DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

[Docket No. 221103–0232; RTID 0648–XR116]

Endangered and Threatened Wildlife and Plants; 12-Month Finding on a Petition To List the Shortfin Mako Shark (Isurus oxyrinchus) as Threatened or Endangered Under the Endangered Species Act

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

ACTION: Notice of 12-month finding and availability of status review document for the shortfin mako shark (*Isurus oxyrinchus*).

SUMMARY: We, NMFS, have completed a comprehensive status review under the Endangered Species Act (ESA) for the shortfin mako shark (*Isurus oxyrinchus*) in response to a petition from Defenders of Wildlife to list the species. After reviewing the best scientific and commercial data available, including the Status Review Report, we have determined that listing the shortfin mako shark as a threatened or endangered species under the ESA is not warranted.

DATES: This finding was made on November 14, 2022.

ADDRESSES: The Status Review Report associated with this determination, its references, and the petition can be accessed electronically online at: *https://www.fisheries.noaa.gov/species/shortfin-mako-shark#conservation-management.*

FOR FURTHER INFORMATION CONTACT: Adrienne Lohe, NMFS Office of Protected Resources, 301–427–8442.

SUPPLEMENTARY INFORMATION:

Background

On January 25, 2021, we received a petition from Defenders of Wildlife to list the shortfin mako shark (*Isurus oxyrinchus*) as a threatened or endangered species under the ESA. The petition asserted that the shortfin mako shark is threatened by four of the five ESA section 4(a)(1) factors: (1) the present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial and recreational purposes; (3) inadequacy of existing regulatory mechanisms; and (4) other natural or manmade factors.

On April 15, 2021, NMFS published a 90-day finding for the shortfin mako shark with our determination that the petition presented substantial scientific and commercial information indicating that the petitioned action may be warranted (86 FR 19863). We also announced the initiation of a status review of the species, as required by section 4(b)(3)(A) of the ESA, and requested information to inform the agency's decision on whether this species warrants listing as endangered or threatened under the ESA. We received information from the public in response to the 90-day finding and incorporated the information into both the Status Review Report (Lohe *et al.* 2022) and this 12-month finding.

Listing Determinations Under the ESA

We are responsible for determining whether species are threatened or endangered under the ESA (16 U.S.C. 1531 *et seq.*). To be considered for listing under the ESA, a group of organisms must constitute a "species," which is defined in section 3 of the ESA to include any subspecies of fish or wildlife or plants, and any distinct population segment (DPS) of any species of vertebrate fish or wildlife which interbreeds when mature (16 U.S.C. 1532(16)). On February 7, 1996, NMFS and the U.S. Fish and Wildlife Service (USFWS; together, the Services) adopted a policy describing what constitutes a DPS of a taxonomic species ("DPS Policy," 61 FR 4722). The joint DPS Policy identifies two elements that must be considered when identifying a DPS: (1) The discreteness of the population segment in relation to the remainder of the taxon to which it belongs; and (2) the significance of the population segment to the remainder of the taxon to which it belongs.

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 (16 U.S.C. 1532(6), 16 U.S.C. 1532(20)). Thus, in the context of the ESA, 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. In other words, the primary statutory difference between a threatened and endangered species is the timing of when a species is in danger of extinction, either presently (endangered) or in the foreseeable future (threatened).

Under section 4(a)(1) of the ESA, we must determine whether any species is endangered or threatened as a result of any one or a combination of any of the following factors: (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence (16 U.S.C. 1533(a)(1)). 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, if any, being made by any state or foreign nation (or subdivision thereof) to protect the species (16 U.S.C. 1533(b)(1)(A)).

Status Review

To determine whether the shortfin mako shark warrants listing under the ESA, we completed a Status Review Report, which summarizes information on the species' taxonomy, distribution, abundance, life history, and biology; identifies threats or stressors affecting the status of the species; and assesses the species' current and future extinction risk. We appointed a biologist in the Office of Protected Resources Endangered Species Conservation Division to compile and complete a scientific review of the best available information on the shortfin mako shark, including information received in response to our request for information (86 FR 19863, April 15, 2021). Next, we convened an Extinction Risk Analysis (ERA) Team of biologists and shark experts to assess the threats affecting the shortfin mako shark, as well as demographic risk factors (abundance, productivity, spatial distribution, and diversity), using the information in the scientific review. The Status Review Report presents the ERA Team's professional judgment of the extinction risk facing the shortfin mako shark but makes no recommendation as to the listing status of the species. The Status Review Report is available electronically (see **ADDRESSES**). Information from the Status Review Report is summarized below in the Biological Review section, and the results of the ERA from the Status Review Report are discussed below.

The Status Review Report was subject to independent peer review as required by the Office of Management and Budget Final Information Quality Bulletin for Peer Review (M–05–03; December 16, 2004). The Status Review

Report was peer reviewed by three independent specialists selected from the academic and scientific community with expertise in shark biology, conservation, and management, and specific knowledge of shortfin mako sharks. The peer reviewers were asked to evaluate the adequacy, appropriateness, and application of data used in the Status Review Report, as well as the findings made in the ''Assessment of Extinction Risk'' section of the report. All peer reviewer comments were addressed prior to finalizing the Status Review Report.

We subsequently reviewed the Status Review Report, its cited references, and peer review comments, and conclude the Status Review Report, upon which this 12-month finding is based, provides the best available scientific and commercial information on the shortfin mako shark. Much of the information discussed below on the species' biology, distribution, abundance, threats, and extinction risk is attributable to the Status Review Report. Following our review of the Status Review Report and consideration of peer review comments, we conclude, however, that the ERA Team's foreseeable future of 25 years for the shortfin mako shark is not adequately justified. Each of the three peer reviewers recommended evaluating the species' risk of extinction over a longer time horizon. Based on these peer review comments and our review of the ERA Team's selection of 25 years as the foreseeable future, we have completed an independent determination of the foreseeable future (see Extinction Risk Analysis). For this reason, while we rely on the ERA Team's assessment of the species' present risk of extinction, we have supplemented the assessment of the species' risk of extinction within the foreseeable future. We have also independently applied the statutory provisions of the ESA, including evaluation of the factors set forth in section 4(a)(1)(A)–(E), our regulations regarding listing determinations,[1] and relevant policies identified herein in making the 12-month finding determination.

[1] On July 5, 2022, the United States District Court for the Northern District of California issued an order vacating the ESA section 4 implementing regulations that were revised or added to 50 CFR 424 in 2019 (''2019 regulations,'' see 84 FR 45020, August 27, 2019) although making no findings on the merits. On September 21, 2022, the U.S. Court of Appeals for the Ninth Circuit granted a temporary stay of the district court's July 5 order. As a result, the 2019 regulations are once again in effect, and we are applying the 2019 regulations here. For purposes of this determination, we considered whether the analysis or its conclusions would be any different under the pre-2019 regulations. We have determined that our analysis and conclusions presented here would not be any different.

Biological Review

Taxonomy and Species Description

The shortfin mako shark belongs to the family Lamnidae in the order Lamniformes, the mackerel sharks (ITIS 2021). Lamnid sharks are littoral to epipelagic with broad distributions in tropical to cold-temperate waters (Compagno 1984). They are fast-swimming and have a modified circulatory system to maintain internal temperatures warmer than the surrounding water (Compagno 1984). The shortfin mako shark belongs to the genus *Isurus* and only has a single living cogeneric species, the longfin mako shark (*Isurus paucus*). The species is relatively large, reaching a maximum total length (TL) of about 445 centimeters (cm) (Weigmann 2016), and has a moderately slender, spindle-shaped body with a conical snout (Compagno 1984). Its pectoral fins are narrow-tipped and moderately broad and long (considerably shorter than the length of the head) as compared to the very long pectoral fins of the longfin mako shark, which also has a less pointed snout and dusky underside (Compagno 1984; Ebert *et al.* 2013). The first dorsal fin is large and the second is very small and pivoting (Compagno 1984). The upper and lower lobes of the caudal fin are of nearly equal size, which is reflected in the genus name *Isurus* from the Greek words for ''equal tail.'' The teeth are large and bladelike without serrations, and the tips of the anterior teeth are strongly reflexed (Compagno 1984). The dorsal surface of the body is dark blue and the ventral side is white (Compagno 1984).

Distribution

The shortfin mako shark is a globally distributed pelagic species, occurring across all temperate and tropical ocean waters from about 50° N (up to 60° N in the northeast Atlantic) to 50° S and across a range of marine habitats (Rigby *et al.* 2019; Santos *et al.* 2020). Compagno (2001) provides the following description of the species' global distribution: in the western Atlantic, the species occurs from the Gulf of Maine to southern Brazil and possibly northern Argentina, including Bermuda, the Caribbean, and the Gulf of Mexico. In the eastern Atlantic, the range spans from Norway, the British Isles, and the Mediterranean to Morocco, Azores, Western Sahara, Mauritania, Senegal, Côte d'Ivoire, Ghana, southern Angola, probably Namibia, and the west coast of South Africa. In the Indo-Pacific basin, the species is found from the east coast of South Africa, Mozambique, Madagascar, Mauritius and Kenya north to the Red Sea, and east to Maldives, Iran, Oman, Pakistan, India, Indonesia, Viet Nam, China, Taiwan, North Korea, South Korea, Japan, Russia, Australia (all states and entire coast except for Arafura Sea, Gulf of Carpentaria and Torres Strait), New Zealand (including Norfolk Island), New Caledonia, and Fiji. In the central Pacific, the shortfin mako shark occurs from south of the Aleutian Islands to the Society Islands, including the Hawaiian Islands, and in the eastern Pacific, from southern California (and sometimes as far north as Washington State) south to Mexico, Costa Rica, Ecuador, Peru, and central Chile. Rare observations outside of this range have also been made, for example in waters of British Columbia (Gillespie and Saunders 1994).

Habitat Use

The shortfin mako shark is known to travel long distances in and between open ocean, continental shelf, shelf edge, and shelf slope habitats (Rogers *et al.* 2015b; Santos *et al.* 2021), making extensive long-distance straight-line movements of several thousand kilometers (km) (Francis *et al.* 2019). From traditional dart and fin tagging data, maximum recorded time at liberty is 12.8 years, and the maximum straight-line distance between tag and recapture localities is 3,043 nautical miles (5,636 km) (Kohler and Turner 2019). Shorter-term electronic tagging results from several studies indicate that the species commonly makes roundtrip migratory movements of more than 20,000 km, with one individual found to undertake an extended migration of 25,550 km over a period of 551 days (Rogers *et al.* 2015b; Francis *et al.* 2019). While the species has also demonstrated fidelity to small geographic areas on or near continental shelves and coastal areas of high productivity, this fidelic behavior is rarely observed in the open ocean (Rogers *et al.* 2015b; Corrigan *et al.* 2018; Francis *et al.* 2019; Gibson *et al.* 2021). Recent research demonstrates that the species regularly switches between these states of activity (*i.e.,* resident or fidelity behavior state and traveling state), spending nearly half their time (44–47 percent) in residency and slightly less than half their time (35–42 percent) in transit (Rogers *et al.* 2015b; Francis *et al.* 2019). It is unknown whether these behavioral states are tied to specific behaviors such as feeding or breeding. Furthermore, this behavioral switching may be affected by factors including environmental variation, spatial areas of sampling, or biotic factors; therefore, these findings may not be representative of the entire species, especially across time and space.

The vertical distribution of shortfin mako sharks is related to numerous environmental variables, including water temperature, dissolved oxygen (DO) concentration, time of day, prey availability, and lunar phase. The species typically occupies waters ranging between 17 °C and 22 °C (Casey and Kohler 1992; Nasby-Lucas *et al.* 2019; Santos *et al.* 2020, 2021), though it has a broad thermal tolerance and has been shown to also occupy waters from 10 °C (Abascal *et al.* 2011) to 31 °C (Vaudo *et al.* 2017). Like other lamnid sharks, the shortfin mako shark has counter-current circulation and is a red muscle endotherm, meaning that it can maintain the temperature of its slow-twitch, aerobic red muscle significantly above ambient temperature (Watanabe *et al.* 2015). Red muscle endothermy allows the species to tolerate a greater range of water temperatures, cruise faster, and have greater maximum annual migration lengths than fish without this trait (Watanabe *et al.* 2015). The high energetic cost of endothermy is suggested to be outweighed by benefits such as increased foraging success, prey encounter rates, and access to other seasonally available resources (Watanabe *et al.* 2015). The routine metabolic rate and maximum metabolic rate of shortfin mako sharks is among the highest measured for any shark species (Sepulveda *et al.* 2007), which may explain why the shortfin mako shark typically inhabits waters with DO concentrations of at least 3 milliliters per liter and avoids areas of low DO (Abascal *et al.* 2011). Individuals primarily occupy the upper part of the water column, but dive to depths of several hundred meters (m) (as deep as 979.5 m reported by Santos *et al.* (2021)), allowing them to forage for mesopelagic fishes and squid, though dives may have other functions including navigation (Holts and Bedford 1993; Francis *et al.* 2019). There is evidence that illumination from a full moon causes shortfin mako sharks to move into deeper water in pursuit of prey (Lowry *et al.* 2007). ''Bounce'' or ''yo-yo'' diving behavior, in which individuals repeatedly descend to deeper water and then ascend to shallow depths, has been regularly observed in both adults and young-of-the-year (YOY) (Sepulveda *et al.* 2004; Abascal *et al.* 2011; Vaudo *et al.* 2016; Santos *et al.* 2021). This type of diving behavior may be associated with feeding, behavioral thermoregulation, energy conservation, and navigation (Klimley *et al.* 2002; Sepulveda *et al.* 2004). Tagging studies have shown that the species typically spends more time in deeper, colder water during the daytime, and moves to shallower, warmer waters at night (Holts and Bedford 1993; Klimley *et al.* 2002; Sepulveda *et al.* 2004; Loefer *et al.* 2005; Stevens *et al.* 2010; Abascal *et al.* 2011; Nasby-Lucas *et al.* 2019). These diel vertical migrations are typically attributed to the pursuit of prey. However, other studies indicate no significant changes in vertical distribution between daytime and nighttime (Abascal *et al.* 2011, Santos *et al.* 2020). Larger individuals can dive to deeper depths than smaller individuals (Sepulveda *et al.* 2004), and juveniles specifically tend to spend much of their time in shallower, warmer water (Holts and Bedford 1993; Nosal *et al.* 2019).

There is some evidence that certain ocean currents and features may limit movement patterns, including the Mid-Atlantic ridge separating the western and eastern Atlantic (Casey and Kohler 1992 using conventional tagging data from 231 recaptured shortfin mako sharks over a 28-year period; Santos *et al.* 2020 using satellite telemetry for 41 shortfin mako sharks over a period of between 30 and 120 days), and the Gulf Stream separating the North Atlantic and the Gulf of Mexico/Caribbean Sea (Vaudo *et al.* 2017 using satellite telemetry for 26 shortfin mako sharks over a period of 78–527 days). However, conventional tagging data indicates that movement does occur across these features. Data from the NMFS Cooperative Shark Tagging Program (n=1,148 recaptured shortfin mako sharks) over a 52-year period show evidence of the species crossing the Mid-Atlantic Ridge demonstrating exchange between the western and eastern Atlantic (Kohler and Turner 2019). In fact, individual shortfin mako sharks (n = 104) that made long distance movements (>1,000 nautical miles) while at liberty for less than one year were primarily tagged off the coast of the U.S. Northeast and were recaptured in the Gulf of Mexico, Caribbean Sea, mid-Atlantic Ocean, and off Portugal, Morocco, and Western Sahara (Kohler and Turner 2019). In the Pacific, tagging data supports east-west mixing in the north and minimal east-west mixing in the south (Sippel *et al.* 2016 using conventional tagging data from 704 recaptured shortfin mako sharks since 1968; Corrigan *et al.* 2018 using satellite telemetry data of 13 individuals over a period of 249–672 days). Trans-equatorial movement appears to be uncommon based on tagging studies (Sippel *et al.* 2016; Corrigan *et al.* 2018), but tagged shortfin mako sharks have been recorded crossing the equator (Rogers et al. 2015a; Santos *et al.* 2021).

The locations of mating grounds and other reproductive areas are not well known for the shortfin mako shark, although the distribution of the youngest age classes may indicate potential pupping and nursery areas. Casey and Kohler (1992) observed YOY shortfin mako sharks offshore in the Gulf of Mexico, hypothesizing that pups are born offshore in the Northwest Atlantic to protect them from predation by large sharks, including other makos. Bite marks observed on mature females caught in the Gulf of Mexico may have resulted from mating behavior, indicating that the area may also be a mating ground (Gibson *et al.* 2021). The presence of mature and pregnant females in the Gulf of Mexico provides further support that this may be a gestation and parturition ground for the species. However, fisheries data suggests that pupping is geographically widespread in the Northwest Atlantic given that neonates are widely distributed along the coast of North America and largely overlap with the distribution of older immature sharks and adults (Natanson *et al.* 2020). Excursions of tagged shortfin mako sharks towards the shelf and slope waters of the Subtropical Convergence Zone, the Canary archipelago, and the northwestern African continental shelf, as well as aggregations of YOY shortfin mako sharks in these areas, may indicate that they serve as pupping or nursery grounds in the Northeast Atlantic (Maia *et al.* 2007; Natanson *et al.* 2020; Santos *et al.* 2021). In the Eastern North Pacific, the Southern California Bight has been suggested as a nursery area as roughly 60 percent of the catch here is made up by YOY and 2- to 4-year-old juveniles (Holts and Bedford 1993; Rodríguez-Madrigal *et al.* 2017; Nasby-Lucas *et al.* 2019). Farther south, the presence of many juveniles and some neonates near fishing camps in Baja California, Mexico, suggests that the area between Bahía Magdalena and Laguna San Ignacio may also be a nursery ground for the shortfin mako shark (Conde-Moreno and Galvan-Magana 2006). Presence of small immature shortfin mako sharks off Caldera, Chile, suggests that this may be a pupping or nursery area for the Southeastern Pacific (Bustamante and Bennett 2013). The temperate waters of the south-west Indian Ocean have been shown to host high concentrations of neonates and adults, suggesting that this area may be a nursery ground (Wu *et al.* 2021). Further, pregnant females have been observed in coastal waters off South Africa, strengthening the evidence that this area may be used for pupping or as a nursery (Groeneveld *et al.* 2014).

Diet and Feeding

The shortfin mako shark is a large, active predator that feeds primarily on teleosts and also consumes cephalopods, other elasmobranchs, cetaceans, and crustaceans (Stillwell and Kohler 1982; Cortés 1999; Maia *et al.* 2006; Gorni *et al.* 2012). It is estimated that shortfin mako sharks must consume 4.6 percent of their body weight per day to meet their high energetic demands (Wood *et al.* 2009). Based on the shortfin mako shark's diet, the species has a trophic level of 4.3 out of 5.0 (tertiary consumers have a trophic level over 4.0, while plants have a trophic level of one), one of the highest of 149 species examined by Cortés (1999) and comparable to other pelagic shark species such as common and bigeye thresher sharks (*Alopias vulpinus* and *Alopias superciliosus*), the salmon shark (*Lamna ditropis*), and the oceanic whitetip shark (*Carcharhinus longimanus*) (Bizzarro *et al.* 2017). Rogers *et al.* (2012) found evidence that the species targets specific prey despite high prey diversity; however, stable isotope analysis indicates that the species is a generalist predator (Maya Meneses *et al.* 2016). The degree of prey selectivity in any given individual's diet is likely strongly correlated with prey availability, with prey being consumed as encountered.

The specific diet of the shortfin mako shark varies by life stage, geographic location, season, and oceanic habitat. In the Northwest Atlantic, bluefish (*Pomatomus saltatrix*) are a major inshore prey item for the species and have been estimated to make up 77.5 percent of diet by volume (Stillwell and Kohler 1982), and more recently, 92.6 percent of diet by weight (Wood *et al.* 2009). In the northeast Atlantic, teleosts made up over 90 percent of the species' diet by weight, and Clupeiformes and garpike (*Belone belone*) are common prey (Maia *et al.* 2006). In the South Atlantic, teleosts are also dominant in the shortfin mako shark's diet (including *Lepidocibium flavobruneum, Scomber colias,* and Trichiruridae), while cephalopods of the orders Teuthida and Octopoda are also consumed (Gorni *et al.* 2012). In the northeast Pacific along the west coast of the United States, jumbo squid (*Dosidicus gigas*) and Pacific saury (*Cololabis saira*) are the two most important prey items, and other frequent teleost prey includes Pacific sardine (*Sardinops sagax*), Pacific mackerel (*Scomber japonicus*), jack mackerel (*Trachurus symmetricus*), and striped mullet (*Mugil cephalus*) (Preti *et al.* 2012). By contrast, YOY and juvenile shortfin mako sharks off Baja California Sur, Mexico, largely consume whitesnout searobin (*Prionotus albirostris*), Pacific mackerel (*S. japonicus*), and a variety of small squids (Velasco Tarelo 2005). As they age, larger teleost species and squids more commonly found in offshore pelagic waters become increasingly important, as evidenced by stable isotope analysis (Velasco Tarelo 2005). A large female shortfin mako shark recreationally caught off the coastline of the Southern California Bight was found to have eaten a California sea lion, *Zalophus californianus,* an event that does not appear uncommon based on previously documented pinnipeds in the stomachs of large shortfin mako sharks (Lyons *et al.* 2015). Shortfin mako sharks in the Indian Ocean prey on teleosts (*Trachurus capensis* and *S. sagax*), elasmobranchs (*Rhizoprionodon acutus* and *Carcharhinus obscurus*), and cephalopods (*Loligo* spp.) (Groeneveld *et al.* 2014). The dominant prey of shortfin mako sharks caught in coastal bather protection nets in the southwest Indian Ocean were elasmobranchs, while the diet of shortfin mako sharks caught in offshore longlines was dominated by teleosts (Groeneveld *et al.* 2014). As the size of individuals caught in coastal bather nets was significantly greater than those caught in offshore longlines, Groeneveld *et al.* (2014) suggest that larger prey attracts larger mako sharks to coastal waters.

Size and Growth

Shortfin mako sharks are long-lived, and are estimated to reach maximum ages of at least 28–32 years based on vertebral band counts validated by bomb radiocarbon and tag-recapture studies (Natanson *et al.* 2006; Dono *et al.* 2015). Longevity in the Pacific has been estimated as high as 56 years (Chang and Liu 2009; Carreon-Zapiain *et al.* 2018). There is uncertainty in the use of vertebral band pair counting to determine age as some authors find evidence for or assume annual growth band deposition periodicity (Cailliet *et al.* 1983; Campana *et al.* 2002; Ardizzone *et al.* 2006; Bishop *et al.* 2006; Semba *et al.* 2009; Dono *et al.* 2015; Liu *et al.* 2018) while others find evidence for the deposition of two growth band pairs each year for either all (Pratt Jr. and Casey 1983) or their first five years of life (Wells *et al.* 2013). Kinney *et al.* (2016) used the recapture of an oxytetracycline-tagged adult male to validate annual band deposition in adult shortfin mako sharks, inferring that juveniles experience more rapid growth and, therefore, exhibit biannual band pair deposition. In addition, there is evidence that vertebral band pair counts do not accurately reflect age in older, large individuals (Harry 2018; Natanson *et al.* 2018). Due to inconsistent information on vertebral band deposition in the Pacific, the International Scientific Committee for Tuna and Tuna-like Species (ISC) Shark Working Group's 2018 stock assessment of shortfin mako sharks in the North Pacific treated data from the western North Pacific as having a constant band pair deposition rate and data from the eastern North Pacific as having a band pair deposition rate that changes from two to one band pairs per year after age 5. The 2017 stock assessment of North and South Atlantic shortfin mako sharks conducted by the International Commission for the Conservation of Atlantic Tunas (ICCAT) assumed annual band pair deposition based on Natanson *et al.* (2006).

Shortfin mako sharks exhibit slow growth rates. Growth coefficient (K) estimates range from 0.043–0.266 year^{-1} in the Atlantic Ocean, 0.0154–0.16 year^{-1} in the Pacific Ocean, and 0.075–0.15 year^{-1} in the Indian Ocean (Pratt Jr. and Casey 1983, Ribot-Carballal *et al.* 2005, Natanson *et al.* 2006, Bishop *et al.* 2006, Cerna and Licandeo 2009, Semba *et al.* 2009, Groeneveld *et al.* 2014, Liu *et al.* 2018). Males and females have similar growth rates until a certain point, when male growth slows down compared to female growth. This has been estimated to occur at 7 years of age in the western and central North Pacific (Semba *et al.* 2009), 11 years of age in the Northwest Atlantic (Natanson *et al.* 2006), and 15 years of age (217 cm fork length (FL)) in the western South Atlantic (Dono *et al.* 2015). Females ultimately attain larger sizes than males, as has been documented in other shark species (Natanson *et al.* 2006). Maximum theoretical length in females is reported to be 370 cm TL in the western and central North Pacific (Semba *et al.* 2009) and 362 cm TL in the eastern North Pacific (Carreon-Zapiain *et al.* 2018). The maximum observed length for the species is 445 cm TL (Weigmann 2016), although Kabasakal and de Maddalena (2011) used photographs to estimate the length of a female caught off Turkey at 585 cm TL.

Age and size at maturity vary by geographic location. In general, males and females reach maturity at approximately 6–9 and 15–21 years (Natanson *et al.* 2006; Semba *et al.* 2009), and at sizes of 180–222 cm TL and 240–289 cm TL (Conde-Moreno and Galvan-Magana 2006; White 2007; Varghese *et al.* 2017), respectively. Additional information on growth and reproductive parameters for the species can be found in Table 1 of the Status Review Report.

Reproductive Biology

Shortfin mako sharks reproduce through oophagous (meaning 'egg eating') vivipary, wherein, after depletion of their yolk-sac, the embryos develop by ingesting unfertilized eggs inside the mother's uterus and are born as live young (Stevens 1983; Mollet *et al.* 2000). Estimates of gestation time vary from nine months to 25 months (Mollet *et al.* 2000; Duffy and Francis 2001; Joung and Hsu 2005; Semba *et al.* 2011) and litter sizes typically range from four to 25 pups (Mollet *et al.* 2000; Joung and Hsu 2005; Semba *et al.* 2011). Several studies find that litter size increases with maternal size (Mollet *et al.* 2000; Semba *et al.* 2011), though others find no evidence of this relationship (Joung and Hsu 2005; Liu *et al.* 2020). Size at birth is approximately 70 cm TL (Mollet *et al.* 2000). The reproductive cycle is estimated to take up to 3 years, with a potential resting period of 18 months (Mollet *et al.* 2000). There is evidence that parturition (birth) occurs in late winter to mid-spring in both the Northern and Southern Hemispheres based on embryonic growth estimates (Mollet *et al.* 2000; Semba *et al.* 2011; Bustamante and Bennett 2013), though Duffy and Francis (2001) found evidence of parturition in summer. With regard to mating strategy, two studies have found genetic evidence for polyandry and multiple paternity within litters, though other mating strategies (*e.g.,* polygyny or monogamy) cannot be ruled out (Corrigan *et al.* 2015; Liu *et al.* 2020).

Population Structure and Genetics

Although certain ocean currents and features may limit movement patterns between different regions as discussed previously (see *Habitat Use*), several genetic studies indicate a globally panmictic (characterized by random mating) population with some genetic structuring among ocean basins.

Heist *et al.* (1996) investigated population structure using restriction fragment length polymorphism analysis of maternally inherited mitochondrial DNA (mtDNA) from shortfin mako sharks in the Northwest Atlantic (n = 21), central North Atlantic (n = 24), western South Atlantic (n = 23), eastern North Pacific (n = 30), and western South Pacific (n = 22). The North Atlantic samples showed significant isolation from other regions ($p < 0.001$) and differed from other regions by the relative lack of rare and unique haplotypes and high abundance of a single haplotype (Heist *et al.* 1996). Significant differences in haplotype frequencies were not detected between the samples from Brazil, Australia, and California (Heist *et al.* 1996). Haplotypes did not seem to be confined to specific regions, and the three most common haplotypes were found in all samples (Heist *et al.* 1996). Clustering of mtDNA haplotypes did not initially support the presence of genetically distinct stocks of shortfin mako shark (Heist *et al.* 1996); however, reanalysis of the data found significant differentiation between the South Atlantic and North Pacific samples (Schrey and Heist 2003) in addition to isolation of the North Atlantic.

A microsatellite analysis of samples from the North Atlantic (n = 152), South Atlantic (Brazil; n = 20), North Pacific (n = 192), South Pacific (n = 43), and Atlantic and Indian coasts of South Africa (n = 26) found very weak evidence of population structure (F_{ST} = 0.0014, P = 0.1292; R_{ST} = 0.0029, P = 0.019) (Schrey and Heist 2003). Pairwise F_{ST} comparisons were not statistically significant after Bonferroni correction, though one pairwise R_{ST} value (North Atlantic vs. North Pacific) showed significant differentiation (R_{ST} = 0.0106, P = 0.0034). These results were insufficient to reject the null hypothesis of a single genetic stock of shortfin mako shark, suggesting that there is sufficient movement of shortfin mako sharks, and therefore gene flow, to reduce genetic differentiation between regions (Schrey and Heist 2003). The authors note that their findings conflict with the significant genetic structure revealed through mtDNA analysis by Heist *et al.* (1996). They suggest that as mtDNA is maternally inherited and nuclear DNA is inherited from both parents, population structure shown by mtDNA data could indicate that female shortfin mako sharks exhibit limited dispersal and philopatry to parturition sites, while male dispersal allows for gene flow that would explain the results from the microsatellite data (Schrey and Heist 2003).

Taguchi *et al.* (2011) analyzed mtDNA samples from the central North Pacific (n = 39), western South Pacific (n = 16), eastern South Pacific (n = 10), North Atlantic (n = 9), eastern Indian Ocean (n = 16), and western Indian Ocean (n = 16), finding evidence of significant differentiation between the North Atlantic, and the central North Pacific and eastern South Pacific (pairwise Φ_{ST} = 0.2526 and 0.3237, respectively). Interestingly, significant structure was found between the eastern Indian Ocean and the Pacific Ocean samples (pairwise Φ_{ST} values for Central North Pacific, Western South Pacific, Eastern South Pacific are 0.2748, 0.1401, and 0.3721, respectively), but not between the eastern Indian and the North Atlantic (Taguchi *et al.* 2011).

Corrigan *et al.* (2018) also found evidence of matrilineal structure from mtDNA data, while nuclear DNA data provide support for the existence of a globally panmictic population. Although there was no evidence of haplotype partitioning by region and most haplotypes were found across many (sometimes disparate) locations, Northern Hemisphere sampling locations were significantly differentiated from all other samples, suggesting reduced matrilineal gene flow across the equator (Corrigan *et al.* 2018). The only significant differentiation indicated by microsatellite data was between South Africa and southern Australia (pairwise F_{ST} = 0.037, Φ_{ST} = 0.043) (Corrigan *et al.* 2018). Clustering analysis showed only minor differences in allele frequencies across regions and little evidence of population structure (Corrigan *et al.* 2018). Overall, the authors conclude that although spatial partitioning exists, the shortfin mako shark is genetically homogenous at a large geographic scale. Taken together, results of genetic analyses suggest that female shortfin mako sharks exhibit fidelity to ocean basins, possibly to utilize familiar pupping and rearing grounds, while males move across the world's oceans and mate with females from various basins, thereby homogenizing genetic variability (Heist *et al.* 1996; Schrey and Heist 2003; Taguchi *et al.* 2011; Corrigan *et al.* 2018).

Haplotype diversity in shortfin mako sharks has been found to be high in several studies. Heist *et al.* (1996) found 25 haplotypes among 120 individuals for an overall haplotype diversity of 0.755 and a nucleotide diversity of 0.347. Taguchi *et al.* (2011) found haplotype and nucleotide diversity to be 0.92 and 0.0070, respectively, across the global range of the species. Corrigan *et al.* (2018) detected 48 unique haplotypes among 365 individuals for a haplotype diversity of 0.894 ± 0.013 and found very low nucleotide diversity of 0.004 ± 0.003.

Demography

Natural mortality for shortfin mako sharks is low and was estimated by Bishop *et al.* (2006) at 0.14 and 0.15 year^{-1} for males and females, respectively. Chang and Liu (2009) calculated natural mortality at 0.077–0.244 year^{-1} for females and 0.091–0.203 year^{-1} for males in the Northwest Pacific. In the North Atlantic, natural mortality was estimated at 0.101 year^{-1} (Bowlby *et al.* 2021). The generation time is estimated at 25 years (Cortés *et al.* 2015; Rigby *et al.* 2019).

In an analysis of productivity and susceptibility to longline fisheries in the Indian Ocean, Murua *et al.* (2018) calculated a population finite growth rate (λ) for shortfin mako sharks of 1.049 year^{-1} (1.036–1.061; Murua *et al.* 2018). Liu *et al.* (2015) estimated values for λ of shortfin mako sharks off California to be 1.1213 ± 0.0635 year^{-1} and 1.0300 ± 0.0763 year^{-1} for those in the Northwest Pacific. As the species displays sexual dimorphism in size, growth rates, and size at maturity, Tsai *et al.* (2015) argue that the use of a two-sex demographic model more accurately estimates the probability of decline risk and, therefore, better informs management decisions. Further, as the mating mechanism of shortfin mako sharks affects the proportion of breeding females and has not been conclusively established, these scenarios (monogamous, polyandrous, polygynous) should be modeled as well (Tsai *et al.* 2015). The authors report that in the Northwest Pacific, without fisheries-related mortality, values for λ were 1.047, 1.010, and 1.075 year^{-1} for females and 1.056, 1.011, and 1.090 year^{-1} for males in monogamous, polyandrous, and polygynous mating scenarios, respectively. Under fishing conditions at the time of the study, all values for λ dropped to less than one (0.943, 0.930, and 0.955 year^{-1} for females and 0.918, 0.892, and 0.939 year^{-1} for males in monogamous, polyandrous, and polygynous mating scenarios, respectively). Thus, population declines were expected regardless of the mating system modeled.

Productivity for the shortfin mako shark is quite low. In a recent analysis using six methods, Cortés (2016) determined that the intrinsic rate of population increase (r_{max}) for Atlantic shortfin mako sharks ranged from 0.036–0.134 yr^{-1}. These values were among the lowest calculated from 65 populations and species of sharks (Cortés 2016).

Abundance and Trends

Currently, there is no estimate of the absolute global abundance of the shortfin mako shark; however, based on the age-structured assessments conducted by ICCAT (2017) and the ISC Shark Working Group (2018), current abundance is estimated to be one million individuals in the North Atlantic and eight million individuals in the North Pacific (FAO 2019). Comprehensive analyses based on available regional stock assessments and standardized catch-per-unit-effort (CPUE) data have been used by the International Union for Conservation of Nature (IUCN) to approximate trends for the species globally.

In the 2019 IUCN Red List assessment, Rigby *et al.* estimated a global population trend using the following data sources: (1) the 2017 stock assessments conducted by ICCAT for the North and South Atlantic, (2) the 2018 stock assessment conducted by the ISC Shark Working Group for the North Pacific, (3) standardized CPUE data for the South Pacific from Francis *et al.* (2014), and (4) a preliminary stock assessment in the Indian Ocean by Brunel *et al.* (2018). Individual trends by region are discussed below. Using Just Another Red List Assessment (JARA) (Winker *et al.* 2018; Sherley *et al.* 2019), a Bayesian state-space tool for trend analysis of abundance indices, Rigby *et al.* (2019) found that the species is declining in all oceans other than the South Pacific, where it is increasing, with the steepest population declines indicated in the North and South Atlantic. Due to the unreliable stock assessment in the South Atlantic (discussed further below), Rigby *et al.* (2019) considered the North Atlantic stock assessment to be representative of the South Atlantic for the trend analysis. However, this may have inaccurately represented the extent of decline in the South Atlantic; the North Atlantic has experienced the largest known degree of decline across the species' range, and while there is some possibility that the South Atlantic has a similar stock status, the 2017 stock assessment does not support that conclusion, and accordingly, ICCAT has not taken comparable regulatory action for the species in the South Atlantic. A global trend was estimated by weighting each region's trend by the relative size of each region. To standardize the time period over which the trends were calculated, JARA projected forward the amount of years without observations that it would take to reach three generation lengths. The overall median population reduction was estimated at 46.6 percent, with the highest probability of 50–79 percent reduction over three generation lengths (72–75 years). Because available datasets for each region cover different time periods and have different durations, the timeframe of this trend is not a comparison between two specific years, but rather a standardized timeframe of three generation lengths. Trends indicated by Rigby *et al.* (2019) do not always align with abundance and trend indicators from other sources, as discussed below. The JARA framework used by Rigby *et al.* (2019) has been described as inappropriate for this long-lived, sexually dimorphic species because it only uses mean annual trends in the population over the assessment period and does not consider size or age structures of the population over recent decades (Kai 2021a). Available information on abundance and trends by region is discussed below. Stock assessments provide information on the status of a stock, with results presented using the terms ''overfished'' and ''overfishing.'' Specific to the context of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), a stock or stock complex is considered ''overfished'' when its biomass has declined below minimum stock size threshold (MSST), defined as the level of biomass below which the capacity of the stock or stock complex to produce maximum sustainable yield (MSY) on a continuing basis has been jeopardized (50 CFR 600.310(e)(2)(E)–(F)). Overfishing occurs whenever a stock or stock complex is subjected to a level of fishing mortality or total catch that jeopardizes the capacity of a stock or stock complex to produce MSY on a continuing basis (50 CFR 600.310(e)(2)(B)). While the stock assessments referenced in this finding do not define ''overfished'' and ''overfishing'' using the exact language above, they use the two terms with equivalent meanings. It is important to note that the terms ''overfished'' and ''overfishing'' do not have any specific relationship to the terms ''threatened'' or ''endangered'' as defined in the ESA. While a stock that is overfished is not able to sustain an exploitive fishery at MSY (*i.e.,* the highest possible annual catch that can be sustained over time), there is a significant difference between a stock that is overfished and a stock that is in danger of extinction. A stock will become overfished long before it is threatened with extinction, and can be stable at biomass levels that do not support MSY. Similarly, one goal of the MSA (and fisheries management organizations) is to ''rebuild'' overfished stocks to biomass levels that will support MSY. This level can be significantly above the biomass levels necessary to ensure that a species is not in danger of extinction. Thus, evidence of declining abundance that threatens the ability of the fishery to provide MSY are relevant, but not dispositive of a threatened or endangered species determination. Therefore, while available information about whether specific stocks are overfished or experiencing overfishing is relevant to and considered in our ESA extinction risk analysis, the fact that a stock may be considered ''overfished'' or experiencing ''overfishing'' does not automatically indicate that any particular status is appropriate under the ESA. Stock assessments, which provide information for determining the sustainability of a fishery, are based on different criteria than status reviews conducted under the ESA, which provide information to assess the likelihood of extinction of the species. When conducting a status review under the ESA, we use relevant information from available stock assessments, such as levels of biomass and fishing mortality, and apply the ESA's definitions of threatened and endangered species to the information in the record using our standard tools of ESA extinction risk analysis. As part of our ESA extinction risk analysis, when examining whether overutilization for commercial purposes is a threat to the species, we consider whether the species has been or is being harvested at levels that contribute to or pose a risk of extinction to the species.

North Atlantic Ocean

The most recent stock assessment by ICCAT indicates a combined 90 percent probability that the North Atlantic stock is in an overfished state and is experiencing overfishing (ICCAT 2017). The nine model runs used in this assessment generally agreed, indicating that stock abundance in 2015 was below biomass at maximum sustainable yield (B_{MSY}) (ICCAT 2017). The age-structured stock assessment model estimates historical declines in spawning stock fecundity (SSF, defined as the number of pups produced in each year) from 1950 (unfished condition) to 2015 at 50 percent and recent declines (from 2006 to 2015) at 32 percent (FAO 2019). All assessment models were consistent, and together indicated that the North Atlantic shortfin mako shark has experienced historical declines in total biomass of between 47–60 percent, and recent declines in total biomass of between 23–32 percent (FAO 2019). Projections conducted in the 2017 assessment using a production model estimated that for a total allowable catch (TAC; in this case, TAC refers to all sources of mortality and is not limited to landings data) of 1,000 metric tons (t), the probability of the stock being rebuilt and not experiencing overfishing (biomass (B) > B_{MSY}, and fishing mortality (F) < fishing mortality at MSY (F_{MSY})) was only 25 percent by 2040 (one generation length).

In 2019, the ICCAT Standing Committee on Research and Statistics (SCRS) carried out new projections for North Atlantic shortfin mako shark through 2070 (two generation lengths) using an integrated model (Stock Synthesis) at the Commission's request. The 2019 update to the stock assessment projects that even with a zero TAC, the North Atlantic stock would have a 53 percent probability of being rebuilt (SSF > SSF_{MSY}) and not experiencing overfishing (F < F_{MSY}) by 2045, and that regardless of TAC (including a TAC of 0 t), the stock will continue declining until 2035 (ICCAT 2019). Projections showed that a TAC of 500 t has a 52 percent probability of rebuilding the stock, with overfishing not occurring, by 2070. The projections indicated that realized TAC must be 300 t or less to ensure that the stock will be rebuilt and not experiencing overfishing with at least a 60 percent probability by 2070 (ICCAT 2019). These TAC options with associated time frames and probabilities of rebuilding were presented to the Commission; however, given the vulnerable biological characteristics of this stock and these pessimistic projections, to accelerate the rate of recovery and to increase the probability of success, the SCRS recommended that the Commission adopt a non-retention policy without exception.

The 2017 stock assessment and 2019 update to the stock assessment present more accurate and rigorous results than the prior 2012 assessment. The 2012 assessment overestimated stock size, underestimated fishing mortality, and suggested a low probability of overfishing (ICCAT 2019). Input data and model structure changed significantly between the 2012 and 2017 ICCAT stock assessments: catch time series start earlier (1950 vs. 1971 in the 2012 assessment), some biological inputs have changed and are sex-specific in the 2017 assessment, and additional length composition data became available (ICCAT 2017). In addition, the CPUE series have been decreasing since 2010, which was the last year in the 2012 assessment models (ICCAT 2017). Finally, the age-structured model in the 2017 stock assessment more accurately captured the time-lags in population dynamics of a long-lived species than the production models used in 2012.

The IUCN's JARA trend analysis for the North Atlantic region relied on the 2017 ICCAT stock assessment. Trend analysis of modeled biomass estimated a median decline of 60 percent in the North Atlantic based on annual rates of decline of 1.2 percent between 1950 and 2017 (Rigby *et al.* 2019), which is consistent with the decrease in total biomass (60 percent) obtained from Stock Synthesis model run 3 from the 2017 ICCAT stock assessment.

There is no stock assessment available for shortfin mako sharks in the Mediterranean Sea. Ferretti *et al.* (2008) compiled data from public and private archives representing sightings, commercial fisheries, and recreational fisheries data in the western Mediterranean Sea and used generalized linear models to conduct a meta-analysis of encounter trends. Long-term combined trends for shortfin mako shark and porbeagle (*Lamna nasus*) in the Mediterranean Sea indicate up to a 99.99 percent decrease in abundance and biomass since the early 19th century, though there was considerable variability among datasets due to geography and sample size (Ferretti *et al.* 2008). While shortfin mako sharks spanning a broad range of sizes (suggesting breeding/pupping in the region) are occasionally reported as bycatch in swordfish and albacore longline fisheries (Megalofonou *et al.* 2005), or in other artisanal or commercial fisheries (Kabasakal 2015), from the eastern Mediterranean Sea, no reliable estimates of abundance are available for this region.

Overall, the best available scientific and commercial information indicates that the North Atlantic shortfin mako shark population has experienced historical declines in biomass of between 47 and 60 percent, and declines will continue until at least 2035 regardless of fishing mortality.

South Atlantic Ocean

Results of the most recent ICCAT stock assessment for shortfin mako sharks in the South Atlantic indicate a high degree of uncertainty (ICCAT 2017). One model (Just Another Gibbs Sampler emulating the Bayesian production model) estimated that the stock was not overfished (B_{2015}/B_{MSY} = 1.69–1.75) but that overfishing may be occurring (F_{2015}/F_{MSY} = 0.86–1.07). Two runs from this model indicate a 0.3–1.4 percent probability of the stock being overfished and overfishing occurring, and a 29–47.4 percent probability of the stock not being overfished but overfishing occurring, or, alternatively, the stock being overfished but overfishing not occurring, and a 52.3–69.6 percent probability of the stock not being overfished and overfishing not occurring (ICCAT 2017). The Just Another Bayesian Biomass Assessment (JABBA) model results indicated an implausible stock trajectory and were, therefore, not relied upon for management advice. The Catch-only Monte-Carlo method (CMSY) model estimates indicate that the stock could be overfished (B_{2015}/B_{MSY} = 0.65 to 1.12) and that overfishing is likely occurring (F_{2015}/F_{MSY} = 1.02 to 3.67). Considering catch scenarios C1 (catches starting in 1950 in the north and 1971 in the south, as reported in the March 2017 ICCAT shortfin mako data preparatory meeting) and C2 (alternative estimated catch series based on ratios (method described by Coelho and Rosa 2017), starting in 1971), Catch-only Monte-Carlo method model estimates indicated a 23–89 percent probability of the stock being overfished and overfishing occurring, a 11–48 percent probability of the stock not being overfished but overfishing occurring, or alternatively, the stock being overfished but overfishing not occurring, and only a 0–29 percent probability of the stock not being overfished and overfishing not occurring. Generally, while CPUE exhibited an increasing trend over the last 15 years, both catches and effort increased contrary to the expectation that the population is expected to decline with increasing catch (FAO 2019). This inconsistency caused the ICCAT working group to consider the assessment highly uncertain, and they conducted no projections for the South Atlantic stock. Nevertheless, the combined assessment models found a 19 percent probability that the stock is overfished and is experiencing overfishing, a 48 percent probability of the stock not being overfished but overfishing occurring, or alternatively, the stock being overfished but overfishing not occurring, and a 36 percent probability that the stock is not being overfished or experiencing overfishing (ICCAT 2017). The assessment also notes that, despite uncertainty, in recent years the stock may have been at, or is already below, B_{MSY}, and fishing mortality is already exceeding F_{MSY}. Based on the uncertainty of the stock status, combined with the species' low productivity, the ICCAT working group concluded that catches should not increase above average catch for the previous 5 years, about 2,900 t (ICCAT 2017; FAO 2019). There is a significant risk that the South Atlantic stock could follow a trend similar to that of the North Atlantic stock given that fishery development in the South Atlantic predictably follows that in the North, and that the biological characteristics of the stock are similar. The 2019 update to the stock assessment (ICCAT 2019) therefore reiterates the recommendation that, at a minimum, catch levels should not exceed the minimum catch in the last 5 years of the assessment (2,001 t with catch scenario C1).

In addition to the ICCAT stock assessment, standardized catch rates in South Atlantic longlines indicate steep declines in the average CPUE of shortfin mako shark between 1979–1997 and 2007–2012 (Barreto *et al.* 2016). However, the methodologies used in this study have several caveats and limitations, including the standardization analysis being applied individually to each of the time series and the use of different variables. Therefore, the results are not directly comparable between the different time periods and cannot be used to infer the total extent of decline over the entirety of the time series (FAO 2019).

Overall, despite high uncertainty in abundance and trends for the species in this region, the best available scientific and commercial data indicate that there is a 19 percent probability that the population is overfished and is experiencing overfishing, and in recent years the stock may have been at, or is already below, B_{MSY} and fishing mortality is already exceeding F_{MSY}.

North Pacific Ocean

The most comprehensive information on trends for shortfin mako sharks in the North Pacific comes from the 2018 ISC Shark Working Group stock assessment, which found that the North Pacific stock was likely not in an overfished condition and was likely not experiencing overfishing between 1975 and 2016 (42 years) (ISC Shark Working Group 2018). This analysis used a Stock Synthesis model that incorporated size- and age-specific biological parameters and utilized annual catch data from 18 fleets between 1975 and 2016, annual abundance indices from five fleets for the same period, and annual size composition data from 11 fleets between 1994 and 2016 (Kai 2021a). This assessment determined that the abundance of mature females was 860,200 in 2016, which was estimated to be 36 percent higher than the number of mature females at maximum sustainable yield (MSY) (ISC Shark Working Group 2018). Future projections indicated that spawning abundances were expected to increase gradually over a 10-year period (2017–2026) if fishing mortality remains constant or is moderately decreased relative to 2013–2015 levels (ISC Shark Working Group 2018). Using results from the ISC stock assessment, historical decline in abundance (1975–1985 to 2006–2016) is estimated at 16.4 percent, and a recent increase (2006–2016) is estimated at 1.8 percent (CITES 2019).

The IUCN Red List Assessment for global shortfin mako shark also used the ISC assessment to model the average trend in the North Pacific stock over three generation lengths (72 years) and indicated a median decline of 36.5 percent based on annual rates of decline of 0.6 percent from 1975–2016 (Rigby *et al.* 2019). A comprehensive comparison of the assessments by the ISC and the IUCN (Kai 2021a) describes JARA (applied by Rigby *et al.* 2019) as a useful tool in extinction risk assessments for data-poor pelagic sharks, but inappropriate for the relatively data-rich North Pacific shortfin mako shark. The assessment by IUCN used only the mean annual trends in the population over the assessment period estimated from Stock Synthesis, and did not consider size or age structure of the population over recent decades. Kai (2021a) concludes that the results of the ISC's assessment of current and future status of North Pacific shortfin mako shark are more robust and reliable than those of the IUCN, and finds a median decline of the population trajectory of 12.1 percent over three generation lengths with low uncertainty.

The ISC Shark Working Group's 2021 indicator-based analysis for shortfin mako sharks in the North Pacific used time series of catch, indices of relative abundance (CPUE), and length-frequency data from multiple fisheries over the time period 1957–2019 to monitor for potential changes in stock abundance since the 2018 benchmark assessment. Catch of shortfin mako shark in 2019 was the second highest value for the last decade, and the scaled CPUEs indicated a stable and slightly increasing trend in the four major fleets (U.S. Hawaii longline shallow-set, Taiwan longline large-scale, Japan research and training vessels, and Mexico observer for longline) (ISC Shark Working Group 2021). The Working Group concluded that there were no signs of major shifts in the tracked indicators that would suggest a revision to the current stock assessment schedule for shortfin mako shark is necessary (ISC Shark Working Group 2021). The next stock assessment is scheduled for 2024.

Observer data from the Western and Central Pacific Fisheries Commission (WCPFC) indicate that longline catch rates of mako sharks in the North Pacific declined significantly by an average of 7 percent (95 percent confidence interval (CI): 3–11 percent) annually between 1995 and 2010 (Clarke *et al.* 2013). However, these data represent trends for both longfin and shortfin mako sharks combined, and the performance of the standardization model was poorer than for other studied shark species, making the estimated trend less reliable. There were also variable size trends for mako sharks in the North Pacific, with females showing significant increases in median length in one region (Clarke *et al.* 2013). In an updated indicator analysis using the same data, Rice *et al.* (2015) noted that the standardized CPUE trend looked relatively stable between 2000 and 2010, but no inference was possible for the last 4 years (2010–2014) due to data deficiencies in some years.

Kai *et al.* (2017) analyzed catch rates in the Japanese shallow-set longline fishery in the western and central North Pacific from 2006–2014, finding an increasing trend since 2008. However, fishery-independent logbook data collected from Japanese research and training vessels in the western and central North Pacific (mainly 0–40° N and 130° E–140° W) from 1992–2016 showed a decreasing catch rate since 2008 (Kai 2019). The opposing trends indicated by fishery-dependent and -independent data in this region may be due to factors such as differing areas of operation, differing gear types, underreporting by both data sources, and differing model structures applied to the data (Kai 2019). Additionally, standardized CPUE estimates from 2011–2019 in the Japanese longline fleet operating in the North Pacific Ocean showed a stable trend from 2011 to 2016, with a slight decline after 2016 (Kanaiwa *et al.* 2021). The authors note that observer coverage in the fleet is low (1.7–3.0 percent in certain areas) and that these results may not represent the overall trend for the North Pacific stock of shortfin mako shark (Kanaiwa *et al.* 2021).

Results from stock assessments and standardized CPUE trends from observer data are more comprehensive, robust, and reliable than trends from fishery logbook data. Therefore, we find that the best scientific and commercial information available indicates that shortfin mako sharks in the North Pacific are neither overfished nor experiencing overfishing, and the population is likely stable and potentially increasing despite evidence of historical decline and indications of recent decline in fishery-independent datasets.

South Pacific Ocean

In the South Pacific, longline catch rates reported to WCPFC did not indicate a significant trend in abundance of mako shark (shortfin and longfin combined) between 1995 and 2010 (Clarke *et al.* 2013). In an updated indicator analysis, standardized CPUEs for the mako shark complex show a relatively stable trend in relative abundance, with low points in 2002 and 2014, though the 2014 point is based on relatively few data and should be interpreted with caution (Rice *et al.* 2015). In New Zealand waters, logbook and observer data from 1995–2013 analyzed by Francis *et al.* (2014) indicate that shortfin mako sharks were not declining, and may have been increasing, over the period from 2005–2013. More recently, an analysis of the data did not result in statistically significant trend fits for two of the data series; those that were significant were increasing (Japanese South 2006–2015, Domestic North 2006–2013, and Observer Data 2004–2013) (FAO 2019). Trend analysis of modeled biomass indicates a median increase of 35.2 percent over three generation lengths based on estimated annual rates of increase of 0.5 percent from 1995–2013 (Rigby *et al.* 2019). In sum, the best scientific and commercial information available indicates that shortfin mako sharks in the South Pacific have an increasing population trend.

Indian Ocean

Only preliminary stock assessments using data-limited assessment methods have been conducted for the shortfin mako shark in the Indian Ocean, with few other stock indicators available. Catch data are thought to be incomplete for several reasons: landings do not reflect the number of individuals finned and discarded at sea, shortfin mako sharks are not sufficiently specified in catch data and are often aggregated with other species, shortfin mako shark may be misidentified as longfin mako shark, and recorded weight may often refer to processed weight rather than live weight (Bonhommeau *et al.* 2020). These factors were a significant consideration in our evaluation of the species. With these caveats in mind, a preliminary assessment by Brunel *et al.* (2018) was carried out based on CPUE estimates from Portuguese (2000–2016) and Spanish (2006–2016) swordfish and tuna longline fleets operating in the Indian Ocean Tuna Commission (IOTC) Convention area. Results from two models (a Bayesian Schaefer-type production model and another model analyzing the trends of catches) indicate that the stock is experiencing overfishing ($F_{2015}/F_{MSY} = 2.57$), but is not yet overfished (B_{2015}/B_{MSY} close to one) (Brunel *et al.* 2018). However, there were considerable uncertainties in the estimates and conflicting trends in biomass between the two models used. Nonetheless, trajectories showed consistent trends toward both overfished and subject to overfishing status (Brunel *et al.* 2018). Using the results of the Schaefer model from Brunel *et al.* (2018), historical decline (1970–1980 to 2005–2015) was estimated at 26 percent, recent decline (2005 to 2015) was estimated at 18.8 percent, and future 10-year decline was projected at 41.6 percent from the historical baseline (1970–1980 to 2015–2025) (CITES 2019). A trend analysis for modeled biomass in the Indian Ocean using Brunel *et al.*'s assessment indicates a median decline of 47.9 percent over three generation lengths based on annual rates of decline of 0.9 percent from 1971–2015 (Rigby *et al.* 2019).

A more recent preliminary assessment using updated catch and CPUE indices also indicates that the shortfin mako shark in the Indian Ocean is experiencing overfishing but is not overfished (Bonhommeau *et al.* 2020). This assessment uses nominal catch of shortfin mako shark as reported to the IOTC (1964–2018) and scaled CPUEs from Japan (1993–2018), Spain (2001–2018), Taiwan (2005–2018), and Portugal (2000–2018). Bonhommeau *et al.* (2020) used JABBA and CMSY models, both of which gave results that were generally consistent with the previous assessment: that the stock is currently undergoing overfishing and is not overfished.

In a separate study, Wu *et al.* (2021) analyzed standardized CPUE trends using observer records and logbook data from 2005–2018 for the Taiwanese longline fishery in the Indian Ocean, which was the second largest shortfin mako shark-catching nation in the region in 2019. The standardized CPUEs indicate a gradual decrease between 2005 and 2007, followed by a sharp increase in 2008, a slow decline between 2008 and 2015, and another increase between 2015 and 2018 (Wu *et al.* 2021). However, Wu *et al.* (2021) note that the rapid increases in CPUEs between 2007 and 2008 and later between 2015 and 2017 may be unrealistic for the stock biomass of such a long-lived species, and suggest that the results may be due to increased reporting by skippers and observers.

Logbook data from Japanese longliners operating in the Indian Ocean from 1993–2018 indicate that abundance of shortfin mako shark decreased from 1993–2009, and increased slightly since then (Kai and Semba 2019). Standardized CPUE has risen after 2008 in Portuguese and Spanish longline fleets as well (Coelho *et al.* 2020; Ramos-Cartelle *et al.* 2020), although these data sets were included in the preliminary stock assessment conducted by Bonhommeau *et al.* (2020). In the Arabian Sea CPUE data suggest variable abundance and little evidence of significant population reduction (Jabado *et al.* 2017). Fishing pressure in this region is high, and because the species has high susceptibility to pelagic fisheries, Jabado *et al.* (2017) estimated that over the past 3 generations the population has declined 20–30 percent, with future declines expected over the next 3 generations. Results from these studies may reflect partial stock status in the Indian Ocean, but may not have sufficient spatial coverage to be indicative of the entire stock status.

In sum, the best available scientific and commercial information indicates that shortfin mako shark population in the Indian Ocean is experiencing overfishing but is not yet overfished, and recent increasing CPUE trends are indicated in Spanish, Portuguese, and Taiwanese longline fleets. Catch data have the potential to be substantially underestimated and the recent increases in CPUE from these fleets may not reflect trends in abundance.

Summary

Overall, while abundance estimates for the shortfin mako shark are not available for all regions, the stock assessments available for the North Atlantic and North Pacific Oceans indicate current numbers of about one million and eight million individuals, respectively (FAO 2019). These estimates were generated by the FAO Expert Advisory Panel, which extracted these numbers using the age-structured assessments conducted by ICCAT (2017) and the ICS Shark Working Group (2018). Rigby *et al.* (2019) conducted a trend analysis of shortfin mako shark abundance indices using the 2017 ICCAT stock assessment in the Atlantic, the 2018 ISC Shark Working Group stock assessment in the North Pacific, a preliminary stock assessment for the Indian Ocean (Brunel *et al.* 2018), and a CPUE indicator analysis from New Zealand for the South Pacific (Francis *et al.* 2014). Due to the unreliable stock assessment in the South Atlantic, Rigby *et al.* (2019) considered the North Atlantic stock assessment to be representative of the South Atlantic for the trend analysis. However, this may have inaccurately represented the extent of decline in the South Atlantic for reasons described above. This assessment estimates the overall median population reduction for the global shortfin mako shark population at 46.6 percent, with the highest probability of 50–79 percent reduction over three generation lengths (72–75 years) (Rigby *et al.* 2019), although the JARA framework used by Rigby *et al.* has been described as inappropriate for this species as it only uses mean annual trends in the population over the assessment period and does not consider size or age structure of the population over recent decades (Kai 2021a).

Population decline has been indicated in the North Atlantic with high certainty, and abundance is likely to continue declining until at least 2035 even in the absence of fishing mortality (ICCAT 2019). In the North Pacific, while there is evidence of historical decline, recent assessments indicate that the stock is neither overfished nor experiencing overfishing, and the population is likely stable or potentially increasing (ISC Shark Working Group 2018). Although a stock assessment has not been completed for shortfin mako sharks in the South Pacific, the best available scientific and commercial data and analyses indicate an increasing population trend (Francis *et al.* 2014; Rigby *et al.* 2019). Abundance of the shortfin mako shark in the South Atlantic and Indian Oceans is not as clear, given significant uncertainties in the data available from these regions. The most recent stock assessments of shortfin mako sharks in the South Atlantic has a high degree of uncertainty, and indicate a combined 19 percent probability that the stock is overfished and experiencing overfishing (ICCAT 2017). Preliminary assessments in the Indian Ocean indicate that the population is experiencing overfishing but is not yet overfished (Brunel *et al.* 2018; Bonhommeau *et al.* 2020).

Extinction Risk Analysis

In evaluating the level of risk faced by a species and deciding whether the species is threatened or endangered, we must consider all relevant data and are required under the ESA to base our conclusions on the best scientific and commercial data available. In evaluating and interpreting the best available data we also apply professional judgment. We evaluate both the viability of the species based on its demographic characteristics (abundance, productivity, spatial distribution, and diversity; see McElhany *et al.* (2000)), and the threats to the species as specified in ESA section 4(a)(1)(A)–(E).

Methods

This section discusses the methods used to evaluate threats and the overall extinction risk to the shortfin mako shark. For purposes of the risk assessment, an ERA Team comprising biologists and shark experts was convened to review the best available information on the species and evaluate the overall risk of extinction facing the shortfin mako shark, now and in the foreseeable future.

According to regulations implementing section 4 of the ESA that were in place during the ERA Team's deliberations, which was consistent with our practice since 2009 in accordance with a legal opinion of the Solicitor of the United States Department of the Interior, ''The Meaning of 'Foreseeable Future' in section 3(20) of the Endangered Species Act'' (M–37021, Jan. 16, 2009; referred to herein as ''the 2009 M-Opinion''), the foreseeable future extends only so far into the future as we can reasonably determine that both the future threats and the species' responses to those threats are likely. *See* 50 CFR 424.11(d). Under our longstanding practice we describe the foreseeable future on a case-by-case basis, using the best available data and taking into account considerations such as the species' life-history characteristics, threat-projection timeframes, and environmental variability. In addition, 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 may not necessarily be reducible to a particular number of years and may not be defined the same way for each threat. Although the regulations were vacated and remanded without a decision on the merits on July 5, 2022, by the United States District Court for the Northern District of California, and that order has been temporarily stayed as of September 21, 2022, whether or not those regulations remain in place does not affect our understanding or application of the ''foreseeable future.'' The 2019 regulations merely codified the approach of our longstanding interpretation of this term in use prior to the issuance of these regulations (see 84 FR 45020, August 27, 2019), and the court did not make any findings on the merits that would call this approach into question. Thus, with or without the 2019 regulations, we would continue to apply an approach to the foreseeable future rooted in the 2009 M-Opinion.

In determining an appropriate foreseeable future timeframe for the shortfin mako shark, the ERA Team first considered the species' life history. The species matures late in life, with females estimated to mature at an age of 15–21 years and males at 6–9 years of age (Bishop *et al.* 2006; Natanson *et al.* 2006; Semba *et al.* 2009; Groeneveld *et al.* 2014). The species has high longevity of at least 28–32 years (Bishop *et al.* 2006; Natanson *et al.* 2006) and exhibits relatively slow growth rates and low productivity (Cortés *et al.* 2015). The ERA Team also considered generation time for the shortfin mako shark, which is defined as the average interval between the birth of an individual and the birth of its offspring, and has been estimated at 25 years (Cortés *et al.* 2015). Given the life history characteristics of the shortfin mako shark, the ERA Team concluded that it would likely take several decades for any conservation management actions to be realized and reflected in population abundance indices.

As the main threats to the species are overutilization in commercial fisheries and the inadequacy of regulatory measures that manage these fisheries (see Summary and Analysis of Section 4(a)(1) Factors below), the ERA Team then considered the time period over which they could reasonably predict the likely impact of these threats on the biological status of the species. The ERA Team took available projections for shortfin mako shark abundance into consideration: the 2019 ICCAT update to the stock assessment for the North Atlantic carried out projections over 2 generation lengths, or 50 years; the ISC Shark Working Group's 2018 stock assessment for North Pacific shortfin mako sharks used 10-year projections; and the IUCN Red List Assessment carried out projections based on available data to achieve a 3 generation length time frame using JARA.

In examining these projections and their respective confidence intervals, the ERA Team noted that uncertainty increased substantially after about one generation length in all cases across multiple regions of the species' range. The ERA Team noted that in the IUCN JARA projections conducted for shortfin mako sharks by region, uncertainty (*i.e.,* the difference between the median and confidence intervals) increased to 50 percent by 2030 for the South Pacific population (about 18 years projected), and 40 percent by 2040 for the Indian and North Pacific populations (about 25 years projected). Additionally, the ERA Team noted that ICCAT's report of the 2019 shortfin mako shark stock assessment update meeting emphasizes that the Kobe II Strategy Matrix (K2SM) used to provide scientific advice for the North Atlantic stock does not capture all uncertainties associated with the fishery and the species' biology. Specifically, ICCAT's SCRS stated that ''the length of the projection period (50 years) requested by the Commission significantly increases the uncertainty of the results. Therefore, the Group advised that the results of the K2SM should be interpreted with caution,'' (ICCAT 2019). As a result of this statement, the ERA Team considered the 50-year projection to have questionable scientific merit, with estimates over that time frame only provided because the Commission requested them. Given the concerns about uncertainty that were repeatedly highlighted by the SCRS (ICCAT 2019), the ERA Team concluded that the 50-year period was not an appropriate time period for the foreseeable future.

In addition to uncertainty in projected abundance trends, the ERA Team discussed the uncertainty associated with future management measures and fishing behavior across regions. ICCAT is currently the only major Regional Fishery Management Organization (RFMO) with management measures specific to shortfin mako sharks, and recently adopted a two-year retention ban for the species in the North Atlantic. The conservation benefit of this measure is uncertain, however, as it does not require fishermen to modify gear or fishing behavior that would reduce at-vessel or post-release mortality of the species. Further, management of the species after this two-year ban expires is unknown. Some of the top shortfin mako shark-catching nations in this region (Spain, Portugal, and Morocco) have very recently announced unilateral retention prohibitions for North Atlantic shortfin mako shark, although the effect these bans will have on the species is again unknown, even if they ultimately are well implemented. Although projections carried out in 2019 by ICCAT's SCRS indicate that the North Atlantic stock will continue declining until approximately 2035 regardless of fishing mortality, the effect on stock status beyond this varies greatly with fishing mortality levels. Beyond the North Atlantic and North Pacific (where fishing data is also considered robust), fishing harvest and, especially, at-vessel and post-release mortality data are less thoroughly documented, introducing considerable uncertainty in projections of fishery impacts past a few decades.

After considering the best available scientific and commercial information on the shortfin mako shark's life history, projected abundance trends, and current and future management measures and fishing behaviors, the ERA Team concluded that a biologically reasonable foreseeable future timeframe would be 25 years, or one generation length, for the shortfin mako shark. Because the main threats to the species are overutilization in commercial fisheries and the inadequacy of existing regulatory mechanisms to prevent overutilization in these fisheries, the ERA Team found that this timeframe would allow for reliable predictions regarding the likely impact of these threats on the future biological status of the species.

While we conclude that the ERA Team assembled the best scientific and commercial information, it is the role of the agency rather than the team to determine the appropriate application of the agency's interpretations of key statutory terms and of agency policy to the factual record, and to ultimately determine the species' listing status under the ESA. Based on the best available scientific and commercial information, we disagree with the ERA Team's conclusion that the foreseeable future extends only 25 years, or one generation length, and have determined that application of a 50-year time frame is more appropriate in this case generally, though for some individual threats our ability to predict the specific trends and the species' responses is less robust than for others. We agree that fisheries mortality and inadequate regulatory mechanisms to address this threat are, and will continue to be, the main threats to the species. While we also agree with the ERA Team's characterization of the shortfin mako shark's life history, we find this information to indicate that it would take more than one generation length for effects of conservation actions to be reflected in abundance indices. During peer review of the Status Review Report, reviewers noted that changes in threats and conservation measures for shortfin mako sharks might take decades to become visible in the mature population, and all three reviewers were of the opinion that a longer time horizon would be appropriate. We find that the ERA Team unnecessarily limited the length of the foreseeable future by relying on statistical confidence levels for projected population trends. The 2009 M-Opinion, which for over a decade has provided the basis for NMFS's interpretation of this term, states that ''the foreseeable future for a given species is not limited to the length of time into the future for which a species' status can be quantitatively modeled or predicted within predetermined limits of statistical confidence; however, uncertainties of any modeling efforts should be considered and documented.'' Although, as the ERA Team noted, uncertainty in abundance projections increases with the length of projections, we have determined that we can use available projections, our knowledge of the species' life history, and predicted levels of fishing mortality to inform what is likely to be the status of the species in a given region over a longer timeframe. Also, although changes in threats (*i.e.,* fisheries removals) would be observable over a 25-year period, we do not find that this time period is sufficient to measure and understand the population-level response to these changes, which would only be observable over a longer time period given the species' late age-at-maturity (this was also noted by a reviewer during the peer review process of the Status Review Report). A 50-year timeframe would encompass the duration over which changes in productivity would be expected to occur and be measurable while also taking into account the considerable uncertainty in future management measures and population trends as described by the ERA Team. To conclude, we find that our knowledge of the species' life history and of the fisheries impacting the species allow us to reasonably determine the likely threats facing the species (overutilization for commercial purposes and the related inadequacy of existing regulatory mechanisms) and the species' likely response to these threats (reflected in abundance trends and other demographic factors) over approximately 50 years, or two generation lengths. We therefore consider the foreseeable future to extend 50 years (two generation lengths) rather than 25 years as determined by the ERA Team.

The ability to measure or document risk factors to a marine species is often limited, and quantitative estimates of abundance and life history information are often lacking altogether. Therefore, in assessing extinction risk of a species with limited data available from certain regions, it is important to include both qualitative and quantitative information. In assessing extinction risk to the shortfin mako shark, the ERA Team considered the demographic viability factors developed by McElhany *et al.* (2000) and the risk matrix approach developed by Wainwright and Kope (1999) to organize and summarize extinction risk considerations. The approach of considering demographic risk factors to help frame the consideration of extinction risk has been used in many of our status reviews (which can be accessed online at *http://www.nmfs.noaa.gov/pr/species*). 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. To some extent these factors reflect the impacts that the operative threats have already had or are having on the species.

Using these concepts, the ERA Team evaluated demographic risks by assigning a risk score to each of the four demographic risk factors. The contribution of each demographic factor to extinction risk was scored according to the following scale: 0—unknown risk, 1—low risk, 2—moderate risk, and 3—high risk. Detailed definitions of the risk scores can be found in the Status Review Report. The scores were then tallied and summarized for each demographic factor. The ERA Team discussed the range of perspectives for each of the factors and the supporting data upon which they were based. ERA Team members were then given the opportunity to revise scores after the discussion if they felt their initial analysis had missed any pertinent data discussed in the group setting.

The ERA Team also performed a threats assessment for the shortfin mako shark by evaluating each threat in terms of its contribution to the extinction risk of the species. The contribution of each threat to the species' extinction risk was scored on the following scale: 0—unknown risk, 1—low risk, 2—moderate risk, and 3—high risk. The scores were then tallied and summarized for each threat, and the ERA Team again discussed the range of perspectives before providing final scores. As part of the threats assessment, the ERA Team considered the synergistic and combined effects of the threats acting together as well as individually. It should be emphasized that the scoring exercise for both demographic risks and threats was simply a tool to help the ERA Team members organize the information and assist in their thought processes for determining the overall risk of extinction for the shortfin mako shark, and is a common and well-accepted feature of our species assessments.

Guided by the results from the demographic risk analysis and the threats assessment, the ERA Team members were asked to use their informed professional judgment to make an overall extinction risk determination for the shortfin mako shark. For this analysis, the ERA Team considered three levels of extinction risk: 1—low risk, 2—moderate risk, and 3—high risk. Detailed definitions of these risk levels are as follows: 1 = Low risk: A species is at low risk of extinction if it is not at a moderate or high level of extinction risk (see ''Moderate risk'' and ''High risk'' below). A species may be at a low risk of extinction if it is not facing threats that result in declining trends in abundance, productivity, spatial structure, or diversity. A species at low risk of extinction is likely to show stable or increasing trends in abundance and productivity with connected, diverse populations; 2 = Moderate risk: A species is at moderate risk of extinction if it is on a trajectory that puts it at a high level of extinction risk in the foreseeable future (50 years in this case) (see description of ''High risk''). A species may be at moderate risk of extinction due to projected threats or declining trends in abundance, productivity, spatial structure, or diversity; 3 = High risk: A species with a high risk of extinction is at or near a level of abundance, productivity, spatial structure, and/or diversity that places its continued persistence in question. The demographics of a species at such a high level of risk may be highly uncertain and strongly influenced by stochastic or depensatory processes. Similarly, a species may be at high risk of extinction if it faces clear and present threats (*e.g.,* confinement to a small geographic area; imminent destruction, modification, or curtailment of its habitat; or disease epidemic) that are likely to create present and substantial demographic risks.

The ERA Team adopted the ''likelihood point'' method for ranking the overall risk of extinction to allow individuals to express uncertainty. Following this method, each ERA Team member distributed 10 ''likelihood points'' across the three extinction risk levels, representing the likelihood that the species falls into each risk category. Each Team member had the ability to cast points in more than one category to account for uncertainty, and the points that each Team member allocated across the categories summed to 10. This method has been used in previous NMFS status reviews (*e.g.,* oceanic whitetip shark, Pacific salmon, Southern Resident killer whale, Puget

Sound rockfish, Pacific herring, and black abalone) to structure the ERA Team's thinking and express levels of uncertainty when assigning risk categories. After scores were provided, the ERA Team discussed the range of perspectives and the supporting data on which scores were based, and members were given the opportunity to revise scores if desired after the discussion. Likelihood points were then summed by extinction risk category. Other descriptive statistics, such as mean, variance, and standard deviation, were not calculated, as the ERA Team concluded that these metrics would add artificial precision to the results.

Finally, consistent with the appropriately limited role of the Team, the ERA Team did not make ultimate recommendations as to whether the species should be listed as threatened or endangered. Rather, the ERA Team drew scientific conclusions about the overall risk of extinction faced by the shortfin mako shark under present conditions and in the foreseeable future based on an evaluation of the species' demographic risks and assessment of threats.

Because we determined to adopt a different period of years as the ''foreseeable future'' for the shortfin mako shark after the ERA Team's work concluded, we also present our own assessment of extinction risk over the foreseeable future (50 years or two generation lengths) in a later section of this document alongside the ERA Team's results.

Demographic Risk Analysis

Abundance

The ERA Team assessed available abundance and trend information by region, including formal stock assessments, preliminary stock assessments using data-limited assessment methods, and standardized CPUE trends. There are no global abundance estimates available; however, using the formal stock assessments available for the North Atlantic and North Pacific, current abundance has been estimated at one million and eight million individuals, respectively (FAO 2019). Using the regional rates of change weighted by an area-based estimate of the size of each region as a proportion of the species' global distribution, the IUCN Red List assessment estimated global decline at 46.6 percent over three generation lengths, with the particular years covered varying by region (Rigby *et al.* 2019). Although historical declines of varying degrees are evident across all oceans, current trends are mixed.

As discussed previously, the most recent stock assessment for shortfin mako shark in the North Atlantic indicates a combined 90 percent probability that the stock is in an overfished state and is experiencing overfishing (ICCAT 2017). The age-structured stock assessment model estimates historical declines in SSF from 1950 (unfished condition) to 2015 at 50 percent, and recent declines (from 2006–2015) at 32 percent (ICCAT 2017, FAO 2019). All nine assessment model runs were consistent, and together indicated that shortfin mako sharks in the North Atlantic have experienced historical declines (1950–2015) in total biomass of 47–60 percent, and recent declines (2006–2015) in total biomass of 23–32 percent (ICCAT 2017, FAO 2019). The 2019 update to the stock assessment projects that even with a zero TAC, there is a 53 percent probability that the North Atlantic stock will be rebuilt and not experiencing overfishing by 2045, and that regardless of TAC (in this case, TAC refers to all sources of mortality and is not limited to landings), the stock will continue declining until 2035 (ICCAT 2019). Overall, the ERA Team agreed that the findings from the stock assessment and projections were concerning. The ERA Team discussed how to appropriately interpret the stock assessment's focus on being rebuilt ($SSF > SSF_{MSY}$) and without overfishing ($F < F_{MSY}$) in the context of assessing extinction risk. As discussed previously in *Abundance and Trends,* while the fisheries management goal of rebuilding an overfished stock relates to achieving biomass levels that will allow for production of MSY, this can be significantly above the biomass levels necessary to ensure that a species is not in danger of extinction. While it will likely take decades for the stock to meet these fisheries management criteria (rebuilt and without overfishing), this does not indicate that the stock is at risk of becoming extirpated now or over the foreseeable future. Additionally, the ERA Team weighed the potential effects of the recent two-year North Atlantic shortfin mako shark retention prohibition on fishing mortality and abundance (ICCAT Recommendation 21–09, discussed in *Inadequacy of Existing Regulatory Mechanisms* below, which entered into force on June 17, 2022). As data for each fishing year is not reported until the following calendar year, the effect of this measure on fishing mortality will not be easily assessed until 2024 when the landings and discard data from 2023 can be analyzed. As noted above, the low productivity and slow population growth of shortfin mako shark may also mean that measurable impacts of this measure on abundance do not manifest for several years, when a new cohort enters the fishery. The Team concluded that there was significant uncertainty concerning both the effect of the measure and the future management of the stock after the two-year time period, and therefore did not significantly rely on any potential effect of the measure when drawing conclusions about the stock's abundance or trends.

We agree with the ERA Team's assessment of abundance and related considerations in the North Atlantic. We also recognize that without a substantial reduction in total fishing mortality (annual TAC of 500 t or less), it is unlikely that the stock will be rebuilt by 2070 (ICCAT 2019). Even if the spawning stock is not considered rebuilt by the stock assessment metric ($SSF > SSF_{MSY}$), this does not necessarily mean that the stock will be in danger of being extirpated. However, given that fishing mortality is still high in this region (1,709 t in 2020) compared to even the greatest assessed TAC level (1,100 t), this level of removal will lead to continued declines. Unless aggressive management measures effectively reduce fishing mortality in this region, declines will likely continue throughout the foreseeable future (50 years). ICCAT has a demonstrated track record of taking multilateral actions to address data gaps and to respond to indications of declining stock status (see previous ICCAT measures specific to the stock in *Inadequacy of Existing Regulatory Mechanisms* below). The two-year retention prohibition adopted by ICCAT in 2021 is the most recent step that has been taken to conserve and manage this stock in line with the ICCAT Convention. ICCAT's track record would indicate that similar or additional measures are likely to be continued or taken, as needed, to ensure ICCAT's objectives of ending overfishing and rebuilding the stock to levels that support MSY are met. Recommendation 21–09 calls for the Commission to review the measure no later than the annual meeting in 2024 to consider additional measures to reduce total fishing mortality. Overall, we conclude that the best available scientific and commercial data indicate that the stock is overfished and experiencing overfishing, has experienced an estimated 50 percent decline in SSF from 1950 to 2015, and will continue decreasing until 2035 regardless of TAC.

The 2017 stock assessment for shortfin mako sharks in the South Atlantic indicated a high degree of uncertainty. The combined assessment models found a 19 percent probability that the population is overfished and is experiencing overfishing (ICCAT 2017). The authors concluded that despite high uncertainty, in recent years the South Atlantic stock may have been at, or already below, B_{MSY} and fishing mortality is likely exceeding F_{MSY} (ICCAT 2017). Projections for the stock were not completed in 2019 due to high uncertainty. The ERA Team agreed that the best available scientific and commercial data indicate some degree of historical and ongoing population decline, but was unable to draw conclusions about the degree of decline due to the highly uncertain results of the 2017 stock assessment. We agree with the ERA Team's assessment of abundance in the South Atlantic.

The most comprehensive information on trends for shortfin mako sharks in the North Pacific comes from the 2018 ISC Shark Working Group stock assessment, which found that the North Pacific stock was likely not in an overfished condition and was likely not experiencing overfishing between 1975 and 2016 (42 years) (ISC Shark Working Group 2018). This assessment determined that the abundance of mature females was 860,200 in 2016, which was estimated to be 36 percent higher than the number of mature females at MSY (ISC Shark Working Group 2018). Future projections indicated that spawning abundance is expected to increase gradually over a 10-year period (2017–2026) if fishing mortality remains constant or is moderately decreased relative to 2013–2015 levels (ISC Shark Working Group 2018). Using results from the ISC stock assessment, historical decline in abundance (1975–1985 to 2006–2016) is estimated at 16.4 percent, and a recent increase (2006–2016) is estimated at 1.8 percent (CITES 2019). While the IUCN used the ISC assessment to model the average trend in the North Pacific stock over three generation lengths (72 years), resulting in a median decline of 36.5 percent (Rigby *et al.* 2019), Kai (2021a) found a median decline of the population trajectory of 12.1 percent over three generation lengths with low uncertainty. The ERA Team concluded that despite evidence of historical decline, the best available scientific and commercial data indicate that shortfin mako sharks in the North Pacific are neither overfished nor experiencing overfishing, and the population is likely stable and potentially increasing. We agree with the ERA Team's conclusion.

Although a stock assessment is not available for shortfin mako sharks in the South Pacific, available information indicates that the population is increasing. Standardized CPUEs for the mako shark complex (*i.e.,* both shortfin and longfin mako shark) show a relatively stable trend in relative abundance, with low points in 2002 and 2014, though the 2014 point is based on relatively few data and should be interpreted with caution (Rice *et al.* 2015). In New Zealand waters, logbook and observer data from 1995–2013 analyzed by Francis *et al.* (2014) indicate that shortfin mako sharks were not declining, and may be increasing, over the period from 2005–2013. More recently, trend estimations using data from these two studies (Francis *et al.* 2014 and Rice *et al.* 2015) did not result in statistically significant trend fits for two of the data series; those that were significant were increasing (Japanese South 2006–2015, Domestic North 2006–2013, and Observer Data 2004–2013) (FAO 2019). Trend analysis of modeled biomass indicates a median increase of 35.2 percent over three generation lengths (Rigby *et al.* 2019). In sum, the ERA Team agreed that the best available scientific and commercial data for shortfin mako sharks in the South Pacific indicate an increasing population trend, and we agree with the ERA Team's conclusion.

Finally, in the Indian Ocean, preliminary stock assessments using data-limited assessment methods are available for shortfin mako sharks and indicate that the stock is experiencing overfishing, but is not yet overfished (Brunel *et al.* 2018; Bonhommeau *et al.* 2020). This means that while the stock is subjected to a level of fishing mortality that jeopardizes the stock's ability to produce MSY, biomass levels are still high enough that the stock is able to produce MSY on a continuing basis. Both preliminary assessments are considered highly uncertain due to limitations in catch data. Using the results of the Schaefer model from Brunel *et al.* (2018), historical decline (1970–1980 to 2005–2015) was estimated at 26 percent, recent decline (2005 to 2015) was estimated at 18.8 percent, and future 10-year decline was projected at 41.6 percent from the historic baseline (1970–1980 to 2015–2025) (CITES 2019). A trend analysis for modeled biomass in the Indian Ocean using Brunel *et al.'s* assessment indicates a median decline of 47.9 percent over three generation lengths (Rigby *et al.* 2019). Recent increases in CPUE trends are indicated in Spanish, Portuguese, and Taiwanese longline fleets (Coelho *et al.* 2020; Ramos-Cartelle *et al.* 2020; Wu *et al.* 2021), though it should be noted that these datasets were included in the assessment by Bonhommeau *et al.* (2020). Overall, the ERA Team concluded that the best available scientific and commercial data indicate some level of historical population decline and indicate that shortfin mako sharks are currently experiencing overfishing in this region. We agree with the ERA Team's conclusion.

The ERA Team considered the risk associated with abundance of the global species using the best available scientific and commercial information, summarized above. Reported landings represent a substantial underestimate of mortality resulting from fisheries interactions because they do not fully account for mortalities that result from fisheries interactions, including sharks that are discarded dead, finned, or that experience post-release mortality, and therefore there is some level of uncertainty in all available stock assessments and abundance indices, particularly so in the South Atlantic and Indian Oceans. However, stock assessments in the North Atlantic and North Pacific were considered robust by the ERA Team. Some degree of historical decline is indicated in all ocean basins, and population declines are ongoing in the North Atlantic. In the South Pacific, there are no available stock assessments, so the positive trends indicated here are based on available studies with limited geographic scope. Overall, there is no indication that global abundance has declined to the point that reproductive success of the species has declined or inbreeding has resulted, nor is there evidence of other depensatory processes associated with small populations. All ERA Team members agreed that the best available scientific and commercial information indicates that the species' abundance does not put it at risk of extinction currently. Several ERA Team members were of the opinion that declining abundance trends would likely contribute to the species' risk of extinction in the foreseeable future as they defined it; however, the majority of ERA Team members concluded that global abundance trends are unlikely to contribute significantly to the species' risk of extinction currently or in the foreseeable future as they defined it. We agree that this factor is not contributing significantly to the species' risk of extinction now.

Over the foreseeable future of 50 years that we have determined is more appropriate to apply for this species, we find that the best available scientific and commercial data indicate that the abundance factor is unlikely to significantly contribute to the species' extinction risk. The shortfin mako shark population in the Pacific Ocean basin (a major segment of the global population) is likely to be stable and/or potentially increasing over this time period. Despite historical levels of decline (estimated at 47–60 percent reduction in total biomass) and likely continued decreases in the North Atlantic until at least 2035 (there is the potential for the population to begin rebuilding after this time with appropriate reduction of fishing mortality through management measures), as well as potential continuing population decreases of unknown degrees in the Indian and South Atlantic Oceans, we conclude that the best available scientific and commercial information indicates that global population abundance will not likely decline to the point that will put the species at risk of extinction over this timeframe.

Productivity

The shortfin mako shark exhibits high longevity (at least 28–32 years; Natanson *et al.* 2006; Dono *et al.* 2015), slow growth rates, late age at maturity (6–9 for males and 15–21 years for females; Natanson *et al.* 2006; Semba *et al.* 2009), long gestation (9–25 months; Mollet *et al.* 2000; Duffy and Francis 2001; Joung and Hsu 2005; Semba *et al.* 2011), and long reproductive cycles (3 years; Mollet *et al.* 2000; Joung and Hsu 2005). Cortés (2016) determined that the intrinsic rate of population increase (r_{max}) for Atlantic shortfin mako sharks ranges from 0.036–0.134 yr^{-1}. This was among the lowest values calculated from 65 populations and species of sharks. The ERA Team therefore concluded that the productivity of the species is quite low. The species also exhibits low natural mortality (0.075–0.244 yr^{-1}; Cortés 2016) and a long generation time (25 years; Cortés *et al.* 2015). Together, the species' life history characteristics indicate that it is highly susceptible to depletion from exploitation or other high-intensity sources of mortality, and will recover slowly from declines brought on by such stressors. The ERA Team was largely in agreement that although this factor doesn't constitute a risk of extinction for the species currently, this factor would likely contribute significantly to the species' risk of extinction in the foreseeable future as they defined it, especially if exacerbated by impacts of fishing mortality and resulting declines in abundance. We agree that this factor is not contributing significantly to the species' risk of extinction now. Similarly, we find that the best available scientific and commercial data indicates that the shortfin mako shark's low productivity will likely contribute significantly to the species' extinction risk over the foreseeable future of 50 years that we have determined is more appropriate to apply for this species.

Spatial Structure/Connectivity

Shortfin mako sharks are globally distributed across all temperate and tropical ocean waters and utilize numerous habitat types including open ocean, continental shelf, shelf edge, and shelf slope habitats (Rogers *et al.* 2015b; Corrigan *et al.* 2018; Francis *et al.* 2019; Rigby *et al.* 2019; Santos *et al.* 2020; Gibson *et al.* 2021). This highly migratory species is capable of undertaking movements of several thousand kilometers (Kohler and Turner 2019; Francis *et al.* 2019), and is able to make vertical migrations in the water column to several hundred meters depth (Santos *et al.* 2021). As a red muscle endotherm, the species is able to regulate its body temperature, allowing it to tolerate a broad range of water temperatures (Watanabe *et al.* 2015). Connectivity among ocean basins has been demonstrated by several genetic studies. Taken together, results of available genetic analyses suggest that female shortfin mako sharks exhibit fidelity to ocean basins, while males readily move across the world's oceans and mate with females from various basins, thereby homogenizing genetic variability (Heist *et al.* 1996; Schrey and Heist 2003; Taguchi *et al.* 2011; Corrigan *et al.* 2018). The ERA Team unanimously agreed that, based on this information, this demographic factor is not likely to contribute significantly to the species' risk of extinction now or in the foreseeable future as they defined it. We agree that this factor is not contributing significantly to the species' risk of extinction now. Over the foreseeable future of 50 years that we have determined is more appropriate to apply for this species, we also find that this demographic factor is not likely to significantly contribute to the shortfin mako shark's risk of extinction because this factor is not currently negatively affecting the species' status and the best available scientific and commercial data suggests no basis to predict that this factor will change over the extended time horizon.

Diversity

In its consideration of the degree to which diversity (or lack thereof) might contribute to the extinction risk of the shortfin mako shark, the ERA Team evaluated available information on genetic diversity as well as diversity of distribution and ecology. Available genetic studies do not indicate that the species has experienced a significant loss of diversity that would contribute to extinction risk. In fact, haplotype diversity has been found to be high in several studies: 0.755 by Heist *et al.* (1996), 0.92 by Taguchi *et al.* (2011), and 0.894 by Corrigan *et al.* (2018). Nucleotide diversity has been found to be lower: 0.347 by Heist *et al.* (1996), 0.007 by Taguchi *et al.* (2011), and 0.004 by Corrigan *et al.* (2018). Genetic studies indicate a globally panmictic population, meaning that there is sufficient movement of shortfin mako sharks, and therefore gene flow, to reduce genetic differentiation among regions (Heist *et al.* 1996; Schrey and Heist 2003; Taguchi *et al.* 2011; Corrigan *et al.* 2018). We found no evidence that gene flow, migration, or dispersal has been reduced. The species occurs across a variety of habitats and regions (Rogers *et al.* 2015b; Rigby *et al.* 2019; Santos *et al.* 2020), and is able to consume a diversity of prey (Stillwell and Kohler 1982; Cortés 1999; Maia *et al.* 2006; Gorni *et al.* 2012); these characteristics protect against catastrophic events that may impact a certain region or prey species. For these reasons, the ERA Team unanimously agreed that it is not likely that this factor significantly contributes to the species' risk of extinction now or in the foreseeable future as they defined it. We agree that this factor is not contributing significantly to the species' risk of extinction now. Similarly, over the foreseeable future of 50 years that we have determined is more appropriate to apply for this species, we also find that this demographic factor is not likely to significantly contribute to the shortfin mako shark's risk of extinction because this factor is not currently negatively affecting the species' status and the best available scientific and commercial data suggests there is no basis to predict that this factor will change over the extended time horizon.

Summary and Analysis of Section 4(a)(1) Factors

As described above, section 4(a)(1) of the ESA and NMFS' implementing regulations (50 CFR 424.11(c)) state that we must determine whether a species is endangered or threatened because of any one or a combination 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. The ERA Team assembled the best available scientific and commercial data and evaluated whether and the extent to which each of the foregoing factors contributed to the overall extinction risk of the global shortfin mako shark population. We summarize information regarding each of these threats below according to the factors specified in section 4(a)(1) of the ESA.

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

The shortfin mako shark is a highly migratory, pelagic species that spends time in a variety of open ocean and nearshore habitat types. The species is globally distributed from about 50° N (up to 60° N in the northeast Atlantic) to 50° S. While distribution is influenced by environmental variables including water temperature, prey distribution, and DO concentration, the shortfin mako shark is able to tolerate a broad thermal range and use a wide variety of prey resources. The ERA Team agreed that because shortfin mako sharks have a high adaptive capacity and do not rely on a single habitat or prey type, they are able to modify their distributional range to remain in an environment conducive to their physiological and ecological needs. Additionally, there is no evidence that range contractions have occurred, or that destruction or modification of their habitat on a global scale has occurred to such a point that it has impacted the status of the species. Therefore, the ERA Team concluded that the best available scientific and commercial information indicates that loss and/or degradation of habitat are not likely to be contributing significantly to the extinction risk of the shortfin mako shark now or in the foreseeable future as they defined it. We agree that this factor is not contributing significantly to the species' risk of extinction now. Because the contribution of habitat destruction, modification or curtailment to extinction risk is not likely to change from 25 to 50 years, we also find that this factor will not contribute significantly to extinction risk over the foreseeable future of 50 years that we have determined is more appropriate to apply for this species.

An analysis of potential threats posed by pollutants and environmental contaminants is carried out in *Other Natural or Manmade Factors Affecting its Continued Existence,* below, because this potential threat affects more than just the habitat or range of the species.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The best available information indicates that the primary threat facing the shortfin mako shark is overutilization in fisheries. The majority of the catch is taken incidentally in commercial fisheries throughout the species' range, and the species is often opportunistically retained due to the high value of its meat and fins (Camhi *et al.* 2008; Dent and Clarke 2015). The species is targeted in semi-industrial and artisanal fisheries in the Indian and Pacific Oceans, and as a sportfish in several recreational fisheries, though recreational fisheries are thought to have minimal contribution to the species' overutilization in comparison to effects from commercial fisheries.

Global reported catches of shortfin mako shark have risen substantially since 1980. According to the Food and Agriculture Organization of the United Nations (FAO) global capture production statistics (accessible at *https://www.fao.org/fishery/statistics-query/en/capture/capture_quantity*), reported catch for shortfin mako shark in the period 2010–2019 totaled 128,743 t, up from 86,912 t in the period 2000–2009 and 29,754 t in the period 1990–1999. In the 2010–2019 time frame, reported landings in the Atlantic Ocean and adjacent seas totaled 61,673 t (~48 percent of global reported catch), in the Pacific Ocean totaled 43,927 t (~34 percent of global reported catch), and in the Indian Ocean totaled 23,143 t (~ 18 percent of global reported catch). Reported landings, however, represent a substantial underestimate of actual catch because they do not fully account for mortalities that result from fisheries interactions, including sharks that are discarded dead, finned, or that experience post-release mortality. For instance, Clarke *et al.* (2006) estimated that shark biomass in the fin trade alone is three to four times higher than catch reported in the FAO capture production data. Therefore, impacts of commercial fishing fleets on the shortfin mako shark are likely much greater than reported catch numbers suggest.

Data from across the species' range indicate that much of the catch of shortfin mako sharks in longline fisheries is composed of immature individuals (N Atlantic: Biton-Porsmoguer 2018, Coelho *et al.* 2020a; S Atlantic: Barreto *et al.* 2016; NW Pacific: Ohshimo *et al.* 2016, Semba *et al.* 2021; E Pacific: Furlong-Estrada *et al.* 2017, Saldaña-Ruiz *et al.* 2019, Doherty *et al.* 2014; Indian: Winter *et al.* 2020, Wu *et al.* 2021). Exploitation of the juvenile life stage reduces the proportion of the population that survives to maturity to reproduce. Due to the late age-at-maturity of the species, many years are required before conservation actions may influence the spawning population. Additionally, abundance indices based on the part of the population that is most vulnerable to fisheries mortality (immature individuals) can be out of phase with those based on the abundance of the spawning stock (*e.g.,* CPUE and age-structured population models, respectively) for decades. For these reasons, the delay between identifying overutilization and addressing it can limit the effectiveness of mitigation and can make fisheries management for the shortfin mako shark difficult.

Rates of at-vessel mortality, or mortality resulting from interactions with fishing gear prior to being brought onboard (also known as hooking or capture mortality), vary by fishing practice and gear type. Campana *et al.* (2016) estimated fisheries mortality of shortfin mako sharks in Northwest Atlantic pelagic longline fisheries targeting swordfish and tuna, in which the majority (88 percent) of hooks used were circle hooks. The types of leaders or branch lines were not reported. Shortfin mako sharks were found to experience a mean at-vessel mortality rate of 26.2 percent, and another 23 percent of incidentally caught shortfin mako sharks were injured at haulback (Campana *et al.* 2016). The proportion of shortfin mako sharks that experienced at-vessel mortality in pelagic longlines was significantly higher than that of blue sharks (*Prionace glauca*), likely because shortfin mako sharks have very high oxygen requirements, and their ability to ram ventilate—or continuously force water across their gills to breathe, typically by swimming at speed—is compromised once hooked (Campana 2016; Campana *et al.* 2016). Data from Portuguese longline vessels targeting swordfish in the North and South Atlantic indicate at-vessel mortality rates of 35.6 percent for shortfin mako shark (Coelho *et al.* 2012). This fleet uses stainless steel J hooks and both monofilament and wire branch lines (Coelho *et al.* 2012). In the North Pacific, shortfin mako sharks incidentally caught in the Hawaii deep-set and American Samoa longline fisheries targeting tuna were found to experience an at-vessel mortality rate of 22.7 percent (Hutchinson *et al.* 2021). Prior to May 2022, the Hawaii deep-set fishery used circle hooks, stainless steel braided wire leader, and monofilament; the American Samoa longline fishery uses circle hooks and all monofilament branch lines (Hutchinson *et al.* 2021). However, in May 2022, NMFS issued a final rule that prohibits the use of wire leader in the Hawaii deep-set longline fishery, which is anticipated to increase survivorship of incidentally caught sharks.

Post-release (or discard) mortality rates are more difficult to accurately assess, although tag-recapture and telemetry studies indicate that they can be relatively low for shortfin mako sharks depending on factors such as hook type, hooking location, and handling. Reported estimates of post-release mortality rate also depend on the duration over which survival is assessed. Any mortality related to capture and handling that occurs after the monitoring period would cause post-release mortality rates to be underestimated (Musyl *et al.* 2009, Musyl and Gilman 2019). Campana *et al.* (2016) estimated that shortfin mako sharks (n=26) caught incidentally in Northwest Atlantic pelagic longlines have post-release mortality rates of 30–33 percent over ~50 days. Bowlby *et al.* (2021) also investigated post-release mortality in North Atlantic pelagic longline fleets, estimating a rate of 35.8 percent for the species over the first 30 days from 104 tagging events. The post-release mortality rate of tagged shortfin mako sharks (n=35) after capture and release by pelagic longliners in the Northeast, Northwest, Equatorial, and Southwest Atlantic was estimated at 22.8 percent over the first 30 days (Miller *et al.* 2020). A telemetry study on post-release mortality rates of five shark species captured in the Hawaii deep-set and American Samoa tuna longline fisheries found relatively low post-release mortality rates for shortfin mako shark (6 percent), with only one mortality observed out of 18 tags that reported (Hutchinson *et al.* 2021). A Bayesian analysis of the post-release mortality rates from all sharks tagged (including shortfin mako shark) found that post-release fate was correlated with the animal's condition at the vessel, handling method, and the amount of trailing gear left on the animals, whereby animals that were left in the water and had most of the gear removed had the lowest mortality rates (Hutchinson *et al.* 2021). Another telemetry study conducted by the WCPFC in three longline fisheries in the South Pacific (New Caledonia, Fiji and New Zealand) with much larger sample sizes (n = 57 shortfin mako shark tags) also found low post-release mortality rates for shortfin mako sharks: 11.6 percent of the tagged, uninjured shortfin mako sharks died within the 60-day monitoring period of the tags, and this estimate increased to 63.2 percent for injured shortfin mako sharks (Common Oceans (ABNJ) Tuna Project 2019). Similar to conclusions from Hutchinson *et al.* 2021, survival rates were higher when trailing gear was minimized, particularly in relation to the size of the animal. Although the practice of hauling sharks on deck was not found to have contributed to mortality, the probability of injury is higher when sharks are hauled onboard, and injured sharks are less likely to survive (Common Oceans (ABNJ) Tuna Project 2019). This suggests that improvements to handling and release methods can help reduce post-release mortality in shortfin mako shark and other shark bycatch species.

In sum, bycatch mortality makes up a substantial amount of total fishery mortality that is not captured in reported landings data. Total non-landed fishery mortality for shortfin mako sharks in the Canadian pelagic longline fishery was estimated at 49.3 percent (95 percent CI: 23–73 percent), indicating that even if retention of the species is prohibited, about half of shortfin mako sharks hooked by this fleet would die during or after fishing (Campana *et al.* 2016). Given that other nations targeting swordfish and tuna in the Northwest Atlantic and other ocean basins use similar gear configurations as used in the study by Campana *et al.* (2016), similar un-reported mortality levels may be expected if landings of shortfin mako shark were prohibited throughout its global range. Hook type, gear configuration, handling (*i.e.,* bringing incidentally caught shortfin mako sharks on deck to remove gear) (Bowlby *et al.* 2021), and bait type (Coelho *et al.* 2012; Amorim *et al.* 2015; Fernandez-Carvalho *et al.* 2015) have been shown to influence catch and mortality rates of shortfin mako sharks (see the Status Review Report for a detailed review of this information).

In the North Atlantic Ocean, shortfin mako sharks are incidentally caught mainly in pelagic and surface longlines, and to a lesser extent, purse seines, bottom trawls, and gillnets. There are no commercial fisheries targeting shortfin mako sharks in this region. Since 2017, and until only recently, ICCAT Contracting Parties and Cooperating Non-Contracting Parties (CPCs) have been required to release live North Atlantic shortfin mako sharks in a manner that causes the least harm. Retention of dead North Atlantic shortfin mako sharks remained acceptable in many cases, and harvest of live individuals was only permitted under very limited circumstances. Reported landings for all CPCs in the North Atlantic (including dead discards) did decline in recent years, though numbers remain high (3,281 t in 2015; 3,356 t in 2016; 3,199 t in 2017; 2,373 t in 2018; 1,882 t in 2019; 1,709 t in 2020) (SCRS 2021). Over 90 percent of recent shortfin mako shark catch in the North Atlantic is attributable to Spain (longline fleet targeting swordfish), Morocco (longline fleet targeting swordfish and purse seine), and Portugal (longline fleet targeting swordfish), with Spain harvesting nearly half of the North Atlantic catch in 2019 (866 t reported). These three countries have each recently announced unilateral retention bans. In early 2021, Spain announced a moratorium on the landing, sale, and trade of North Atlantic shortfin mako shark. The retention ban reportedly applies to 2021 catches from all Spanish vessels, whether operating in domestic water or on the high seas, and the ban on sale and trade extends to a 90 t stockpile of all mako shark fins landed by Spanish vessels in 2020. Shortly afterwards, Portugal announced a moratorium on landings of shortfin mako sharks caught in the North Atlantic high seas fisheries, the source of the majority of Portugal's mako shark catch. In February 2022, the government of Morocco announced a 5-year national prohibition on the fishing, storage, and trade of shortfin mako shark. Due to at-vessel and post-release mortality, retention bans will not eliminate fishery mortality. However, because approximately 50 percent of catches would be expected to survive as discussed above, these retention bans may significantly reduce shortfin mako shark mortality in pelagic longline fleets operating in the North Atlantic, and therefore overall mortality in this region.

Shortfin mako sharks are incidentally caught by the U.S. pelagic longline fleets targeting swordfish and tuna (*Thunnus* spp.), including in the Gulf of Mexico and the Caribbean Sea. A total of 2,406 t of shortfin mako shark was landed and sold by this fishery between 1985 and 2008, valued at $4,562,402 (Levesque 2013). Commercial landings of incidentally caught shortfin mako shark ranged from 17.6 t in 1985 to 266.8 t in 1993, with a mean of 100.24 t year^{-1} (Levesque 2013). As described below in *Inadequacy of Existing Regulatory Mechanisms,* after the 2017 ICCAT stock assessment indicated that North Atlantic shortfin mako sharks were overfished and experiencing overfishing, the United States took immediate action to end overfishing and work towards rebuilding of the stock through emergency rulemaking. These measures led to a reduction in North Atlantic shortfin mako shark landings by the U.S. longline fleet, with 112 t landed in 2017, 42 t landed in 2018, and 33 t landed in 2019 (NMFS 2021). Shortfin mako shark catch in U.S. pelagic longlines represented only 0.8 percent of total international longline catch of the species across the entire Atlantic Ocean in 2019 (NMFS 2021), and due to the poor reporting of other ICCAT CPCs, this percentage is likely significantly lower. A detailed overview of other fleets that contribute to shortfin mako shark mortality in the North Atlantic can be found in the Status Review Report.

Risk assessments have repeatedly found shortfin mako sharks to be at high risk of overexploitation by pelagic longline fisheries in the North Atlantic. Using an ecological risk assessment, the inflection point of the population growth curve (a proxy for B_{MSY}), and IUCN Red List status, Simpfendorfer *et al.* (2008) found the shortfin mako shark to have the highest risk among the pelagic shark species taken in Atlantic longline fisheries. Similar results were found by Cortés *et al.* (2010) in an ecological risk assessment of 11 pelagic elasmobranchs across the North and South Atlantic, which incorporated estimates of productivity (intrinsic rate of increase, r) and susceptibility to the fishery (a product of the availability of the species to the fleet, encounterability of the gear given the species' vertical distribution, gear selectivity, and post-capture mortality). The authors found the shortfin mako shark to be at high risk of overexploitation (Cortés *et al.* 2010). In an expanded assessment, the shortfin mako shark's low productivity ($r=0.058\ year^{-1}$) and high susceptibility to capture (0.220, calculated as the product of four factors: availability of the species to the fleet, encounterability of the gear given the species' vertical distribution, gear selectivity, and post-capture mortality) continued to give the species one of the highest risks of overexploitation of sharks caught by Atlantic pelagic longline fleets (Cortés *et al.* 2015).

In the North Atlantic, fisheries mortality has led to substantial population declines, and the stock is currently both overfished and experiencing overfishing. ICCAT Recommendations 17–08 and 19–06 have required live shortfin mako sharks to be released except in very limited circumstances since 2017, though reported landings are still high (1,709 t in 2020, inclusive of dead discards (SCRS 2021)). The ERA Team considered whether a newly adopted retention prohibition (Recommendation 21–09) would be adequate to reduce fishing mortality and allow the stock to begin to rebuild, given that at-vessel mortality will not be addressed by this measure. Given the status of the stock, the continued high level of fishing effort, high catches, and low productivity, the ERA Team concluded, and we agree, that the best available scientific and commercial information indicates that overutilization of shortfin mako shark is occurring in the North Atlantic Ocean. Recent management measures may decrease the degree to which overutilization threatens the species over the foreseeable future (50 years), although this depends on whether current management measures are effectively implemented, and whether additional management measures, including measures addressing fishing gear and behavior, are implemented in the future (this is discussed further in *Inadequacy of Existing Regulatory Mechanisms*).

Shortfin mako sharks are frequently incidentally caught in pelagic longlines in the South Atlantic, where fishing effort has been increasing since the 1970s (Barreto *et al.* 2016). Recent reported landings and dead discards of South Atlantic shortfin mako shark by all ICCAT CPCs are as follows: 2,774 t in 2015; 2,765 t in 2016; 2,786 t in 2017; 3,158 t in 2018; 2,308 t in 2019; 2,855 t in 2020 (SCRS 2021). An analysis of historical catches in longline fishing fleets in the South Atlantic found three distinct phases of fishery exploitation: phase A (1979–1997), characterized by the use of deep multifilament line with J hooks to target tunas; phase B (1998–2007), during which monofilament lines and circle hooks were used to target sharks and tunas, and phase C (2008–2011), during which several measures regulating shark fishing came into effect (Barreto *et al.* 2016). The authors found that standardized catch rates of shortfin mako shark from a zero-truncated model increased 8-fold in phase A (1979–1997), decreased by 55 percent in phase B (1998–2007), and increased 1.3-fold in phase C (2008–2011), even though nominal catch rates for all sharks combined were highest in phase B. Dramatic catch rate declines in phase B coincided with significant fishing effort increases as well as a lack of regulatory measures, and Barreto *et al.* (2016) conclude that shortfin mako sharks are depleted in the South Atlantic.

Significant contributors to South Atlantic shortfin mako shark landings as reported by the ICCAT SCRS are Spain, Namibia, Brazil, Portugal, and South Africa. Spanish longline fleets in the South Atlantic reported shortfin mako shark catches of 1,049 t in 2017, 1,044 t in 2018, 1,090 t in 2019, and 799 t in 2020 (SCRS 2021). The Spanish fleet has retained the vast majority of shortfin mako shark bycatch due to the high value of the species. Therefore, catches and landings have been roughly equivalent since the beginning of this fishery (Mejuto et al. 2009). In Brazil, pelagic longline vessels targeting tuna have been fishing since 1956, and part of the longline fleet shifted to targeting swordfish in 1994 (Lucena Frédou *et al.* 2015). Although there are no directed fisheries for shortfin mako shark in the South Atlantic, the species is frequently retained due to its high value, and is one of eight shark species commonly caught in the Brazilian longline fleet (Lucena Frédou *et al.* 2015). Data from 2004–2010 indicate that mako sharks (shortfin and longfin combined, though longfin are rarely caught) were the second most common shark, making up 5.4 percent of all individuals caught (Lucena Frédou *et al.* 2015). Reported catch has been increasing in Brazil over the past few years: 124 t in 2016, 275 t in 2017, 399 t in 2018, 739 t in 2019, and 542 t in 2020 (no discards have been reported) (SCRS 2021). The South African pelagic longline fleet targeting tuna and swordfish operates in South Africa's Exclusive Economic Zone (EEZ) where the Southeast Atlantic meets the Southwest Indian Ocean. Based on landings, logbook, and observer data, the South African pelagic longline fleet was estimated to catch 50,000 shortfin mako sharks in 2015, with less than 1,000 estimated to have been released in good condition (Jordaan *et al.* 2020). In total, 96 percent of hooked shortfin mako sharks were retained, and of those discarded, 82 percent were dead (Jordaan *et al.* 2020). Most of the shortfin mako shark catch occurred in waters of the Indian Ocean and was, therefore, reported to the IOTC; smaller quantities of the species are caught in Atlantic waters (Jordaan *et al.* 2020). There have been steep increases in fishing effort (from 0.45 million hooks set in 2000 to 1.7 million hooks set in 2015) as well as shortfin mako shark fishing mortality in the South African pelagic longline fleet (Jordaan *et al.* 2018). Additional information on fishing practices of other fleets that contribute to shortfin mako shark mortality in the South Atlantic can be found in the Status Review Report.

In the South Atlantic, the shortfin mako shark has an overall 19 percent probability of being overfished with overfishing occurring (ICCAT 2017). Data quality in the South Atlantic is poor, and the stock assessment in this region has high uncertainty. Therefore, given the high fishing effort and low productivity of the species, the ERA Team concluded, and we agree, that the best available scientific and commercial data indicate that overutilization may be occurring in the South Atlantic.

In the Western and Central Pacific Ocean, shortfin mako sharks commonly interact with longline fisheries and are more rarely targeted by certain fleets. Fisheries information and catch data for this region are available from the WCPFC, and although historical catch data are lacking, reporting has improved in recent years with required reporting of catches of key shark species. Despite reporting requirements, recent catches of key shark species have not been provided to the WCPFC for a number of longline fleets, including Indonesia, which is the top shark fishing nation in the world (Dent and Clarke 2015; Okes and Sant 2019). Fleets with the highest reported numbers of shortfin mako sharks caught in recent years (as reported in WCPFC data catalogs available at *https://www.wcpfc.int/data-catalogue*) include Taiwan, the United States (Hawaii), Japan, Spain, and New Zealand. In the western North Pacific, Taiwanese coastal and offshore longline fishing vessels mainly target dolphinfish (also known as mahi mahi; *Coryphaena hippurus*), tunas, and billfishes from April to October, and switch to targeting sharks by changing gear configuration from November to March (Liu *et al.* 2021a). Liu *et al.* (2021a) carried out a productivity-susceptibility analysis for these Taiwanese fleets, where intrinsic rate of population growth (r) was used to express productivity, and susceptibility was estimated by multiplying catchability, selectivity, and post-capture mortality. Based on the shortfin mako shark's low productivity (r = 0.0300) and high susceptibility (1.1754), the authors found the species to be at highest ecological risk. However, when conducting an integrated ERA (incorporating the ERA, IUCN Red List index, annual body weight variation trend, and the inflection point of population growth curve), Liu *et al.* (2021a) found the species to be in the least risk group, possibly because the average body weight of the species in the western North Pacific has not experienced significant decline. The authors found this result to be reasonable as the latest stock assessment for North Pacific shortfin mako shark indicates that the stock is not overfished and overfishing is not occurring. The shortfin mako shark is one of the most commonly caught shark species in the Taiwanese large-scale tuna longline fleet. Taiwan's catch of mako sharks (shortfin and longfin) in all longline fleets as reported in WCPFC data catalogs are high in the most recent 6 years of data: 1,216 t in 2015; 1,073 t in 2016; 1,088 t in 2017; 1,146 t in 2018; 1,680 t in 2019; and 1,665 t in 2020.

While there are no directed commercial fisheries for shortfin mako sharks in Hawaii, the species is caught relatively frequently in the Hawaii-based pelagic longline fishery targeting swordfish in the shallow-set sector, and bigeye tuna (*Thunnus obesus*) in the deep-set sector (Walsh *et al.* 2009; Carvalho 2021). Substantially higher numbers of shortfin mako sharks are caught in the deep-set sector than the shallow-set sector. From 1995–2006, shortfin mako sharks made up 2.9 percent of all observed shark catch in Hawaii-based pelagic longline fisheries, with higher nominal CPUE rates in the shallow-set sector than the deep-set sector (Walsh *et al.* 2009). Between 1995–2000 and 2004–2006, catch rates for shortfin mako sharks were stable for the deep-set sector, and increased 389 percent in the shallow-set sector to 0.911 sharks per 1000 hooks (Walsh *et al.* 2009). Comparing the same two time periods, minimum estimates of shortfin mako shark mortality decreased in both the deep-set and shallow-set sectors (from 80.6 to 47 percent, and from 68 to 31.6 percent, respectively) (Walsh *et al.* 2009). This reduction in mortality may be a result of the prohibition of shark finning in 2000, and the requirement of the use of relatively large circle hooks rather than traditional J-hooks in the shallow-set sector beginning in 2004 (Walsh *et al.* 2009; Carvalho *et al.* 2014). Data from Hawaii and California-based Pelagic Longline Vessels Annual Reports (available at *https://www.fisheries.noaa.gov/resource/data/hawaii-and-california-longline-fishery-logbook-summary-reports*) indicate that from 2008 to 2019, Hawaii longline fisheries have steadily increased the portion of mako catch that is released alive, with 58 percent being released alive in 2008 and 89 percent being released alive in 2019. Data from the report also shows that from 2008 to 2019, mako sharks comprised, on average, only 0.71 percent of all species landed in the shallow-set and deep-set fisheries combined. Additional information on other fleets that contribute to shortfin mako shark mortality in the Western and Central Pacific Ocean can be found in the Status Review Report.

Although historical catch data for the Western and Central Pacific are lacking, reporting has improved in recent years with the implementation of conservation and management measures that require reporting of catches of key shark species. A noteworthy exception are catches from Indonesia, recognized as the top shark fishing nation in the world. Interactions with shortfin mako shark commonly occur in pelagic longline fleets in this region. While RFMOs, and therefore landings data, fishing practices, and regulatory measures, are divided into the Eastern and Western and Central Pacific, abundance data in the Pacific are separated by North and South Pacific. Therefore, we take into consideration abundance data available for both the North and South Pacific when assessing overutilization of the Western and Central Pacific shortfin mako shark population. The latest stock assessment for shortfin mako sharks in the North Pacific indicates that the stock is not overfished and overfishing is not occurring, and CPUE trends from the South Pacific indicate increasing shortfin mako shark abundance. Based on the best available scientific and commercial data on current and historical levels of fishing mortality and abundance, the ERA Team concluded that overutilization is not likely occurring in the Western and Central Pacific Ocean, and we agree.

In the Eastern Pacific Ocean, the species is mainly taken as bycatch in commercial longline, drift gillnet, and purse seine fleets (Read 2008). According to the Inter-American Tropical Tuna Commission's (IATTC) Report on the tuna fishery, stocks, and ecosystem in the Eastern Pacific Ocean in 2020, purse seine fisheries have contributed very little to the take of mako sharks (*Isurus* spp.) in the Eastern Pacific from 1993–2020 (estimated <3 t each year on average). Longline vessels are a more important source of fishery mortality for the genus in the Eastern Pacific Ocean. Estimated catch of mako sharks (*Isurus* spp.) was 2,882 t in 2018 and 1,927 t in 2019, and the total estimated catch in longlines from 1993–2019 was 36,036 t (IATTC 2020). The California/Oregon drift gillnet fishery targeting swordfish and thresher sharks incidentally catches shortfin mako sharks, the large majority of which are retained. Annual landings of the species ranged from 278 t in 1987 to 31 t in 2006, and have annually declined since the late 1990s (Read 2008; Sippel *et al.* 2014). Analysis of NMFS observer records from 1990–2015 indicates that shortfin mako sharks make up only 4.92 percent of the total catch in this fishery (Mason *et al.* 2019). Within Mexico's

EEZ in the Pacific, shortfin mako sharks are taken in the artisanal fishery and the pelagic longline fishery, and were historically taken in the drift gillnet fishery until 2010 (Sosa-Nishizaki *et al.* 2017). Gillnet and longline fleets in Ecuador and Peru also contribute to catch of the species in this region (Alfaro-Shigueto *et al.* 2010; Doherty *et al.* 2014; Martinez-Ortiz *et al.* 2015). Additionally, despite being defined as small-scale, Peruvian longline fisheries targeting dolphinfish have a high magnitude of fishing effort and proportion of juvenile shortfin mako sharks landed; this may have a large effect on the population off of Peru. Additional information on other fleets that contribute to shortfin mako shark mortality in the Eastern Pacific can be found in the Status Review Report.

While RFMOs, and therefore landings data, fishing practices, and regulatory measures, are divided into the Eastern and Western and Central Pacific, abundance data in the Pacific are separated by North and South Pacific. Therefore, we take into consideration abundance data available for both the North and South Pacific when assessing overutilization of the Eastern Pacific shortfin mako shark population. The latest stock assessment for shortfin mako shark in the North Pacific indicates that the stock is not overfished and overfishing is not occurring. CPUE trends available from a variety of fisheries in the South Pacific indicate population increases, although a stock assessment is not available for this region. Despite this lack of a cohesive population model, the available data indicate flat or increasing abundance trends in the South Pacific. Based on the best available scientific and commercial data on current and historical levels of fishing mortality and abundance, the ERA Team concluded, and we agree, that overutilization is not demonstrably occurring in the Eastern Pacific Ocean, despite variation in the certainty associated with estimates.

In the Indian Ocean, shortfin mako sharks are caught in pelagic longline, gillnet, and purse seine fleets, with the majority of catch coming from longlines targeting swordfish and sharks. Nominal reported catches of sharks in the IOTC Convention area have generally been increasing since the 1950s, though reporting of shark catches has been very irregular and information on shark catch and bycatch is considered highly incomplete (Murua *et al.* 2018). Fisheries catch data for the Indian Ocean are available from the IOTC, which requires CPCs to annually report shortfin mako shark catch data (IOTC Resolutions 17/05, 15/01, and 15/02). However, prior to the adoption of resolution 05/05 in 2005 (superseded by resolution 17/05 in 2017), there was no requirement for sharks to be recorded at the species level in logbooks. It was not until 2008 that some statistics became available on shark catch, mostly representing retained catch and not accounting for discards (IOTC 2018). Several countries continue to not report on their interactions with bycatch species as evidenced by high rates of bycatch reported by other fleets using similar gear configurations (IOTC 2018). When catch statistics are provided, they may not represent total catches of the species, but those simply retained on board, with weights that likely refer to processed specimens (IOTC 2018). Misidentification of shark species is also a common problem, and reporting by species is very uncommon for gillnet fleets where the majority of shark catches are reported as aggregates (IOTC 2020). Reported shark catches dropped significantly after 2017 when India stopped reporting aggregated shark catches and did not replace that reporting with detailed reports by species. Decreases in reported shark catches by Mozambique and Indonesia are thought to represent similar reporting issues (IOTC 2020). In sum, although reporting has improved substantially in recent years, there is a lack of historical data that does not allow for establishment of long-term trends, and current reported catches continue to be incomplete and largely underestimated. The major contributors to mako shark (longfin and shortfin combined) catch reported to IOTC are Japan, Madagascar, Indonesia, Spain, Sri Lanka, Pakistan, Taiwan, South Africa, Portugal, and Guinea. A detailed overview of fleets that contribute to shortfin mako shark mortality in the Indian Ocean can be found in the Status Review Report.

Using the methodology of Cortés *et al.* (2010), a preliminary Productivity-Susceptibility Analysis for sharks caught in IOTC longline fisheries revealed that shortfin mako sharks have among the highest vulnerability to overexploitation in this fishery due to the species' low productivity (λ=1.061) and high susceptibility (0.929) (Murua *et al.* 2012). In an updated ecological risk assessment of IOTC longline, gillnet, and purse seine fisheries, Murua *et al.* (2018) found that the most vulnerable species to the IOTC pelagic longline fleet is the shortfin mako shark based on its low productivity (λ=1.059) and high susceptibility (0.867). Shortfin mako sharks had lower susceptibility to catch in the purse seine and gillnet fisheries (0.129 and 0.318, respectively) and were therefore found to be less vulnerable to overexploitation by these fleets (Murua *et al.* 2018). The post-capture mortality rate in Indian Ocean purse seine fleets was reduced between the 2012 and 2018 assessments due to the European fleet implementing safe release best practices in 2014, but is still quite high for shortfin mako sharks (approximately 55 percent) (Murua *et al.* 2018). Post-capture mortality represents the proportion of captured animals that die as a result of interaction with the gear, calculated as the sum of landings and dead discards (Cortes *et al.* 2010).

Available preliminary stock assessments for shortfin mako sharks in the Indian Ocean indicate that overfishing is occurring but the stock is not yet overfished. Underreporting of catch is suspected to be continuing in this region, and the ERA Team therefore had low certainty that these assessments accurately reflect the status of the species here. However, recent CPUE trends in certain fleets indicate increasing abundance trends in this region. The ERA Team concluded that, while overutilization in commercial fisheries is likely impacting shortfin mako sharks in the Indian Ocean, the severity of this threat is highly uncertain. The best available scientific and commercial information on current and historical levels of fishing mortality and abundance indicates that overutilization is likely impacting the species in this region to some degree, and will continue to impact the species in this region over the foreseeable future (50 years).

Demand for shark products, specifically meat and fins, has rapidly increased over the last 4 decades and has led to the overexploitation of shark populations worldwide. While trade in shark fins appears to have decreased slightly since the early 2000s, the trade in shark meat has grown over the last decade or so (Dent and Clarke 2015). In fact, domestic shark meat consumption in India is indicated to be the main driver of local shark harvest rather than the global fin trade (Karnad *et al.* 2020). The vast majority of shark fins in international trade are imported into and consumed in East and Southeast Asia, including China, Hong Kong, Taiwan, Singapore, Malaysia, and Vietnam, while the largest importers and consumers of shark meat include Italy, Brazil, Uruguay, and Spain (Dent and Clarke 2015). Spain, Indonesia, Taiwan, and Japan are the major shark fin exporting producers, and as the trade in shark meat has increased in recent years, these producers have also begun exporting large volumes of shark meat to the markets in Italy and Brazil (Dent and Clarke 2015). While available data on the trade in shark products are incomplete due to inconsistent identification of species and tracking of product types and volumes, FAO statistics conservatively estimate the average declared value of total world shark fin imports at $377.9 million per year from 2000–2011, with an average annual volume imported of 16,815 t (Dent and Clarke 2015). Annual average figures for shark meat from 2000–2011 were 107,145 t imported, worth $239.9 million (Dent and Clarke 2015). Quantifying the amount of individual sharks harvested for the international shark trade is more difficult given that a substantial proportion of harvest is illegal, unregulated, or unreported (Clarke *et al.* 2006b). Using shark fin trade data to estimate the total number of sharks traded worldwide, Clarke *et al.* (2006b) found that between 26 and 73 million individual sharks of all species are traded annually (median = 38 million each year), with a median biomass estimate of 1.70 million t per year (range: 1.21–2.29 million t each year).

Shortfin mako sharks are commonly retained for their highly valued meat when incidentally caught, with fins often kept as a by-product (Fowler *et al.* 2021). The meat is utilized fresh, frozen, smoked, dried, and salted for human consumption (CITES 2019; Dent and Clarke 2015). Shortfin mako shark liver oil, teeth, jaws, and skin are also traded, though most of these products are of lower value and are not traded in significant quantities (CITES 2019).

The shortfin mako shark is a preferred species in the Hong Kong fin market, one of the largest fin trading markets in the world (Fields *et al.* 2018). Clarke *et al.* (2006a) analyzed 1999–2001 Hong Kong trade auction data in conjunction with species-specific fin weights and genetic information to estimate the annual number of globally traded shark fins. The authors estimated that the shortfin mako shark makes up approximately 2.7 percent (95 percent probability interval: 2.3–3.1 percent) of the Hong Kong shark fin trade, the fourth highest proportion of auctioned fin weight after blue (17.3 percent), hammerhead (*Sphyrna zygaena* or *S. lewini,* 4.4 percent) and silky (*Carcharhinus falciformis,* 3.5 percent) sharks. This translates to an estimated 300,000–1,000,000 shortfin mako sharks utilized in the global shark fin trade each year, totaling between 20,000 and 55,000 t in biomass (Clarke *et al.* 2006b). Although these data are fairly dated, more recent studies demonstrate the continued prevalence of shortfin mako shark fins in international trade. Fields *et al.* (2018) found shortfin mako shark to be the ninth most commonly traded species in Hong Kong based on random samples of fin trimmings from retail markets, making up 2.77 percent of fin trimming samples and comprising 0.6 percent of modeled trimmings. In another recent study, shortfin mako shark fins made up 4.16 percent and 2.37 percent of samples taken in the fin markets of Guangzhou, the largest fin trade hub in mainland China, and Hong Kong, respectively (Cardeñosa *et al.* 2020).

Shortfin mako sharks were listed under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) effective November 26, 2019. As such, exports of the species must be found to be non-detrimental to the survival of the species in the wild and the specimen must have been legally acquired. As the numbers presented above predate the CITES listing of shortfin mako sharks, current levels of exploitation for the international trade in meat and fins may be lower than prior to the listing (this regulatory measure is discussed further in *Inadequacy of Existing Regulatory Mechanisms*). With the trade in shark meat on the rise, the preference for shortfin mako shark meat in addition to their continued prevalence in the fin trade presents a concern for overutilization of the species.

Several ERA Team members cited the estimation by Clarke *et al.* (2006b) that 300,000–1,000,000 shortfin mako sharks may be utilized in the global shark fin trade each year in their assessment of this threat. Although this is not a recent study, and recent regulatory mechanisms may reduce pressure from the fin trade on this species, this estimate is still cause for concern given the low productivity of the species. Considering the recent declines in the fin trade and increases in the meat trade, the ERA Team generally concluded, and we agree, that the preference for shortfin mako shark meat (in addition to fins) presents a concern for overutilization of the species in the future.

After considering the best available scientific and commercial data, several conclusions are indicated. Overall, although catch and mortality data are underreported globally, with very low confidence in data from both the Indian and South Atlantic Oceans, the ERA Team recognized the ESA's requirement to consider the best scientific and commercial data available, as summarized above and detailed in the Status Review Report. The majority of ERA Team members concluded that overutilization of the shortfin mako shark for commercial purposes (in both fisheries and trade) is not likely currently significantly contributing to the species' status but will likely contribute to the extinction risk of the species in the foreseeable future as they defined it, especially if management measures are inadequate. We agree with the ERA Team that overutilization for commercial purposes is not likely contributing significantly to the shortfin mako shark's risk of extinction now. However, over the foreseeable future of 50 years that we have determined is more appropriate to apply for this species, we conclude that overutilization for commercial purposes is likely to contribute to its risk of extinction. Recent management measures in the North Atlantic (including retention prohibitions adopted by ICCAT and by the top three shortfin mako shark-catching nations in the region) indicate increasing international efforts to reduce the effects of fishing mortality on the species in this region. Specifically, Recommendation 21–09 prohibits harvest of live individuals (previously allowed under limited circumstances) and contains strong provisions to improve data reporting, and particularly, the catch reporting of live releases and fish discarded dead. The measure does not require changes to fishing behavior or gear, and therefore will not address at-vessel or post-release mortality of incidentally caught shortfin mako sharks. Because of ICCAT's track record of taking multilateral conservation and management actions for the stock in response to indications of declining status, we have a reasonable basis to predict that similar or additional measures are likely to be continued or taken, as needed, to ensure ICCAT's objectives of ending overfishing and rebuilding the stock to levels that support MSY are met. While it is likely that the level of overutilization in this region will decline to some degree over the foreseeable future due to these efforts, it is unclear if Recommendation 21–09 will reduce mortality to a point that will allow the North Atlantic stock to rebuild. The low productivity of the shortfin mako shark means that the biological response to the measure will likely not be detectable for many years, despite assessment efforts. Therefore, at this time it is not possible to assess the adequacy of this measure to address the ongoing threat of overfishing in the North Atlantic. In the South Atlantic Ocean, fishing effort has been increasing since the 1970s and there are no specific management measures at the international level to address fishing mortality in this region. This indicates that overutilization may increasingly impact the species over the foreseeable future in this region. In the Indian Ocean, overutilization will continue to impact the species over the foreseeable future. Shortfin mako sharks in the Pacific Ocean are not subject to overutilization at this time and there is no indication that this will change significantly over the foreseeable future.

Recreational fishermen target shortfin mako sharks in certain regions due to the high quality of their meat and the strong fight experienced by the angler. In the U.S. Atlantic, recreational landings of shortfin mako sharks have been significantly reduced after management measures were implemented in 2018 and 2019. In the Pacific, both U.S. and Australian recreational fisheries for the species are largely catch-and-release. Further, population-level impacts of recreational fishing at a global scale are unlikely to occur due to vessel limitations that prevent the vast majority of the ''fleet'' from accessing the whole of the species' habitat. For these reasons, the ERA Team unanimously concluded that the best available scientific and commercial data indicate that recreational fishing is unlikely to contribute significantly to the species' risk of extinction now or in the foreseeable future as they defined it. We agree that recreational fishing is not contributing significantly to the species' risk of extinction now. Over the foreseeable future of 50 years that we have determined is more appropriate to apply for this species, we also find that recreational fishing is not likely to significantly contribute to the shortfin mako shark's risk of extinction because there is no basis to predict that the impact of recreational fisheries on the species will change over the extended time horizon.

Disease and Predation

Shortfin mako sharks are known to host a number of parasites, but the ERA Team found no evidence that disease is impacting the status of the species, nor any indication that disease may influence the species' status in the foreseeable future.

The shortfin mako shark is a large apex predator with few natural predators. Given current population estimates and distribution, impacts from predation on a global scale are not likely to affect the species' extinction risk. While climate change may cause changes to the marine food web (and therefore, potentially influence predation on juvenile shortfin mako sharks) over the next several decades, the ERA Team could not accurately predict how these changes may impact the species.

The ERA Team concluded that the best available scientific and commercial information indicates that neither disease nor predation are factors that are contributing or will likely contribute significantly to the species' extinction risk now or in the foreseeable future as they defined it. We agree that neither disease nor predation are contributing significantly to the species' extinction risk now. Over the foreseeable future of 50 years that we have determined is more appropriate to apply for this species, we also find that this factor is not likely to significantly contribute to the shortfin mako shark's risk of extinction because there is no basis to predict that this factor will change over the extended time horizon.

Inadequacy of Existing Regulatory Mechanisms

The ERA Team evaluated existing regulatory mechanisms to determine whether they may be inadequate to address threats to the shortfin mako shark from overutilization. Below is a description and evaluation of current and relevant domestic and international management measures that affect the shortfin mako shark. More detailed information on these management measures can be found in the Status Review Report.

U.S. Domestic Regulatory Mechanisms

The U.S. Secretary of Commerce has the authority to manage highly migratory species (HMS) in the U.S. EEZ of the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea (16 U.S.C. 1811 and 16 U.S.C. 1854(f)(3)). The Atlantic HMS Management Division within NMFS develops regulations for Atlantic HMS fisheries and primarily coordinates the management of HMS fisheries in federal waters (domestic) and the high seas (international), while individual states establish regulations for HMS in state waters. However, federally permitted shark fishermen are required to follow federal regulations in all waters, including state waters, unless the state has more restrictive regulations. For example, the Atlantic States Marine Fisheries Commission (ASMFC) developed an interstate coastal shark Fisheries Management Plan (FMP) that coordinates management measures among all states along the Atlantic coast (Florida to Maine) in order to ensure that the states are following federal regulations. This interstate shark FMP became effective in 2010.

Shortfin mako sharks in the Atlantic are managed under the pelagic species complex of the Consolidated Atlantic HMS FMP. The first Atlantic Shark FMP of 1993 classified the status of pelagic sharks as unknown because no stock assessment had been conducted for this complex. At that time, MSY for pelagic sharks was set at 1,560 t dressed weight (dw), which was the 1986–1991 commercial landings average for this group. However, as a result of indications that the abundance of Atlantic sharks had declined, commercial quotas for pelagic sharks were reduced in 1997. The quota for pelagic sharks was then set at 580 t. In 1999, the U.S. FMP for Atlantic Tunas, Swordfish, and Sharks implemented the following measures affecting pelagic sharks: (1) reducing the recreational bag limit to one Atlantic shark per vessel per trip, with a minimum size of 137 cm fork length for all sharks; (2) increasing the annual commercial quota for pelagic sharks to 853 t dw, apportioned between porbeagle (92 t), blue sharks (273 t dw), and other pelagic sharks (488 t dw), with the pelagic shark quota being reduced by any overharvest in the blue shark quota; and (3) making bigeyed sixgill (*Hexanchus nakamurai*), bluntnose sixgill (*Hexanchus griseus*), broadnose sevengill (*Notorynchus cepedianus*), bigeye thresher, and longfin mako sharks, among other species, prohibited species that cannot be retained.

The management measures for the conservation and management of the domestic fisheries for Atlantic swordfish, tunas, sharks, and billfish are published in the 2006 Consolidated HMS FMP and implementing regulations at 50 CFR part 635 (71 FR 58058, October 2, 2006; NMFS 2006). Since 2006, this FMP has been amended 12 times, with four additional amendments currently under development. Amendment 2, finalized in June 2008, requires that all shark fins remain naturally attached through landing in both the commercial and recreational fisheries (73 FR 35778, June 24, 2008; corrected in 73 FR 40658, July 15, 2008). Limited exceptions to this requirement allowed by Amendment 9 (80 FR 73128, November 24, 2015) do not apply to shortfin mako sharks.

Any fisherman who fishes for, retains, possesses, sells, or intends to sell, Atlantic pelagic sharks, including shortfin mako sharks, needs a Federal Atlantic Directed or Incidental shark limited access permit. Generally, directed shark permits (which do not authorize the retention of shortfin mako sharks at this time) allow fishermen to target sharks while incidental permits allow fishermen who normally fish for other species to land a limited number of sharks. The permits are administered under a limited access program and NMFS is no longer issuing new shark limited access permits. To enter the directed or incidental shark fishery, fishermen must obtain a permit via transfer from an existing permit holder who is leaving the fishery. Until recently, under a directed shark permit, there was no numeric retention limit for pelagic sharks, subject to quota limitations (see below for a description of a recent final rule regarding the retention limit for shortfin mako sharks). An incidental permit allows fishermen to keep up to a total of 16 pelagic or small coastal sharks (all species combined) per vessel per trip. Authorized gear types include: pelagic or bottom longline, gillnet, rod and reel, handline, or bandit gear. All fins must remain naturally attached. The annual quota for pelagic sharks (other than blue sharks or porbeagle sharks) is currently 488.0 t dw (Amendment 2 to the 2006 Consolidated Atlantic HMS FMP (73 FR 35778, June 24, 2008; corrected version 73 FR 40658, July 15, 2008)).

NMFS monitors the catch of each of the different shark species and complexes in relation to its respective annual quota and will close the fishing season for each fishery if landings reach, or are projected to reach, an 80 percent threshold of the available quota, and are also projected to reach 100 percent of the available quota before the end to the fishing year. Atlantic sharks and shark fins from federally permitted vessels may be sold only to federally permitted dealers; however, all sharks must have their fins naturally attached through offloading. The head may be removed and the shark may be gutted and bled, but the shark cannot be filleted or cut into pieces while onboard the vessel. Logbook reporting is required for selected fishermen with a federal commercial shark permit. In addition, fishermen may be selected to carry an observer onboard, and some fishermen are subject to vessel monitoring systems depending on the gear used and locations fished. Since 2006, bottom longline and gillnet fishermen fishing for sharks have been required to attend workshops to learn how to release sea turtles and protected species in a manner that maximizes survival. In 2017, these workshops were modified to include a section on releasing prohibited shark species. Additionally, NMFS published a final rule on February 7, 2007 (72 FR 5633), that requires participants in the Atlantic shark bottom longline fishery to possess, maintain, and utilize handling and release equipment for the release of sea turtles, other protected species, and prohibited shark species. In an effort to reduce bycatch, NMFS has also implemented a number of time/area closures with restricted access to fishermen with HMS permits who have pelagic longline gear onboard their vessel.

The HMS Management Division also published an amendment to the 2006 Consolidated HMS FMP that specifically addresses Atlantic HMS fishery management measures in the U.S. Caribbean territories (77 FR 59842, October 1, 2012). Due to substantial differences between some segments of the U.S. Caribbean HMS fisheries and the HMS fisheries that occur off the mainland of the United States (including permit possession, vessel size, availability of processing and cold storage facilities, trip lengths, profit margins, and local consumption of catches), the HMS Management Division implemented measures to better manage the traditional small-scale commercial HMS fishing fleet in the U.S. Caribbean Region. Among other things, this rule created an HMS Commercial Caribbean Small Boat (CCSB) permit, which: allows fishing for and sales of big-eye, albacore, yellowfin, and skipjack tunas, Atlantic swordfish, and Atlantic sharks within local U.S. Caribbean market; collects HMS landings data through existing territorial government programs; authorizes specific gears; is restricted to vessels less than or equal to 45 feet (13.7 m) length overall; and may not be held in combination with any other Atlantic HMS vessel permits. Until 2021, fishermen who held the CCSB permit were prohibited from retaining any Atlantic sharks. However, at this time, fishermen who hold the CCSB permit are prohibited from retaining shortfin mako sharks, and are restricted to fishing for authorized sharks with only rod and reel, handline, and bandit gear. Both the CCSB and Atlantic HMS regulations have helped protect shortfin mako sharks while in the Northwest Atlantic Ocean, Gulf of Mexico, and Caribbean Sea through permitting, monitoring, quotas, and retention restrictions.

After the 2017 ICCAT stock assessment indicated that North Atlantic shortfin mako sharks were overfished and experiencing overfishing, the United States took action to end overfishing and take steps toward rebuilding the stock through emergency rulemaking in March 2018. The measures immediately required release of all live shortfin mako sharks caught by commercial pelagic longliners with a minimum of harm while giving due consideration to the safety of crew members, and only allowed retention in pelagic longline gear if the shortfin mako shark was dead at haulback. The measures required commercial fishermen using non-pelagic longline gear (*e.g.,* bottom longline, gillnet, handgear) to release all shortfin mako sharks, alive or dead, with a minimum of harm while giving due consideration to the safety of crew members. For recreational fisheries, the emergency rulemaking increased the minimum size limit for both male and female shortfin mako sharks to 83 inches FL. These temporary measures were replaced by long-term management measures finalized as Amendment 11 to the 2006 Consolidated HMS FMP in March 2019. The final management measures for commercial fisheries allowed retention of shortfin mako sharks caught with longline or gillnet gears if sharks were dead at haulback. Further, vessels with pelagic longline gear were required to have a functional electronic monitoring system to verify condition for compliance purposes. For recreational fisheries, the minimum size limit was increased from 54 inches to 71 inches FL for males and 83 inches FL for females, and the use of circle hooks was required for all recreational shark fishing. These measures led to the reduction of the United States' total landings of North Atlantic shortfin mako shark (commercial and recreational) from 302 t in 2017, to 165 t in 2018, to 57 t in 2019, with 2 t of dead discards, an 81 percent reduction from 2017. In 2020, U.S. recreational landings of North Atlantic shortfin mako shark were 24 t, reduced by over 90 percent from the 2013–2017 average.

Following the adoption of Recommendation 21–09 at the November 2021 ICCAT annual meeting (described further below), NMFS published a final rule to implement a flexible shortfin mako shark retention limit with a default limit of zero in all commercial and recreational HMS fisheries (87 FR 39373; July 1, 2022). The rule meets domestic management objectives, implements Recommendation 21–09, and acknowledges the possibility of future retention (limited retention of shortfin mako sharks may be allowed in 2023 and future years if ICCAT determines that fishing mortality is at a low enough level North Atlantic-wide to allow retention consistent with the conservation objectives of the recommendation). The rule, effective July 5, 2022, requires that all commercial and recreational fishermen release all shortfin mako sharks, whether dead or alive, at haulback. Any sharks released alive must be released promptly in a manner that causes the least harm to the shark.

In the U.S. Pacific, HMS fishery management is the responsibility of adjacent states and three regional management councils that were established by the Magnuson-Stevens Fishery Conservation and Management Act (MSA): the Pacific Fishery Management Council (PFMC), the North Pacific Fishery Management Council (NPFMC), and the Western Pacific Regional Fishery Management Council (WPRFMC). Based on the range of the shortfin mako shark, only the PFMC and WPRFMC directly manage the species.

The PFMC's area of jurisdiction is the EEZ off the coasts of California, Oregon, and Washington. Prior to the development of a West Coast-based FMP for HMS, the fisheries were managed by the states of California, Oregon, and Washington, although some federal laws also applied. In late October 2002, the PFMC adopted its FMP for U.S. West Coast HMS Fisheries. This FMP's management area also covers adjacent high seas waters for fishing activity under the jurisdiction of the HMS FMP. The final rule implementing the HMS FMP was published in the **Federal Register** on April 7, 2004 (69 FR 18443). Since its implementation, this FMP has been amended five times, most recently in 2018. The FMP requires a federal permit for all commercial HMS vessels that fish for HMS off of California, Oregon or Washington, or land HMS in these states. The permit is endorsed with a specific endorsement for each gear type to be used, and any commercial fisher may obtain the required gear endorsements. Legal HMS gear includes harpoon, surface hook and line, large mesh drift gillnet, purse seine, and pelagic longline; however, the use of these gears are subject to state regulatory measures. For commercial passenger recreational fishing vessels, a federal permit is required by the FMP, though existing state permits or licenses for recreational vessels can meet this requirement. Legal recreational gear includes rod-and-reel, spear, and hook and line. Per the FMP, due to the stock's vulnerability, possible importance of the U.S. West Coast EEZ as nursery habitat, and poorly known total catches and extent of the stock, the recommended harvest guideline for shortfin mako sharks is 150 t round weight. This harvest guideline is a general objective, not a quota. Although attainment of a harvest guideline doesn't require management action such as closure of the fishery, it does prompt a review of the fishery.

The WPRFMC's area of jurisdiction is the EEZs of Hawaii, Territories of American Samoa and Guam, Commonwealth of the Northern Mariana Islands, and the Pacific Remote Island Areas, as well as the domestic fisheries that occur on the adjacent high seas. The WPRFMC developed the Fishery Ecosystem Plan for Pacific Pelagic Fisheries of the Western Pacific Region (FEP; formerly the Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region) in 1986 and NMFS, on behalf of the U.S. Secretary of Commerce, approved the Plan in 1987. Since that time, the WPRFMC has recommended, and NMFS has approved, numerous amendments to the Plan as necessary for conservation and management purposes. The WPRFMC manages HMS fisheries pursuant to the FEP, and species that are managed under FMPs or FEPs are called Management Unit Species (MUS), and typically include those species that are caught in quantities sufficient to warrant management or specific monitoring by NMFS and the Council. In the FEP, shortfin mako sharks are designated as a Pelagic MUS and, thus, are subject to regulations under the FEP. These regulations are intended to minimize impacts to targeted stocks as well as protected species. Fishery data are also analyzed in annual reports and used to amend the FEP as necessary.

In addition to fishing regulations for highly migratory species, the United States has implemented several significant laws for the conservation and management of sharks. The Tuna Conventions Act of 1950, Atlantic Tunas Convention Act of 1975, and Western and Central Pacific Fisheries Convention Implementation Act (enacted in 2007) authorize the U.S. Secretary of Commerce to promulgate regulations for U.S. vessels that fish for tuna or tuna-like species in the IATTC, ICCAT, and WCPFC Convention areas, respectively. The MSA, originally enacted in 1976, is the primary law governing marine fisheries management in U.S. federal waters (3–200 miles offshore), and aims to prevent overfishing, rebuild overfished stocks, increase long-term economic and social benefits, and ensure a safe and sustainable supply of seafood. The MSA created eight regional fishery management councils, whose main responsibility is the development and subsequent amendment of FMPs for managed stocks. The MSA requires NMFS to allocate both overfishing restrictions and recovery benefits fairly and equitably among sectors of the fishery. In the case of an overfished stock, NMFS must establish a rebuilding plan through an FMP or amendment to such a plan. The FMP or amendment to such a plan must specify a time period for ending overfishing and rebuilding the fishery that shall be as short as possible, taking into account the status and biology of the stock, the needs of fishing communities, recommendations by international organizations in which the United States participates, and the interaction of the overfished stock within the marine ecosystem. The rebuilding plan cannot exceed ten years, except in cases where the biology of the stock, other environmental conditions, or management measures under an international agreement in which the United States participates dictate otherwise.

The Shark Finning Prohibition Act of 2000 prohibits any person under U.S. jurisdiction from: (i) engaging in the finning of sharks; (ii) possessing shark fins aboard a fishing vessel without the corresponding carcass; and (iii) landing shark fins without the corresponding carcass, among other things. The Shark Conservation Act of 2010 strengthened shark finning measures by prohibiting any person from removing shark fins at sea (with a limited exception for smooth dogfish, *Mustelus canis*); or possessing, transferring, or landing shark fins unless they are naturally attached to the corresponding carcass.

Management measures implemented in response to the status of the North Atlantic shortfin mako shark stock were finalized in March 2019, and have been effective in reducing U.S. landings of the species in this region (both recreationally and commercially) as previously discussed. NMFS recently published a final rule to implement ICCAT Recommendation 21–09, requiring that all U.S. commercial and recreational fishermen release all shortfin mako sharks, whether dead or alive, at haulback. The adequacy of this retention prohibition cannot be assessed at this time; as data for each fishing year is not reported until the following calendar year, the effect of this measure will not be easily assessed until 2024 when the landings and discard data from 2023 can be analyzed. In the Pacific, the available stock assessment for the North Pacific region indicates that the species is neither overfished nor experiencing overfishing (ISC Shark Working Group 2018). For the foregoing reasons, it is likely that U.S. domestic fisheries management measures are adequate to address threats of overfishing to the species in U.S. waters. With regard to the fin and meat trade, declines in U.S. exports of shark fins followed implementation of both the Shark Finning Prohibition Act and the Shark Conservation Act, and recent declines in the mean value of U.S. exports per metric ton have been reported by NMFS. Additionally, 14 U.S. states and three U.S. territories have enacted legislation controlling shark finning by banning possession and sale of shark fins (see details in the Status Review Report). These state laws have reduced U.S. landings of sharks and therefore U.S. trade and consumption of shark fins, although it is important to note that the United States has traditionally played a relatively minimal role in the global shark fin trade (0.3 and 0.4 percent of global imports and exports in U.S. dollars according to Ferretti *et al.* 2020). Measures that prohibit the possession and sale of shark fins may provide some limited conservation benefit to sharks, including the shortfin mako shark, by discouraging the landing of any sharks. The ERA Team therefore concluded that the best available scientific and commercial data indicate that U.S. domestic regulatory measures are adequate to manage impacts from fisheries on the species in U.S. waters, as evidenced by the reduction in U.S. shortfin mako shark catch (commercial and recreational) in the Atlantic following the 2017 ICCAT stock assessment, stable population status in the North Pacific, and strong prohibitions on shark finning for those subject to U.S. jurisdiction. We agree with their assessment.

International Regulatory Mechanisms

Despite adequate management in U.S. waters, the ERA Team concluded that regulatory measures to address threats of incidental catch, targeted catch (in certain limited areas and fleets), and trade across the species' range may not be adequate in certain regions.

RFMOs that manage HMS play perhaps the most significant role in regulating catch and mortality of shortfin mako sharks in commercial fisheries worldwide. Of the four major RFMOs that manage shortfin mako sharks, only ICCAT has management measures specific to the species, while IATTC, WCPFC, and IOTC have general shark management measures.

ICCAT is the main international regulatory body for managing shortfin mako sharks on the high seas in the Atlantic Ocean. In 2004, following the development and implementation of the International Plans of Action for Conservation and Management of Sharks (IPOA-Sharks), ICCAT adopted Recommendation 04–10 requiring CPCs to annually report data for catches of sharks, including available historical data. This Recommendation specifically called for the SCRS to review the assessment of shortfin mako sharks and recommend management alternatives for consideration by the Commission, and to reassess the species no later than 2007. In 2005, ICCAT adopted Recommendation 05–05, which amended Recommendation 04–10 by requiring CPCs to annually report on their implementation of the Recommendation, and instructing those that have not yet implemented this recommendation to reduce North Atlantic shortfin mako shark mortality to implement it and report to the Commission. In 2006, ICCAT adopted Recommendation 06–10, which further amended Recommendation 04–10 and called for a shortfin mako shark stock assessment in 2008. A supplemental Recommendation by ICCAT (07–06, adopted in 2007 and entered into force in 2008) called for CPCs to submit catch data including estimates of dead discards and size frequencies in advance of SCRS assessments, to take appropriate measures to reduce fishing mortality for the North Atlantic shortfin mako shark, and to implement research on pelagic sharks in the Convention area to identify potential nursery areas. Recommendation 10–06 (adopted in 2010 and entered into force in 2011) instructed CPCs to report on how they have implemented the three recommendations described above, particularly steps they have taken to improve data collection for direct and incidental catches. It also recommended that CPCs that do not report catch data for shortfin mako sharks be prohibited from retaining the species, and that the SCRS conduct a stock assessment for shortfin mako sharks in 2012. Recommendation 14–06 (adopted in 2014 and entered into force in 2015) replaced and repealed Recommendations 05–05 and 10–06, among others, and it calls for CPCs to improve data collection for shortfin mako shark and report information on domestic catch of shortfin mako shark to ICCAT and encourages CPCs to undertake research on biology and life history of the shortfin mako shark.

Based on the 2017 shortfin mako shark stock assessment, which concluded there was a 90 percent probability of the stock being in an overfished state and experiencing overfishing (as discussed previously in *Abundance and Trends*), the Commission adopted Recommendation 17–08 (adopted in 2017 and entered into force in 2018), requiring CPCs to release North Atlantic shortfin mako sharks in a manner that causes the least harm. Retention of dead North Atlantic shortfin mako sharks remained acceptable in many cases, and harvest of live shortfin was only permitted under very limited circumstances. In 2019, the SCRS carried out new projections for North Atlantic shortfin mako shark through 2070 (two generation lengths) at the Commission's request (projections are described above in *Abundance and Trends*). Multiple TAC options with associated time frames and probabilities of rebuilding were presented to the Commission. Based on the resulting negative projections and high susceptibility of the species to overexploitation, and to accelerate the rate of recovery and to increase the probability of success, the SCRS recommended that the Commission adopt a non-retention policy without exception. While a non-retention policy would ostensibly reduce mortality, shortfin mako sharks frequently interact with surface longline fisheries and the potential inability for fishermen to avoid the species may not lead to sufficient decreases in mortality. Therefore, the SCRS noted that other management measures, such as time-area closures, reduction of soak time, safe handling, and best release practices may also be required (ICCAT 2019).

In 2019, several countries presented proposals to end overfishing and rebuild the North Atlantic stock of shortfin mako shark; however, none were ultimately adopted (see Status Review Report for more detail). The United States, Senegal, Canada, the EU, and Morocco met several times to discuss the proposals, but were unable to reach agreement on the elements of a combined measure. In a proposal presented by the ICCAT Chair and adopted in 2019 (Recommendation 19–06), it was agreed to extend and update the existing provisions in Recommendation 17–08. Recommendation 19–06 also urged the Commission to adopt a new management recommendation for the North Atlantic shortfin mako shark at its 2020 annual meeting in order to establish a rebuilding plan with a high probability of avoiding overfishing and rebuilding the stock to B_{MSY} within a timeframe that takes into account the biology of the stock. Due to the COVID–19 pandemic, however, ICCAT did not host an annual meeting in 2020 and management decisions were made through a correspondence process. Due to the difficulty associated with this process, no consensus could be made on a new measure and Recommendation 19–06 remained in place.

In 2021, the ICCAT annual meeting was conducted virtually and the conservation of the North Atlantic shortfin mako shark stock was a priority. Commission members reached consensus on Recommendation 21–09, which puts into place a 2-year retention ban that aims to reduce mortality and establishes a process to evaluate if and when retention may be allowed in the future, in line with scientific advice. The measure contains strong provisions to improve data reporting, and particularly, the catch reporting of live releases and fish discarded dead, by all ICCAT parties. This measure entered into force on June 17, 2022, and as data for each fishing year is not reported until the following calendar year, the management effect of Recommendation 21–09 will not be easily assessed until 2024 when the landings and discard data from 2023 can be analyzed. Despite this important step forward, ICCAT's work to end overfishing and rebuild North Atlantic shortfin mako shark is not complete; within Recommendation 21–09 a provision exists to revisit the measure ''no later than 2024 to consider additional measures to reduce total fishing mortality.'' Future efforts will likely be focused on reducing the at-haulback and post-release mortality of North Atlantic shortfin mako shark unintentionally captured alongside target species.

The low productivity of the shortfin mako shark means that the biological response to the recently adopted ICCAT measure will likely not be detectable for many years, despite assessment efforts. Therefore, at this time it is not possible to assess the adequacy of this measure to address the ongoing threat of overfishing in the North Atlantic. The ERA Team raised some concerns and uncertainties with regard to Recommendation 21–09. The measure does not require changes to fishing behavior or gear, and therefore will not address at-vessel or post-release mortality of incidentally caught shortfin mako sharks. Based on recent reported landings allowed under Recommendation 19–06 indicating high numbers of shortfin mako sharks dead at-haulback, it is unclear if Recommendation 21–09 will reduce mortality to a point that will allow the North Atlantic stock to rebuild. It is also unclear what measures will be in place after the 2-year period ends.

The IATTC is responsible for the conservation and management of tuna and other pelagic species in the Eastern Pacific. There are currently no specific resolutions related to the management of shortfin mako shark; however, IATTC does have resolutions relating to sharks in general. Resolution C–16–05 on the management of shark species requires that purse-seine vessels promptly release any shark that is not retained as soon as it is seen in the net or on deck, and includes provisions for safe release of such sharks. Resolution C–05–03 requires that fins onboard vessels total no more than 5 percent of the weight of sharks onboard. The IATTC requires 100 percent observer coverage onboard the largest purse seine vessels, and 5 percent observer coverage on larger longline vessels.

The WCPFC is responsible for the conservation and management of highly migratory species in the Western and Central Pacific Ocean. The WCPFC aims to address issues related to the management of high seas fisheries resulting from unregulated fishing, over-capitalization, excessive fleet capacity, vessel re-flagging to escape controls, insufficiently selective gear, unreliable databases, and insufficient multilateral cooperation with respect to conservation and management of highly migratory fish stocks. There are currently no management measures specific to shortfin mako sharks in the WCPFC; however, their management is addressed under the Conservation and Management Measure for Sharks (CMM 2019–04). This measure prohibits finning, requires that vessels land sharks with their fins naturally attached, and calls for vessels to reduce bycatch and practice safe release of sharks. In order to reduce bycatch mortality, the measure calls for longline fisheries targeting billfish and tuna to either not use wire branch lines or leaders, or not use shark lines (branch lines running directly off longline floats or drop lines). Further, the measure requires catches of key shark species to be reported to the Commission annually.

In Indian Ocean waters, the IOTC serves to promote cooperation among CPCs to ensure, through appropriate management, the conservation and optimum utilization of stocks, and encourage sustainable development of fisheries based on such stocks. The United States is not a member. Conservation and management measures are adopted in the form of either resolutions, which require a two-thirds majority of Members present and voting to adopt them and are binding for contracting parties, or recommendations, which are non-binding and rely on voluntary implementation. While a number of measures have been adopted by IOTC parties that apply to sharks and bycatch in general, there are currently no specific resolutions related to the management of shortfin mako shark (see IOTC 2019). In Resolution 15/01 on the recording of catch and effort by fishing vessels in the IOTC area of competence, all purse seine, longline, gillnet, pole and line, handline, and trolling fishing vessels are required to have a data recording system and provide aggregated data to the Secretariat each year. Resolution 15/02 mandates statistical reporting requirements for IOTC CPCs by species and gear for all species under the IOTC mandate as well as the most commonly caught elasmobranch species and lays out requirements for observer coverage. IOTC Resolution 17/05 on the conservation of sharks caught in association with fisheries managed by IOTC requires that sharks landed fresh not have their fins removed prior to first landing, and for sharks landed frozen, CPCs must abide by the 5 percent fins-to-carcass weight ratio. Further, CPCs must report data for catches of sharks including all available historical data, estimates and life status of discards (dead or alive), and size frequencies under this resolution. Despite these requirements, reporting of shark catches has been very irregular and information on shark catch and bycatch is considered highly incomplete (Murua *et al.* 2018). A number of countries continue to not report on their interactions with bycatch species as evidenced by high rates of bycatch reported by other fleets using similar gear configurations (IOTC 2018). The lack of reliable records of catch and lack of a formal stock assessment make it difficult to determine whether the regulatory mechanisms described above are adequate to address overutilization of the species in the Indian Ocean.

Regarding the general shark conservation measures in place for WCPFC, IATTC, and IOTC, the ERA Team had concerns regarding low compliance with reporting requirements, especially in the Indian Ocean and South Atlantic Ocean. The lack of reliable catch data in these regions, as well as a lack of formal stock assessments in the Indian Ocean and South Pacific Ocean, make it difficult to assess whether regulatory mechanisms in these areas are adequate to address threats of overutilization to the species.

As the shortfin mako shark is highly valued for both its meat and fins, regulatory mechanisms ensuring that trade does not lead to overexploitation are critical to the species' survival. Many individual countries and RFMOs have implemented measures to curb the practice of shark finning and the sale of or trade in shark products over the last decade (see detailed information in the Status Review Report), and the shortfin mako shark was listed on Appendix II of CITES as of November 2019. CITES is an international convention that aims to ensure that international trade in animals and plants does not threaten their survival, and while CITES regulates international trade, it does not regulate take or trade within a country. Appendix II includes species not necessarily threatened with extinction, but trade must be controlled to ensure utilization is compatible with their survival. As an Appendix II-listed species, international trade in specimens of shortfin mako shark is allowed with an export permit, re-export certificate, or introduction from the sea certificate granted by the proper management authority. The above permits or certificates may be granted if the trade is found to be non-detrimental to the survival of the species in the wild and the specimen was found to have been legally acquired. A number of countries have taken a reservation to the listing (Botswana, Democratic Republic of the Congo, Eswatini, Japan, Namibia, Norway, South Africa, United Republic of Tanzania, Zambia, and Zimbabwe) meaning they have made a unilateral decision to not be bound by the provisions of CITES relating to trade in this species.

Although the CITES listing is a positive step to ensure the sustainability of the international trade of shortfin mako sharks, it is difficult to assess the effectiveness of this measure over such a short period of time. An analysis of trade data and fin trimmings from a Hong Kong market led Cardeñosa *et al.* (2018) to conclude that compliance with reporting and permitting requirements for CITES-listed shark species listed at the 16th CITES Conference of the Parties (2013) was low in 2015–2016. Therefore, the CITES listing of shortfin mako shark may not have a strong impact on the number of individuals harvested for the international fin and meat trades. While the fin trade has declined, recent increases in the trade of shark meat signify the continued need for regulatory mechanisms to address the threat of overutilization in the international fin and meat trades.

Overall, while the ERA Team recognized the strong regulatory measures in place for shortfin mako sharks in U.S. domestic waters, retention bans that have been put in place for the species in several countries and recently by ICCAT, and increased global efforts to end shark finning, the ERA Team expressed concern about the adequacy of existing regulatory mechanisms to monitor and manage mortality from fisheries interactions on the high seas and the international meat and fin trade. The ERA Team was split on how this factor contributes to the extinction risk of the species, with just over half of the group concluding that the inadequacy of existing regulatory mechanisms will likely contribute significantly to the species' risk of extinction in the foreseeable future as they defined it, but is not likely contributing to the species' extinction risk currently. The remaining members found it unlikely that this factor is significantly contributing to the species' extinction risk now or would do so in the foreseeable future as they defined it. We agree with the ERA Team's assessment that the inadequacy of existing regulatory mechanisms is not likely contributing to the species' risk of extinction currently. Over the foreseeable future of 50 years that we have determined is more appropriate to apply for this species, we find that existing regulatory mechanisms may be inadequate to address overutilization, especially given the species' low productivity and prevalence in both meat and fin markets.

Other Natural or Manmade Factors Affecting Its Continued Existence

Under this factor, the ERA Team considered potential threats posed by pollutants and environmental contaminants, climate change, and shark control/bather protection efforts.

As high-level predators, shortfin mako sharks bioaccumulate and biomagnify heavy metals and organic contaminants; however, the impacts of these pollutants on the physiology and productivity of the species (and sharks in general) are poorly studied. While results of few available studies of other species of sharks and fish provide some evidence that sharks may experience negative physiological impacts and potentially reduced fitness as a result of contaminant exposure, the ERA Team found no evidence that individuals or populations are adversely affected to a degree that would impact the status of the species. Therefore, the ERA Team unanimously agreed that pollutants and environmental contaminants are unlikely to be contributing significantly to the species' extinction risk now or in the foreseeable future as they defined it. We agree that pollutants and environmental contaminants are not likely contributing significantly to the species' extinction risk now. Over the foreseeable future of 50 years that we have determined is more appropriate to apply for this species, we find that pollutants and environmental contaminants are not likely to significantly contribute to the shortfin mako shark's risk of extinction because this factor is not currently negatively affecting the species' status and the best available scientific and commercial data suggests no basis to predict that this will change over the extended time horizon.

When considering the potential threat of climate change to the shortfin mako shark, the ERA Team considered projected impacts to the marine environment (including warming waters, acidification, and shifting habitat suitability and prey distributions), and the species' potential responses to these impacts. While long-term climate projections (through 2100) are available and considered reliable, the ERA Team found that the species' responses to these projected environmental changes that far into the future could not be predicted with any certainty. While some studies predict that the species may be subject to significant habitat loss and potential behavioral and fitness impairments by 2100, the shortfin mako shark's broad prey base and thermal tolerance, among other factors, may give them a high adaptive capacity. A detailed review of available studies can be found in the Status Review Report. The majority of the ERA Team considered it unlikely that climate change is currently contributing to the species' extinction risk, or will contribute to the species' extinction risk in the foreseeable future as they defined it. Several ERA Team members concluded that the contribution of climate change to the extinction risk of the species in the foreseeable future could not be determined due to the lack of available information on the species' response to climate change. We agree that the best available scientific and commercial information indicates that climate change is not significantly contributing to the species' extinction risk now. Over the foreseeable future of 50 years that we have determined to be more appropriate to apply for this species, we also find that climate change is not likely to significantly contribute to the shortfin mako shark's risk of extinction because it is not currently negatively affecting the species' status and the best available scientific and commercial data suggests no basis to predict that this will change over the extended time horizon.

A small number of shortfin mako sharks experience mortality as a result of shark control/bather protection programs in South Africa and Australia, which aim to reduce the risk of shark attacks on humans near public beaches. Due to the localized geographic extent of the programs and the very low number of individuals impacted, the ERA Team did not find that shark control programs are likely contributing to the extinction risk of the species now, and found it unlikely that these programs would contribute significantly to extinction risk in the foreseeable future as they defined it. We agree that the best available scientific and commercial information indicates that these programs are not likely contributing significantly to the species' extinction risk now. Over the foreseeable future of 50 years that we have determined to be more appropriate to apply for this species, we also find that bather protection nets are not likely to significantly contribute to the shortfin mako shark's risk of extinction because they are not currently negatively affecting the species' status and the best available scientific and commercial information suggests no basis to predict that this will change over the extended time horizon.

In sum, the ERA Team did not identify any other natural or manmade factors affecting the continued existence of the shortfin mako shark, and we agree with their assessment.

Synergistic Impacts

We considered whether the impacts from threats described here and in the Status Review Report may cumulatively or synergistically affect the shortfin mako shark beyond the scope of each individual stressor. As discussed previously, overutilization has resulted in historical declines across the species' range and is expected to continue to affect the species in certain regions over the foreseeable future. The impact of overutilization on the species increases when regulatory mechanisms to address this threat are inadequate. The species' low productivity means that it will take longer to rebuild a stock if it becomes depleted due to overutilization. While there is no evidence that range contractions have occurred, or that destruction or modification of shortfin mako shark habitat on a global scale has occurred to such a point that it has impacted the status of the species or is likely to in the foreseeable future, climate change has the potential to alter the distribution of prey species and suitable habitat that may result in changes in distribution. This may in turn impact the frequency of fisheries interactions and resulting fishing mortality. Further, climate change-induced shifts in the marine food web have the potential to influence predation on juvenile shortfin mako sharks over the next several decades. We cannot reasonably predict either of these changes and their effects on the shortfin mako shark based on the best available scientific and commercial information. While some studies project that the species may be subject to significant habitat loss by 2100, the shortfin mako shark's broad prey base and thermal tolerance, among other factors, may give them a high adaptive capacity (see the Status Review Report). The specific impacts that climate change will have on the species, and how the species might be able to adapt to changing oceanic conditions, is unknown. Therefore, while we considered these potential synergistic effects, we conclude that the best available scientific and commercial information indicates that climate change is not likely to act synergistically with other threats to increase the extinction risk of the shortfin mako shark now or in the foreseeable future.

Extinction Risk Determination

Guided by the results and discussions from the demographic risk analysis and ESA Section 4(a)(1) factor assessment, the ERA Team analyzed the overall risk of extinction to the global shortfin mako shark population. In this process, the ERA Team considered the best available scientific and commercial information regarding the shortfin mako shark from all regions of the species' global range, and analyzed the collective condition of these populations to assess the species' global extinction risk. The ERA Team was fairly confident in determining the overall extinction risk of the species, placing two-thirds of their likelihood points in the low risk category. Some uncertainty was reflected in the allocation of points to the moderate risk category, largely due to poor reporting of catches and low confidence in abundance and trends in certain regions. No points were allocated to the high risk category (see definitions of risk categories in *Methods*).

The ERA Team acknowledged that the shortfin mako shark has experienced historical declines of varying degrees in all ocean basins, mainly due to interactions with commercial fishing vessels, however, current abundance trends are mixed. A robust recent stock assessment in the North Pacific indicates that the species is stable and potentially increasing there, and population increases are also indicated in the South Pacific. In other words, across the entire Pacific Ocean basin, the species is either stable and/or potentially increasing. The recent stock assessment in the North Atlantic, which the ERA Team also considered highly reliable, indicates ongoing declines that will continue into the foreseeable future. However, the ERA Team concluded that this region is not at risk of extirpation based on available projections carried out by ICCAT's SCRS, information on current fisheries mortality, and predictions about future management and levels of fisheries mortality. The South Atlantic may also have a declining population trend, but this is highly uncertain. Fisheries mortality remains high in the region. In the Indian Ocean, preliminary stock assessments indicate that the shortfin mako shark population is experiencing overfishing but is not overfished, and increasing CPUE trends are indicated in several key fisheries in this region. Compliance with reporting requirements is quite low in this region, however, so the ERA Team felt that the extent of the species' decline in this region is highly uncertain and potentially underestimated. Even with continued declines in the North Atlantic and likely population declines of uncertain degrees in the South Atlantic and Indian Oceans, the stable and potentially increasing population status in the Pacific Ocean, a major segment of the global population, led the majority of the ERA Team to conclude that abundance would not contribute significantly to the extinction risk of the species now or in the foreseeable future. The ERA Team also concluded that the shortfin mako shark's high genetic and ecological diversity, connectivity between populations, and wide spatial distribution reduce the species' extinction risk by providing resilience in the face of stochastic events and threats concentrated in certain regions. The ERA Team did, however, find that the low productivity of the species would likely contribute significantly to the species' risk of extinction in the foreseeable future as the species is highly susceptible to depletion from exploitation, and will recover slowly from such declines.

Overutilization in commercial fisheries and inadequate regulatory mechanisms to manage these fisheries are the main drivers of observed population declines. While regulatory mechanisms have recently been adopted to at least temporarily prohibit retention of the species in the North Atlantic and to ensure the sustainability of the international trade in shortfin mako shark products, it is too soon to accurately assess the adequacy of these measures to address overutilization. The ERA Team did consider the lack of compliance with reporting requirements in the Indian Ocean and South Atlantic Ocean concerning for the species, especially considering the high value of the species in the meat and fin trade. The low confidence in catch data also made it difficult for the ERA Team to assess whether regulatory mechanisms are inadequate to address the threat of overutilization in these regions.

Overall, the ERA Team concluded that the species is not at high or moderate risk of extinction based on the following: (1) the high adaptability of the species based on its use of multiple habitat types, tolerance of a wide range of water temperatures, and generalist diet; (2) the existence of genetically and ecologically diverse, sufficiently well-connected populations; (3) the species' wide spatial distribution with no indication of range contractions or extirpations in any region, even in areas where there is heavy bycatch mortality and utilization of the species' high-value fins and meat; (4) the stable and potentially increasing population trend indicated in the Pacific Ocean, a major segment of the species' range; (5) abundance estimates of one million and eight million individuals in the North Atlantic and North Pacific, respectively; and (6) no indication that the species is experiencing depensatory processes due to low abundance. Based on all of the foregoing information, which represents the best scientific and commercial data available regarding current demographic risks and threats to the species, the ERA Team concluded that the shortfin currently has a low risk of extinction rangewide.

We agree with the ERA Team's assessment that the shortfin mako shark is not at high risk of extinction rangewide for the above reasons. Extending the foreseeable future to 50 years (two generation lengths), as we have determined is more appropriate to apply for this species, does not alter this conclusion and, for the reasons summarized here, we continue to find that the species is at low risk of extinction throughout its range. In the North Atlantic, the population is estimated to have experienced declines in total biomass of 47–60 percent and declines in SSF of 50 percent from 1950 to 2015 (ICCAT 2017). Since then, levels of fishing mortality in the North Atlantic have declined in response to management measures implemented in recent years (3,281 t in 2015; 3,356 t in 2016; 3,199 t in 2017; 2,373 t in 2018; 1,882 t in 2019; 1,709 t in 2020) (SCRS 2021). While we recognize that current levels of mortality (1,709 t in 2020) are higher than any of the TAC levels examined in the projections carried out by the SCRS (up to 1,100 t inclusive of dead discards, ICCAT 2019), over the next 50 years, recently adopted retention prohibitions and increasing international efforts to reduce the effects of fishing mortality on the species in this region will likely result in further decreases in fishing mortality in this region (although we are unable to conclude the magnitude of potential declines, or whether they will be large enough to rebuild the stock). Therefore, the best available scientific and commercial information supports our forecast that the rate of decline will likely slow compared to the 1950–2015 time period. Although the stock is expected to decline until 2035 because the immature sharks that have been depleted in the past will age into the mature population over the next few decades, it is possible that the stock may be able to begin to rebuild if fishing mortality is low enough. Based on the above information, we find that future levels of total fishing mortality are not likely to lead to extirpation of the stock over the foreseeable future, even given estimates of historical and recent population decline. In the South Atlantic, the status of the shortfin mako shark is currently unclear. While it is probable that the population is experiencing declines due to high fishing effort, current stock status is highly uncertain, and it is difficult to predict the magnitude of decline over the next 50 years. The South Pacific has an increasing trend and there is no indication that this will change over the next 50 years, although this trend is based on a shorter time period, introducing some uncertainty into the future status of the species in this region. In the North Pacific, the ISC Shark Working Group stock assessment (2018) indicates that spawning abundances are expected to increase gradually over a 10-year period (2017–2026) if fishing mortality remains constant or is moderately decreased relative to 2013–2015 levels. We take this to indicate that the current levels of fishing mortality in this region are allowing the population to grow, and there is no indication that this will change significantly in the foreseeable future. In the Indian Ocean, it is difficult to determine the stock status over the foreseeable future as current stock status is highly uncertain, with declines potentially underestimated due to poor reporting and data problems discussed above. The best available scientific and commercial information for the species in this region, including two preliminary stock assessments, indicates that the species is undergoing overfishing but is not overfished, and recent increasing CPUE trends are indicated in Spanish, Portuguese, and Taiwanese longline fleets. Thus, although there is significant uncertainty regarding the future status of this stock, and we acknowledge that declines have been indicated, we conclude that the species is not at risk of extirpation in this region over the next 50 years. In sum, although fishing mortality remains high throughout the species' range and its low productivity life history does present a concern for the species' risk of extinction over the foreseeable future, we conclude on the basis of the best available scientific and commercial data that the rangewide species is neither currently in danger of extinction nor likely to become so within the foreseeable future.

Significant Portion of Its Range

Under the ESA and our implementing regulations, a species may warrant listing if it is in danger of extinction or likely to become so within the foreseeable future throughout all or a significant portion of its range. Having determined that the shortfin mako shark is not in danger of extinction or likely to become so within the foreseeable future throughout all of its range, we now consider whether the shortfin mako shark is in danger of extinction or likely to become so within the foreseeable future in a significant portion of its range—that is, whether there is any portion of the species' range for which it is true that both (1) the portion is significant; and (2) the species, in that portion, is in danger of extinction or likely to become so within the foreseeable future. A joint USFWS–NMFS policy, finalized in 2014, provided the agencies' interpretation of this phrase (''SPR Policy,'' 79 FR 37578, July 1, 2014) and explains that, depending on the case, it might be more efficient for us to address the ''significance'' question or the ''status'' question first. Regardless of which question we choose to address first, if we reach a negative answer with respect to the first question, we do not need to evaluate the other question for that portion of the species' range.

We note that the definition of ''significant'' in the SPR Policy has been invalidated in two District Court cases that addressed listing decisions made by the USFWS. The SPR Policy set out a biologically-based definition that examined the contributions of the members in the portion to the species as a whole, and established a specific threshold (*i.e.,* when the loss of the members in the portion would cause the overall species to become threatened or endangered). The courts invalidated the threshold component of the definition because it set too high a standard. Specifically, the courts held that, under the threshold in the policy, a species would never be listed based on the status of the species in the portion, because in order for a portion to meet the threshold, the species would be threatened or endangered rangewide. *Center for Biological Diversity, et al.* v. *Jewell, 248 F. Supp. 3d 946, 958 (D. Ariz. 2017); Desert Survivors* v. *DOI 321 F. Supp. 3d. 1011 (N.D. Cal., 2018).* However, those courts did not take issue with the fundamental approach of evaluating significance in terms of the biological significance of a particular portion of the range to the overall species. NMFS did not rely on the definition of ''significant'' in the policy when making this 12-month finding. The ERA Team instead chose to first address the question of the species' status in portions of its range. While certain other aspects of the policy have also been addressed by courts, the policy framework and key elements remain in place, and until the policy is withdrawn we are bound to apply those aspects of it that remain valid.

Because there are infinite ways to divide up the species' range for an SPR analysis, the ERA Team only considered portions with a reasonable likelihood of being both in danger of extinction or likely to become so within the foreseeable future, and biologically significant to the species. In asking the ''status'' question first, the ERA Team considered whether the threats posed by overutilization and inadequate regulatory measures are geographically concentrated in any portion of the species' range at a biologically meaningful scale, or whether these threats are having a greater impact on the status of the species in any portions relative to other portions. While the shortfin mako shark is subject to the threat of overutilization in commercial fisheries across its range, fishing mortality is substantially affecting the species in the North Atlantic Ocean, and is projected to continue impacting the species' status in this region over the next several decades. Because the North Atlantic stock of shortfin mako shark is currently experiencing substantial negative effects of overfishing and inadequate regulatory mechanisms (*i.e.,* declines in SSF of 50 percent from 1950 to 2015, as well as a 90 percent probability of being overfished and experiencing overfishing), and will continue to be impacted over the foreseeable future, the ERA Team concluded that there was a reasonable likelihood that the species is at greater risk of extinction in this portion relative to the remainder of the range and determined to proceed to consider whether in fact the individuals in that area were at moderate or high risk of extinction. The ERA Team also considered whether the Atlantic Ocean as a whole is a portion that may be at risk of extinction now or in the foreseeable future based on indications of the species' decline in this portion, and to ensure a thorough analysis of the species' status in this ocean basin.

Separate from the ERA Team, we (NMFS) went on to consider whether other portions (the South Atlantic and the Indian Ocean) that were not explicitly considered by the ERA Team had a reasonable likelihood of being both in danger of extinction or likely to become so within the foreseeable future, and biologically significant to the species. In the South Atlantic, population declines of an unknown degree are likely occurring, and fishing mortality remains high. The best available scientific and commercial information indicates that the population has only a 19 percent probability of being overfished and experiencing overfishing, a 48 percent probability of not being overfished but overfishing occurring, or alternatively, being overfished but overfishing not occurring, and a 36 percent probability of not being overfished or experiencing overfishing (ICCAT 2017). The 2017 stock assessment of the population found conflicting results from different models, resulting in high uncertainty. However, the stock assessment notes that despite uncertainty, in recent years the stock may have been at, or is already below, B_{MSY}, and fishing mortality is already exceeding F_{MSY}. While the best available scientific and commercial information leads us to find that high levels of fishing mortality are likely leading to population declines in this region, there is no indication that the resulting decline reflects that the species in this portion has a reasonable likelihood of being in danger of extinction or likely to become so within the foreseeable future. Therefore, we did not consider the portion further. The best available scientific and commercial information indicates that the shortfin mako shark population in the Indian Ocean is considered to be experiencing overfishing but is not yet overfished, and recent CPUE increases have occurred in Spanish, Portuguese, and Taiwanese longline fleets. Although population declines are potentially underestimated due to poor reporting and data problems discussed previously, we do not have any indication that the preliminary stock assessments available for this region are invalid or suffer from methodological or other flaws that would lead us to discount them. As the stock is not considered overfished in either of these assessments, meaning that biomass has not declined below the biomass at which the stock can produce maximum sustainable yield on a continuing basis, we find it unlikely that fishing mortality is impacting abundance to a degree that causes the species to be at risk of extinction or likely to become so in the foreseeable future in this portion of its range. Therefore, the best available information does not support a conclusion that the species has a reasonable likelihood of being at greater risk of extinction in this portion relative to the remainder of the range, and the Indian Ocean was not assessed further in the SPR analysis. Overutilization of the species does not appear to be occurring in the Pacific Ocean: the North Pacific population appears stable and is neither overfished nor experiencing overfishing based on robust data, and the South Pacific population has been indicated to be increasing with moderate certainty. There is no indication that any region in the Pacific has a reasonable likelihood of being in danger of extinction or likely to become so within the foreseeable future, and therefore no portions in the Pacific Ocean were considered further. The ERA Team therefore went on to assess the extinction risk of two portions: the North Atlantic Ocean and the Atlantic Ocean as a whole.

To determine extinction risk in each portion, the ERA Team used the likelihood point method as described previously in *Methods.* The ERA Team evaluated the best available information on the demographic threats and ESA Section 4(a)(1) factors for shortfin mako sharks in each portion, beginning with the North Atlantic Ocean portion. The recent stock assessment conducted by ICCAT indicates that the North Atlantic shortfin mako shark has experienced declines in biomass of between 47–60 percent from 1950–2015, and predicts that SSF will continue to decline until 2035 regardless of fishing mortality levels. Despite the species' low productivity and the relatively high level of fishing mortality impacting the species, the ERA Team concluded that the species is not at high risk of extinction based on the current abundance of the species in the portion (estimated at one million individuals by FAO (2019)) and recent increased efforts to reduce fishing mortality that are likely to be effective, at least to some degree, in reducing the effect of overutilization on the species here. Many of the ERA Team's points were placed in the moderate risk category for the North Atlantic Ocean portion, which is reflective of the species' low productivity and the considerable uncertainty associated with potential effects of existing and future regulatory mechanisms aimed at rebuilding and ending overfishing of the North Atlantic shortfin mako stock over the next few decades (*i.e.,* whether or not the resulting reduction in fishing mortality is significant enough to end overfishing and begin to rebuild the species). However, the ERA Team placed the majority of its likelihood points in the low risk category and concluded that the North Atlantic portion has a low extinction risk. Despite its continuing declining trend, based on the best available scientific and commercial information, the ERA Team did not conclude that the rate of decline in the foreseeable future would be great enough to put the species in this portion at high risk of extinction in the foreseeable future (see the Status Review Report).

When conducting the analysis of the status of the species in the Atlantic Ocean as a whole, the ERA Team considered the highly uncertain fishing and abundance data available for the South Atlantic. Despite this uncertainty, the best available scientific and commercial data indicate that it is likely that the species' abundance in this region is declining, with ICCAT's SCRS finding a 19 percent probability that the stock is overfished and experiencing overfishing. The ERA Team also considered the possible effects of the retention prohibition in the North Atlantic and the potential for a shift in fishing effort for the species to the South Atlantic. Overall, the ERA Team found that the individuals of the species in the Atlantic Ocean portion as a whole were not at high risk of extinction based on available abundance and threats information. The ERA Team did place many points in the moderate risk category to reflect the species' low productivity, and the uncertainty in data and future regulatory mechanisms. However, the ERA Team placed the majority of its points in the low risk category because the level of fishing mortality and population decline expected within the foreseeable future does not place the species in this portion at high or moderate extinction risk in this timeframe.

Thus, to summarize, the ERA Team did not find the shortfin mako shark to be in danger of extinction or likely to become so within the foreseeable future in either of these portions of its range. As a result, the ERA Team did not continue the analysis to evaluate whether either of these portions constitutes a biologically significant portion of the shortfin mako shark's range.

We agree with the ERA Team's conclusions that the species is not in danger of extinction now within the North Atlantic or the Atlantic Ocean as a whole. When we extended the foreseeable future to 50 years, which we have determined is more appropriate to apply for this species, we also reached the same conclusion as the ERA Team. The North Atlantic shortfin mako shark population is estimated to have experienced declines in total biomass of 47–60 percent and declines in SSF of 50 percent from 1950 to 2015 (ICCAT 2017). Since then, levels of fishing mortality in the North Atlantic have declined in response to management measures implemented in recent years (3,281 t in 2015; 3,356 t in 2016; 3,199 t in 2017; 2,373 t in 2018; 1,882 t in 2019; 1,709 t in 2020) (SCRS 2021). While we recognize that current levels of mortality (1,709 t in 2020) are higher than any of the TAC levels examined in the projections carried out by the SCRS (up to 1,100 t inclusive of dead discards, ICCAT 2019), over the next 50 years, recently adopted retention prohibitions and increasing international efforts to reduce the effects of fishing mortality on the species in this region will likely result in further decreasing levels of fishing mortality in this region (although we are unable to conclude the magnitude of potential declines, or whether they will be large enough to rebuild the stock). Therefore, the best available scientific and commercial information supports our forecast that the rate of decline will likely slow compared to the 1950–2015 time period. Although the stock is expected to decline until 2035 because the immature sharks that have been depleted in the past will age into the mature population over the next few decades, it is possible that the stock may be able to begin to rebuild if fishing mortality is low enough. We find that future levels of fishing mortality are not likely to place the species in danger of extinction in the foreseeable future within this portion, even given estimates of historical and recent decline. In the South Atlantic, it is likely that the population is experiencing decline of an unknown degree due to continued high fishing effort and mortality. Results of the 2017 stock assessment indicate a 19 percent probability that the stock is overfished and experiencing overfishing, with conflicting results from different models used. Current stock status is highly uncertain, and it is therefore difficult to predict the magnitude of decline over the next 50 years. However, the greater abundance, habitat area, spatial distribution, and ecological diversity of the North and South Atlantic populations together as a portion provide additional resilience that makes extinction less likely. Therefore, we do not find that the Atlantic portion is likely to be in danger of extinction in the foreseeable future. Because we did not find the shortfin mako shark to be in danger of extinction or likely to become so within the foreseeable future in either of these portions, and because to support a listing on the basis of SPR the individuals in a portion would need to both have a threatened or endangered status and be biologically significant to the overall species, we did not consider whether these portions qualify as significant portions of the shortfin mako shark's range.

Distinct Population Segments

The petition to list the shortfin mako shark requested that NMFS list the species throughout its range, or alternatively, as DPSs, in the event that NMFS concludes that they exist. Therefore, we examined the best available information to determine whether DPSs may exist for this species. The petition did not provide information regarding potential DPSs of shortfin mako shark.

As discussed previously, the DPS Policy provides guidelines for defining DPSs and identifies two elements to consider in a decision regarding whether a population qualifies as a DPS: discreteness and significance of the population segment to the species (61 FR 4722; February 7, 1996). A population may be considered discrete if it is markedly separate from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors, or if it is delimited by international governmental boundaries. Genetic differences between the population segments being considered may be used to evaluate discreteness. If a population segment is considered discrete, its biological and ecological significance must then be evaluated. Significance is evaluated in terms of the importance of the population segment to the overall welfare of the species. Some of the considerations that can be used to determine a discrete population segment's significance to the taxon as a whole include: (1) persistence of the population segment in an unusual or unique ecological setting; (2) evidence that loss of the population segment would result in a significant gap in the range of the taxon; and (3) evidence that the population segment differs markedly from other populations of the species in its genetic characteristics.

To determine whether any discrete populations of shortfin mako sharks exist, we looked at available information on shortfin mako shark population structure, including tagging, tracking, and genetic studies. As discussed previously in *Habitat Use* and *Population Structure and Genetics,* although certain ocean currents and features may limit movement patterns between different regions, available genetic studies indicate a globally panmictic population with some genetic structuring among ocean basins.

Heist *et al.* (1996) investigated genetic population structure using restriction fragment length polymorphism analysis of maternally inherited mtDNA from shortfin mako sharks in the North Atlantic, South Atlantic, North Pacific, and South Pacific. The North Atlantic samples showed significant isolation from other regions ($p < 0.001$), and differed from other regions by the relative lack of rare and unique haplotypes, and high abundance of a single haplotype (Heist *et al.* 1996). Reanalysis of the data found significant differentiation between the South Atlantic and North Pacific samples (Schrey and Heist 2003) in addition to isolation of the North Atlantic.

A microsatellite analysis of samples from the North Atlantic, South Atlantic (Brazil), North Pacific, South Pacific, and Atlantic and Indian coasts of South Africa found very weak evidence of population structure ($F_{ST} = 0.0014$, $P = 0.1292$; $R_{ST} = 0.0029$, $P = 0.019$) (Schrey and Heist 2003). These results were insufficient to reject the null hypothesis of a single genetic stock of shortfin mako shark, suggesting that there is sufficient movement of shortfin mako sharks, and therefore gene flow, to reduce genetic differentiation between regions (Schrey and Heist 2003). The authors note that their findings conflict with the significant genetic structure revealed through mtDNA analysis by Heist *et al.* (1996). They suggest that as mtDNA is maternally inherited and nuclear DNA is inherited from both parents, population structure shown by mtDNA data could indicate that female shortfin mako sharks exhibit limited dispersal and philopatry to parturition sites, while male dispersal allows for gene flow that would explain the results from the microsatellite data (Schrey and Heist 2003).

Taguchi *et al.* (2011) analyzed mtDNA samples from the North and South Pacific, North Atlantic, and Indian Oceans, finding evidence of significant differentiation between the North Atlantic and the Central North Pacific and Eastern South Pacific (pairwise $\Phi_{ST} = 0.2526$ and 0.3237, respectively). Interestingly, significant structure was found between the eastern Indian Ocean and the Pacific Ocean samples (pairwise Φ_{ST} values for Central North Pacific, Western South Pacific, Eastern South Pacific are 0.2748, 0.1401, and 0.3721, respectively), but not between the eastern Indian and the North Atlantic.

Corrigan *et al.* (2018) also found evidence of matrilineal structure from mtDNA data, while nuclear DNA data provide support for a globally panmictic population. Although there was no evidence of haplotype partitioning by region and most haplotypes were found across many (sometimes disparate) locations, Northern Hemisphere sampling locations were significantly differentiated from all other samples, suggesting reduced matrilineal gene flow across the equator (Corrigan *et al.* 2018). The only significant differentiation indicated by microsatellite data was between South Africa and southern Australia (pairwise $F_{ST} = 0.037$, $\Phi_{ST} = 0.043$) (Corrigan *et al.* 2018). Clustering analysis showed only minor differences in allele frequencies across regions, and little evidence of population structure (Corrigan *et al.* 2018). Overall, the authors conclude that although spatial partitioning exists, the shortfin mako shark is genetically homogenous at a large geographic scale.

Taken together, results of genetic analyses suggest that female shortfin mako sharks exhibit fidelity to ocean basins, possibly to utilize familiar pupping and rearing grounds, while males move across the world's oceans and mate with females from various basins (Heist *et al.* 1996; Schrey and Heist 2003; Taguchi *et al.* 2011; Corrigan *et al.* 2018). This finding does not support the existence of discrete population segments of shortfin mako sharks.

We also considered whether available tracking data support the existence of discrete population segments of shortfin mako shark. There is some evidence that certain ocean currents and features may limit movement patterns, including the Mid-Atlantic ridge separating the western and eastern North Atlantic, and the Gulf Stream separating the North Atlantic and the Gulf of Mexico/ Caribbean Sea (Casey and Kohler 1992; Vaudo *et al.* 2017; Santos *et al.* 2020). However, conventional tagging data indicates that movement does occur across these features (Kohler and Turner 2019). In the Pacific, tagging data supports east-west mixing in the north and minimal east-west mixing in the south (Sippel *et al.* 2016; Corrigan *et al.* 2018). Trans-equatorial movement may be uncommon based on some tagging studies, though tagged shortfin mako sharks have been recorded crossing the equator (Sippel *et al.* 2016; Corrigan *et al.* 2018; Santos *et al.* 2021). Therefore, we conclude that there do not appear to be major barriers to the species' dispersal that would result in marked separation between populations.

Overall, we find that the best available scientific and commercial information does not support the existence of discrete populations of shortfin mako shark. Because both standards, of discreteness and significance, have to be met in order to conclude that a population would constitute a DPS, we conclude that there are no population segments of the shortfin mako shark that would qualify as a DPS under the DPS Policy.

Final Listing Determination

Section 4(b)(1) of the ESA requires that NMFS make listing determinations based solely on the best scientific and commercial data available after conducting a review of the status of the species and taking into account those efforts, if any, being made by any state or foreign nation, or political subdivisions thereof, to protect and conserve the species. We relied on available literature and information from relevant countries to evaluate efforts to protect and conserve the species, including National Plans of Action for the Conservation and Management of Sharks (NPOA-Sharks), which are developed under the IPOA–SHARKS and aim to ensure the conservation, management, and long-term sustainable use of sharks. While the development of NPOAs provide some indication of the level of commitment of a catching country to manage its shark fisheries and provides a benefit to sharks, the quality of existing NPOA-Sharks varies, and there are no reporting mechanisms on implementation of the NPOAs; thus, it remains uncertain whether a particular plan is being implemented or what impact the plan has had on conservation and management of sharks. These conservation efforts do not change the conclusion we would otherwise have reached regarding the species' status. We have independently reviewed the best available scientific and commercial information, including the petitions, public comments submitted in response to the 90-day finding (86 FR 19863; April 15, 2021), the Status Review Report, and other published and unpublished information. We considered each of the statutory factors to determine whether each contributed significantly to the extinction risk of the species. As required by the ESA, section 4(b)(1)(a), we also took into account efforts to protect shortfin mako sharks by states, foreign nations, or political subdivisions thereof, and evaluated whether those efforts provide a conservation benefit to the species. As previously explained, we could not identify a significant portion of the species' range that is threatened or endangered, nor did we find that any DPSs of the species exist. Therefore, our determination is based on a synthesis and integration of the foregoing information, factors and considerations, and their effects on the status of the species throughout its entire range.

We have determined the shortfin mako shark is not presently in danger of extinction, nor is it likely to become so in the foreseeable future throughout all or a significant portion of its range. This finding is consistent with the statute's requirement to base our findings on the best scientific and commercial data available, summarized and analyzed above. Therefore, the shortfin mako shark does not meet the definition of a threatened species or an endangered species and does not warrant listing as threatened or endangered at this time.

This is a final action, and, therefore, we are not soliciting public comments.

References

A complete list of the references used in this 12-month finding is available online (see **ADDRESSES**) and upon request (see **FOR FURTHER INFORMATION CONTACT**).

Peer Review

In December 2004, the Office of Management and Budget (OMB) issued a Final Information Quality Bulletin for Peer Review establishing minimum peer review standards, a transparent process for public disclosure of peer review planning, and opportunities for public participation. The OMB Bulletin, implemented under the Information Quality Act (Pub. L. 106–554) is intended to enhance the quality and credibility of the Federal Government's scientific information, and applies to influential or highly influential scientific information disseminated on or after June 16, 2005. To satisfy our requirements under the OMB Bulletin, we obtained independent peer review of the Status Review Report. Three independent specialists were selected from the academic and scientific community for this review. All peer reviewer comments were addressed prior to dissemination of the final Status Review Report and publication of this 12-month finding. The Peer Review Report can be found online at: *https://www.noaa.gov/information-technology/endangered-species-act-status-review-report-shortfin-mako-shark-isurus-oxyrinchus-id430.*

Authority: The authority for this action is the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

Dated: November 4, 2022.

Samuel D. Rauch, III,

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

[FR Doc. 2022–24493 Filed 11–10–22; 8:45 am]

BILLING CODE 3510–22–P