the other populations (with estimates ranging from 12.8–46.9 individuals). All analyses revealed very low values of haplotype and nucleotide diversity from the recombinant DNA genes. Based on the low level of genetic diversity detected in *S. guggenheim*, Garcia *et al.* (2015) suggest the species has either undergone a long-term population decline or experienced a population bottleneck and recent expansion. Either scenario suggests a vulnerability to overexploitation, given the species' longevity and low reproductive potential. However, additional genetic studies are needed to better understand these patterns (Garcia *et al.* 2015).

Demography

Information on natural mortality rates or the intrinsic rate of population increase of the spiny angel shark is currently unavailable.

Historical and Current Distribution and Population Abundance

In northern Argentina, spiny angel sharks are considered to be a eurythermic coastal shelf species with highest abundances on the outer coastal shelf between depths of 28.9 m and 49.6 m (Jaureguizar *et al.* 2006). In the Rio de la Plata estuary, Argentina, spiny angel sharks were present most frequently in the deepest estuarine zone (12.6 m–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 AUCFZ, spiny angel shark distribution appears to be influenced by temperature, with clear avoidance of water temperatures below 5 °C and above 20 °C (Vögler *et al.* 2008). Specifically, Vögler *et al.* (2008) found that spiny angel sharks concentrate in water temperatures between 13.2 °C and 18.5 °C in the spring and between 7.0 °C and 15.0 °C in the fall. They prefer salinities between 33.4 and 33.5, with avoidance of salinities below 33.0 and above 34.0. Additionally, 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 (Vögler *et al.* 2008). In Rio de la Plata, in the AUCFZ, spiny angel shark densities are particularly high along the Uruguayan coast in the spring, which is thought to be related to the presence of higher salinity waters on the Uruguayan coast than the Argentine coast during this season (Colonello *et al.* 2007).

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 (at depths between 10 m and 100 m) from Solidão to Chuí, with some areas recording CPUE densities as high as 50 kg/h (Vooren and Klippel 2005a). According to Vooren and Klippel (2005a), a portion of the *S. guggenheim* population makes seasonal migrations across the continental shelf, which is related to the 3-year reproductive cycle of the species (*i.e.*, one third of adult females in the population will migrate per year to give birth). Specifically, this inshore migration is into depths between 10 m and 40 m and occurs in the spring and summer (September–March) for pupping and likely mating purposes (as adults of both sexes conduct this migration in addition to pregnant females) (Vooren 1997; Miranda and Vooren 2003). As mentioned previously, newborns remain in these shallow waters (<20 m) for the first year of their life before migrating to deeper waters on the continental shelf. The other, larger portion of the population, which is not moving seasonally and includes both juveniles and adults of both sexes, are most abundant in depths of 40 m to 60 m year-round (Vooren and Klippel 2005a). In fact, research surveys off of Ubatuba, São Paulo, Brazil caught spiny angel sharks in shallow sampling stations around 20 m deep, but found

that they were most abundant near 50 m depths (Rocha *et al.* 1998).

In general, very few abundance estimates are available for the species. According to Chiaramonte and Vooren (2007), the spiny angel shark is likely composed of smaller, localized populations throughout its range. In Argentinian waters, fishery surveys and commercial data provide limited indication of abundance and trends in this part of the species' range. In 1993, for example, the abundance of spiny angel sharks in the San Matías Gulf, Argentina (southern Argentina) was estimated to be 192.53 t (Argentina FAO NPOA-sharks 2009); however, the San Matías Gulf makes up a very small portion (approximately 9.6 percent) of the spiny angel shark's range and no recent abundance estimates could be found. Surveys of the continental shelf in northern Argentina (between 34° S. and 41° S.; approximately 20 percent of the species' range), conducted during the spring when abundance of spiny angel sharks is highest, provided estimates of mean biomass density of 0.518 t/nm² in 1981, 1.305 t/nm² in 1995, and 0.394 t/nm² in 1999 (Jaureguizar *et al.* 2006). Catch rates of the species were also fairly high based on data from trawl research surveys conducted in this same area from October 1997 to June 1998, especially during the inshore spring/summer migration months (September to March). Specifically, CPUE ranged from 25 sharks/30 min of trawling in March to 80 sharks/30 min of trawling in October (Vogler *et al.* 2008). A later study, conducted from 2000–2003 and in the same area, also recorded high densities of the species during the spring months (November–December) with estimates of 750 to <1500 kg/km² (equivalent to 2.58–5.15 t/nm²) (Colonello *et al.* 2007). However, based on fishery-independent data collected during research surveys conducted in the winter of 1993 and 2004, and spring of 1994, 1999, 2003, and 2005, Massa and Hozbor (2008) observed a decrease in the biomass of *S. guggenheim*, mainly between the winter seasons of 1993 and 2004. Trends in biomass for the spring time cruises were less clear, with decreases estimated between 1994 and 1999 and between 2003 and 2005, and increases between 1999 and 2003 (Massa and Hozbor 2008). Declines were also observed in the CPUE of fishing fleets operating on the Argentinian shelf, particularly for the smaller-sized vessels (<28 m) that fish in shallower waters on the shelf and would most likely interact with spiny angel sharks. These vessels saw declines of up to 58 percent in CPUE of *Squatina*

spp. (of which spiny angel sharks are thought to comprise the majority) between the years of 1992 and 1998 (Massa and Hozbor 2003). In the spring of 2003, the estimated biomass of spiny angel sharks for all of coastal Argentina was 23,600 t (Massa *et al.* 2004b). Information about effort was not provided and more recent abundance or biomass estimates could not be found.

In Brazil, there are no biomass estimates for the species and most of the fisheries data for angel sharks is grouped into a general *Squatina* spp. category; however, spiny angel sharks are thought to comprise the majority of the group (Vooren and da Silva 1991; Cousseau and Figueroa 2001; Vooren and Klippel 2005a). Off Rio Grande do Sul (between 35° S. and 28° S.), where spiny angel sharks are primarily exploited in Brazil, mean annual landings of all angel sharks were over 2000 t from 1985 to 1994 but fell to 607 t by 1997. In 1995, mortality rates of *S. guggenheim* exceeded population growth rates leading to an annual population decline rate of 16 percent (Vooren and Klippel 2005a citing Vieira 1996). Based on CPUE data from fisheries operating in this area, the population of *S. guggenheim* is estimated to have declined by 85 percent between 1986 and 2002 (Vooren and Klippel 2005a). Catches of angel sharks have continued to decline; however, landings of both *S. guggenheim* and *S. occulta* have been prohibited in Brazil since 2004, and this could explain why catches have declined.

Summary of Factors Affecting the Spiny Angel Shark

We reviewed the best available information regarding historical, current, and potential threats to the spiny angel shark. We find that the main threat to this species is overutilization for commercial purposes. We consider the severity of this threat to be somewhat reduced by the species' relatively high abundance in the southern portions of its range; however, its demographic characteristics (including very low productivity, limited connectivity, and low genetic diversity) increase the susceptibility of the species to depletion and, with the continued fishing pressure on the species, places it at an increased risk of extinction. We summarize information regarding these threats and their interactions below according to the factors specified in section 4(a)(1) of the ESA. Available information does not indicate that habitat destruction or curtailment, disease, predation or other natural or manmade factors are

operative threats on these species; therefore, we do not discuss these factors further in this finding. See Casselbury and Carlson (2015e) for discussion of these ESA section 4(a)(1) threat categories.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The primary threat to spiny angel sharks is overutilization in commercial and artisanal fisheries as the species is heavily fished throughout its entire range, including within its nursery grounds. As noted previously, the vast majority of fisheries information available on angel sharks from Argentina, Uruguay, and Brazil is reported as *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, whereas information specific to *S. guggenheim* will specifically reference spiny angel sharks.

In Argentina, there is no directed fishery for angel sharks, but they are captured in multispecies artisanal shark fisheries and are considered a valuable bycatch species (Chiaramonte 1998; Bornatowski *et al.* 2011). The spiny angel shark, in particular, is commercially exploited in local fisheries that occur in the San Matías Gulf, Argentina (Perier *et al.* 2011), which comprises around 10 percent of its range. The species is also commercially exploited by the fisheries operating in the AUCFZ, which, based on survey data, overlaps with areas of higher concentration of the species (Jaureguizar *et al.* 2006; Colonello *et al.* 2007; Massa and Hozbor 2008; Vögler *et al.* 2008) and comprises around 25 percent of the species' range. 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), and in 2007, angel shark export revenue in Argentina totaled \$2,732,274 U.S. dollars (Argentina FAO NPOA-sharks 2009).

In Argentina, in the 1990s, angel sharks were considered commercially important bycatch, particularly in the Necochea school shark (*Galeorhinus galeus*) gillnet fishery. During the 1980s, the school shark became an important resource for coastal fisheries, and by the 1990s, it was the main shark fishery in the Southwest Atlantic (Chiaramonte 1998). As the school shark was traditionally fished using gillnets, the fishery also landed significant amounts of demersal angel sharks (*S. guggenheim* and *S. argentina*), the majority of which

were gravid females (Chiaramonte 1998). Angel sharks (likely comprised primarily of *S. guggenheim*) became the second most important fish in the Necochea artisanal gillnet fishery (Chiaramonte 1998). In fact, total declared landings of angel sharks in Argentina between 1992 and 1996 steadily rose from 1,358.6 mt to 4,281.1 mt with the majority (66 to 75 percent) of the landings attributed to coastal fishing vessels (Chiaramonte 1998). Massa and Hozbor (2003) report even higher landings figures for the years of 1992 to 1995, with landings over 3,500 mt and totaling more than 14,500 t for that time period. From 1996 to 1998, annual landings of angel sharks reached over 4,000 mt (Massa and Hozbor 2003). Although landings of angel sharks were relatively high and fairly stable throughout the 1990s, there were corresponding decreases in CPUE, signifying a decline in the abundance of angel sharks that can likely be attributed to overutilization of *S. guggenheim*. According to Massa and Hozbor (2003), the small coastal vessels (<20 m in length), which were responsible for the majority of angel shark landings, saw CPUE decline from 12 kg/hour in 1992 to around 5 kg/hour by 1998, a decrease of around 58 percent. The larger fishing vessels (of 20 m–28 m in length and >28 m in length), which focus effort on the inner and outer continental shelf (habitat for larger juveniles and adults of the species), experienced declines in CPUE of angel sharks of around 44 and 50 percent, respectively (Massa and Hozbor 2003).

Current fishing pressure remains high on the spiny angel shark in Argentinian waters. In fact, recent landings of angel sharks, and just from the AUCFZ portion of the species' Argentinian range, suggest total Argentinian landings have likely been of similar magnitude as those totals reported in the 1990s (CTMFM 2015). In 2010, total landings in the AUCFZ amounted to 3,763 t and were over 3,000 t in 2011. In 2012, landings were 2,736 t and by 2013 and 2014 dropped to below 2,300 t (CTMFM 2015). Although landings have remained high in recent years, they also appear to be on a declining trend. Given that catch levels in the 1990s, which resulted in declines of up to 58 percent in the species' abundance, remained at similar levels in 2010 and 2011, suggests that the decrease in landings may likely be a result of a declining spiny angel shark population as opposed to a decrease in fishing effort. In fact, since 2006, the total number of vessels in Argentina's fishing fleet has remained fairly stable (OECD

2014), and, as of June 2014, there were 635 vessels authorized to operate in the AUCFZ, with more than half of these vessels identified as trawlers (CTMFM 2015). Additionally, of the 635 vessels, around 20 percent identified as coastal vessels, suggesting that fishing pressure and associated fishery-related mortality will continue to be a threat to all life stages of the species into the foreseeable future.

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). The Uruguayan artisanal and industrial trawling fleets primarily operate at depths between 10 m and 200 m, which covers the entire depth range of the spiny angel shark. Annual catches of angel sharks in Uruguay were less than 100 t from 1977 to 1996 and ranged between 200 t and 400 t between 1997 and 2005, with the majority likely spiny angel sharks (Domingo *et al.* 2008). Currently, Uruguay has a fishing fleet of 62 vessels operating within the AUCFZ, with Uruguayan vessels responsible for around 5.6–7.5 percent of the total angel shark landings from this area from 2010 to 2013. In 2014, this proportion sharply increased to 18.4 percent as did the total number of landings (from 26 t in 2012 to 142 t and 158 t in 2013 and 2014, respectively) indicating a potential increasing trend in the exploitation of the spiny angel shark by Uruguayan fishing vessels.

In southern Brazil, spiny angel sharks have been heavily fished by industrial trawlers and gillnet fleets for the past few decades (Haimovici 1998; Vögler *et al.* 2008). In fact, mean annual landings of all angel sharks (of which the majority were likely *S. guggenheim*) were over 2000 t from 1985 to 1994, with a peak of 2,296 t in 1993. Given the depth and distribution of *S. guggenheim* on the Plataforma Sul, (which likely extends from <10 m to up to 150 m depths based on species accounts in Argentina; Cousseau 1973; Vooren and da Silva 1991; Chiaramonte and Vooren 2007), it is highly susceptible to being caught by the various types of industrial fleets operating on the continental shelf, including the pair trawl fleet, which primarily operates off the coast and on the inner continental shelf (up to depths of 100 m), and the simple trawl fleet, which primarily focuses the outer continental shelf (in depths of 50 m to <200 m) (Vooren *et al.* 2005 a; Klippel *et al.* 2005). Although *S. guggenheim* did not appear to be a species of interest

in the mid-1970s, this started to change by the early 1980s. For example, in the simple trawl fleet, which operated out of Rio Grande in depths of 50 m–100 m and engaged in multi-species fisheries directed towards bony fishes (Klippel *et al.* 2005; Vooren and Klippel 2005a), the proportion of angel sharks (*S. guggenheim* and *S. occulata*) in the landings steadily rose from 1975 to 1986. From 1975–1979, the proportion of angel sharks in the landings data was estimated to be 3.5 percent (range: 2.6–4.1 percent) and for the period covering 1980–1986, this had increased to 6.2 percent (range: 5.3–7.2 percent) (Vooren and Klippel 2005a). Although the simple trawl fleet did not specifically target *Squatina* spp., the increase of angel sharks in landings suggests a greater interest in the species and indicates that it was incidentally caught and retained during regular fishing operations (Vooren and Klippel 2005a). In 1987, the proportion of angel sharks in the landings reached a peak of 9.5 percent, which Vooren and Klippel (2005a) suggest may be evidence of a directed fishery for the species in the simple trawl fleet. However, after 1987, the angel shark proportion in the landings significantly decreased, dropping to 5.4 percent in 1990 and 0.5 percent by 2001 (Vooren and Klippel 2005a). The CPUE of angel sharks (*S. guggenheim* and *S. occulata*) by the simple trawl fleets also decreased over this time period, from an average of 2.75 t/trip (range: 2.59–3.02 t/trip) from 1980–1988 to 0.41 t/trip (range: 0.26–0.62 t/trip) over the years 1997–2002. This 85 percent decrease in CPUE of the species suggests that the declining trend in the landings data was likely indicative of overexploitation that led to a decline in the species' abundance in the fishing area where these fleets operate (Vooren and Klippel 2005a). Additionally, given that CPUE of angel sharks (*S. guggenheim* and *S. occulata*) in the Rio Grande pair trawl fleet also declined over this time period, the decrease in abundance of angel sharks was likely widespread over the continental shelf. In the pair trawl fleet, CPUE decreased from 0.94 t/trip (range: 0.34–1.39 t/trip) to 0.12 t/trip (range: 0.08–0.17 t/trip) between the periods of 1980–1988 and 1997–2002, a decline of 87 percent (Vooren and Klippel 2005a). In 1995, it was estimated that the fishing mortality rate of *S. guggenheim* had exceeded its population growth rate, resulting in an annual rate of population decline of 16 percent (Vooren and Klippel 2005a citing Vieira 1996). Based on the above data, as well as data from fishery research surveys, Vooren and

Klippel (2005a) estimate that the *S. guggenheim* population on the Plataforma Sul decreased by around 85 percent between 1986 and 2002, with the decline occurring simultaneously with the increase in fishing effort and caused by overexploitation of the species.

However, spiny angel sharks are not only at risk of fishing mortality from the industrial trawl fleets operating on the Plataforma Sul, but also from the commercial oceanic gillnet fisheries which began expanding in the 1990s. As the trawl fleets saw catches start to decline, due to the overexploitation of the marine resources, many trawlers began converting their boats to gillnet vessels in the early 1990s. These vessels would fish at depths of up to 300 m, with the oceanic bottom gillnet fishermen specifically targeting sharks and, based on CPUE data, potentially *Squatina* species (Miranda and Vooren 2003). The number of gillnet vessels as well as fishing effort increased throughout the 1990s, with annual landings of angel sharks by the oceanic gillnet fleet of more than 800 t between the years 1992 to 1998 (Klippel *et al.* 2005). Mazzoleni and Schwingel (1999; cited by Klippel *et al.* 2005) report that landings of the three angel shark species (*S. guggenheim*, *S. occulta* and *S. argentina*) were common in the Santa Catarina bottom gillnet fleet operating on the Plataforma Sul between 1994 and 1999. However, from 1999 to 2002, annual landings of angel sharks had dropped in half (Klippel *et al.* 2005). The CPUE of the fleet also decreased, from a maximum of 4.3 t/trip in 1992 to values that varied between 0.5 t/trip and 1 t/trip in the following years (from 1994–2002; Klippel *et al.* 2005).

Likely contributing to the decreases in CPUE seen in both the industrial trawl and gillnet fleets is the fact that the majority of landings from these fisheries consist of juvenile angel sharks which, after spending their first year in depths <20 m, migrate out over the continental shelf (see *Historical and Current Distribution and Population Abundance* section). In an examination of landings at the Port of Rio Grande between June 2002 and July 2003, Klippel *et al.* (2005) found that around 70–85 percent of the spiny angel sharks were juveniles (TL <72 cm). The proportion of juveniles was highest in the landings from the double-rig trawl fleet, which is to be expected as the fleet primarily operates in depths <50 m (Klippel *et al.* 2005). However, the proportion of juveniles was still high, around 70 percent, in the landings of the bottom gillnet, pair, and single trawl fleets, which operate from the coast to depths >200 m (Klippel *et*

al. 2005). The removal of primarily juveniles from a population can have significant negative impacts on recruitment, especially for a species with a 3-year reproductive cycle. And, in fact, in a 2005 bottom trawl survey conducted in the coastal waters of the Plataforma Sul between Torres and Chuí, only neonate spiny angel sharks were caught, despite the fact that both juveniles and adults would be expected within the trawled depth range (7 m–20 m) (Vooren *et al.* 2005b). The CPUE of *S. guggenheim* was also low compared to historical estimates, with an estimate of only 0.18 kg/h (Vooren *et al.* 2005b).

Despite the decreases observed in spiny angel shark abundance on the Plataforma Sul, fishing effort remains high. Additionally, all life stages of spiny angel sharks are susceptible to the industrial shelf fisheries as the fleets operate year round covering the entire depth distribution of the species. In fact, in 2002, it was estimated that the fishing effort of the industrial trawl fleet from Rio Grande do Sul and Santa Catarina (the two largest fishing fleets operating on the Plataforma Sul) trawled around 141,000 km², corresponding to approximately 50 percent of the land area of the state of Rio Grande do Sul (Klippel *et al.* 2005). Hypothetically, if the area swept by each trawl vessel was different, the 100,907 km² of the Plataforma Sul would be completely swept every 9 months (Klippel *et al.* 2005). When considering the number of gillnet vessels, nets, and the total length of these nets operating on the Plataforma Sul, it was estimated that the length of these gillnets (combined) would equate to around 8,250 km, which corresponds to approximately the entire length of the Brazilian coast (Klippel *et al.* 2005). In 2002, a total of 892 t of angel sharks were landed, with 62 percent landed in Santa Catarina and 38 percent in the Rio Grande do Sul. The oceanic gillnet fleet was responsible for most of the landings (42 percent), followed by double-rig trawl fleet (25 percent), and the coastal gillnet, pair, and single trawl fleets, which each contributed about 10 percent of the landings (Klippel *et al.* 2005). These fleets, which historically contributed to the decline in *S. guggenheim* on the Plataforma Sul, remain active today.

Furthermore, as previously discussed in the other species assessments, these fleets operate at high efforts on the Plataforma Sul and especially within important coastal nursery and inner shelf habitats for the species. Although landings of the species are currently prohibited, the fleets' extensive operations will continue to contribute to the fishing mortality of all life stages of

the species as the spiny angel shark likely has high discard mortality rates based on rates estimated for similar angel shark species. For example, the at-vessel mortality rate reported for the African angel shark (*S. africana*) is 60 percent in prawn trawlers (Fennessy 1994) and 67 percent in protective shark gillnets (Shelmerdine and Cliff 2006). For the Australian angel shark (*S. australis*), mortality rate estimates of 25 percent and 34 percent have been reported for sharks caught in gillnets (Reid and Krogh 1992; Braccini *et al.* 2012). These two angel shark species have similar life history traits and ecology, including: Reproductive characteristics (ovoviviparous and produce small litters; Compagno 1984; Rowling *et al.* 2010), maturity and maximum sizes (Compagno 1984), depth distribution (continental shelf and upper slope), behavior, and diet (mainly teleosts; Shelmerdine and Cliff 2006; Rowling *et al.* 2010). Given the general similarities, it seems reasonable to infer similar discard survival rates for the spiny angel shark from these other two *Squatina* species. As such, given the sensitive life history traits of the spiny angel shark as well as the evidence of significant population declines, an assumed 60 percent at-vessel mortality rate in trawl fisheries and 25–67 percent mortality in gillnets is likely to significantly contribute to the overutilization of the species and increase its extinction risk.

These industrial trawl and gillnet fleets currently participate in nationally important fisheries and, as such, the threat they pose to *S. guggenheim* is unlikely to decrease in the foreseeable future. In fact, in the oceanic drift gillnet fishery, the fishery responsible for the highest landings of angel sharks, the main fish species targeted (*Umbrina canosai*, *Cynoscion guatucupa*, and *Micropogonias furnieri*) represented around 12.8 percent of the total national marine fish landings in 2011 for all of Brazil. *Micropogonias furnieri* is the second most landed fish nationally, and *U. canosai* is the seventh most landed. Based on the above information, the significant level of fishing effort and associated fishing mortality, especially of juvenile angel sharks, likely caused and will continue to cause substantial declines in the spiny angel shark population.

Inadequacy of Existing Regulatory Mechanisms

In the AUCFZ, the area comprising around one quarter of the species' range, and where survey data suggest the species is likely at highest concentration (Jaureguizar *et al.* 2006; Colonello *et al.*

2007; Massa and Hozbor 2008; Vogler *et al.* 2008), spiny angel sharks are commercially exploited. Similar to the narrownose smoothhound, the CTMFM manages this exploitation through the implementation of catch limits and fishery closures. As stated previously, the CTMFM implements an annual prohibition against demersal trawling in a large section of the AUCFZ, extending across the continental shelf, in order to protect vulnerable chondrichthyans from fishery-related mortality. The CTMFM also establishes additional area closures to trawling gear throughout the year in the AUCFZ to protect other species, with these closures also indirectly protecting spiny angel sharks from further fishery-related mortality from trawl gear. In terms of the direct management of spiny angel sharks, since 2012, the CTMFM has set a total permissible catch limit for all *Squatina* spp. at 2,600 t (Res. N° 8/14, Res. N° 10/13, Res. N° 10/12). In November 2012, this limit was met and landings of *Squatina* spp. were banned for the month of December (Res. N° 13/12). In 2013, an additional reserve of 400 t was proposed to be allowed if the 2,600 t limit was reached; however, total landings had decreased from the previous year to 2,103 t (CTMFM 2015). In 2014 a 10 percent increase in total allowable catch was allowed to be added to the limit if the CTMFM saw fit (Res. N° 10/13, Res. N° 8/14); but this was unnecessary as landings amounted to only 2,281 t (CTMFM 2015). In 2015, the CTMFM kept the same limit that was implemented in 2014 (2,600 t with an allowance of 10 percent increase; Res. N° 07/15). Although McCormack *et al.* (2007) report that elasmobranch quotas and size regulations are largely ignored in Argentina and poorly enforced, *Squatina* landings have been below the maximum catch limit in recent years, providing evidence that regulations are potentially being followed. However, without effort information, it is unclear whether these regulations and the corresponding decreases in landings can be attributed to adequate control of the exploitation of the species or rather reflects the lower abundance of the species from declining populations, or more likely a combination of the two scenarios.

In Uruguay, regulations that likely contribute to decreasing the fishery-related mortality of the species include a summer trawling ban in 25 m to 50 m depths between La Paloma and Chuy and specific fishery area closures in the spring, summer, and autumn on the Uruguayan continental shelf, designated to protect juvenile hake (*Merluccius*

hubbsi) (Pereyra *et al.* 2008). Although the depth distribution of the spiny angel shark in Uruguayan waters is unresolved, in southern Brazilian waters, the species was previously common year-round at depths between 10 m and 100 m. Specifically, adults were frequently found in waters between 40 m and 100 m during the autumn and winter and between 10 m and 40 m in the spring and summer; and both adults and juveniles were abundant in depths of 40 m–60 m year-round (Vooren 1997; Miranda and Vooren 2003; Vooren and Klippel 2005a). In northern Argentina, spiny angel sharks displayed highest abundances on the outer coastal shelf between 29 m and 50 m depths (Jaureguizar *et al.* 2006). Using the above depth distribution in areas just north and south of Uruguay as a proxy for the species' depth distribution in Uruguayan waters, it is likely that the proposed fishery closures and trawling bans will provide some level of protection from fishery-related mortality, especially during the species' spring/summer migration to shallower waters for pupping and potentially mating purposes.

The spiny angel shark is also listed as a species of high priority in Uruguay's FAO NPOA-sharks (Domingo *et al.* 2008). The plan, as stated previously, has set goals to collect the necessary information on its priority species in order to conduct abundance assessments, review current fishing licenses, and promote public awareness to release captured individuals. However, no updated results from the goals and priorities of this plan could be found.

In Brazil, the spiny angel shark is listed on Annex 1 of Brazil's endangered species list and classified as critically endangered (Directive N° 445). As described in previous species accounts, an Annex 1 listing prohibits the catch of the species except for scientific purposes, which requires a special license from IBAMA. There is also a prohibition of trawl fishing within three nautical miles from the coast of southern Brazil, although the enforcement of this prohibition has been noted as difficult (Chiaramonte and Vooren 2007). In addition, the species is still susceptible to being caught as bycatch in the legally permitted coastal gillnet fisheries and offshore trawl and gillnet fisheries and vulnerable to the associated bycatch mortality (Lessa and Vooren 2007). The spiny angel shark is also listed as one of the 12 species of concern under Brazil's FAO NPOA-sharks and would benefit from the proposed fishing closures and other

management measures outlined in the plan. This includes the fishing moratorium and marketing ban, which is proposed to be in effect until there is scientific evidence that supports population recovery of the spiny angel shark. It also suggests that a fishing exclusion area be established in the coastal zone (specifically over a large region of the coast of Rio Grande do Sul at depths of 20 m) to protect important nursery grounds for the species. However, as mentioned previously, the plan was only just approved as of December 2014 and will not be fully implemented for another 5 years. Thus, the implementation and effectiveness of the recommendations outlined in the plan remain uncertain, with the best available information indicating that current regulatory measures in Brazil to protect vulnerable species are poorly enforced.

Extinction Risk

The best available information provides multiple lines of evidence indicating that the *S. guggenheim* currently faces a moderate risk of extinction. Below, we present the demographic risk analysis, threats assessment, and the overall risk of extinction for the spiny angel shark.

Demographic Risk Analysis

Abundance

Spiny angel sharks are likely the most abundant angel shark species from southern Brazil to Argentina; however, current quantitative estimates of abundance of the species throughout its range are unavailable. In Argentina, the abundance of spiny angel sharks in the San Matías Gulf (which comprises around 9.6 percent of the species' range) was estimated to be 192.53 t in 1993. In 2003, the estimated biomass of spiny angel sharks for all of coastal Argentina was 23,600 t. No other population estimates have been calculated for the species. Additionally, between 1981 and 2004, catch rates and density estimates for areas off the Argentine continental shelf have been variable; however, fishing fleets reported declines of up to 58 percent in CPUE between 1992 and 1998.

In Brazil, quantitative information, in the form of CPUE and landings data for the fishing fleets operating on the Plataforma Sul, is available for all angel shark species, of which *S. guggenheim* likely comprises a majority. These data provide insight into trends in abundance of the spiny angel shark in roughly 20 percent of its range. Based on a comparison of the CPUE estimates of angel sharks caught on the Plataforma

Sul in both the single and pair trawl fishing fleets over the time periods of 1980–1988 and 1997–2002, the population of *S. guggenheim* off southern Brazil has declined by around 85 percent since 1985 (Miranda and Vooren 2003; Vooren and Klippel 2005a). More recent landings data from the Santa Catarina oceanic gillnet fishery, covering the years 2001–2010, show a peak in angel shark landings in 2004 of 340 mt before significantly dropping, with only 2.6 mt landed in 2010. However, in 2004, landings of *S. guggenheim* along with *S. occulta* were prohibited and, as such, the decline in landings data after 2004 may be a reflection of this prohibition.

Based on the commercial fishery information, it is likely that spiny angel sharks have experienced varying levels of population decline throughout its range. In the northern half of the species' range (off Brazil), the best available information indicates the species has undergone rather substantial population declines, with evidence of negative population growth rates that led to significant decreases in the overall abundance of the species to the point where catch rates and observations of spiny angel sharks are extremely low. Off Uruguay and Argentina, where reported biomass estimates suggest the species was and is likely still most concentrated, the higher abundance levels may explain why the magnitude of population decline is estimated to be smaller in this portion of the species' range. Therefore, while the species may not be of such low abundance such that it is currently at risk of extinction, given the high exploitation of the species throughout its range and subsequent population decline in the northern half, coupled with the species' low productivity, abundance levels will likely continue to decline through the foreseeable future to the point where it may be a significant contributing factor to the species' overall extinction risk.

Growth Rate/Productivity

There is minimal information on the growth rate and productivity of the species. Based on the estimated von Bertalanffy growth parameters, the spiny angel shark exhibits rather fast growth rates for a shark species (with a growth coefficient (k) of 0.275/year; Vooren and Klippel 2005a). Fast growth rates help protect species from extinction by allowing species to attain larger sizes at earlier ages, protecting it from predation, and also allowing species to attain sexual maturity sooner, thereby contributing to population growth. The fast growth rates of the

spiny angel shark likely led to the species being the most common angel shark found in the southwest Atlantic. However, despite its fast growth rates, the spiny angel shark has a significantly lengthy reproductive cycle of 3 years, with a litter size ranging between 2 and 8 pups and an average of around 4–5 pups/litter. This translates to an annual fecundity between 0.67 and 2.67 pups per year. Spiny angel sharks are also thought to have cloacal gestation during the latter half of pregnancy, which is thought to be the reason why *Squatina* species are observed easily aborting embryos during capture or handling. Given the already low annual fecundity of the species, any further loss of embryos would significantly decrease their already low reproductive output. Overall, these reproductive characteristics suggest the species has relatively low productivity, similar to other elasmobranch species, which may hinder the species' ability to quickly rebound from threats that decrease its abundance (such as overutilization) and render the spiny angel shark more vulnerable to extinction in the face of other demographic risks and threats.

Spatial Structure/Connectivity

The spiny angel shark has a widespread range in the southwest Atlantic but is thought to be comprised of smaller, more localized populations (Chiaromonte and Vooren 2007); however, information to support this is currently unavailable. Information on the connectivity among *S. guggenheim* populations throughout its range is limited. The populations occurring on the Plataforma Sul, off southern Brazil, are assumed to carry out their entire lifecycle within the same area. This behavior indicates that these populations maintain population growth by recruiting within each area without producing a necessary excess of recruits with the potential to migrate to other areas (Vooren and Klippel 2005a). As a result, *S. guggenheim* populations on the Plataforma Sul likely have limited movement and dispersal migration between neighboring populations, with migrants having no impact on the short term abundance of a population. Based on genetic studies, there is also evidence of limited connectivity between populations found in other parts of the species' range. For example, genetic analyses of individuals found around the Rio de la Plata estuary indicate a high level of population genetic structure between the spiny angel sharks that occur on the outer shelf and those that are found in the outer estuarine and coastal waters (with very few immigrants between these

populations) (Garcia *et al.* 2015). In other words, the evidence of limited inter-population exchange observed in the species reduces the recovery potential for the depleted and small local populations found throughout the range, and may increase the risk of local extirpations, possibly leading to complete extinction.

Diversity

A recent genetic analysis using maternally-inherited mitochondrial DNA markers from spiny angel sharks in and around the Rio de la Plata Estuary (approximately mid point of the species' range) found no evidence of population genetic structuring (Garcia *et al.* 2015). However, analyses using biparentally-inherited nuclear recombinant DNA genes indicated that there was a remarkably high level of population genetic structure between spiny angel sharks found on outer shelf and those in the coastal and outer estuarine areas (Garcia *et al.* 2015). The 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, with the genetic patterns of exchange potentially explained by sex-biased behavior or long term shifts in spatial and temporal environmental variables leading to current displacements (Garcia *et al.* 2015). However, 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) and will likely render the spiny angel shark more susceptible to extinction in the face of other demographic risks and threats.

Threats Assessment

The primary threat to *S. guggenheim* is overutilization in artisanal and commercial fisheries. The vast majority of fisheries information on angel sharks is generally reported as "*Squatina spp*" throughout Brazil, Uruguay, and Argentina; however, spiny angel sharks are thought to be the most abundant angel shark species from southern Brazil to Argentina and, therefore, likely comprise the majority of the *Squatina* species that are landed.

In Argentina, although the species is not directly targeted, they are caught incidentally in multispecies artisanal shark fisheries and are considered a valuable bycatch species (Chiaramonte 1998; Bornatowski *et al.* 2011). Fishery-independent research surveys have recorded relatively high densities of the species on the Argentinian shelf; however, based on CPUE data, the

population saw declines of up to 58 percent in the late 1990s. Although exploitation of the species in the AUCFZ, where the species appears to be at highest concentration, has been managed since 2012 with area closures and catch limits, the lack of recent abundance estimates or trends hinders an evaluation of the adequacy of current regulatory measures in preventing the overutilization of the species from this portion of its range. It is important to note that landings prior to 2012 from this area were on the same order of magnitude as those reported for all of Argentina and which subsequently led to the declines observed in the late 1990s. Landings have since decreased since the implementation of the catch limits, and appear to be on a declining trend; however, the number of fishing vessels authorized to operate in the AUCFZ has remained fairly stable, potentially indicating that fishing effort has not decreased substantially in recent years. In other words, the recent declining trend in landings, even below total allowable catch limits, may indicate decreasing abundance of the species in this part of its range.

In Uruguay, spiny angel sharks are both targeted and caught as bycatch by industrial trawling fleets in coastal and offshore waters (Vögler *et al.* 2008; Domingo *et al.* 2008). All life stages of the species are exploited as the fleets operate over the entire depth range of the species (between 10 m and 200 m). Abundance and trends of the species within this region are unknown; however, declines in populations just north and south of this region have been observed, with the species listed as high priority in Uruguay's FAO NPOA-sharks. Additionally, landings of angel sharks by Uruguayan vessels in the AUCFZ have increased in both number and proportion of total angel shark landings in the AUCFZ, indicating a potential increase in fishing effort of this vulnerable species.

In Brazil, spiny angel sharks have been heavily exploited by industrial trawlers and gillnet fleets since the 1980s (Haimovici 1998; Vögler *et al.* 2008). In southern Brazil, angel shark landings are recorded in industrial single trawl, pair trawl, oceanic bottom gillnet, and coastal artisanal fisheries. These industrial and coastal artisanal fleets operate year round in depths that span <20 m to 300 m, including during the sharks' reproductive seasonal migrations, and hence capture all life stages of spiny angel sharks (Vooren and Klippel 2005a). The impact of this fishing pressure and effort led to observed declines in *S. guggenheim* (around 85 percent), with fishing

mortality rates exceeding population growth rates and resulting in an annual rate of population decline of 16 percent for spiny angel sharks in the mid 1990s (Vorren and Klippel 2005a). Although many trawlers began converting their boats to gillnet vessels in the early 1990s (due to decreases in catch), the threat of overutilization remains as the oceanic bottom gillnet fishermen also fish at depths of up to 300 m and now land the majority of angel sharks, of which 70–85 percent are juveniles (Klippel *et al.* 2005). Although spiny angel sharks have been a prohibited species since 2004, the fishing effort (both by trawl and gillnet fleets) on the Plataforma Sul remains high and poorly regulated, and, therefore, the susceptibility of the species' to fishery-related mortality also remains high. The industrial gillnet and trawl fleets, which contributed to the historical decline in the population off southern Brazil, are active today and participate in nationally important fisheries. Given the percentage of juveniles caught by these fisheries coupled with the assumed discard mortality rates, the continued operations of these fleets will likely have significant negative impacts on *S. guggenheim* recruitment to the population, especially for a species with a 3-year reproductive cycle. The present level of fishing effort by the artisanal and industrial fisheries on Brazil's continental shelf will continue to lead to declines in the spiny angel shark population and, hence, contribute to the extinction risk of the species.

Risk of Extinction

There is significant uncertainty regarding the current abundance of the species throughout its entire range. While the Brazilian populations have experienced substantial declines and remain at risk from overutilization by fisheries, the same cannot be concluded with certainty for the populations farther south in the species' range. Based on the available data, the populations off Uruguay and Argentina have likely experienced moderate declines, with recent landings and vessel data potentially indicating a decreasing trend in abundance and stable or increasing trend in fishing effort. The significant demographic risks to the species (*e.g.*, extremely low fecundity, declining population growth rate, and limited connectivity), the decline and subsequent rarity of the species in an area that comprises around half of its range, and the evidence of continued and heavy fishing pressure on the species throughout its entire range, place the species on a trajectory indicating that it will more likely than

not be at a high level of extinction risk in the foreseeable future. Therefore, based on the best available information and the above analysis, we conclude that *S. guggenheim* is presently at a moderate risk of extinction throughout its range.

Protective Efforts

With the exception of the recommendations within the FAO NPOA-sharks discussed above, we were unable to find any other information on protective efforts for the conservation of spiny angel sharks in Argentina, Uruguay, or Brazil that would potentially alter the extinction risk for the species. We seek additional information on other conservation efforts in our public comment process (see below).

Proposed Determination

Based on the best available scientific and commercial information as presented in the status review report and this finding, we find that the spiny angel shark is not presently in danger of extinction throughout its range but likely to become so in the foreseeable future. We assessed the ESA section 4(a)(1) factors and conclude that the species faces ongoing threats from overutilization and inadequacy of existing regulatory mechanisms throughout its range. Due to the species' relatively fast growth rate (for elasmobranchs) and high biomass in the southern portion of its range, the species has not yet declined to abundance levels that would likely trigger the onset of compensatory processes. However, the species' demographic risks (including very low fecundity, low genetic diversity, and connectivity) coupled with the significant reduction in the population from the northern portion of its range, greatly increases the species' vulnerability to extinction from environmental variation or anthropogenic perturbations. Furthermore, given the evidence of decreasing landings despite stable (or even increasing) fishing effort, we find that the level of exploitation in the area where spiny angel sharks are currently most concentrated is likely contributing to unsustainable fishing mortality rates. We therefore conclude that the species is on a trajectory indicating that it will more likely than not be at risk of extinction in the foreseeable future. We also found no evidence of protective efforts for the conservation of spiny angel sharks that would reduce the level of extinction risk faced by the species. We therefore propose to list the spiny angel shark as a threatened species.

Argentine Angel Shark (*Squatina argentina*)

Species Description

In addition to the spiny angel shark, the Argentine angel shark was petitioned for listing under the ESA. The Argentine angel shark occurs in the Southwest Atlantic and can be distinguished from its sympatric species by its coloration, dental formula, 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. The pectoral fins are large, twice as long as they are wide, with the anterior margins strongly convex, creating a visible "shoulder" area at the base of the head (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). 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).

Range and Habitat Use

While there is some conflicting information regarding the range of Argentine angel shark, it is clear that they have a restricted range in the Southwest Atlantic, and are present in southern Brazil (from Rio de Janeiro southward), Uruguay, and at least the northern part of Argentina (*i.e.*, Buenos Aires). Argentine angel sharks live on muddy or sandy bottom substrates on the continental shelf and slope at depths between 100 m and 400 m, with a principal depth range of 120 m–320 m (Cousseau 1973; Vooren and da Silva 1991; Vooren and Klippel 2005a). 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 2005a).

Diet and Feeding

Like the spiny angel shark, the Argentine angel shark is thought to be a sit-and-wait predator, lying motionless on the bottom until prey passes closely overhead. The prey is then grasped by an upward bite (Vooren and da Silva 1991). There is limited information regarding the Argentine angel shark diet. In a study that analyzed stomach contents of 53 individuals, results showed that fish made up 68.33 percent of the diet, and crustaceans and molluscs made up 15 percent and 1.6 percent of the diet, respectively (Cousseau 1973). The rest of the diet contained unidentifiable remains. The most common fish species was *Cynoscion striatus*, while the shrimp *Artemesia longinaris* and *Hymenopenaeus mulleri* were the most common crustaceans, and *Loligo brasiliensis* was the most common mollusc (Cousseau 1973). Argentine angel sharks are also thought to occasionally consume the short-finned squid (*Illex argentinus*) (dos Santos and Haimovici 2000).

Growth and Reproduction

Little is known about the growth and reproduction of the Argentine angel shark. Their maximum total length is estimated at 138 cm with a size at sexual maturity of 120 cm TL; however, age at first maturity and size at birth are unknown (Vooren and da Silva 1991; Vooren and Klippel 2005a). Gravid females and neonates are rarely found, so little is known about the reproductive characteristics of the species. Gestation is lecithotrophic (developing embryos depend on yolk for nutrition) (Vooren 1997) and litter size ranges from 7–11 pups (most commonly 9 or 10 pups) (Vooren and Klippel 2005a). Like *S. occulta* and *S. guggenheim*, the Argentine angel shark may have cloacal gestation during the latter half of pregnancy (Vooren and Klippel 2005a). Based on the location and capture of two neonates of 35 cm and 37 cm TL in Santa Catarina, Brazil, it is assumed that Argentine angel sharks reproduce on the slope of the southern Brazilian continental shelf (Vooren and Klippel 2005a). Additionally, the Bahia Engano in coastal Patagonia is thought to serve as a nursery area for the Argentine angel shark (Van der Molen *et al.* 1998).

Genetics and Population Structure

Studies examining the genetics of the species or information on its population structure could not be found.

Demography

Information regarding natural mortality rates or the intrinsic rate of

population increase of the Argentine angel shark is currently unknown.

Historical and Current Distribution and Population Abundance

As previously described, there is conflicting information regarding the range of the Argentine angel shark, and the species' distribution is poorly defined. While there are no specific population abundance estimates for Argentine angel sharks, they are considered to be the least common species of angel shark found in the southwestern Atlantic, particularly in Argentina (Vooren and Klippel 2005a). According to one paper, Argentine angel sharks occur in highest densities (from 1 to 11.4 t/nm²) along the Uruguayan coast in the AUCFZ, where salinities are higher than the Argentine coast (Díaz de Astarloa *et al.* 1997). However, this paper refers to all *Squatina* species as Argentine angel sharks and, based on the distribution of *S. guggenheim* (see species assessment; Colonello *et al.* 2007), the authors have likely misidentified spiny angel sharks as Argentine angel sharks.

In Brazil, Argentine angel sharks of all life stages are most abundant between Rio Grande and Chuí in Rio Grande do Sul, with no evidence of abundant populations outside of this area (Vooren and Klippel 2005a; Vooren and Chiaramonte 2006). Specifically, the outer shelf and upper slope of the southern Brazilian continental shelf, south of latitude 32 °S., are important habitat areas for *S. argentina*. However, based on fishery independent research surveys from 1986–2002, the abundances of both the Argentine angel shark and the hidden angel shark (*S. occulta*) within this area have declined by approximately 80 percent (Vooren and Klippel 2005a).

Summary of Factors Affecting the Argentine Angel Shark

We reviewed the best available information regarding historical, current, and potential threats to the Argentine angel shark species. We find that the main threat to this species is overutilization for commercial purposes. We consider the severity of this threat to be exacerbated by the species' natural biological vulnerability to overexploitation, which has led to significant declines in abundance of the species. We find current regulatory measures inadequate to protect the species from further overutilization. Hence, we identify these factors as additional threats contributing to the species' risk of extinction. We summarize information regarding these threats and their interactions below

according to the factors specified in section 4(a)(1) of the ESA. Available information does not indicate that habitat destruction or modification, disease, predation or other natural or manmade factors are operative threats on these species; therefore, we do not discuss these factors further in this finding. See Casselbury and Carlson (2015f) for discussion of these ESA section 4(a)(1) threat categories.

Overutilization for Commercial, Recreational, Scientific or Educational Purposes

The primary threat to *S. argentina* is overutilization by commercial fisheries, particularly the trawl and bottom gillnet fisheries in Brazil, where the species is likely most concentrated. As mentioned previously, the vast majority of fisheries information on angel sharks is documented as “*Squatina spp*” throughout Brazil, Uruguay, and Argentina; however, the Argentine angel shark is the rarest *Squatina* species in the region. Additionally, incorrect species identification of angel sharks is a problem that persists in the AUCFZ, particularly in Argentine landings (Milessi *et al.* 2001); therefore, determining the magnitude of threats currently acting specifically on *S. argentina* is challenging. However, some information, including fisheries effort, catch and landings data, provides insight into the current status of Argentine angel shark, as described below.

As discussed in the spiny angel shark assessment, angel sharks, in general, have been historically caught in the multispecies artisanal shark fisheries and considered valuable bycatch species in Argentina (see spiny angel shark: *Overutilization* section). However, the Argentine angel shark is considered relatively rare in Argentina (Menni *et al.* 1984 cited in Vooren and Klippel 2005a), with *S. guggenheim* comprising the majority of the catch (Massa *et al.* 2004b). From 1981–1982, Otero *et al.* (1982) noted the low density of *S. argentina* off the Buenos Aires coast and estimated an annual biomass of only 4,050 t. In the 1990s, angel sharks became commercially important bycatch, particularly in the Necochea school shark (*Galeorhinus galeus*) gillnet fishery, and were a prevalent bycatch species in the Patagonian coastal trawl fisheries. According to 1993–1996 observer data from the Patagonian fishery, Argentine angel sharks were bycaught with medium frequency, particularly in the San Matias Gulf and Bahia Engano. By 1993, declared landings of *S. argentina* were on the same order of magnitude as the

total biomass of the population estimated from the early 1980s, at 3,974.7 mt, and landings remained near this level in 1994 at 3,621.8 mt (Chiaramonte 1998). However, by 1998, CPUE values indicated that the level of fishing mortality on the *Squatina* shark populations was leading to declines in abundance of angel sharks. Specifically, Massa and Hozbor (2003) estimated that CPUE of angel sharks declined by 58 percent between 1992 and 1998 for vessels operating on the Argentine shelf, and since 1998, landings of *Squatina* species have been on a decline (Massa *et al.* 2004b).

In Uruguay, Argentine angel sharks are targeted in the Atlantic gillnet fishery and bottom trawl fisheries. They are also caught as bycatch in bottom longline, estuarine gillnet, and bottom trawl fisheries (Domingo *et al.* 2008). Both artisanal and industrial trawl fleets operate at depths between 10 m and 200 m in Uruguay, which overlap with the principal depth range of *S. argentina*. Annual catches of all angel sharks in Uruguay have increased over time, with less than 100 t landed from 1977 to 1996 and increasing to between 200 t and 400 t from 1997 to 2005. In 2012, catches for *Squatina spp.* exceeded the set catch limit in the AUCFZ (2,600 t), resulting in the closure of the fishery for the following month. However, similar to catch composition reported in Argentina, it is likely that the majority of these reported angel shark landings are spiny angel sharks rather than Argentine angel sharks (Domingo *et al.* 2008).

In Brazil, Argentine angel sharks are most abundant between Rio Grande and Chuí in Rio Grande do Sul, off southern Brazil (Vooren and Klippel 2005a; Vooren and Chiaramonte 2006); however, they are the least captured *Squatina* species in Brazilian fisheries (Perez and Wahlrich 2005). In general, angel shark landings are recorded in single trawl, pair trawl, oceanic gillnet, and coastal artisanal fisheries. Historically, angel sharks were fished on the Brazilian shelf by double rig trawlers down to 140 m depths, with *S. guggenheim* comprising the majority of the catch (Haimovici 1998).

As catch rates of shelf resources decreased, and international markets for traditionally discarded or poorly known species expanded, deep-water demersal fishing operations off southern Brazil (from 20° S.–34° S.) increased in the early 1990s (Valentini *et al.* 1991; Haimovici 1998) and greatly accelerated after 1999. This was largely a result of shrimp and groundfish trawlers expanding their fishing grounds towards the previously unexploited resources of

the outer shelf and slope (Valentim *et al.* 2007; Perez and Wahrlich 2005), but also reflected the increasing number of gillnet vessels operating on the outer shelf. In fact, in the early 1990s, in response to a decline in trawl catch of marine resources, many trawlers began converting their boats to gillnet vessels. These vessels would fish at depths of up to 300 m, with the oceanic bottom gillnet fisheries specifically targeting sharks and, based on CPUE data, potentially *Squatina* species (Miranda and Vooren 2003). The number of gillnet vessels as well as fishing effort increased throughout the 1990s, with annual landings of angel sharks by the oceanic gillnet fleet of more than 800 t between the years 1992 to 1998. Landings of the three angel shark species (*S. guggenheim*, *S. occulta* and *S. argentina*) were especially common in the Santa Catarina bottom gillnet fleet operating on the Plataforma Sul between 1994 and 1999 (Mazzoleni and Schwingel 1999; cited by Klippel *et al.* 2005). However, in the following years, from 1999 to 2002, annual landings of angel sharks dropped in half and the CPUE of the bottom gillnet fleet also decreased, from a maximum of 4.3 t/trip in 1992 to values that varied between 0.5 t/trip and 1 t/trip in the years 1994–2002 (Klippel *et al.* 2005).

As the regional Brazilian fleets gradually occupied slope grounds in the 1990s, they were joined by foreign fleets chartered by national companies as part of a deep-water fishing development program promoted by Brazilian authorities (Perez *et al.* 2003). This program was implemented in 2000, with chartered vessels operating at depths of 200 m to 900 m in the Brazilian EEZ, using traps, longlines, gillnets, and trawl nets (Perez and Pezzuto 2006 cited in Perez *et al.* 2009). Together, both national and foreign trawlers concentrated their efforts in the southern and southeastern sectors of the Brazilian coast, exploiting three discrete bathymetric strata: shelf break (100–250 m), upper slope (250–500 m), and lower slope (≤ 500 m) (Perez and Pezzuto 2006 cited in Perez *et al.* 2009). Brazilian trawlers concentrated their activities on the shelf break (at 100–200 m) while chartered gillnet vessels concentrated their efforts in deeper areas of the upper slope (at 300–400 m). As a result of this expansion of fishing activities into deeper waters, deep-water monkfish (*Lophius gastrophysus*) was the first fishing resource that proved abundant enough to sustain profitable deepwater fishing operations off southern Brazil, and thus a targeted fishery developed for the species. In 2001, a total of 7,094

t of monkfish were landed, mostly by national double-rig trawlers (58 percent) and foreign chartered gillnetters (36 percent) operating in a fishing area that extended along the southern Brazilian slope, from 21° S. to 34° S. and within the 100–600 m isobaths (Perez *et al.* 2005). Monkfish biomass also happened to be concentrated between 125 m and 350 m depths, which overlaps with the principal depth distribution of the Argentine angel shark (120 m–320 m). As a result, Argentine angel sharks were reported as a significant bycatch species in the monkfish gillnet fishery. In fact, Perez and Wahrlich (2005) noted that *S. argentina* was one of the most retained bycatch species in the monkfish gillnet fishery, with bycatch estimated at 1.052 per 100 nets in 2001 (total 8,698 individuals). This fishing regime that contributed to the significant bycatch of Argentine angel shark continued operating at high levels through most of the following year (2002), with monkfish landings of 5,129 t (Perez *et al.* 2009). The numerous incidental catches produced by monkfish gillnetting suggests that the development of this fishery off southern Brazil substantially increased the levels of fishery-related mortality in the *S. argentina* population and potentially introduced adverse effects in the recruitment process (*i.e.*, recruitment overfishing), especially considering that the species' reproductive cycle may exceed 1 year (Cousseau and Perrota 1998 cited in Perez and Wahrlich 2005). In fact, research bottom trawl surveys of the outer shelf and upper slope from Cape Santa Marta Grande to Chuí (the main habitat of Argentine angel sharks) found decreases in both the CPUE and frequency of occurrence of Argentine angel sharks during the winter and fall seasons between the years 1986/87 and 2001/02. Specifically, these surveys detected declines of 75 and 96 percent in *S. argentina* CPUE (kg/hour) and frequency of occurrence, respectively, during the winter months, and declines of 97 and 63 percent, respectively, during the fall surveys. These declines confirm that the abundance of *S. argentina* in southern Brazil decreased by roughly 80 percent from its original level as a result of recruitment overfishing, primarily due to the bottom gillnet fishery (Vooren and Lamónaca 2002; Vooren and Klippel 2005a).

In 2003, the fishery regime changed, as the foreign chartered vessels abandoned Brazilian waters as a result of conflicts with national trawlers (Perez *et al.* 2009). Since then, exploitation has been maintained mostly by double-rig trawlers along with a few vessels of the

national fleet transformed to fish with the new gillnet technology (Wahrlich *et al.* 2004 cited in Perez *et al.* 2009). Landings of monkfish decreased by roughly 50 percent from 2002 to 2003, and have remained stable around 2,500 t ever since (Perez *et al.* 2009). The large reduction in monkfish biomass after 2002 (and the stabilization at biologically insecure levels thereafter) is largely attributed to the fact that landed catches have been systematically higher than maximum recommended catches (Perez, 2007a; Anon 2007 cited in Perez *et al.* 2009). In 2004, the monkfish fishery was declared overexploited, with subsequent biomass assessments lacking any signs of recovery for the monkfish stock (Perez *et al.* 2009). Given the significant bycatch of Argentine angel sharks in the monkfish fishery in 2001, and the subsequent 80 percent decline in the angel shark population by 2002, the continued intense exploitation by the monkfish fishery within the Argentine angel shark habitat likely contributed to further abundance declines of *S. argentina* after 2002. This is especially probable considering the fact that the fishery operates on the outer and upper slope areas of the continental shelf, where the Argentine angel shark reproduces and likely carries out its entire lifecycle. Thus, the significant increase in fishing effort on the outer shelf and slope areas, particularly by the monkfish fishery, likely impacted all life stages of the species, resulting in recruitment overfishing and, ultimately, overutilization of the species leading to a significant population decline.

Argentine angel sharks are still likely susceptible to fishing pressure in the monkfish fishery, as the fishery is still operational today. Recent landings of monkfish for years 2009, 2010, and 2011 were 2,744 mt, 2,592 mt and 2,616 mt, respectively (IBAMA 2011). While this is a large reduction from peak landings in 2001 of 7,094 mt, Argentine angel sharks of all life stages are likely still bycaught by this fishery, which may limit the species from recovering from its initial 80 percent population decline, especially considering the species' low productivity. In addition, the Argentine angel shark likely has high discard mortality rates based on rates estimated for similar angel shark species (see spiny angel shark—Threats Assessment). Given general similarities between the Argentine angel shark and other *Squatina* species, it seems reasonable to infer similar discard survival rates for the Argentine angel shark (*i.e.*, ~60 percent at-vessel

mortality rate in trawl fisheries and ~25–67 percent mortality in gillnets).

Thus, while the bottom gillnet fishery specifically targeting monkfish has been restricted in terms of overall effort, with only the national trawl fleet continuing to operate on the upper slope (Perez *et al.* 2009), the threat of overutilization remains. However, the monkfish fishery is not the only fishery presently operating within the Argentine angel shark habitat. There are a number of oceanic bottom gillnet fisheries targeting other species (e.g., *Umbrina canosai*, *Cynoscion guatucupa*, and *Micropogonias furnieri*) that currently operate on the shelf and slope at depths of up to 300 m. In fact, due to their effort and fishing area of operation, these oceanic bottom gillnet fisheries now land the majority of angel sharks in Brazil (Klippel *et al.* 2005). As described in the spiny angel shark assessment, fishing effort (both by trawl and gillnet fleets) on the Plataforma Sul remains high and poorly regulated, and therefore, the susceptibility of the species' to fishery-related mortality also remains high. As such, given the best available information and the above analysis, we conclude that overutilization is a factor that is significantly contributing to the extinction risk of the species.

Inadequacy of Existing Regulatory Mechanisms

In Argentina, catches of angel sharks are regulated through annual catch limits and fisheries closures. Since 2013, *Squatina* landings have been below the maximum catch limit in recent years, providing evidence that regulations are potentially being followed. However, without effort information, it is unclear whether these regulations are adequately controlling the exploitation of angel sharks and given that Argentine angel sharks are particularly rare in Argentina, the degree to which these regulations are decreasing the threat of overutilization of the species in this portion of its range is uncertain.

In Uruguay, the Argentine angel shark is listed as a species of high priority in the country's FAO NPOA-sharks (Domingo *et al.* 2008). The plan, as stated previously, has set goals to collect the necessary information on its priority species in order to conduct abundance assessments, review current fishing licenses, and promote public awareness to release captured individuals. However, no updated results from the goals and priorities of this plan could be found.

Like the spiny angel shark, and other species described previously in this

proposed rule, the Argentine angel shark was listed as "critically endangered" under Annex I of Brazil's endangered species list in 2004. As described in previous species assessments, an Annex 1 listing prohibits the catch of the species except for scientific purposes, which requires a special license from IBAMA. There is also a prohibition of trawl fishing within three nautical miles from the coast of southern Brazil, although enforcement of this prohibition has been noted as difficult (Chiaromonte and Vooren 2007), and moreover, the ban only covers depths of <10 m, which does little to provide any protection to the Argentine angel shark given its principal depth distribution of 120–320 m. As described in previous species assessments, Brazil has a FAO NPOA-sharks; however, the Argentine angel shark is not considered one of the 12 species of concern.

Finally, there are some regulatory mechanisms in place for the monkfish fishery in Brazil, which operates in the primary habitat of the Argentine angel shark and has been a significant source of bycatch-related mortality for the species. In mid-2002, government regulations were implemented to prohibit foreign gillnetters from operating south of 21°S (to the southern extent of Brazil's EEZ), which roughly encompasses the entirety of the Argentine angel shark's Brazilian range. This regulation effectively terminated foreign chartered gillnet operations off Brazil and left a national fleet of 5 licensed units to continue the fishery (Perez *et al.* 2009). However, despite this reduction of the monkfish fishery fleet, uncontrolled exploitation continued and the stock was declared overexploited in 2004. It was not until 2005 that a management plan for the monkfish fishery was eventually developed, which included the implementation of 100 percent observer coverage for monitoring the fishery, logbooks, and a recommendation to ban fishing shallower than 250 m (Perez *et al.* 2009). However, the principal depth range of *S. argentina* exceeds the 250 m restriction, thus this recommendation only theoretically protects a portion of the species' depth range. In 2008, catch limits of 1,500 t per year were imposed for the monkfish gillnet fishery, as well as bycatch limits of certain species; however, though the catch limits should help reduce overall fishing effort, the species is still susceptible to bycatch-related mortality in the fishery.

Overall, regulatory mechanisms for the monkfish fishery, particularly the ban of chartered foreign gillnets from 21° S. to the southern extent of Brazil's

EEZ, which were responsible for catching a total of 157,656 monkfish (compared to a total of only 16,697 monkfish landed by all gears of the national fleet) from 2000–2007, and recent catch limits of 1,500 tons for the gillnet fishery, have likely reduced the level of fishing pressure and subsequent mortality of Argentine angel sharks. However, the fact that enforcement of management rules for the monkfish fishery has been poor, with no evident signs of recovery for this overexploited resource (Perez *et al.* 2009), may indicate that the regulations outlined in the management plan for the monkfish are inadequate to control for indirect overutilization of Argentine angel sharks. Given that the conservation status of the Argentine angel shark likely relies heavily upon the success of the management plan for the southern Brazil gillnet monkfish fishery (Vooren and Chiaromonte 2006) and that the monkfish fishery is still operational throughout the species' Brazilian range via the national fleet, with reportedly poor enforcement of management rules, the fishery is likely still exerting fishing pressure and contributing to the overutilization of the already at-risk *S. argentina* population. This continued exploitation is concerning for a species that has already undergone such significant declines in a critical portion of its range, with no indication of a reversal of this trend. As such, we conclude that existing regulatory mechanisms to control for overutilization of the Argentine angel shark are inadequate, particularly in Brazil, where the species is most heavily concentrated and utilized.

Extinction Risk

Demographic Risk Analysis

Abundance

Estimates of population abundance specifically for Argentine angel shark (*Squatina argentina*) throughout its range are not available. However, some qualitative information as well as density and biomass estimates are available from parts of the species' range. Compared to congeners *S. guggenheim* and *S. occulta*, the Argentine angel shark is the rarest species of angel shark found in the southwestern Atlantic, particularly in Argentina. Biomass of *S. argentina* in Argentina was estimated to be 40,000 mt in 1998, although there is high uncertainty with this estimate. In Brazil, this species is reportedly most abundant between Rio Grande and Chui in Rio Grande do Sul, with no evidence of abundant populations outside this region. Based on fishery-independent

surveys conducted from 1986–2002, abundance of Argentine angel shark declined by approximately 80 percent on the outer shelf and upper slope of the Plataforma Sul, which is where the highest concentrations of the species is located. Due to uncertainties regarding the range and distribution of the species, as well as identification issues between *S. argentina* and other *Squatina* spp. in the region, the current abundance of the species cannot be determined at this time. However, given the intense year-round fishing pressure from trawl and gillnet fisheries within the very restricted range of this rare species, combined with the species' presumed low reproductive output, it is likely that *S. argentina* is experiencing continued population declines throughout its range, which is significantly contributing to its extinction risk.

Growth Rate/Productivity

There is limited information regarding the growth and reproduction of the Argentine angel shark, and information on natural mortality rates or the potential intrinsic rate of population increase for the species is unavailable. The species has an estimated maximum total length of 138 cm with a size at sexual maturity of 120 cm TL, which means the species must grow to approximately 87 percent of its maximum size before reaching sexual maturity. Gravid females and neonates are rarely found, so little is known about the gestation and birth of this species; however, litter sizes range from 7–11 pups (with 9–10 pups being common) and their reproductive cycle is reportedly at least biennial (Vooren and Chiaramonte 2006). These reproductive characteristics suggest the species has relatively low productivity, similar to other elasmobranch species, which has likely hindered its ability to quickly rebound from threats that decrease its abundance (such as overutilization) and renders the species more vulnerable to extinction. In addition, similar to its congener *S. guggenheim*, *S. argentina* is thought to have cloacal gestation during the latter half of pregnancy, which increases the likelihood that the species will abort pups upon capture and significantly decreases their already low reproductive output.

Spatial Structure/Connectivity

The Argentine angel shark has a very restricted range, from Santa Catarina, Brazil to northern Argentina (i.e., Buenos Aires). Currently, there is no evidence of abundant populations outside of southern Brazil. Argentine angel sharks are sedentary, territorial,

and assumed to carry out their entire lifecycles within the same area. This indicates that populations of the species maintain population growth by recruiting within each area without producing a necessary excess of recruits with the potential to migrate to other areas (Vooren and Klippel 2005a). As a result, *S. argentina* populations reportedly have limited movement and dispersal migration between neighboring populations, with migrants having no impact on the short term abundance of a population. This limited inter-population exchange reduces the recovery potential for the depleted and small local populations and may increase the risk of local extirpations, possibly leading to complete extinction. Given the lack of evidence of abundant populations outside of southern Brazil, and the limited connectivity between the populations of southern Brazil and populations elsewhere throughout the species' range, conservation of the southern Brazilian populations of *S. argentina* is likely critical for the conservation of the taxon as a whole. Thus, based on the available information, low dispersal rates among populations of *S. argentina* poses a significant risk of extinction to the species.

Diversity

The loss of diversity can increase a species' extinction risk through decreasing a species' capability of responding to episodic or changing environmental conditions. This can occur through a significant change or loss of variation in life history characteristics (such as reproductive fitness and fecundity), morphology, behavior, or other genetic characteristics. Although it is unknown if *S. argentina* has experienced a loss of diversity, the significant decline estimated for the population in southern Brazil, as well as the likely small populations elsewhere throughout its range, and limited connectivity of these populations, suggest the species may be at an increased risk of inbreeding depression or random genetic drift and could experience the fixing of recessive detrimental genes, reducing the overall fitness of the species.

Threats Assessment

The primary threat to *S. argentina* is overutilization by commercial fisheries, with particular vulnerability to trawl and bottom gillnet fisheries. As previously mentioned, the vast majority of fisheries information on angel sharks is documented as "*Squatina* spp" throughout Brazil, Uruguay, and Argentina; therefore, determining the

magnitude of threats currently acting specifically on *S. argentina* is challenging. However, there are some landings and CPUE data for *S. argentina*, which suggest the historical and continued level of fishing pressure has led to significant observed declines in the species.

Historically, angel sharks, including *S. argentina*, were caught in multispecies artisanal shark fisheries and considered a valuable bycatch species. In Argentina, in the 1990s, angel sharks were considered commercially important bycatch, particularly in the Necochea school shark (*Galeorhinus galeus*) gillnet fishery, and between 1992 and 1998, landings of angel sharks in Argentina were fairly stable. However, declines in CPUE over this time period (of up to 58 percent) were recorded for vessels operating on the Argentine shelf, indicating a level of fishing mortality on the angel shark population that was leading to declines in abundance, and since 1998, landings have been on a decline (Massa *et al.* 2004b). In Uruguay, catches of angel sharks (*Squatina* spp) have actually been on an increasing trend since the 1970s, and exceeded the catch limit imposed in the AUCFZ for 2012 (2,600 mt). However, in both Argentina and Uruguay, Argentine angel sharks are relatively rare, with the majority of angel shark landings comprised of *S. guggenheim*. As such, it is unclear whether overutilization is significantly contributing to the species' extinction risk in this portion of its range.

Off southern Brazil, angel sharks have been and continue to be heavily exploited by the trawl and gillnet fisheries (see the *S. guggenheim* assessment for more details). This heavy exploitation has led to observed declines in the abundance of *S. argentina* on the Plataforma Sul as a result of recruitment overfishing (primarily by the bottom gillnet fishery targeting monkfish). Given the natural rarity and low productivity of the species, these declines (of up to 80 percent) have placed the Argentine angel shark at an increased risk of extinction from stochastic and compensatory processes. In addition, it is likely that the population of Argentine angel shark has continued to decline (from the 80 percent estimate in 2002) as a result of the continued exploitation of the species by the monkfish gillnet fishery that continued unabated until 2004, and the present fishing pressure by the reduced monkfish fishery and the other oceanic gillnet fisheries operating within the species' habitat. Further, few existing regulations appear adequate to

control the overutilization of *S. argentina*. In the monkfish fishery, which catches significant amounts of Argentine angel shark as bycatch, a management plan was implemented in 2005. Though the monkfish fishery has been significantly reduced in terms of overall effort through catch limits and fisheries restrictions, enforcement of management rules has been poor with no evident signs of recovery for this overexploited resource (Perez *et al.* 2009). Additionally, in 2004, the Argentine angel shark was classified as “critically endangered” on Brazil’s endangered species list, which effectively prohibited the catch of this species. However, for the most part, there is reportedly minimal control of the fisheries operating on the Plataforma Sul, and this regulation does not address the threat of bycatch-related mortality of the species. Additionally, although landings of the species are currently prohibited, the fleets’ extensive operations will continue to contribute to the fishing mortality of all life stages of the species as the Argentine angel shark likely has high discard mortality rates based on rates estimated for similar angel shark species (see spiny angel shark—*Threats Assessment*). Thus, given general similarities between the Argentine angel shark and other *Squatina* species, it seems reasonable to infer similar discard survival rates for the Argentine angel shark from these other *Squatina* species. As such, given the sensitive life history traits of the Argentine angel shark as well as the evidence of significant population declines, an assumed 60 percent at-vessel mortality rate in trawl fisheries and 25–67 percent mortality in gillnets is likely to significantly contribute to the overutilization of the species and increase its extinction risk.

Overall, it is likely that *S. argentina* has suffered significant population declines throughout its restricted range as a result of historical and continued overutilization of the species from direct and indirect fishing pressure. Given the reduction of the species’ critically important southern Brazilian population of at least 80 percent, combined with inadequate regulatory mechanisms in this part of the species’ range to control the high level of fishing pressure on the species, we conclude that overutilization is significantly contributing to the species’ risk of extinction.

Risk of Extinction

Although there is significant uncertainty regarding the current abundance of the species, it appears that

the Argentine angel shark is relatively rare outside of southern Brazil, where small, isolated populations have experienced substantial declines and remain at risk from overutilization by fisheries targeting deep-water monkfish. Best available information indicates the species has experienced at least an 80 percent reduction of its critically important southern Brazil population as a result of intense year-round fishing pressure, and will continue to decline without adequate protection from overutilization. Given the species’ restricted range and present rarity throughout the range, combined with its limited movement and dispersal between populations and low reproductive output, *S. argentina* is likely strongly influenced by stochastic or compensatory processes. This vulnerability is further exacerbated by the present threats of overutilization and inadequacy of existing regulatory measures that are and will continue to significantly contribute to the decline of the existing populations (based on its demographic risks), compromising the species’ long-term viability. Therefore, based on the best available information and the above analysis, we conclude that *S. argentina* is presently at a high risk of extinction throughout its range.

Protective Efforts

Aside from the management goals outlined in the previously described FAO NPOA-sharks in Uruguay, we could not find any additional information regarding protective efforts for the Argentine angel shark.

Proposed Determination

Based on the best available scientific and commercial information as presented in the status review report and this finding, we find that the Argentine angel shark is presently at risk of extinction throughout all of its range. We assessed the ESA section 4(a)(1) factors and conclude that the species faces ongoing threats from overutilization and inadequacy of existing regulatory mechanisms throughout its range. The species’ present rarity and restricted range, combined with its natural biological vulnerability to overexploitation and demographic risks (*e.g.*, low and declining abundance, low productivity, likely small and/or isolated populations at an increased risk of random genetic drift, and limited dispersal capabilities) are exacerbating the negative effects of the aforementioned threats, placing this species in danger of extinction. We also found no evidence of protective efforts for the conservation of Argentine angel shark that would reduce the level of

extinction risk faced by the species or otherwise alter its current status. We therefore propose to list the Argentine angel shark as an endangered species.

Graytail Skate (*Bathyraja griseocauda*)

Species Description

The graytail skate, *Bathyraja griseocauda*, is a member of the genus *Bathyraja*, the most speciose genus of the family Arhynchobatidae (McCormack *et al.* 2007). Physical features of the graytail skate include a disc that is rhomboidal in shape (Bizikov *et al.* 2004), brownish in color with traces of darker spots or rings on its dorsal surface, and white or yellow coloring on the ventral side (Norman 1937; Bigelow and Schroeder 1965). The posterior margins of the pelvic and pectoral fins are dusky, and the tail is grayish brown in color (Norman 1937), with the underside covered in dark spots (Bizikov *et al.* 2004). The dorsal surface is covered in numerous small spinules, but the tip of the snout and axils of the pectoral fins lack spinules (Bigelow and Schroeder 1965). There are 18–20 strong median spines on the tail that 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 rows with 5–7 thorns per row (Bizikov *et al.* 2004).

Range and Habitat Use

The graytail skate occurs in Southwest Atlantic waters off the coasts of Argentina, Uruguay, Chile, and the Falkland Islands, and in the Southeast Pacific off of Chile (Sáez and Lamilla 2004). They have been caught at latitudes as far north as 39° S. in the Pacific Ocean and 34° S. in the Atlantic Ocean, and as far south as 60° S. in the Southern Ocean on the Antarctic shelf (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. There are also unconfirmed records of graytail skate in the Southern Ocean in Prydz Bay, Antarctica (GBIF 2013). If these records are validated, this would extend the range of the skate beyond the southwest Atlantic Ocean and eastern Pacific.

Diet and Feeding

Various studies on graytail skate diet indicate they are opportunistic predators that consume a variety of prey items, but primarily favor fish. The most extensive study of the diet and feeding

habits of the graytail skate caught around the Falkland Islands found that skates smaller than 50 cm (DW) preyed mostly on benthic gammarid amphipods and isopods, such as *Serolis* spp., whereas skates larger than 50 cm DW preyed increasingly on fishes (Brickle *et al.* 2003). 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 percent 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.

Growth and Reproduction

Graytail skates have a lifespan of approximately 28 years, with a maximum observed disc width of 130 cm and a maximum weight of 30.4 kg (Arkhipkin *et al.* 2008; Wakeford *et al.* 2005). 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 TL and an 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 9 years of life and decline to 4.3 cm/year between 14 and 20 years old (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). However, based on observed size data, these parameters still slightly underestimate growth (Gallagher 2000).

Little is known about the reproduction of the graytail skate (Sánchez and Mabragaña 2002) and available age and growth studies from the same region provide conflicting estimates for length and age at maturity. For example, in the Falkland Islands, Gallagher (2000) estimated a total length at 50 percent 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 percent maturity to be 108.2 cm for females and 94.5 cm for males, with age at maturity

of 14 years for males and 17.8 years for females. Based on commercial fleet observer and research cruise data collected around the Falkland Islands, males reached 50 percent maturity at a disc width of 76–77 cm (Agnew *et al.* 2000; Wakeford *et al.* 2005). A Falkland Islands study of graytail skate suggests that graytail skate females may spawn year-round with a weak spawning peak in the spring and summer months observed (Arkhipkin *et al.* 2008). 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) and in waters south of 51° latitude (Dr. Andreas Winter, Falkland Islands Fisheries Stock Assessment Scientist, personal communication 2015). Based on catches of the smallest skates, it is thought that hatchlings have disc widths between 9 cm and 12 cm (Brickle *et al.* 2003; Arkhipkin *et al.* 2008).

Genetics and Population Structure

Studies examining the genetics of the species or information on its population structure could not be found.

Demography

Little is known about the population growth and natural mortality of the graytail skate. However, based on the life history parameters described previously, like other elasmobranchs, the graytail skate is a K -selected species with slow growth rates and late age at maturity, which is indicative of low productivity (Gallagher 2000; Bücker 2006; Arkhipkin *et al.* 2008).

Historical and Current Distribution and Population Abundance

Graytail skate occur 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). In the Falkland Islands, graytail skate are caught in 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; Arkhipkin *et al.* 2012). 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; Arkhipkin *et al.* 2012). In Argentina, graytail skate are found on the continental shelf and slope around Argentina south of 37° S. and 41° S. respectively (McCormack *et al.* 2007), where they exhibit strict

stenothermic and stenohaline behavior. In other words, the species appears to tolerate very narrow ranges of temperature and salinity (Figueroa *et al.* 1999), with catch data that suggest that the species occurs at water temperatures below 6 °C (Menni and Lopez 1984; Colonello and Massa 2004) and salinity above 33.9 psu (Colonello and Massa 2004).

Throughout their range, graytail skates are found at depths between 106 m and 1,010 m, but have been caught as shallow as 77 m in Argentine waters (Bücker 2006). Graytail skate are typically most common at depths below 300 m (Bigelow and Schroeder 1965; Menni and Lopez 1984; Brickle *et al.* 2003; Laptikhovsky *et al.* 2005; Wakeford *et al.* 2005; Arkhipkin *et al.* 2008; Arkhipkin *et al.* 2012). However, in Argentina, the highest density of graytail skate catches was reported at depths of 120 m on the Argentina platform between 45° S. and 41° S. during the late winter and early spring months (Colonello and Massa, 2004). As graytail skates mature, they display an ontogenetic shift in depth preference (Arkhipkin *et al.* 2008). For example, in Falkland Islands waters, hatchlings occupy nursery grounds of approximately 300 m–350 m depth, but transition to deeper waters of 400 m–600 m as juveniles (Arkhipkin *et al.* 2008). At 20 cm–30 cm DW, some individuals migrate up to shallower depths of 200 m–400 m, while others move into water deeper than 600 m (Arkhipkin *et al.* 2008). Skates 80 cm–90 cm DW or larger occur most commonly at depths of 400 m–600 m (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; Wakeford *et al.* 2005; Winter *et al.* unpublished).

Range-wide abundance estimates for graytail skate are not available; however, biomass estimates exist for the populations off the Falkland Islands and Argentina. In the Falkland Islands, graytail skate were part of the fish assemblage of both the southern and northern skate and ray stocks. They were particularly abundant south of the islands, making them dominant in catches of the southern skate and ray assemblage. However, due to declining CPUEs of the southern stock, especially for graytail skate, the southern rajid fishery was closed in 1996 (Agnew *et al.* 1999; Agnew *et al.* 2000; Wakeford *et al.* 2005). Current biomass estimates from this area could not be found. North of

the Falkland Islands, declines in the CPUE of graytail skate were also observed between 1992 and 2001 (Wakeford *et al.* 2005); however, based on recent biomass estimates, the population appears to have recovered and stabilized. Specifically, analysis of 2010 fishery survey cruise data resulted in an estimated biomass of graytail skate of 7,232 t, which is consistent with the earlier biomass estimates for the species from the 1990s (Falkland Islands Government 2011). As this biomass estimate is just for the graytail skate population north of the Falkland Islands, it is likely a significant underestimation of the total biomass for the entire Falkland Islands population, especially considering the southern stock, which was historically more abundant, has been protected from targeted fishing since 1996.

In 2002, Sánchez and Mabragaña (2002) estimated the population abundance of the graytail skate on the continental Argentine shelf between 48° S. and 55° S. to be 259,210 individuals, or 2,431.98 t. This estimate was calculated prior to the apparent recovery of the graytail skate in the Falkland Islands and also corresponds to when CPUE of the graytail skate was at its minimum in the Falkland Islands (Wakeford *et al.* 2005). As such, it could be assumed that biomass has since increased on the shelf; however, with no recent abundance estimates available, the trends within this portion of the species' range cannot be determined with certainty.

Farther north on the Argentine shelf, between 45° S. and 41° S., the biomass of graytail skate was estimated to be 503 t in 2004, but had a large confidence interval ($\pm 2,237$ t), with an average density of the species of 0.05 t/nm² (Colonello and Massa 2004). More recent estimates or trends in population abundance or biomass levels for graytail skate are not available.

There is very little information pertaining to the presence of graytail skate in Uruguayan and Chilean waters. No information on commercial, recreational, or research catches of graytail skate is available from Uruguay. Likewise, there is no estimate of abundance from this area. In Chile, graytail skate are found south of 41° S. and at depths of 137 m to 595 m (McCormack *et al.* 2007). In 1995, Saez and Lamilla (2004) caught 42 graytail skate between March and December at 350 m depth approximately 20 miles from Punta Galera; however, no other information is available on scientific or commercial catch distribution or population abundance from this area.

Summary of Factors Affecting the Graytail Skate

We reviewed the best available information regarding historical, current, and potential threats to the graytail skate species. We find that the main threat to this species is overutilization for commercial purposes; however, we consider the severity of this threat to be greatly reduced by the regulatory mechanisms in place in the Falkland Islands, where the species was historically most heavily exploited. Thus, we find that historical and present levels of utilization are not exceeding the species' biological capacity to sustain current levels of exploitation. We also find that current regulatory measures are adequate to protect the species from further overutilization. Additionally, available information does not indicate that habitat destruction or modification, disease, predation or other natural or manmade factors are operative threats on these species. We summarize information regarding these factors and their interactions below according to section 4(a)(1) of the ESA. See Casselbury and Carlson (2015g) for a more detailed discussion of these factors.

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

Trawl fisheries occur throughout the graytail skate'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); however, there is no specific information available that indicates this habitat modification has had a direct effect on the abundance of the graytail skate, or is specifically responsible for the curtailment of its habitat or range.

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 fishery by foreign fleets (Agnew *et al.* 1999; Falkland Islands Government 2005–2013). Prior to the 1990s, catches from the Falkland Islands were mainly attributed to Spanish vessels fishing in a mixed groundfish fishery, with rajid catches of less than 1,500 t per year (Wakeford *et al.* 2005). However, in 1989, Korean vessels began to specifically target rajids in this fishery using demersal trawls, and by 1991 catches of skates and rays rose to more than 7,000 t/year (Wakeford *et al.* 2005). Subsequently, two rather distinct rajid fisheries developed within the Falkland Islands: a southern rajid fishery that fished in a small area south of the Falkland Islands (a ray “hot spot;” Agnew *et al.* 2000), and a northern rajid fishery that operated in a more extensive area to the north of the Falkland Islands (primarily on the slope between 200 m–400 m depths; Wakeford *et al.* 2005). In the 1990s, the graytail skate was the most important species caught in the Falkland Islands multispecies rajid fisheries based on catch weight, and was estimated to make up approximately 58 percent of the catch in the southern rajid fishery and 39 percent of the catch in the northern rajid fishery between 1993 and 1995 (Agnew *et al.* 1999; Bizikov *et al.* 2004). However, with this heavy exploitation on the skate populations by Korean fleets (which were responsible for 88 percent of the directed rajid catch between 1990 and 1997; Agnew *et al.* 2000), the proportional catches of graytail skate declined in all areas that were fished. This decline was particularly precipitous in the southern batoid aggregation area, where graytail skate spawn (A. Winter, pers. comm. 2015) and had previously comprised the majority of the catch (Agnew *et al.* 1999). Agnew *et al.* (2000) calculated that total mortality rates (fishing mortality rates + natural mortality rates) in the northern and southern areas were significantly higher than what could be sustained by the batoid assemblage, particularly graytail skates. Specifically, the authors estimated that graytail skates could sustain total mortality rates of less than 0.3/year; however, the total mortality rate in the northern area from 1991–1995 was on the order of 0.42/year and in the southern area was 0.61/year (Agnew *et al.* 2000). Consequently, significant declines in CPUE were observed between 1990 and 1997. A steep 58 percent decline was noted in the southern rajid fishery from 1993 to 1996, which was attributed to the decline in graytail skate abundance

(Agnew *et al.* 1999, 2000) and declines ranging from 44 to 65 percent were observed for the northern rajid fishery from 1990–1996 (Agnew *et al.* 2000). For catches of graytail skate, Wakeford *et al.* (2005) estimated a decline in CPUE of around 70 percent between 1992 and 2001 in the northern rajid fishery, and observer data indicate CPUE of graytail skate continued to decline through 2007 (Winter *et al.* unpublished). Catches of graytail skate also showed a reduction in average disc width. From 1993–1995, average disc width declined from 52.18 cm to 31.91 cm (Agnew *et al.* 2000), and based on observer data collected from the Falkland Islands Inner Conservation and Management Zone (located between 49° S.–54° S. and 64° W.–54° W.), the majority of graytail skate catches in the commercial trawl fishery from 1997–2006 were still relatively small skates with modal disc widths between 25 cm and 40 cm (Arkhipkin *et al.* 2008). Additionally, about 54 percent of the catches were female skates with disc widths between 10 cm and 80 cm, and the majority were under the estimated size at 50 percent maturity (Arkhipkin *et al.* 2008).

As a result of the marked declines in CPUE, particularly for the entire southern batoid aggregation, which was presumed to be driven by declines in graytail skate (Agnew *et al.* 1999, 2000; Wakeford *et al.* 2005), the southern ray fishery was closed in 1996 and separate skate target trawling licenses and catch limits (of around 3,000 t through the late 1990s) were imposed in the northern ray fishery. Following the implementation of these catch limits, which equated to between 6.5 and 7.6 percent of the estimated pre-exploitation biomass, the northern rajid stock appeared to stabilize by 2000 (Agnew *et al.* 2000). In fact, based on a stock assessment of the northern skate stock, with updated data through 2014, estimated biomass of the entire stock has gradually and consistently increased since 1996, from a low of 13,641 t in 1989 (95 percent CI: 10,591–24,214), which marked the start of heavy exploitation, to a recent peak high of 34,558 t in 2014 (90 percent CI: 27,284–59,806) (Fisheries Committee 2015). In addition, CPUE of the northern stock has been gradually increasing over the years (Agnew *et al.* 2000; Falkland Islands Fisheries Committee 2015) whereas targeting of skate and ray species in the Falkland Islands has been decreasing, with a large portion (almost half) of the skate catch now taken as bycatch under finfish licenses (Falkland Islands Government 2014). In fact, the most recent data from the fishery show

that in 2014 total skate catch amounted to 5,543.2 t, with 53 percent of this total representing targeted skate catch (Fisheries Committee 2015).

Furthermore, even with the proportional increase in bycaught skates and decrease in targeted skate catch, the total skate catch for the fishery appears sustainable as it falls below the Maximum Sustainable Yield (MSY) estimate, which is the theoretical largest catch that can be taken from a stock. Based on the latest stock assessment of the northern skate assemblage, MSY is estimated to be 6,048 t (95 percent CI: 6,198–46,811), which is approximately 8 percent higher than the 2014 total skate catch (Fisheries Committee 2015).

In terms of the graytail skate, despite the reported historical reductions in CPUE, *B. griseocauda* remains one of the most abundant species caught in the Falkland Islands multispecies skate fishery (Agnew *et al.* 1999; Arkhipkin *et al.* 2008; Falkland Islands Government 2005, 2006, 2007, 2008, 2010, 2011, 2012) and presently makes up between 11 percent and 18 percent of the skate trawl catch and bycatch identified by observers (Agnew *et al.* 2000; Falkland Islands Government 2010, 2011, 2012, 2014). Recent data from the Falkland Islands Government (2012) also indicate that the modal disc width of graytail skate catches has increased to 63 cm in 2012. The increase in modal disc width could be indicative of population recovery for graytail skates in recent years. This is supported by the fact that in 2010, fishery-independent surveys conducted to estimate skate biomass in the northern area of the Falkland Islands (the area that generally yields the highest skate catches by the targeted skate fishery) confirm that total skate biomass, and particularly the predominant skate species, including graytail skate, have remained stable in recent years. Using CPUE as an index of abundance, an analysis incorporating more recent data from 1994 to 2013 revealed that *B. griseocauda* was in decline until about 2007, with a decrease in CPUE from 120.1 kg/hr in 1994 to 22.6 kg/hr in 2007 (Winter *et al.* unpublished). However, CPUE has since increased to an estimated 70.1 kg/hr in 2013, similar to levels observed in 1997–2001, with abundance continuing on a positive trend (Winter *et al.* unpublished). Furthermore, given that these estimates are only for graytail skate in the northern area of the Falkland Islands, it is likely that the total abundance of the Falkland Islands population is significantly higher and has recovered even more so due to the complete ban on commercial skate

fishing in the southern batoid aggregation area, where the spawning grounds of the species are mostly located (A. Winter, pers. comm. 2015).

Given the evidence of increasing CPUE and biomass of the northern skate assemblage, skate catch estimates that are below MSY, stable biomass estimates of graytail skate, and increasing abundance and sizes of graytail skates in catches, the current fishing effort and level of exploitation of skates in general, and graytail skate in particular, in the Falkland Islands appears to be sustainable (Falkland Islands Government 2014). In other words, overutilization of the species in this portion of its range is not a threat that is contributing significantly to its risk of extinction.

In Argentina, an active commercial elasmobranch fishery, which exploits sharks, skates, and rays, has shown an increasing trend in both catches and number of vessels reporting skate and ray landings since the early 1990s. Historically, skates and rays were mainly discarded as fisheries bycatch, but are now landed as both target and non-target catch (Chiaramonte 1998; Massa and Hozbor 2003). Specifically, catches have increased from 183 t in 1991 to 13,265 t in 2000, and vessels reporting landings have increased from 69 in 1992 to 377 in 1998 (Sánchez and Mabragna 2002; Massa and Hozbor 2003). From 1994–1998, Massa and Hozbor (2003) estimated a decline of around 36 percent in the CPUE of large fishing vessels (>28 m in length) for all skates and rays on the Argentine shelf between 34 and 48° S.; however, the data are not species-specific and deep-water skates, like the graytail skate, are generally not monitored despite the fact that they are under fishing pressure (Massa *et al.* 2004b). Additionally, the CPUE of skates and rays for smaller fishing vessels (with lengths <28 m) did not show similar declines; rather, CPUE for these vessels on the Argentine shelf remained fairly stable from 1994–1998 (Massa and Hozbor 2003).

Along the Patagonian shelf, the graytail skate has also been observed as bycatch in the scallop (*Zygochlamys patagonica*) fishery. This Patagonian scallop fishery primarily operates along the 100 m isobath, between 36°43' S and 48°30' S, and uses non-selective bottom otter trawls (Schejter *et al.* 2012). In a research study examining the bycatch composition from this fishery, the graytail skate occurred in 6.8 percent of the sampled fishing sites (n=177) (Schejter *et al.* 2012); however, no information on abundance of the species within those sites was provided. Overall, the limited abundance data as

well as the lack of species-specific information and trends data makes it difficult to determine the magnitude of utilization that may be occurring specifically for *B. griseocauda* in this part of its Argentinian range, and whether this level of utilization is contributing significantly to the species' extinction risk.

Similarly, 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 the yellownose skate (*Zearaja chilensis*), and although information on the depth at which the fishery operates could not be found, *Z. chilensis* lives at depths between 28 m and 435 m. This depth range overlaps with the shallower half of the graytail skate's depth range (Kyne *et al.* 2007) and thus this fishery may also incidentally catch graytail skates. Since 1979, declines in *Z. chilensis* catches have been reported, and it is suspected that other skate species, including the graytail skate, have also been affected (McCormack *et al.* 2007); however, graytail skate comprise less than 5 percent of the skate landings in this fishery (McCormack *et al.* 2007). As such, the impact of this fishery on graytail skate abundance and overall extinction risk is likely to be minimal.

Disease or Predation

At this time, there is no available information regarding diseases or predators of the species. As such, there is no evidence to indicate that these factors are a threat to the graytail skate.

Inadequacy of Existing Regulatory Mechanisms

In the Falkland Islands, there are numerous management measures in place that provide for the protection of graytail skate from overutilization. The Falkland Islands multispecies fishery, where graytail skate is presumably most heavily exploited, is rigorously managed through fishing effort controls. In order to protect the southern batoid aggregation area that displayed marked declines in CPUE in the early 1990s (Agnew *et al.* 1999), the Falkland Islands government implemented a number of management measures to ensure long-term sustainability of the rajid fishery, including: (1) The placement of observers on vessels to identify batoids to species and collect other biological data to inform fisheries management; (2) the development of specific skate and ray fishery seasons and licenses to better regulate the catch of rajids; and (3) the implementation and continuation of a prohibition on trawling for skates and rays south of 51°

S, which effectively closed the southern ray fishery. Before the prohibition, graytail skate were particularly abundant south of the islands, where its spawning grounds are mostly located (A. Winter, pers. comm. 2015), and made up a significant portion of the catch from this area. Thus, this measure helps protect not only a large segment of the population from further depletion in an area where they were historically most concentrated, but also important life history behavior required for the survival of the species (Agnew *et al.* 2000). In addition to the closure of the southern ray fishery via the trawl prohibition, catch limits were also imposed for the northern rajid fishery in 1996. Since then, the northern batoid stock has seen a gradual increase in both CPUE and biomass, with total catches lower than MSY, suggesting regulatory measures are adequate in providing for the sustainable exploitation of the northern skate assemblage in Falkland waters. Data also suggest that these regulatory measures have allowed for the recovery of the graytail skate population, as indicated by the increasing CPUE and sizes of graytail skate in recent catches. As such, the Fisheries Committee, which advises the Falkland Islands Fisheries Department, recommended maintaining the skate target catch at the current level of effort allocation for the 2016 fishing year as these limits are effective at maintaining a sustainable multispecies fishery and appear adequate to protect the graytail skate from extinction.

In Argentina, the graytail skate is covered under the country's FAO NPOA-sharks; however, it is not considered a priority species. Several sources have noted that Argentina does little to actively protect elasmobranchs, particularly skates and rays, in its waters (Massa and Hozbor 2003; Massa *et al.* 2004b, 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 Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP) set the recommended total allowable catch for all skates and rays at 9,000 t and a landing limit for skates and rays was set at no more than 30 percent of the catch. However, due to the lack of information regarding the status of the graytail skate in Argentina, there is no indication that existing regulatory mechanisms are inadequate in controlling threats to the species or are contributing significantly to the species' risk of extinction.

In Uruguay, the graytail skate is considered a species of high priority

under Uruguay's FAO NPOA-sharks, which outlines plans to: investigate the species' age, growth, reproduction, diet, distribution, and habitat use in Uruguayan waters; generate a time series for catch and effort of the skate in fisheries; conduct an abundance assessment; establish measures to review current fishing licenses for graytail skate and determine possible modifications to the licenses; and finally, prohibit new fishing permits. However, aside from the species' presence in Uruguayan waters, there is a significant lack of information regarding the status of graytail skate in Uruguay; thus, there is no indication that existing regulatory mechanisms are inadequate in controlling threats to the species in this portion of its range, or are contributing significantly to its risk of extinction.

In Chile, there are little to no regulations for the protection of graytail skate; however, the exploitation of the species in Chilean waters is minimal. While there are regulations pertaining to other fisheries in Chilean waters that overlap the graytail skate's range, it is unknown how these regulations affect the status of graytail skate. Based on the available information, there is no indication that existing regulatory mechanisms are inadequate in controlling threats to the species in this portion of its range, or are contributing significantly to its risk of extinction.

Other Natural or Manmade Factors Affecting the Species

Besides the information already discussed above in the other factor sections, no additional information was found regarding threats to the species that would fall under this category. As such, there is no evidence to indicate that this factor is a threat to the graytail skate.

Extinction Risk

Demographic Risk Analysis

Abundance

Although range-wide abundance estimates for graytail skate are unavailable; biomass estimates and trends exist for the areas where the species was historically and is currently most abundant. In the Falkland Islands, graytail skate represented a dominant part of the southern rajid assemblage in the mid-1990s and comprised around 39 percent of the northern rajid catch. Due to heavy fishing pressure contributing to unsustainable mortality rates, significant declines in the CPUE of the species were observed between 1992 and 2007 indicating a likely reduction in population abundance. However,

since the decline, CPUE (as an index of abundance of graytail skate) from north of the Falkland Islands has been increasing, already reaching levels observed in 1997–2001, with biomass of the species in 2010 estimated to be 7,232 t, consistent with biomass estimates from the early 1990s. Additionally, the graytail skate remains one of the most abundant species caught in the Falkland Islands multispecies skate fishery. Therefore, while the species likely experienced historical declines in abundance as a result of heavy exploitation in the early 1990s, the available information on biomass estimates and trends between the 1990s and 2014 indicate that the population is potentially stabilized and even recovering. Therefore, the species' present level of abundance is unlikely to pose a demographic risk to the species. Furthermore, there is no other abundance information or trend data from the rest of the species' range to indicate that the species' present abundance level is contributing significantly to its risk of extinction.

Growth Rate/Productivity

Relative growth rates (k) of graytail skates were estimated to be 0.064 year^{-1} in Argentinean waters (*i.e.*, low), and 0.02 year^{-1} to 0.033 year^{-1} in the Falkland Islands (*i.e.*, very low). Graytail skates are long-lived species, with an estimated lifespan of approximately 28 years, and a maximum disc width of 130 cm. Although age and growth studies from skates in the same region provide conflicting estimates for length and age at maturity, with age of maturity estimates ranging from 14–17.6 years for males and 17.8–24.8 years for females, all estimates indicate a very late age of maturity. While there is some evidence to suggest that graytail skates may reproduce year-round, overall, these reproductive characteristics suggest the species has relatively low productivity, similar to other elasmobranch species, which may hinder its ability to quickly rebound from threats that decrease its abundance (such as overutilization) and render the species more vulnerable to extinction in the face of other demographic risks and threats. Additionally, the observed decrease in the species' mean disc width in catches from 1993–1995 and 1997–2006 (to sizes that ranged between 25 cm and 40 cm) likely portended a declining growth rate for the species. This is because changes in metrics, such as average size, can significantly impact other important life history functions, like fecundity or even natural mortality rates (Audzijonyte *et al.* 2015), that affect the

instantaneous per capita growth rate of a species. However, since 2006, data from the Falkland Islands Government show an increase in size of the modal disc width of graytail skate catches, with the most recent size estimate of 63 cm in 2012, likely indicating that the population is recovering and that growth rate is no longer declining.

Spatial Structure/Connectivity

Based on trends in commercial fisheries data from the Falkland Islands and Argentina, Wakeford *et al.* (2005) concluded that graytail skates have limited spatial and temporal movements and, therefore, may likely exist as localized populations. Limited inter-population exchange reduces the recovery potential for depleted and small local populations and may increase the risk of local extirpations, possibly leading to complete extinction. However, no other information is available regarding spatial structure or connectivity of graytail skate populations throughout its range, and there is no evidence to suggest this demographic risk is presently significantly contributing to the graytail skate's risk of extinction.

Diversity

The loss of diversity can increase a species' extinction risk through decreasing a species' capability of responding to episodic or changing environmental conditions. This can occur through a significant change or loss of variation in life history characteristics (such as reproductive fitness and fecundity), morphology, behavior, or other genetic characteristics. Currently, there is no information regarding the graytail skates' diversity throughout its range, thus we can not conclude whether its present level of diversity is contributing to its extinction risk.

Threats Assessment

The best available information indicates that graytail skates are most heavily exploited in the Falkland Islands multispecies skate and ray fishery by foreign fleets and likely suffered significant declines in abundance due to overexploitation in the early 1990s. However, since 1996, the area of operation of the Falkland Islands rajid fishery has been significantly restricted (to an area north of the Islands) with imposed catch limits to manage the northern batoid stock assemblage (which includes graytail skates) within this area. As a result of these management measures, there has been a gradual increase in CPUE and biomass of the northern

batoid stock assemblage. As for graytail skates specifically, they remain one of the most abundant species caught in the Falkland Islands multispecies skate fishery. Recent data from the Falkland Islands Government shows an increasing trend in the CPUE of the species as well as in the modal disc width of graytail skate catches, with the latest estimate of 63 cm DW in 2012. While 63 cm is still below the size of sexual maturity (*i.e.*, 75 cm) it is a marked improvement from the modal disc widths between 1993 and 2006 (after heavy exploitation), which ranged between 25 cm and 40 cm, and indicates potential recovery of the population. Additionally, since the early 2000s, there has been a general decreasing trend in the targeting of skate and ray species in the Falkland Islands, with most species now taken as bycatch in the finfish fishery. Furthermore, total skate catch in recent years has remained below MSY, indicating that current catch and effort of the skate and ray fishery are likely sustainable. Based on the above information, it is clear that existing regulatory measures, including current catch limits and trawling closures, are adequate to protect the graytail skate in the Falkland Islands from extinction.

In Argentina, there is an active commercial elasmobranch fishery, which exploits sharks, skates, and rays, and it has shown an increasing trend in both catches and number of vessels reporting skate and ray landings (Massa and Hozbor 2003). However, based on the lack of species-specific information from the region, it is highly uncertain if present levels of utilization of skates and rays are a threat that is contributing significantly to the extinction risk of the graytail skate.

In Chile, a directed skate fishery that primarily targets *Zearaja chilensis* in areas where graytail skate may also occur has reported declines in catch since 1979. It is suspected that other skate species, including the graytail skate, have also been affected. However, there are no available data that indicate a decline in graytail skate abundance or catch, and given that the species comprises less than 5 percent of the total skate landings in this fishery, it is unlikely that this fishery is significantly contributing to the extinction risk of the graytail skate.

Overall, while the species likely experienced historical declines in abundance during the 1990s due to exploitation by the Falkland Islands multispecies rajid fisheries, the available biomass estimates and trends over the past decade, including gradual increases in the CPUE and biomass of

the northern batoid stock and specifically the graytail skate in recent years, as well as an increasing trend in graytail modal disc width size, indicate the population is potentially stable and possibly moving towards recovery. This is likely a result of rigorous regulations implemented by the Falkland Islands government to sustainably manage the rajid fishery by reducing fishing effort, accomplished by setting catch limits in the northern rajid fishery and closing the southern rajid fishery area, where graytail skates likely spawn and were historically most heavily exploited. It should be noted that while this closure helps to protect the Falkland Islands population, due to uncertainty surrounding the connectivity of graytail skate populations, these regulations may not provide protection to skate populations found outside of Falkland waters. However, based on the available information, it appears that the Falkland Islands is where the species is most concentrated, and, hence, the protection of this population from extinction is likely critical for the survival of the species. Outside of the Falkland Islands, the minimal available information on the species does not indicate that present levels of utilization or any other factors are contributing significantly to the extinction risk of the species.

Risk of Extinction

While the species' demographic characteristics increase its inherent vulnerability to depletion, and likely contributed to past population declines of varying magnitudes, the best available information suggests these risks have decreased due to the adequate control of exploitation of the species. In the Falkland Islands, where the species was most heavily exploited and is likely presently most concentrated, abundance estimates and trends from the 1990s to 2013, and increases in the species' mean disc width, suggest potential stabilization and even recovery of the population. The continued rigorous management and monitoring of the fishery appears adequate in protecting the species from levels of overutilization that would increase its extinction risk. Despite fishing pressure in other parts of the species' range (e.g., Chile and Argentina) and evidence of it being taken as bycatch in various fisheries, graytail skates are not monitored and we have no other information (e.g., catch rates, abundance trends, or any other species-specific data) to indicate that present levels of utilization or any other factors are significantly contributing to the species' risk of extinction. Thus, considering the above information and

analysis, we conclude that *B. griseocauda* is at a low risk of extinction throughout its range, and as such, does not warrant listing as a threatened or endangered species throughout its range.

Significant Portion of Its Range Analysis

Because our range-wide analysis for the species leads us to conclude that the species is not threatened or endangered throughout its range, under the final Significant Portion of Its Range (SPR) policy announced in July 2014, we must go on to consider whether the species may have a higher risk of extinction in a significant portion of its range (79 FR 37577; July 1, 2014).

The final policy explains that it is necessary to fully evaluate a portion for potential listing under the "significant portion of its range" authority only if information indicates that the members of the species in a particular area are likely both to meet the test for biological significance and to be currently endangered or threatened in that area. Making this preliminary determination triggers a need for further review, but does not prejudge whether the portion actually meets these standards such that the species should be listed:

To identify only those portions that warrant further consideration, we will determine whether there is substantial information indicating that (1) the portions may be significant and (2) the species may be in danger of extinction in those portions or likely to become so within the foreseeable future. We emphasize that answering these questions in the affirmative is not a determination that the species is endangered or threatened throughout a significant portion of its range—rather, it is a step in determining whether a more detailed analysis of the issue is required (79 FR 37586, July 1, 2014).

Thus, the preliminary determination that a portion may be both significant and endangered or threatened merely requires NMFS to engage in a more detailed analysis to determine whether the standards are actually met (*Id.* at 37587). Unless both are met, listing is not warranted. The policy further explains that, depending on the particular facts of each situation, NMFS may find it is more efficient to address the significance issue first, but in other cases it will make more sense to examine the status of the species in the potentially significant portions first. Whichever question is asked first, an affirmative answer is required to proceed to the second question. *Id.* ("[I]f we determine that a portion of the range is not "significant," we will not need to determine whether the species is

endangered or threatened there; if we determine that the species is not endangered or threatened in a portion of its range, we will not need to determine if that portion was "significant."'). Thus, if the answer to the first question is negative—whether that regards the significance question or the status question—then the analysis concludes and listing is not warranted.

After a review of the best available information, we identified the Falkland Islands as likely constituting a "significant" portion of the graytail skate range. Under the policy, a portion of a species' range is significant if, without that portion, the species would have an increased vulnerability to threats to the point that the overall species would be in danger of extinction or likely to become so in the foreseeable future. As mentioned previously, the historical and current fisheries data indicate that graytail skate are likely most concentrated in Falkland waters. Graytail skate have also been identified and caught elsewhere throughout its range, such as north of the Falkland Islands on the Argentinian shelf between 45° S. and 41° S., and on the Pacific coast off Chile (south of 41° S.); however, based on trends in commercial fisheries data from the Falkland Islands and Argentina, Wakeford *et al.* (2005) concluded that graytail skates have limited spatial and temporal movements and, therefore, may likely exist as localized or isolated populations. If we assume the Falkland Islands population is isolated from the populations of graytail skate elsewhere throughout its range, then, technically, loss of this population would not directly affect the abundance of the other remaining populations. However, loss of this population could significantly increase the extinction risk of the species as a whole, as only small, fragmented, and isolated populations of the species (based on the best available abundance information—see the *Historical and Current Distribution and Population Abundance* and *Demographic Risk Analysis* sections above) would remain, making them more vulnerable to catastrophic events and environmental or anthropogenic perturbations. Limited inter-population exchange also reduces the recovery potential for these small local populations and increases the risk of local extirpations and overall complete extinction.

Under the policy, if we believe the Falkland Islands population may constitute a "significant" portion of the range, then we must either evaluate the extinction risk of this population first to determine whether it is threatened or endangered in that portion or determine

if this portion is, in fact, “significant.” Ultimately, of course, both tests have to be met to qualify the species for listing. Given the extremely limited amount of information on the species outside of its Falkland Islands range, it is difficult to conduct a more definitive analysis to determine whether or not this portion does, in fact, constitute a “significant” portion of the range of the graytail skate. Additionally, there is no information to suggest that any other portion may be significant. However, even if we were to assume that the Falklands Islands population does constitute a “significant” portion of the graytail skate range, based on the information and analysis in the previous extinction risk section, there are no identified threats concentrated in this portion that are significantly contributing to the species’ risk of extinction. In fact, the most recent available information indicate that existing regulatory measures are adequate in protecting the graytail skate in the Falkland Islands from extinction, with graytail skate abundance on a positive trend and exhibiting signs of population recovery based on both CPUE and size data. Thus, under the policy, the preliminary determination that a portion of the species’ range may be both significant and endangered or threatened has not been met. Therefore, listing is not warranted under the SPR policy.

Proposed Determination

Based on the best available scientific and commercial information as presented in the status review report and this finding, we find that the graytail skate is not presently in danger of extinction throughout all or a significant portion of its range, nor is it likely to become so in the foreseeable future. We summarize the factors supporting this conclusion as follows: (1) Although there is no formal estimate of the current population size and historical declines in biomass have been observed, current biomass estimates from the Falkland Islands, where the species is likely most concentrated, suggest the population is stable and CPUE trends indicate abundance is increasing; (2) a reduction in mean disc width of the Falkland Islands population occurred in the late 1990s and early 2000s as a result of intensive fishing pressure; however, recent evidence suggests an increase in modal disc width, which is likely indicative of population recovery; (3) while an identified threat to the species was historical overutilization in the Falkland Islands commercial fisheries, subsequent fishery closures in the southern rajid fishery and catch limits

in the northern rajid fishery of the Falkland Islands have contributed to a significant reduction of fishing pressure on the species, leading to increases in the abundance of the population and providing for sustainable fishing of the northern Falkland Islands rajid assemblage; (4) targeting of skates and rays in the Falkland Islands, where the species was most heavily exploited, has been on a decreasing trend since the early 2000s; (5) there is no evidence that destruction of habitat, disease or predation are factors contributing to an increased risk of extinction for the species; and (6) the continual implementation of rigorous monitoring and fishery management measures in the Falkland Islands appears effective in addressing the most important threat to the species (overharvest) now and into the foreseeable future. Based on these findings, we conclude that the graytail skate is not presently in danger of extinction throughout all or a significant portion of its range, nor is it likely to become so within the foreseeable future. Accordingly, the graytail skate does not meet the definition of a threatened or endangered species and therefore does not warrant listing as threatened or endangered at this time.

Effects of Listing

Conservation measures provided for species listed as endangered or threatened under the ESA include recovery actions (16 U.S.C. 1533(f)); concurrent designation of critical habitat, if prudent and determinable (16 U.S.C. 1533(a)(3)(A)); Federal agency requirements to consult with NMFS under section 7 of the ESA to ensure their actions do not jeopardize the species or result in adverse modification or destruction of critical habitat should it be designated (16 U.S.C. 1536); and prohibitions on taking for endangered species (16 U.S.C. 1538). Recognition of the species’ plight through listing promotes conservation actions by Federal and state agencies, foreign entities, private groups, and individuals. The main effects of the proposed endangered listings are prohibitions on take, including export and import.

Identifying Section 7 Conference and Consultation Requirements

Section 7(a)(2) (16 U.S.C. 1536(a)(2)) of the ESA and NMFS/USFWS regulations require Federal agencies to consult with us to ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of listed species or destroy or adversely modify critical habitat. Section 7(a)(4) (16 U.S.C. 1536(a)(4)) of the ESA and NMFS/USFWS regulations

also require Federal agencies to confer with us on actions likely to jeopardize the continued existence of species proposed for listing, or that result in the destruction or adverse modification of proposed critical habitat of those species. It is unlikely that the listing of these species under the ESA will increase the number of section 7 consultations, because these species occur outside of the United States and are unlikely to be affected by Federal actions.

Critical Habitat

Critical habitat is defined in section 3 of the ESA (16 U.S.C. 1532(5)) as: (1) The specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the ESA, on which are found those physical or biological features (a) essential to the conservation of the species and (b) that may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by a species at the time it is listed upon a determination that such areas are essential for the conservation of the species. “Conservation” means the use of all methods and procedures needed to bring the species to the point at which listing under the ESA is no longer necessary. Section 4(a)(3)(A) of the ESA (16 U.S.C. 1533(a)(3)(A)) requires that, to the extent prudent and determinable, critical habitat be designated concurrently with the listing of a species. However, critical habitat shall not be designated in foreign countries or other areas outside U.S. jurisdiction (50 CFR 424.12(h)).

The best available scientific and commercial data as discussed above identify the geographical areas occupied by *Isogomphodon oxyrinchus*, *Rhinobatos horkelii*, *Mustelus fasciatus*, *M. schmitti*, *Squatina guggenheim* and *S. argentina* as being entirely outside U.S. jurisdiction, so we cannot designate critical habitat for these species.

We can designate critical habitat in areas in the United States currently unoccupied by the species, if the area(s) are determined by the Secretary to be essential for the conservation of the species. Regulations at 50 CFR 424.12(e) specify that we shall designate as critical habitat areas outside the geographical range presently occupied by the species only when the designation limited to its present range would be inadequate to ensure the conservation of the species. The best available scientific and commercial information on these species does not indicate that U.S. waters provide any

specific essential biological function for any of the species proposed for listing. Therefore, based on the available information, we do not intend to designate critical habitat for *Isogomphodon oxyrhynchus*, *Rhinobatos horkelii*, *Mustelus fasciatus*, *M. schmitti*, *Squatina guggenheim* or *S. argentina*.

Identification of Those Activities That Would Constitute a Violation of Section 9 of the ESA

On July 1, 1994, NMFS and FWS published a policy (59 FR 34272) that requires us to identify, to the maximum extent practicable at the time a species is listed, those activities that would or would not constitute a violation of section 9 of the ESA.

Because we are proposing to list *Isogomphodon oxyrhynchus*, *Rhinobatos horkelii*, *Mustelus fasciatus* and *Squatina argentina* as endangered, all of the prohibitions of section 9(a)(1) of the ESA will apply to these species. These include prohibitions on the import, export, use in foreign commerce, or “take” of the species. These prohibitions apply to all persons subject to the jurisdiction of the United States, including in the United States, its territorial sea, or on the high seas. Take is defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.” The intent of this policy is to increase public awareness of the effects of this listing on proposed and ongoing activities within the species’ range. Activities that we believe could result in a violation of section 9 prohibitions for these species include, but are not limited to, the following:

- (1) Possessing, delivering, transporting, or shipping any individual or part (dead or alive) taken in violation of section 9(a)(1);
- (2) Delivering, receiving, carrying, transporting, or shipping in interstate or foreign commerce any individual or part, in the course of a commercial activity;
- (3) Selling or offering for sale in interstate commerce any part, except antique articles at least 100 years old;
- (4) Importing or exporting these species or any part of these species.

We emphasize that whether a violation results from a particular activity is entirely dependent upon the facts and circumstances of each incident. Further, an activity not listed may in fact constitute a violation.

Identification of Those Activities That Would Not Constitute a Violation of Section 9 of the ESA

We will identify, to the extent known at the time of the final rule, specific activities that will not be considered likely to result in a violation of section 9 of the ESA. Although not binding, we are considering the following actions, depending on the circumstances, as not being prohibited by ESA section 9:

- (1) Take authorized by, and carried out in accordance with the terms and conditions of, an ESA section 10(a)(1)(A) permit issued by NMFS for purposes of scientific research or the enhancement of the propagation or survival of the species;
- (2) Continued possession of parts that were in possession at the time of listing. Such parts may be non-commercially exported or imported; however, the importer or exporter must be able to provide evidence to show that the parts meet the criteria of ESA section 9(b)(1) (i.e., held in a controlled environment at the time of listing, in a non-commercial activity).

Protective Regulations Under Section 4(d) of the ESA

We are proposing to list *Mustelus fasciatus* and *Squatina guggenheim* as threatened species. In the case of threatened species, ESA section 4(d) leaves it to the Secretary’s discretion whether, and to what extent, to extend the section 9(a) “take” prohibitions to the species, and authorizes us to issue regulations necessary and advisable for the conservation of the species. Thus, we have flexibility under section 4(d) to tailor protective regulations, taking into account the effectiveness of available conservation measures. The 4(d) protective regulations may prohibit, with respect to threatened species, some or all of the acts which section 9(a) of the ESA prohibits with respect to endangered species. These 9(a) prohibitions apply to all individuals, organizations, and agencies subject to U.S. jurisdiction. We will consider extending some or all potential protective regulations pursuant to section 4(d) for the proposed threatened species. We seek public comment on potential 4(d) protective regulations (see below).

Public Comments Solicited

To ensure that any final action resulting from this proposed rule will be as accurate and effective as possible, we are soliciting comments and information from the public, other concerned governmental agencies, the scientific community, industry, and any other

interested parties on information in the status review and proposed rule. Comments are encouraged on these proposals (See **DATES** and **ADDRESSES**). We must base our final determination on the best available scientific and commercial information when making listing determinations. We cannot, for example, consider the economic effects of a listing determination. Final promulgation of any regulation(s) on these species’ listing proposals will take into consideration the comments and any additional information we receive, and such communications may lead to a final regulation that differs from this proposal or result in a withdrawal of this listing proposal. We particularly seek:

- (1) Information concerning the threats to any of the six species proposed for listing;
- (2) Taxonomic information on any of these species;
- (3) Biological information (life history, genetics, population connectivity, etc.) on any of these species;
- (4) Efforts being made to protect any of these species throughout their current ranges;
- (5) Information on the commercial trade of any of these species;
- (6) Historical and current distribution and abundance and trends for any of these species;
- (7) Current or planned activities within the range of these species and their possible impact on these species; and,
- (8) Information relevant to potential ESA section 4(d) protective regulations for any of the proposed threatened species.

We request that all information be accompanied by: (1) Supporting documentation, such as maps, bibliographic references, or reprints of pertinent publications; and (2) the submitter’s name, address, and any association, institution, or business that the person represents.

Role of Peer Review

In December 2004, the Office of Management and Budget (OMB) issued a Final Information Quality Bulletin for Peer Review establishing a minimum peer review standard. Similarly, a joint NMFS/FWS policy (59 FR 34270; July 1, 1994) requires us to solicit independent expert review from qualified specialists, concurrent with the public comment period. The intent of the peer review policy is to ensure that listings are based on the best scientific and commercial data available. We solicited peer review comments on the species’ status review reports (Casselbury and Carlson 2015a–

g) from 22 scientists from the academic and scientific community that were either familiar with the species or had expertise in elasmobranch biology, ecology, or conservation. We received comments from nine scientists and incorporated those comments into the status review reports and this proposed rule. Their comments on the status reviews are also summarized in the peer review report available at http://www.cio.noaa.gov/services_programs/prplans/PRsummaries.html.

References

A complete list of the references used in this proposed rule is available upon request (see **ADDRESSES**).

Classification

National Environmental Policy Act

The 1982 amendments to the ESA, in section 4(b)(1)(A), restrict the information that may be considered when assessing species for listing. Based on this limitation of criteria for a listing decision and the opinion in *Pacific Legal Foundation v. Andrus*, 675 F. 2d 825 (6th Cir. 1981), we have concluded that ESA listing actions are not subject to the environmental assessment requirements of the National Environmental Policy Act (NEPA) (See NOAA Administrative Order 216–6).

Executive Order 12866, Regulatory Flexibility Act, and Paperwork Reduction Act

As noted in the Conference Report on the 1982 amendments to the ESA,

economic impacts cannot be considered when assessing the status of a species. Therefore, the economic analysis requirements of the Regulatory Flexibility Act are not applicable to the listing process. In addition, this proposed rule is exempt from review under Executive Order 12866. This proposed rule does not contain a collection-of-information requirement for the purposes of the Paperwork Reduction Act.

Executive Order 13132, Federalism

In accordance with E.O. 13132, we determined that this proposed rule does not have significant Federalism effects and that a Federalism assessment is not required. In keeping with the intent of the Administration and Congress to provide continuing and meaningful dialogue on issues of mutual state and Federal interest, this proposed rule will be given to the relevant governmental agencies in the countries in which the species occurs, and they will be invited to comment. We will confer with the U.S. Department of State to ensure appropriate notice is given to foreign nations within the range of all three species. As the process continues, we intend to continue engaging in informal and formal contacts with the U.S. State Department, giving careful consideration to all written and oral comments received.

List of Subjects

50 CFR Part 223

Endangered and threatened species, Exports, Imports, Transportation.

50 CFR Part 224

Endangered and threatened species, Exports, Imports, Transportation.

Dated: November 30, 2015.

Samuel D. Rauch, III,

Deputy Assistant Administrator for Regulatory Programs, National Marine Fisheries Service.

For the reasons set out in the preamble, 50 CFR parts 223 and 224 are proposed to be amended as follows:

PART 223—THREATENED MARINE AND ANADROMOUS SPECIES

■ 1. The authority citation for part 223 continues to read as follows:

Authority: 16 U.S.C. 1531–1543; subpart B, § 223.201–202 also issued under 16 U.S.C. 1361 *et seq.*; 16 U.S.C. 5503(d) for § 223.206(d)(9).

■ 2. In § 223.102, amend the table in paragraph (e) by adding new entries for two species in alphabetical order under the “Fishes” table subheading to read as follows:

§ 223.102 Enumeration of threatened marine and anadromous species.

* * * * *

(e) * * *

Species ¹			Citation(s) for listing determination(s)	Critical habitat	ESA rules
Common name	Scientific name	Description of listed entity			
*	*	*	*	*	*
Fishes					
*	*	*	*	*	*
Shark, spiny angel	<i>Squatina guggenheim</i>	Entire species	Federal Register citation and date when published as a final rule.	NA	NA
Shark, narrownose smoothhound.	<i>Mustelus schmitti</i>	Entire species	Federal Register citation and date when published as a final rule.	NA	NA
*	*	*	*	*	*

¹ Species includes taxonomic species, subspecies, distinct population segments (DPSs) (for a policy statement, see 61 FR 4722, February 7, 1996), and evolutionarily significant units (ESUs) (for a policy statement, see 56 FR 58612, November 20, 1991).

² Jurisdiction for sea turtles by the Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, is limited to turtles while in the water.

[79 FR 20806, Apr. 14, 2014, as amended at 79 FR 38240, July 3, 2014; 79 FR 40015, July 11, 2014; 79 FR 54122, Sept. 10, 2014; 80 FR 7978, Feb. 13, 2015]

PART 224—ENDANGERED MARINE AND ANADROMOUS SPECIES

Authority: 16 U.S.C. 1531–1543 and 16 U.S.C 1361 *et seq.*

“Fishes” table subheading to read as follows:

■ 3. The authority citation for part 224 continues to read as follows:

■ 4. In § 224.101, paragraph (h), amend the table by adding new entries for four species in alphabetical order under the

§ 224.101 Enumeration of endangered marine and anadromous species.

* * * * *
(h) * * *

Species ¹			Citation(s) for listing determination(s)	Critical habitat	ESA rules
Common name	Scientific name	Description of listed entity			
*	*	*	*	*	*
Fishes					
*	*	*	*	*	*
Guitarfish, Brazilian	<i>Rhinobatos horkelii</i>	Entire species	Federal Register citation and date when published as a final rule.	NA	NA
Shark, Argentine angel	<i>Squatina argentina</i>	Entire species	Federal Register citation and date when published as a final rule.	NA	NA
Shark, daggenose	<i>Isogomphodon oxyrinchus</i> .	Entire species	Federal Register citation and date when published as a final rule.	NA	NA
Shark, striped smoothhound.	<i>Mustelus fasciatus</i>	Entire species	Federal Register citation and date when published as a final rule.	NA	NA
*	*	*	*	*	*

¹ Species includes taxonomic species, subspecies, distinct population segments (DPSs) (for a policy statement, see 61 FR 4722, February 7, 1996), and evolutionarily significant units (ESUs) (for a policy statement, see 56 FR 58612, November 20, 1991).

² Jurisdiction for sea turtles by the Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, is limited to turtles while in the water.

[79 FR 20814, Apr. 14, 2014, as amended at 79 FR 31227, June 2, 2014; 79 FR 38241, July 3, 2014; 79 FR 74005, Dec. 12, 2014; 79 FR 78725, Dec. 31, 2014; 79 FR 68372, Nov. 17, 2014; 80 FR 7978, Feb. 13, 2015; 80 FR 7390, Feb. 10, 2015]

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