DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

[Docket No. 200626–0172; RTID 0648–XG232]

Endangered and Threatened Wildlife and Plants; Endangered Species Act Listing Determination for the Coral Pocillopora meandrina

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

ACTION: Notice; 12-month finding and availability of status review documents.

SUMMARY: We, NMFS, have completed a comprehensive status review under the Endangered Species Act (ESA) for the Indo-Pacific, reef-building coral *Pocillopora meandrina.* After reviewing the best scientific and commercial data available, including the General Status Review of Indo-Pacific Reef-building Corals and the *P. meandrina* Status Review Report, we have determined that listing *P. meandrina* as threatened or endangered based on its status throughout all or a significant portion of its range under the ESA is not warranted at this time.

DATES: This finding was made on July 6, 2020.

ADDRESSES: The petition, General Status Assessment of Indo-Pacific Reef-building Corals, *P. meandrina* Status Review Report, **Federal Register** notice, and the list of references can be accessed electronically online at: *https://www.fisheries.noaa.gov/species/pocillopora-meandrina-coral#conservation-management.*

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SUPPLEMENTARY INFORMATION:

Background

This 12-month finding is a response to a petition to list *P. meandrina* under the ESA. Background to the petition, 90-day finding, and policy on listing species under the ESA is provided below.

Petition and 90-Day Finding

On March 14, 2018, we received a petition from the Center for Biological Diversity to list the Indo-Pacific reef-building coral *Pocillopora meandrina* in Hawaii as an endangered or threatened species under the ESA. Under the ESA, a listing determination addresses the status of a species, its subspecies, and, for any vertebrate species, any distinct population segment (DPS) that interbreeds when mature (16 U.S.C. 1532(16)). Under the ESA, a species is ''endangered'' if it is in danger of extinction throughout all or a significant portion of its range, or ''threatened'' if it is likely to become endangered within the foreseeable future throughout all or a significant portion of its range (ESA sections 3(6) and 3(20), respectively, 16 U.S.C. 1532(6) and (20)). The petition requested that the Hawaii portion of the species' range be considered a significant portion of its range, thus the petition focused primarily on the status of *P. meandrina* in Hawaii. However, the petition also requested that *P. meandrina* be listed throughout its range, and provided some information on its status and threats outside of Hawaii. In light of recent court decisions regarding our policy on the interpretation of the phrase ''significant portion of its range'' (SPR) under the ESA (79 FR 37577, July 1, 2014), we interpreted the petition as a request to first consider the status of *P. meandrina* throughout its range, followed by an SPR review consisting of: (1) Analysis of any SPRs, including the portion of the range within Hawaii; and (2) determination of the status of SPRs.

On September 20, 2018, we published a 90-day finding (83 FR 47592) announcing that the petition presented substantial scientific or commercial information indicating that *P. meandrina* may be warranted for listing under the ESA throughout all or a significant portion of its range. We also announced the initiation of a status review of the species, as required by section 4(b)(3)(a) of the ESA, and requested information to inform the agency's decision on whether this species warrants listing as endangered or threatened under the ESA.

Listing Species Under the Endangered Species Act

We are responsible for determining whether *P. meandrina* is 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 subspecies and, for any vertebrate species, any DPS that interbreeds when mature (16 U.S.C. 1532(16)). As noted previously, because *P. meandrina* is an invertebrate species, the ESA does not consider listing individual populations as DPSs.

Section 3 of the ESA defines an endangered species as any species which is in danger of extinction throughout all or a significant portion of its range, and a threatened species as one which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. 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 (that is, at a later time). The key statutory difference between a threatened and endangered species is the timing of when a species is or is likely to become in danger of extinction, either presently (endangered) or in the foreseeable future (threatened).

When we consider whether a species qualifies as threatened under the ESA, we must consider the meaning of the term ''foreseeable future.'' It is appropriate to interpret ''foreseeable future'' as the horizon over which predictions about the conservation status of the species can be reasonably relied upon. What constitutes the foreseeable future for a particular species depends on species-specific factors such as the life history of the species, habitat characteristics, availability of data, particular threats, ability to predict threats, and the reliability to forecast the effects of these threats and future events on the status of the species under consideration. That is, the foreseeability of a species' future status is case specific and depends upon both the foreseeability of threats to the species and foreseeability of the species' response to those threats. Our consideration of the foreseeable future for this status review is described in the Global Climate Change and the Foreseeable Future section below.

The statute 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 any of the following factors: The present or threatened destruction, modification, or curtailment of its habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; the inadequacy of existing regulatory mechanisms; or other natural or manmade factors affecting its continued existence. 16 U.S.C. 1533(a)(1). We are also required to make listing determinations based solely on the best scientific and commercial data available, after conducting a review of the species' status and after taking into account efforts, if any, being made by any state or foreign nation (or subdivision thereof) to protect the species. 16 U.S.C. 1533(b)(1)(A).

General Status Assessment, Status Review Report, and Extinction Risk Assessment Team

The rangewide Status Review of *P. meandrina* consists of two documents: (1) The General Status Assessment (GSA) of Indo-Pacific Reef-building Corals (Smith 2019a); and (2) the *P. meandrina* Status Review Report (SRR; Smith 2019b). The GSA (Smith 2019a) provides contextual information on the status and trends of Indo-Pacific reef-building corals, and the SRR (Smith 2019b) reports the status and trends of *P. meandrina* based on the best available scientific information. Based on the information provided in the Status Review reports (Smith 2019a,b), an Extinction Risk Assessment (ERA) was carried out as specified in the ''Guidance on Responding to Petitions and Conducting Status Reviews under the Endangered Species Act'' (NMFS 2017). As per the guidance, an ERA Team was established, consisting of seven reef-building coral subject matter experts, and the Team used the information in the Status Review reports to provide ratings of *P. meandrina'*s extinction risk, described in the final section of the SRR (Smith 2019b).

The two reports that make up this Status Review (Smith 2019a,b) represent a compilation of the best available scientific and commercial information on the *P. meandrina'*s biology, ecology, life history, threats, and status from information contained in the petition, our files, a comprehensive literature search, and consultation with Indo-Pacific reef coral experts. We also considered information submitted by the public in response to our 90-day finding (83 FR 47592; September 20, 2018). The draft Status Review reports (Smith 2019a,b) underwent independent peer review by reef coral experts as required by the Office of Management and Budget (OMB) Final Information Quality Bulletin for Peer Review (M–05–03; December 16, 2004). The peer reviewers were asked to evaluate the adequacy, appropriateness, and application of data used in the Status Review reports, including the Extinction Risk Assessment methodology. Peer reviewer comments were addressed prior to dissemination and finalization of the Status Review reports and publication of this finding, as described in the Peer Review Report.

We subsequently reviewed the Status Review reports (Smith 2019a,b), their cited references, and peer review comments, and believe the Status Review reports, upon which this 12-month finding are based, provide the best available scientific and commercial information on *P. meandrina.* Much of the information discussed below on the species' biology, distribution, abundance, threats, and extinction risk is presented in the Status Review reports (Smith 2019a,b). However, in making the 12-month finding determinations (*i.e.,* our decisions that *P. meandrina* is not warranted for listing rangewide, nor as any SPRs), 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 at 50 CFR part 424. The Status Review reports (Smith 2019a,b) and the Peer Review Report are available on our website at *http://www.cio.noaa.gov/services_programs/prplans/PRsummaries.html.*

Global Climate Change and the Foreseeable Future

Many of the threats to *P. meandrina,* including the most severe threats, stem from global climate change (Smith 2019b). As described in the preceding ''Listing Species Under the Endangered Species Act'' section, the purpose of this finding is to determine the extinction risk of the species now and in the foreseeable future. The extinction risk of *P. meandrina* now and in the immediate future depends on the impacts of threats resulting from the continuation of ongoing climate change. Its extinction risk in the future depends on how far into the future climate change threats are foreseeable, and what impacts those threats will have on the species over that timeframe. Thus, this section provides an overview of global climate change and existing guidance, a description of the climate change status quo, the rationale for our determination of the length of the foreseeable future for the most important threats to *P. meandrina* (ocean warming and ocean acidification), and descriptions of the impacts of those threats on the species over the foreseeable future.

Overview of Global Climate Change and Existing Guidance

Global climate change refers to increased concentrations of greenhouse gases (GHGs; primarily carbon dioxide, but also methane, nitrous oxide, and others) in the atmosphere from anthropogenic emissions, and subsequent warming of the earth, acidification of the oceans, rising sea-levels, and other impacts since the beginning of the industrial era in the mid-19th century. Since that time, the release of carbon dioxide (CO_2) from industrial and agricultural activities has resulted in atmospheric CO_2 concentrations that have increased from approximately 280 ppm in 1850 to 410 ppm in 2019 (Smith 2019a). The resulting warming of the earth has been unequivocal, and each of the last three decades has been successively warmer than any preceding decade since 1850. The climate change components of the *P. meandrina* Status Review were based on the International Panel on Climate Change's (IPCC) Fifth Assessment Report ''Climate Change 2013: The Physical Science Basis'' (AR5; IPCC 2013a), the IPCC's ''Global Warming of 1.5° C'' (1.5° Report; IPCC 2018), and other climate change literature cited in the GSA and SRR. The IPCC published the 1.5° Report to compare the impacts of global warming of 1.5° C vs. 2.0° C above pre-industrial levels, in response to the 2015 Paris Agreement's objective of limiting global warming to 1.5° C. The IPCC's AR5 and the 1.5° Report together represent the largest synthesis of global climate change physical science ever compiled. The IPCC is currently compiling its Sixth Assessment Report (AR6), due to be published in 2021 or 2022 (Smith 2019a).

Observed and projected global mean surface temperatures (GMST) from the pre-industrial baseline period of 1850–1900 to the year 2100 provide context for the climate change threats facing *P. meandrina* and other species. GMST refers to the mean of land and sea temperatures observed at the earth's surface. Since the pre-industrial period, GMST has increased by nearly 1° C due to GHG emissions, and estimated anthropogenic global warming is currently increasing at approximately 0.2° C per decade due to past and ongoing GHG emissions. Warming greater than the global annual average is being experienced in many land regions and seasons, including two to three times higher in the Arctic. Warming is generally higher over land than over the ocean, thus warming of the ocean lags behind warming of air at the earth's surface. Regardless of future emissions, warming from past anthropogenic GHG emissions since the pre-industrial period will persist for centuries to millennia, and will continue to cause further long-term changes in the climate system, such as sea-level rise, with associated impacts (Smith 2019a).

In order to ensure consistency in the application of climate change science to

ESA decisions, in 2016 NMFS issued ''Guidance for Treatment of Climate Change in NMFS Endangered Species Act Decisions'' (Climate Guidance, NMFS 2016). The Climate Guidance provides seven policy considerations, the first two of which are particularly relevant to the *P. meandrina* finding: (1) ''Consideration of future climate condition uncertainty—For ESA decisions involving species influenced by climate change, NMFS will use climate indicator values (*i.e.,* quantitative projections of ocean warming, ocean acidification, and other climate change impacts) projected under the International Panel on Climate Change (IPCC)'s Representative Concentration Pathway 8.5 when data are available. When data specific to that pathway are not available we will use the best available science that is as consistent as possible with RCP 8.5'', and (2) ''Selecting a climate change projection timeframe—(A) When predicting the future status of species in ESA Section 4, NMFS will project climate change effects for the longest time period over which we can foresee the effects of climate change on the species' status.'' (NMFS 2016). The application of these two policy considerations to the *P. meandrina* finding are described below.

RCP8.5 As the Status Quo

AR5 (IPCC 2013a) projected GMST from 2006 over the remainder of the 21st century using a set of four representative concentration pathways (RCPs) that provide a standard framework for consistently modeling future climate change under different assumptions. The four RCPs span a range of possible futures, from high GHG emissions peaking near 2100 (RCP8.5), to intermediate emissions (RCP6.0 and RCP4.5), to low emissions (RCP2.6). The 1.5° Report (IPCC 2018) developed additional pathways with lower emissions than RCP2.6. The IPCC's pathways are based on projected concentrations of CO_2 and other GHGs in the earth's atmosphere. As atmospheric GHG concentrations increase, less of the sun's heat can be radiated back into space, causing the earth to absorb more heat. The increased heat forces changes on the earth's climate system, and thus is referred to as ''radiative forcing.'' AR5's four RCPs are named according to radiative forcing of 2.6, 4.5, 6.0, and 8.5 Watts per square meter of the earth's surface. These result from atmospheric CO_2 concentrations of 421 (RCP2.6), 538 (RCP4.5), 670 (RCP6.0), and 936 (RCP8.5) ppm in 2100. The 1.5° Report includes pathways with lower CO_2 levels than RCP2.6 (IPCC 2013a, 2018).

The various pathways were developed with the intent of providing different potential climate change projections to guide policy discussions. The IPCC does not attach likelihoods to the pathways. Taken together, the four pathways in AR5 project wide ranges of increases in GMSTs, ocean warming, ocean acidification, sea level rise, and other changes globally throughout the 21st century (Smith 2019a). Summaries of the most recent information on observed and projected ocean warming, ocean acidification, and sea-level rise are provided in the GSA (Smith 2019a), and support RCP8.5 as representative of the status quo. For example, according to the most recent Global Carbon Budget report (Friedlingstein *et al* 2019), global CO_2 emissions from fossil fuels and industry grew continuously from 2010 to 2019; and global atmospheric CO_2 concentration grew from approximately 385 in 2010 to 410 ppm in 2019, with each year setting new historic highs, according to NOAA's Earth System Research Laboratory (ESRL) station on Mauna Kea, Hawaii (*https://www.esrl.noaa.gov/gmd/ccgg/trends/,* accessed December 2019). This rapid growth in global CO_2 emissions and atmospheric CO_2 is more consistent with RCP8.5 than any of the other pathways in AR5 (IPCC 2013a) or the 1.5° C Report (IPCC 2018).

The Foreseeable Future for P. meandrina

The Climate Guidance (NMFS 2016) directs us to determine the longest period over which we can reasonably foresee the effects of climate change on the species. The IPCC pathways (IPCC 2013a, IPCC 2018) use the year 2100 as the main end-point for their climate change projections. The IPCC's AR5 and the 1.5° Reports (IPCC 2013a, IPCC 2018), together with the large and growing scientific literature on projected impacts of the IPCC pathways on coral reef ecosystems, provide considerable information on how climate change threats are likely to affect corals and coral reefs from now to 2100. Although there is wide variability in the IPCC pathways (*e.g.,* RCP8.5 vs. the 1.5° Report's pathways would result in highly contrasting impacts to most of the world's ecosystems over the 21st century), 2100 is foreseeable because some pathways are more likely than others over that timeframe, as explained in the following paragraph.

Since the status quo is best represented by RCP8.5, we consider climate indicator values projected under RCP8.5 to be likely over at least the near future. Beyond that, current GHG emissions policies resulting from the 2015 Paris Agreement may eventually lead to climate indicator values projected under the intermediate emissions pathways RCPs 6.0 and 4.5 (CAT 2019, Hausfather and Peters 2020, UNEP 2019). However, such projections have high inherent uncertainty (IPCC 2018, Jeffery *et al.* 2018), thus climate indicator values projected under RCP8.5 may continue to prevail beyond the near future. Therefore, based on the status quo, current policies, and uncertainty, we consider it likely that climate indicator values between now and 2100 will be within the collective ranges of those projected under RCPs 8.5, 6.0, and 4.5.

The two most severe threats to *P. meandrina* are ocean warming and ocean acidification, both of which are caused by climate change (Smith 2019a,b). Projections of climate indicator values for ocean warming (sea surface temperature) and ocean acidification (sea surface pH and aragonite saturation state) under RCPs 8.5, 6.0, and 4.5 within the range of *P. meandrina* are described in the following sections. These projections lead to our conclusions about the length of the foreseeable future for ocean warming and ocean acidification that will be applied to the *P. meandrina* 12-month finding.

The Foreseeable Future for Ocean Warming and P. meandrina. Global warming projections under RCPs 8.5, 6.0, and 4.5 over the 21st century, and subsequent ocean warming impacts on *P. meandrina,* are described in NMFS (2020a) and summarized here. AR5's Supplementary Materials (IPCC 2013b,c,d) provide detailed projections of future warming of air over land and sea grid points of the earth's surface under each RCP for the time periods 2016–2035, 2046–2065, and 2081–2100, including regional projections within the range of *P. meandrina.* Warming of seawater at the sea's surface lags behind warming of air at the sea's surface. Although AR5's detailed projections in the Supplementary Materials are for air at the sea's surface, they indicate likely proportional warming of seawater (NMFS 2020a, Fig. 1).

For each RCP (8.5, 6.0, 4.5) and time period (2016–2035, 2046–2065, 2081–2100), AR5 provides global maps of projected annual warming across the earth's surface, as explained in more detail in NMFS (2020a). Projected additional warming above what has already occurred is highest under RCP8.5, intermediate under RCP6.0, and lowest under RCP4.5 (NMFS 2020a, Fig. 2). The ranges of projected warming under the three RCPs overlap with one another, illustrating the high variability in the projections (NMFS 2020a, Fig. 3). Within the range of *P. meandrina,* AR5 provides regional maps of projected annual warming for the eastern Pacific Ocean, the western Indian Ocean, the northern Indian Ocean, the Coral Triangle, northern Australia, and the tropical Pacific. As with the global projections, projected additional warming within the range of *P. meandrina* above what has already occurred is highest under RCP8.5 (2–4 °C), intermediate under RCP6.0 (1–3 °C), and lowest under RCP4.5 (1–2 °C), but with high variability (NMFS 2020a, Figs. 4–9).

Ocean warming can result in the bleaching of the tissues of reef-building coral colonies, including *P. meandrina* colonies, whereby the unicellular photosynthetic algae living within their tissues (zooxanthellae) are expelled in response to stress. For many reef-building coral species, including *P. meandrina,* an increase of only 1 °C–2 °C above the normal local seasonal maximum ocean temperature can induce bleaching. Corals can withstand mild to moderate bleaching; however, severe, repeated, or prolonged bleaching can lead to colony death (Smith 2019a).

The projected responses of reef-building corals to ocean warming in the 21st century under RCPs 8.5, 6.0 and 4.5 have been modeled in several recent papers. An analysis of likely disease outbreaks in reef-building corals resulting from ocean warming projected by RCP8.5 and RCP4.5 concluded that both pathways are likely to cause sharply increased coral disease before 2100 (Maynard *et al.* 2015). An analysis of the timing and extent of Annual Severe Bleaching (ASB) of the world's coral reefs under RCPs 8.5 and 4.5 found that the average timing of ASB would be only 11 years earlier under RCP8.5 (2043) than RCP4.5 (2054; van Hooidonk *et al.* 2016). Similarly, an analysis of the timing and extent of warming-induced bleaching of the world's coral reefs under RCPs 8.5, 6.0, and 4.5 found little difference between the pathways, with 60–100 percent of Indo-Pacific coral reefs experiencing severe bleaching by 2100 under all three pathways (Hoegh-Guldberg *et al.* 2017). A study of the adaptive capacity of a population of the Indo-Pacific reef-building coral *Acorpora hyacinthus* to ocean warming projected that it would go extinct by 2055 and 2080 under RCPs 8.5 and 6.0, respectively, and decline by 60 percent by 2100 under RCP4.5 as a result of warming-induced bleaching (Bay *et al.* 2017). These papers illustrate that the overall projected trends are sharply downward under all three RCPs in terms of ocean warming impacts on Indo-Pacific reef-building corals.

As far as we know, there are no reports that model projected responses of *P. meandrina* to ocean warming in the 21st century under any of the RCPs. As described in the SRR (Smith 2019b), we consider *P. meandrina's* vulnerability to ocean warming in the 21st century to be high, based on observed susceptibility to the ocean warming that has occurred over the past several decades, together with increasing exposure as the oceans continue to warm throughout the remainder of the century. We expect vulnerability of *P. meandrina* to ocean warming to increase in the 21st century as climate change worsens, resulting in higher frequency, severity, and magnitude of warming-induced bleaching events (Smith 2019b).

Based on the available information, we cannot distinguish the likely responses of *P. meandrina* to projected ocean warming under the three RCPs from one another because: (1) All three RCPs project large increases in warming relative to historical rates of change (NMFS 2020a, Fig. 1), especially in the late 21st century (NMFS 2020a, Fig. 2); (2) the ranges of warming projected by each RCP are broad and overlapping with one another (NMFS 2020a, Fig. 3), reflecting high uncertainty; (3) the projections are for warming of air at the sea's surface, but warming of the ocean itself lags behind, reducing distinctions between RCPs; and (4) as has already been documented, there is high spatial variability in how *P. meandrina's* responds to a given warming event, and high temporal variability in how a given *P. meandrina* population responds to multiple warming events over time (Smith 2019b), reflecting high uncertainty in projecting the responses of this species to warming.

The Foreseeable Future for Ocean Acidification and P. meandrina. Ocean acidification projections under RCPs 8.5, 6.0, and 4.5 over the 21st century are described in AR5 (IPCC 2013a), and summarized in NMFS (2020a) for *P. meandrina's* range. Unlike for global warming, AR5 does not include detailed regional comparisons of projected ocean acidification under the different RCPs. Ocean acidification, however, reduces the aragonite saturation state (Ω_{arg}) in seawater by lowering the supersaturation of carbonite minerals including aragonite, the form of calcite that makes up the skeletons of reef-building corals (Smith 2019a).

Under RCP8.5, mean global pH of open surface waters is projected to decline from the 1986–2005 average of approximately 8.12 to approximately 7.77 by 2100, with the greatest reductions in the higher latitude areas of the *P. meandrina's* range, such as the southern Great Barrier Reef (GBR) and the northern Philippines, resulting in Ω_{arg} levels dropping to 1.75–2.5 in open surface waters within most of the species' range by 2090. Under RCP6.0, mean pH is projected to decline to approximately 7.88 by 2100, resulting in Ω_{arg} levels dropping to 2.25–3 within most of the species' range by 2090. Under RCP4.5, mean pH is projected to decline to approximately 7.97 by 2100, resulting in Ω_{arg} levels dropping to 2.75–3.25 within most of the species' range by 2090 (NMFS 2020a, Figs. 10–12).

These general projections are for open surface waters, and are not necessarily representative of nearshore waters, because of multiple physical factors that cause high natural variability in pH of seawater and Ω_{arg} on coral reefs. The projected ocean acidification of open surface waters is expected to eventually result in proportional reductions in seawater pH and Ω_{arg} on coral reefs, but these changes will lag behind open surface waters and be much more variable both spatially and temporally (Smith 2019a). For example, while the Ω_{arg} levels of open surface waters are projected to decline to 1.75–2.5 within most of the range of *P. meandrina* by 2090 (NMFS 2020a, Fig. 12), an analysis of 19 coral reefs in the Indo-Pacific projected Ω_{arg} levels to range from approximately 1.4 to 3.0 at the sites in 2100 (Eyre *et al.* 2018).

As described in more detail in the GSA (Smith 2019a), ocean acidification impacts reef-building corals and coral reef communities in several ways. The reduced Ω_{arg} levels from ocean acidification result in decreased calcification of coral colonies, leading to lower skeletal growth rates and lower skeletal density. Generally, Ω_{arg} should be >3 to enable adequate calcification of reef-building corals, and Ω_{arg} levels of <3 result in reduced calcification. Reduced pH from ocean acidification can also inhibit coral reproduction, leading to lower fertilization, settlement, and recruitment. Reduced Ω_{arg} levels also cause increased dissolution of the calcium carbonate structure of coral reefs, leading to reef erosion rates outpacing accretion rates (Smith 2019a).

The projected responses of reef-building corals and coral reefs to ocean acidification in the 21st century under conditions projected for RCPs 8.5, 6.0 and 4.5 have been reviewed or modeled in several recent papers. A review of laboratory studies on the effects of ocean acidification and ocean warming spanning the entire range of conditions projected under the three RCPs found that RCP8.5 would result in the greatest reduction in calcification (≤20 percent), but that the impacts of different levels of ocean acidification were complicated by species, habitat type, and interactions with warming (Kornder *et al.* 2018). A model of the effects of ocean acidification alone (*i.e.,* without considering the additive effect of ocean warming) projected under RCP8.5 found that the skeletal density of reef-building *Porites* corals is likely to decrease by 20 percent by 2100 (Mollica *et al.* 2018). An analysis of the timing and extent of ocean acidification and ocean warming on the world's coral reefs under the three RCPs found that there would be progressively greater and earlier declines in calcification under RCPs 8.5, 6.0, and 4.5, respectively, over the 21st century. Spatial variability in the projected calcification reductions was very high, especially in the Indo-Pacific (van Hooidonk *et al.* 2014).

As far as we know, there are no reports that model projected responses of *P. meandrina* to ocean acidification in the 21st century under any of the RCPs. As described in the SRR (Smith 2019b), we consider *P. meandrina's* vulnerability to ocean acidification in the 21st century to be high, based on high susceptibility and moderate to high exposure throughout the remainder of the century. We expect vulnerability of *P. meandrina* to ocean acidification to increase in the 21st century as climate change worsens, resulting in reductions in calcification and skeletal growth (Smith 2019b).

Based on the available information, we cannot distinguish the likely responses of *P. meandrina* to projected ocean acidification under the three RCPs from one another because: (1) All three RCPs project worsening ocean acidification and reduced Ω_{arg} levels over the 21st century (NMFS 2020a, Fig. 10–12); (2) the ranges of reduced Ω_{arg} levels projected by each RCP are broad and overlapping with one another (NMFS 2020a, Fig. 12), reflecting high uncertainty; (3) the projections of reduced Ω_{arg} levels vary depending on whether feedbacks are considered (NMFS 2020a, Fig. 12), reflecting additional uncertainty; and (4) the above projections are for open surface waters, but many abiotic and biotic factors cause greater fluctuations and different mean values in pH and Ω_{arg} on coral reefs than in open surface waters, resulting in high spatial and temporal variability in the impacts of ocean acidification on reef-building corals such as *P. meandrina* (Smith 2019b), thereby further blurring the distinctions between projections of the three RCPs.

Foreseeable Future Conclusion. Ocean warming and ocean acidification represent the two greatest threats to *P. meandrina* in the foreseeable future, both of which are caused by climate change. While different levels of ocean warming are projected under RCPs 8.5, 6.0, and 4.5 from now to 2100, the projected impacts of warming-induced bleaching on *P. meandrina* are not clearly distinctive between the RCPs, and all three RCPs result in substantially worsening impacts. Thus, impacts of warming-induced bleaching on *P. meandrina* are reasonably foreseeable to 2100.

Likewise, while different levels of ocean acidification are projected under RCPs 8.5, 6.0, and 4.5 from now to 2100, the projected impacts of reduced Ω_{arg} levels on *P. meandrina* are not clearly distinctive between the RCPs, and all three RCPs result in substantially worsening impacts. Thus, impacts from ocean acidification and reduced Ω_{arg} levels on *P. meandrina* are also reasonably foreseeable to 2100.

Indo-Pacific Reef-Building Corals

Indo-Pacific reef-building corals share many biological characteristics, occupy many similar habitat types, are subject to similar key trends, and are threatened primarily by the same suite of global climate change and local threats. In addition, typically more information is available on the status and trends of reef coral communities (*e.g.,* live coral cover) than species-specific information. Thus, to provide context for determining the status of *P. meandrina,* general information on Indo-Pacific reef-building coral biology, habitats, key trends, and threats is provided in the GSA (Smith 2019a) and summarized below.

Biology and Habitats

Reef-building corals are defined by symbioses with unicellular photosynthetic algae living within their tissues (zooxanthellae), giving them the capacity to grow large skeletons and thrive in nutrient-poor tropical and subtropical seas. Since reef-building corals are defined by their symbiosis with zooxanthellae, they are sometimes referred to as ''zooxanthellate'' or ''hermatypic'' corals. Reef-building corals collectively produce shallow coral reefs over time, but also occur in non-reef and mesophotic areas, both of which are defined in the habitat section below. That is, these species are reef-building, but they are not reef-dependent, thus reef-building corals are not limited to shallow coral reefs (NMFS 2014).

Reef-building corals are marine invertebrates in the phylum Cnidaria that occur as polyps, usually forming colonies of many clonal polyps on a calcium carbonate skeleton. The Cnidaria include true stony corals (class Anthozoa, order Scleractinia, including both reef-building, zooxanthellate and non-reef-building, azooxanthellate species), the blue coral (class Anthozoa, order Helioporacea), and fire corals (class Hydrozoa, order Milleporina). Most reef-building corals form complex colonies made up of a tissue layer of polyps (a column with mouth and tentacles on the upper side) growing on top of a calcium carbonate skeleton, which the polyps produce through the process of calcification (Brainard *et al.* 2011). As of 2019, Veron estimates that 758 species of reef-building corals occur in the Indo-Pacific, over 90 percent of the world's total (Corals of the World, *http://www.coralsoftheworld.org,* November 2019).

Most Indo-Pacific reef-building corals have many biological features that complicate the determination of the status of any given species, including but not necessarily limited to the following: They are modular, colonial, and sessile; the definition of the individual is ambiguous; the taxonomy of many species is uncertain; field identification of species is difficult; each colony is a collection of coral-algae-microbe symbiotic relationships; they have high skeletal plasticity; they utilize a combination of sexual and asexual reproduction; hybridization may be common in many species; and they typically occur as many populations across very large ranges. These and other biological features of Indo-Pacific reef-building corals are described in more detail in the GSA (Smith 2019a).

Indo-Pacific reef-building corals occur on shallow coral reefs (<30 m depth), as well as in non-reef and mesophotic areas (≤30 m depth), in the tropical and sub-tropical waters of the Indian and Pacific Oceans, including the eastern Pacific. This vast region includes over 50,000 islands and over 40,000 km of continental coastline, spanning approximately 180 degrees longitude and 60 degrees latitude, and including more than 90 percent of the total coral reefs of the world. In addition to this region's extensive shallow coral reefs, the Indo-Pacific includes: (1) Abundant non-reef habitat, defined as areas where environmental conditions prevent reef formation by reef-building corals, but some reef-building coral species are present; and (2) vast but scarcely known mesophotic habitat, defined as areas deeper than 30 meters of depth where reef-building corals are present. Shallow coral reefs, non-reef habitat, and mesophotic habitat are not necessarily sharply delineated from one another, thus one may gradually blend into another. The total area of non-reef and mesophotic habitats is likely far greater than the total area of shallow coral reef habitats in the Indo-Pacific (NMFS 2014).

In addition to the biological features described above, there are several habitat features of Indo-Pacific reef-building coral species that should be considered in the determination of the status of any given species including, but not necessarily limited to: (1) Specific substrate and water quality requirements of each life history stage; (2) ranges of many of these species encompass shallow coral reef, non-reef, and mesophotic habitats that vary tremendously across latitude, longitude, depth, distance from land, and in other ways; and (3) physical variability in habitat characteristics within the ranges of these species produces spatial and temporal refuges from threats. That is, habitat heterogeneity and refugia produce a patchy mosaic of conditions across the ranges of Indo-Pacific reef-building corals, which complicates the determination of the status of any given species. These and other habitat features of Indo-Pacific reef-building corals are described in more detail in the GSA (Smith 2019a).

Key Trends

The health of reef-building coral communities is largely determined by the extent of disturbance, together with recovery from it. The most common measure of the condition of Indo-Pacific reef-building corals is live coral cover. Resilience is the capacity of a community to recover from disturbance. Observations and projections of anthropogenic disturbance, recovery time, coral cover, and overall resilience of Indo-Pacific reef-building coral communities provide insight on the status and trends of these communities.

The main threats to Indo-Pacific reef-building corals are acute and chronic anthropogenic disturbances, most of which have been increasing over the last half-century or more. In particular, warming-induced coral bleaching events are acute disturbances that have been increasing in frequency, severity, and magnitude over the last several decades, especially since 2014. Other disturbances of Indo-Pacific coral reef communities are chronic, such as ocean acidification because of its continual effects on both coral calcification and reef accretion, and localized land-based sources of pollution and coral disease outbreaks. Both acute and chronic anthropogenic disturbances are broadening and worsening on coral reefs near human populations throughout the Indo-Pacific, and all anthropogenic disturbances of Indo-Pacific coral reefs are projected to worsen throughout the foreseeable future (Smith 2019a,b).

Studies of the recovery of Indo-Pacific reef-building corals (excluding the eastern Pacific) show that the majority of sites showed significant recovery from, or resistance to, anthropogenic disturbance over the latter part of the 20th century and early part of the 21st century (Tables 1a and 1b, Smith 2019a). The available information does not indicate that the capacity for recovery of Indo-Pacific reef-building corals has substantially declined. However, due to increased frequency of disturbance, the amount of time available for corals to recover has declined. Furthermore, since the frequency of disturbance is projected to increase as climate change worsens, recovery time is projected to continue to decrease throughout the foreseeable future (Smith 2019a,b).

The available information clearly indicates that mean coral cover has declined across much of the Indo-Pacific since the 1970s (Tables 2 and 3, Smith 2019a), and likely many decades before then in some locations. High spatial and temporal variability influenced by a large number of natural and anthropogenic factors can mask the overall trend in coral cover, but long-term monitoring programs and meta-analyses demonstrate downward temporal trends in most of the Indo-Pacific. Because disturbance is projected to increase in frequency throughout the foreseeable future (Smith 2019a,b), and this is expected to result in reduced recovery times, mean coral cover in the Indo-Pacific is also projected to decrease, especially as climate change worsens (Smith 2019a).

Despite increasing disturbance, decreasing recovery times, and decreasing coral cover, the available information suggests that overall resilience of Indo-Pacific reef-building corals remains quite high because: (1) Observed impacts of disturbances on corals have been spatially highly variable due to habitat heterogeneity; (2) factors that confer resilience (high habitat heterogeneity, large ecosystem size, high coral and reef fish species diversity) have not declined; (3) observed responses of corals to disturbances indicate that most either recovered or were resistant; and (4) observed responses of corals to disturbances indicate that phase shifts have so far been either rare or reversed. However, the trends in disturbance, recovery time, and coral cover are projected to worsen with climate change, thus overall resilience is also projected to decrease throughout the foreseeable future (Smith 2019a,b).

Threats

We consider global climate change-related threats of ocean warming, ocean acidification, and sea-level rise, and the local threats of fishing, land-based sources of pollution, coral disease, predation, and collection and trade, to be the most important to the extinction risk of Indo-Pacific reef-building corals currently and throughout the foreseeable future. The most important of these is ocean warming. In addition, five lesser global and local threats are also described (changes in ocean circulation, changes in tropical storms, human-induced physical damage, invasive species, and changes in salinity). The interactions of threats with one another could be significantly worse than any individual threat, especially as each threat grows. Each threat, and the interactions of threats, are described both in terms of observed effects since relevant scientific information became available (usually mid-20th century), and projected effects throughout the foreseeable future (Smith 2019a,b).

The effects of most threats to Indo-Pacific reef-building corals have already been observed to be worsening, based on the monitoring results and the scientific literature. Ocean warming in conjunction with the other threats have recently resulted in the worst impacts to Indo-Pacific reef-building corals ever observed. These impacts are further described in terms of increasing disturbance, less time available for recovery, decreasing coral cover, and decreasing resilience in the trends section above. All threats are projected to worsen throughout the foreseeable future (Smith 2019a,b), based on the scientific literature, climate change models, and other information such as human population trends in the Indo-Pacific.

Summary for Indo-Pacific Reef-Building Corals

Indo-Pacific reef-building corals are a diverse group (≈760 species) with many biological features that complicate the determination of the status of any given species. These species occur in vast and diverse habitats including shallow coral reefs, non-reef areas, and mesophotic areas throughout the Pacific and Indian Oceans. Key observed trends include increasing anthropogenic disturbances, decreasing recovery time, and decreasing live coral cover, while overall resilience remains high. However, all trends are projected to worsen throughout the foreseeable future (Smith 2019a,b). Community trends do not necessarily represent individual species trends, but they provide valuable context that inform investigations of the status of species within the community such as *P. meandrina.*

Pocillopora meandrina Status Review

This status review of *P. meandrina* is based on the methodology provided in the ''Guidance on Responding to Petitions and Conducting Status Reviews under the Endangered Species Act'' (NMFS 2017): An overall extinction risk assessment of the species is based on dual assessments of its demographic risk factors (distribution, abundance, productivity, diversity) and a threats evaluation. Thus, the *P. meandrina* SRR (Smith 2019b) covers introductory information (biology, habitat), demographic risk factors, threats evaluation, and extinction risk assessment, which are summarized below.

Biology and Habitats

Pocillopora meandrina was described by James Dana from specimens collected in Hawai'i (Dana 1846a, b), thus the formal scientific name is ''*Pocillopora meandrina,* Dana 1846''. Morphologically, *P. meandrina* colonies are small upright bushes, with branches radiating from the initial point of growth. Adult colonies are commonly 20–40 cm (8–16 in) in diameter, with branches radiating from the initial point of growth. Coloration is typically light brown or cream, but may also be green or pink (Fenner 2005, Corals of the World website,*http://www.coralsoftheworld.org,* accessed November 2019).

Taxonomic uncertainty refers to how a species should be scientifically classified. Taxonomic uncertainty appears to be lower for *P. meandrina* than some other *Pocillopora* species, and available information supports the conclusion that *P. meandrina* is a valid species. Whereas taxonomic uncertainty refers to how a species should be scientifically classified, species identification uncertainty refers to how a species should be identified in the field. We do not believe that species identification uncertainty for *P. meandrina* affects the quality of the information used in this status review. The taxonomic and species identification uncertainty for *P. meandrina* are described in detail in the SRR (Smith 2019b).

As with most other reef-building corals, *P. meandrina* is modular (the primary polyp produces genetically-identical secondary polyps or ''modules'') and colonial (the polyps aggregate to form a colony). The primary and secondary polyps are connected seamlessly through both tissue and skeleton into a colony. A colony can continue to exist even if numerous polyps die, the colony is broken apart, or otherwise damaged (Smith 2019a,b). Under the ESA, the ''physiological colony'' (Hughes 1984), defined as any colony of the species whether sexually or asexually produced, is considered an individual for reef-building colonial coral species such as *P. meandrina* (NMFS 2014).

Reef-building corals like *P. meandrina* build reefs because they are sessile (the colony is attached to the substrate), secreting their own custom-made substrates which grow into skeletons, providing the primary building blocks for coral reef structure. One of the most important aspects of sessile life history for consideration of extinction risk is that colonies cannot flee from unfavorable environmental conditions, thus must have substantial capacity for acclimatization to the natural variability in environmental conditions at their location. Likewise, since *P. meandrina* populations are distributed throughout a large range with environmental conditions that vary by latitude, longitude, proximity to land, etc., the populations must have substantial capacity for adaptation to the natural variability in environmental conditions across their ranges (Smith 2019a,b).

Reef-building corals like *P. meandrina* act as plants during the day by utilizing photosynthesis (autotrophic feeding), and they act as animals during the night by utilizing predation (heterotrophic feeding). Autotrophic feeding is accomplished via symbiosis with unicellular photosynthetic algae living within the host coral's tissues (zooxanthellae). The host coral benefits by receiving fixed organic carbon and other nutrients from the zooxanthellae, and the zooxanthellae benefit by receiving inorganic waste metabolites from the coral host as well as protection from grazing. This exchange of nutrients allows both partners to flourish and helps the host coral secrete calcium carbonate that forms the skeletal structure of the coral colony. Heterotrophic feeding is accomplished by extending their nematocyst-containing tentacles to sting and capture zooplankton (Smith 2019a,b).

Pocillopora meandrina reproduces both sexually and asexually. Sexual reproduction is by broadcast spawning, and asexual reproduction is by fragmentation. The larvae of *P. meandrina* disperse by swimming, drifting, or rafting, providing the potential for high dispersal. The larvae readily recruit to both natural and artificial hard surfaces. Like many branching coral species, *P. meandrina* has high skeletal growth rates relative to most other Indo-Pacific reef-building coral species (Smith 2019b). *Pocillopora meandrina* has been classified as a competitive species, based on its broadcast spawning, rapid skeletal growth, and branching colony morphology, which allow it to recruit quickly to available substrate and successfully compete for space (Darling *et al.* 2012). More information about *P. meandrina'*s reproduction, dispersal, recruitment, and growth is provided in the Productivity portion of the Demographic Factors section, and in the SRR (Smith 2019b).

The preferred habitat of *P. meandrina* is high energy reef crests and upper reef slopes. In Hawai'i where there are relatively few other coral species to compete with, *P. meandrina* dominates such high energy habitat to the extent that it has been termed the ''*P. meandrina* zone'' (Dollar 1982). The species is abundant in other types of high energy habitats, including non-reef habitats like lava bedrock, and unconsolidated rocks and boulders. The species also occurs in lower abundances in most other habitats where reef-building corals are found, such as middle and lower reef slopes, back-reef areas such as reef flats and patch reefs, and atoll lagoons. In addition, *P. meandrina* can be one of the most common corals found on artificial substrates, such as concrete structures and metal buoys. Although much more common in shallow water, *P. meandrina* occurs at depths of >30 m (98 ft; Smith 2019b).

In summary, several characteristics of *P. meandrina'*s biology and habitat moderate its extinction risk. As with most other reef-building corals, *P. meandrina* occurs as colonies of polyps that can continue to exist even if numerous polyps die, the colony is broken apart, or otherwise damaged. Since colonies are sessile, they cannot flee from unfavorable environmental conditions, thus must have substantial capacity for acclimatization and adaptation to the natural variability in environmental conditions at their location. In addition, *P. meandrina* has a high capacity to successfully compete for space with other reef-building corals, especially following disturbances when it is often one of the first coral species to colonize denuded substrates. With regard to habitat, it is most abundant in high energy habitats with strong currents and constant wave action such as reef crests and upper reef slopes throughout its range, but is also found on deeper reef slopes, back-reef areas, lava, boulders, and artificial substrates (Smith 2019b).

Demographic Factors

In order to determine the extinction risk of species being considered for ESA listing, NMFS uses a demographic risk analysis framework that considers the four demographic factors of distribution, abundance, productivity, and diversity (NMFS 2017). Each demographic risk factor is described for *P. meandrina* below.

Distribution. Pocillopora meandrina is found on most coral reefs of the Indo-Pacific and eastern Pacific, with its range encompassing >230° longitude from the western Indian Ocean to the eastern Pacific Ocean, and ≈60° latitude from the northern Ryukyu Islands to central western Australia in the western Pacific, and the Gulf of California to Easter Island in the eastern Pacific. Distribution of *P. meandrina* is summarized here in terms of geographic distribution across the Indo-Pacific area, as well as depth distribution, based on the detailed descriptions in the SRR (Smith 2019b).

The Corals of the World website (*http://www.coralsoftheworld.org*) provides comprehensive range information for all 758 currently known Indo-Pacific reef-building corals, based on presence/absence in 133 Indo-Pacific ecoregions. As of February 2019, the website showed *P. meandrina* as present in 91 of the 133 ecoregions, from Madagascar in the western Indian Ocean to the Pacific coast of Colombia, and from southern Japan to the southern Great Barrier Reef (GBR) in Australia (Fig. 2, Smith 2019b). In addition, we found information confirming *P. meandrina* in four ecoregions in the southeastern and eastern Pacific, including the Austral Islands, the Tuamotu Archipelago, the Marquesas Islands, and Clipperton Atoll. Therefore, these 95 ecoregions are considered to be the current, known range of *P. meandrina.* There is no evidence of any reduction in its range due to human impacts, thus we consider its historic and current ranges to be the same (Smith 2019b).

Although *P. meandrina* is usually more common at depths of <5 m (16 ft) than in deeper areas, its habitat breadth encompasses most habitats found on coral reefs and non-reef habitat between the surface and >30 m (98 ft) of depth. For example, in a transect from 8 m (26 ft) to 36 m (118 ft) depth on Fanning Island in Kiribati surveyed in the early 1970s, colonies of *P. meandrina* were recorded at 31 m (102 ft) and 34 m (112 ft). Maximum cover of *P. meandrina* on the transect was at 10 m (33 ft), where it made up 25 percent of live coral cover. The cover of *P. meandrina* may have been even greater at depths <8 m, but those shallower areas were not surveyed (Maragos 1974). Observations of *P. meandrina* elsewhere also indicate that the species sometimes occurs at 30 m (98 ft) or deeper (Smith 2019b). Based on this information, we consider the depth range of *P. meandrina* from the surface to at least 34 m (112 ft).

We conclude that *P. meandrina'*s distribution is very large and stable. The geographic distribution of *P. meandrina* encompasses >230° longitude and ≈60° latitude, and includes 95 of the 133 Indo-Pacific ecoregions, giving it a larger range than about two-thirds Indo-Pacific reef-building coral species. Although *P. meandrina* is usually more common at depths of <5 m (16 ft) than in deeper areas, its depth range is from the surface to at least 34 m (112 ft). There is no evidence of any reduction in its range due to human impacts, and we consider its historic and current ranges to be the same (Smith 2019b).

Abundance. Three types of abundance information are summarized below for *P. meandrina* from ecoregions for which information is available: (1) Relative abundances from 65 ecoregions; (2) absolute abundances from eight ecoregions; and (3) abundance trends from 10 ecoregions. With regard to relative abundances, in the 65 ecoregions for which information is available, it is dominant in seven, common in 18, uncommon in 36, and rare in four ecoregions (Fig. 3, Smith 2019b). The majority of *P. meandrina'*s ecoregions are in the western Pacific and the Indian Oceans, where it has an intermediate level of abundance (common or uncommon; DeVantier and Turak 2017). It is a very common species in many of the *Pocillopora*-dominated reef coral communities of the central Pacific. While coral reef communities of the eastern Pacific are also *Pocillopora*-dominated, *P. meandrina* is one of the less common *Pocillopora* species in much of that area. It is only rare around the fringes of its range (Smith 2019b).

With regard to absolute abundance, we estimate *P. meandrina'*s total population is at least several tens of billions of colonies. The estimated total population for the eight ecoregions (four entire ecoregions and portions of four others) within U.S. waters in 2012–2018 was 1.48 billion colonies (Table 3, Smith 2019b). U.S. waters make up approximately 1 percent of the species' range, but relative abundances are higher in some of the ecoregions within U.S. waters (especially the main Hawaiian Islands) than most of the rest of the species' range. We base our estimate of *P. meandrina'*s total population on estimated population abundance of *P. meandrina* in U.S. waters (1.48 billion colonies), the proportion of the species' range within U.S. waters (≈1 percent), and the assumption that the population density of *P. meandrina* is lower in foreign waters than U.S. waters (Smith 2019b).

With regard to abundance trends, in the 10 ecoregions for which time-series abundance data or information are available, abundance of *P. meandrina* appears to be decreasing in five ecoregions and stable in five ecoregions. The abundance of *P. meandrina* has decreased by over 90 percent since 1975 in the Chagos Archipelago Ecoregion, by approximately 70 percent since 1999 in the Main Hawaiian Islands Ecoregion, and appears to have also decreased by an undeterminable amount in the Marianas Islands, Northwestern Hawaiian Islands, and Galapagos Islands Ecoregions. In contrast, based on the abundance data and information, *P. meandrina* abundance appears to be relatively stable in the GBR Far North, GBR North-central, Samoa-Tuvalu-Tonga, Society Islands, and Mexico West Ecoregions (Smith 2019b).

We conclude that *P. meandrina'*s overall abundance is very high, but its overall abundance trend is unknown. Abundance is very high because (1) the relative abundance results indicate that *P. meandrina* is dominant or common in about one-third of its very large range; and (2) the absolute abundance results show that the U.S. population alone (which makes up only ≈1 percent of the species' range) is approximately 1.48 billion colonies. Because we only have abundance trend data or information from 10 of the 95 ecoregions, the trend in *P. meandrina'*s overall abundance is unknown. Of the 10 ecoregions for which abundance trend data or information are available, *P. meandrina'*s abundance appears to be decreasing in five ecoregions, and relatively stable in five ecoregions (Smith 2019b).

Productivity. Productivity refers to the overall population growth rate of *P. meandrina* in all 95 ecoregions combined. The most important factors influencing *P. meandrina'*s productivity (reproduction, dispersal, recruitment, growth, and adaptability) provide a qualitative indication of its productivity. The species has high reproductive capacity, which helps it outcompete other coral species, especially in response to disturbances. It also has the potential for broad pelagic dispersal of larvae, either by swimming, drifting, or rafting; the latter refers to settlement of larvae on natural or artificial flotsam which then carries the coral to permanent settlement habitat (Smith 2019b). Recruitment of *P. meandrina* has been studied in Hawai'i, where it has been shown to be the most successful coral species at colonizing new substrates, such as fresh lava flows on the Big Island (Grigg and Maragos 1974). The species also recruits unusually well to a variety of artificial substrates, including metal, concrete, and PVC pipe (Smith 2019b). Like many branching coral species, *P. meandrina* has high skeletal growth rates relative to most other Indo-Pacific reef-building coral species (Jokiel and Tyler 1992). Unlike most other reef corals, typical colonies of *P. meandrina* stop growing at around 40 cm (16 in) in diameter, and the species has a relatively short life span compared to other corals (Coles and Brown 2007). The high recruitment, rapid growth, and short life span of *P. meandrina* result in rapid turnover of the population at a given location (Smith 2019b).

Rapid turnover of *P. meandrina* populations provide capacity to adjust to changing conditions (adaptability) because the most resistant genotypes survive disturbances like bleaching events, then reproduce relatively quickly to claim open substrate. The high reproductive capacity, broad dispersal, high recruitment, rapid skeletal growth, and adaptability of *P. meandrina* allow it to pioneer available substrate and successfully compete for space (Coles and Brown 2007, Darling *et al.* 2012). These life history characteristics of *P. meandrina* provide buffering against threats such as warming-induced bleaching by providing the potential for rapid recovery from die-offs. High reproductive capacity, broad dispersal, high recruitment, rapid skeletal growth, and adaptability are all characteristics of high productivity, *i.e.,* they all positively affect population growth rate. Thus, we consider *P. meandrina'*s productivity to be high. Also, *P. meandrina* has made strong recoveries in recent years from various types of disturbances at multiple locations throughout its range, displacing less competitive coral species and becoming more abundant than before the disturbances (*e.g.,* GBR, Society Islands). These recoveries demonstrate continued high productivity, thus we consider *P. meandrina'*s productivity to be stable (Smith 2019b).

We conclude that *P. meandrina'*s productivity is both high and stable. The high reproductive capacity, broad dispersal, high recruitment, rapid skeletal growth, and adaptability of *P. meandrina* are all characteristics of high productivity, *i.e.,* they all positively affect population growth rate. In addition, *P. meandrina'*s abundance has remained stable in recent years in half the ecoregions (5/10) where information is available, whether there have been disturbances or not (Smith 2019b).

Diversity. Diversity includes both the diversity of genotypes (*i.e.,* the genetic constitution of an individual) and phenotypes (*i.e.,* the observable characteristics of an individual) within a population. Genotypic diversity is defined as the numbers of genotypes present in a population. Phenotypic diversity is defined as the numbers of phenotypes present in a population, and is affected by both genotype and environmental factors (Smith 2019b). Robust populations have higher levels of genotypic and phenotypic diversity. Although there is little information available on the diversity of *P. meandrina,* the few species-specific studies that are available show high genotypic (Magalon *et al.* 2005; Dr. Rob Toonen, personal communication) and phenotypic (Hughes *et al.* 2018, Muir *et al.* 2017) diversity within portions of individual ecoregions.

The spatial and temporal habitat heterogeneity of *P. meandrina'*s range is very high, contributing to the maintenance of high phenotypic diversity for the species. Phenotypic diversity can be maintained by spatial and temporal variation in habitat characteristics, because variable environmental factors result in the expression of different phenotypes. As described above, *P. meandrina* occurs in 95 ecoregions, and has a depth range of at least 0–34 m (112 ft). The spatial variation in *P. meandrina'*s habitats is very high due to the habitat heterogeneity of its range. In addition, these habitats are exposed to a great deal of temporal variation in conditions on diurnal, lunar, seasonal, and decadal timescales. The broad geographic and depth distribution of *P. meandrina* includes nearly the entire range of habitats for Indo-Pacific reef-building corals (Smith 2019).

We conclude that *P. meandrina'*s diversity is both high and stable. Although there is little information available on the genotypic and phenotypic diversity of *P. meandrina,* the evidence summarized above suggests that both types of diversity are high for this species, mainly because of its large distribution and habitat heterogeneity. Furthermore, the species' distribution has not been reduced, and abundance has not declined in half of the ecoregions for which information is available.

Demographic Factors Conclusion. The distribution, abundance, productivity, and diversity of *P. meandrina* substantially moderate its extinction risk. The geographic distribution of *P. meandrina* includes 95 of the 133 Indo-Pacific coral reef ecoregions, giving it a very large range. While *P. meandrina* is most commonly found in shallow, high-energy habitats such as reef crests and shallow forereefs, its depth distribution extends from the surface to at least 34 m (112 ft). Because of its broad geographic and depth distributions, *P. meandrina* occurs in many different types of habitats, from shallow to deep, high to low latitudes, offshore to inshore, and so on. These different habitat types provide different environmental conditions in response to any given disturbance, ensuring that some populations will be less affected than others, thereby moderating extinction risk (Smith 2019b).

The relative abundance of *P. meandrina* varies substantially across its range, from one of the most dominant reef-building coral species in the low-diversity coral reef communities of the central Pacific, to an uncommon species in the high-diversity coral reef communities of the Coral Triangle and surrounding areas. It is a dominant or common species in 25 of its 95 ecoregions. The absolute abundance of *P. meandrina* is estimated as at least several tens of billions of colonies. In the 10 ecoregions for which abundance trend information is available, *P. meandrina* appears to be decreasing in five ecoregions, and stable in five ecoregions. Because we only have abundance trend information from 10 of the 95 ecoregions, the trend in *P. meandrina'*s overall abundance is unknown. Despite declining abundance in some ecoregions, the species' abundance moderates extinction risk by providing tens of billions of colonies distributed across many ecoregions that can replenish reefs depleted by disturbance (Smith 2019b).

The high reproductive capacity, broad dispersal, high recruitment, rapid skeletal growth, and adaptability of *P. meandrina* are all characteristics of high productivity, *i.e.,* they all positively affect population growth rate. Such high productivity moderates extinction risk by providing the potential for rapid recovery from die-offs, as documented in some of its 95 ecoregions (Smith 2019b).

Genetic studies show high genotypic diversity in *P. meandrina* on small geographic scales (*e.g.,* one island), and genotypic diversity is likely even higher within individual ecoregions, l*et al*one across the 95 ecoregions that make up the range of the species. Studies of the responses of *P. meandrina* to elevated seawater temperatures show high phenotypic diversity in multiple locations. Such high diversity moderates extinction risk by providing the capacity to adapt to changing local conditions (Smith 2019b).

Threats Evaluation

Section 4(a)(1) of the ESA and NMFS' implementing regulations (50 CFR part 424) state that the agency must determine whether a species is endangered or threatened because of any one or a combination of the following five factors: (A) Present or threatened destruction, modification, or curtailment of habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence. Based on the 2011 SRR (Brainard *et al.* 2011), the 2014 final coral listing rule (NMFS 2014), and the GSA (Smith 2019a), there are 10 main types of threats to Indo-Pacific reef-building corals, including *P. meandrina,* currently and in the foreseeable future: Ocean warming, ocean acidification, sea-level rise, fishing, land-based sources of pollution, coral disease, predation, collection and trade, a group of secondary threats (weakening ocean currents, increasing tropical storms, physical damage, invasive species, and changes in salinity), and the interactions of threats. The inadequacy of existing regulatory mechanisms is an important influence on the threats, and thus is also described in this section.

The observed and projected trends of each threat, as well as the vulnerability of *P. meandrina* to each threat, are described. Vulnerability of a species to a threat is a function of susceptibility and exposure, considered at the appropriate spatial and temporal scales. The spatial scale is the 95 ecoregions that make up the current range of *P. meandrina* (Fig. 2, Smith 2019b), and the temporal scale is the foreseeable future (now to 2100). Susceptibility refers to the response of *P. meandrina* colonies to the adverse conditions produced by the threat. Exposure refers to the degree to which *P. meandrina* colonies are likely to be subjected to the threats throughout its range, thus the overall vulnerability of a coral species to threats depends on the proportion of colonies that are exposed to the threats. A species may not necessarily be highly vulnerable to a threat even when it is highly susceptible to the threat, if exposure is low. Consideration of the appropriate spatial and temporal scales is particularly important, because of potential high variability in threats both spatially over *P. meandrina's* large range, and temporally over the 21st century (NMFS 2014).

Ocean Warming (Factor E). As described in the GSA (Smith 2019a) and NMFS (2020a), the available information regarding ocean warming and Indo-Pacific reef-building corals including *P. meandrina* leads to the following conclusions about this threat: (1) Substantial ocean warming, including in the tropical/subtropical Indo-Pacific, has already occurred and continues to occur; (2) ocean warming, including in the tropical/subtropical Indo-Pacific, is projected to continue at an accelerated rate under RCPs 8.5, 6.0, and 4.5 throughout the foreseeable future; (3) substantial warming-induced mass bleaching of Indo-Pacific reef coral communities has already occurred and continues to occur; (4) warming-induced mass bleaching of Indo-Pacific reef coral communities is projected to rapidly increase in frequency, intensity, and magnitude under RCPs 8.5, 6.0, and 4.5 throughout the foreseeable future; and (5) coral reefs will be severely affected by such warming (Smith 2019a, NMFS 2020a).

The vulnerability of *P. meandrina* to ocean warming is summarized here in terms of its susceptibility and exposure to this threat, based on information in the SRR (Smith 2019b). Genus-level surveys of warming-induced bleaching susceptibility have found that *Pocillopora* species can be among the more susceptible of reef-building corals. Species-level studies and observations of *P. meandrina* at many locations recorded high susceptibilities to the 1998, 2014–17, and other bleaching events (Sheppard *et al.* 2017, Smith 2019b). However, studies and observations of *P. meandrina* have also recorded resistance to warming-induced bleaching at many locations throughout the species' range, or that bleached colonies recovered readily (Muir *et al.* 2017, Hughes *et al.* 2018, Smith 2019b). Thus, we consider the overall susceptibility of *P. meandrina* to ocean warming to be moderate to high (Smith 2019b). Exposure of colonies of *P. meandrina* to ocean warming varies spatially with latitude, depth, habitat type, and other spatial factors (*e.g.,* windward vs. leeward sides of islands), and temporally with tidal, diurnal, seasonal, and decadal cycles (Smith 2019b). However, as described in the GSA and summarized above, several factors suggest that *P. meandrina's* exposure to ocean warming is already quite high, and rapidly increasing. Thus we consider exposure of *P. meandrina* to ocean warming to be high. We consider the current vulnerability of *P. meandrina* to ocean warming to be high, based on moderate to high susceptibility combined with high exposure. We expect vulnerability of *P. meandrina* to ocean warming to increase throughout the foreseeable future as climate change worsens, resulting in higher frequency, severity, and magnitude of warming-induced bleaching events (Smith 2019a,b, NMFS 2020a).

Ocean Acidification (Factor E). As described in the GSA (Smith 2019a) and NMFS (2020a), the available information regarding ocean acidification and Indo-Pacific reef-building corals including *P. meandrina* leads to the following conclusions about this threat: (1) Ocean acidification has already occurred in the tropical/subtropical Indo-Pacific and continues to occur; (2) ocean acidification, including in the tropical/subtropical Indo-Pacific, is projected to continue at an accelerated rate under RCPs 8.5, 6.0, and 4.5 throughout the foreseeable future; (3) ocean acidification has already affected Indo-Pacific reef-building coral communities by reducing calcification rates and subsequent effects on skeletal growth (reduced growth rates and skeletal densities) of corals, and by increasing erosion of coral reefs; and (4) the effects of ocean acidification on Indo-Pacific reef-building coral communities are projected to steadily increase under RCPs 8.5, 6.0, and 4.5 throughout the foreseeable future by reducing coral calcification, increasing reef erosion, impacting coral reproduction, reducing reef coral diversity, and simplifying coral reef communities (Smith 2019a, NMFS 2020a).

The vulnerability of *P. meandrina* to ocean acidification is summarized here in terms of its susceptibility and exposure to this threat, based on information in the SRR (Smith 2019b). Some studies have found that ocean acidification reduces calcification and skeletal growth rates of *P. meandrina* and other *Pocillopora* species (Muehllehner and Edmunds 2008, Fabricius *et al.* 2011), while others have found that *Pocillopora* species have some capacity to resist the effects of ocean acidification (Comeau *et al.* 2014, Putnam *et al.* 2013). The currently available information does not indicate that *P. meandrina* or other *Pocillopora* species have the capacity to acclimatize to, adapt to, or resist the effects the levels of ocean acidification expected in the foreseeable future (Smith 2019b). Exposure of *P. meandrina* colonies to ocean acidification will likely continue to be highly variable, but also likely to increase throughout the foreseeable future because of the projected increase in ocean acidification, as described in the GSA (Smith 2019b). We consider the current vulnerability of *P. meandrina* to ocean acidification to be high, based on high susceptibility combined with highly variable exposure. We expect vulnerability of *P. meandrina* to ocean acidification to increase throughout the foreseeable future as climate change worsens, resulting in higher severity and magnitude of ocean acidification (Smith 2019a,b).

Sea Level Rise (Factor E). As described in the GSA (Smith 2019a), the available information regarding sea-level rise and Indo-Pacific reef-building corals including *P. meandrina* leads to the following conclusions about this threat: (1) Sea-level rise has already occurred and continues to occur globally; (2) sea-level rise in parts of the tropical/subtropical Indo-Pacific has been approximately three times the global rate; (3) sea-level rise projected under RCP8.5 for the 21st century will exceed recent rates both globally and in the Indo-Pacific; (4) the effects of sea-level rise to date on Indo-Pacific reef-building corals are complex, with no clear trend yet apparent; and (5) the effects of sea-level rise on Indo-Pacific reef coral communities are projected to steadily increase and broaden under RCP8.5 throughout the foreseeable future (Smith 2019a).

The vulnerability of *P. meandrina* to sea level rise is summarized here in terms of its susceptibility and exposure to this threat, based on information in the SRR (Smith 2019b). We consider the susceptibility of *P. meandrina* to sea level rise to be low. As far as we know, there is no species-specific information available on the susceptibility of *P. meandrina* to sea level rise. Reef-building corals that are unable to keep up with rising sea levels, unable to settle on newly available substrates, and occur in nearshore habitats such as reef flats, would be the most susceptible to sea level rise (Smith 2019a). As described in the SRR (Smith 2019b), *P. meandrina* is a colonizing species that readily settles on newly available substrates, has relatively rapid skeletal growth, and occurs primarily on reef crests and shallow forereefs (not reef flats). Exposure of *P. meandrina* colonies to sea-level rise will likely continue to be highly variable, but also likely to increase throughout the foreseeable future (Smith 2019a,b). We consider the current vulnerability of *P. meandrina* to sea-level rise to be low, based on low susceptibility combined with highly variable exposure. We expect vulnerability of *P. meandrina* to sea-level rise to increase throughout the foreseeable future as climate change worsens, resulting in higher severity and magnitude of sea-level rise (Smith 2019a,b).

Fishing (Factor A). As described in the GSA (Smith 2019a), the available information regarding fishing and Indo-Pacific reef-building corals including *P. meandrina* leads to the following conclusions about this threat: (1) Direct effects of fishing, namely damage from fishing gears and methods used in food fish and marine aquarium fisheries, have been observed in much of the Indo-Pacific; (2) indirect effects, or the trophic effects of fishing, have not been observed in the Indo-Pacific as they have in the Caribbean; and (3) both direct and indirect effects of fishing are projected to increase in the Indo-Pacific throughout the foreseeable future (Smith 2019a).

The vulnerability of *P. meandrina* to fishing is summarized here in terms of its susceptibility and exposure to this threat, based on information in the SRR (Smith 2019b). We consider the susceptibility of *P. meandrina* to the direct and indirect effects of fishing to be moderate. Direct effects include entanglement, abrasion, and breakage by fishing line and other gear where fishing pressure is high, such as in the main Hawaiian Islands (Asoh *et al.* 2004). However, *P. meandrina* populations remain high in areas that have been heavily fished for many decades (Smith 2019b). While exposure of *P. meandrina* to fishing is high in certain areas, it is low to none in a large proportion of the species' range, resulting in low exposure overall. Much of *P. meandrina's* range occurs in remote areas that are difficult to reach by fishers, or in marine protected areas where fishing is restricted or banned. In addition, *P. meandrina* is found primarily on reef crests and upper reef slopes, where constant wave action discourages human access and fishing (Smith 2019b). We consider the current vulnerability of *P. meandrina* to fishing to be low to moderate, based on moderate susceptibility combined with low exposure. We expect vulnerability of *P. meandrina* to fishing to increase throughout the foreseeable future as the human population and fishing pressure increase (Smith 2019a,b).

Land-Based Sources of Pollution (Factor A). Land-based sources of pollution (LBSP) refers to turbidity, sediment, nutrients, contaminants, and other types of pollution affecting reef-building corals that originate from coastal development, urbanization, agriculture, and other human activities on land. The many different forms of LBSP collectively affect all life history stages of reef-building corals in numerous ways. As described in the GSA (Smith 2019a), based on the available information regarding the effects of LBSP on Indo-Pacific reef-building corals, we conclude that: (1) Effects of LBSP have been observed in much of the Indo-Pacific, namely impacts on coral growth, reproduction, and survival in areas with the highest levels of pollution; and (2) such effects are projected to increase in much of the Indo-Pacific throughout the foreseeable future (Smith 2019a).

The vulnerabilities of *P. meandrina* to turbidity, sediment, nutrients, and contaminants are summarized here in terms of its susceptibility and exposure to this threat. Based on the information described in the SRR (Smith 2019b), we consider the susceptibilities of *P. meandrina* to be low for turbidity, moderate for sediment and nutrients, and high for contaminants. We consider *P. meandrina's* overall susceptibility to all LBSP combined to be moderate (Smith 2019b). Exposure of colonies of *P. meandrina* to LBSP is likely high in areas subject to intense coastal development, urbanization, agriculture, and other human activities on land. However, some of *P. meandrina's* range is far from human activities on land (*e.g.,* uninhabited atolls, islands, barrier reefs, etc.), also limiting exposure. Thus, exposure of *P. meandrina* to LBSP is high in some areas, but low to none in a large proportion of the species' range, resulting in low exposure overall (Smith 2019b). We consider the current vulnerability of *P. meandrina* to LBSP to be low to moderate, based on moderate overall susceptibility combined with low overall exposure. We expect vulnerability of *P. meandrina* to LBSP to increase throughout the foreseeable future as the human population and coastal development increase (Smith 2019a,b).

Coral Disease (Factor C). As described in the GSA (Smith 2019a), the available information regarding diseases of Indo-Pacific reef-building corals including *P. meandrina* leads to the following conclusions about this threat: (1) Coral diseases and subsequent mortalities of Indo-Pacific reef-building corals are being increasingly observed, and while quantifiable temporal trends are lacking, the environmental stressors that lead to coral diseases (especially ocean warming) have clearly increased; and (2) environmental stressors that lead to coral diseases are projected to increase sharply in the Indo-Pacific under RCP8.5 throughout the foreseeable future, thus coral diseases and subsequent coral mortalities are also likely to increase (Smith 2019a).

The vulnerability of *P. meandrina* to coral disease is summarized here in terms of its susceptibility and exposure to this threat, based on information in the SRR (Smith 2019b). Studies of coral disease in the Hawaiian Islands have consistently found *P. meandrina* to have low susceptibility to disease (Aeby 2006, Aeby *et al.* 2009). Furthermore, genus and family level information from Hawaii and elsewhere in the Indo-Pacific indicate low susceptibilities of *Pocillopora* and Pocilloporidae to coral disease relative to other reef-building corals (Brainard *et al.* 2012, Ruiz-Moreno *et al.* 2012). Exposure of colonies of *P. meandrina* to coral disease depends on exposure to other threats, especially ocean warming and LBSP. As noted above, exposure of *P. meandrina* to ocean warming and LBSP is highly variable across the species' range, but for different reasons. Exposure to both threats is expected to increase throughout the foreseeable future. Thus, *P. meandrina's* exposure to coral disease is likely highly variable across its range (Smith 2019b). We consider the current vulnerability of *P. meandrina* to coral disease to be low, based on low susceptibility combined with highly variable exposure. We expect vulnerability of *P. meandrina* to coral disease to increase throughout the foreseeable future as ocean warming, LBSP, and other threats increase, because these threats generally produce conditions that favor coral disease (Smith 2019a,b).

Predation (Factor C). As described in the GSA (Smith 2019a), the available information regarding predation of Indo-Pacific reef-building corals including *P. meandrina* leads to the following conclusions about this threat: (1) Both chronic and acute predation, especially acute crown of thorns starfish (COTS) outbreaks, have been observed in many parts of the Indo-Pacific and, while quantifiable temporal trends are lacking, environmental stressors that lead to predator outbreaks (*e.g.,* land-based sources of pollution) have also increased; and (2) both chronic and acute predation and its impacts are projected to increase in much of the Indo-Pacific throughout the foreseeable future (Smith 2019a).

The vulnerability of *P. meandrina* to predation is summarized here in terms of its susceptibility and exposure to this threat, based on information in the SRR (Smith 2019b). The crown of thorns starfish (COTS) is considered the most important predator because of its large size, potential for extremely large outbreaks, high coral tissue consumption rate, and capacity to remove tissue from entire coral colonies (Glynn 1976). *Acropora* and *Pocillopora* species are among the most favored coral prey of COTS, and sharp reductions in populations of both genera in response to COTS outbreaks have been recorded across the Indo-Pacific (Pratchett *et al.* 2017, Keesing *et al.* 2019). Aside from COTS, other predators such as *Drupella* snails can result in colony damage and mortality of *Pocillopora* species including *P. meandrina,* especially after bleachings or other events that weaken the colonies. However, generally these other predators do not cause severe damage because they typically remove a small portion of tissue or skeleton, and do not often occur in large numbers. Thus, the susceptibility of *P. meandrina* to predation is moderate (Smith 2019b). Exposure of colonies of *P. meandrina* to predation depends on predator abundances. Generally, predator abundances and exposure are low most of the time on coral reefs, interspersed with brief periods of high abundances and subsequent high exposure. Thus, *P. meandrina's* exposure to predation is likely highly variable across its range (Smith 2019b). We consider the current vulnerability of *P. meandrina* to predation to be moderate, based on moderate susceptibility combined with highly variable exposure. We expect vulnerability of *P. meandrina* to predation to increase throughout the foreseeable future as LBSP, fishing, and other threats increase, because these threats generally produce conditions that favor predators (Smith 2019a,b).

Collection and Trade (Factor B). Collection and trade refers to the physical process of taking reef-building corals from their natural habitat (collection) for the purpose of sale in the marine aquarium and ornamental industries (trade). As described in the GSA (Smith 2019a), the available information regarding collection and trade of Indo-Pacific reef-building corals including *P. meandrina* leads to the following conclusions about this threat: (1) Collection and trade of Indo-Pacific reef-building corals has grown significantly in recent decades, along with the resulting detrimental effects to corals and their habitats; and (2) collection and trade, and their effects are projected to increase in much of the Indo-Pacific throughout the foreseeable future, although these effects may be partially offset by increases in mariculture (Smith 2019a).

The vulnerability of *P. meandrina* to collection and trade is summarized here in terms of its susceptibility and exposure to this threat, based on information in the SRR (Smith 2019b). As of May 2019, none of the largest marine aquarium coral wholesalers in the United States, an industry that sells a vast diversity of both captive bred and wild caught corals, had *P. meandrina* listed for sale, nor does it appear to have been sold over the last 15 years (Smith 2019b). In contrast to its lack of popularity in the marine aquarium industry, *P. meandrina* was among the top four genera in the ornamental industry (Thornhill 2012). Skeletons are cleaned and sold as curios or decorations, and colonies of *Acropora* and *Pocillopora* species are especially popular in many countries. Data collected by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) suggests that collection of *Pocillopora* species including *P. meandrina* for the domestic curio trade may be substantial in many countries (Smith 2019b). Exposure of colonies of *P. meandrina* to collection and trade depends on the proportion of the total population that is harvested annually. The total annual harvest of *P. meandrina* for the ornamental industry is not likely to be more than a few hundreds of thousands to a few million colonies. Even if a few million colonies are collected annually, that is still relatively small compared to the tens of billions of colonies in *P. meandrina's* total population, thus exposure to collection and trade is considered to be low (Smith 2019b). We consider the current vulnerability of *P. meandrina* to collection and trade to be low to moderate, based on moderate susceptibility combined with low exposure. We expect vulnerability of *P. meandrina* to collection and trade to increase throughout the foreseeable future, because future domestic and international demand for ornamental corals is expected to grow as the human population and affluence grow (Smith 2019a,b).

Other Threats (Factors A, E). In addition to the above primary threats, other threats to Indo-Pacific reef-building corals include two global threats (changes in ocean circulation and tropical storms, Factor E), and three local threats (human-induced physical damage, Factor A; invasive species, and changes in salinity, both Factor E; Brainard *et al.* 2011). These are not considered primary threats because they are either uncertain (the global threats) or highly localized on small spatial scales (the local threats). Nevertheless, they may affect the extinction risk of some Indo-Pacific reef-building coral species, including *P. meandrina,* throughout the foreseeable future (Smith 2019a).

The vulnerabilities of *P. meandrina* to these other threats are summarized here in terms of its susceptibility and exposure to these five threats, based on information in the SRR (Smith 2019b). We consider the current vulnerabilities of *P. meandrina* to changes in ocean circulation and tropical storms to be low, based on low susceptibilities combined with highly variable exposures. We expect vulnerabilities of *P. meandrina* to changes in ocean circulation and tropical storms to increase in the foreseeable future as climate change worsens. We consider the current vulnerabilities of *P. meandrina* to human-induced physical damage, invasive species, and changes in salinity to be very low to low, based on low susceptibilities combined with very low exposures. We expect vulnerabilities of *P. meandrina* to human-induced physical damage, invasive species, and changes in salinity to increase throughout the foreseeable future as human activities increase and climate change worsens (Smith 2019a,b).

Interactions of Threats (Factor E). The threats described above often affect Indo-Pacific reef-building corals simultaneously or sequentially, thus threats may interact with one another to affect corals in different ways than they would individually. As described in the GSA (Smith 2019a), there are many types of potential interactions, almost all of which are negative, such as the worsening of warming-induced coral bleaching by ocean acidification (Anthony *et al.* 2011, 2016) and LBSP (Fabricius 2011, Wooldridge 2016). Most studies oversimplify the interactions of threats by only considering interactions of two threats. The reality is that most or all threats interact with one another at various spatial and temporal scales, thus the effects of these interactions could be significantly worse than any individual threat alone, especially as each threat grows throughout the foreseeable future (Smith 2019a).

We consider the current vulnerabilities of *P. meandrina* to the interactions of the threats with one another to be unknown. As explained in the SRR (Smith 2019b), there is very little information available on the interactions of the threats with one another for *P. meandrina* or other *Pocillopora* species, thus the available information is inadequate to determine *P. meandrina'*s susceptibilities to the interactions of threats. Likewise, the available information is inadequate to determine exposure, thus we consider *P. meandrina'*s susceptibilities and exposures to the interactions of threats to be unknown (Smith 2019b). However, based on the available information on the effects of the interactions of these threats on other Indo-Pacific reef-building corals, as described in the GSA (Smith 2019a), we consider it likely that the overall effect of the interactions of these threats with one another on *P. meandrina* is negative, and that these impacts will worsen throughout the foreseeable future as threats worsen (Smith 2019a,b).

Inadequacy of Existing Regulatory Mechanisms (Factor D). While not a threat, existing regulatory mechanisms are a very important influence on the threats, and thus constitute one of the five listing factors. Existing regulatory mechanisms refers to treaties, agreements, laws, and regulations at all levels of government that may affect the continued existence of Indo-Pacific reef-building corals. Relevant regulatory mechanisms include all those related to GHG management globally, and the management of local threats in the 68 countries with Indo-Pacific reef-building corals (NMFS 2012, 2014), the great majority of which have *P. meandrina* in their waters (Smith 2019b).

As described in more detail in the GSA (Smith 2019a), GHGs are regulated through international agreements (*e.g.,* the Paris Agreement, signed in 2016), and through statutes and regulations at the national, state, and local levels. Twenty countries, the ''G20'' nations, are responsible for approximately 78 percent of global emissions, and are led by the top three emitters, China, the United States, and India, which are together responsible for about half of global emissions (UNEP 2019). All 20 signed the Paris Agreement; however, in 2017, the US announced its withdrawal, to take effect in November 2020. Previous international agreements on reducing GHGs, such as the Kyoto Protocol of 1997, have not been effective at controlling global GHG emissions, as shown by the increase in global GHG emissions over the past decades. Even if implementation of the Paris Agreement successfully limits global temperature increases to 1.5 °C during the 21st century as intended (*i.e.,* 0.5 °C warmer than now), impacts to reef-building corals, including *P. meandrina,* would still occur because these communities are already on a downward trajectory, and the additional warming would make things worse (IPCC 2018, Smith 2019a,b).

As described in more detail in the GSA (Smith 2019a), existing regulatory mechanisms that address the major local threats (*i.e.,* fishing, land-based sources of pollution, coral diseases, coral predators, collection and trade) consist primarily of national and local fisheries, coastal, and watershed management laws and regulations in the 68 countries where Indo-Pacific reef-building corals occur, but also include some international conventions. Regulatory mechanisms align well with some threats (*e.g.,* fishing, collection and trade) but not others (*e.g.,* coral diseases and predators). The relevant regulatory mechanisms generally consist of five categories: general coral protection, coral collection control, fishing controls, pollution controls, and managed areas, each of which are summarized below for the 68 countries. These regulatory mechanisms do not address climate change threats, but they typically were not intended to do so (NMFS 2012, NMFS 2014, Smith 2019a).

General coral protection regulatory mechanisms include overarching environmental laws that may protect corals from damage, harm, and destruction, and specific coral reef management laws. Of the 68 countries, 18 (27 percent) have general coral protection laws. Coral collection and trade regulatory mechanisms include specific laws that prohibit the collection, harvest, and mining of corals. Of the 68 countries, 32 (50 percent) have laws prohibiting the collection of live corals from coral reefs. Fishing regulations that pertain to reefs, include regulations that prohibit explosives, poisons and chemicals, electrocution, spearfishing, specific mesh sizes of nets, or other fishing gear. Of the 68 countries, 53 (78 percent) have laws that regulate coral reef fisheries. Pollution control regulations include oil pollution laws, marine pollution laws, ship-based pollution laws, and coastal land use and development laws. Of the 68 countries, 23 (34 percent) have laws that regulate pollution of coral reef waters. Managed area regulatory mechanisms include the capacity to create national parks and reserves, sanctuaries, and marine protected areas. Of the 68 countries, nearly all have managed areas that include coral reefs. Details about these five categories of regulatory mechanisms for the management of local threats are provided in the GSA (Smith 2019a).

The 2014 final coral listing rule concluded that global regulatory mechanisms for GHG emissions management were ineffective at reducing global climate change-related impacts to Indo-Pacific reef-building coral species at that time (NMFS 2014). Since then, the Paris Agreement was developed in 2015 and signed in 2016 (UN 2016), representing a major potential advance in GHG emissions management because its successful implementation would limit GMST to 1.5 °C above pre-industrial, as explained in the GSA (Smith 2019a). However, there are several reasons why there is uncertainty with regard to successful implementation of the Paris Agreement: (1) Despite past international agreements for GHG emissions management (*e.g.,* 1997 Kyoto Protocol, 2009 Copenhagen Accord), global GHG emissions and atmospheric CO_2 levels have both risen to historically high levels and continue to do so; (2) the world's second largest GHG emitter, the United States withdrew from the Paris Agreement in 2017; and (3) the most recent Emissions Gap Report from November 2019 concludes that globally, current policies are on track to result in global warming of 3.5° C by 2100 (UNEP 2019). Finally, even successful implementation of the Paris Agreement (*i.e.,* limiting warming to 1.5 °C) would still result in additional warming, and thus worsening of the current conditions. Therefore, we conclude that current global regulatory mechanisms for management of GHG emissions are expected to be unsuccessful at reducing global climate change-related impacts to Indo-Pacific reef-building corals, including *P. meandrina* (Smith 2019a,b).

The 2014 final coral listing rule concluded that national, state, local, and other regulatory mechanisms in the 68 countries with Indo-Pacific reef-building corals were generally ineffective at preventing or sufficiently controlling local threats to these species (NMFS 2014). Since that time, new coral reef MPAs have been established in the Indo-Pacific, slightly increasing the total proportion of coral reef ecosystems protected by MPAs in the region. However, human populations have also grown in many Indo-Pacific countries during that time, most likely leading to an increase in local threats since we completed our analysis in 2014. Thus, we conclude that current regulatory mechanisms are ineffective at reducing the impacts of local threats to Indo-Pacific reef-building corals including *P. meandrina* (Smith 2019a,b).

Threats Conclusion. We consider global climate change-related threats of ocean warming, ocean acidification, and sea-level rise, and the local threats of fishing, land-based sources of pollution, coral disease, predation, and collection and trade, to be the most significant to the extinction risk of Indo-Pacific reef-building corals, including *P. meandrina,* currently and throughout the foreseeable future. The most important of these threats is ocean warming. In addition, the interactions of threats with one another could be significantly worse than any individual threat, especially as each threat grows. Most threats have already been observed to be worsening, based on the monitoring results and the scientific literature. Ocean warming in conjunction with the other threats have recently resulted in the worst impacts to Indo-Pacific reef-building corals ever observed. All threats are expected to worsen throughout the foreseeable future, and to be exacerbated by the inadequacy of existing regulatory mechanisms (Smith 2019a).

The current susceptibilities, exposures, and subsequent vulnerabilities of *P. meandrina* to the threats are described in the SRR (Smith 2019b) and summarized here. For each threat, vulnerability is a function of susceptibility and exposure. Based on these vulnerability ratings, the six worst threats to *P. meandrina* currently are ocean warming (high), ocean acidification (high), predation (moderate), fishing (low to moderate), land-based sources of pollution (low to moderate), and collection and trade (low to moderate). There is not enough information to determine *P. meandrina's* vulnerability to the interactions of threats. Vulnerabilities of *P. meandrina* to all threats are expected to increase throughout the foreseeable future, and to be exacerbated by the inadequacy of existing regulatory mechanisms (Smith 2019a,b).

Rangewide Extinction Risk Assessment

An extinction risk assessment (ERA) was carried out by a seven member ERA Team for *P. meandrina* across its entire range, in accordance with the ''Guidance on Responding to Petitions and Conducting Status Reviews under the Endangered Species Act'' (NMFS 2017). The Team used the information provided in both the GSA and SRR (Smith 2019a,b) to provide the rangewide quantitative ratings of *P. meandrina's* demographic risk, threats, and overall extinction risk under RCP8.5 over the foreseeable future. Draft ratings were conducted in August and September, 2019, then a Team meeting was held on September 30, 2019, to discuss the draft ratings and to ensure that all Team members had a common understanding of the guidance. The final ratings were completed in October 2019.

Demographic Risk Factors. The demographic risk assessment utilized the information provided in the SRR (Smith 2019b) on *P. meandrina's* four demographic risk factors of distribution, abundance, productivity, and diversity. ERA Team members were instructed to assign a risk rating to each of the four demographic risk factors, based on information in the SRR, on a scale of 1 (low risk) to 3 (high risk), for the foreseeable future, assuming conditions projected under RCP8.5. Draft and final ratings were conducted based on the same written information, resulting in mean ratings of 1.0 to 1.6 for the four demographic factors (Table 1).

TABLE 1—ERA TEAM'S DRAFT AND FINAL RATINGS OF *P. meandrina'S* DEMOGRAPHIC RISK FACTORS, WHERE 1 = LOW RISK, 2 = MODERATE RISK, AND 3 = HIGH RISK, UNDER RCP8.5 OVER THE FORESEEABLE FUTURE

[Now to 2100; Smith 2019b]

ERA Team's ratings of demographic risk factors	Mean Ratings (± Standard Deviation)	
	Draft	Final
Distribution	1.1 (±0.38)	1.1 (±0.38)
Abundance	1.6 (±0.53)	1.6 (±0.53)
Productivity	1.0 (±0.00)	1.0 (±0.00)
Diversity	1.1 (±0.38)	1.0 (±0.00)

The Team rated *P. meandrina's* distribution as a low risk in both the draft and final ratings (Table 1). The distribution of *P. meandrina* is larger than about two-thirds of Indo-Pacific reef-building coral species, and includes most coral reefs in the Indo-Pacific. The species also has a broad depth range, occurring from the surface to at least 34 m (112 ft). There is no evidence of any reduction in its range due to human impacts, thus its historic and current ranges are considered to be the same. Although all threats are projected to increase under RCP8.5 over the foreseeable future *P. meandrina's* distribution is not likely to contribute significantly to extinction risk.

The Team rated *P. meandrina's* abundance as a moderate risk in both the draft and final ratings (Table 1). In the 10 ecoregions for which time-series abundance data or information are available, abundance appears to be decreasing in five ecoregions and stable in five ecoregions. Because of these declines in abundance that have already been observed, and projections of increasing threats under RCP8.5 over the foreseeable future, *P. meandrina'*s abundance is likely to contribute significantly to extinction risk.

The Team rated *P. meandrina'*s productivity as the lowest possible risk in both the draft and final ratings (Table 1). Productivity of *P. meandrina* is high due to its high reproductive capacity, broad dispersal, high recruitment, rapid skeletal growth, and adaptability, *i.e.,* these characteristics of the species all positively affect population growth rate. Although all threats are projected to increase under RCP8.5 over the foreseeable future, *P. meandrina'*s productivity is not likely to contribute significantly to extinction risk.

The Team rated *P. meandrina'*s diversity as a low risk in both the draft and final ratings (Table 1). Diversity of *P. meandrina* is due to high genotypic and phenotypic diversity, and a large range with very high habitat heterogeneity. There is no evidence that either productivity or diversity have been reduced. Although all threats are projected to increase under RCP8.5 over the foreseeable future, *P. meandrina'*s diversity is not likely to contribute significantly to extinction risk.

In conclusion, *P. meandrina'*s demographic factors are indicative of a robust and resilient species that is better suited for responding to ongoing and projected threats than most other reef-building coral species. While abundance has declined in some ecoregions in recent years, the species' high productivity provides capacity for recovery. All threats are projected to worsen under RCP8.5 over the foreseeable future, but *P. meandrina'*s demographic factors moderate its extinction risk (Smith 2019b).

Threats Evaluation. The threats assessment utilized the information provided in the GSA and SRR (Smith 2019a,b) on *P. meandrina'*s 10 threats of ocean warming, ocean acidification, sea-level rise, fishing, land-based sources of pollution, coral disease, predation, collection and trade, other threats, and interactions of threats, ERA Team members were instructed to assign a risk rating to each of the 10 threats, based on information in the GSA and SRR (Smith 2019a,b), on a scale of 1 (low risk) to 3 (high risk), for the foreseeable future, assuming conditions projected under RCP8.5. Draft and final ratings were conducted based on the same written information, resulting in mean ratings of 0.7 to 2.1 for the 10 threats (Table 2).

TABLE 2—MEAN RESULTS OF THE 7-MEMBER ERA TEAM'S DRAFT AND FINAL RATINGS OF *P. meandrina'*S THREATS, WHERE 1 = LOW RISK, 2 = MODERATE RISK, AND 3 = HIGH RISK, UNDER RCP8.5 OVER THE FORESEEABLE FUTURE

[Now to 2100; Smith 2019b]

ERA Team's ratings of threats	Mean Ratings (± Standard Deviation)	
	Draft	Final
Ocean warming	2.1 (±0.69)	1.9 (±0.38)
Ocean acidification	1.9 (±0.90)	1.7 (±0.76)
Sea-level rise	1.0 (±0.00)	1.0 (±0.00)
Fishing	1.4 (±0.53)	1.2 (±0.39)
Land-based sources pollution	1.3 (±0.49)	1.3 (±0.49)
Coral disease	1.3 (±0.49)	1.3 (±0.49)
Predation	1.3 (±0.49)	1.3 (±0.49)
Collection and trade	1.2 (±0.39)	1.2 (±0.39)
Other threats	0.7 (±0.52)	0.7 (±0.52)
Interactions of threats	1.9 (±0.69)	1.9 (±0.38)

In both the draft and final ratings, the Team rated ocean warming, ocean acidification, and interactions of threats as posing moderate risk to the species (1.7–2.1), while the other seven threats were rated as posing low risk (0.7–1.4; Table 2). The worst threats to *P. meandrina* include those caused by global climate change (ocean warming and ocean acidification), and the Team unanimously agreed that these threats stem from the inadequacy of regulatory mechanisms for greenhouse gas emissions management. Ocean warming and ocean acidification were rated as posing increased risk (Table 2), because of observed impacts that are already occurring, but mostly because the frequency, severity, and magnitude of these threats are likely to worsen under RCP8.5 over the foreseeable future.

The interactions of threats were also rated as posing increased risk to *P. meandrina* in both the draft and final ratings (Table 2). While there is little information available on the effects of the interactions of threats on *P. meandrina,* general information on the negative effects of interactions of threats on reef-building corals indicates a large number of negative interactions (Smith 2019a). In addition, there are likely to be many negative interactions that are still unknown, and these interactions are likely to become worse under RCP8.5 over the foreseeable future.

While the other seven threats were all rated as relatively less severe in both the draft and final ratings (Table 2), at least some of them can be severe on small spatial scales, and most or all have the potential to negatively interact with other threats. For example, fishing, land-based sources of pollution, and predation heavily impact *P. meandrina* in portions of its range, and may negatively interact with one another and other threats.

In conclusion, *P. meandrina* faces a multitude of growing, interacting threats that are projected to worsen in the foreseeable future under RCP8.5. The species' strong demographic factors moderate all threats, but the gradual worsening of threats is expected to result in a steady increase in extinction risk under RCP8.5 over the foreseeable future (Smith 2019b).

Overall Extinction Risk. Guided by the results from their demographic risk and threats assessments, each ERA Team member independently applied their professional judgment to rate the overall extinction risk of *P. meandrina* across its range as Low, Moderate, or High, using the definitions provided in the SRR (Smith 2019b). The extinction risk ratings were made assuming conditions projected under RCP8.5 over the foreseeable future. In contrast to the demographic risk and threats ratings, extinction risk was rated using the ''likelihood point'' method, whereby each Team member had 10 'likelihood points' that could be distributed among the three extinction risk categories. The likelihood point method allows expression of uncertainty by Team members (NMFS 2017). The draft, final, and mean extinction risk ratings are shown in Table 3 below.

TABLE 3—DRAFT, FINAL, AND MEAN RESULTS OF THE 7-MEMBER ERA TEAM'S RATINGS OF *P. meandrina*'S OVERALL EXTINCTION RISK UNDER RCP8.5 OVER THE FORESEEABLE FUTURE

[Now to 2100; Smith 2019b]

ERA Team's ratings of extinction risk	Number of Likelihood Points (%)		
	Draft	Final	Mean
Low	33.5 (47.9%)	24.5 (35.0%)	29 (41.4%)
Moderate	26.5 (37.9%)	39.5 (56.4%)	33 (47.1%)
High	10 (14.3%)	6 (8.6%)	8 (11.4%)
Total	70	70	

The Low extinction risk category received 33.5 points (47.9 percent) in the draft rating, and 24.5 points (35.0 percent) in the final rating, for a mean of 29 points (41.4 percent; Table 3). Several Team members moved likelihood points from Low to Moderate for the final rating following the September 30, 2019, Team meeting at which the climate change assumptions in the SRR were emphasized (*i.e.,* assumption of conditions projected under RCP8.5 from now to 2100). Species at Low extinction risk have stable or increasing trends in abundance and productivity with connected, diverse populations, and are not facing threats that result in declining trends in distribution, abundance, productivity, or diversity. Currently, *P. meandrina* has high and stable productivity and diversity, a very large distribution, very high abundance, and stable (five ecoregions) or decreasing (five ecoregions) abundance in the 10 ecoregions for which abundance trend data or information are available. The species has life history characteristics that provide resilience to disturbances and a high capacity for recovery. However, *P. meandrina* faces multiple threats, the worst of which are expected to increase under RCP8.5 over the foreseeable future. Thus, on the one hand, most demographic factors suggest Low extinction risk of *P. meandrina,* but on the other hand, recent declining abundance trends in five of the 10 known ecoregions, as well as increasing threats under RCP8.5 over the foreseeable future, suggest higher extinction risk in the foreseeable future.

The Moderate extinction risk category received 26.5 points (37.9 percent) in the draft rating, and 39.5 points (56.4 percent) in the final rating, for a mean of 33 points (47.1 percent; Table 3). Several Team members moved likelihood points from Low to Moderate, and one Team member moved likelihood points from High to Moderate, for the final rating following the September 30, 2019, Team meeting. Species at Moderate extinction risk are on a trajectory that puts them at a high level of extinction risk in the foreseeable future, due to projected threats or declining trends in distribution, abundance, productivity, or diversity. While *P. meandrina's* distribution, productivity, and diversity are currently strong and stable, recent abundance trends are declining in half of the ecoregions for which data or information are available (five of 10 ecoregions). In addition, all threats are expected to worsen in the foreseeable future, especially the most important threats to the species. Ocean warming and ocean acidification are projected to worsen under RCP8.5 over the foreseeable future, resulting in increased frequency, magnitude, and severity of warming-induced coral bleaching, reduced coral calcification, and increased reef erosion. These climate change threats are likely to be exacerbated by local threats such as fishing and land-based sources of pollution throughout much of *P. meandrina's* range.

The High extinction risk category received 10 points (14.3 percent) in the draft rating, and 6 points (8.6 percent) in the final rating, for a mean of 8 points (11.4 percent; Table 3). One Team member moved likelihood points from High to Moderate, for the final rating following the September 30, 2019, Team meeting in response to clarification regarding the temporal distinction between High and Moderate extinction risk (Smith 2019b). Species at High extinction risk are those whose continued persistence is in question due to weak demographic factors, or that face clear and present threats such as imminent destruction. However, *P. meandrina* has strong demographic factors, with the possible exception of abundance. Thus, while threats to *P. meandrina* are expected to occur over the foreseeable future (now to 2100), impacts so severe as to place the species at high extinction risk are not expected in the immediate future (now to 2030), therefore the species is not considered to be at high risk of extinction.

In conclusion, the information in the GSA (Smith 2019a), the SRR (Smith 2019b), and the ERA Team's results (Tables 1–3) provide support for *P. meandrina* currently being at low risk of extinction throughout its range, and at low to moderate risk of extinction throughout its range in the foreseeable future. The ERA was conducted assuming that conditions projected under RCP8.5 will occur within the range of *P. meandrina* over the foreseeable future. The ERA Team's ratings were only for *P. meandrina* rangewide, thus the Team did not consider whether any smaller areas within its range constitute Significant Portions of its Range (Smith 2019b).

Rangewide Determination

Section 4(b)(1)(A) 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 (83 FR 47592; September 20, 2018), the GSA (Smith 2019a), the SRR (Smith 2019b), and literature cited therein and in this finding. In addition, we have consulted with a large number of species experts and individuals familiar with *P. meandrina* (Smith 2019b). This rangewide determination is based on our interpretation of the status of *P. meandrina* throughout its range currently and over foreseeable future (now to 2100).

Pocillopora meandrina can be characterized as a species with strong demographic factors facing broad and worsening threats: It has a very large and stable distribution, very high overall abundance but unknown overall abundance trend, high and stable productivity, and high and stable diversity. But it faces multiple global and local threats, all of which are worsening, and existing regulatory mechanisms are inadequate to ameliorate the major threats. Based on the same written information, the ERA Team rated *P. meandrina'*s extinction risk twice, resulting in 47.9, 37.9, and 14.3 percent, and 35.0, 56.4, and 8.6 percent, in the Low, Moderate, High risk categories, respectively, in the draft and final ratings (Table 3). Before the final rating, an ERA Team meeting was held to emphasize that the Team was to assume the worst-case climate change pathway (RCP8.5, and only RCP8.5) over the foreseeable future for the extinction risk ratings. As explained in the Foreseeable Future for *P. meandrina* section above, we consider it likely that climate indicator values between now and 2100 will be within the collective ranges of those projected under RCPs 8.5, 6.0, and 4.5, and not necessarily limited to the range of conditions projected by the worst-case pathway RCP8.5. However, all three pathways lead to worsening conditions in the foreseeable future, and their impacts on *P. meandrina* cannot be clearly distinguished from one another based on the existing data and uncertainties. Thus, we interpret their final extinction risk rating as representing the worst-case scenario for *P. meandrina.*

Although all threats are projected to worsen within *P. meandrina'*s range over the foreseeable future (Smith 2019a,b; NMFS 2020a), the following characteristics of the species moderate its extinction risk, as documented in the SRR (Smith 2019b): (1) The species' unusually large geographic distribution (95 ecoregions; SRR, Section 3.2.1), broad depth distribution (0–34 m; SRR, Section 3.2.2), and wide habitat breadth (SRR, section 2.4), provide *P. meandrina* uncommonly high habitat heterogeneity (SRR, section 3.4), which creates patchiness of conditions across its range at any given time, thus many portions of its range are unaffected or lightly affected by any given threat; (2) its very high abundance (at least several tens of billions of colonies; SRR, Section 3.2.2), together with high habitat heterogeneity, likely result in many billions of colonies surviving even the worst disturbances; (3) even when high mortality occurs, its high productivity provides the capacity for the affected populations to recover quickly, as has been documented at sites within several ecoregions (*e.g.,* on the GBR, at Fagatele Bay in American Samoa, at the Kahe Power Plant in the main Hawaiian Islands, and at Moorea in the Society Islands; SRR, Section 3.2.3); (4) likewise, its high productivity provides the capacity for populations to recover relatively quickly from disturbances compared to more sensitive reef coral species, allowing *P. meandrina* to take over denuded substrates and to sometimes become more abundant after disturbances than before them, as has been documented in several ecoregions (SRR, Section 3.3); (5) it recruits to artificial substrates more readily than most other Indo-Pacific reef corals, often dominating the coral communities on the metal, concrete, and PVC surfaces of seawalls, Fish Aggregation Devices, pipes, and other manmade structures (SRR, Section 3.3); (6) in some populations that suffered high mortality from warming-induced bleaching, subsequent warming resulted in much less mortality (*e.g.,* west Mexico, SRR, Section 4.1), suggesting acclimatization (*i.e.,* surviving colonies became acclimated to the changing conditions) or adaptation (*i.e.,* relatively heat-resistant progeny of surviving colonies were naturally selected by the changing conditions) of the surviving populations; and (7) adaptation may be enhanced by its high genotypic diversity (*i.e.,* some of its many distinct populations likely have genotypes that will be naturally selected by the changing conditions) and high dispersal (*i.e.,* the progeny of naturally selected genotypes may widely disperse, establishing new populations with improved fitness; SRR, Sections 3.3 and 3.4).

Taken together, these demographic characteristics of *P. meandrina* are expected to substantially moderate the impacts of the worsening threats over the foreseeable future. While broadly deteriorating conditions will likely result in a downward trajectory of *P. meandrina'*s overall abundance in the foreseeable future, the demographic characteristics summarized above are expected to allow the species to at least partially recover from many disturbances, thereby slowing the downward trajectory. Thus, our interpretation of the information in the GSA (Smith 2019a), SRR (Smith 2019b), and this finding is that *P. meandrina* is currently at low risk of extinction throughout its range. As explained in the Listing Species Under the Endangered Species Act section of this finding, an ''endangered species'' is presently at risk of extinction throughout all or a significant portion of its range. Because *P. meandrina* is currently at low risk of extinction throughout its range, it does not meet the definition of an endangered species, and is thus not warranted for listing as endangered at this time.

As also explained in the Listing Species Under the Endangered Species Act section of this finding, a ''threatened species'' is not currently at risk of extinction, but is likely to become so in the foreseeable future. Based on the information in the GSA (Smith 2019a), SRR (Smith 2019b), and this finding, *P. meandrina* is expected to face low to moderate extinction risk in the foreseeable future throughout its range. That is, we expect its extinction risk to increase slightly from its current low level, to low to moderate in the foreseeable future, in response to worsening threats. We do not expect extinction risk to grow rapidly in the foreseeable future, because as described earlier in this section, *P. meandrina* has several demographic characteristics that moderate its extinction risk. As described in the Rangewide Extinction Risk Assessment section, we interpret the ERA Team's final extinction risk rating (approximately 35, 56, and 9 percent in the Low, Moderate, High risk categories, respectively, Table 3) as representing the worst-case scenario for *P. meandrina,* because the Team assumed the high emissions climate change pathway (RCP8.5, and only RCP8.5) in the foreseeable future for the extinction risk ratings. As explained in the Foreseeable Future for *P. meandrina* section, we consider it likely that climate indicator values between now and 2100 will be within the collective ranges of those projected by RCP8.5 and the intermediate emissions pathways RCPs 6.0, and 4.5, rather than limited to those projected by RCP8.5 alone. Because we expect *P. meandrina* to face a low to moderate risk of extinction in the foreseeable future throughout its range, it does not meet the definition of a threatened species, and is thus not warranted for listing as threatened at this time.

The definitions of both ''threatened'' and ''endangered'' in the ESA contain the phrase ''significant portion of its range'' (SPR), referring to an area smaller than the entire range of the species which must be considered when evaluating a species' risk of extinction. Under the final SPR Policy announced in July 2014, should we find that the species is of low extinction risk throughout its range and not warranted for listing, as we have for *P. meandrina,* then we must go on to consider whether the species may have a higher risk of extinction in a significant portion of its range (79 FR 37577; July 1, 2014). If the species within the SPR meets the definition of threatened or endangered, then the species should be listed throughout its range based on the status within that SPR. The following sections provide the SPR analysis and determinations for *P. meandrina.*

SPR Analysis

The SPR analysis for *P. meandrina* consists of two steps: (1) Identification of any portions of its range that are significant, and thus qualify as SPRs; and (2) assessment of the extinction risk of each SPR. This SPR analysis is based on the SPR policy in light of recent court decisions, as explained below. In two recent District Court cases challenging listing decisions made by the U.S. Fish and Wildlife Service, the definition of ''significant'' in the SPR Policy was invalidated. The courts held that the threshold component of the definition was ''impermissible,'' because it set too high a standard. Specifically, the courts held that under the threshold in the policy, a species would never be listed based on the status of the portion, because in order for a portion to meet the threshold, the species would be threatened or endangered rangewide. Center for Biological Diversity, *et al.* v. Jewell, 248 F. Supp. 3d 946, 958 (D. Ariz. 2017); Desert Survivors v. DOI 321 F. Supp. 3d. 1011 (N.D. Cal., 2018). Accordingly, we do not rely on our definition in the policy, but instead our analysis independently construes and applies a biological significance standard, drawing from the demographic factors for *P. meandrina* described in the SRR (*i.e.,* distribution, abundance, productivity, and diversity) as they apply to each SPR. That is, each *P. meandrina* SPR is identified based on its significance to the viability of the species, in terms of that SPR's distribution, abundance, productivity, and diversity.

Identification of the Four SPRs

The first step of the SPR analysis is to identify any SPRs. We determined that several portions of *P. meandrina'*s range are significant to the viability of the species, in terms of each SPR's demographic factors (distribution, abundance, productivity, and diversity). The range of this species encompasses 95 ecoregions spread across the Indo-Pacific from the western Indian Ocean to the eastern Pacific Ocean, including the western Indian Ocean (Ecoregions #1–10), the western Pacific Ocean (Ecoregions #11–68), the central Pacific Ocean (Ecoregions #69–87), and the eastern Pacific Ocean (Ecoregions #88–95; NMFS 2020b, Map 1). Based on the information in the SRR (Smith 2019b) and NMFS (2020b), which is the best currently available information on the distribution of *P. meandrina,* we identified four SPRs: (1) SPR A, the 68 ecoregions within the western Indian and western Pacific areas (NMFS 2020b, Map 2); (2) SPR B, the 27 ecoregions within the central Pacific and eastern Pacific areas (NMFS 2020, Map 3); (3) SPR C, the 58 ecoregions within the western Pacific area (NMFS 2020b, Map 4); and (4) SPR D, the 19 ecoregions within the central Pacific area (NMFS 2020b, Map 5). As shown on the maps (NMFS 2020b), SPR A encompasses SPR C, and SPR B encompasses SPR D. Rationales for why each of these four areas qualify as an SPR are provided below. Other portions of *P. meandrina'*s range were considered, but found not to qualify as SPRs.

SPR A qualifies as an SPR because it is significant to the viability of *P. meandrina,* based on the population's distribution and diversity. SPR A's distribution consists of 68 ecoregions (#1–68), or over 70 percent of *P. meandrina'*s ecoregions (68/95 ecoregions), and approximately 85 percent of *P. meandrina'*s coral reef area (Table 4). The population's ecoregions extend from the western edge of the species' range in the western Indian Ocean to the central western portion of its range in the Pacific Ocean (NMFS 2020b). Because SPR A's distribution covers over 70 percent of the species' ecoregions and approximately 85 percent of its coral reef area (NMFS 2020b), SPR A includes approximately 70 to 85 percent of *P. meandrina'*s total abundance. Distribution and abundance strongly influence a population's productivity and diversity (see SRR, Sections 3.3 and 3.4), thus SPR A likely contains approximately 70 to 85 percent of *P. meandrina'*s total productivity and diversity. Since SPR A includes most of *P. meandrina'*s distribution, abundance, productivity, and diversity, the species would not be viable in the absence of this population. Therefore, SPR A is significant to the viability of *P. meandrina* and qualifies as an SPR.

SPR B qualifies as an SPR because it is significant to the viability of *P. meandrina,* based on the population's distribution, abundance, and productivity. SPR B's distribution consists of 27 ecoregions (#69–95), or approximately 30 percent of *P. meandrina'*s ecoregions (27/95 ecoregions) and approximately 15 percent of its coral reef area (Table 4). The population's ecoregions extend from the central eastern portion of its range to the eastern fringe of its range in the Pacific Ocean (NMFS 2020b). SPR B's distribution covers less than one-third of the species' ecoregions, and an even lower proportion of its coral reef area. However, the western portion of the population (*i.e.,* Ecoregions #69–87) connects the eastern Pacific ecoregions (#88–95) with the rest of the species (*i.e.,* Ecoregions #1–68). In addition, the abundance of this population is important because all ecoregions where *P. meandrina* is dominant occur within this population (NMFS 2020b). Distribution and abundance strongly influence a population's productivity and diversity (see SRR, Sections 3.3 and 3.4), thus SPR B likely contains approximately 15 to 30 percent of *P. meandrina'*s total productivity and diversity. Even though SPR B represents less than one-third of *P. meandrina'*s ecoregions, the following characteristics of the population are especially valuable for maintaining the species' viability as threats worsen throughout the 21st century: (1) It contains all ecoregions where *P. meandrina* is dominant; (2) it provides a link to between the species' isolated ecoregions in the eastern Pacific to the bulk of its ecoregions in the western Pacific; and (3) it contains a high proportion of islands and atolls with small or no human populations (NMFS 2020b) where local threats are likely to be relatively low in the foreseeable future, and thus may provide refuges for maintaining the species' resilience as conditions deteriorate. Therefore, SPR B is significant to the viability of *P. meandrina* and qualifies as an SPR.

SPR C qualifies as an SPR because it is significant to the viability of *P. meandrina,* based on the population's distribution and diversity. SPR C's distribution consists of 58 ecoregions (#11–68), or approximately 60 percent of *P. meandrina'*s ecoregions (58/95 ecoregions) and approximately 76 percent of its coral reef area (Table 4). The population's ecoregions all occur within the central western portion of its range in the Pacific Ocean. SPR C includes a high proportion of *P. meandrina'*s coral reef area (76 percent) because it encompasses the entire Coral Reef Triangle, which has the highest density of coral reefs in the world (NMFS 2020b). In addition, SPR C connects the western Indian Ocean ecoregions (#1–10) with the rest of the species' ecoregions to the east (*i.e.,* Ecoregions #69–95). Distribution and abundance strongly influence a population's productivity and diversity (see SRR, Sections 3.3 and 3.4), thus SPR C likely contains approximately 60 to 76 percent of *P. meandrina'*s total productivity and diversity. Since SPR C includes the large majority of *P. meandrina'*s distribution, abundance, productivity, and diversity, the species would not be viable in the absence of this population. Therefore, SPR C is significant to the viability of *P. meandrina* and qualifies as an SPR.

SPR D qualifies as an SPR because it is significant to the viability of *P. meandrina,* based on the population's distribution, abundance, and productivity. SPR D's distribution consists of 19 ecoregions (#69–87), representing only 20 percent of *P. meandrina'*s ecoregions (19/95 ecoregions) and approximately 14 percent of its coral reef area (Table 4). The population's ecoregions are located in the central eastern portion of its range in the Pacific Ocean (NMFS 2020b). While SPR D's distribution covers only one-fifth of the species' ecoregions, this population connects the eastern Pacific ecoregions (#88–95) with the rest of the species (*i.e.,* Ecoregions #1–68). In addition, the abundance of this population is important because all ecoregions where *P. meandrina* is dominant occur within this population (NMFS 2020b). Distribution and abundance strongly influence a population's productivity and diversity (see SRR, Sections 3.3 and 3.4), thus SPR D likely contains approximately 14 to 20 percent of *P. meandrina'*s total productivity and diversity. Even though SPR D represents less than one-quarter of *P. meandrina'*s ecoregions, the following characteristics of the population are especially valuable for maintaining the species' viability as threats worsen throughout the 21st century: (1) It contains all ecoregions where *P. meandrina* is dominant; (2) it provides a link to between the species' isolated ecoregions in the eastern Pacific to the bulk of its ecoregions in the western Pacific; and (3) it contains a high proportion of islands and atolls with small or no human populations (NMFS 2020b) where local threats are likely to be relatively low in the foreseeable future, and thus may provide refuges for maintaining the species' resilience as conditions deteriorate. Therefore, SPR D is significant to the viability of *P. meandrina* and qualifies as an SPR.

Aside from SPRs A–D, no other portions of the range of *P. meandrina* considered were found to qualify as SPRs, based on the currently available best information, as presented in the SRR (Smith 2019b) and NMFS (2020b). The ecoregions on the fringes of the species' range in the western Indian Ocean (#1–10) and in the eastern Pacific Ocean (#88–95), are not significant to the viability of *P. meandrina* because: (1) Their distributions represent small proportions of the species' range, and do not connect large portions of the species' range with one another; (2) their abundances are much smaller than SPRs A–D; (3) productivity depends on abundance, thus their productivities are likely relatively low; and (4) diversity depends on distribution, thus their diversities are likely relatively low. Likewise, other groupings of ecoregions are not significant to the viability of *P. meandrina* for the same reasons, even groups with more ecoregions than SPRs B (27 ecoregions) and D (19 ecoregions) such as those of the Coral Triangle (#15–42, 28 ecoregions), because they do not possess the unique characteristics described above for SPRs B and D.

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Table 4. Summary of demographic factors for SPRs A-D (an extended version of this table is available in NMFS 2020b).

SPR	Distribution				Abundance				Productivity	Diversity
	Ecoregions	Depth	Reef Area (% of total)	Overall	Relative (ccoregions)	Absolute	Trend (ccoregions)	Overall		
A	68 (#1-68)	0-≥30 m	≈197,000 km² (≈85%)	Very large and stable.	Dominant: 0 Common: 8 Uncommon: 29 Rare: 1 Unknown: 30	A few tens of billions of colonies.	Declining: 2 Stable: 2 Unknown: 64	Very high, but trend unknown.	High and stable. Recent recoveries from disturbance in one ecoregion.	High and stable.
B	27 (#69-95)	0-34 m	≈35,000 km² (≈15%)	Large and stable.	Dominant: 7 Common: 10 Uncommon: 7 Rare: 3 Unknown: 0	At least several billion colonies.	Declining: 3 Stable: 3 Unknown: 21	High, but trend unknown.	High and stable. Signs of recovery in some ecoregions with declining abundance.	High and stable.
C	58 (#11-68)	0-≥30 m	≈178,000 km² (≈76%)	Very large and stable.	Dominant: 0 Common: 7 Uncommon: 27 Rare: 0 Unknown: 24	A few tens of billions of colonies.	Declining: 1 Stable: 2 Unknown: 55	Very high, but trend unknown.	High and stable. Recent recoveries from disturbance in one ecoregion.	High and stable.
D	19 (#69-87)	0-≥30 m	≈32,000 km² (≈14%)	Large and stable.	Dominant: 7 Common: 7 Uncommon: 5 Rare: 0 Unknown: 0	At least several billion colonies.	Declining: 2 Stable: 2 Unknown: 15	High, but trend unknown.	High and stable. Signs of recovery in some ecoregions with declining abundance.	High and stable.

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Extinction Risk Assessments of the Four SPRs

The second step in our SPR analysis was to determine the status of each SPR with an Extinction Risk Assessment (ERA) similar to the process described in the Rangewide Extinction Risk Assessment section, except that the ERA Team was not involved. Instead, based on the information in the GSA (Smith 2019a), SRR (2019b), and NMFS (2020b), staff of the NMFS Pacific Islands Regional Office analyzed the demographic factors and threats for each of the four SPRs to inform its extinction risk.

SPR A. SPR A's distribution consists of *P. meandrina's* Ecoregions #1–68, an area ≈15,500 km (9,630 mi) wide from the western Indian Ocean to the western Pacific Ocean, encompassing approximately 197,000 km^2 of coral reefs. Its range includes some remote areas with small or no human populations, including most of the Maldives and Seychelles in the Indian Ocean, and parts of eastern Indonesia, the northern GBR, and the Kimberley Coast of Australia in the Pacific Ocean, and many others (Smith 2019b, Fig. 2; NMFS 2020b). As is typical of *P. meandrina,* SPR A is more common at depths of <5 m (16 ft) than in deeper areas. The deepest *P. meandrina* colonies recorded within SPR A are from 30 m (98 ft) at Farallon de Medinilla in the Mariana Islands, and deepest colonies recorded for the species as a whole are from a depth of 34 m (112 ft; Smith 2019b, Section 3.1.2). Thus, SPR A's depth range is from the surface to at least 30 m. There is no evidence of any reduction in its range due to human impacts, thus we consider SPR A's historic and current ranges to be the same. Therefore, based on the best available information provided in the SRR (Smith 2019b), we consider SPR A's distribution to be very large and stable (Table 4).

Of SPR A's 68 ecoregions, relative abundance information is available for 38 ecoregions, in which it is not dominant in any, common in eight, uncommon in 29, and rare in one (Smith 2019b, Fig. 2; NMFS 2020b). We estimate *P. meandrina's* total population to be at least several tens of billions of colonies (Smith 2019b, Section 3.2.2), and SPR A includes approximately 85 percent of the species' coral reef area (Table 4, NMFS 2020b). However, the relative abundances of *P. meandrina* in SPR A's ecoregions are mostly uncommon, unlike the central Pacific where it is common or dominant. Thus, we estimate the population of SPR A to be a few tens of billions of colonies. In the four ecoregions for which time-series abundance data or information are available for SPR A, abundance appears to be decreasing in two ecoregions (Chagos Archipelago, Marianas Islands) and stable in two ecoregions (GBR Far North, GBR North-central; Smith 2019b, Table 4; NMFS 2020b). Therefore, based on the best available information provided above, we consider SPR A's overall abundance to be very high, but its overall abundance trend is unknown (Table 4).

Based on the information in the SRR, we consider SPR A's productivity to be high, despite declining abundance trends in some ecoregions. Evidence for high productivity is provided by observations from the GBR indicating strong recoveries in recent years from disturbances by displacing less competitive coral species and becoming more abundant than before the disturbances. In addition, studies and observations from ecoregions in other populations have documented multiple recoveries (Smith 2019b, Section 3.2.3). These recoveries demonstrate continued high productivity, thus we consider SPR A's productivity to be high and stable (Table 4).

Although there is little information available on the genotypic and phenotypic diversity of SPR A, its large distribution and high habitat heterogeneity suggest that both types of diversity are high for this population. In addition, the population's distribution has not been reduced (Smith 2019b, Section 3.1). Therefore, we consider SPR A's diversity to be high and stable (Table 4).

The vulnerabilities of *P. meandrina* to each of the 10 threats were rated in the SRR, based on the species' susceptibility and exposure to each threat, over the foreseeable future assuming that RCP8.5 is the most likely future climate scenario (Smith 2019b, Table 6). Since SPR A includes approximately 85 percent of the range of *P. meandrina* in terms of coral reef area (Table 4), the threats to SPR A are similar as to the entire species, thus the threat vulnerability ratings are applicable to SPR A. Threat vulnerabilities were rated as: High for ocean warming and ocean acidification; Moderate for predation; Low to Moderate for fishing, land-based sources of pollution, and collection and trade; Low for sea-level rise, disease, and other threats (global); Very Low to Low for other threats (local), and Unknown for interactions of threats. Vulnerabilities to all threats are expected to increase throughout the foreseeable future under RCP8.5 (Smith 2019b, Table 6). SPR A's strong demographic factors moderate all threats, but the gradual worsening of threats is expected to result in a steady increase in extinction risk throughout the foreseeable future (Smith 2019b).

The extinction risk of SPR A depends on its demographic factors and threats. Populations at Low extinction risk have stable or increasing trends in abundance and productivity with connected, diverse populations, and are not facing threats that result in declining trends in distribution, abundance, productivity, or diversity (NMFS 2017). Currently, SPR A has a very large distribution, very high abundance, stable (two ecoregions) or decreasing (two ecoregions) abundance in the four ecoregions for which abundance trend data or information are available, and high and stable productivity and diversity. The population has life history characteristics that provide resilience to disturbances and a high capacity for recovery. However, SPR A faces multiple threats, the worst of which are expected to increase in the foreseeable future (NMFS 2020a, Smith 2019a). Thus, on the one hand, most demographic factors suggest Low extinction risk for SPR A, but on the other hand, recent declining abundance trends in two of the four known ecoregions, as well as increasing threats throughout the foreseeable future, suggest increased extinction risk.

Species at Moderate extinction risk are on a trajectory that puts them at a high level of extinction risk in the foreseeable future, due to projected threats or declining trends in distribution, abundance, productivity, or diversity. While SPR A's distribution, productivity, and diversity are currently strong and stable, recent abundance trends are declining in half of the ecoregions for which data or information are available (two of four ecoregions). In addition, all threats are expected to worsen throughout the foreseeable future, including the two greatest threats, ocean warming and ocean acidification, resulting in increased frequency, magnitude, and severity of warming-induced coral bleaching, reduced coral calcification, and increased reef erosion. These climate change threats are likely to be exacerbated by local threats such as fishing and land-based sources of pollution throughout much of SPR A's range. In conclusion, the information in the GSA (Smith 2019a), the SRR (Smith 2019b), and NMFS (2020b) provide support for SPR A currently being at low to moderate extinction risk throughout the foreseeable future.

SPR B. SPR B's distribution consists of *P. meandrina's* Ecoregions #69–95, an area ≈13,300 km (8,300 mi) wide in the central and eastern Pacific Ocean, encompassing approximately 35,000 km² of coral reefs as well as extensive non-reef and mesophotic habitats (NMFS 2020b). Its range includes many remote areas with small or no human populations, including the Northwestern Hawaiian Islands, Line Islands, Tuamotu Archipelago, most of the Galapagos Islands, Revillagigedo Islands, Clipperton Atoll, and others (Smith 2019b, Fig. 2; NMFS 2020b). As is typical of *P. meandrina,* SPR B is more common at depths of <5 m (16 ft) than in deeper areas. The deepest *P. meandrina* colonies on record are from SPR B at a depth of 34 m (112 ft; Smith 2019b, Section 3.1.2). Thus, SPR B's depth range is from the surface to 34 m. There is no evidence of any reduction in its range due to human impacts, thus we consider SPR B's historic and current ranges to be the same. Therefore, based on the best available information provided in the SRR (Smith 2019b), we consider SPR B's distribution to be large and stable (Table 4).

Relative abundance information is available for all of SPR B's 27 ecoregions, in which it is dominant in seven, common in 10, uncommon in seven, and rare in three. It is a very common species in many of the *Pocillopora*-dominated reef coral communities of the central Pacific, and is common to rare in the eastern Pacific (Smith 2019b, Fig. 2; NMFS 2020b). We estimate *P. meandrina'*s total population to be at least several tens of billions of colonies (Smith 2019b, Section 3.2.2), but SPR B includes only about 15 percent of the species' coral reef area (Table 4, NMFS 2020b). However, this population includes all seven ecoregions where *P. meandrina* is dominant, and the species is dominant or common in 17 of the population's 27 ecoregions. Thus, we estimate SPR B's total population to be at least several billion colonies. In the six ecoregions for which time-series abundance data or information are available for SPR B, abundance appears to be decreasing in three ecoregions (Northwestern Hawaiian Islands, Main Hawaiian Islands, Galapagos Islands) and stable in three ecoregions (Samoa-Tuvalu-Tonga, Society Islands, Mexico West; Smith 2019b, Table 4; NMFS 2020b). Therefore, based on the best available information provided above, we consider SPR B's overall abundance to be high, but its overall abundance trend is unknown (Table 4).

Based on the information in the SRR, we consider SPR B's productivity to be high, despite declining abundance trends in some ecoregions. Evidence for high productivity is provided by SPR B's recovery from disturbance in several ecoregions, including: (1) Demographic data suggests that recovery from back-to-back bleaching events is occurring in the MHI Ecoregion (*i.e.,* fewer adults colonies in 2016 than in 2013 show adult colony mortality from the 2014 and 2015 bleaching events, but more juvenile colonies in 2016 than in 2013 suggests the initial stages of recovery from the bleaching events); and (2) studies and observations in other ecoregions (*e.g.,* GBR, Society Islands) indicate strong recoveries in recent years from various types of disturbances at multiple locations throughout its range, by displacing less competitive coral species and becoming more abundant than before the disturbances (Smith 2019b, Section 3.2.3). These recoveries demonstrate continued high productivity, thus we consider SPR B's productivity to be high and stable (Table 4).

Although there is little information available on the genotypic and phenotypic diversity of SPR B, its large distribution and high habitat heterogeneity suggest that both types of diversity are very high for this population. In addition, information from portions of individual ecoregions within SPR B shows high genotype and phenotypic diversity (Smith 2019b, Section 3.4). Furthermore, the population's distribution has not been reduced (Smith 2019b, Section 3.1). Therefore, we consider SPR B's diversity to be high and stable (Table 4).

The vulnerabilities of *P. meandrina* to each of the 10 threats were rated in the SRR, based on the species' susceptibility and exposure to each threat, for the foreseeable future assuming that RCP8.5 is the most likely future climate scenario (Smith 2019b, Table 6). Threat vulnerabilities were rated as: High for ocean warming and ocean acidification; Moderate for predation; Low to Moderate for fishing, land-based sources of pollution, and collection and trade; Low for sea-level rise, disease, and other threats (global); Very Low to Low for other threats (local), and Unknown for interactions of threats. Vulnerabilities to all threats are expected to increase in the foreseeable future under RCP8.5 (Smith 2019b, Table 6). Since SPR B has lower human population density and a higher proportion of remote areas than *P. meandrina'*s entire range (Smith 2019b), local threats (fishing, land-based sources of pollution, collection and trade, and other local threats) are likely less severe in SPR B's range than across the range of the species. However, the vulnerability of SPR B to climate change threats (ocean warming, ocean acidification, sea-level rise) are likely similar as for *P. meandrina* rangewide. SPR B's strong demographic factors moderate all threats, but the gradual worsening of threats is expected to result in a steady increase in extinction risk throughout the 21st century (Smith 2019b).

The extinction risk of SPR B depends on its demographic factors and threats. Populations at Low extinction risk have stable or increasing trends in abundance and productivity with connected, diverse populations, and are not facing threats that result in declining trends in distribution, abundance, productivity, or diversity (NMFS 2017). Although SPR B only includes approximately 15 percent of the range of *P. meandrina,* it nevertheless covers approximately 35,000 km² of reef area, and extensive non-reef and mesophotic habitats (NMFS 2020b). Currently, SPR B has a large distribution, high abundance, stable (three ecoregions) or decreasing (three ecoregions) abundance in the six ecoregions for which abundance trend data or information are available, and high and stable productivity and diversity. The population has life history characteristics that provide resilience to disturbances and a high capacity for recovery. However, SPR B faces multiple threats, the worst of which are expected to increase in the foreseeable future (NMFS 2020a, Smith 2019a). Thus, on the one hand, most demographic factors suggest Low extinction risk for SPR B, but on the other hand, recent declining abundance trends in two of the four known ecoregions, as well as increasing threats throughout the foreseeable future, suggest increased extinction risk.

Species at Moderate extinction risk are on a trajectory that puts them at a high level of extinction risk in the foreseeable future, due to projected threats or declining trends in distribution, abundance, productivity, or diversity. While SPR B's distribution, productivity, and diversity are currently strong and stable, recent abundance trends are declining in half of the ecoregions for which data or information are available (three of six ecoregions). In addition, all threats are expected to worsen in the foreseeable future, including the two greatest threats, ocean warming and ocean acidification, resulting in increased frequency, magnitude, and severity of warming-induced coral bleaching, reduced coral calcification, and increased reef erosion. These climate change threats are likely to be exacerbated by local threats such as fishing and land-based sources of pollution in some of SPR B's range. In conclusion, the information in the GSA (Smith 2019a), the SRR (Smith 2019b), and NMFS (2020b) provide support for SPR B currently being at low to moderate extinction risk throughout the foreseeable future.

SPR C. SPR C's distribution consists of *P. meandrina's* Ecoregions #11–68 from the western Indian Ocean to the western Pacific Ocean. Its range encompasses the densest aggregations of coral reefs in the world, amounting to approximately 178,000 km^2 of coral reef area (Table 4). The population includes some remote areas with small or no human populations, including parts of eastern Indonesia, the northern GBR, the Kimberley Coast of northwest Australia, and parts of New Guinea and the Solomon Islands, in addition to others (Smith 2019b, Fig. 2; NMFS 2020b). As is typical of *P. meandrina,* SPR C is more common at depths of <5 m (16 ft) than in deeper areas. The deepest *P. meandrina* colonies recorded within SPR C are from 30 m (98 ft) at Farallon de Medinilla in the Mariana Islands, and deepest colonies recorded for the species as a whole are from a depth of 34 m (112 ft; Smith 2019b, Section 3.1.2). Thus, SPR C's depth range is from the surface to at least 30 m. There is no evidence of any reduction in its range due to human impacts, thus we consider SPR C's historic and current ranges to be the same. Therefore, based on the best available information provided in the SRR (Smith 2019b), we consider SPR C's distribution to be very large and stable (Table 4).

Of SPR C's 58 ecoregions, relative abundance information is available for 34 ecoregions, in which it is common in seven, and uncommon in 27 (Smith 2019b, Fig. 2; NMFS 2020b). SPR C contains the entire Coral Triangle (Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands), which has over half of the coral reef area in the Indo-Pacific (Smith 2019a). While many of the Coral Triangle's ecoregions are relatively small, they collectively include over 25,000 islands, providing extensive habitat for SPR C. The total abundance estimate for *P. meandrina* is at least several tens of billions of colonies (Smith 2019b, Section 3.2.2), and SPR C includes approximately 76 percent of the species' coral reef habitat area (NMFS 2020b), although *P. meandrina* is uncommon in most of the population's ecoregions. Thus, we estimate SPR C's abundance to be a few tens of billions of colonies. In the three ecoregions for which time-series abundance data or information are available for SPR C, abundance appears to be decreasing in one ecoregion (Marianas Islands) and stable in two ecoregions (GBR Far North, GBR North-central; Smith 2019b, Table 4; NMFS 2020b). Therefore, based on the best available information provided above, we consider SPR C's overall abundance to be very high, but its overall abundance trend is unknown (Table 4).

Based on the information in the SRR, we consider SPR C's productivity to be high, despite declining abundance trends in one ecoregion. Evidence for high productivity is provided by observations from the GBR indicating strong recoveries in recent years from disturbances by displacing less competitive coral species and becoming more abundant than before the disturbances. In addition, studies and observations from ecoregions outside of SPR C have documented multiple recoveries (Smith 2019b, Section 3.2.3). These recoveries demonstrate continued high productivity, thus we consider SPR C's productivity to be high and stable (Table 4).

Although there is little information available on the genotypic and phenotypic diversity of SPR C, its large distribution and high habitat heterogeneity suggest that both types of diversity are high for this population. In addition, the population's distribution has not been reduced (Smith 2019b, Section 3.1). Therefore, we consider SPR C's diversity to be high and stable (Table 4).

The vulnerabilities of *P. meandrina* to each of the 10 threats were rated in the SRR, based on the species' susceptibility and exposure to each threat, for the foreseeable future assuming that RCP8.5 is the most likely future climate scenario (Smith 2019b, Table 6). Since SPR C includes approximately 76 percent of the range of *P. meandrina,* the threats to SPR C are similar as to the entire species, thus the threat vulnerability ratings are applicable to SPR C. Threat vulnerabilities were rated as: high for ocean warming and ocean acidification; Moderate for predation; Low to Moderate for fishing, land-based sources of pollution, and collection and trade; Low for sea-level rise, disease, and other threats (global); Very Low to Low for other threats (local), and Unknown for interactions of threats. Vulnerabilities to all threats are expected to increase in the foreseeable future under RCP8.5 (Smith 2019b, Table 6). While the global threats to SPR C are likely very similar as to the species as a whole, the local threats such as fishing, land-based sources of pollution, collection and trade, etc. are likely somewhat worse for SPR C because of the large human population and rapid industrialization within much of the Coral Triangle. However, SPR C also includes many remote areas with small or no human populations where local threats are virtually absent, such as parts of eastern Indonesia, northern Australia, Papua New Guinea, the Solomon Islands, and others (Smith 2019a; NMFS 2020b). SPR C's strong demographic factors moderate all threats, but the gradual worsening of threats is expected to result in a steady increase in extinction risk throughout the foreseeable future (Smith 2019b).

The extinction risk of SPR C depends on its demographic factors and threats. Populations at Low extinction risk have stable or increasing trends in abundance and productivity with connected, diverse populations, and are not facing threats that result in declining trends in distribution, abundance, productivity, or diversity (NMFS 2017). Currently, SPR C has a very large distribution, very high abundance, stable (two ecoregions) or decreasing (one ecoregion) abundance in the three ecoregions for which abundance trend data or information are available, and high and stable productivity and diversity. The population has life history characteristics that provide resilience to disturbances and a high capacity for recovery. However, SPR C faces multiple threats, the worst of which are expected to increase in the foreseeable future (Smith 2019a). Thus, on the one hand, most demographic factors suggest Low extinction risk for SPR C, but on the other hand, recent declining abundance trends in one of the three known ecoregions, as well as increasing threats in the foreseeable future, suggest increased extinction risk.

Species at Moderate extinction risk are on a trajectory that puts them at a high level of extinction risk in the foreseeable future, due to projected threats or declining trends in distribution, abundance, productivity, or diversity. While SPR C's distribution, productivity, and diversity are currently strong and stable, recent abundance trends are declining in one of the three ecoregions for which data or information are available. In addition, all threats are expected to worsen in the foreseeable future, including the two greatest threats, ocean warming and ocean acidification, resulting in increased frequency, magnitude, and severity of warming-induced coral bleaching, reduced coral calcification, and increased reef erosion. These climate change threats are likely to be exacerbated by local threats such as fishing and land-based sources of pollution throughout much of SPR C's range. In conclusion, the information in the GSA (Smith 2019a), the SRR (Smith 2019b), and NMFS (2020b) provide support for SPR C currently being at low to moderate extinction risk throughout the foreseeable future.

SPR D. SPR D's distribution consists of *P. meandrina's* Ecoregions #69–87. Although the smallest SPR, and the one with the fewest ecoregions, the population encompasses an area ≈6,500 km (4,000 mi) wide in the central Pacific Ocean that includes approximately 32,000 km^2 of coral reefs as well as extensive non-reef and mesophotic habitats (NMFS 2020b). Its range includes many remote areas with small or no human populations, including the Northwestern Hawaiian Islands, the Line Islands, and the Tuamotu Archipelago, and others (Smith 2019b, Fig. 2; NMFS 2020b). As is typical of *P. meandrina,* SPR D is more common at depths of <5 m (16 ft) than in deeper areas. The deepest *P. meandrina* colonies on record are from SPR D at a depth of 34 m (112 ft; Smith 2019b, Section 3.1.2). Thus, SPR D's depth range is from the surface to 34 m. There is no evidence of any reduction in its range due to human impacts, thus we consider SPR D's historic and current ranges to be the same. Therefore, based on the best available information provided in the SRR (Smith 2019b), we consider SPR D's distribution to be large and stable (Table 4).

Relative abundance information is available for all of SPR D's 19 ecoregions, in which it is dominant in seven, common in 7, and uncommon in five. Many of the coral reef communities within this population are *Pocillopora*-dominated, and *P. meandrina* is one of the most common species in many of SPR D's ecoregions (Smith 2019b, Fig. 2; NMFS 2020b). We estimate *P. meandrina's* total population to be at least several tens of billions of colonies (Smith 2019b, Section 3.2.2), but SPR D includes only about 14 percent of the species' coral reef area (NMFS 2020b). However, this population includes all seven ecoregions where *P. meandrina* is dominant, and the species is dominant or common in 14 of the population's 19 ecoregions. Thus, we estimate SPR D's total population to be at least several billion colonies. In the four ecoregions for which time-series abundance data or information are available for SPR D, abundance appears to be decreasing in two ecoregions (Northwestern Hawaiian Islands, Main Hawaiian Islands) and stable in two ecoregions (Samoa-Tuvalu-Tonga, Society Islands; Smith 2019b, Table 4; NMFS 2020b). Therefore, based on the best available information provided above, we consider SPR D's overall abundance to be high, but its overall abundance trend is unknown (Table 4).

Based on the information in the SRR, we consider SPR D's productivity to be high, despite declining abundance trends in some ecoregions. Evidence for high productivity is provided by SPR D's recovery from disturbance in several ecoregions, including: (1) Demographic data suggests that recovery from back-to-back bleaching events is occurring in the MHI Ecoregion (*i.e.,* fewer adults colonies in 2016 than in 2013 show adult colony mortality from the 2014 and 2015 bleaching events, but more juvenile colonies in 2016 than in 2013 suggests the initial stages of recovery from the bleaching events); and (2) studies and observations in other ecoregions (*e.g.,* Society Islands) indicate strong recoveries in recent years from various types of disturbances at multiple locations throughout its range, by displacing less competitive coral species and becoming more abundant than before the disturbances (Smith 2019b, Section 3.2.3). These recoveries demonstrate continued high productivity, thus we consider SPR D's productivity to be high and stable (Table 4).

Although there is little information available on the genotypic and phenotypic diversity of SPR D, its large distribution and high habitat heterogeneity suggest that both types of diversity are very high for this population. In addition, information from portions of individual ecoregions within SPR D shows high genotype and phenotypic diversity (Smith 2019b, Section 3.4). Furthermore, the population's distribution has not been reduced (Smith 2019b, Section 3.1). Therefore, we consider SPR D's diversity to be high and stable (Table 4).

The vulnerabilities of *P. meandrina* to each of the 10 threats were rated in the SRR, based on the species' susceptibility and exposure to each threat, for the foreseeable future assuming that RCP8.5 is the most likely future climate scenario (Smith 2019b, Table 6). Threat vulnerabilities were rated as: high for ocean warming and ocean acidification; Moderate for predation; Low to Moderate for fishing, land-based sources of pollution, and collection and trade; Low for sea-level rise, disease, and other threats (global); Very Low to Low for other threats (local), and Unknown for interactions of threats. Vulnerabilities to all threats are expected to increase in the foreseeable future under RCP8.5 (Smith 2019b, Table 6). Since SPR D has lower human population density and a higher proportion of remote areas than *P. meandrina's* entire range (Smith 2019b), local threats (fishing, land-based sources of pollution, collection and trade, and other local threats) are likely less severe in SPR D's range than across the range of the species. However, the vulnerability of SPR D to climate change threats (ocean warming, ocean acidification, sea-level rise) are likely similar as for *P. meandrina* rangewide. SPR D's strong demographic factors moderate all threats, but the gradual worsening of threats is expected to result in a steady increase in extinction risk throughout the 21st century (Smith 2019b).

The extinction risk of SPR D depends on its demographic factors and threats. Populations at Low extinction risk have stable or increasing trends in abundance and productivity with connected, diverse populations, and are not facing threats that result in declining trends in distribution, abundance, productivity, or diversity (NMFS 2017). Currently, SPR D has a large distribution, high abundance, stable (two ecoregions) or decreasing (two ecoregions) abundance in the four ecoregions for which abundance trend data or information are available, and high and stable productivity and diversity. The population has life history characteristics that provide resilience to disturbances and a high capacity for recovery. However, SPR D faces multiple threats, the worst of which are expected to increase in the foreseeable future (Smith 2019a). Thus, on the one hand, most demographic factors suggest Low extinction risk for SPR D, but on the other hand, recent declining abundance trends in two of the four known ecoregions, as well as increasing threats in the foreseeable future, suggest increased extinction risk.

Species at Moderate extinction risk are on a trajectory that puts them at a high level of extinction risk in the foreseeable future, due to projected threats or declining trends in distribution, abundance, productivity, or diversity. While SPR D's distribution, productivity, and diversity are currently strong and stable, recent abundance trends are declining in half of the ecoregions for which data or information are available (two of four ecoregions). In addition, all threats are expected to worsen in the foreseeable future, including the two greatest threats, ocean warming and ocean acidification, resulting in increased frequency, magnitude, and severity of warming-induced coral bleaching, reduced coral calcification, and increased reef erosion. These climate change threats are likely to be exacerbated by local threats such as fishing and land-based sources of pollution in some of SPR D's range. In conclusion, the information in the GSA (Smith 2019a), the SRR (Smith 2019b), and NMFS (2020b) provide support for SPR D currently being at low to moderate extinction risk throughout the foreseeable future.

SPR Determinations

Determinations based on status of the species within SPRs follow the process described in the introduction to the Rangewide Determination above. If the species within the SPR meets the definition of threatened or endangered, then the species should be listed throughout its range based on the status within that SPR. The determinations for *P. meandrina's* four SPRs are based on our interpretation of the information described above on the status of each SPR throughout its range currently and over foreseeable future.

SPR A

SPR A can be characterized as a population with strong demographic factors facing broad and worsening threats: It has a very large and stable distribution, very high overall abundance but unknown overall abundance trend, high and stable productivity, and high and stable diversity (Table 4). But it faces multiple global and local threats, all of which are worsening, and existing regulatory mechanisms are inadequate to ameliorate the threats. As explained in the Foreseeable Future for *P. meandrina* section above, we consider it likely that climate indicator values between now and 2100 will be within the collective ranges of those projected under RCPs 8.5, 6.0, and 4.5.

Although all threats are projected to worsen within SPR A's range over the foreseeable future (Smith 2019a,b; NMFS 2020a), the following characteristics of the population moderate its extinction risk, summarized from information in the SRR (Smith 2019b), NMFS (2020b), and the SPR A component of the Extinction Risk Assessments of the SPRs section above: (1) Its very large geographic distribution (68 ecoregions, ≈197,000 km² of reef area; NMFS 2020b), broad depth distribution (0-≥30 m; NMFS 2020b), and wide habitat breadth (SRR, Section 2.4), provide SPR A high habitat heterogeneity (SRR, section 3.4), which creates patchiness of conditions across its range at any given time, thus many portions of its range are unaffected or lightly affected by any given threat; (2) its very high abundance (a few tens of billions of colonies; NMFS 2020b), together with high habitat heterogeneity, likely result in many billions of colonies surviving even the worst disturbances; (3) even when high mortality occurs, its high productivity provides the capacity for the affected populations to recover quickly, as has been documented at sites in the GBR (SRR, Section 3.2.3); (4) likewise, its high productivity provides the capacity for populations to recover relatively quickly from disturbances compared to more sensitive reef coral species, allowing SPR A to take over denuded substrates and to sometimes become more abundant after disturbances than before them, as has been documented at sites in the GBR (SRR, Section 3.3); (5) it recruits to artificial substrates more readily than most other Indo-Pacific reef corals, often dominating the coral communities on the metal, concrete, and PVC surfaces of seawalls, Fish Aggregation Devices, pipes, and other manmade structures (SRR, Section 3.3); (6) in other *P. meandrina* populations that suffered high mortality from warming-induced bleaching, subsequent warming resulted in less mortality (SRR, Section 4.1), suggesting the potential for acclimatization and adaptation in this population; and (7) adaptation may be enhanced by its high genotypic diversity (SRR, Section 3.3) and high dispersal (SRR, Section 3.4).

Taken together, these demographic characteristics of SPR A are expected to substantially moderate the impacts of the worsening threats over the foreseeable future. While broadly deteriorating conditions will likely result in a downward trajectory of SPR A's overall abundance in the foreseeable future, the demographic characteristics summarized above are expected to allow the population to at least partially recover from many disturbances, thereby slowing the downward trajectory. Thus, our interpretation of the information in the GSA (Smith 2019a), SRR (Smith 2019b), and this finding is that SPR A is currently at low risk of extinction, and that it will be at low to moderate risk of extinction in the foreseeable future. Therefore, *P. meandrina* is not warranted for listing as endangered or threatened under the ESA at this time based on its status within SPR A.

SPR B

SPR B can be characterized as a population with strong demographic factors facing broad and worsening threats: it has a large and stable distribution, high overall abundance but unknown overall abundance trend, high and stable productivity, and high and stable diversity (Table 4). But it faces multiple global and local threats, all of which are worsening, and existing regulatory mechanisms are inadequate to ameliorate the threats. As explained in the Foreseeable Future for *P. meandrina* section above, we consider it likely that climate indicator values between now and 2100 will be within the collective ranges of those projected under RCPs 8.5, 6.0, and 4.5.

Although all threats are projected to worsen within SPR B's range over the foreseeable future (Smith 2019a,b; NMFS 2020a), the following characteristics of the population moderate its extinction risk, summarized from information in the SRR (Smith 2019b), NMFS (2020b), and the SPR B component of the Extinction Risk Assessments of the SPRs section above: (1) Its large geographic distribution (27 ecoregions, ≈35,000 km² of reef area, extensive non-reef and mesophotic habitats; NMFS 2020b), broad depth distribution (0–34 m; NMFS 2020b), and wide habitat breadth (SRR, Section 2.4), provide SPR B high habitat heterogeneity (SRR, section 3.4), which creates patchiness of conditions across its range at any given time, thus many portions of its range are unaffected or lightly affected by any given threat; (2) its high abundance (at least several billion colonies; NMFS 2020b), together with high habitat heterogeneity, likely result in billions of colonies surviving even the worst disturbances; (3) even when high mortality occurs, its high productivity provides the capacity for the affected populations to recover quickly, as has been documented at sites within several ecoregions (*e.g.,* at Fagatele Bay in American Samoa, at the Kahe Power Plant in the main Hawaiian Islands, and at Moorea in the Society Islands; SRR, Section 3.2.3); (4) likewise, its high productivity provides the capacity for populations to recover relatively quickly from disturbances compared to more sensitive reef coral species, allowing SPR B to take over denuded substrates and to sometimes become more abundant after disturbances than before them, as has been documented in some of SPR B's ecoregions (SRR, Section 3.3); (5) it recruits to artificial substrates more readily than most other Indo-Pacific reef corals, often dominating the coral communities on the metal, concrete, and PVC surfaces of seawalls, Fish Aggregation Devices, pipes, and other manmade structures (SRR, Section 3.3); (6) in some sub-populations that suffered high mortality from warming-induced bleaching, subsequent warming resulted in less mortality (*e.g.,* Oahu, main Hawaiian Islands, SRR, Section 4.1), suggesting acclimatization or adaptation of the surviving populations; and (7) adaptation may be enhanced by its high genotypic diversity (SRR, Section 3.3) and high dispersal (SRR, Section 3.4).

Taken together, these demographic characteristics of SPR B are expected to substantially moderate the impacts of the worsening threats over the foreseeable future. Although SPR B only consists of approximately 15 percent of the range of *P. meandrina,* it nevertheless covers approximately 35,000 km² of reef area (Table 4), as well as extensive non-reef and mesophotic habitats, spread across the central and eastern Pacific, thus constituting a large distribution. In addition, SPR B's distribution includes over 1,000 atolls and islands with small or no human populations (NMFS 2020b) where local threats are relatively low. While broadly deteriorating conditions will likely result in a downward trajectory of SPR B's overall abundance in the foreseeable future, the demographic characteristics summarized above are expected to allow the population to at least partially recover from many disturbances, thereby slowing the downward trajectory. Thus, our interpretation of the information in the GSA (Smith 2019a), SRR (Smith 2019b), and this finding is that SPR B is currently at low risk of extinction, and that it will be at low to moderate risk of extinction in the foreseeable future. Therefore, *P. meandrina* is not warranted for listing as endangered or threatened under the ESA at this time based on its status within SPR B.

SPR C

SPR C can be characterized as a population with strong demographic factors facing broad and worsening threats: it has a very large and stable distribution, very high overall abundance but unknown overall abundance trend, high and stable productivity, and high and stable diversity (Table 4). But it faces multiple global and local threats, all of which are worsening, and existing regulatory mechanisms are inadequate to ameliorate the threats. As explained in the Foreseeable Future for *P. meandrina* section above, we consider it likely that climate indicator values between now and 2100 will be within the collective ranges of those projected under RCPs 8.5, 6.0, and 4.5.

Although all threats are projected to worsen within SPR C's range over the foreseeable future (Smith 2019a,b; NMFS 2020a), the following characteristics of the population moderate its extinction risk, summarized from information in the SRR (Smith 2019b), NMFS (2020b), and the SPR C component of the Extinction Risk Assessments of the SPRs section above: (1) Its very large geographic distribution (58 ecoregions, ≈178,000 km² of reef area; NMFS 2020b), broad depth distribution (0-≥30 m; NMFS 2020b), and wide habitat breadth (SRR, Section 2.4), provide SPR C high habitat heterogeneity (SRR, section 3.4), which creates patchiness of conditions across its range at any given time, thus many portions of its range are unaffected or lightly affected by any given threat; (2) its very high abundance (a few tens of billions of colonies; NMFS 2020b), together with high habitat heterogeneity, likely result in many billions of colonies surviving even the worst disturbances; (3) even when high mortality occurs, its high productivity provides the capacity for the affected populations to recover quickly, as has been documented on the GBR (Section 3.2.3); (4) likewise, its high productivity provides the capacity for populations to recover relatively quickly from disturbances compared to more sensitive reef coral species, allowing SPR C to take over denuded substrates and to sometimes become more abundant after disturbances than before them, as has been documented on the GBR (SRR, Section 3.3); (5) it recruits to artificial substrates more readily than most other Indo-Pacific reef corals, often dominating the coral communities on the metal, concrete, and PVC surfaces of seawalls, Fish Aggregation Devices, pipes, and other manmade structures (SRR, Section 3.3); (6) in other *P. meandrina* populations that suffered high mortality from warming-induced bleaching, subsequent warming resulted in less mortality (SRR, Section 4.1), suggesting the potential for acclimatization and adaptation in this population; and (7) adaptation may be enhanced by its high genotypic diversity (SRR, Section 3.3) and high dispersal (SRR, Section 3.4).

Taken together, these demographic characteristics of SPR C are expected to substantially moderate the impacts of the worsening threats over the foreseeable future. While broadly deteriorating conditions will likely result in a downward trajectory of SPR C's overall abundance in the foreseeable future, the demographic characteristics summarized above are expected to allow the population to at least partially recover from many disturbances, thereby slowing the downward trajectory. Thus, our interpretation of the information in the GSA (Smith 2019a), SRR (Smith 2019b), and this finding is that SPR C is currently at low risk of extinction, and that it will be at low to moderate risk of extinction in the foreseeable future. Therefore, *P. meandrina* is not warranted for listing as endangered or threatened under the ESA at this time based on its status within SPR C.

SPR D

SPR D can be characterized as a population with strong demographic factors facing broad and worsening threats: it has a large and stable distribution, high overall abundance but unknown overall abundance trend, high and stable productivity, and high and stable diversity (Table 4). But it faces multiple global and local threats, all of which are worsening, and existing regulatory mechanisms are inadequate to ameliorate the threats. As explained in the Foreseeable Future for *P. meandrina* section above, we consider it likely that climate indicator values between now and 2100 will be within the collective ranges of those projected under RCPs 8.5, 6.0, and 4.5.

Although all threats are projected to worsen within SPR D's range over the foreseeable future (Smith 2019a,b; NMFS 2020a), the following characteristics of the population moderate its extinction risk, summarized from information in the SRR (Smith 2019b), NMFS (2020b), and the SPR D component of the Extinction Risk Assessments of the SPRs section above: (1) Its large geographic distribution (19 ecoregions, ≈32,000 km² of reef area, extensive non-reef and mesophotic habitats; NMFS 2020b), broad depth distribution (0–34 m; NMFS 2020b), and wide habitat breadth (SRR, Section 2.4), provide SPR D high habitat heterogeneity (SRR, section 3.4), which creates patchiness of conditions across its range at any given time, thus many portions of its range are unaffected or lightly affected by any given threat; (2) its high abundance (at least several billion colonies; NMFS 2020b), together with high habitat heterogeneity, likely result in billions of colonies surviving even the worst disturbances; (3) even when high mortality occurs, its high productivity provides the capacity for the affected populations to recover quickly, as has been documented at sites within several ecoregions (*e.g.,* at Fagatele Bay in American Samoa, at the Kahe Power Plant in the main Hawaiian Islands, and at Moorea in the Society Islands; SRR, Section 3.2.3); (4) likewise, its high productivity provides the capacity for populations to recover relatively quickly from disturbances compared to more sensitive reef coral species, allowing SPR D to take over denuded substrates and to sometimes become more abundant after disturbances than before them, as has been documented in some of SPR D's ecoregions (SRR, Section

3.3); (5) it recruits to artificial substrates more readily than most other Indo-Pacific reef corals, often dominating the coral communities on the metal, concrete, and PVC surfaces of seawalls, Fish Aggregation Devices, pipes, and other manmade structures (SRR, Section 3.3); (6) in some sub-populations that suffered high mortality from warming-induced bleaching, subsequent warming resulted in less mortality (*e.g.,* Oahu, main Hawaiian Islands, SRR, Section 4.1), suggesting acclimatization or adaptation of the surviving populations; and (7) adaptation may be enhanced by its high genotypic diversity (SRR, Section 3.3) and high dispersal (SRR, Section 3.4).

Taken together, these demographic characteristics of SPR D are expected to substantially moderate the impacts of the worsening threats over the foreseeable future. Although SPR D only consists of approximately 14 percent of the range of *P. meandrina,* it nevertheless covers approximately 32,000 km^2 of reef area (Table 4), as well as extensive non-reef and mesophotic habitats, spread across the central Pacific, thus constituting a large distribution. In addition, SPR D's distribution includes over 1,000 atolls and islands with small or no human populations (NMFS 2020b) where local threats are relatively low. While broadly deteriorating conditions will likely result in a downward trajectory of SPR D's overall abundance in the foreseeable future, the demographic characteristics summarized above are expected to allow the population to at least partially recover from many disturbances, thereby slowing the downward trajectory. Thus, our interpretation of the information in the GSA (Smith 2019a), SRR (Smith 2019b), and this finding is that SPR D is currently at low risk of extinction, and that it will be at low to moderate risk of extinction in the foreseeable future. Therefore, *P. meandrina* is not warranted for listing as endangered or threatened under the ESA at this time based on its status within SPR D.

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

References

A complete list of the references used in this 12-month finding is available at *https://www.fisheries.noaa.gov/species/pocillopora-meandrina-coral#conservation-management* and upon request (see **FOR FURTHER INFORMATION CONTACT**).

Authority

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

Dated: June 29, 2020.

Donna Wieting,

Director, Office of Protected Resources, National Marine Fisheries Service.

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