(x) Have disinfecting supplies, gloves, masks, and plastic for containing contaminated materials.

(xi) Have a fabrication facility information system, paper or digital, that can track the production, list component part number (and serial number if available), quantity, that is linked to patient information and be Health Insurance Portability and Accountability Act compliant. Such a system must allow facility staff and management, including those fabricating, to identify any parts that could be recalled at a later date.

(xii) Have parallel bars, a full-length mirror, and other appropriate assessment tools.

(xiii) Have a process using precautions to handle used patient devices that are contaminated.

(xiv) Have repair and disinfecting areas clearly labeled.

(xv) Have the ability to handle all potentially hazardous materials in facility properly.

(xvi) Have an emergency management plan and a safety management plan.

(xvii) Have policy for detecting/reporting counterfeit supplies.

(xviii) Have the proper tools, equipment, and computers commonly used in the fabrication of particular items and typically associated with the particular technical approach (negative impression/positive model, CAD–CAM, or direct formed), as applicable: These tools and equipment would include, but are not limited to the following

(A) Computers with appropriate graphics/modeling capacity and technology.

(B) Band saw.

(C) Disc sander.

(D) Sanding paper.

(E) Flexible shaft sander.

(F) Lathe.

(G) Drill press.

(H) Sewing machine.

(I) Grinding equipment.

(J) Paint-spraying equipment.

(K) Welding equipment.

(L) Alignment jig.

(M) Ovens capable of heating plastics for molding.

(N) Computer controlled milling machine.

(O) Lockable storage areas for raw materials and finished devices.

(P) Air compressor.

* * * * *

■ 3. Section 424.58 is amended as follows:

■ a. Revising the section heading.

■ b. Redesignating paragraphs (c) through (e) as paragraphs (d) through (f) respectively.

■ c. Adding a new paragraph (c).

The revision and addition read as follows:

§ 424.58 Requirements for DMEPOS accreditation organizations.

* * * * *

(c) *Additional requirements for accrediting qualified suppliers.* To accredit qualified suppliers that fabricate or bill Medicare for prosthetics and custom-fabricated orthotics as specified in § 424.57(c)(22)(ii), an independent accreditation organization must be one of the following:

(1) American Board for Certification in Orthotics and Prosthetics, Incorporated (ABC).

(2) Board for Orthotist/Prosthetist Certification International, Incorporated (BOC).

(3) An organization that—

(i) Employs or contracts with an orthotist, prosthetist, occupational therapist or physical therapist who—

(A) Meets the definition of qualified practitioner specified in § 424.57(a); and

(B) Is utilized for the purpose of surveying the supplier or practitioner for compliance; and

(ii) Has the authority granted by CMS to approve or deny the accreditation of qualified suppliers as defined in § 424.57(a) based on a determination that the organization has standards equivalent to the ABC or BOC.

* * * * *

■ 4. Section § 424.535 is amended as follows:

■ a. Revising the section heading.

■ b. In paragraph (a)(2) introductory text by removing the phrase ‘‘the provider or supplier is—’’ and adding in its place ‘‘the provider or supplier is any of the following:’’.

■ c. In paragraph (a)(2)(ii) by removing the phrase ‘‘Is debarred, suspended, or’’ and adding in its place the phrase ‘‘Debarred, suspended or’’.

■ d. Adding paragraph (a)(2)(iii).

The revision and addition reads as follows:

§ 424.535 Revocation of enrollment and billing privileges in the Medicare program.

(a) * * *

(2) * * *

(iii) A qualified supplier as defined in § 424.57(a) that submitted a claim for payment for a prosthetic or custom-fabricated orthotic that was not—

(A) Furnished by a qualified practitioner; and

(B) Fabricated by a qualified practitioner or qualified supplier as defined in § 424.57(a) at a fabrication facility as defined in § 424.57(a).

* * * * *

Dated: December 9, 2016.

Andrew M. Slavitt,

Acting Administrator, Centers for Medicare & Medicaid Services.

Dated: December 22, 2016.

Sylvia M. Burwell

Secretary, Department of Health and Human Services.

[FR Doc. 2017–00425 Filed 1–11–17; 8:45 am]

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DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Part 223

[Docket No. 160105011–6999–02]

RIN 0648–XE390

12-Month Finding on a Petition To List Giant and Reef Manta Rays as Threatened or Endangered Under the Endangered Species Act

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

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

SUMMARY: We, NMFS, announce a 12-month finding on a petition to list the giant manta ray (*Manta birostris*) and reef manta ray (*Manta alfredi*) as threatened or endangered under the Endangered Species Act (ESA). We have completed a comprehensive status review of both species in response to this petition. Based on the best scientific and commercial information available, including the status review report (Miller and Klimovich 2016), and after taking into account efforts being made to protect these species, we have determined that the giant manta ray (*M. birostris*) is likely to become an endangered species within the foreseeable future throughout a significant portion of its range. Therefore, we propose to list the giant manta ray as a threatened species under the ESA. Any protective regulations determined to be necessary and advisable for the conservation of the proposed threatened giant manta ray under ESA section 4(d) would be proposed in a subsequent **Federal Register** announcement. Should the proposed listing be finalized, we would also designate critical habitat for the species, to the maximum extent prudent and determinable. We solicit information to assist this proposed listing determination, the development of proposed protective regulations, and

designation of critical habitat in the event the proposed threatened listing for the giant manta ray is finalized. Additionally, we have determined that the reef manta ray (*M. alfredi*) is not currently in danger of extinction throughout all or a significant portion of its range and is not likely to become so within the foreseeable future. Therefore, we find that the reef manta ray does not warrant listing under the ESA at this time.

DATES: Comments on the proposed rule to list the giant manta ray must be received by March 13, 2017. Public hearing requests must be made by February 27, 2017.

ADDRESSES: You may submit comments on this document, identified by NOAA–NMFS–2016–0014, by either of the following methods:

- *Electronic Submissions:* Submit all electronic public comments via the Federal eRulemaking Portal. Go to *www.regulations.gov/#!docketDetail;D=NOAA-NMFS-2016-0014.* Click the ''Comment Now'' icon, complete the required fields, and enter or attach your comments.
- *Mail:* Submit written comments to Maggie Miller, NMFS Office of Protected Resources (F/PR3), 1315 East West Highway, Silver Spring, MD 20910, USA.

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

You can find the petition, status review report, **Federal Register** notices, and the list of references electronically on our Web site at *www.fisheries.noaa.gov/pr/species/fish/manta-ray.html.*

FOR FURTHER INFORMATION CONTACT: Maggie Miller, NMFS, Office of Protected Resources, (301) 427–8403.

SUPPLEMENTARY INFORMATION:

Background

On November 10, 2015, we received a petition from Defenders of Wildlife to list the giant manta ray (*M. birostris*), reef manta ray (*M. alfredi*) and Caribbean manta ray (*M. c.f. birostris*) as threatened or endangered under the ESA throughout their respective ranges, or, as an alternative, to list any identified distinct population segments (DPSs) as threatened or endangered. The petitioners also requested that critical habitat be designated concurrently with listing under the ESA. On February 23, 2016, we published a positive 90-day finding (81 FR 8874) announcing that the petition presented substantial scientific or commercial information indicating that the petitioned action may be warranted for the giant manta ray and reef manta ray, but that the Caribbean manta ray is not a taxonomically valid species or subspecies for listing, and explained the basis for that finding. We also announced the initiation of a status review of the giant manta ray and reef manta ray, as required by section 4(b)(3)(a) of the ESA, and requested information to inform the agency's decision on whether these species warrant listing as endangered or threatened under the ESA.

Listing Species Under the Endangered Species Act

We are responsible for determining whether giant and reef manta rays are threatened or endangered under the ESA (16 U.S.C. 1531 *et seq.*). To make this determination, we first consider whether a group of organisms constitutes a ''species'' under section 3 of the ESA, then whether the status of the species qualifies it for listing as either threatened or endangered. Section 3 of the ESA defines species to include ''any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature.'' On February 7, 1996, NMFS and the U.S. Fish and Wildlife Service (USFWS; together, the Services) adopted a policy describing what constitutes a DPS of a taxonomic species (61 FR 4722). The joint DPS policy identified two elements that must be considered when identifying a DPS: (1) The discreteness of the population segment in relation to the remainder of the species (or subspecies) to which it belongs; and (2) the significance of the population segment to the remainder of the species (or subspecies) to which it belongs.

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.'' Thus, in the context of the ESA, the Services interpret an ''endangered species'' to be one that is presently at risk of extinction. A ''threatened species'' is not currently at risk of extinction, but is likely to become so in the foreseeable future. The key statutory difference between a threatened and endangered species is the timing of when a species may be in danger of extinction, either now (endangered) or in the foreseeable future (threatened).

Additionally, as the definition of ''endangered species'' and ''threatened species'' makes clear, the determination of extinction risk can be based on either assessment of the range wide status of the species, or the status of the species in a ''significant portion of its range.'' The Services published a final policy to clarify the interpretation of the phrase ''significant portion of the range'' in the ESA definitions of ''threatened species'' and ''endangered species'' (79 FR 37577; July 1, 2014) (SPR Policy). The policy consists of the following four components:

(1) If a species is found to be endangered or threatened in only an SPR, and the SPR is not a DPS, the entire species is listed as endangered or threatened, respectively, and the ESA's protections apply across the species' entire range.

(2) A portion of the range of a species is ''significant'' if its contribution to the viability of the species is so important that without that portion, the species would be in danger of extinction or likely to become so in the foreseeable future.

(3) The range of a species is considered to be the general geographical area within which that species can be found at the time USFWS or NMFS makes any particular status determination. This range includes those areas used throughout all or part of the species' life cycle, even if they are not used regularly (*e.g.,* seasonal habitats). Lost historical range is relevant to the analysis of the status of the species, but it cannot constitute an SPR.

(4) If a species is not endangered or threatened throughout all of its range but is endangered or threatened within an SPR, and the population in that significant portion is a valid DPS, we will list the DPS rather than the entire taxonomic species or subspecies.

The statute also requires us to determine whether any species is endangered or threatened throughout all or a significant portion of its range as a result of any one or a combination of the following five 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 (ESA section 4(a)(1)(A)–(E)). Section 4(b)(1)(A) of the ESA requires us to make listing determinations based solely on the best scientific and commercial data available after conducting a review of the status of the species and after taking into account efforts being made by any State or foreign nation or political subdivision thereof to protect the species. In evaluating the efficacy of existing domestic protective efforts, we rely on the Services' joint *Policy on Evaluation of Conservation Efforts When Making Listing Decisions* (''PECE''; 68 FR 15100; March 28, 2003) for any conservation efforts that have not been implemented, or have been implemented but not yet demonstrated effectiveness.

Status Review

A NMFS biologist in the Office of Protected Resources led the status review for the giant manta ray and reef manta ray (Miller and Klimovich 2016). The status review examined both species' statuses throughout their respective ranges and also evaluated if any portion of their range was significant as defined by the Services' SPR Policy (79 FR 37578; July 1, 2014).

In order to complete the status review, information was compiled on each species' biology, ecology, life history, threats, and status from information contained in the petition, our files, a comprehensive literature search, and consultation with experts. We also considered information submitted by the public in response to our petition finding. In assessing the extinction risk of both species, we considered the demographic viability factors developed by McElhany et al. (2000). The approach of considering demographic risk factors to help frame the consideration of extinction risk has been used in many of our status reviews, including for Pacific salmonids, Pacific hake, walleye pollock, Pacific cod, Puget Sound rockfishes, Pacific herring, scalloped, great, and smooth hammerhead sharks, and black abalone (see *www.nmfs.noaa.gov/pr/species/* for links to these reviews). In this approach, the collective condition of individual populations is considered at the species level according to four viable population descriptors: abundance, growth rate/productivity, spatial structure/connectivity, and diversity. These viable population descriptors reflect concepts that are well-founded in conservation biology and that individually and collectively provide strong indicators of extinction risk (NMFS 2015).

The draft status review report was subjected to independent peer review as required by the Office of Management and Budget (OMB) Final Information Quality Bulletin for Peer Review (M–05–03; December 16, 2004). The draft status review report was peer reviewed by independent specialists selected from the academic and scientific community, with expertise in manta ray biology, conservation, and management. The peer reviewers were asked to evaluate the adequacy, appropriateness, and application of data used in the status review, including the extinction risk analysis. All peer reviewer comments were addressed prior to dissemination and finalization of the draft status review report and publication of this finding.

We subsequently reviewed the status review report, its cited references, and peer review comments, and believe the status review report, upon which this 12-month finding and proposed rule is based, provides the best available scientific and commercial information on the two manta ray species. Much of the information discussed below on manta ray biology, distribution, abundance, threats, and extinction risk is attributable to the status review report. However, in making the 12-month finding determination and proposed rule, we have independently applied the statutory provisions of the ESA, including evaluation of the factors set forth in section 4(a)(1)(A)–(E) and our regulations regarding listing determinations. The status review report is available on our Web site (see **ADDRESSES** section) and the peer review report is available at *http://www.cio.noaa.gov/services_programs/prplans/PRsummaries.html.* Below is a summary of the information from the status review report and our analysis of the status of the giant manta ray and reef manta ray. Further details can be found in Miller and Klimovich (2016).

Description, Life History, and Ecology of the Petitioned Species

Species Description

Manta rays are large bodied, planktivorous rays, considered part of the Mobulidae subfamily that appears to have diverged from Rhinoptera around 30 million years ago (Poortvliet et al. 2015). *Manta* species are distinguished from other Mobula rays in that they tend to be larger, with a terminal mouth, and have long cephalic fins (Evgeny 2010). The genus *Manta* has a long and convoluted taxonomic history due partially to the difficulty of preserving such large specimens and conflicting historical reports of taxonomic characteristics (Couturier et al. 2012; Kitchen-Wheeler 2013). All manta rays were historically categorized as *Manta birostris,* but Marshall et al. (2009) presented new data that supported the splitting of the monospecific *Manta* genus into two species: *M. birostris* and *M. alfredi.*

Both *Manta* species have diamond-shaped bodies with wing-like pectoral fins; the distance over this wingspan is termed disc width (DW). There are two distinct color types in both species: chevron and black (melanistic). Most of the chevron variants have a black dorsal surface and a white ventral surface with distinct patterns on the underside that can be used to identify individuals (Marshall et al. 2008; Kitchen-Wheeler 2010; Deakos et al. 2011). While these markings are assumed to be permanent, there is some evidence that the pigmentation pattern of *M. birostris* may actually change over the course of development (based on observation of two individuals in captivity), and thus caution may be warranted when using color markings for identification purposes in the wild (Ari 2015). The black color variants of both species are entirely black on the dorsal side and almost completely black on the ventral side, except for areas between the gill-slits and the abdominal area below the gill-slits (Kitchen-Wheeler 2013).

Range, Distribution and Habitat Use

Manta rays are circumglobal in range, but within this broad distribution, individual populations are scattered and highly fragmented (CITES 2013). The ranges of the two manta species sometimes overlap; however, at a finer spatial scale, the two species generally appear to be allopatric within those habitat areas (Kashiwagi et al. 2011) and exhibit different habitat use and movement patterns (inshore versus offshore reef habitat use) (Marshall and Bennett 2010b; Kashiwagi et al. 2011). Clark (2010) suggests that the larger *M. birostris* may forage in less productive pelagic waters and conduct seasonal migrations following prey abundance, whereas *M. alfredi* is more of a resident species in areas with regular coastal productivity and predictable prey abundance. Kashiwagi et al. (2010) observed that even in areas where both species are found in large numbers at the same feeding and cleaning sites, the two species do not interact with each other (*e.g.,* they are not part of the same feeding group, and males of one species do not attempt to mate with females of the other species). Additional studies on habitat use for both species are needed, particularly investigating how these individuals influence their environment as studies have shown that the removal of large plankton feeders, like manta rays, from the ecosystem can cause significant changes in species composition (Springer et al. 2003).

The giant manta ray can be found in all ocean basins. In terms of range, within the Northern Hemisphere, the species has been documented as far north as southern California and New Jersey on the United States west and east coasts, respectively, and Mutsu Bay, Aomori, Japan, the Sinai Peninsula and Arabian Sea, Egypt, and the Azores Islands (Gudger 1922; Kashiwagi et al. 2010; Moore 2012; CITES 2013). In the Southern Hemisphere, the species occurs as far south as Peru, Uruguay, South Africa, New Zealand and French Polynesia (Mourier 2012; CITES 2013). Despite this large range, sightings are often sporadic. The timing of these sightings also varies by region (for example, the majority of sightings in Brazil occur during June and September, while in New Zealand sightings mostly occur between January and March) and seems to correspond with the movement of zooplankton, current circulation and tidal patterns, seawater temperature, and possibly mating behavior (Couturier et al. 2012; De Boer et al. 2015; Armstrong et al. 2016).

Within its range, *M. birostris* inhabits tropical, subtropical, and temperate bodies of water and is commonly found offshore, in oceanic waters, and near productive coastlines (Marshall et al. 2009; Kashiwagi et al. 2011). As such, giant manta rays can be found in cooler water, as low as 19 °C, although temperature preference appears to vary by region (Duffy and Abbott 2003; Marshall et al. 2009; Freedman and Roy 2012; Graham et al. 2012). Additionally, giant manta rays exhibit a high degree of plasticity in terms of their use of depths within their habitat, with tagging studies that show the species conducting night descents of 200–450 m depths (Rubin et al. 2008; Stewart et al. 2016b) and capable of diving to depths exceeding 1,000 m (A. Marshall et al. unpubl. data 2011 cited in Marshall et al. (2011a)).

The giant manta ray is considered to be a migratory species, with satellite tracking studies using pop-up satellite archival tags registering movements of the giant manta ray from Mozambique to South Africa (a distance of 1,100 km), from Ecuador to Peru (190 km), and from the Yucatan, Mexico, into the Gulf of Mexico (448 km) (Marshall et al. 2011a). In a tracking study of six *M. birostris* individuals from off Mexico's Yucatan peninsula, Graham et al. (2012) calculated a maximum distance travelled of 1,151 km (based on cumulative straight line distance between locations; tag period ranged from 2 to 64 days). Similarly, Hearn et al. (2014) report on a tagged *M. birostris* that was tracked from Isla de la Plata (Ecuador) to west of Darwin Island (tag was released after 104 days), a straight-line distance of 1,500 km, further confirming that the species is capable of fairly long distance migrations but also demonstrating connectivity between mainland and offshore islands. However, a recent study by Stewart et al. (2016a) suggests that the species may not be as highly migratory as previously thought. Using pop-up satellite archival tags in combination with analyses of stable isotope and genetic data, the authors found evidence that *M. birostris* may actually exist as well-structured subpopulations off Mexico's coast that exhibit a high degree of residency (Stewart et al. 2016a). Additional research is required to better understand the distribution and movement of the species throughout its range.

In terms of range of the reef manta ray, *M. alfredi,* the species is currently only observed in the Indian Ocean and the western and south Pacific. The northern range limit for the species in the western Pacific is presently known to be off Kochi, Japan (32°48′ N., 132°58′ E.), and its eastern limit in the Pacific is known to be Fatu Hiva in French Polynesia (10°29′ S.; 138°37′ W.) (Kashiwagi et al. 2010; Mourier 2012). However, it is difficult to estimate the historical range of *M. alfredi* due to confusion until recently about its identification (Marshall et al. 2009). For example, prior to the splitting of the genus, it was assumed that all manta rays found in the Philippines were *M. birostris;* however, based on recent survey efforts, it has been confirmed that both *M. birostris* and *M. alfredi* occur in these waters (Verdote and Ponzo 2014; Aquino et al. 2015; Rambahiniarison et al. 2016). This may be the case elsewhere through its range and underscores the need for concentrated survey effort in order to better understand the distribution of these two manta ray species.

Manta alfredi is commonly seen inshore near coral and rocky reefs and appears to avoid colder waters (<21 °C) (Rohner et al. 2013; Braun et al. 2014). Reef manta rays prefer habitats along productive nearshore environments (such as island groups or near upwelling events), and while recent tracking studies indicate that *M. alfredi* is capable of traveling long distances, similar to *M. birostris* (Yano et al. 1999; Germanov and Marshall 2014), reef manta rays are considered a more resident species than giant manta rays (Homma et al. 1999; Dewar et al. 2008; Clark 2010; Kitchen-Wheeler 2010; Anderson et al. 2011a; Deakos et al. 2011; Marshall et al. 2011b; McCauley et al. 2014), with residencies estimated at up to 1.5 years (Clark 2010). For example, along the east coast of Australia, mark-recapture methods and photographic identification of reef manta rays from 1982 to 2012 revealed a re-sighting rate of more than 60 percent (with females more likely to be re-sighted than males), suggesting high site fidelity to aggregation sites, including several locations within a range of up to 650 km (Couturier et al. 2014). In Hawaii, 76 percent of 105 *M. alfredi* individuals observed over 15 years of surveys were re-sighted along the Kona coast, also confirming the high site fidelity behavior of the species (Clark 2010). Additionally, predictable seasonal aggregations of *M. alfredi,* largely thought to be feeding-related and influenced by the seasonal distribution of prey (Anderson et al. 2011a), have been documented off the Maldives (Anderson et al. 2011a), Maui, Hawaii (Deakos et al. 2011), Lady Elliott Island, Australia (Couturier et al. 2014), Ningaloo Reef, Western Australia (McGregor et al. 2008), and southern Mozambique (Marshall et al. 2011c; Rohner et al. 2013).

Diet and Feeding

As previously mentioned, manta feeding habits appear to be influenced by the movement and accumulation of zooplankton (Armstrong et al. 2016). Both manta species primarily feed on planktonic organisms such as euphausiids, copepods, mysids, decapod larvae and shrimp, but some studies have noted their consumption of small and moderate sized fishes as well (Bertolini 1933; Bigelow and Schroeder 1953; Carpenter and Niem 2001; The Hawaii Association for Marine Education and Research Inc. 2005). Mantas appear to be primarily nocturnal feeders, consistent with the upward migration of zooplankton at night, increasing their accessibility (Cushing 1951; Forward 1988). Known manta feeding areas that have been reported in the literature are summarized in Table 1 of Miller and Klimovich (2016); however, it is likely that additional feeding areas exist throughout both species' respective ranges.

Growth and Reproduction

Manta rays are viviparous (*i.e.,* give birth to live young), with a gestation period of around one year (Matsumoto and Uchida 2008; Uchida et al. 2008), and a reproductive periodicity of anywhere from 1 to 5 years (see Table 3 in Miller and Klimovich (2016)). Generally, not much is known about manta ray growth and development. Free swimming wild mantas have been observed as small as 1.02 m DW and 1.22 m DW (Kitchen-Wheeler 2013), with size at birth estimates ranging from 0.9 m DW to 1.92 m DW (see Tables 2 and 3 in Miller and Klimovich (2016)); however, the lack of observations of small manta rays throughout the species' respective ranges may indicate that manta rays segregate by size, with different habitats potentially used by neonates and juveniles (Deakos 2010b). While these habitats have yet to be identified, Erdmann (2014) presents a hypothesis, based on tagging data of a juvenile *M. alfredi* (~1.5m DW), that mantas likely give birth in protected areas, such as lagoons, that provide protection from larger predators.

In *M. alfredi,* Deakos (2012) observed that sexual maturity was delayed until growth had reached 90 percent of maximum size, pointing to large body size providing a reproductive advantage. Deakos (2010) concluded that the minimum size at sexual maturity was 3.37 DW for female *M. alfredi* and 2.80 m DW for males in Maui. There is no evidence that male size affects mating success of *M. alfredi* in any way, but larger females were observed to have higher rates of pregnancy than smaller females (Deakos 2012). Homma et al. (1999) hypothesized that age at sexual maturity was 8–13 years in mantas and the data of Uchida et al. (2008), Marshall et al. (2011a) and Marshall and Bennett (2010b) confirmed this estimate. However, a population of female *M. alfredi* in the Maldives displayed late maturity (15 years or more) and lower reproductive rates than previously reported (one pup every five years, instead of biennially) (G. Stevens in prep. as cited in CITES (2013)). In contrast, Clark (2010) described a rapid transition to maturity for *M. alfredi* in Kona, Hawaii, with estimates of males reaching sexual maturity as early as 3–4 years.

In terms of mating behavior, during courting, manta rays are commonly observed engaging in ''mating chains,'' where multiple males will pursue a single female. The mating displays can last hours or days, with the female swimming rapidly ahead of the males and occasionally somersaulting or turning abruptly (Deakos et al. 2011). Sexual dimorphism is present in manta rays, with female *M. alfredi* as much as 18 percent larger than males, so it is unlikely that a male could force a female to mate against her will (Deakos 2010; Marshall and Bennett 2010b). Additionally, males have never been observed to compete with each other directly for the attention of the female, so these mating chains may function as a kind of endurance rivalry (Andersson 1994; Deakos 2012). No copulations have been observed in the wild, so it is difficult to determine which males have a mating advantage, but this kind of endurance trial usually selects for the success of larger males (Andersson and Iwasa 1996; Deakos 2012).

Although mantas have been reported to live to at least 40 years old (Marshall and Bennett 2010b; Marshall et al. 2011b; Kitchen-Wheeler 2013) with low rates of natural mortality (Couturier et al. 2012), the time needed to grow to maturity and the low reproductive rates mean that a female will be able to produce only 5–15 pups in her lifetime (CITES 2013). Generation time for both species (based on *M. alfredi* life history parameters) is estimated to be 25 years (Marshall et al. 2011a; Marshall et al. 2011b). Known life history characteristics of *M. birostris* and *M. alfredi* are summarized in Tables 2 and 3 in Miller and Klimovich (2016).

Population Structure

Since the splitting of the *Manta* genus, most of the recent research has examined the genetic discreteness, phylogeny, and the evolutionary speciation in manta rays (Cerutti-Pereyra et al. 2012; Kashiwagi et al. 2012; Poortvliet et al. 2015). Very few studies have focused on the population structure within each species. However, based on genetic sampling, photo-identification, and tracking studies, preliminary results tend to indicate that reef manta rays exist in isolated and potentially genetically divergent populations. For example, using genetic sequencing of mitochondrial DNA (which is maternally-inherited) Cerutti-Pereyra et al. (2012) found low genetic divergence (<1 percent) but ''phylogeographic disjunction'' between the *M. alfredi* samples from Australia (n = 2; Ningaloo Reef) and Indonesia (n = 2), suggesting biogeographic factors may be responsible for population differentiation within the species. Although based on very few samples (4 total), these findings are consistent with photo-identification and tracking studies, which suggest high site-fidelity and residency for *M. alfredi* in many portions of its range, including Indonesia, Ningaloo Reef, Hawaii, Fiji, New Caledonia, and eastern Australia (Dewar et al. 2008; Clark 2010; Couturier et al. 2011; Deakos et al. 2011; Cerutti-Pereyra et al. 2012; Couturier et al. 2014).

The population structure for the wider-ranging *M. birostris* is less clear. While Clark (2010), using photo-identification survey data collected between 1992 and 2007 along the Kona, Hawaii, coast, found low site-fidelity for *M. birostris* and high rate of immigration, indicative of a population that is pelagic rather than coastal or island-associated, Stewart et al. (2016a) provided recent evidence to show that the giant manta rays off Pacific Mexico may exist as isolated subpopulations, with distinct home ranges. Additionally, researchers are presently investigating whether there is a potential third manta ray species resident to the Yucatán coastal waters of the Gulf of Mexico (previously identified as *M. birostris*) (Hinojosa-Alvarez et al. 2016). Using the mitochondrial *ND5* region (maternally-inherited DNA), Hinojosa-Alvarez et al. (2016) found shared haplotypes between Yucatán manta ray samples and known *M. birostris* samples from Mozambique, Indonesia, Japan, and Mexico, but discovered four new manta ray haplotypes, exclusive to the Yucatán samples. While analysis using the nuclear *RAG1* gene (bi-parentally-inherited DNA) showed the Yucatán samples to be consistent with identified *M. birostris* samples, the authors suggest that the *ND5* genetic evidence indicates the potential for a third, distinctive manta genetic group or possibly *M. birostris* subspecies. At this time, additional studies, including in-depth taxonomic studies and additional genetic sampling, are needed to better understand the population structure of both species throughout their respective ranges.

Population Demographics

Given their large sizes, manta rays are assumed to have fairly high survival rates after maturity (*e.g.,* low natural predation rates). Using estimates of known life history parameters for both giant and reef manta rays, and plausible range estimates for the unknown life history parameters, Dulvy et al. (2014) calculated a maximum population growth rate of *Manta* spp. and found it to be one of the lowest values when compared to 106 other shark and ray species. After taking into consideration different model assumptions, and the criteria for assessing productivity in Musick (1999), Dulvy et al. (2014) estimated realized productivity (r) for manta rays to be 0.029 (Dulvy et al.

2014). This value is similar to the productivity estimate from Kashiwagi (2014) who empirically determined an r value of 0.023 using capture-mark-recapture analyses. Ward-Paige et al. (2013) calculated slightly higher estimates for the intrinsic rate of population increase, with r = 0.05 for *M. alfredi* and r = 0.042 for *M. birostris;* however, these estimates still place both manta ray species into or at the very edge of the ''very low'' productivity category (r <0.05), based on the productivity parameters and criteria in Musick (1999).

In order to determine how changes in survival may affect populations, Smallegange et al. (2016) modeled the demographics of reef manta rays. Results showed that increases in yearling or adult annual survival rates resulted in much greater responses in population growth rates, mean lifetime reproductive success, and cohort generation time compared to similar increases in juvenile annual survival rates (Smallegange et al. 2016). Based on the elasticity analysis, population growth rate was most sensitive to changes in the survival rate of adults (Smallegange et al. 2016). In other words, in order to prevent populations from declining further, Smallegange et al. (2016) found that adult survival rates should be increased, such as through protection of adult aggregation sites or a reduction in fishing of adult manta rays (Smallegange et al. 2016). For those populations that are currently stable, like the Yaeyama Islands (Japan) population (where adult annual survival rate is estimated at 0.95; noted above), Smallegange et al. (2016) note that any changes in adult survival may significantly affect the population.

Overall, given their life history traits and productivity estimates, particularly their low reproductive output and sensitivity to changes in adult survival rates, giant and reef manta ray populations are inherently vulnerable to depletions, with low likelihood of recovery.

Historical and Current Distribution and Population Abundance

There are no current or historical estimates of the global abundance of *M. birostris.* Despite their larger range, they are encountered with less frequency than *M. alfredi.* Most estimates of subpopulations are based on anecdotal diver or fisherman observations, which are subject to bias. These populations seem to potentially range from around 100 to1,500 individuals (see Table 4 in Miller and Klimovich (2016)). In the proposal to include manta rays on the appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), it states that because 10 populations of *M. birostris* have been actively studied, 25 other aggregations have been anecdotally identified, and all other sightings are rare, the total global population may be small (CITES 2013). The greatest number of *M. birostris* identified in the four largest known aggregation sites ranges from 180 to 1,500. Ecuador is thought to be home to the largest identified population of *M. birostris* in the world, with large aggregation sites within the waters of the Machalilla National Park and the Galapagos Marine Reserve (Hearn et al. 2014). Within the Indian Ocean, numbers of giant manta rays identified through citizen science in Thailand's waters (primarily on the west coast, off Khao Lak and Koh Lanta) have been increasing over the past few years, from 108 in 2015 to 288 in 2016. These numbers reportedly surpass the estimate of identified giant mantas in Mozambique (n = 254), possibly indicating that Thailand may be home to the largest aggregation of giant manta rays within the Indian Ocean (MantaMatcher 2016). In the Atlantic, very little information on *M. birostris* populations is available, but there is a known, protected population within the Flower Garden Banks National Marine Sanctuary in the Gulf of Mexico. However, researchers are still trying to determine whether the manta rays in this area are only *M. birostris* individuals or potentially also comprise individuals of a new, undescribed species (Marshall et al. 2009; Hinojosa-Alvarez et al. 2016).

In areas where the species is not subject to fishing, populations may be stable. For example, Rohner et al. (2013) report that giant manta ray sightings remained constant off the coast of Mozambique over a period of 8 years. However, in regions where giant manta rays are (or were) actively targeted or caught as bycatch, such as the Philippines, Mexico, Sri Lanka, and Indonesia, populations appear to be decreasing (see Table 5 in Miller and Klimovich (2016)). In Indonesia, declines in manta ray landings are estimated to be on the order of 71 to 95 percent, with potential extirpations noted in certain areas (Lewis et al. 2015). Given the migratory nature of the species, population declines in waters where mantas are protected have also been observed but attributed to overfishing of the species in adjacent areas within its large home range. For example, White et al. (2015) provide evidence of a substantial decline in the *M. birostris* population in Cocos Island National Park, Costa Rica, where protections for the species have existed for over 20 years. Using a standardized time series of observations collected by dive masters on 27,527 dives conducted from 1993 to 2013, giant manta ray relative abundance declined by approximately 89 percent. Based on the frequency of the species' presence on dives (4 percent), with a maximum of 15 individuals observed on a single dive, the authors suggest that Cocos Island may not be a large aggregating spot for the species, and suggest that the decline observed in the population is likely due to overfishing of the species outside of the National Park (White et al. 2015).

Given that all manta rays were identified as *M. birostris* prior to 2009, information on the historical abundance and distribution of *M. alfredi* is scarce. In the proposal to include the reef manta ray on the appendices of the Convention on the Conservation of Migratory Species of Wild Animals (CMS), it states that current global population numbers are unknown and no historical baseline data exist (CMS 2014). Local populations of *M. alfredi* have not been well assessed either, but appear generally to be small, sparsely distributed, and isolated. Photo-identification studies in Hawaii, Yap, Japan, Indonesia, and the eastern coast of Australia suggest these subpopulations range from 100 to 350 individuals (see Table 6 in Miller and Klimovich (2016)), despite observational periods that span multiple decades. However, in the Maldives, population estimates range from 3,300 to 9,677 individuals throughout the 26 atolls in the archipelago (Kitchen-Wheeler et al. 2012; CITES 2013; CMS 2014), making it the largest identified population of *M. alfredi* in the world. Other larger populations may exist off southern Mozambique (superpopulation estimate of 802–890 individuals; Rohner et al. (2013); CITES (2013)) and Western Australia (metapopulation estimate = 1,200–1,500; McGregor (2009) cited in CITES (2013)).

In terms of trends, studies report that the rate of population reduction appears to be high in local areas, from 50–88 percent, with areas of potential local extirpations of *M. alfredi* populations (Homma et al. 1999; Rohner et al. 2013; Lewis et al. 2015). In the portions of range where reef manta rays are experiencing anthropogenic pressures, including Indonesia and Mozambique, encounter rates have dropped significantly over the last 5 to 10 years (CMS 2014). However, where *M. alfredi* receives some kind of protection, such as in Australia, Hawaii, Guam, Japan, the Maldives, Palau, and Yap, CITES (2013) reports that subpopulations are likely to be stable. For example, in Hawaii, based on photo-identification survey data collected between 1992 and 2007 along the Kona Coast, Clark (2010) used a discovery curve to estimate that an average of 4.27 new pups were entering the population per year. Off the Yaeyama Islands, Japan, Kashiwagi (2014) conducted quantitative analyses using encounter records, biological observations, and photo-ID of manta rays over the period of 1987 to 2009 and found that the apparent population size increased steadily but slowly over the 23-year period, with a population growth rate estimate of 1.02–1.03. Based on aerial surveys of Guam conducted from 1963 to 2012, manta ray observations were infrequent but showed an increase over the study period (Martin et al. 2015). Off Lady Elliott Island, Australia, Couturier et al. (2014) modeled annual population sizes of *M. alfredi* from 2009 to 2012 and found an annual increase in abundance for both sexes, but cautioned that the modeled increase could be an artifact of improvements in photo-identification by observers over the study period. Within Ningaloo Marine Park, the status of reef manta rays was assessed as ''Good'' in 2013, but with low confidence in the ratings (Marine Parks & Reserves Authority 2013). Overall, however, the reef manta ray population of Australia is deemed to be one of the world's healthiest (Australian Government 2012).

Species Finding

Based on the best available scientific and commercial information described above, we find that *M. birostris* and *M. alfredi* are currently considered taxonomically-distinct species and, therefore, meet the definition of ''species'' pursuant to section 3 of the ESA. Below, we evaluate whether these species warrant listing as endangered or threatened under the ESA throughout all or a significant portion of their respective range.

Summary of Factors Affecting Giant and Reef Manta Rays

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; inadequacy of existing regulatory mechanisms; or other natural or man-made factors affecting its continued existence. We evaluated whether and the extent to which each of the foregoing factors contribute to the overall extinction risk of both manta ray species, with a ''significant'' contribution defined, for purposes of this evaluation, as increasing the risk to such a degree that the factor affects the species' demographics (*i.e.,* abundance, productivity, spatial structure, diversity) either to the point where the species is strongly influenced by stochastic or depensatory processes or is on a trajectory toward this point. This section briefly summarizes our findings and conclusions regarding threats to the giant and reef manta rays and their impact on the overall extinction risk of the species. More details can be found in the status review report (Miller and Klimovich 2016).

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

Due to their association with nearshore habitats, manta rays are at elevated risk for exposure to a variety of contaminants and pollutants, including brevotoxins, heavy metals, polychlorinated biphenyls, and plastics. Many pollutants in the environment have the ability to bioaccumulate in fish species; however, only a few studies have specifically examined the accumulation of heavy metals in the tissues of manta rays (Essumang 2010; Ooi et al. 2015), with findings that discuss human health risks from the consumption of manta rays. For example, Essumang (2010) found platinum levels within *M. birostris* samples taken off the coast of Ghana that exceeded the United Kingdom (UK) dietary intake recommendation levels, and Ooi et al. (2015) reported concentrations of lead in *M. alfredi* tissues from Lady Elliot Island, Australia, that exceeded maximum allowable level recommendations for fish consumption per the European Commission and the Codex Alimentarius Commission (WHO/FAO). While consuming manta rays may potentially pose a health risk to humans, there is no information on the lethal concentration limits of these metals or other toxins in manta rays. Additionally, at this time, there is no evidence to suggest that current concentrations of these environmental pollutants are causing detrimental physiological effects to the point where either species may be at an increased risk of extinction.

Plastics within the marine environment may also be a threat to the manta ray species, as the animals may ingest microplastics (through filter-feeding) or become entangled in plastic debris, potentially contributing to increased mortality rates. Jambeck et al. (2015) found that the Western and Indo-Pacific regions are responsible for the majority of plastic waste. These areas also happen to overlap with some of the largest known aggregations for manta rays. For example, in Thailand, where recent sightings data have identified over 288 giant manta rays (MantaMatcher 2016), mismanaged plastic waste is estimated to be on the order of 1.03 million tonnes annually, with up to 40 percent of this entering the marine environment (Jambeck et al. 2015). Approximately 1.6 million tonnes of mismanaged plastic waste is being disposed of in Sri Lanka, again with up to 40 percent entering the marine environment (Jambeck et al. 2015), potentially polluting the habitat used by the nearby Maldives aggregation of manta rays. While the ingestion of plastics is likely to negatively impact the health of the species, the levels of microplastics in manta ray feeding grounds and frequency of ingestion are presently being studied to evaluate the impact on these species (Germanov 2015b; Germanov 2015a).

Because manta rays are migratory and considered ecologically flexible (*e.g.,* low habitat specificity), they may be less vulnerable to the impacts of climate change compared to other sharks and rays (Chin et al. 2010). However, as manta rays frequently rely on coral reef habitat for important life history functions (*e.g.,* feeding, cleaning) and depend on planktonic food resources for nourishment, both of which are highly sensitive to environmental changes (Brainard et al. 2011; Guinder and Molinero 2013), climate change is likely to have an impact on the distribution and behavior of both *M. birostris* and *M. alfredi.* Currently, coral reef degradation from anthropogenic causes, particularly climate change, is projected to increase through the future. Specifically, annual, globally averaged surface ocean temperatures are projected to increase by approximately 0.7 °C by 2030 and 1.4 °C by 2060 compared to the 1986–2005 average (IPCC 2013), with the latest climate models predicting annual coral bleaching for almost all reefs by 2050 (Heron et al. 2016). As declines in coral cover have been shown to result in changes in coral reef fish communities (Jones et al. 2004; Graham et al. 2008), the projected increase in coral habitat degradation may potentially lead to a decrease in the abundance of manta ray cleaning fish (*e.g., Labroides* spp., *Thalassoma* spp., and *Chaetodon* spp.) and an overall reduction in the number of cleaning stations available to manta rays within these habitats. This potential decreased access to cleaning stations may negatively impact the fitness of the mantas by hindering their ability to reduce parasitic loads and dead tissue, which could lead to increases in diseases and declines in reproductive fitness and survival rates. However, these scenarios are currently speculative, as there is insufficient information to indicate how and to what extent changes in reef community structure will affect the status of both manta ray species.

Changes in climate and oceanographic conditions, such as acidification, are also known to affect zooplankton structure (size, composition, diversity), phenology, and distribution (Guinder and Molinero 2013). As such, the migration paths and locations of both resident and seasonal aggregations of manta rays, which depend on these animals for food, may similarly be altered (Australian Government 2012; Couturier et al. 2012). It is likely that those *M. alfredi* populations that exhibit site-fidelity behavior will be most affected by these changes. For example, resident manta ray populations may be forced to travel farther to find available food or randomly search for new productive areas (Australian Government 2012; Couturier et al. 2012). As research to understand the exact impacts of climate change on marine phytoplankton and zooplankton communities is still ongoing, the severity of this threat to both species of manta rays has yet to be fully determined.

Overutilization for Commercial, Recreational, Scientific or Educational Purposes

Manta rays are both targeted and caught as bycatch in fisheries worldwide. In fact, according to Lawson et al. (2016), manta ray catches have been recorded in at least 30 large and small-scale fisheries covering 25 countries. The majority of fisheries that target mobulids are artisanal (Croll et al. 2015) and target the rays for their meat; however, since the 1990s, a market for mobulid gill rakers has significantly expanded, increasing the demand for manta ray products, particularly in China. The gill rakers of mobulids are used in Asian medicine and are thought to have healing properties, such as curing diseases from chicken pox to cancer, boosting the immune system, purifying the body, enhancing blood circulation, remedying throat and skin ailments, curing male kidney issues, and helping with fertility problems (Heinrichs et al. 2011). The use of gill rakers as a remedy, which was widespread in Southern China many years ago, has recently gained renewed popularity over the past decade as traders have increased efforts to market its healing and immune boosting properties directly to consumers (Heinrichs et al. 2011). As a result, demand has significantly increased, incentivizing fishermen who once avoided capture of manta rays to directly target these species (Heinrichs et al. 2011; CITES 2013). According to Heinrichs et al. (2011), it is primarily the older population in Southern China as well as Macau, Singapore, and Hong Kong, that ascribes to the belief of the healing properties of the gill rakers; however, unlike products like shark fins, the gill rakers are not considered ''traditional'' or ''prestigious'' items and many consumers and sellers are not even aware that gill rakers come from manta or mobula rays. Meat, cartilage, and skin of manta rays are also utilized, but valued significantly less than the gill rakers, and usually enter local trade or are kept for domestic consumption (Heinrichs et al. 2011; CITES 2013). Indonesia, Sri Lanka, and India presently represent the largest manta ray exporting range state countries; however, Chinese gill plate vendors have also reported receiving mobulid gill plates from other countries and regions as well, including Malaysia, Vietnam, South Africa, South America, the Middle East, and the South China Sea (CMS 2014). To examine the impact of this growing demand for gill rakers on manta ray populations, information on landings and trends (identified by species where available) are evaluated for both fisheries that target mantas and those that catch mantas as bycatch.

Targeted Fisheries

Indonesia is reported to be one of the countries that catch the most mobulid rays (Heinrichs et al. 2011). Manta and mobula ray fisheries span the majority of the Indonesian archipelago, with most landing sites along the Indian Ocean coast of East and West Nusa Tenggara and Java (Lewis et al. 2015). Manta rays (presumably *M. birostris,* but identified prior to the split of the genus) have traditionally been harvested in Indonesia using harpoons and boats powered by paddles or sails, with manta fishing season lasting from May through October. Historically, the harvested manta rays would be utilized by the village, but the advent of the international gill raker market in the 1970s prompted the commercial trade of manta ray products, with gill plates generally sent to Bali, Surabaya (East Java), Ujung Pandant (Sulawasi), or Jakarta (West Java) for export to Hong Kong, Taiwan, Singapore and other places in Asia (Dewar 2002; White et al. 2006; Marshall and Conradie 2014). This economic incentive, coupled with emerging technological advances (*e.g.,* motorized vessels) and an increase in the number of boats in the fishery, greatly increased fishing pressure and harvest of manta rays in the 1990s and 2000s (Dewar 2002). In Lamakera, Indonesia, one of the main landing sites for mobulids, and particularly manta rays, Dewar (2002) estimates that the total average harvest of ''mantas'' during the 2002 fishing season was 1,500 individuals (range 1,050–2,400), which is a significant increase from the estimated historical harvest levels of around 200–300 mantas per season. However, Lewis et al. (2015) note that this estimate likely represents all mobulid rays, not just manta rays.

However, given these amounts, it is perhaps unsurprising that anecdotal reports from fishermen indicate possible local population declines, with fishermen noting that they have to travel farther to fishing grounds as manta rays are no longer present closer to the village (Dewar 2002; Lewis et al. 2015). In fact, using the records from Dewar (2002) and community (local) catch records, Lewis et al. (2015) show that there has been a steady decline in manta landings at Lamakera since 2002 (despite relatively unchanged fishing effort), with estimated landings in 2013–2014 comprising only 25 percent of the estimated numbers from 2002–2006. These declines in manta landings are not just limited to Lamakera, but also appear to be the trend throughout Indonesia at the common mobulid landing sites. For example, Lewis et al. (2015) reports a 95 percent decline in manta landings in Tanjung Luar (between 2001–2005 and 2013–2014), a decrease in the average size of mantas being caught, and a 71 percent decline in manta landings in the Cilacap gillnet fishery between 2001–2005 and 2014. Areas in Indonesia where manta rays have potentially been fished to extirpation, based on anecdotal reports (*e.g.,* diver sightings data and fishermen interviews), include Lembeh Strait in northeast Sulawesi, Selayer Islands in South Sulawesi, and off the west coast of Alor Island (which may have been a local *M. alfredi* population) (Lewis et al. 2015).

Although fishing for manta rays was banned within the Indonesian exclusive economic zone (EEZ) in February 2014 (see *The Inadequacy of Existing Regulatory Mechanisms*), in May 2014, manta rays were still being caught and processed at Lamakera, with *M. birostris* the most commonly targeted species (Marshall and Conradie 2014). Around 200 fishing vessels targeting mantas rays are in operation (Marshall and Conradie 2014). Most of the fishing occurs in the Solor Sea and occasionally in the Lamakera Strait, with landings generally comprising around one to two dozen manta rays per day. Taking into account the manta ray fishing season in Lamakera (June to October), Marshall and Conradie (2014) estimate that between 625 and 3,125 manta rays (likely majority *M. birostris*) may be landed each season. Lewis et al. (2015), however, report a much smaller number, with 149 estimated as landed in 2014.

It is unlikely that fishing effort and associated utilization of the species will significantly decrease in the foreseeable future because interviews with fishermen indicate that many are excited for the new prohibition on manta rays in Indonesian waters, as it is expected to drive up the price of manta ray products and significantly increase the current income of resident fishermen (Marshall and Conradie 2014). Based on unpublished data, O'Malley et al. (2013) estimate that the total annual income from the manta ray fisheries in Indonesia is around $442,000 (with 94 percent attributed to the gill plate trade). Dharmadi et al. (2015) noted that there are still many fishermen, particularly in Raja Ampat, Bali, and Komodo, whose livelihoods depend on shark and ray fishing. Without an alternative for income, it is unlikely that these fishing villages will stop their traditional fishing practices. Additionally, enforcement of existing laws appears to be lacking in this region (Marshall and Conradie 2014). The high market prices for manta products, where a whole manta (~5 m DW) will sell for anywhere from $225–$450 (Lewis et al. 2015), drives the incentive to continue fishing the species, and evidence of continued targeted fishing despite prohibitions suggests that overutilization of the Indonesian manta ray populations (primarily *M. birostris,* based on the data) is likely to continue to occur into the foreseeable future.

In the Philippines, fishing for manta rays mainly occurs in the Bohol Sea. According to Acebes and Tull (2016), the manta ray fishery can be divided into two distinct periods based on technology and fishing effort: (1) 1800s to 1960s, when mantas were mainly hunted in small, non-motorized boats using harpoons from March to May; and (2) 1970s to 2013 (present), when boats became bigger and motorized and the fishing technique switched to drift gillnets, with the manta hunting season extending from November to June. In the earlier period, the manta fishing grounds were fairly close to the shore (<5 km), noted along the coasts of southern Bohol, northwestern and southern coasts of Camiguin and eastern coasts of Limasawa. Boats would usually catch around one manta per day, with catches of 5–10 mantas for a fishing village considered a ''good day'' (Acebes and Tull 2016). As the fishery became more mechanized in the 1970s, transitioning to larger and motorized boats, and as the primary gear changed from harpoons to non-selective driftnets, fishermen were able to access previously unexplored offshore fishing grounds, stay out for longer periods of time, and catch more manta rays (Acebes and Tull 2016). Additionally, it was during this time that the international gill raker market opened up, increasing the value of gill rakers, particularly for manta species. By 1997, there were 22 active mobulid ray fishing sites in the Bohol Sea (Acebes and Tull 2016). In Pamilacan, 18 boats were fishing for mobulids in 1993, increasing to 40 by 1997, and in Jagna, at least 20 boats were engaged in mobulid hunting in the 1990s (Acebes and Tull 2016). Catches from this time period, based on the recollection of fishermen from Pamilacan and Baclayon, Bohol, were around 8 manta rays (for a single boat) in 1995 and 50 manta rays (single boat) in 1996 (Alava et al. 2002). However, it should be noted that the mobulid fishery ended in Lila and Limasawa Island in the late 1980s and in Sagay in 1997, around the time that the whale fishery closed and a local ban in manta ray fishing was imposed (Acebes and Tull 2016).

Despite increases in fishing effort, catches of manta rays began to decline in Philippine waters, likely due to a decrease in the abundance of the population, prompting fishermen to shift their fishing grounds farther east and north. Although a ban on hunting and selling giant manta rays was implemented in the Philippines in 1998 (see *The Inadequacy of Existing Regulatory Mechanisms*), this has not seemed to impact the mobulid fishery in any way. In Pamilacan, there were 14 mobulid hunting boats reported to be in operation in 2011 (Acebes and Tull 2016). In the village of Bunga Mar, Bohol, there were 15 boats targeting mobulids in 2012, and out of 324 registered fishermen, over a third were actively engaged in ray fishing (Acebes and Tull 2016). Acebes and Tull (2016) monitored the numbers of manta rays landed at Bunga Mar over a period of 143 days from April 2010 to December 2011 (during which there were around 16–17 active fishing boats targeting mobulids), and in total, 40 *M. birostris* were caught. In 2013, records from a single village (location not identified) showed over 2,000 mobuilds landed from January to May, of which 2 percent (n = 51 individuals) were *M. birostris* (Verdote and Ponzo 2014). As there is little evidence of enforcement of current prohibitions on manta ray hunting, and no efforts to regulate the mobulid fisheries, with mobulid fishing providing the greatest profit to fishermen, it is unlikely that fishing for mantas, of which the majority appears to be *M. birostris,* will decrease in the future.

Manta rays are also reportedly targeted in fisheries in India, Ghana, Peru, Thailand, Mozambique, Tonga, Micronesia, possibly the Republic of Maldives, and previously in Mexico. In India, Ghana, Peru, and Thailand, little information is available on the actual level of take of manta rays. In India, manta rays are mainly landed as bycatch in tuna gillnetting and trawl fisheries; however, a harpoon fishery at Kalpeni, off Lakshadweep Islands, is noted for ''abundantly'' landing mantas (likely *M. alfredi;* A.M. Kitchen-Wheeler pers. comm. 2016) during peak season (from June–August) (Raje et al. 2007). In Ghana, there is no available data on the amount of manta rays landed in Ghanaian fisheries; however, Debrah et al. (2010) observed that giant manta rays were targeted using wide-mesh drift gillnets in artisanal fisheries between 1995 and 2010, and D. Berces (pers. comm. 2016) confirmed that manta rays are taken during artisanal fishing for pelagic sharks, and not ''infrequently,'' with manta rays consumed locally. In Peru, Heinrichs et al. (2011), citing to a rapid assessment of the mobulid fisheries in the Tumbes and Piura regions, reported estimated annual landings of *M. birostris* on the order of 100–220 manta rays for one family of fishermen. As such, total landings for Peru are likely to be much larger. According to Heinrichs et al. (2011), dive operators in the Similan Islands, Thailand, have also observed an increase in fishing for manta rays, including in protected Thai national marine parks, and while information on catches is unavailable, sightings of *Manta* spp. (likely *M. birostris*) decreased by 76 percent between 2006 and 2012 (CITES 2013b).

In southern Mozambique, reef manta rays are targeted by fishermen, with estimates of around 20–50 individuals taken annually from only a 50 km section of studied coastline (Rohner et al. 2013). As annual estimates of this *M. alfredi* population range only from 149 to 454 individuals (between 2003 and 2007), this take is equivalent to removing anywhere from 4 percent to 34 percent of the population per year. This removal rate is potentially unsustainable for a species with such a low productivity, and has likely contributed to the estimated 88 percent decline that has already been observed in the local reef manta ray population (Rohner et al. 2013). *Manta birostris,* on the other hand, has not exhibited a decline off Mozambique, represents only 21 percent of the identified manta rays in this area, and is rarely observed in the local fishery (one observed caught over an 8-year period), indicating that fishing pressure is likely low for this species (Rohner et al. 2013; Marine Megafauna Foundation 2016).

Opportunistic hunting of manta rays (likely *M. alfredi*) has been reported in Tonga and Micronesia (B. Newton and J. Hartup pers. comms. cited in CMS 2014), and in the Maldives, Anderson and Hafiz (2002) note that very small catches of manta rays occur in the traditional fisheries, with meat used for bait for shark fishing and skin used for musical drums. Given the available information, it is unlikely that fishing pressure on either manta ray species is significant in these areas.

In Mexico, giant manta rays and mobula rays were historically targeted for their meat in the Gulf of California. In 1981, Notarbartolo di Sciara (1988) observed a seasonally-active mobulid fishery located near La Paz, Baja California Sur. Mobulids were fished in the Gulf of California using both gillnets and harpoons, with their meat either fileted for human consumption or used as shark bait. The giant manta ray was characterized as ‘‘occasionally captured’’ by the fishery, and while it is unclear how abundant *M. birostris* was in this area, by the early 1990s, Homma et al. (1999) reported that the entire mobulid fishery had collapsed.

Bycatch

Given the global distribution of manta rays, they are frequently caught as bycatch in a number of commercial and artisanal fisheries worldwide. In a study of elasmobranch bycatch patterns in commercial longline, trawl, purse seine and gillnet fisheries, Oliver et al. (2015) presented information on species-specific composition of ray bycatch in 55 fisheries worldwide. Based on the available data, Oliver et al. (2015) found that manta rays comprised the greatest proportion of ray bycatch in the purse seine fisheries operating in the Indian Ocean (specifically *M. birostris;* ~40 percent) and especially the Eastern Pacific Ocean (identified as *Manta* spp.*;* ~100 percent, but would be *M. birostris* as well), but were not large components of the ray bycatch in the longline, trawl, or gillnet fisheries in any of the ocean basins.

In the Atlantic Ocean, bycatch of giant manta rays has been observed in purse seine, trawl, and longline fisheries; however, *M. birostris* does not appear to be a significant component of the bycatch. For example, in the European purse seine fishery, which primarily operates in the Eastern Atlantic off western Africa, observer data collected over the period of 2003–2007 (27 trips, 598 sets; observer coverage averaged 2.93 percent) showed only 11 *M. birostris* caught, with an equivalent weight of 2.2 mt (Amandè et al. 2010). In the U.S. bottom longline and gillnet fisheries operating in the western Atlantic, *M. birostris* is also a very rare occurrence in the elasmobranch catch, with the vast majority that are caught released alive (see NMFS Reports available at *http://www.sefsc.noaa.gov/labs/panama/ob/bottomline observer.htm* and *http://www.sefsc.noaa.gov/labs/panama/ob/gillnet.htm*). Overall, given the present low fishing pressure on giant manta rays, and evidence of minimal bycatch of the species (see Miller and Klimovich (2016) for additional discussion), it is unlikely that overutilization as a result of bycatch mortality is a significant threat to *M. birostris* in the Atlantic Ocean. However, information is severely lacking on both population sizes and distribution of the giant manta ray as well as current catch and fishing effort on the species throughout this portion of its range.

In the Indian Ocean, manta rays (primarily *M. birostris*) are mainly caught as bycatch in purse seine and gillnet fisheries. In the western Indian Ocean, data from the pelagic tuna purse seine fishery suggests that manta and mobula rays, together, are an insignificant portion of the bycatch, comprising less than one percent of the total non-tuna bycatch per year (Romanov 2002; Amandè et al. 2008). However, in the eastern Indian Ocean, manta rays appear at higher risk of capture from the fisheries operating throughout this area, with two of the top three largest *Manta* spp. fishing and exporting range states (Sri Lanka and India) located in this region (Heinrichs et al. 2011). In Sri Lanka, manta rays are primarily caught as bycatch in the artisanal gillnet fisheries. While fishermen note that they generally tend to avoid deploying nets near large aggregations of manta rays or regularly release them when caught, as recently as 2011, giant manta rays were observed being sold at Sri Lanka fish markets (Fernando and Stevens 2011). Additionally, although Sri Lankan fishermen state that they try to release pregnant and young manta rays alive, based on 40 observed *M. birostris* being sold at markets (from May through August 2011), 95 percent were juveniles or immature adults (Fernando and Stevens 2011). Extrapolating the observed market numbers to a yearly value, Fernando and Stevens (2011) estimated total annual landings for *M. birostris* in Sri Lanka to be around 1,055 individuals, which they concluded would likely result in a population crash (Fernando and Stevens 2011). Additionally, more recent data from the Indian Ocean Tuna Commission (IOTC) database (*http://www.iotc.org/iotc-online-data-querying-service*) covering the time period of 2012–2014 indicate that over 2,400 mt of *M. birostris* were recorded caught by the Sri Lankan gillnet and longline fleets primarily engaged in artisanal fishing. This amount is almost double the 1,413 mt total catch that was reported in Clarke and IOTC Secretariat (2014) by both Sri Lanka and Sudan fleets from a time period that was more than twice as long (2008–2013). Using the maximum observed weight of *M. birostris* in the Indian Ocean (2,000 kg; which was described as ‘‘unusually large’’ (Kunjipalu and Boopendranath 1982)), this translates to a minimum of around 400 giant manta rays caught annually in recent years by Sri Lankan fishing fleets. Given that fishermen have already noted a decrease in catches of manta rays over the past 5 years, it is likely that the continued and heavy fishing pressure on *M. birostris,* and associated bycatch mortality, is significantly contributing to the overutilization of the species in this portion of its range.

Manta ray landings have also become a more common occurrence in the bycatch of fishermen operating off India. Here, mobulids, including mantas, are landed as bycatch during tuna gillnetting and trawling operations and are auctioned off for their gill plates, while the meat enters the local markets. Historical reports (from 1961–1995) indicate that manta rays were only sporadically caught by fishermen along the east and west coasts of India, likely due to the fact that the species was rarely found near the shore (Pillai 1998). However, based on available information, it appears that landings have increased in recent years, particularly on the southwest coast. For the years 2003 and 2004, Raje et al. (2007) reported 647 mt of *M. birostris* from the southwest coast of India by the trawl fisheries. In a snapshot of the Indian tuna gillnet fishery, Nair et al. (2013) documented 5 individuals of *M. birostris* that were landed by fishermen off the coast of Vizhinjam, Kovalam and Colachel over the course of only 7 days. On the east coast of India, Raje et al. (2007) documented 43 mt of *M. birostris* landed in 2003 and 2004 at the Chennai fishing harbor. The apparent increase in landings since the sporadic reports of the species in the mid-1990s is likely due to the demand for the species' gill rakers, with *M. birostris* gill plates characterized as ''First Grade'' and fetching the highest price at auction at the major fishing port of Cochin Fisheries Harbour (Nair et al. 2013).

While *Manta* spp. are rarely reported in the catch from the western Pacific, with Hall and Roman (2013) noting that *M. japonica* represents the most abundant mobulid in the fisheries data, the available information still suggests the potential for bycatch mortality and indicates declining trends within this region. For example, based on observer data from the Western and Central Pacific Fisheries Commission (WCPFC) fisheries, *M. birostris* is observed at a rate of 0.0017 individuals per associated set and 0.0076 individuals per unassociated set in the purse seine fisheries, and at a rate of 0.001–0.003 individuals per 1,000 hooks in the longline fisheries (Tremblay-Boyer and Brouwer 2016). The longline standardized catch-per-unit-effort data, while covering observations from only the past decade, indicates that *M. birostris* is observed less frequently in recent years compared to 2000–2005 (Tremblay-Boyer and Brouwer 2016). Additionally, a sharp decline in the catches of manta rays off Papua New Guinea, where WCPFC fishing effort is high, was observed in Papua New Guinea purse seiner bycatch in 2005–2006, after a previously steady rise in manta ray catches from 1994–2005 (C. Rose pers. comm. cited in Marshall et al. 2011b).

In the eastern Pacific, giant manta rays are frequently reported as bycatch in the purse seine fisheries; however, identification to species level is difficult, and, as such, most manta and mobula ray captures are pooled together (Hall and Roman 2013). Based on reported *M. birostris* catch to the Inter-American Tropical Tuna Commission (IATTC), including available national observer program data, an average of 135 giant manta rays were estimated caught per year from 1993–2015 in the eastern Pacific purse seine fishery by IATTC vessels (Hall unpublished data). While the impact of these bycatch levels on giant manta ray populations is uncertain, effort in the fishery appears to coincide with high productivity areas, such as the Costa Rica Thermal Dome, west of the Galapagos, off the Guayas River estuary (Ecuador), and off central and northern Peru, where giant mantas are likely to aggregate and have been observed caught in sets (Hall and Roman 2013). If effort is concentrated in manta ray aggregation areas, this could lead to substantial declines and potential local extirpations of giant manta ray populations. Already, evidence of declines in this portion of the giant manta ray's range is apparent, with White et al. (2015) estimating an 89 percent decline in the relative abundance of *M. birostris* off Cocos Island, Costa Rica. Presently, the largest population of *M. birostris* is thought to reside within the waters of the Machalilla National Park and the Galapagos Marine Reserve (Hearn et al. 2014); however, given the distribution of purse seine fishing effort, and the migratory nature of the species, it is likely that individuals from this population are highly susceptible to the purse seine fisheries operating in the area.

Overall, given that the majority of observed declines in landings and sightings of manta rays originate from the Indo-Pacific and eastern Pacific portions of their range (see Table 5 in Miller and Klimovich 2016), additional pressure on these species through bycatch mortality may have significant negative effects on local populations throughout this area. This is particularly a risk for *M. birostris,* which appears to be the species most frequently observed in the fisheries catch and bycatch, with this pressure already contributing to declines in the species (of up to 95 percent) throughout many areas (*i.e.,* Indonesia, Philippines, Sri Lanka, Thailand, Madagascar, Costa Rica). As such, we find that current fisheries-related mortality rates are a threat significantly contributing to the overutilization of *M. birostris* throughout this portion of its range. Additionally, given the high market prices for manta ray gill plates, we find that the practice of landing these species as valuable bycatch will likely continue through the foreseeable future.

Disease or Predation

No information has been found to indicate that disease or predation is a factor that is significantly and negatively affecting the status of manta rays. Manta rays are frequently observed congregating in inshore cleaning stations, often associated with coral reefs, where small cleaner fish remove parasites and dead tissue from their bodies (Marshall and Bennett 2010a; O'Shea et al. 2010; CITES 2013). They may remain at these cleaning stations for large periods of time, sometimes up to 8 hours a day, and may visit daily (Duinkerken 2010; Kitchen-Wheeler 2013; Rohner et al. 2013). While there is no information on manta ray diseases, or data to indicate that disease is contributing to population declines in either species, impacts to these cleaning stations (such as potential loss through habitat degradation) may negatively impact the fitness of the mantas by decreasing their ability to reduce their parasite load. However, at this time, the impact and potential loss of cleaning stations is highly speculative.

In terms of predation, manta rays are frequently sighted with non-fatal injuries consistent with shark attacks, although the prevalence of these sightings varies by location (Homma et al. 1999; Ebert 2003; Mourier 2012). For example, Deakos et al. (2011) reported that scars from shark predation, mostly on the posterior part of the body or the wing tip, were evident in 24 percent of *M. alfredi* individuals observed at a manta ray aggregation site off Maui, Hawaii. At Lady Elliott Island, off eastern Australia, Couturier et al. (2014) observed 23 percent of individuals had shark scars. In contrast, in southern Mozambique, between 2003 and 2006, 76.3 percent of the *M. alfredi* identified by Marshall and Bennett (2010a) exhibited shark-inflicted bite marks, the majority of which were already healed. Rohner et al. (2013) found a lower rate for *M. birostris,* with only 35 percent of individuals observed with bite marks. Marshall and Bennett (2010a) also recorded two mid-pregnancy abortions by pregnant female *M. alfredi* attributed to damage from shark attacks. The authors observed that the rate of shark-inflicted bites in southern Mozambique appears to be higher than predation rates in other manta ray populations, which is generally noted at less than five percent (Ito 2000; Kitchen-Wheeler et al. 2012), but it is unknown why this difference exists.

Because the damage from a shark bite usually occurs in the posterior region of the manta ray, there may be disfigurement leading to difficult clasper insertion during mating or inhibited waste excretion (Clark and Papastamatiou 2008). Given the already low reproductive ability of these species, attacks by sharks (or occasionally killer whales, see Fertl et al. (1996) and Visser and Bonoccorso (2003)) may pose a threat to the species by further impairing the manta rays' ability to rebuild after depletion. However, at this time, the impact of shark bites on manta ray reproduction, or predation mortality rates on the status of either species, is highly speculative.

The Inadequacy of Existing Regulatory Mechanisms

Protections for manta rays are increasing, yet there are still a number of areas where manta rays are targeted or allowed to be landed as bycatch. In fact, only one of the Regional Fishery Management Organizations (RFMOs) has prohibited retention of bycaught manta rays. Additionally, because both manta species were identified as *M. birostris* prior to 2009, some national protections that were implemented before 2009 are specific only to giant manta rays, despite both species being present in that nation's waters. Below we provide an analysis of the adequacy of measures in terms of controlling threats to each species where available data permit. A list of current protections for manta rays can be found in the Appendix of Miller and Klimovich (2016).

Overutilization of *M. birostris*

Based on the available data, *M. birostris* appears to be most at risk of overutilization in the Indo-Pacific and eastern Pacific portions of its range. Targeted fishing and incidental capture of the species in Indonesia, Philippines, Sri Lanka, and India, and throughout the eastern Pacific, has led to observed declines in the *M. birostris* populations. Despite national protections for the species, poor enforcement and illegal fishing have essentially rendered the existing regulatory mechanisms inadequate to achieve their purpose of protecting the giant manta ray from fishing mortality.

In Indonesia, *M. birostris* and *M. alfredi* were provided full protection in the nation's waters in 2014 (4/KEPMEN–KP/2014), with the creation of the world's largest manta ray sanctuary at around 6 million km^2. Fishing for the species and trade in manta ray parts are banned. Despite this prohibition, fishing for manta rays continues, with evidence of the species being landed and traded in Indonesian markets (AFP 2014; Marshall and Conradie 2014; Dharmadi et al. 2015). As mentioned previously (see *Overutilization for commercial, recreational, scientific, or educational purposes*), many fishermen throughout Indonesia rely on shark and ray fishing for their livelihoods, and without an alternative source of income, are unlikely to stop their traditional fishing practices, including the targeting of manta rays. Additionally, in interviews with fishermen, many viewed the prohibition positively because it would likely drive up the market price of manta ray products (Marshall and Conradie 2014). Given the size of the Indonesian archipelago, and current resources, Dharmadi et al. (2015) note there are many issues with current enforcement of regulations. For example, the collection of data is difficult due to insufficient fisheries officers trained in species identification and the large number of landing sites that need to be monitored (over 1,000). Catch data are typically not accurately recorded at the smaller landing sites either, with coastal waters heavily fished by artisanal fishermen using non-selective gear (Dharmadi et al. 2015). Given the issues with enforcement and evidence of illegal fishing, existing regulatory mechanisms are inadequate to protect the species from further declines due to overutilization.

In the Philippines, legal protection for manta rays was introduced in 1998; however, similar to the situation in Indonesia, enforcement of the prohibitions is lacking and illegal fishing of the species is evident. For example, in a random sampling of 11 dried products of sharks and rays confiscated for illegal trading, Asis et al. (2016) found that four of the products could be genetically identified as belonging to *M. birostris.* Dried manta meat and gill rakers were frequently observed in markets between 2010 and 2012, and fishing boats specifically targeting mobulids (including manta rays) were identified in a number of local fishing villages in the Philippines, with landings consisting of *M. birostris* individuals. Fishing for mobulids is a ''way of life'' and the primary source of income for many fishermen, and with the high prices for manta gill rakers in the Philippine markets (where an average manta ray of around 3 m DW could fetch up to $808; Acebes and Tull (2016)), it is unlikely that pressure on the species will decrease. With essentially no efforts to regulate the mobulid fisheries in the Philippines, and a severe lack of enforcement of the current manta ray hunting prohibition, current regulations to protect *M. birostris* from overutilization in the Philippines are inadequate.

In the eastern and central Indian Ocean, very few national protections have been implemented for *M. birostris.* Essentially, fishing for the species and retention of bycatch is allowed except within the Republic of Maldives EEZ and within specific marine parks of Western Australia. Given the declines observed in the species throughout the Indian Ocean, and the migratory nature of the animal, with the potential for the species to move out of protected areas into active fishing zones (*e.g.,* from the Maldives to Sri Lanka—a distance of ~820 km, well within the ability of *M. birostris*), it is likely that existing regulatory measures within this portion of the species' range are inadequate to protect it from overutilization.

In the eastern Pacific portion of the species' range, the IATTC recently implemented a prohibition on the retention, transshipment, storage, landing, and sale of all devil and manta (mobula and manta) rays taken in its large-scale fisheries (Resolution C–15–04). This regulation went into force on August 1, 2016. Cooperating members must report mobulid catch data and ensure safe release; however, developing countries were granted an exception for small-scale and artisanal fisheries that catch these species for domestic consumption. Given that *M. birostris* is primarily caught as bycatch in the IATTC purse seine fisheries, the adequacy of this prohibition in protecting the species from overutilization depends on the post-release survival rate of the species. While injuries from entanglements in fishing gear (*e.g.,* gillnets and longlines) have been noted (Heinrichs et al. 2011), at this time, at-vessel and post-release mortality rates for manta rays in purse seine nets are unknown. For other Mobula species, Francis and Jones (2016) provided preliminary evidence that may indicate a potential for significant post-release mortality of the spinetail devilray (*Mobula japanica*) in purse seine fisheries; however, the study was based on only seven observed individuals and, because of this, the authors caution that it is ''premature to draw conclusions about survival rates.'' In fact, based on observer data in the New Zealand purse seine fishery, mentioned in Francis and Jones (2016), rays that were caught during sets and released were ''usually lively'' and swam away from the vessel and judged by the observers as ''likely to survive.'' Although decreasing purse seine fishing effort in manta ray hotspots would significantly decrease the likelihood of bycatch mortality, without further information on post-release survival rates, it is highly uncertain if the prohibition will be adequate in decreasing the mortality of the species.

Additionally, in 2016, prohibitions on the fishing and sale of *M. birostris* and requirement for immediate release of mantas caught as bycatch were implemented in Peru. Ecuador banned the fishing, landing and sale of manta rays in its waters back in 2010. Given that the largest population of *M. birostris* is found in the waters between Peru and Ecuador (with the Isla de la Plata population estimated at around 1,500 individuals), these prohibitions should provide some protection to the species from fishing mortality when in these waters. However, illegal fishing still occurs in these waters. For example, in Ecuador's Machalilla National Park (a major *M. birostris* aggregation site), researchers have observed large numbers of manta rays with life-threatening injuries as a result of incidental capture in illegal wahoo (*Acanthocybium solandri*) trawl and drift gillnet fisheries operating within the park (Heinrichs et al. 2011; Marshall et al. 2011a). Depending on the extent of the activities, illegal fishing could potentially contribute to local declines in the population if not adequately controlled. Also, given the migratory nature of the species, national protections may not be adequate to protect the species from overutilization throughout its range, particularly when the species crosses boundary lines where protections no longer exist, as evidenced by the significant decline in *M. birostris* observed in Cocos Island National Park, Costa Rica (White et al. 2015).

Overutilization of *M. alfredi*

Despite a significant overlap in range with *M. birostris* in the Indian and Pacific Oceans, and the more nearshore and reef-associated resident behavior, *M. alfredi* is rarely identified in commercial and artisanal fisheries catch. While the prior lumping of all manta rays as *M. birostris* may account for these findings, in certain portions of the species' range, the distribution of *M. alfredi* may not overlap with the areas of fishing operations. For example, in the Philippines, Rambahiniarison et al. (2016) explains that capture of reef manta rays is unusual, as the main mobulid fishing ground in the Bohol Sea lies offshore in deeper waters, where the presence of the more coastal *M. alfredi* is unlikely. Additionally, while *M. alfredi* are known to make night time deep-water dives offshore for foraging (≤150 m; Braun et al. (2014)), the driftnets deployed by the mobulid fishermen are set at night at much shallower maximum depths of 40 m and thus are unlikely to catch the species (Rambahiniarison et al. 2016). However, Acebes and Tull (2016) did observe a new, active mobulid fishery off Dinagat Island in northern Mindanao that appears to target *M. alfredi* around seamounts in the Leyte Gulf. In 2010, there were 4 active fishing boats in this fishery, supplying manta ray products to Bohol during the ''off season'' (Acebes and Tull 2016). While it is uncertain whether fishing pressure on *M. alfredi* will increase in the future (given that the majority of effort is presently concentrated outside of their distribution), current regulations in the Philippines only prohibit fishing of *M. birostris,* and, as such, are inadequate to protect the species from potential declines in the future.

In Indonesia, while the majority of landings data is reported as *M. birostris,* anecdotal reports from fishermen note that *M. alfredi* used to be caught as bycatch in drift gillnets. Evidence of declines and extirpations of local reef manta ray populations suggest that the species is at risk of overutilization by fisheries in these local, inshore areas, despite a lack of records. As such, the inadequacy of existing mechanisms (discussed previously) may pose a threat to the remaining local reef manta ray populations in Indonesia.

In the Indian Ocean, *M. alfredi* is subject to targeted fishing in the western Indian Ocean (off Mozambique) where declines of up to 88 percent have been observed but no fishery protections or regulatory measures are in place. While the Commonwealth of Australia has now listed both species of *Manta* on its list of migratory species under its Environment Protection and Biodiversity Conservation Act 1999, which means that any action that may have a significant impact on the species must undergo an environmental assessment and approval process, there are no specific regulatory protections for the species throughout Western Australian waters. *Manta* spp. are only explicitly protected from targeted fishing within Ningaloo Marine Park and, collectively, with all species in small designated zones along the Western Australian coast; however, it is important to note that neither species is subject to directed fishing in these waters. In fact, in those portions of the species' range where populations are either not fished and/or are afforded protection and appear stable, we find existing regulatory measures to be adequate in protecting the species from overutilization. These areas include waters of Australia, Hawaii, Guam, Japan, the Republic of Maldives, Palau, and Yap. Given the more coastal and resident behavior of *M. alfredi,* national measures prohibiting fishing of manta rays are likely to provide adequate protection to the species from overutilization through the foreseeable future.

Tourism Impacts

Codes of conduct have been developed by a number of organizations and used by dive operators to promote the safe viewing of manta rays and reduce the potential negative impacts of these activities on manta rays (see *Other Natural or Man-Made Factors Affecting Its Continued Existence* for discussion of this threat). The Manta Trust, a UK-registered charity, has developed a number of guidelines for divers, snorkelers, tour group operators, and in-water tourists, based on studies of interaction effects conducted by the organization from 2005–2013 (available here: *http://www.mantatrust.org/awareness/resources/*). The Hawaii Association for Marine Education and Research Inc. (2014) notes that codes of conduct for manta ray dive operators have been implemented in a number of popular manta ray diving locales, including Kona, Hawaii, Western Australia, Mozambique, Bora Bora, and in the Maldives; however, information on the adherence to, effectiveness, or adequacy of these codes of conduct in minimizing potential negative impacts of tourism activities on the populations could not be found.

Other Natural or Man-Made Factors Affecting Its Continued Existence

Manta rays are known to aggregate in various locations around the world, in groups usually ranging from 100–1,000 for *M. birostris* and 100–700 for *M. alfredi* (Notarbartolo-di-Sciara and Hillyer 1989; Graham et al. 2012; Venables 2013). These sites function as feeding sites, cleaning stations, or sites where courtship interactions take place (Heinrichs et al. 2011; Graham et al. 2012; Venables 2013), with the appearance of manta rays at these locations generally predictable and related to food availability (Notarbartolo-di-Sciara and Hillyer 1989; Heinrichs et al. 2011; Jaine et al. 2012). Additionally, manta rays exhibit learned behaviors, with diving spots using artificial lights to concentrate plankton and attract manta rays (Clark 2010). These behavioral traits, including the predictable nature of manta ray appearances, combined with their slow swimming speeds, large size, and lack of fear towards humans, may increase their vulnerability to other threats, such as overfishing, which was previously discussed, and tourism (O'Malley et al. 2013; CMS 2014).

Tourism was identified as a potential threat to the species, given that interacting (*i.e.,* swimming) with manta rays is a significant tourist attraction throughout the range of both species. In fact, O'Malley et al. (2013) estimated that the manta ray tourism industry provides $140 million annually in direct revenue or economic impact. Regular manta ray concentrations off Mozambique, parts of Indonesia, Australia, Philippines, Yap, southern Japan, Hawaii, and Mexico have all become tourist attractions where manta dives are common (Anderson et al. 2011b). Estimates of the number of people interacting with manta rays per year at these popular dive sites are significant, ranging from over 10,000 at Ho'ona Bay (Hawaii; Clark (2010)) to at least 14,000 in the Maldives (Anderson et al. 2011b).

While manta ray tourism is far less damaging to the species than the impact of fisheries, this increasing demand to see and dive with the animals has the potential to lead to other unintended consequences that could harm the species. For example, Osada (2010) found that a popular manta dive spot in Kona, Hawaii, had fewer emergent zooplankton and less diversity compared to a less used dive spot, and attributed the difference to potential inadvertent habitat destruction by divers. Tour groups may also be engaging in inappropriate behavior, such as touching the mantas. Given the increasing demand for manta ray tourism, with instances of more than 10 tourism boats present at popular dive sites with over 100 divers in the water at once (Anderson et al. 2011b; Venables 2013), without proper tourism protocols, these activities could have serious consequences for manta ray populations.

Already, evidence of tourism activities potentially altering manta ray behavior has been observed. For example, from 2007–2008, low numbers of mantas were observed at normally popular manta dive sites in the Maldives while manta ray numbers remained stable at less visited sites (Anderson et al. 2011b). Similarly, De Rosemont (2008) noted the disappearance of a resident manta ray colony from a popular cleaning station in a Bora Bora lagoon in 2005, and attributed the absence to new hotel construction and increased tourism activities; however, by 2007, the author notes that the mantas had returned to the site. In a study of the tourism impacts on *M. alfredi* behavior in Coral Bay, Western Australia, Venables (2013) observed that mantas exhibited a variety of behavioral changes in response to swim group interactions (*i.e.,* their response was different than their behavior prior to the approach of the swim group). Although the long-term effects of tourism interactions are at this time unknown, the results from the Venables (2013) study provide a preliminary estimate of the potentially minimum response of the species to interactions with tourists, and indicates that these interactions can cause the species to alter (and even stop) behaviors that serve critical biological functions (such as feeding and cleaning). Additional studies on both the short-term and long-term impact of tourist interactions with manta rays are needed in order to evaluate if this interaction is a potential threat to the survival of the species.

In addition to tourism activities, another potential threat to both manta ray species is an increase in mortality from boat strikes and entanglements. Because manta ray aggregation sites are sometimes in areas of high maritime traffic (such as Port Santos in Brazil or in the Caribbean (Marshall et al. 2011a; Graham et al. 2012)), manta rays are at potential risk of being struck and killed by boats. Mooring and boat anchor line entanglement may also wound manta rays or cause them to drown (Deakos et al. 2011; Heinrichs et al. 2011). For example, in a Maui, Hawaii, *M. alfredi* population (n = 290 individuals), Deakos et al. (2011) observed that 1 out of 10 reef manta rays had an amputated or disfigured non-functioning cephalic fin, likely a result of line entanglement. Internet searches also reveal photographs of mantas with injuries consistent with boat strikes and line entanglements, and manta researchers report that such injuries may affect manta fitness in a significant way (The Hawaii Association for Marine Education and Research Inc. 2005; Deakos et al. 2011; Heinrichs et al. 2011; Couturier et al. 2012; CMS 2014; Germanov and Marshall 2014; Braun et al. 2015), potentially similar to the impacts of shark or orca attacks. However, there is very little quantitative information on the frequency of these occurrences and no information on the impact of these injuries on the overall health of the populations.

Assessment of Extinction Risk

The ESA (section 3) defines an endangered species as ''any species which is in danger of extinction throughout all or a significant portion of its range.'' A threatened species is defined as ''any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.'' For the term ''foreseeable future,'' we define it as the time frame over which identified threats could be reliably predicted to impact the biological status of the species. For the assessment of extinction risk for both manta ray species, the ''foreseeable future'' was considered to extend out several decades (>50 years). Given both species' life history traits, with longevity estimated to be greater than 20–40 years, maturity ranges from 3 to >15 years, reproductive periodicity anywhere from an annual cycle to a 5-year cycle, with a litter of only 1 pup, and a generation time estimated to be around 25 years, it would likely take more than a few decades (*i.e.,* multiple generations) for any recent management actions to be realized and reflected in population abundance indices. Similarly, the impact of present threats to both species could be realized in the form of noticeable population declines within this time frame, as demonstrated in the very limited available sightings time-series data. As the main potential operative threat to the species is overutilization by commercial and artisanal fisheries, this time frame would allow for reliable predictions regarding the impact of current levels of fishery-related mortality on the biological status of the two species. Additionally, this time frame allows for consideration of the previously discussed impacts on manta ray habitat from climate change and the potential effects on the status of these two species.

In determining the extinction risk of a species, it is important to consider both the demographic risks facing the species as well as current and potential threats that may affect the species' status. To this end, a demographic analysis was conducted for the giant manta ray and the reef manta ray. A demographic risk analysis is an assessment of the manifestation of past threats that have contributed to the species' current status and informs the consideration of the biological response of the species to present and future threats. This analysis evaluated the population viability characteristics and trends available for the manta rays, such as abundance, growth rate/productivity, spatial structure and connectivity, and diversity, to determine the potential risks these demographic factors pose to each species. The information from this demographic risk analysis was considered alongside the information previously presented on threats to these species, including those related to the factors specified by the ESA section 4(a)(1)(A)–(E) (and summarized in a separate Threats Assessment section below) and used to determine an overall risk of extinction for *M. birostris* and *M. alfredi.* Because species-specific information is sporadic and sometimes uncertain (due to the prior lumping of the *Manta* genus), the qualitative reference levels of ''low risk,'' ''moderate risk'' and ''high risk'' were used to describe the overall assessment of extinction risk, with detailed definitions of these risk levels found in the status review report (Miller and Klimovich 2016).

Demographic Risk Analysis

Giant Manta Ray

Abundance

Current and accurate abundance estimates are unavailable for the giant manta ray, as the species tends to be only sporadically observed. While observations of individuals in local aggregations range from around 40 individuals to over 600, estimates of subpopulation size have only been calculated for Mozambique (n = 600 individuals) and Isla de la Plata, Ecuador (n = 1,500 individuals).

If a population is critically small in size, chance variations in the annual number of births and deaths can put the population at added risk of extinction. Demographic stochasticity refers to the variability of annual population change arising from random birth and death events at the individual level. When populations are very small, chance demographic events can have a large impact on the population. The conservation biology ''50/500'' rule-of-thumb suggests that the effective population size (*Ne;* the number of reproducing individuals in a population) in the short term should not be <50 individuals in order to avoid inbreeding depression and demographic stochasticity (Franklin 1980; Harmon and Braude 2010). In the long-term, *Ne* should not be <500 in order to decrease the impact of genetic drift and potential loss of genetic variation that will prevent the population from adapting to environmental changes (Franklin 1980; Harmon and Braude 2010). Given the two available subpopulation estimates, *M. birostris* is not likely to experience extreme fluctuations that could lead to depensation; however, data are severely lacking. The threshold for depensation in giant manta rays is also unknown. Additionally, the genetic diversity in the giant manta ray has not been investigated. While a preliminary study suggests that the species may exist as isolated subpopulations, available tracking information indicates these manta rays are pelagic and migratory and can likely travel large distances to reproduce. It is this more transient and pelagic nature of the species that has made it difficult to estimate population sizes.

Yet, given the reports of anecdotal declines in sightings and decreases in *M. birostris* landings (of up to 95 percent) in areas subject to fishing (particularly the Indo-Pacific and eastern Pacific portions of the species' range), with take estimates that currently exceed those subpopulation and aggregation estimates (*e.g.,* 50–3,125 individuals), abundance of these particular populations may be at levels that place them at increased risk of genetic drift and potentially at more immediate risks of inbreeding depression and demographic stochasticity. Extirpations of these populations would inherently increase the overall risk of extinction for the entire species.

Growth Rate/Productivity

The current net productivity of *M. birostris* is unknown due to the imprecision or lack of available abundance estimates or indices. Fecundity, however, is extremely low, with one pup per litter and a reproductive periodicity of 1–2 years. Using estimates of life history parameters for both giant and reef manta rays, Dulvy et al. (2014) calculated a median maximum population growth rate to be 0.116 (one of the lowest values compared to other shark and ray species), and estimated productivity (r) to be 0.029. Ward-Paige et al. (2013) calculated a slightly higher intrinsic rate of population increase for *M. birostris* at r = 0.042; however, both these estimates indicate that the giant manta ray has very low productivity and, thus, is extremely susceptible to decreases in its abundance.

Given their large sizes, manta rays are assumed to have a fairly high survival rate after maturity (*e.g.,* low natural predation), with estimated annual survival rates for *M. alfredi* populations supporting this assumption. Based on modeling work on *M. alfredi,* adult survival rate was found to be the most significant factor affecting the viability of the population.

Additionally, at this time, no changes in demographic or reproductive traits or barriers to the exploitation of requisite habitats/niches/etc. have been observed in *M. birostris.*

Spatial Structure/Connectivity

The giant manta ray inhabits tropical, subtropical, and temperate bodies of water and is commonly found offshore, in oceanic waters, and near productive coastlines. It occurs over a broad geographic range and is found in all ocean basins. Most tagging and tracking studies indicate that the home range of individuals is likely large, with the species exhibiting migratory behavior and distances tracked of up to 1,500 km. However, a recent study of the *M. birostris* population found off Pacific Mexico suggests there may be a degree of spatial structuring within the species. At this time, it is unknown whether natural rates of dispersal among populations are too low to prevent sufficient gene flow among populations. Additionally, there is no information to indicate that *M. birostris* is composed of conspicuous source-sink populations or habitat patches.

Diversity

Rates of dispersal and gene flow are not known to have been altered in *M. birostris.* Presently, giant manta rays are wide-ranging inhabitants of offshore, oceanic waters and productive coastline ecosystems and thus are continually exposed to ecological variation at a broad range of spatial and temporal scales. As such, large-scale impacts that affect ocean temperatures, currents, and potentially food chain dynamics, may pose a threat to this species. However, given the migratory behavior of the giant manta ray and tolerance to both tropical and temperate waters, these animals likely have the ability to shift their range or distribution to remain in an environment conducive to their physiological and ecological needs, providing the species with resilience to these effects. At this time, there is no information to suggest that natural processes that cause ecological variation have been significantly altered to the point where *M. birostris* is at risk.

Reef Manta Ray

Abundance

Current and accurate abundance estimates are unavailable for the reef manta ray. Observations of individuals in local aggregations range from 35 individuals to over 2,400; however, many are on the order of 100–600 individuals. Subpopulation sizes range from 100 to 350 individuals, with the exception of the Maldives at 3,300–9,677 individuals. Meta-population estimates for southern Mozambique and Ningaloo Reef, Australia are 802–890 and 1,200–1,500 individuals, respectively.

The rather low subpopulation estimates for *M. alfredi* throughout most of its range suggest that the species may be at increased risk of genetic drift and potential loss of genetic variation. Unlike the giant manta ray, *M. alfredi* is thought to be a more resident species, with populations that occur year-round at certain sites. This reproductive isolation further increases the risk of inbreeding depression and potential inability of the population to respond to environmental variation or anthropogenic perturbations. For example, Kashiwagi (2014) recently estimated the effective population size of the *M. alfredi* population off the Yaeyama Islands to be *Ne* = 89, indicating that the population is not part of a large gene pool and may be close to a level where viability could be jeopardized in the shorter term. Total population was estimated at 165–202 individuals, indicating long-term viability vulnerability. With most available subpopulation estimates ranging only from 100 to 600 individuals (with the exception of Western Australia, Maldives, and Southern Mozambique), it is likely that these populations similarly have low effective population sizes that may increase their vulnerability to inbreeding depression, the loss of genetic variants, or fixation of deleterious mutations.

Overall, based on the information above, the estimates of small and isolated subpopulations throughout most of the species' range, with the three exceptions off Mozambique, Maldives, and Western Australia, inherently place *M. alfredi* at an increased risk of extinction from environmental variation or anthropogenic perturbations. However, the trend in overall abundance of *M. alfredi* is highly uncertain.

Growth Rate/Productivity

The current net productivity of *M. alfredi* is unknown due to the imprecision or lack of available abundance estimates or indices. Fecundity, however, is extremely low, with one to, rarely, two pups per litter and a reproductive periodicity of anywhere from 1–5 years. Estimated productivity (r) values range from 0.023 to 0.05, indicating that the reef manta ray has very low productivity and, thus, is extremely susceptible to decreases in its abundance.

Annual survival rate for reef manta rays is fairly high. Estimated survival rates for subpopulations range from 0.95 to 1 off Australia, Hawaii, and Japan (Deakos et al. 2011; Couturier et al. 2014; Kashiwagi 2014). In Mozambique, rates were lower, between 0.6–0.7; however shark attacks are also more common in this area (Marshall et al. 2011c). Based on modeling work, Smallegange et al. (2016) showed that population growth rate was most sensitive to changes in the survival of adults.

Additionally, no changes in demographic or reproductive traits or barriers to the exploitation of requisite habitats/niches/etc. have been observed.

Spatial Structure/Connectivity

The reef manta ray is commonly seen inshore near coral and rocky reefs. The species is associated with warmer waters (≤21 °C) and productive nearshore habitats (such as island groups). It is considered a more resident species than *M. birostris.* While the species has been tracked undertaking long-distance movements (≤700 km), usually to exploit offshore productive areas, reef manta rays tend to return to known aggregation sites, indicating a degree of site-fidelity. Based on photo-identification surveys of the *M. alfredi* population off Maui, Hawaii, Deakos et al. (2011) suggested that geographic barriers, such as deep channels, might be barriers to movement between neighboring *M. alfredi* populations. Collectively, this information suggests that gene flow is likely limited among populations of *M. alfredi,* particularly those separated by deep ocean expanses.

With the exception of the Yaeyama, Japan population of *M. alfredi,* which Kashiwagi (2014) hypothesized may be a ''sink'' population but is presently increasing with a population growth rate of 1.02–1.03, there is no information to indicate that *M. alfredi* is composed of conspicuous source-sink populations or habitat patches whose loss may pose a risk of extinction.

Diversity

Given their tendency towards site fidelity, *M. alfredi* likely exists as isolated populations with low rates of dispersal and little gene flow among populations. Currently, there is no information to suggest that natural processes that cause ecological variation have been significantly altered to the point where the species is at risk. Reef manta rays also likely have the ability to shift their distribution to remain in an environment conducive to their physiological and ecological needs, providing the species with resilience to these effects. For example, in response to changing ecological conditions, like the biannual reversal of monsoon currents, reef manta rays will migrate to the downstream side of atolls, potentially to remain in nutrient-rich waters year-round (Anderson et al. 2011a). Presently, there is no information to suggest that natural processes that cause ecological variation have been significantly altered to the point where *M. alfredi* is at risk.

Threats Assessment

Giant Manta Ray

The most significant and certain threat to the giant manta ray is overutilization for commercial purposes. Giant manta rays are both targeted and caught as bycatch in a number of global fisheries throughout their range. Estimated take of giant manta rays, particularly in many portions of the Indo-Pacific, frequently exceeds numbers of observed individuals in those areas, and is accompanied by observed declines in sightings and landings of the species. Efforts to address overutilization of the species through regulatory measures appear inadequate, with evidence of targeted fishing of the species despite prohibitions (Indo-Pacific; Eastern Pacific) and only one regional measure to address bycatch issues, with uncertain effectiveness (Eastern Pacific). Additionally, given the migratory and pelagic behavior, national protections for the species are less likely to adequately protect the species from fisheries-related mortality. Giant manta rays are not confined by national boundaries and may, for example, lose certain protections as they conduct seasonal migrations or even as they move around to feed if they cross particular national jurisdictional boundaries (*e.g.,* between the Maldives and Sri Lanka or India), move outside of established Marine Protected Areas, or enter into high seas. While the species recently has been added to CITES Appendix II (added in March 2013 with a delayed effectiveness of September 2014), which may curb targeted fishing as countries must ensure that manta ray products are legally obtained and trade is sustainable, the species is still likely to be caught as bycatch in the industrial fisheries and targeted by artisanal fisheries for domestic consumption.

Other threats to *M. birostris* that potentially contribute to long-term risk of the species include (micro) plastic ingestion rates, increased parasitic loads as a result of climate change effects, and potential disruption of important life history functions as a result of increased tourism; however, due to the significant data gaps, the likelihood and impact of these threats on the status of the species is highly uncertain.

Reef Manta Ray

Given their more inshore distribution and association with shallow coral and rocky reefs, *M. alfredi* does not appear to be as vulnerable to commercial and larger-scale artisanal fishing operations as *M. birostris.* These fisheries tend to operate in deeper and more pelagic waters, targeting migratory and commercially valuable species (like tunas, billfishes, and sharks), and, hence, have a higher likelihood of catching giant manta rays. In the available information, only two countries are reported to have targeted artisanal fisheries for *M. alfredi:* The Philippines (documented 4 fishing boats) and Mozambique. The species has been identified in bycatch from Indonesia, Papua New Guinea, and Kiribati, with subsequent observed declines in sightings, and potential local extirpations; however, the extent of fishing mortality on the species throughout its range is highly uncertain. Additionally, the lumping of both species as *M. birostris* prior to 2009, as well as the fact that much of the catch is not reported down to species level, also significantly contributes to this uncertainty. However, based on the data available, many of the identified populations of *M. alfredi* throughout the western and central Pacific are currently protected by regulations and appear stable, indicating that these existing regulatory measures are adequate at protecting the species from declines due to fishing mortality. Within the Indian Ocean, national protections exist for the large population of *M. alfredi* off the Maldives, and while specific protections for *M. alfredi* have not been implemented in Western Australia, the species is not subject to directed fishing (or prevalent in bycatch) and is presently one of the largest identified populations.

Climate change was identified as a potential threat contributing to the long-term extinction risk of the species. Because *M. alfredi* are more commonly associated with coral reefs compared to giant manta rays, frequently aggregating within these habitats and showing a high degree of site-fidelity and residency to these areas, we found the impact of climate change on coral reefs to be a potential risk to the species. Although the species itself is not dependent on corals, which are most susceptible to the effects of climate change, the manta rays rely on the reef community structure, like the abundance of cleaner fish, to carry out important functions, such as removing parasite loads and dead tissue. Coral reef community structure is likely to be altered as a result of increasing events of coral bleaching through the foreseeable future; however, what this change will look like and its subsequent impact on the species is highly uncertain. Similarly, changes in zooplankton communities and distribution, including in and around coral reefs, are also likely to occur as a result of climate change, affecting the potential previous predictability of *M. alfredi* food resources. Reef manta rays may need to venture out farther to find available food or search for new productive areas; however, given that the species has been shown capable of making long-distance foraging movements, the impact of this potential displacement or change in distribution of zooplankton may not be a significant contributor to the species' extinction risk.

Other threats that potentially contribute to long-term risk of the species include (micro) plastic ingestion rates, and potential disruption of important life history functions or destruction of habitat as a result of increased tourism; however, due to the significant data gaps, the likelihood and impact of these threats on the status of the species is highly uncertain.

Overall Risk Summary

Giant Manta Ray

Given the extremely low reproductive output and overall productivity of the giant manta ray, it is inherently vulnerable to threats that would deplete its abundance, with a low likelihood of recovery. While there is considerable uncertainty regarding the current abundance of *M. birostris* throughout its range, the best available information indicates that the species has experienced population declines of potentially significant magnitude within areas of the Indo-Pacific and eastern Pacific portions of its range, primarily due to fisheries-related mortality. Yet, larger subpopulations of the species still exist, including off Mozambique (where declines were not observed) and Ecuador. However, as giant manta rays are a migratory species and continue to face fishing pressure, particularly from the industrial purse seine fisheries and artisanal gillnet fisheries operating within the Indo-Pacific and eastern Pacific portions of its range, overutilization will continue to be a threat to these remaining *M. birostris* populations through the foreseeable future, placing them at a moderate risk of extinction.

While we assume that declining populations within the Indo-Pacific and eastern Pacific portions of its range will likely translate to overall declines in the species throughout its entire range, there is very little information on the abundance, spatial structure, or extent of fishery-related mortality of the species within the Atlantic portion of its range. As such, we cannot conclude that the species is at a moderate risk of extinction throughout its *entire* range. However, under the final *Significant Portion of Its Range (SPR) policy,* we must consider whether the species may be in danger of extinction, or likely to become so within the foreseeable future, in a significant portion of its range (79 FR 37577; July 1, 2014).

Significant Portion of Its Range (SPR) Analysis

To identify only those portions that warrant further consideration under the SPR Policy, we must determine whether there is substantial information indicating that (1) the portions may be significant and (2) the species may be in danger of extinction in those portions or likely to become so within the foreseeable future. With respect to the second of those determinations, as mentioned previously, the best available information indicates that the giant manta ray faces concentrated threats throughout the Indo-Pacific and eastern Pacific portion of its range. Estimated take of giant manta rays is frequently greater than the observed individuals in those areas, with observed declines in sightings and landings of the species of up to 95 percent. Efforts to address overutilization of the species through regulatory measures appear inadequate in this portion of its range, with evidence of targeted fishing of the species despite prohibitions and bycatch measures that may not significantly decrease fisheries-related mortality rates of the species. Based on the demographic risks and threats to the species in this portion, we determined that the species has a moderate risk of extinction in this portion of its range.

Next, we must evaluate whether this portion is ''significant.'' As defined in the SPR Policy, a portion of a species' range is ''significant'' ''if the species is not currently endangered or threatened throughout its range, but the portion's contribution to the viability of the species is so important that, without the members in that portion, the species would be in danger of extinction, or likely to become so in the foreseeable future, throughout all of its range'' (79 FR 37578; July 1, 2014). Without the Indo-Pacific and eastern Pacific portion of the species' range, the species would have to depend on only its members in the Atlantic for survival. While areas exhibiting source-sink dynamics, which could affect the survival of the species, are not known, the largest subpopulations and records of individuals of the species come from the Indo-Pacific and eastern Pacific portion. The only data from the Atlantic on the abundance of the species are records of >70 individuals in the Flower Garden

Banks Marine Sanctuary (Gulf of Mexico) and 60 manta rays from waters off Brazil (see Table 4 in Miller and Klimovich (2016)). Given that the species is rarely identified in the fisheries data in the Atlantic, it may be assumed that populations within the Atlantic are small and sparsely distributed. These demographic risks, in conjunction with the species' inherent vulnerability to depletion, indicate that even low levels of mortality may portend drastic declines in the population. As such, without the Indo-Pacific and eastern Pacific portion, the minimal targeted fishing of the species by artisanal fishermen and bycatch mortality from the purse seine, trawl, and longline fisheries operating in the Atlantic becomes a significant contributing factor to the extinction risk of the species. Based on the above findings, we conclude that the Indo-Pacific and eastern Pacific portion of the giant manta ray's range comprises a significant portion of the range of the species because this portion's contribution to the viability of *M. birostris* is so important that, without the members in this portion, the giant manta ray would likely become in danger of extinction within the foreseeable future, throughout all of its range.

Under the SPR policy, we conclude that the Indo-Pacific and eastern Pacific portion of the giant manta ray's range qualifies as a significant portion of the species' range. Additionally, based on the information above and further discussed in our demographic risks analysis and threats assessment, as well as the information in the status review report, we conclude that *M. birostris* is at a moderate risk of extinction within this significant portion of its range.

Distinct Population Segment (DPS) Analysis

In accordance with the SPR policy, if a species is determined to be threatened or endangered in a significant portion of its range, and the population in that significant portion is a valid distinct population segment (DPS), NMFS will list the DPS rather than the entire taxonomic species or subspecies. Because the Indo-Pacific and eastern Pacific represents a significant portion of the range of the species, and this portion is at a risk of extinction that is higher than ''low,'' we performed a DPS analysis on the population within this portion to see if it qualifies as a valid DPS.

The Services' policy on identifying DPSs (61 FR 4722; February 7, 1996) identifies two criteria for DPS designations: (1) The population must be discrete in relation to the remainder of the taxon (species or subspecies) to which it belongs; and (2) the population must be ''significant'' (as that term is used in the context of the DPS policy, which is different from its usage under the SPR policy) to the remainder of the taxon to which it belongs.

In terms of discreteness, a population segment of a vertebrate species may be considered discrete if it satisfies either one of the following conditions: (1) ''It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation''; or (2) ''it is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D)'' of the ESA (61 FR 4722; February 7, 1996).

Research on the genetics of the species, which may provide evidence of discreteness between populations, is ongoing. As discussed previously in this finding, while there may be evidence of a potential *M. birostris* subspecies, or new manta species, found off the Yucatán coast in the Gulf of Mexico, the study by Hinojosa-Alvarez et al. (2016) also showed that some of the Yucatán manta rays found in the area shared haplotypes with *M. birostris* samples from the Indo-Pacific and eastern Pacific. Additionally, based on nuclear DNA, the Yucatán samples were consistent with the *M. birostris* samples from the Indo-Pacific and eastern Pacific portions of its range. This is the only study that we are aware of that has compared potential genetic differences between ocean basins for giant manta rays. Given the available data, we do not find evidence to indicate genetic discreteness between *M. birostris* in the Atlantic and *M. birostris* in the Indo-Pacific and eastern Pacific.

In terms of physical, physiological, morphological, ecological, behavioral, and regulatory factors, there is no evidence that the Indo-Pacific and eastern Pacific population of *M. birostris* is markedly separate from the population in the Atlantic. There is no evidence of differences in the morphology or physiology between the populations, nor any information to indicate changes in habitat use or behavior across ocean basins. Also, given that the species is highly migratory and pelagic, with no identified barriers to movement, these populations cannot be delimited by international governmental boundaries. As such, we find that the *M. birostris* population in the Indo-Pacific and eastern Pacific does not meet the discreteness criteria of the DPS policy, and, thus, is not a valid DPS.

Reef Manta Ray

Overall, the species' life history characteristics increase its inherent vulnerability to depletion. Its tendency towards site fidelity and high residency rates suggests that there may be little gene flow between subpopulations, meaning that reestablishment after depletion is unlikely. Additionally, because these aggregations tend to be small, even light fishing may lead to population depletion. However, despite these inherent risks, the species does not appear subjected to significant threats that are causing declines, or likely to cause declines, to the point where the species would be at risk of extinction. As mentioned in the threats analysis, targeted fishing of the species has only been observed in a select few locations, and its identification in bycatch is limited. The majority of the known *M. alfredi* subpopulations, particularly throughout the western and Central Pacific, while small, are protected from fishing mortality and appear stable. Some of the larger known *M. alfredi* subpopulations, such as off the Maldives (n = 3,300–9,677 individuals) and Western Australia (n = 1,200–1,500 individuals), are not subject to directed fishing, with Australia's overall population considered to be one of the world's healthiest. While climate change may alter aspects of the habitat and food resources of the species, the subsequent impact on the species is highly uncertain. Thus, based on the above evaluation of demographic risks and threats to the species, we find that the reef manta ray is likely to be at a low overall risk of extinction.

SPR Analysis

As was done for the giant manta ray, we must conduct an SPR analysis to determine if the species is in danger of extinction, or likely to become so within the foreseeable future, in a significant portion of its range. In applying the policy, we first examined where threats are concentrated to evaluate whether the species is at risk of extinction within those portions. Targeted fishing and subsequent declines in populations of *M. alfredi* are known from waters off Mozambique and the Philippines, and the species has also been identified in bycatch from Indonesia, Papua New Guinea, and Kiribati. However, with the exception of the southern Mozambique population, the extent of decline of the species throughout these other areas has not been quantified. But while the rate of decline is unknown, fishing pressure on the species continues in these portions of range and, combined with the species' demographic risks of isolated, small populations and extremely low productivity, these threats are likely placing these populations on a trajectory toward a higher risk of extinction.

The second question that needs to be addressed in the SPR analysis is whether these portions can be considered ''significant.'' Without these portions, would the species be in danger of extinction, or likely to become so in the foreseeable future, throughout all of its range? We find that this is unlikely to be the case. Even if these populations were gone, the species would still exist as small, isolated populations throughout the Indo-Pacific. There is no evidence of source-sink dynamics between these portions and other areas, which could affect the survival of the species. In fact, the only indication of a potential source-sink dynamic was hypothesized for the *M. alfredi* population off Yaeyama, Japan, which Kashiwagi (2014) found is presently increasing, indicating no risk of loss to this population. In fact, many of the *M. alfredi* populations outside of the portions identified above, while small in size, are presently thought to be stable or increasing. Additionally, these populations, such as the largest identified *M. alfredi* population, off the Maldives, benefit from national protections that prohibit the fishing, landing, or selling of the species. Because these populations occur nearshore, and the species exhibits high residency rates and site-fidelity behavior, these protections will be adequate to prevent overutilization of the species through the foreseeable future. As such, even without the portions identified above, the species will unlikely be in danger of extinction throughout all of its range now or in the foreseeable future.

Thus, under the SPR policy, we could not identify any portions of the species' range that meet both criteria (*i.e.,* the portion is biologically significant *and* the species may be in danger of extinction in that portion, or likely to become so within the foreseeable future). Therefore, we find that our conclusion about the species' overall risk of extinction does not change and conclude that *M. alfredi* is likely to be at a low risk of extinction throughout its range.

Protective Efforts

There are many conservation efforts presently ongoing to collect research on manta ray life history, ecology, and biology, and to raise awareness of threats to manta rays (see Miller and Klimovich (2016) for detailed discussion). The available research and citizen science data that have resulted from these conservation efforts have already been considered in the above analysis, and future research activities will continue to provide valuable information on these manta ray species. Additionally, the efforts by these organizations to educate the public, such as through awareness campaigns, could eventually lead to decreases in the demand for manta ray products. For example, Lawson et al. (2016), citing unpublished data, noted an 18-month awareness-raising campaign conducted in 2015 in Guangzhou, China, that seemed to indicate a level of success in decreasing consumer demand for gill rakers, which, in turn, decreased the interest of traders to carry gill plates in the future. While more monitoring of trade and consumer behavior is required to evaluate the success of these efforts, it may indicate that awareness-raising campaigns could be successful tools for influencing customer behavior. With demand reduction viewed as a potential avenue to indirectly reduce fishing pressure on manta rays, these campaigns may ultimately help decrease the main threat to the species (Lawson et al. 2016).

Awareness campaigns are also being used to educate the public on appropriate tourist behavior during manta ray dives, which can help decrease potential negative impacts of tourism activities on manta rays. As mentioned previously, best practice codes of conduct have been developed by a number of organizations and are increasingly being used by dive operators at a number of popular manta ray diving sites, including Kona, Hawaii, Western Australia, Mozambique, Bora Bora, and the Maldives, to promote the safe viewing of manta rays.

While we find that these efforts will help increase the scientific knowledge and promote public awareness about manta rays, with the potential (but not certainty) to decrease the impacts of specific threats in the future, we do not find that these efforts have significantly altered the extinction risk for the giant manta ray to where it would not be at risk of extinction in the foreseeable future. However, we seek additional information on these and other conservation efforts in our public comment process (see below).

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 have independently reviewed the best available scientific and commercial information including the petition, public comments submitted on the 90-day finding (81 FR 8874; February 23, 2016), the status review report (Miller and Klimovich 2016), and other published and unpublished information, and have consulted with species experts and individuals familiar with manta rays. We considered each of the statutory factors to determine whether it presented an extinction risk to each species on its own, now or in the foreseeable future, and also considered the combination of those factors to determine whether they collectively contributed to the extinction risk of the species, now or in the foreseeable future.

Based on our consideration of the best available scientific and commercial information, as summarized here and in Miller and Klimovich (2016), including our SPR and DPS analyses, we find that the giant manta ray (*Manta birostris*) is at a moderate risk of extinction within a significant portion of its range, with the species likely to become in danger of extinction within the foreseeable future throughout that portion. We did not find that the significant portion meets the criteria of a DPS. Therefore, we have determined that the giant manta ray meets the definition of a threatened species and, per the SPR policy, propose to list it is as such throughout its range under the ESA.

Based on our consideration of the best available scientific and commercial information, as summarized here and in Miller and Klimovich (2016), we find that the reef manta ray (*Manta alfredi*) faces an overall low risk of extinction throughout its range. As previously explained, we could not identify any portion of the species' range that met both criteria of the SPR policy. Accordingly, the reef manta ray does not meet the definition of a threatened or endangered species, and thus, the reef manta ray does not warrant listing as threatened or endangered at this time. This is a final action on the aforementioned petition to list the reef manta ray under the ESA, and, therefore, we do not solicit comments on it.

Effects of Listing

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

Identifying Section 7 Conference and Consultation Requirements

Section 7(a)(2) (16 U.S.C. 1536(a)(2)) of the ESA and NMFS/USFWS regulations require Federal agencies to confer with us on actions likely to jeopardize the continued existence of species proposed for listing, or that result in the destruction or adverse modification of proposed critical habitat. If a proposed species is ultimately listed, Federal agencies must consult on any action they authorize, fund, or carry out if those actions may affect the listed species or its critical habitat and ensure that such actions do not jeopardize the species or result in adverse modification or destruction of critical habitat should it be designated. Examples of Federal actions that may affect the giant manta ray include, but are not limited to: Alternative energy projects, discharge of pollution from point sources, non-point source pollution, contaminated waste and plastic disposal, dredging, pile-driving, development of water quality standards, vessel traffic, military activities, and fisheries management practices.

Critical Habitat

Critical habitat is defined in section 3 of the ESA (16 U.S.C. 1532(3)) as: (1) The specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the ESA, on which are found those physical or biological features (a) essential to the conservation of the species and (b) that may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by a species at the time it is listed upon a determination that such areas are essential for the conservation of the species. ''Conservation'' means the use of all methods and procedures needed to bring the species to the point at which listing under the ESA is no longer necessary. Section 4(a)(3)(a) of the ESA (16 U.S.C. 1533(a)(3)(A)) requires that, to the extent prudent and determinable, critical habitat be designated concurrently with the listing of a species. Designations of critical habitat must be based on the best scientific data available and must take into consideration the economic, national security, and other relevant impacts of specifying any particular area as critical habitat. If we determine that it is prudent and determinable, we will publish a proposed designation of critical habitat for the giant manta ray in a separate rule. Public input on features and areas in U.S. waters that may meet the definition of critical habitat for the giant manta ray is invited.

Protective Regulations Under Section 4(d) of the ESA

We are proposing to list the giant manta ray (*Manta birostris*) as a threatened species. In the case of threatened species, ESA section 4(d) leaves it to the Secretary's discretion whether, and to what extent, to extend the section 9(a) ''take'' prohibitions to the species, and authorizes us to issue regulations necessary and advisable for the conservation of the species. Thus, we have flexibility under section 4(d) to tailor protective regulations, taking into account the effectiveness of available conservation measures. The 4(d) protective regulations may prohibit, with respect to threatened species, some or all of the acts which section 9(a) of the ESA prohibits with respect to endangered species. We are not proposing such regulations at this time, but may consider potential protective regulations pursuant to section 4(d) for the giant manta ray in a future rulemaking. In order to inform our consideration of appropriate protective regulations for the species, we seek information from the public on the threats to giant manta rays and possible measures for their conservation.

Role of Peer Review

The intent of peer review is to ensure that listings are based on the best scientific and commercial data available. 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. Independent specialists were selected from the academic and scientific community for this review. All peer reviewer comments were addressed prior to dissemination of the status review report and publication of this proposed rule.

Public Comments Solicited on Listing

To ensure that the final action resulting from this proposal will be as accurate and effective as possible, we solicit comments and suggestions from the public, other governmental agencies, the scientific community, industry, environmental groups, and any other interested parties. Comments are encouraged on this proposal (See **DATES** and **ADDRESSES**). Specifically, we are interested in information regarding: (1) New or updated information regarding the range, distribution, and abundance of the giant manta ray; (2) new or updated information regarding the genetics and population structure of the giant manta ray; (3) habitat within the range of the giant manta ray that was present in the past but may have been lost over time; (4) new or updated biological or other relevant data concerning any threats to the giant manta ray (*e.g.,* post-release mortality rates, landings of the species, illegal taking of the species); (5) current or planned activities within the range of the giant manta ray and their possible impact on the species; (6) recent observations or sampling of the giant manta ray; and (7) efforts being made to protect the giant manta ray.

Public Comments Solicited on Critical Habitat

We request information describing the quality and extent of habitats for the giant manta ray, as well as information on areas that may qualify as critical habitat for the species in U.S. waters. Specific areas that include the physical and biological features essential to the conservation of the species, where such features may require special management considerations or protection, should be identified. Areas outside the occupied geographical area should also be identified, if such areas themselves are essential to the conservation of the species. ESA implementing regulations at 50 CFR 424.12(g) specify that critical habitat shall not be designated within foreign countries or in other areas outside of U.S. jurisdiction. Therefore, we request information only on potential areas of critical habitat within waters under U.S. jurisdiction.

Section 4(b)(2) of the ESA requires the Secretary to consider the ''economic impact, impact on national security, and any other relevant impact'' of designating a particular area as critical habitat. Section 4(b)(2) also authorizes the Secretary to exclude from a critical habitat designation those particular areas where the Secretary finds that the benefits of exclusion outweigh the benefits of designation, unless excluding that area will result in extinction of the species. For features and areas potentially qualifying as critical habitat, we also request information describing: (1) Activities or other threats to the essential features or activities that could be affected by designating them as critical habitat; and (2) the positive and negative economic, national security and other relevant impacts, including benefits to the recovery of the species, likely to result if these areas are designated as critical habitat. We seek information regarding the conservation benefits of designating areas within waters under U.S. jurisdiction as critical habitat. In keeping with the guidance provided by OMB (2000; 2003), we seek information that would allow the monetization of these effects to the extent possible, as well as information on qualitative impacts to economic values.

Data reviewed may include, but are not limited to: (1) Scientific or commercial publications; (2) administrative reports, maps or other graphic materials; (3) information received from experts; and (4) comments from interested parties. Comments and data particularly are sought concerning: (1) Maps and specific information describing the amount, distribution, and use type (*e.g.,* foraging or migration) by the giant manta ray, as well as any additional information on occupied and unoccupied habitat areas; (2) the reasons why any habitat should or should not be determined to be critical habitat as provided by sections 3(5)(A) and 4(b)(2) of the ESA; (3) information regarding the benefits of designating particular areas as critical habitat; (4) current or planned activities in the areas that might be proposed for designation and their possible impacts; (5) any foreseeable economic or other potential impacts resulting from designation, and in particular, any impacts on small entities; (6) whether specific unoccupied areas may be essential to provide additional habitat areas for the conservation of the species; and (7) potential peer reviewers for a proposed critical habitat designation, including persons with biological and economic expertise relevant to the species, region, and designation of critical habitat.

References

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

Classification

National Environmental Policy Act

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

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

As noted in the Conference Report on the 1982 amendments to the ESA, economic impacts cannot be considered when assessing the status of a species. Therefore, the economic analysis requirements of the Regulatory Flexibility Act are not applicable to the listing process. In addition, this proposed rule is exempt from review under Executive Order 12866. This proposed rule does not contain a collection-of-information requirement for the purposes of the Paperwork Reduction Act.

Executive Order 13132, Federalism

In accordance with E.O. 13132, we determined that this proposed rule does not have significant Federalism effects and that a Federalism assessment is not required. In keeping with the intent of the Administration and Congress to provide continuing and meaningful dialogue on issues of mutual state and Federal interest, this proposed rule will be given to the relevant governmental agencies in the countries in which the species occurs, and they will be invited to comment. As we proceed, we intend to continue engaging in informal and formal contacts with the states, and other affected local, regional, or foreign entities, giving careful consideration to all written and oral comments received.

List of Subjects in 50 CFR Part 223

Endangered and threatened species.

Dated: January 5, 2017.

Samuel D. Rauch, III,

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

For the reasons set out in the preamble, 50 CFR part 223 is proposed to be amended as follows:

PART 223—THREATENED MARINE AND ANADROMOUS SPECIES

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

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

■ 2. In § 223.102, in the table in paragraph (e) add a new entry for ''ray, giant manta'' in alphabetical order by common name under the ''Fishes'' subheading to read as follows:

§ 223.102 Enumeration of threatened marine and anadromous species.

* * * * *

(e) * * *

Species[1]			Citation(s) for listing determination(s)	Critical habitat	ESA rules
Common name	Scientific name	Description of listed entity			
*	*	*	* * *		*
Fishes					
*	*	*	* * *		*
Ray, giant manta	*Manta birostris* ...	Entire species	[Insert **Federal Register** page where the document begins], [Insert date of publication when published as a final rule].	NA	NA.
*	*	*	* * *		*

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

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