

Cantharellus noumeae
Siderastrea glynni
Tubastraea floreana

**5-Year Review:
*Summary and Evaluation***



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**National Marine Fisheries Service
Office of Protected Resources
Silver Spring, MD**

5-YEAR REVIEW

Species reviewed: *Cantharellus noumeae*, *Siderastrea glynni*, *Tubastraea floreana*

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5-YEAR REVIEW

Cantharellus noumeae, *Siderastrea glynni*, *Tubastraea floreana*

1.0 GENERAL INFORMATION

1.1 Reviewers

NMFS Office of Protected Resources: Adrienne Lohe, 301-427-8442

1.2 Methodology used to complete review

The purpose of the Endangered Species Act of 1973, citation as amended (ESA; 16 U.S.C. 1531 *et seq.*) is to provide a means to conserve the ecosystems upon which endangered and threatened species depend, to provide a program for the conservation of endangered and threatened species, and to take appropriate steps to recover endangered and threatened species. One of our responsibilities under the ESA is to conduct a review of each listed species at least every 5 years to determine whether its endangered or threatened status should be changed or removed (i.e., 5-year review, 16 U.S.C. 1533(c)(2)). The ESA requires us to make these determinations solely on the basis of the best scientific and commercial data available (16 U.S.C. 1533(b)(1)(A)). In 2015, after a status review of the species (the Status Review; Meadows 2014), the National Marine Fisheries Service (NMFS) listed the three coral species as endangered (80 FR 60560; October 7, 2015; listing effective November 6, 2015). On April 7, 2020, we initiated this 5-year review for the three foreign coral species: *Cantharellus noumeae*, *Siderastrea glynni*, and *Tubastraea floreana* (85 FR 19456).

To compile the best available scientific and commercial data on the species, we first reviewed the Status Review (Meadows 2014), which was based on the best available scientific and commercial data available at that time. We then searched for relevant new information on the three coral species, their biology and habitat, and threats to their existence. Specifically, we searched for published literature using scientific search engines (including Clarivate's Web of Science, ScienceDirect, BioOne Complete, ProQuest's Aquatic Sciences and Fisheries Abstracts, JSTOR, EBSCO Academic Search and Environment Complete, and Google Scholar) and NMFS' scientific literature database. We solicited relevant information from other Federal agencies, States, Territories, Tribes, foreign governments, academia, nonprofit organizations, industry groups, and individuals by publishing a request in the Federal Register (85 FR 19456; April 7, 2020). We also solicited information from subject matter experts and/or individuals with expertise on particular species. Though we did not receive any responses to our Federal Register notice, we compiled, reviewed, and evaluated available data. We did not conduct new empirical studies because the ESA requires the use of the best *available* scientific and commercial information.

After compiling the data, we considered the biology and habitat of the three coral species. We identified information that has become available since the publication of the Status Review in 2014. We also reviewed the best available information on abundance and trends, genetics, spatial distribution, and habitat conditions.

We also assessed threats to each of the species by identifying and evaluating the ESA section 4(a)(1) factors (i.e., the five factor analysis; 16 U.S.C. 1533(a)(1)):

1. Present or threatened destruction, modification, or curtailment of habitat or range
2. Overutilization for commercial, recreational, scientific, or educational purposes
3. Disease or predation
4. Inadequacy of existing regulatory mechanisms
5. Other natural or manmade factors affecting its continued existence

Because the abundance and trends present a manifestation of past threats, we focused on present threats. For each factor, we evaluated its likely impact and magnitude, as well as the vulnerability and exposure of each species.

We synthesized the above information to assess the status of each species. We identified the factors that weighed most heavily in our evaluation. We also described areas of high confidence, remaining uncertainties, and their relevance to our overall assessment. Based on this information, we provide a recommendation on the status of each of the three foreign coral species.

1.3 Background

1.3.1 FRN Notice citation announcing initiation of this review

FR notice: 85 FR 19456

Date published: April 7, 2020

Purpose: NMFS gave notice of our initiation of a 5-year review of three foreign coral species: *Cantharellus noumeae*, *Siderastrea glynni*, and *Tubastraea floreana*; we requested relevant information from the public.

1.3.2 Listing History

Original Listing

FR notice: 80 FR 60560; October 7, 2015

Date listed: November 6, 2015

Entity listed: *Cantharellus noumeae*, *Siderastrea glynni*, and *Tubastraea floreana*

Classification: Endangered

1.3.3 Review History

- On July 15, 2013, WildEarth Guardians petitioned us to list 81 marine species, including *Cantharellus noumeae*, *Siderastrea glynni*, and *Tubastraea floreana*, as threatened or endangered under the ESA and designate critical habitat. On October 25, 2013, we found that the petition presented substantial scientific information indicating that listing these three species may be warranted (78 FR 63941) and conducted the Status Review (Meadows 2014).
- On April 7, 2020, NMFS gave notice of our initiation of a 5-year review of the three foreign coral species and requested relevant information from the public (85 FR 19456).

1.3.4 Species' Recovery Priority Number at start of 5-year review

Not applicable.

1.3.5 Recovery Plan or Outline

Recovery plans were not prepared for these three species. This is in accordance with NMFS' May 10, 2016 finding that a recovery plan would not promote their conservation as all three occur in foreign waters and therefore the threats to the species occur under foreign jurisdictions.

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate?

Yes
 No

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

Yes
 No

2.3 Updated Information and Current Species Status

2.3.1 *Cantharellus noumeae*

2.3.1.1 Species introduction

Cantharellus noumeae was listed as an endangered species effective November 6, 2015 based on its small, restricted range, likely low growth rate and genetic diversity, and potential threats posed by development, water pollution, sedimentation, heavy metals, and potential illegal activities (80 FR 60560). At the time of listing, the species was thought to occur only in a restricted area of less than 225 km² on reefs in sheltered bays in New Caledonia, on the southern tip of the main island of Grand Terre.

2.3.1.2 Biology and life history

Cantharellus noumeae is a cup-shaped fungiid or mushroom coral that remains attached to the substrate for its entire life, unlike most other fungiids (Hoeksema and Best 1984). It may be solitary or grow within small colonies (Veron *et al.* 2016) and receives most of its energy from symbiotic zooxanthellae (Wildscreen Arkive 2018). The species occurs in enclosed bays, settling on hard substrates in silty and muddy habitats at approximately 5 to 30 meters depth (Gilbert *et al.* 2015). It appears tolerant of high turbidity and metal-rich environments as individuals occur in relatively high densities in Grande Rade, a harbor polluted with high concentrations of iron, nickel, chromium, and manganese from a nearby nickel processing plant (Gilbert *et al.* 2015). As other fungiids are known to shed sediment, even when completely buried (Bongaerts *et al.* 2012), *Cantharellus noumeae* may use a similar mechanism to tolerate such conditions (Gilbert *et al.* 2015).

The reproductive methods of the species remain unknown, though they are likely the same as those used by other fungiids (Wildscreen Arkive 2018). This family is known to use several reproductive strategies, including both sexual and asexual reproduction. Depending on the species, certain fungiids reproduce sexually through broadcast spawning, in which gonochoric individuals release eggs and sperm into the water column, or brood spawning, in which fertilization occurs internally and larva are released (Colley *et al.* 2000; Loya *et al.* 2009). In both cases, larva experience high mortality prior to settling on suitable substrate to continue their development (Brainard *et al.* 2011). Certain fungiids such as *Ctenactis crassa* and *Fungia scruposa* are known to change sex (Loya *et al.* 2009). Asexual reproduction is also known to occur in certain fungiids through budding or fragmentation (Gilmour 2004; Hoeksema and Gittenberger 2010). As reproductive strategies vary widely across Fungiidae, we cannot draw any specific conclusions about the reproductive methods of *C. noumeae* without further study.

2.3.1.3 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends

The Status Review concluded that no information on species abundance or trends were available at the time of publication, but noted that the species was thought to be uncommon and to occur in low densities. Since then, the first quantitative assessment of the species was carried out in Grande Rade, a turbid and significantly polluted harbor in Nouméa, New Caledonia. Abundance, density, and population structure were surveyed on both a natural subtidal patch reef (the Japanese Bank) and a nearby artificial embankment made up of scoria, a by-product of nickel production, located near a nickel mining complex. Densities were found to average 288 colonies per 50 m² on the natural Japanese Bank and 82 colonies per 50 m² on a nearby artificial embankment (Gilbert *et al.* 2015). On the natural Japanese Bank, 47% of observed colonies had sizes of less than 1.5 cm, representing new recruits, while only 5% were large colonies (4.0-6.5 cm) (Gilbert *et al.* 2015). Artificial embankment sites had low proportions of recent recruits (between 7-14%). Medium sized individuals (between 1.5 and 4.0 cm) were found in similar proportions at the two locations (between 46% and 59%) (Gilbert *et al.* 2015). Both overall abundance and recruitment were higher on natural rock than artificial substrate (Gilbert *et al.* 2015).

Though abundance was relatively high in Grande Rade, there are few records of the species despite numerous coral reef surveys in New Caledonia over the last decade, likely due to the narrow range of suitable conditions for the species (Gilbert *et al.* 2015). We found no information on abundance in other areas or population trends. We conclude that though abundance and density is relatively high in Grande Rade, the species is likely rare as it has been recorded in very few other locations despite high search effort.

2.3.1.4 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.)

We found no new information on the genetics or genetic variation of the species, though it is likely that the species has low genetic diversity because such a small number of colonies are known to exist. The species' low genetic diversity reduces its adaptive capacity, therefore increasing its extinction risk.

2.3.1.5 Taxonomic classification or changes in nomenclature

There has been no change in taxonomic classification or nomenclature since the species was last reviewed. It remains as follows:

Kingdom: Animalia

Phylum: Cnidaria

Class: Anthozoa

Order: Scleractinia

Family: Fungiidae

Genus: *Cantharellus*

Species: *noumeae*

2.3.1.6 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.)

The species is currently considered endemic to New Caledonia (Gilbert *et al.* 2015; B. Hoeksema, personal communication 2020). Unconfirmed records from other localities, including the Great Barrier Reef and New Guinea (Fenner and Muir 2007), are now known to be misidentifications (Gilbert *et al.* 2015; B. Hoeksema, personal communication 2020). Records of the species are limited to the north-west, north-east, south-west and south of the island of Grande-Terre, as well as fringe and submerged reefs near Nouméa (Gilbert *et al.* 2015). The spatial distribution of the species is very limited (Hoeksema and Waheed 2015), and the best available estimate of its area of occupancy, as reported in the Status Review, is 225 km² (Hoeksema *et al.* 2008). The narrow distribution of the species increases its risk of extinction because a narrowly distributed species is more likely to go extinct due to environmental perturbations or catastrophic events than one that is widely distributed.

2.3.1.7 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem)

In Grande Rade, Nouméa, the species is 3.5 times more abundant on natural rock substrate than on a nearby artificial embankment made up of scoria, a byproduct of nickel processing (Gilbert *et al.* 2015). Additionally, Gilbert *et al.* (2015) found natural rock substrate to host higher proportions of recently recruited individuals than the artificial embankment (47% vs. 7-14%). These observations indicate that the artificial embankment made up of scoria is less suitable habitat than natural

substrate (Gilbert *et al.* 2015). Even so, the authors note that the coral communities at the natural Japanese Bank have suffered from environmental change and extensive rubble cover due to runoff from nearby mining operations (Gilbert *et al.* 2015). From this limited data we conclude that the most suitable habitat for *C. noumeae* is experiencing degradation from mining activities. As the species has a narrow range of suitable habitat conditions (enclosed bays with high sedimentation rates) (Gilbert *et al.* 2015), the loss of suitable habitat increases the species' extinction risk.

2.3.1.8 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

Present or threatened destruction, modification or curtailment of its habitat or range

Climate change

Climate change and associated ocean warming and acidification are modifying *C. noumeae* habitat. To evaluate the impact of climate change on the species, we used the best available data, which includes the Intergovernmental Panel on Climate Change (IPCC) Special Report on Oceans and Cryosphere (IPCC 2019). The Revised Guidance for Treatment of Climate Change in NMFS' ESA Decisions (NMFS 2016) requires us to use climate indicator values projected under the IPCC Representative Concentration Pathway (RCP) 8.5 when data are available. RCP8.5 reflects a continued increase of greenhouse gas emissions and assumes that few mitigation measures will be implemented.

The IPCC (2019) reports that the global ocean has warmed unabated since 1970 and has taken up more than 90% of the excess heat in the climate system (high confidence). It is virtually certain that the ocean will continue warming throughout the 21st century and by 2100, the top 2000 m of the ocean will very likely take up 5 to 7 times more heat under RCP8.5 than observed heat uptake since 1970 (IPCC 2019). Warmer ocean temperatures are a significant cause of coral bleaching, a process in which a coral's symbiotic zooxanthellae are expelled in response to stress (Brainard *et al.* 2011). The loss of photosynthetic energy resulting from bleaching can lead to starvation, disease, failure to reproduce, and reduced ability to compete with other benthic organisms (Hoegh-Guldberg *et al.* 2017). Though corals can survive mild bleaching events, prolonged bleaching leads to colony mortality (Brainard *et al.* 2011). As many coral physiological processes are locally optimized, increases of only 1°C–2°C above the normal local seasonal maximum can induce bleaching, though susceptibility to bleaching varies by taxa (Brainard *et al.* 2011). Marine heatwaves (occurring when the daily sea surface temperature exceeds the local 99th percentile) have already caused large-scale coral bleaching events at increasing frequency (very high confidence), and coral reef recovery may take more than 15 year if it occurs at all (high confidence) (IPCC 2019).

It is very likely that the ocean has taken up 20 to 30 percent of total anthropogenic carbon dioxide emissions since the 1980s, leading to ocean acidification rates of 0.017 to 0.027 pH units per decade since the late 1980s (IPCC 2019). It is

virtually certain that continued carbon uptake through 2100 will exacerbate ocean acidification, and under RCP8.5, open ocean surface pH is projected to decrease by around 0.3 pH units by 2081–2100, relative to 2006–2015 (IPCC 2019). As discussed in detail by Brainard *et al.* (2011), ocean acidification can reduce coral skeleton calcification rates, potentially leading to reduced structural stability, slower recovery from breakage, increased mortality for newly settled corals, and later maturation.

In addition to ocean warming and acidification, climate change modifies coral habitat through sea level rise, changes to ocean circulation (including El Niño-Southern Oscillation (ENSO)), and increased storm activity (Brainard *et al.* 2011). The melting of glaciers and ice sheets is the primary driver of sea level rise, which has accelerated in recent years (very high confidence; IPCC 2019). By 2100 (relative to 2005), global mean sea level is projected to rise 0.84 m with a likely range of 0.61 to 1.1 m, where likely refers to 66 to 100 percent probability (IPCC 2019). Sea level rise is likely to outpace vertical growth by many corals and under RCP8.5 scenarios, most reefs are predicted to experience mean water depth increases of more than 0.5 m by 2100 (Perry *et al.* 2018). This is of concern as a change of this magnitude has been shown to impact near-shore sediment dynamics and coastal wave exposure (Perry *et al.* 2018). Changes to ocean currents and circulation will directly affect critical coral life processes such as larval transport and recruitment, nutrient enrichment, heating and cooling, respiration, photosynthesis, and calcification (Brainard *et al.* 2011). The IPCC (2019) reports with medium confidence that Extreme El Niño and La Niña events are projected to become more frequent, and that the average intensity of tropical cyclones, the proportion of Category 4 and 5 tropical cyclones, and average precipitation rates are projected to increase with a 2°C global temperature increase. Though natural disturbance from storms has affected corals for millennia, other anthropogenic stressors such as ocean acidification have reduced the capacity of corals to recover from such events (Brainard *et al.* 2011). It is uncertain how sea level rise, changes to ocean circulation, or increased storm activity will specifically affect *C. noumeae*.

Climate change poses a serious threat to corals globally, though recent studies show that corals may have some ability to acclimatize, evolve, or relocate in response to changing conditions (Hoegh-Guldberg *et al.* 2017). Corals may be able to shift the ratios of different *Symbiodinium* varieties within their tissues, which play a role in tolerance of extreme temperatures (Hoegh-Guldberg *et al.* 2017). Additionally, the short generation time and high rate of mutation in *Symbiodinium* relative to its coral host could allow for more rapid adaptations to changing thermal conditions (Torda *et al.* 2017). Another possible method of acclimatization is transgenerational plasticity (TGP), in which the phenotype of offspring is influenced by the environment experienced by its parent, leading to improved tolerance of the same environment by the offspring (Torda *et al.* 2017). Initial studies have provided evidence of this type of response in coral (Putnam and Gates 2015), though significant uncertainty remains regarding the

mechanisms behind TGP and how it could help corals adapt to climate change. Genetic adaptation in response to climate change may be possible, though corals likely do not have evolutionary rates that would enable them to keep up with the rapid environmental change that corals are experiencing (Hoegh-Guldberg *et al.* 2017). Shifts of coral ranges to higher latitudes have been documented, though many factors such as availability of shallow water habitat and sufficient light and aragonite saturations at those latitudes may limit the success of this mechanism, as discussed by Hoegh-Guldberg *et al.* (2017). While there are several potential ways in which corals may respond to climate change, future projected changes based on current and expected future greenhouse gas emissions limit their ability to keep up.

Several factors may reduce the vulnerability of *C. noumeae* to ocean warming. In a global analysis of spatial variation in warming trends and thermal stress, New Caledonia had a lower than expected increase in bleaching stress events between 1985-1991 and 2006-2012 based on its summertime warming rate, indicating that it may be a refuge from thermal stress (Heron *et al.* 2016). Further, turbid near-shore environments in New Caledonia have been shown to serve as refuges from high sea surface temperature (SST) and high irradiance, providing shade for corals and protecting against bleaching (Cacciapaglia and van Woesik 2016). This protective effect varies by taxa, and though *C. noumeae* was not examined in the study by Cacciapaglia and van Woesik (2016), its existence in turbid waters leads us to conclude that effects of ocean warming, including bleaching, may be mitigated to some unknown degree from this relationship. In addition, the growth form of the species is less susceptible to thermal stress and bleaching, as compared to branching corals with thin tissue layers (Wooldridge 2014).

Despite evidence that *C. noumeae* may have reduced vulnerability to thermal stress, bleaching of New Caledonian corals has occurred. A large-scale bleaching event in 2016 affected two-thirds of New Caledonian reefs (Payri *et al.* 2019). Though warmer than usual SST lasted for months, most corals were able to recover (Payri *et al.* 2019). Given the projected continued uptake of heat and carbon dioxide by the ocean, thermal stress remains a threat to *C. noumeae* and other corals in this region. While we found no information specifically addressing *C. noumeae*'s response or vulnerability to climate change, ocean warming, acidification, and other impacts described above are known to threaten corals globally and are therefore expected to have similar impacts on the abundance, productivity, and spatial distribution of the species. For this reason, we consider climate change a threat to the species based on the best available information.

Mining

The economy of New Caledonia is driven by nickel mining, and the country is currently the fifth largest producer of nickel in the world (Biscéré *et al.* 2017; USGS 2020). Open-cast mining sites located along the coast of Grande Terre contribute to soil erosion and introduction of sediments and metals to the marine environment (Moreton *et al.* 2009; Heintz *et al.* 2015). In Grande Rade, the

location of a large nickel processing complex, metals were found in superficial sediments in the following descending order of concentration: iron, nickel, chromium, cobalt, manganese, and copper (Gilbert *et al.* 2015). Cadmium, lead, and zinc were below their limit of detection (Gilbert *et al.* 2015). Moreton *et al.* (2009) found dissolved iron concentrations to be 0.03 µg/L outside the New Caledonian Barrier Reef; they ranged from 0.12-0.20 µg/L at the end of Grande Rade bay and were as high as 25.4 µg/L in Prony Bay, also home to a large nickel processing plant. As compared to a background dissolved nickel concentration of 0.09 µg/L outside the New Caledonian Barrier Reef, nickel concentrations in Grande Rade varied from 3.29-4.35 µg/L at the end of the bay, and certain areas in Prony Bay were as high as 37.4 µg/L (Moreton *et al.* 2009). Other dissolved metal concentrations in coastal New Caledonian waters were found as follows: cobalt as high as 59.28 µg/L, copper as high as 1.2 µg/L, and manganese as high as 1964 µg/L (Moreton *et al.* 2009).

Sedimentation may affect corals by limiting the amount of light available for photosynthesis by *Symbiodinium*, as well as reducing their ability to capture zooplankton (Heintz *et al.* 2015). Corals are known to rid themselves of sediment through ciliary action, mucus production, and polyp inflation (Bongaerts *et al.* 2012; Erftemeijer *et al.* 2012). Though *C. noumeae* appears tolerant of sedimentation, the energy required to remove sediment reduces the resources available for other essential functions such as growth and reproduction (Erftemeijer *et al.* 2012). As such, sedimentation can lead to reduced growth, reduced productivity, increased susceptibility to disease, bleaching, and mortality (Erftemeijer *et al.* 2012).

The contamination of the marine environment by metals further impacts corals. Moderate cobalt enrichment (0.2 µg/L, versus 0.03 µg/L control) has been shown to decrease calcification rates of *Acropora muricata* and *Stylophora pistillata* by 28% (Biscéré *et al.* 2015). In *S. pistillata*, manganese enrichment (4.1 µg/L, versus 0.06 µg/L control) was found to increase symbiont photosynthesis and therefore mitigate against thermal stress-induced bleaching, though iron enrichment (3 µg/L, versus <0.22 µg/L control) decreased calcification rates and counteracted any positive effects from manganese on coral bleaching (Biscéré *et al.* 2018). Relatively high copper enrichment (32 and 65 µg/L) led to bleaching and alteration of the microbiome of *A. muricata* (Gissi *et al.* 2019). Acute exposure to moderate nickel concentrations (2.71 µg/L, versus 0.15 µg/L ambient) has been shown to result in significant increases of 27% and 47% in coral calcification rates in *Pocillopora damicornis* and *A. muricata*, respectively (Biscéré *et al.* 2017). However, this positive impact is reversed under higher temperature scenarios (32°C vs. ambient 26°C) as indicated by decreased growth rates and increased coral respiration, indicating that climate change and nickel exposure have a synergistic negative effect on scleractinians (Biscéré *et al.* 2017). More recently, when exposed to dissolved nickel (200 µg/L and 400 µg/L) and nickel-contaminated sediment, *A. muricata* was found to bleach and accumulate nickel (Gillmore *et al.* 2020). Sediment in this study was contaminated with

nickel at 6,000 mg/kg to represent high concentrations that have been observed near mining facilities (Gillmore *et al.* 2020).

While the effects of exposure to high sedimentation and metal contamination on *C. noumeae* remain unclear, available data summarized above indicate that these conditions likely have sublethal negative effects on coral fitness, potentially leading to mortality at certain levels. Nickel production in New Caledonia has increased since the Status Review (165,000 metric tons produced in 2014, 220,000 in 2019; USGS 2020), and is expected to continue increasing as all metal processing plants reach full production capacity (Plaza-Toledo 2019). Therefore, mining continues to pose a major threat to *C. noumeae* that is expected to increase in the future.

Overutilization for commercial, recreational, scientific, or educational purposes

The CITES trade database reports no trade in the species or genus from 2012-2019. The Status Review reported trade of less than 50 *Cantharellus* spp. individuals between 1975 and 2012. It does not appear that the species is impacted by international trade, and we have no information on use for other purposes. As such, overutilization does not appear to threaten the species.

Disease or predation

Disease prevalence was found to be low in corals, including fungiids, studied at four reefs in New Caledonia downstream of mining sites (Heintz *et al.* 2015). Though growth anomalies and abnormal pigmentation in response to stress were observed in fungiid corals, corals were not identified to species and therefore it is unclear if *C. noumeae* is affected by disease (Heintz *et al.* 2015).

Outbreaks of the coral predator *Acanthaster* spp., the crown-of-thorns seastar, are common in the Indo-Pacific region. However, they are localized, ephemeral, and appear naturally contained in New Caledonian reefs (Adjeroud *et al.* 2018). Despite this, following a major coral bleaching event in 2016, an outbreak of crown-of-thorns seastars prevented the recovery of many corals and led to high mortality (Payri *et al.* 2019). We did not find any reports of the crown-of-thorns seastar preying on *C. noumeae* specifically. Predation by *Acanthaster* spp. may threaten *C. noumeae* by reducing the abundance of the species, though it is unclear to what degree.

Inadequacy of existing regulatory mechanisms

The following international, regional, national, local regulatory mechanisms apply to *C. noumeae*:

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

CITES is an international convention that aims to ensure that international trade in animals and plants does not threaten their survival. CITES affords varying degrees of protection to over 37,000 species and is legally binding for Parties. All scleractinian corals, including *C. noumeae*, were listed in Appendix II of CITES

in 1989, meaning that they may be traded under certain conditions, above all that trade must not be detrimental to the survival of the species in the wild. Though only certain scleractinian species were in trade at the time of the CITES listing, all scleractinians were included due to difficulties distinguishing between species. According to Article II of CITES, species listed on Appendix II are those that are “not necessarily now threatened with extinction but may become so unless trade in specimens of such species is subject to strict regulation in order to avoid utilization incompatible with their survival.” There are 183 Parties to CITES as of July 2020.

Lagoons of New Caledonia UNESCO World Heritage Site

In 2008, 15,743 km² of New Caledonian reefs and lagoons across six sites were inscribed under UNESCO World Heritage protections, though these sites are all located away from mining operations (Gilbert *et al.* 2015). The sites are currently protected by fisheries legislation, and management plans are being developed for with involvement of stakeholders and the indigenous Kanak community (<https://whc.unesco.org/en/list/1115/>).

Natural Park of the Coral Sea

This protected area was designated in 2014 to protect the integrity of New Caledonia’s marine environment. The park encompasses New Caledonia’s entire exclusive economic zone, totaling 1.3 million km². In March 2018, a management plan extending to the year 2022 was formally adopted, and in August 2018, new reserves within the park were established over reefs, lagoons and islets, and surrounding waters totaling 28,000 km². Within these reserves, all fishing is prohibited, access is subject to government authorization, and recreational use is restricted. (<https://mer-de-corail.gouv.nc/en>). According to the Pew Bertarelli Ocean Legacy Project, President Philippe Germain of New Caledonia built on the August designation by committing to designate 200,000 to 400,000 km² as ‘highly protected’ by the end of 2019 (<https://www.pewtrusts.org/en/about/news-room/press-releases-and-statements/2018/10/29/new-caledonia-commits-to-protecting-more-of-its-coral-sea-natural-park>). The park’s website does not reflect this change as of the publication of this review.

The Mining Code of New Caledonia

The Mining Code was established in 2009 to restructure and simplify New Caledonia’s mining regulations (Plaza-Toledo 2019). It provides procedures for foreign investment in mining activity, lists an inventory of New Caledonia’s mineral resources, sets conditions for the export of metallurgic products, and establishes an environmental protection framework (Plaza-Toledo 2019). The Mining Code requires an environmental impact study prior to the opening of a processing plant. Mining companies also must rehabilitate degraded mining sites, and if a company fails to do so, the President of the Provincial Assembly may order a rehabilitation at the mining company’s expense (https://www.businessadvantagepng.com/wp-content/uploads/2013/02/New_Caledonia_Investment_Guide.pdf). The

government agency responsible for the mining industry is the Direction de l'Industrie, des Mines et de l'Énergie (Department of Industry, Mines and Energy, or DIMENC).

While there are several different regulatory mechanisms protecting corals and their habitats in New Caledonian waters, there is a high prevalence of sediment damage and algal overgrowth on reefs within close proximity to mining operations (Heintz *et al.* 2015) and many areas show high levels of metal contamination (Moreton *et al.* 2009; Gilbert *et al.* 2015). For this reason, we conclude that existing regulatory mechanisms are inadequate to protect *C. noumeae* from habitat degradation due to mining activity.

Other natural or manmade factors affecting its continued existence

We found no other natural or manmade factors affecting the continued existence of the species.

2.3.1.9 Synthesis

Cantharellus noumeae was listed as an endangered species effective November 6, 2015 based on its small, restricted range, likely low growth rate and genetic diversity, and potential threats posed by development, water pollution, sedimentation, heavy metals, and potential illegal activities (80 FR 60560). We conducted this 5-year review to evaluate the best available information and to determine whether to recommend a change in the status of the species.

Little information is available on the abundance, trends, and distribution of the species. At the time of the 2014 Status Review, no abundance data was available, though the species was thought to be uncommon. The first quantitative study on the species occurred in 2015 (Gilbert *et al.*) in Grande Rade, Nouméa, where densities were found to average 288 colonies per 50 m² on a natural embankment. Though the density of the species was found to be high in this harbor, the species is still considered rare as few records of it exist despite numerous coral reef surveys in New Caledonia over the last decade (Gilbert *et al.* 2015). Due to the small number of colonies of *C. noumeae*, it is likely that the species has low genetic diversity, which reduces its adaptive capacity and increases its extinction risk. Further, the species continues to have very narrow spatial distribution, which increases its risk of extinction because a narrowly distributed species is more likely to go extinct due to environmental perturbations or catastrophic events than one that is widely distributed.

Main threats to *C. noumeae* include climate change, mining activity in New Caledonia, and inadequate regulatory mechanisms to protect the species from the effects of mining.

Climate change is projected to continue warming the ocean, and by 2100 the top 2000 m of the ocean will very likely take up 5 to 7 times more heat under RCP8.5 than observed heat uptake since 1970 (IPCC 2019). Warmer temperatures are a

significant cause of coral bleaching, and the resulting loss of photosynthetic energy can lead to starvation, disease, failure to reproduce, and reduced ability to compete with other benthic organisms (Hoegh-Guldberg *et al.* 2017). Prolonged exposure can lead to coral mortality (Brainard *et al.* 2011). Though *C. noumeae* occurs in areas that are considered potential refuges from thermal stress and bleaching, severe coral bleaching events have affected New Caledonian reefs, including a large-scale event in 2016 in which two-thirds of reefs were affected (Payri *et al.* 2019). Climate change is also projected to result in continuing acidification of the ocean, which can affect corals by reducing skeleton calcification rates, potentially leading to reduced structural stability, slower recovery from breakage, increased mortality for newly settled corals, and later maturation (Brainard *et al.* 2011). Other potential impacts include sea level rise, changes to ocean circulation (including ENSO), and increased storm activity. The response and vulnerability of *C. noumeae* to climate change is unstudied, however, we conclude that ocean acidification and other impacts described above are known to threaten corals globally and are therefore expected to have similar impacts on the abundance, productivity, and spatial distribution of the species.

The nickel mining industry of New Caledonia threatens *C. noumeae* through increased soil erosion and introduction of sediments and metals to the marine environment (Moreton *et al.* 2009; Heintz *et al.* 2015). Exposure to increased sedimentation and metal pollutants including iron, nickel, copper and cobalt have been shown to reduce calcification rates and cause bleaching in corals (Biscéré *et al.* 2015; Biscéré *et al.* 2017; Biscéré *et al.* 2018; Gissi *et al.* 2019; Gillmore *et al.* 2020). *C. noumeae* occurs in areas affected by mining and appears tolerant of high turbidity and metal-rich waters (Gilbert *et al.* 2015) though more research is needed to clarify the effects of these conditions on the species. Available data indicate that mining activity likely has sublethal negative effects on coral fitness, potentially leading to mortality at certain levels, and therefore we consider this a threat to the abundance, productivity, and spatial distribution of the species. Nickel production in New Caledonia has increased since the Status Review and is expected to continue increasing.

Although there are a number of regulatory mechanisms aimed at protecting corals and their habitats in New Caledonia, observed levels of pollution and sedimentation (Moreton *et al.* 2009; Gilbert *et al.* 2015; Heintz *et al.* 2015) lead us to conclude that these mechanisms are inadequate to protect against the environmental impact of mining.

Synthesizing the best available data, we conclude that the status of the species has not changed since it was listed as endangered in 2015. The species continues to have low abundance, low genetic diversity, and small spatial distribution. In addition to these demographic threats, the species faces the destruction and degradation of its habitat through climate change and mining activity, both of which have increased in intensity since the Status Review. Existing regulatory mechanisms are not adequate to protect the *C. noumeae*'s habitat from adverse

impacts of the mining industry. For these reasons, *C. noumeae* continues to be at risk of extinction now (rather than in the foreseeable future) and we conclude that the status of the species should remain endangered.

2.3.2 *Siderastrea glynni*

2.3.2.1 Species introduction

S. glynni was listed as an endangered species effective November 6, 2015 based on the lack of known populations in the wild, a small captive population in a single location, likely low growth rates and genetic diversity, and potential increased threats from El Niño, climate change, disease, habitat degradation and other development (should the species be reintroduced to Panama) (80 FR 60560). At the time of listing, the range of the species was considered to be a small area of the Pacific Ocean near the island of Urabá in Panama Bay, a few kilometers from the opening of the Panama Canal.

2.3.2.2 Taxonomic classification or changes in nomenclature

The discovery of *S. glynni* occurred in 1992 at Urabá Island, Panama Gulf, where five live colonies of *Siderastrea* sp. were found, one of which was collected and designated as the holotype for the new species (Budd and Guzmán 1994). The remaining four colonies of *S. glynni* were subsequently transplanted to aquaria at the Smithsonian Tropical Research Institute on Naos Island, Panama, and despite extensive search efforts, no other colonies have been found in the area (Glynn *et al.* 2016). The presence of the species in the eastern Pacific was noteworthy because the other extant *Siderastrea* species were only known to occur in the western Pacific and the tropical Atlantic (Glynn *et al.* 2016). Additionally, no fossil evidence exists for *Siderastrea* occurring in the eastern Pacific over the last 5 million years (LaJeunesse *et al.* 2016).

As reported in the Status Review, a study by Forsman *et al.* (2005) found *Siderastrea glynni* to be genetically very similar to the Caribbean coral species *Siderastrea siderea*. The study provided two possible explanations for these results: (1) that *S. siderea* and *S. glynni* are the same species and that *S. glynni* may have recently passed through or been carried across the Panama Canal to the Pacific Ocean side, or (2) the alternate possibility that *S. glynni* evolved from *S. siderea*, likely about 2 to 2.3 million years ago during a period of high sea level when the Isthmus of Panama may have been breached, allowing inter-basin transfer of species' ancestors. The Status Review concluded that *S. glynni* was a valid and unique species until more precise genetic studies could resolve the uncertainty about its status.

Since the Status Review, significant new information regarding the taxonomic classification of *S. glynni* has become available. LaJeunesse *et al.* (2016) found *S. glynni* to host endosymbionts *Symbiodinium trenchii* and *Sy. goreau*, both of which occur in *S. siderea* in the Atlantic. In fact, the study by LaJeunesse *et al.* (2016) provided the first record of both of these *Symbiodinium* spp. in the eastern Pacific. A comparison of the single multilocus genotype of *Sy. trenchii* found in

all five *S. glynni* colonies to other *Sy. trenchii* genotypes from several regions around the world provide evidence that the *Sy. trenchii* genotype from the eastern Pacific originated from the Greater Caribbean. The *Sy. trenchii* genotype found in the *S. glynni* colonies was an exact match to the *Sy. trenchii* genotype of a *S. siderea* colony in Curacao, indicating that the presence of *Sy. trenchii* in the eastern Pacific is almost certainly a result of an introduction from the Atlantic (LaJeunesse *et al.* 2016). Furthermore, the genotype of *Sy. trenchii* recovered from *S. glynni* was found to be genetically distinct from other genotypes of closely related *Symbiodinium* living in eastern Pacific *Pocillopora*, and therefore is atypical of the region (LaJeunesse *et al.* 2016). The authors conclude that *S. glynni* is likely to be *S. siderea* introduced from the Atlantic.

Glynn *et al.* (2016) discuss several lines of evidence further supporting the synonymy of *S. glynni* and *S. siderea*. First, the authors discuss the location and timing of the introduction of *S. siderea* to the site where *S. glynni* was discovered. In the early 1980s, blocks of *S. siderea* skeletons were transplanted from the Caribbean side of Panama to a reef at Urabá Island in the eastern Pacific as part of a comparative study of bioerosion (Kleemann 1990). After a period of several months, regenerating patches of *S. siderea* on the blocks were apparent; several fragments from these blocks were redeposited on the Urabá patch reef (the same site where *S. glynni* was discovered) in 1982 and were not retrieved (Glynn *et al.* 2016). Using the initial size (approximately 1 cm diameter) and expected growth rate (5.2 mm per year over a 10-yr period) of the introduced *S. siderea* fragments, a 10 cm spherical colony would be expected after 10 years (Glynn *et al.* 2016). The five colonies found in 1992 measured between 7 and 10 cm in diameter, supporting the timeline of introduction (Budd and Guzmán 1994).

Glynn *et al.* (2016) also provide morphological evidence for the proposed synonymy. Despite observed variability in micro-skeletal traits among *S. siderea*, *S. radians*, and the type specimen of *S. glynni*, a single-factor MANOVA showed no significant differences with respect to all of the examined traits across the three species ($F_{3,17} = 2.2937$, $p = 0.1146$) (Glynn *et al.* 2016). The authors suggest that as the oceanic conditions in the Gulf of Panama are quite different from those in the Caribbean, certain skeletal features of the Pacific colonies could have been environmentally influenced, leading Budd and Guzmán to declare the discovered colonies a new species of *Siderastrea* (Glynn *et al.* 2016).

Based on the substantial genetic and morphological evidence, Glynn *et al.* (2016) conclude that the live fragments of *S. siderea* deposited by Kleeman in 1982 are the same that were found by Guzmán in 1992, and therefore, that *S. glynni* should be considered a junior synonym of *S. siderea*. After reviewing the available data, we agree that *S. glynni* is a synonym of *S. siderea*, and therefore that *S. glynni* does not meet the statutory definition of a species under the ESA.

2.3.2.3 Synthesis

Siderastrea glynni was listed as an endangered species effective November 6, 2015 based on the lack of known populations in the wild, a small captive population in a single location, likely low growth rates and genetic diversity, and

potential increased threats from El Niño, climate change, disease, habitat degradation and other development (should the species be reintroduced to Panama) (80 FR 60560). We conducted this 5-year review to evaluate the best available information and to determine whether to recommend a change in the status of the species. Recent genetic and morphological analyses have established that the five colonies of *S. glynni* discovered by Budd and Guzmán in 1992 were in fact *S. siderea* introduced from the Caribbean in 1982 (Glynn *et al.* 2016). For this reason, *S. glynni* should be considered a junior synonym of *S. siderea*, and therefore does not meet the statutory definition of a species under the ESA. We therefore recommend that *Siderastrea glynni* be delisted.

2.3.3 *Tubastraea floreana*

2.3.3.1 Species introduction

Tubastraea floreana was listed as an endangered species effective November 6, 2015 based on its small, restricted range, documented declines, likely low levels of genetic diversity, and threats from El Niño, climate change, development, and illegal activities (80 FR 60560). At the time of listing, the species was considered endemic to a few sites on a number of islands in the Galápagos Islands chain.

2.3.3.2 Biology and life history

T. floreana is a non-reef building azooxanthellate coral, meaning the species lacks symbiotic photosynthetic zooxanthellae that live within the tissues of most scleractinian corals (Feingold and Glynn 2014). The species has cylindrical corallites between 4 and 6 mm in diameter, with bright pink polyps (Wells 1982). It is found in cryptic habitats such as the ceilings of caves and rock overhangs at depths of 2 to 46 m (Hickman *et al.* 2007). The reproductive strategy for the species is unknown. Other members of the genus, *T. coccinea* and *T. tagusensis*, are brooders known to produce larvae both sexually and asexually (Capel *et al.* 2017; Creed *et al.* 2017).

2.3.3.3 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends

Prior to the 1982-83 El Niño, *T. floreana* was known from six sites on four islands in the Galápagos, and is presumed to have been widespread and not uncommon as these sightings occurred at a time of very little survey activity (Hickman *et al.* 2007). After the El Niño, the species was not seen until the early 1990s, when three colonies were observed at Cousin's Rock near Santiago (Banks *et al.* 2016). These colonies were observed annually through 2001, though they have not been seen since (Banks *et al.* 2016). At the time of the Status Review, the species was considered extremely rare and is estimated to have declined over 80% since 1982 (Hickman *et al.* 2007). Based on monitoring efforts running from 1994-2014, the species has not been observed since 2004 on Isla Gardner near Floreana, despite searches for the coral throughout the archipelago (Banks *et al.* 2016). We conclude that the species abundance is extremely low.

2.3.3.4 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.)

We found no new information on the genetic variation of the species, although it is likely that the species has low genetic diversity because such a small number of colonies are known to exist. The species' low genetic diversity reduces its adaptive capacity, therefore increasing its extinction risk.

2.3.3.5 Taxonomic classification or changes in nomenclature

There has been no change in taxonomic classification or nomenclature since the species was last reviewed. It remains as follows:

Kingdom: Animalia
Phylum: Cnidaria
Class: Anthozoa
Order: Scleractinia
Family: Dendrophylliidae
Genus: *Tubastraea*
Species: *floreana*

2.3.3.6 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.)

The species distribution is restricted to two locations in the Galápagos archipelago: Cousin's Rock, Santiago, and Isla Gardner at Floreana Island (Feingold and Glynn 2014), though colonies at Cousin's Rock have not been seen since 2001 and those at Isla Gardner have not been seen since 2004 (Banks *et al.* 2016). Prior to the 1982-83 El Niño this species was known from six sites on four islands in the Galápagos, and is presumed to have been widespread and not uncommon as these sightings occurred at a time of very little survey activity (Hickman *et al.* 2007). The species' distribution is very narrow, which increases its risk of extinction because a narrowly distributed species is more likely to go extinct due to environmental perturbations or catastrophic events than one that is widely distributed. This has not changed since the 2014 Status Review.

2.3.3.7 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem)

We found no new information regarding the amount, distribution, or suitability of the species' habitat or ecosystem.

2.3.3.8 Five-Factor Analysis

Present or threatened destruction, modification or curtailment of its habitat or range
Climate change and ENSO

Climate change is expected to affect coral habitat as described in section 2.3.1.8. Thermal stress threatens *T. floreana* as evidenced by dramatic declines

immediately following the 1982-83 El Niño (Hickman *et al.* 2007). The Galápagos Islands are a location of particularly strong effects of ENSO perturbations, and experienced the highest coral mortality in the eastern equatorial Pacific during the 1982-83 El Niño (Feingold and Glynn 2014; Glynn *et al.* 2015). A second very strong El Niño event occurred in 1997-98, though impacts to corals were far less serious, likely because survivors of the 1982-83 event possessed a genetic advantage allowing them to tolerate warmer conditions (Glynn *et al.* 2018). Cold shock associated with La Niña also caused significant coral mortality on a pocilloporid reef at Devil's Crown, Floreana Island in 2007, though it is unclear how cold temperatures affect *T. floreana* (Glynn *et al.* 2018). The IPCC (2019) reports with medium confidence that extreme El Niño and La Niña events are projected to become more frequent in the 21st century, with extreme El Niño events projected to become twice as likely under RCP 8.5 in the 21st century as compared to the 20th century (IPCC 2019). Even if the remaining colonies of *T. floreana* survived past El Niño events due to a genetic predisposition for tolerance of thermal stress, the increasing number of stressful events pose a continuing threat to the species.

Although we found no information specific to *T. floreana*'s response or vulnerability to other impacts of climate change, ocean acidification and other impacts described in section 2.3.1.8 are known to threaten corals globally and are therefore expected to have similar impacts on the abundance, productivity, and spatial distribution of the species. For this reason, we consider climate change a threat to the species based on the best available information.

Tourism and development

Tourism has driven recent economic growth in the Galápagos Islands, but it has also caused significant ecological change through increased human impact and resource use (Alava *et al.* 2014). The number of tourists that visited the protected areas of the Galápagos grew from 204,395 in 2013 to 241,800 in 2017 (Dirección del Parque Nacional Galápagos 2017) and is nearing the established limits for visits in natural sites (Espin *et al.* 2019). Tourism has also driven population growth in the archipelago as people immigrate from mainland Ecuador to seek employment in the tourism industry (Espin *et al.* 2019). As a whole, the impact of increased human presence on the islands has led to issues such as waste and sewage management, introduction of invasive species and pathogens, increased risk of oil spills as more fuel is transported to the archipelago, and runoff of pesticides and persistent organic pollutants (Alava *et al.* 2014). Impacts from tourism and development to *T. floreana* have not been quantified, though Glynn *et al.* (2018) consider tourism to be one of the greatest potential threats to coral reef recovery and persistence. We conclude that tourism likely threatens the species by degrading the coral habitat and reducing productivity to an unknown degree.

[Overutilization for commercial, recreational, scientific, or educational purposes](#)

The CITES database reports one instance of international trade between 2012 and 2019, in which 5 wild specimens were exported from Ecuador to the United States for scientific purposes in 2015. As CITES exports must be found to be non-

detrimental to the survival of the species in the wild and recorded trade is extremely limited, we conclude that international trade does not appear to affect the species.

Disease or predation

Grazing by large populations of the sea urchin *Eucidaris galapagensis* in the central and southern Galápagos Islands has been shown to inhibit coral settlement, survivorship, and recovery (Glynn *et al.* 2015). This may inhibit the ability of *T. floreana* to recover from catastrophic events.

Inadequacy of existing regulatory mechanisms

The following international, regional, national, local regulatory mechanisms apply to *T. floreana*:

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

T. floreana is listed as an Appendix II species under CITES. For additional information on CITES, see section 2.3.1.8.

UNESCO World Heritage Protections

The Galápagos Islands and surrounding Galápagos Marine Reserve are protected as a UNESCO World Heritage Site, extending 40 nautical miles offshore of the archipelago and comprising 133,000 km² in total area (<https://whc.unesco.org/en/list/1/>).

Special Regime Law for the Conservation and Sustainable Development in the Province of the Galápagos

The Special Law of the Galápagos designated the Galápagos Marine Reserve as a protected area and gave responsibility for the Reserve to the Galápagos National Park Service. The 1998 law established a framework for regulating fisheries, residency and migration of people to the islands, tourism, agriculture, waste management, and control of introduced species. Within this framework, the National Park Service prepares Management Plans, including a zoning system to establish areas of sustainable use. Regulatory measures for artisanal, commercial, and recreational fishing in the Galápagos are required to control direct and indirect impacts of overfishing on coral condition (Glynn *et al.* 2018).

Local regulatory measures in the Galápagos offer a high level of protection for the natural environment, including corals. The main threat to the species is thermal stress due to extreme El Niño events. Though ENSO is a naturally occurring climate pattern, El Niño events are projected to become more frequent in the 21st century due to climate change, which has not been adequately addressed by regulatory mechanisms on a global scale.

Other natural or manmade factors affecting its continued existence

We found no other natural or manmade factors affecting the continued existence of the species.

2.3.3.9 Synthesis

Tubastraea floreana was listed as an endangered species effective November 6, 2015 based on its small, restricted range, documented declines, likely low levels of genetic diversity, and threats from El Niño, climate change, development, and illegal activities (80 FR 60560). At the time of listing, the species was considered endemic to a few sites on a number of islands in the Galápagos Islands chain. We conducted this 5-year review to evaluate the best available information and to determine whether to recommend a change in the status of the species.

The species abundance continues to be extremely low as *T. floreana* has not been seen since 2004 despite specific search effort throughout the Galápagos archipelago (Banks *et al.* 2016). Accordingly, we can assume that the genetic diversity for the species is quite low and the spatial distribution is very limited. Low genetic diversity reduces the species' adaptive capacity and increases its extinction risk. Narrow spatial distribution increases the species' risk of extinction because a narrowly distributed species is more likely to go extinct due to environmental perturbations or catastrophic events than one that is widely distributed.

The main threats to *T. floreana* include climate change and tourism-related development in the Galápagos.

Climate change is projected to continue warming the ocean, and by 2100 the top 2000 m of the ocean will very likely take up 5 to 7 times more heat under RCP8.5 than observed heat uptake since 1970 (IPCC 2019). Thermal stress threatens the species as evidenced by dramatic declines immediately following the 1982-83 El Niño (Hickman *et al.* 2007). The Galápagos Islands are a location of particularly strong effects of ENSO perturbations, and extreme El Niño events are projected to become twice as likely under RCP 8.5 in the 21st century as compared to the 20th century (IPCC 2019). Climate change is also projected to result in continuing acidification of the ocean, which can affect corals by reducing skeleton calcification rates, potentially leading to reduced structural stability, slower recovery from breakage, increased mortality for newly settled corals, and later maturation (Brainard *et al.* 2011). Other potential impacts include sea level rise and increased storm activity. The response and vulnerability of *T. floreana* to climate is unstudied, however, the projected increase in frequency of El Niño events is likely to pose a major threat to the species by reducing abundance and productivity. Additionally, ocean acidification and other impacts are known to threaten corals globally and are therefore expected to have similar impacts on the abundance, productivity, and spatial distribution of the species.

Tourism and associated immigration of workers in the tourism industry have resulted in significant ecological change through increased human impact and

resource use (Alava *et al.* 2014). As a whole, the impact of increased human presence on the islands has led to issues such as waste and sewage management, introduction of invasive species and pathogens, increased risk of oil spills as more fuel is transported to the archipelago, and runoff of pesticides and persistent organic pollutants (Alava *et al.* 2014). Impacts from tourism and development to *T. floreana* have not been quantified, though Glynn *et al.* (2018) consider human population growth stemming from tourism to be one of the greatest potential threats to coral reef recovery and persistence in the Galápagos. We conclude that tourism and development likely threaten the species by reducing productivity to an unknown degree.

Synthesizing the best available data, we conclude that the status of the species has not changed since it was listed as endangered in 2015. The species continues to have extremely low abundance and has not been observed since 2004. The spatial distribution of the species is considered quite low as it has only been known to occur in two locations since the 1982-1983 El Niño (Feingold and Glynn 2014). Due to its low abundance, the species is also likely to have low genetic diversity. In addition to these serious demographic threats, the species faces the destruction and degradation of its habitat through climate change and the tourism industry, both of which have increased in intensity since the Status Review. For these reasons, *T. floreana* continues to be at risk of extinction now (rather than in the foreseeable future) and we conclude that the status of the species should remain endangered.

3.0 RESULTS

3.1 Recommended Classification

Cantharellus noumeae

- Downlist to Threatened**
- Uplist to Endangered**
- Delist** (Indicate reason for delisting per 50 CFR 424.11):
 - Extinction*
 - Species does not meet the definition of an endangered or threatened species*
 - Listed entity does not meet definition of a species*
- No change is needed**

Siderastrea glynni

- Downlist to Threatened**
- Uplist to Endangered**
- Delist** (Indicate reason for delisting per 50 CFR 424.11):
 - Extinction*
 - Species does not meet the definition of an endangered or threatened species*

species

Listed entity does not meet definition of a species

No change is needed

Tubastraea floreana

Downlist to Threatened

Uplist to Endangered

Delist (*Indicate reason for delisting per 50 CFR 424.11*):

Extinction

Species does not meet the definition of an endangered or threatened species

Listed entity does not meet definition of a species

No change is needed

3.2 New Recovery Priority Number

(Indicate if no change; see Appendix E):

Brief Rationale: The species does not currently have a recovery priority number.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Very few studies on *C. noumeae* and *T. floreana* have been published in the last 5 years, and information on life history, abundance, demographics, genetics, and spatial distribution are lacking for both species. Additional survey effort in New Caledonia will be important to understanding *C. noumeae*'s abundance and spatial distribution. Although impacts of mining including sedimentation and metal contamination have been studied in other corals, we did not find any studies that specifically involved *C. noumeae*. It would be helpful to investigate the degree to which the species is able to tolerate highly turbid and contaminated conditions in order to clearly understand the threat posed by the growing nickel mining industry of New Caledonia. As *T. floreana* has not been observed since 2004 despite searches for the species throughout the Galápagos archipelago, continuing surveys are critical to determining its status.

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NATIONAL MARINE FISHERIES SERVICE
5-YEAR REVIEW
Cantharellus noumeae

Current Classification: Endangered

Recommendation resulting from the 5-Year Review

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change is needed

Review Conducted By: Adrienne Lohe, Office of Protected Resources

LEAD OFFICE APPROVAL:

Director, Office of Protected Resources, NOAA Fisheries

Approve: _____ Date: _____

HEADQUARTERS APPROVAL:

Assistant Administrator, NOAA Fisheries

Concur Do Not Concur

Signature _____ Date _____

NATIONAL MARINE FISHERIES SERVICE
5-YEAR REVIEW
Siderastrea glynni

Current Classification: Endangered

Recommendation resulting from the 5-Year Review

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change is needed

Review Conducted By: Adrienne Lohe, Office of Protected Resources

LEAD OFFICE APPROVAL:

Director, Office of Protected Resources, NOAA Fisheries

Approve: _____ Date: _____

HEADQUARTERS APPROVAL:

Assistant Administrator, NOAA Fisheries

Concur Do Not Concur

Signature _____ Date _____

NATIONAL MARINE FISHERIES SERVICE
5-YEAR REVIEW
Tubastraea floreana

Current Classification: Endangered

Recommendation resulting from the 5-Year Review

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change is needed

Review Conducted By: Adrienne Lohe, Office of Protected Resources

LEAD OFFICE APPROVAL:

Director, Office of Protected Resources, NOAA Fisheries

Approve: _____ Date: _____

HEADQUARTERS APPROVAL:

Assistant Administrator, NOAA Fisheries

Concur Do Not Concur

Signature _____ Date _____