Before the Secretary of Commerce

Petition to List the Black Teatfish, *Holothuria nobilis*, under the U.S. Endangered Species Act

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Center for Biological Diversity

14 May 2020

Notice of Petition

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The Center for Biological Diversity (Center, Petitioner) submits to the Secretary of Commerce and the National Oceanographic and Atmospheric Administration (NOAA) through the National Marine Fisheries Service (NMFS) a petition to list the black teatfish, *Holothuria nobilis*, as threatened or endangered under the U.S. Endangered Species Act (ESA), 16 U.S.C. § 1531 *et seq*. Alternatively, the Service should list the black teatfish as threatened or endangered throughout a significant portion of its range. This species is found exclusively in foreign waters, thus 30-days' notice to affected U.S. states and/or territories was not required.

The Center is a non-profit, public interest environmental organization dedicated to the protection of native species and their habitats. The Center has more than 1.7 million members and online activists worldwide. The Center and its members seek to conserve imperiled species like the black teatfish through science, policy, and effective implementation of the ESA.

NMFS has jurisdiction over this Petition. This petition sets in motion a specific process requiring NMFS to make an initial finding as to whether the Petition "presents substantial scientific or commercial information indicating that the petitioned action may be warranted." (16 U.S.C. § 1533(b)(3)(A).) NMFS must make this initial finding "[t]o the maximum extent practicable, within 90 days after receiving the petition." (*Id.*) Petitioner need not demonstrate that the listing is warranted, but rather present information demonstrating that such action may be warranted. The Center believes the best available scientific information demonstrates that listing the black teatfish as threatened or endangered throughout all or a significant portion of its range is warranted, and the available information clearly indicates that listing the species may be warranted. As such, NMFS must promptly make a positive finding on the Petition and commence a status review as required by 16 U.S.C. § 1533(b)(3)(B).

Respectfully submitted this 14th day of May, 2020.

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Executive Summary

In the shallow, nearshore waters of the tropical Indian Ocean lives a species both relatively unknown and highly prized: the black teatfish, *Holothuria nobilis*. One of approximately 1700 extant sea cucumber species, the black teatfish until recently went unrecognized both by the general public and many ecologists. But when the dried sea cucumber (bêche-de-mer) market exploded alongside rising prosperity in China in the late 1980s and early 1990s, overfishing of this species led to decimation and local extirpations across its range. Scientists estimate the black teatfish has declined by 60-70% across 80% of the species' range, and its global population continues to decrease.

Overfishing to supply the growing luxury seafood market in Asia poses the primary threat to black teatfish. Because they live in shallow water habitats and are large and slow moving, black teatfish make easy targets for capture. The species remains at high risk due to increasing demand and inadequate fisheries management regimes in the countries in whose jurisdiction the black teatfish is found.

Climate change poses another existential threat to black teatfish. Most black teatfish live in coral reef habitats, which continue to deteriorate due to warming ocean waters, ocean acidification, and associated disease. Many reefs in the black teatfish's range were among the worst hit by the 1997-98 coral reef bleaching event and remain at high risk. Degradation of seagrass beds, another habitat utilized by the black teatfish, also threatens the species' continued viability. The species' rarity presents its own risk to the black teatfish's continued existence because the species needs sufficient density to successfully reproduce.

Listing under the U.S. Endangered Species Act provides a critical mechanism for effectively shielding the black teatfish from threats to its continued existence. The black teatfish is in danger of extinction, or likely to become so within the foreseeable future, due to overfishing/trade, climate change, and inadequate regulatory mechanisms. The Center for Biological Diversity thus respectfully requests that the National Marine Fisheries Service list the black teatfish under the U.S. Endangered Species Act to provide this species with essential and much-needed legal protections.

PART I. SPECIES ACCOUNT

1. *INTRODUCTION AND SPECIES DESCRIPTION*

The black teatfish,[1] *Holothuria nobilis*, is one of approximately 1700 extant sea cucumber species—and one of the most imperiled.[2] Sea cucumbers, or holothurians, are elongated, soft-bodied, benthic echinoderms that live throughout the global ocean.[3] They are characterized by radial symmetry, an intra-dermic skeleton, and a water vascular system.[4] The sea cucumber species known as teatfish are relatively sedentary, non-migratory species that live in the tropical and subtropical waters of the Indo-Pacific.[5] Black teatfish are restricted to the Indian Ocean and are one of the most highly valued commercially harvested sea cucumber species.[6]

Sea cucumber stocks worldwide have been overexploited and continue to decline due to increasing market demand, rampant overfishing, and inadequate fisheries management.[7] These species are especially vulnerable to overexploitation due to several life history characteristics including low or infrequent recruitment, high longevity, and density-dependent reproduction.[8] They also are relatively easy to capture. As a result, "[m]any sea cucumber species"—including the highly prized black teatfish—"face a high risk of extinction."[9] Degradation of primary black teatfish habitats including coral reefs and seagrass beds by climate change and other factors further threaten this species. Protection under the U.S. Endangered Species Act (ESA) will provide black teatfish with critical protections necessary for the species' conservation and recovery.

A. Taxonomy

Taxonomists have identified at least 1700 holothuroid species from the global ocean, including the black teatfish *Holothuria nobilis*.[10] These species inhabit ecosystems from intertidal to deep sea, tropical to polar.[11] The class Holothuroidea encompasses five orders: Dendrochirotida, Aspidochirotida, Elasipodida, Apodida, and Molpadida.[12] These orders have been differentiated based upon the shape of the mouth tentacles and the presence or absence of tube feet, oral retractor muscles, respiratory trees, and Cuvierian tubules.[13]

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[1] Other common names for this species include Holothurie noire à mamelles (FAO), benono (Madagascar), barbara (Mauritius), bawny black (Egypt), abu habhab aswed (Eritrea), and pauni mweusi (Kenya and Zanzibar, Tanzania).
[2] Conand (2018) at 590.
[3] Conand (2009) at 222; Anderson *et al.* (2011) at 318; Webster & Hart (2018) at 10.
[4] Conand (2009) at 222.
[5] Purcell *et al.* (2010) at 11; FAO (2019) at 63.
[6] Uthicke *et al.* (2004) at 837; Purcell *et al.* (2012) at 69; Conand *et al.* (2013) at 1.
[7] Purcell *et al.* (2010) at 1, 7; Conand & Muthinga (2013) at iii.
[8] Conand & Muthiga (2007) at iii; Purcell *et al.* (2010) at 2, 7; Purcell *et al.* (2011) at 38.
[9] Purcell *et al.* (2011) at 49.
[10] Conand (2018) at 590.
[11] Bruckner (2006) at 33; Anderson *et al.* (2011) at 318; Purcell *et al.* (2016) at 367.
[12] Bruckner (2006) at 33. While Bruckner (2006) also lists Dactylochirotida as an extant order, this appears to be contested. *See* WoRMS (2020).
[13] Bruckner (2006) at 33. Cuvierian tubules are peculiar structures found in sea cucumber species, including some in the genus *Holothuria*. (Becker & Flammang (2010) at 87.) In *Holothuria*, these smooth tubules occur in great numbers attached to the basal portion of the respiratory tree. (*Id.*) When threatened, the sea cucumber can expel

Taxonomists historically relied upon a suite of morphological characteristics to distinguish among sea cucumber species. Such characteristics included the distribution and morphology of calcareous ossicles[14] within the body wall, tentacles and tube feet, and the structure of the calcareous ring.[15] However, more recent studies have found that most types of ossicles and calcareous rings exhibit a range of morphological variability across teatfish species, rendering them unreliable markers of identification.[16] Cuvierian tubules, too, exhibit high intraspecies variability.[17]

Given the unreliability of morphological attributes in teatfish identification, scientists have turned to more sophisticated genetic analysis to assist with taxonomic classification. A 2004 study by Uthicke, O'Hara and Byrne used molecular phylogeny with mtDNA sequencing to resolve historic confusion regarding the taxonomy of teatfish from the western Indian and southwestern Pacific Oceans. Their analysis found three haplotype clusters that correspond with distinct color forms: (1) *Holothuria whitmaei:* black/dark brown teatfish from Australia and the southwest Pacific; (2) *H. fuscogilva:* white/beige teatfish with dark markings from Australia and the southwest Pacific; and (3) *H. nobilis:* black teatfish with white ventro-lateral patches from the western Indian Ocean.[18] The two "black teatfish" species, *H. whitmaei* and *H. nobilis*, appear strictly allopatric with the former occupying Pacific waters and the latter Indian Ocean waters.[19] *See* Fig. A. The molecular tree suggests a genetic distance of approximately 9.2% between the species, implying a divergence in the Pliocene (~1.8-4.6 million years).[20] A separate molecular analysis further confirmed that *H. nobilis* and *H. fuscogilva* are separate species.[21]

the tubules through the cloaca; they become sticky and can entangle and mobilize a predator in seconds. (Demeuldre *et al.* (2017) at 2108.)

[14] Ossicles are small pieces of calcified material that form part of a sea cucumber's skeleton. Common shapes include table, button, rod, anchor, plate and roxette. (Kamarudin & Rehan (2015) at 89.)

[15] Uthicke, O'Hara & Byrne (2004) at 845; Ahmed, Aamer & Lawrence (2016) at 1.

[16] Uthicke, O'Hara & Byrne (2004) at 845.

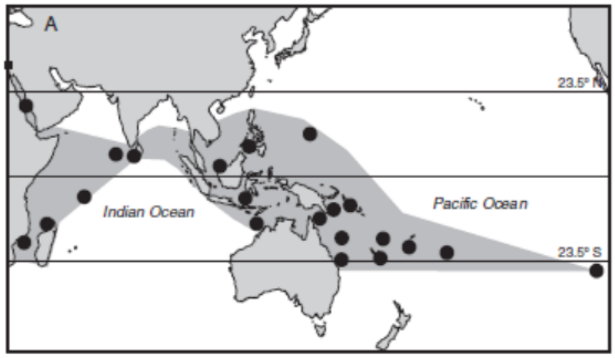
[17] *Id*.

[18] *Id*. at 844.

[19] *Id*. at 845.

[20] *Id*. at 845-46.

[21] Ahmed, Aamer & Lawrence (2016) at 5.



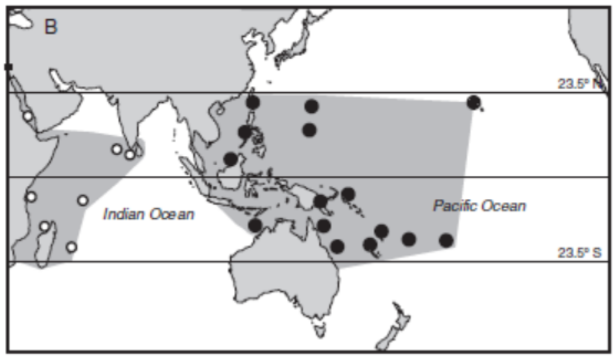


Fig. A. Distribution of three teatfish species, as resolved by Uthicke, O'Hara & Byrne (2004). Panel A shows the distribution of *H. fuscogilva*. Panel B shows the allopatric distribution of *H. nobilis* (white dots) and *H. whitmaei* (black dots). (Uthicke, O'Hara & Byrne (2004).)

The currently accepted taxonomy of black teatfish thus breaks down as follows:

Kingdom: Animalia
Phylum: Echinodermata
Class: Holothuroidea
Order: Aspidochirotida
Family: Holothuriidae
Genus: *Holothuria*
Subgenus: *Microthele*
Species: *nobilis*

B. Physiology, Morphology and Behavior

Despite their large size, ecological and economic importance, and conservation concern, basic biological and ecological characteristics of teatfish—including black teatfish—remain largely unknown.[22] According to one prominent study, "[i]t is now apparent that there is hardly any information on the ecology of the 'real' *H. nobilis*."[23] The following discussion thus pertains to sea cucumbers more broadly, teatfish where possible, and *H. nobilis* if and as information is available.

[22] Mmbaga & Mgaya (2004) at 199; Bruckner (2006) at 6, 34, 36, 41; Conand (2007) at 1-5; Conand (2009) at 225; Hasan (2009) at 31; Anderson *et al.* (2011) at 319, 333; Purcell *et al.* (2011) at 37; Eriksson, Byrne & de la Torre-Castro (2012) at 159-60; Conand & Muthinga (2013) at 3; CITES (2019a) at 9.
[23] Uthicke, O'Hara & Byrne (2004) at 846.

Life history information can be difficult to ascertain in sea cucumbers because "they have few hard body parts, are not generally amenable to conventional measuring, weighing or tagging methods and can undergo shrinkage and regrowth in body weight as adults."[24] Larvae cannot yet be identified to species level, precluding analysis of dispersal and settlement events.[25] Juveniles are cryptic, preventing direct estimates of recruitment.[26] Juveniles also develop at different rates, confounding cohort analysis.[27] The two most promising methods for long-term monitoring of sea cucumbers, genetic fingerprinting and fluorochrome marking of ossicles, also have limitations.[28]

Teatfish typically have pentaradial body symmetry with secondary biradial symmetry. They have a stout, non-segmented, dorsally arched, ventrally flattened cylindrical body that ranges in length from 30 to 70 cm.[29] The average length for black teatfish is 35 cm, and individuals of this species typically do not exceed 60 cm.[30] Average fresh weight for black teatfish varies by country, with 230 g reported for Mauritius, 800-3000 g reported for Réunion, and 1500 g for Egypt.[31]

The black teatfish's body wall consists of a thin cuticle, an epidermis, and an underlying dermis.[32] The outer body covering (tegument) is thick, relatively rigid, and (for black teatfish in the field) usually covered with fine sand.[33] The dermis is made of fibrous connective tissue with pigments, coelomocytes,[34] and microscopic skeletal elements called spicules.[35] Sea cucumbers have an endoskeleton of calcareous ossicles and a large, complex, chambered body cavity (coelom) that combines respiration, locomotion, and sensory function.[36] The integument (the part consumed by humans) is thick, which contributes to the species' high commercial value.[37]

Among sea cucumbers, teatfish are distinguished by a row of prominent processes or "teats" along the body's ventrolateral margin. [38] *See* Fig. B. Black teatfish typically have six to ten ventral teats.[39] These teats allow for generic identification of harvested species (*i.e.*, identification as "teatfish") in both fresh and processed form.[40] Lack of reliable morphological characteristics confounds identification of

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[24] Purcell *et al.* (2011) at 37; FAO (2019) at 63; *see also* Purcell *et al.* (2010) at 11.
[25] Purcell *et al.* (2011) at 37.
[26] *Id*.; Conand & Muthinga (2013) at 47. In one breeding trial, scientists obtained 10,392 juvenile *H. nobilis* from 3,521,600 fertilized eggs, a success rate of 0.295%. (Minami (2011) at 393.)
[27] Purcell *et al.* (2011) at 37.
[28] *Id*.
[29] Bruckner (2006) at 33; Purcell, Samyn & Conand (2012) at 70; CITES (2019a) at 5-6.
[30] Purcell, Samyn & Conand (2012) at 70; CITES (2019a) at 26. For specific countries, the average fresh length for black teatfish is 14 cm for Mauritius, 35 cm for Réunion, and 55 cm for Egypt. (Purcell, Samyn & Conand (2012) at 70; CITES (2019a) at 26.)
[31] CITES (2019a) at 26.
[32] Bruckner (2006) at 33; Conand (2009) at 222.
[33] Conand (2008) at 154; CITES (2019a) at 5, 26.
[34] Coelomocytes include cells responsible for mounting immune defenses, such as lymphocytes, phagocytes, spherulocytes and "giant" cells. (Ramírez-Gómez *et al.* (2010) at 175.)
[35] Bruckner (2006) at 33.
[36] *Id*.; *see also* Purcell, Samyn & Conand (2012) at 70.
[37] Conand (2008) at 143; Conand (2009) at 222; Conand (2018) at 591.
[38] Uthicke, O'Hara & Byrne (2004) at 837; CITES (2019a) at 5.
[39] Purcell, Samyn & Conand (2012) at 70; CITES (2019a) at 26.
[40] CITES (2019a) at 18.

processed teatfish to the species level, however.[41] This is because processing for the dried sea cucumber product bêche-de-mer typically involves removal of the epidermal pigment layer.[42]

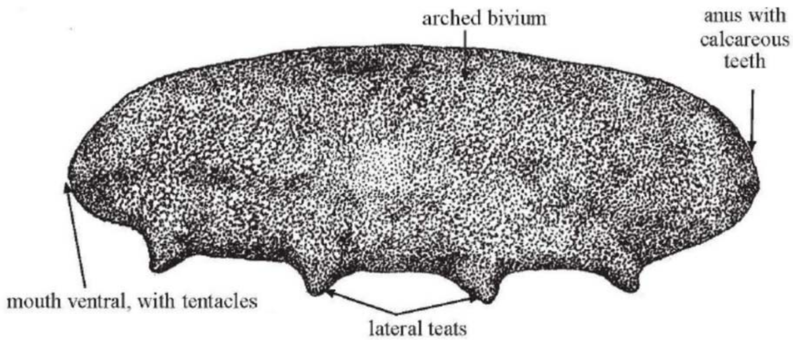

Fig. B. Teatfish (*H. whitmaei*) schema. (CITES (2019a).)

Black teatfish are black dorsally, with white or golden spots and blotches on the teats.[43] Juvenile teatfish have a different coloration pattern than adults.[44] Sweet, Ducarme and Conand (2016) report on the discovery of a possible nursery ground for juvenile black teatfish in the Maldives. They found four individuals that were black dorsally and light brown or orange on the sides; the ventral face had a white sole and was covered with gray podia.[45]

Teatfish have a simple reproductive system consisting of an unpaired genital gland with a tuft of tubules terminating anteriorly in a genital papilla.[46] The nervous system is uncentralized and the alimentary canal complete.[47] The hemal system is associated with the digestive system, which contains a muscular pharynx, esophagus, stomach, and three-loop intestine that terminates into a large cloaca.[48] Two respiratory trees also terminate in the cloaca.[49] Conand (2008) states that black teatfish have Cuvierian tubules but they are not expelled, while CITES reports that black teatfish lack Cuvierian tubules.[50]

Black teatfish have small dorsal papillae, five small calcareous anal teeth, and a large number of ventral podia, or tube feet.[51] Podia are hollow, tubular projections that extend from the body wall.[52] They can lengthen, retract, and flex.[53] Each podium ends in a flat disc that can adhere to the substratum during

[41] Uthicke, O'Hara & Byrne (2004) at 846; CITES (2019c) at 1.
[42] Uthicke, O'Hara & Byrne (2004) at 846.
[43] Conand (2008) at 154; Purcell, Samyn & Conand (2012) at 70.
[44] Conand *et al.* (2013) at 5; *see also* Ahmed, Aamer & Lawrence (2016) at 1-2; Sweet, Ducarme & Conand (2016) at 82.
[45] Sweet, Ducarme & Conand (2016) at 82.
[46] Bruckner (2006) at 33, 34. A papillae is a small proturberance from the body.
[47] *Id*. at 33, 34. The alimentary canal is the entire mouth-to-anus passage through which food passes.
[48] *Id*. at 33; Conand (2009) at 223. A cloaca is a common cavity at the end of the digestive tract that allows the release of both excretory products and gametes.
[49] Bruckner (2006) at 34.
[50] Conand (2008) at 154; CITES (2019a) at 26.
[51] CITES (2019a) at 5, 26.
[52] Conand (2009) at 222.
[53] *Id*.

locomotion.[54] The dorsal podia of black teatfish are small and sparse, while ventral podia are numerous, short, and grey in color.[55] The mouth, surrounded by 20 stout buccal tentacles, also is ventral.[56] *See* Fig. C. The tentacles are peltate, each with a central stalk, and are retractile.[57] Detailed anatomy of *H. whitmaei*, believed to be the same as *H. nobilis*, is depicted in Fig. D.

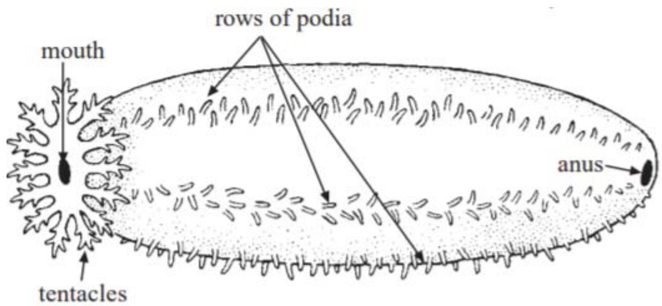

Fig. C. Sea cucumber diagram, ventral view. (Conand (1998).)

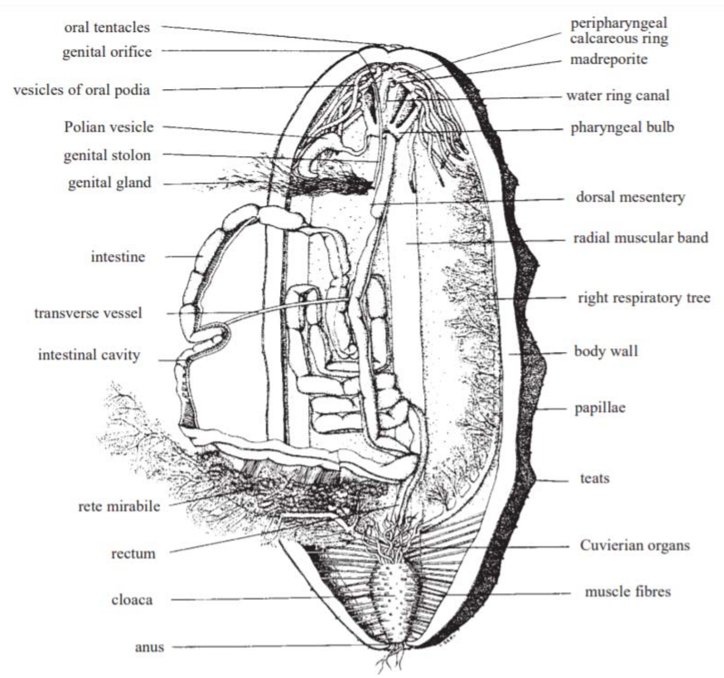

Fig. D. *Holothuria whitmaei* anatomy, believed to be the same for *H. nobilis*. (Conand (1998); Conand (pers. commun. 2020).)

The life span of sea cucumbers is lengthy, likely exceeding ten years and perhaps up to 100 years.[58] Most sea cucumber species take years to attain adult size.[59] *H. nobilis* probably lives at least for several

[54] *Id*.
[55] CITES (2019a) at 26.
[56] Bruckner (2006) at 33; CITES (2019a) at 5, 26.
[57] Conand (2009) at 222.
[58] Lawrence *et al.* (2004) at 80; Conand *et al.* (2013) at 1; CITES (2019a) at 5.
[59] Purcell, Hair & Mills (2012) at 69; Conand *et al.* (2013) at 5; FAO (2019) at 63.

decades.[60] There is some indication that some sea cucumber species do not go through senescence, but instead regenerate.[61]

Sea cucumbers reach sexual maturity between two and six years, the exact timing of which depends on species and body weight.[62] Black teatfish are reported to mature at four years of age.[63] Body size influences reproductive fitness when food is not limiting.[64] Specifically, larger individuals have larger gonads, produce more gametes, and exhibit higher fecundity.[65] The sex ratio appears balanced for many species.[66] While sea cucumbers largely are gonochoric, they do not exhibit sexual dimorphism and sex is ascertainable only through microscopic examination.[67]

Most sea cucumber species (including black teatfish) reproduce sexually using broadcast spawning, whereby they release sperm and oocytes[68] directly into the water column.[69] Environmental cues (*e.g.*, tidal conditions, lunar phases, temperature fluctuations) and chemical cues trigger the release of gametes.[70] *H. nobilis* is believed to reproduce annually during the cold season.[71] Successful fertilization depends upon sufficient population density and proximity of adults.[72] Overall productivity often is low.[73] It is not known if the species can successfully reproduce in deeper waters.[74]

For tropical species with small oocytes (like the black teatfish), fertilized eggs quickly develop into free-swimming larvae—sometimes within a day.[75] These larvae, many of which exhibit bilateral symmetry, spend 50-90 days in plankton feeding on algae; they may be widely dispersed by ocean currents.[76] If widespread larval dispersal occurs for *H. nobilis*, areas outside those currently occupied may be vital for the species' conservation. One breeding trial found that the planktonic period of *H. nobilis* ranged from 44-51 days.[77] After metamorphosis, sea cucumbers settle on the seafloor (the specific habitat depending

[60] Purcell, Hair & Mills (2012) at 69; Conand *et al.* (2013) at 5.
[61] Conand *et al.* (2013) at 5.
[62] CITES (2019a) at 5.
[63] Conand *et al.* (2013) at 5.
[64] Conand (2018) at 591.
[65] *Id*.
[66] CITES (2019a) at 5, 8.
[67] Conand (2009) at 224; Purcell *et al.* (2010) at 9; Purcell *et al.* (2011) at 37; CITES (2019a) at 5.
[68] The oocytes of most species are small (< 200 µm in diameter) and neutrally buoyant in the water column. (Purcell *et al.* (2010) at 9.)
[69] Conand (2009) at 224; Purcell *et al.* (2010) at 9; CITES (2019a) at 5; FAO (2019) at 63.
[70] Purcell *et al.* (2010) at 9.
[71] Purcell, Samyn & Conand (2012) at 71; Conand *et al.* (2013) at 5; CITES (2019a) at 5. The few studies done on *H. whitmaei* and *H. fuscogvila* indicate large differences in reproductive timing and habitat preference. (Uthicke, O'Hara & Byrne (2004) at 846.)
[72] Purcell *et al.* (2010) at 9; Purcell *et al.* (2011) at 37, 53; CITES (2019a) at 5; FAO (2019) at 63. Minimum population densities for successful reproduction have yet to be determined, yet sustainable harvest requires safeguarding the reproductive capacity of breeding stocks. (Purcell *et al.* (2011) at 37, 49.)
[73] FAO (2019) at 63.
[74] Conand *et al.* (2013) at 1.
[75] Purcell *et al.* (2010) at 9.
[76] Conand (2009) at 224; Purcell *et al.* (2010) at 10; CITES (2019a) at 5.
[77] Minami (2011) at 393.

on the species).[78] Mortality of pelagic larvae is believed to be high, while natural mortality rates of adults is believed to be low.[79]

2. DISTRIBUTION: GEOGRAPHIC AND BIOLOGICAL SETTING

The black teatfish occurs only in the Indian Ocean.[80] Specifically, it can be found off the east coast of Africa, the west coast of India, and around associated islands.[81] *See* Fig. E. Countries in whose waters the black teatfish can be found include India, the Maldives, Mayotte, Reunion, Kenya, Zanzibar, Tanzania, Egypt, Madagascar, Eritrea, Mauritius, Sri Lanka, Seychelles, Mozambique, Sudan, Yemen, Somalia, Israel, Comoros, Jordan, Saudi Arabia, Oman, South Africa, and Djibouti.[82] The species does not occur in the United States or its territories.

Fig. E. *Holothuria nobilis* range map. (Conand *et al.* (2013).)

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[78] Conand (2009) at 224; Purcell *et al.* (2010) at 9.
[79] CITES (2019a) at 5; FAO (2019) at 63.
[80] Conand *et al.* (2013) at 1.
[81] *Id*.
[82] Conand *et al.* (2013); CITES (2019a) at 4.

The distribution and abundance of black teatfish depends on a variety of factors including habitat suitability, competition, predation, recruitment, and fishing.[83] Black teatfish utilize several habitats, including coral reefs, seagrass beds, and rocky habitats.[84] While the species appears to prefer coral reefs in many areas, seagrasses also appear important, especially during early life history stages.[85]

3. ABUNDANCE AND POPULATION TRENDS

Although abundance data for sea cucumber populations is sparse,[86] regional estimates indicate that the black teatfish abundance has significantly declined. Overall, the black teatfish has declined by 60-70% across 80% of the species' range, and its global population continues to decrease.[87]

Teatfish populations vary by location and year and estimates differ based on sampling method.[88] According to several studies, the mean density of *H. nobilis* in areas where the species still exists ranges from 0.12 to 10 individuals per hectare.[89] Historically, they may have occurred in greater densities.[90] Observations almost exclusively tally adults, as juvenile teatfish rarely are seen in the field.[91]

Teatfish populations are considered depleted (*i.e.*, a loss of ≥ 60-80%) or overexploited across most of their range,[92] and populations of *H. nobilis* continue to decline. For example, for *H. nobilis*,

- In the Chagos Marine Protected Area, illegal fishing has led to population declines over the past 4-5 years;
- In Egypt, fishing has virtually eliminated the black teatfish;
- In Madagascar, overfishing led to depletion of stocks and very few individuals have been seen in recent years;
- In Tanzania, this species—which previously dominated the sea cucumber fishery—now comprises a very small percentage of total catch and individuals caught are small (suggesting overharvest of larger adults);
- Fishing-related depletion also has occurred in Mozambique, India, Sri Lanka, the Red Sea, the Maldives, and possibly Kenya.[93]

A more thorough discussion of *H. nobilis* trends by country or jurisdiction is provided in Part III.2, *infra*.

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[83] Conand & Muthinga (2013) at 3.
[84] Lawrence *et al.* (2004) at 8; Hasan (2009) at 33, 34; Conand *et al.* (2013) at 5; Idreesbabu & Sureshkumar (2017) at 571.
[85] Lampe-Ramdoo, Pillay & Conand (2014) at 21; Mulochau (2018) at 26.
[86] Anderson *et al.* (2011) at 321.
[87] Conand *et al.* (2014) at 5; Conand *et al.* (2013) at 1, 4; CITES (2019a) at 8.
[88] CITES (2019a) at 8.
[89] *Id*. at 7.
[90] Conand (2018) at 591.
[91] Conand & Muthinga (2013) at 47; Conand (2018) at 591; CITES (2019a) at 8. *But see* Sweet, Ducarme & Conand (2016) (noting possible finding of a black teatfish nursery in the Maldives).
[92] CITES (2019a) at 8.
[93] *Id*. at 8, 9.

4. HABITAT USE

Teatfish live in shallow coastal waters, generally in coral reefs and seagrass beds.[94] Black teatfish appear to prefer reef ecosystems (lagoons, reef flats, and reef slopes), though they occasionally are found in seagrass beds and on coarse, sandy bottoms or rocky areas as well.[95] They typically occupy waters up to 40 meters in depth.[96]

Teatfish are benthic species, meaning they live on the seafloor.[97] In unfished areas, they may exceed 35 individuals per square meter.[98] They play an important role in ecosystems (*see generally* Parts I.4, I.5, *infra*) and their removal triggers cascading effects on coral reefs and seagrass beds.[99] In addition, sea cucumbers serve as an important source of ecosystem biodiversity, hosting more than 200 species of symbionts, parasites, and commensal organisms.[100] Some of these relationships are exclusive and all serve to increase total ecosystem biodiversity.[101] *H. nobilis* hosts two genera of annelids (*Arctonoe*, *Gastrolepidia*).[102]

5. DIET AND FEEDING ECOLOGY

Black teatfish are deposit and detritus feeders that play a vital role in nutrient recycling, sediment health, water quality/chemistry regulation, and oxygenation.[103] They ingest large amounts of sediment using retractile tentacles; digest bacteria, cyanobacteria, decaying plant matter, copepods, diatoms, foraminiferans, and fungi; and defecate sand that is less organic rich than that which they consumed.[104] In unfished areas, sea cucumbers may exist in high densities (>35/m^2) and consume large quantities of organic matter—up to 82 kg per individual per year.[105] This consumption can help control parasite and pathogen populations and inhibit production of cyanobacterial mats.[106] While they may consume infauna associated with benthic habitat, more research is needed to determine what is consumed and digested.[107] Teatfish do not appear to consume macroalgae or seagrass, so they are not in competition with macroherbivores.[108]

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[94] Lawrence *et al.* (2004) at 85; Conand *et al.* (2013) at 5; CITES (2019a) at 4, 6.

[95] Bruckner (2006) at 36; Conand (2008) at 148; Eriksson, Byrne & de la Torre-Castro (2012) at 165; Purcell, Samyn & Conand (2012) at 71; Conand *et al.* (2013) at 5; *see also* Mmbaga (2013) at 1113 (noting higher abundance of *H. nobilis* in rocky areas than in sandy areas); CITES (2019a) at 3, 5.

[96] Purcell, Samyn & Conand (2012) at 71; Conand *et al.* (2013) at 5; CITES (2019a) at 5.

[97] CITES (2019a) at 4.

[98] *Id*. at 6.

[99] Eriksson, Byrne & de la Torre-Castro (2012) at 160; Purcell *et al.* (2016) at 368, 379-80.

[100] Conand (2009) at 224; Purcell *et al.* (2016) at 368, 373-77; Conand (2018) at 591; CITES (2019a) at 6.

[101] Purcell *et al.* (2016) at 375; CITES (2019a) at 6.

[102] Purcell *et al.* (2016) at 374; CITES (2019a) at 6.

[103] Uthicke, O'Hara & Byrne (2004) at 837; Bruckner (2006) at 33; Purcell, Patrois & Fraisse (2006) at 516; Conand (2009) at 224; Hasan (2009) at 31; Purcell *et al.* (2010) at 11; Anderson *et al.* (2011) at 319; Purcell *et al.* (2011) at 38; Purcell *et al.* (2014) at 7; Conand (2018) at 590, 591; Webster & Hart (2018) at 7; CITES (2019a) at 2, 6; *see generally* Purcell *et al.* (2016).

[104] Anderson *et al.* (2011) at 319; Purcell *et al.* (2016) at 369-71; Webster & Hart (2018) at 7.

[105] Purcell *et al.* (2016) at 370; Conand (2018) at 591; CITES (2019a) at 6.

[106] Purcell *et al.* (2011) at 38; Purcell *et al.* (2016) at 371; CITES (2019a) at 6.

[107] Purcell *et al.* (2016) at 370.

[108] *Id*.

Teatfish act as bioremediators and "gardeners," and their feeding activities increase the productivity of the ecosystems they inhabit.[109] Black teatfish primarily inhabit nutrient-sparse coral reef ecosystems, where their role in nutrient cycling can be substantial.[110] They ingest coral sand and rubble, digesting attached organic matter.[111] Digestion of nitrogen-rich compounds such as proteins converts organic nitrogen to inorganic forms, which in turn can be utilized by primary producers.[112] Even partial digestion is beneficial, as it makes the excreted material more amenable to digestion by bacteria and other biota.[113] Aquaria and field experiments including experiments in coral reefs have evidenced that commercially harvested sea cucumber species can increase primary productivity.[114] Sea cucumber elimination from ecosystems can result in sea floor hardening and habitat elimination for other benthic organisms.[115]

In addition, sea cucumbers' slightly acidic gut dissolves $CaCO_3$ particles that, when excreted, increase ambient alkalinity.[116] Sea cucumbers also excrete ammonia (NH_3) which is ionized in seawater and further increases ambient alkalinity.[117] By increasing local alkalinity and depositing $CaCO_3$, sea cucumbers potentially buffer coral reef ecosystems against the effects of climate change including ocean acidification.[118] *See* Fig. F; Part III.1.A, *infra* (discussing effects of climate change on coral reefs). Further, ammonia excretion may increase the productivity of coral symbionts called zooxanthellae.[119] While contributions of these compounds by individual sea cucumbers may be small, daily fluxes can be high in areas with healthy sea cucumber densities.[120]

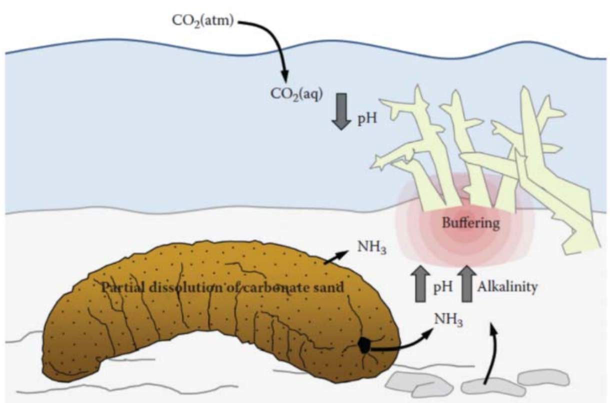

Fig. F. Sea cucumber influence on local water chemistry. (Purcell *et al.* (2016).)

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[109] *Id*. at 371; Conand (2018) at 591; Webster & Hart (2018) at 7; CITES (2019a) at 6.
[110] Purcell *et al.* (2011) at 38; Purcell *et al.* (2016) at 371.
[111] Schneider *et al.* (2011) at G04032.
[112] Purcell *et al.* (2011) at 38; Purcell *et al.* (2016) at 371.
[113] Purcell *et al.* (2016) at 372.
[114] Purcell *et al.* (2011) at 38; Purcell *et al.* (2016) at 371. Removing them, in turn, may decrease primary production in the affected ecosystem. (Purcell *et al.* (2011) at 38.)
[115] Anderson *et al.* (2011) at 319; CITES (2019a) at 6.
[116] Schneider *et al.* (2011) at G04032; Purcell *et al.* (2016) at 372.
[117] Schneider *et al.* (2011) at G04032; Purcell *et al.* (2016) at 371, 372. Small amounts of phosphate also are excreted. *Id.* at 371.
[118] Anderson *et al.* (2011) at 319; Eriksson, Byrne & de la Torre-Castro (2012) at 160; Purcell *et al.* (2014) at 7; Purcell *et al.* (2016) at 372; *see generally* Schneider *et al.* (2011).
[119] Purcell *et al.* (2016) at 372.
[120] *Id*. at 371, 373.

6. CAUSES OF MORTALITY

A. Natural Causes

The extent to which diseases and parasites result in sea cucumber mortality, including black teatfish mortality, is largely unknown. While *H. nobilis* is not yet cultured commercially, recent reports from other cultured sea cucumber species list the following afflictions that theoretically could affect black teatfish as well:

- Outbreaks of dipteran flies ("bloodworms") which compete with juvenile sea cucumbers for resources;
- Internal parasitisation of juvenile sea cucumbers by protozoans, leading to disease;
- Highly contagious bacterial infections of the body wall of juvenile and adult sea cucumbers, which can cause skin lesions and body wall breakdown;
- Competition for food by copepods.[121]

The impact of predation on *H. nobilis* also remains unknown. Many sea cucumbers produce chemical defenses (*e.g.,* saponins, terpenes), which reduce predation to some degree.[122] However, predators of at least seven phyla have overcome these defenses and prey on holothuroids (perhaps especially juveniles).[123] These include ~30 species of fish, 19 species of sea star, 17 species of crustacean, and several gastropods.[124] Birds, sea turtles, and marine mammals may prey on sea cucumbers on occasion as well.[125] The literature demonstrates the importance of sea cucumbers in food webs, as they provide energy transfer to a high number of benthic and benthopelagic species.[126]

B. Anthropogenic Causes

The primary threat facing the black teatfish is overfishing/commercial exploitation for international trade.[127] Fishermen target approximately 60-70 wild sea cucumber species, including 32 from the western Indian Ocean; the black teatfish is one of the most highly valued and thus most exploited of these tropical species.[128]

Sea cucumbers including black teatfish are particularly vulnerable to overexploitation due to several life history traits including slow growth, late sexual maturity, limited mobility, density-dependent

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121 Purcell, Hair & Mills (2012) at 72.
122 Conand (2009) at 224; Purcell *et al.* (2010) at 12; Purcell *et al.* (2016) at 377; Webster & Hart (2018) at 7.
123 Purcell *et al.* (2011) at 38; Purcell *et al.* (2016) at 377-79; Conand (2018) at 591; Webster & Hart (2018) at 7; CITES (2019a) at 6, 8.
124 Purcell *et al.* (2010) at 12; Purcell *et al.* (2016) at 368, 377-79; Conand (2018) at 591; Webster & Hart (2018) at 7; CITES (2019a) at 6.
125 Purcell *et al.* (2010) at 12.
126 Purcell *et al.* (2016) at 379.
127 Bruckner (2006) at 2, 41; Conand (2008) at 184; Purcell *et al.* (2010) at 149; Conand *et al.* (2014) at 6; CITES (2019a) at 9, 14; CITES (2019c) at 1; FAO (2019) at 62, 64.
128 Uthicke, O'Hara & Byrne (2004) at 837; Bruckner (2006) at 36; Conand & Muthinga (2013) at 54; Conand (2018) at 590; Purcell *et al.* (2018) at 127; Purcell, Williamson & Ngaluafe (2018) at 58.

recruitment, and low recruitment rates.[129] They also are easy to capture because of their large size, diurnal activity, and limited mobility.[130] Fishing techniques tend to be unsophisticated; sea cucumbers can be harvested through hand collection in shallow waters, using small wooden or glass boats, or diving using hookahs or SCUBA tanks alongside spears, hooks, or dip nets.[131] In areas where overharvest has driven fishermen into deeper waters, small trawlers (*e.g.*, roller pulling nets, beam trawl nets, scallop-drag gear) may be used.[132] These factors together have led to a "boom and bust" fishery cycle, where overexploitation of a harvested species on traditional fishing grounds leads fishermen to move to deeper waters, new locations, to the harvest of smaller individuals and/or different (usually lower-value) species.[133] *See* Fig. G. One analysis suggests sea cucumber fisheries "may frequently be crashing nearly as quickly as they are expanding," and that they are reaching their peak in catch faster over time.[134] For example, in Egypt, sea cucumber fisheries collapsed in less than five years after they began.[135] In contrast to many other fisheries, biological overexploitation—driven by high market value—often occurs before economic overexploitation.[136]

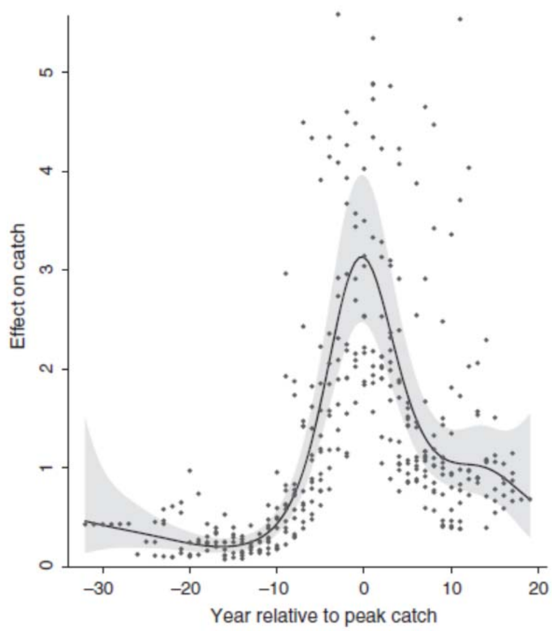

Fig. G. Typical sea cucumber fishery trajectory with 95% confidence interval. (Anderson *et al.* (2011).)

[129] Uthicke *et al.* (2004) at 837; Bruckner (2006) at 2, 75; Conand & Muthiga (2007) at iii; Al-Rashdi & Claereboudt (2010) at 13; Anderson *et al.* (2011) at 319; Purcell *et al.* (2011) at 49; CITES (2019a) at 2, 9; CITES (2019c) at 1; FAO (2019) at 62.
[130] Uthicke *et al.* (2004) at 837; Bruckner (2006) at 2; Anderson *et al.* (2011) at 319; Purcell *et al.* (2011) at 37; CITES (2019a) at 2, 9.
[131] Bruckner (2006) at 76, 77; Toral-Granda, Lovatelli & Vasconcellos (2008) at 2; Anderson *et al.* (2011) at 318; Purcell *et al.* (2011) at 10; Conand *et al.* (2013) at 5; CITES (2019a) at 10; FAO (2019) at 64.
[132] Bruckner (2006) at 77; Anderson *et al.* (2011) at 319; CITES (2019a) at 10.
[133] Lawrence *et al.* (2004) at 87; Bruckner (2006) at 2, 74, 75; Ahmed & Lawrence (2007) at 16; Purcell *et al.* (2011) at 36; Anderson *et al.* (2011) at 329, 330, 332; Purcell *et al.* (2014) at 6; FAO (2019) at 62, 74.
[134] Anderson *et al.* (2011) at 330, 332.
[135] *Id*. at 330; Purcell *et al.* (2011) at 52.
[136] Ahmed & Lawrence (2007) at 14; *see generally* Purcell *et al.* (2014).

Overharvest of sea cucumbers has been documented in many tropical countries, from Papua New Guinea and Australia to Madagascar and Fiji.[137] Anderson *et al.* (2011) report that at least 69% of sea cucumber fisheries are overexploited and 81% have experienced fishery-related declines.[138] This trend holds in the Indo-Pacific region, where a global analysis "revealed an alarmingly high incidence of over-exploitation and depletion of sea cucumber stocks."[139] *See* Fig. H; Table 1.

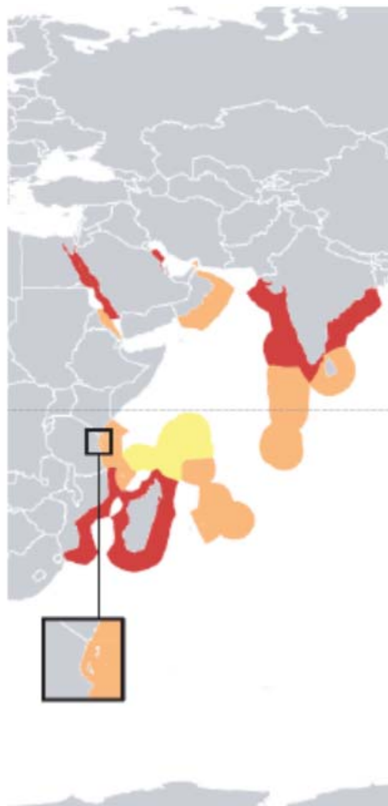

Fig. H. Current status of sea cucumber fisheries in the Indian Ocean. Red is depleted, orange is over exploited, and yellow is fully exploited. (Purcell *et al.* (2011).)

[137] Uthicke, O'Hara & Byrne (2004) at 837; Purcell, Williamson & Ngaluafe (2018) at 59, 61.
[138] Anderson *et al.* (2011) at 328.
[139] Purcell *et al.* (2011) at 41; *see also* Lawrence *et al.* (2004) at 80; Conand (2007) at 1-5; Purcell *et al.* (2010) at 17; CITES (2019a) at 12.

Western Indian Ocean		Overexploited	Fully exploited	Moderate	Underutilized	NA or other regional review
Red Sea	**Egypt**	X				
	Sudan					NA
	Eritrea		X	X		
	Saudi Arabia					NA
	Israel					NA
	UAE					NA
Aden Gulf	Djibouti					NA
Western Arabian Sea	**Oman**					
	Yemen					
	Iran IR					
Eastern Arabian Sea	Pakistan					NA
	India	X				
	Chagos	X				
	Maldives	X				
Somalia, Kenya, Tanzania	Somalia					NA
	Kenya	X				
	Tanzania	X				
Madagascar, Mozambique channel	**Madagascar**	X				
	Comoros	X	X			
	Mayotte	X				
Islands	**Mauritius**		X	X		
	Réunion				X	
	Seychelles		X	X		
Mozambique	**Mozambique**	X				

Table 1. Exploitation status of sea cucumber fisheries in the Western Indian Ocean by country and area. Bold indicates documented sea cucumber fisheries. (Conand (2008).)

H. nobilis is among the species of highest value and thus highest concern off the east coast of Africa and in the Red Sea.[140] Catch of black teatfish has declined in many areas and the species is considered depleted in Mozambique, India, Sri Lanka, Madagascar, Egypt, the Red Sea, Maldives, and likely also Tanzania and Kenya. A lack of effective fishery management regimes for sea cucumber species alongside systemic misreporting of take have led to widespread stock depletion, fishery collapse, and local extirpation in this region.[141]

Because sea cucumbers exhibit slow growth, late sexual maturity, limited mobility, density-dependent recruitment, and low recruitment rates, they may not recover even after fisheries are closed.[142] *See* Part III.5.B, *infra* (discussing risks of rarity). According to leading sea cucumber scientists, "[p]opulations of high-value sea cucumbers have been so decimated in some areas that better fisheries governance and regulatory measures alone may be incapable of restoring populations."[143] Even relatively low fishing rates may lead to population decline. For example, a fishing rate of just 5% of virgin biomass per year has been shown to lead to depletion of breeding stocks of *H. whitmaei*.[144] At minimum, it may take upwards of 50 years for overexploited populations to rebound.[145] Exploration of mariculture both for

[140] Bruckner (2006) at 4, 21.
[141] Uthicke, O'Hara & Byrne (2004) at 837; Bruckner (2006) at 22; Anderson *et al.* (2011) at 328; Purcell, Williamson & Ngaluafe (2018) at 62.
[142] Al-Rashdi & Claereboudt (2010) at 13; Anderson *et al.* (2011) at 319; CITES (2019a) at 14; FAO (2019) at 62; *see also* Conand & Muthinga (2013) at iii (noting that insufficient supply "coupled with declining stocks and weak management systems indicate that sea cucumber stocks are unlikely to recover to sustainable levels in the near future").
[143] Purcell, Hair & Mills (2012) at 69.
[144] Purcell *et al.* (2010) at 11, 53.
[145] Lawrence *et al.* (2004) at 80, 88; Anderson *et al.* (2011) at 319; CITES (2019a) at 14; FAO (2019) at 62; Oury, Léopold & Magalon (2019) at 3501.

rebuilding wild stocks and supplying the luxury market continues but is not yet sufficient to relieve pressure on wild stocks.[146]

7. CONSERVATION STATUS

Existing legislation and protections for the black teatfish remain inadequate to halt and reverse the species' decline toward extinction. *See* Parts III.2, III.4, *infra*. As a result, the black teatfish is listed as endangered on the IUCN Red List.[147] A species is listed as IUCN "endangered" when there is a very high risk of extinction in the immediate future.[148]

The IUCN Red List uses standardized, quantitative criteria to determine a species' probability of extinction.[149] Experts compiled and analyzed data on the black teatfish's taxonomy, distribution, population trend, ecology, life history, past and existing threats, and conservation efforts and determined that the species merited a designation of "endangered."[150] The black teatfish warrants the same designation (threatened or endangered) under the U.S. Endangered Species Act.

PART II. THE BLACK TEATFISH IS A LISTABLE ENTITY UNDER THE ESA

The black teatfish is a "species" as defined by taxonomists, and thus constitutes a listable entity under the U.S. Endangered Species Act. *See* Part I.1.A, *supra*. The Endangered Species Act extends its protection to "species," a term broadly defined to include "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature."[151] The black teatfish, *Holothuria nobilis*, is recognized as a species by taxonomists and thus qualifies for the ESA's protections.

PART III. THE BLACK TEATFISH QUALIFIES AS THREATENED OR ENDANGERED UNDER THE ESA

The threats facing the black teatfish, including overfishing, climate change, inadequate regulatory mechanisms, and risks of rarity, place this species at risk of extinction. NMFS must conduct a status review to evaluate the black teatfish's "endangered or threatened status … based on the Act's definitions of those terms and a review of the factors enumerated in section 4(a)." Under the ESA, an "endangered species" is defined as "any species which is in danger of extinction throughout all or a significant portion of its range."[152] A "threatened species" is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."[153] The factors enumerated in section 4(a) include:

(A) the present or threatened destruction, modification, or curtailment of its habitat or range;

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[146] *See generally* Minami (2011); *see also* Purcell, Patrois & Fraisse (2006); Purcell, Hair & Mills (2012); Conand *et al.* (2014) at 6; CITES (2019a) at 17.
[147] Conand *et al.* (2013); CITES (2019a) at 10.
[148] IUCN Glossary.
[149] Conand *et al.* (2014) at 3.
[150] *Id*. at 4, 5.
[151] 16 U.S.C. § 1532 (16).
[152] *Id*. § 1532(6).
[153] *Id.* § 1532(20).

(B) overutilization for commercial, recreational, scientific, or educational purposes;
(C) disease or predation;
(D) the inadequacy of existing regulatory mechanisms; or
(E) other natural or manmade factors affecting its continued existence.[154]

The agency's review and determination must be based solely on the best scientific and commercial data available.[155]

1. THE PRESENT OR THREATENED DESTRUCTION, MODIFICATION, OR CURTAILMENT OF THE BLACK TEATFISH'S HABITAT OR RANGE

Degradation of primary black teatfish habitats including coral reefs and seagrass beds contributes to the species' decline toward extinction.[156] Myriad pressures threaten coral reefs and seagrass beds including overfishing, destructive fishing practices (*e.g.,* explosives, cyanide), sedimentation, pollution (*e.g.,* nutrients, contaminants), coastal development, and climate change-associated ocean warming, ocean acidification, and storm regimes.[157] Scientists have urged conservation of sea cucumber habitat in addition to sea cucumbers themselves to provide a future for these species.[158]

A. Coral reefs

Coral reef-dependent sea cucumber species including *H. nobilis* are at increasing risk of extinction as tropical reefs deteriorate worldwide.[159] Indo-Pacific reefs have lost nearly 70% coral cover since the late 1960s. *See* Fig. I. As explained by Anthony and Maynard (2011):

> Coral reefs in many third-world countries, in particularly in Southeast Asia and East Africa, are in the 'emergency room' for two reasons. First, their localized traumas (e.g., overfishing and pollution) are in many places so severe that they are vulnerable to any worsening of the systemic condition (levels of atmospheric carbon). Reefs in parts of … East Africa are heavily and destructively overfished, leading to persistent algal dominance and shrinking habitat for fish and invertebrate resources. Second, reefs here support the livelihoods of hundreds of millions of people, posing societal challenges for how management actions can be implemented.[160]

[154] *Id*. § 1533(a).
[155] *Id*. § 1533(b)(1)(A).
[156] Bruckner (2006) at 41; Aumeeruddy & Conand (2008) at 205; Conand (2008) at 183; Mmbaga (2013) at 1120-21; CITES (2019c) at 1; FAO (2019) at 64.
[157] Aumeeruddy & Conand (2008) at 205-06; Toral-Granda, Lovatelli & Vasconcellos (2008) at 3; CITES (2019a) at 7. Tsunamis also pose a threat. (CITES (2019a) at 10.)
[158] Bruckner (2006) at 43.
[159] Conand (2008) at 183; CITES (2019a) at 7.
[160] Anthony & Maynard (2011) at 216; *see also* Obura (2005) at 353; *see generally* Wagner (2004); Cinner (2010).

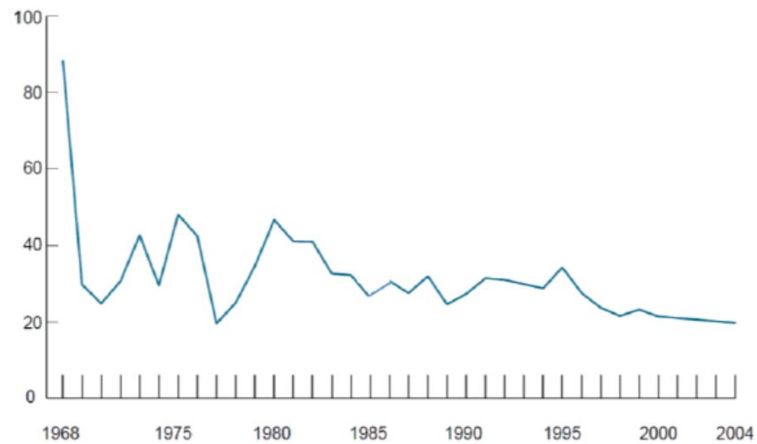

Fig. I. Percentage change in coral cover in the Indo-Pacific region over time. (Modified from WWF (2015), at 13.)

Anthony and Maynard point to the root causes of coral reef degradation and destruction, both of which are anthropogenic: direct pressure and climate change. The direct anthropogenic causes of coral reef decline in this region are myriad, including overfishing, destructive fishing practices (*e.g.,* dynamiting/blast fishing, poisoning, seine netting, trapping, breaking, trampling), anchor damage, boat grounding, industrial and agricultural wastes (leading to eutrophication, chemical pollution, and bacterial pollution), increased freshwater inputs, sedimentation, storm events including cyclones (and associated siltation, flooding, and wave damage), urbanization, tourism, coral extraction, sand mining, dredging, maritime shipping and associated pollution (including oil spills), and seaweed farming.[161] For example, overfishing and reef gleaning (using iron bars) damages reefs in Tanzania, Madagascar, the Comoros, and Mauritius.[162] Blast fishing is quite common in the Comoros, reducing coral reefs to rubble.[163] Deforestation and poor agricultural practices have led to sedimentation and smothering of reefs in Madagascar, Mauritius, and the Seychelles.[164] The extraction of coral and sand for building is degrading reefs in Madagascar and the Comoros.[165] In general, reefs near human populations show more signs of degradation while remote reefs fare somewhat better.[166] This observation holds in East Africa and the Comoros.[167]

One of the primary ongoing causes of coral reef degradation in the Indo-Pacific is climate change. Climate change underlies three primary threats facing coral reefs: ocean warming, disease, and ocean acidification. Ocean warming and acidification caused by greenhouse gas pollution are wreaking havoc on reef ecosystems worldwide. The world's oceans have absorbed more than 90 percent of the excess heat caused by climate change, resulting in average sea surface warming of 0.7°C (1.3°F) per century since 1900.[168] Global average sea surface temperature is projected to rise by 2.7°C (4.9°F) by the end of

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[161] Maragos, Crosby & McManus (1996) at 89, 92-93; Lindén *et al.* (2002) at 7; Obura (2002) at 15, 17; Wilhelmsson (2002) at 93, 96-97; Wagner (2004) at 227, 230-32; Obura (2005) at 356; WWF (2006) at 7; Cinner (2010) at 321; Anthony & Maynard (2011) at 215-16; *see generally* Ahamada *et al.* (2002).
[162] Ahamada *et al.* (2002) at 90; Wagner (2004) at 227-28.
[163] Ahamada *et al.* (2002) at 90.
[164] *Id*.
[165] *Id*.
[166] McClenahan (1997) at 97; Ahamada *et al.* (2002) at 80; Lindén *et al.* (2002) at 9.
[167] Ahamada *et al.* (2002) at 81; *see generally* McClenahan (1997).
[168] USGCRP (2017).

the century under a higher emissions scenario.[169] In addition, climate change contributes to marine heat waves—periods of extreme warm surface temperatures—which have become longer-lasting and more frequent in recent decades. The number of heat wave days doubled between 1982 and 2016 and is projected to increase 23 times under 2°C warming.[170] At present, 87 percent of marine heat waves are attributable to human-induced warming.[171]

Scientific research definitively links anthropogenic ocean warming to the catastrophic, mass coral bleaching events that have been documented since 1980 and are increasing in frequency alongside rising atmospheric CO_2 concentrations.[172] These bleaching events occur when the thermal stress of rising ocean temperatures disrupts the relationship between corals and their algal symbionts.[173] When the corals expel these symbionts, they lose their color and suffer nutritional stress and physiological damage. (*Id.*) Prolonged bleaching often results in high levels of coral mortality.[174] Severe bleaching has increased five-fold in the past several decades and now occurs every six years on average, which is too frequent to allow corals to fully recover between bleaching events.[175] Most reefs worldwide will suffer annual bleaching scenarios by 2050.[176]

The global coral bleaching event that lasted from 2014 to 2017 was the longest, most widespread, and likely most destructive on record, affecting more reefs than any previous mass bleaching event and causing bleaching at previously sheltered reef sites.[177] A 2017 scientific review concluded that "unless rapid advances to the goals of the Paris Climate Change Agreement occur over the next decade," coral reefs will likely "degrade rapidly over the next 20 years, presenting fundamental challenges for the 500 million people who derive food, income, coastal protection, and a range of other services from" these ecosystems.[178]

More frequent, strong El Niño events also trigger coral bleaching. For example, elevated sea surface temperatures associated with the 1997-98 El Niño Southern Oscillation (in addition to an increase in background temperatures) triggered a global coral bleaching event that decimated reefs in the Western Indian Ocean, inflicting 30% regional mortality with 80-100% mortality for certain reef ecosystems and nations.[179] Areas in the northern and central Indian Ocean (including the Maldives, Seychelles, and Chagos), the East African coast (Mozambique, Kenya, Tanzania), Sri Lanka, and parts of India

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[169] *Id*.
[170] Frolicher *et al.* (2018).
[171] *Id.*
[172] Hoegh-Guldberg *et al.* (2007); Donner *et al.* (2009); Eakin *et al.* (2010); NMFS (2015); Hughes *et al.* (2017); Hughes *et al.* (2018b); Manzello *et al.* (2019); Cheng *et al.* (2019); Leggat *et al.* (2019).
[173] Hughes *et al.* (2017). *See also* Manzello *et al.* (2019) (discussing the relationship between symbiont and coral bleaching resistance).
[174] Hughes *et al.* (2017).
[175] Hughes *et al.* (2018b); *see also* Neal *et al.* (2017) (noting that in the Caribbean, many important reef-building corals have not recovered from repeated bleaching events).
[176] van Hooidonk *et al.* (2013); Hughes *et al.* (2018b); Manzello *et al.* (2019).
[177] Heron *et al.* (2017); Eakin *et al.* (2018); Raymundo *et al.* (2019).
[178] Hoegh-Guldberg *et al.* (2017).
[179] Ahamada *et al.* (2002) at 89; Lindén *et al.* (2002) at 7; Obura (2002) at 16; Spalding & Jarvis (2002) at 309; Wilhelmsson (2002) at 93, 94; Obura (2005) at 353; Payet & Agricole (2006) at 187; Collier & Humber (2007) at 339; Ateweberhan & McClanahan (2010) at 964; *see also* Chong-Seng, Graham & Pratchett (2014) at 449.

experienced extensive coral mortality.[180] The reefs of the Lakshadweep Islands off of India lost 43-87% of their live coral cover, and certain colonies in the Seychelles suffered 95-100% mortality.[181]

Unfortunately, high sea surface temperatures are no longer restricted to El Niño years; in fact, "tropical sea surface temperatures are warmer now during current *La Niña* conditions that they were during El Niño events three decades ago."[182] Additionally problematic to long-term health and persistence of corals are the permanently elevated sea surface temperatures associated with climate change.[183] Scientists have found that sea surface temperatures only 1-2°C above ambient can induce bleaching in corals; global sea surface temperatures have already increased 1°C since pre-industrial times. (Heron *et al.* 2017). For the Indian Ocean, "temperature conditions that were catastrophic in 1998 are predicted to be repeated 1 in 5 years by about the year 2020 within the most vulnerable latitudes in the Indian Ocean (about 10-15°S), and within a further 10-20 years, farther north and south."[184] As a result, "[c]limate change-associated coral bleaching and mortality now represent the greatest threats to coral reefs in the [Western Indian Ocean], over and above the many local threats affecting coral reefs in the region."[185] Likewise, coral reefs in the Arabian Gulf also have been measurably affected by climate change already.[186] Scientists predict that ocean warming in the tropics will make life for corals physiologically impossible in the next 20-50 years.[187]

Exacerbating the harms from rising temperatures is ocean acidification. The global ocean has absorbed more than a quarter of the CO_2 emitted to the atmosphere by human activities, which has increased its surface acidity by more than 30 percent.[188] This increase has occurred at a rate likely faster than anything experienced in the past 300 million years.[189] Ocean acidity could increase 150 percent by the end of the century if CO_2 emissions continue unabated.[190] By reducing the availability of key chemicals (namely, aragonite and calcite), ocean acidification negatively affects a wide range of calcifying marine creatures like corals by hindering their ability to build skeletons and by disrupting metabolism and critical biological functions.[191] The adverse effects of ocean acidification already are reducing

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[180] Lindén *et al.* (2002) at 9; Obura (2002) at 15-16; Wilhelmsson (2002) at 93-96.
[181] Ahamada *et al.* (2002) at 89; Obura (2002) at 16; Wilhelmsson (2002) at 93, 94; Payet & Agricole (2006) at 187; Collier & Humber (2007) at 339.
[182] Hughes *et al.* (2018b) (emphasis added).
[183] *Id.*; Payet & Agricole (2006) at 182.
[184] Obura (2005) at 354.
[185] *Id*. That said, "the long term effects of local threats such as overfishing, sedimentation and pollution are still strong, and in many cases influence recovery from climate-related threats." Obura (2002) at 15.
[186] Riegl (2003) at 433.
[187] Price *et al.* (2019).
[188] Simpson *et al.* (2009) correlate a Caribbean open-ocean aragonite saturation state of 4.0, which is needed to protect corals from degradation from ocean acidification, with an atmospheric CO_2 level of 340 to 360 ppm—far below current levels.
[189] Hönisch *et al.* (2012); USGCRP (2017).
[190] Orr *et al.* (2005); Feely *et al.* (2009).
[191] Fabry *et al.* (2008); Kroeker *et al.* (2013).

calcification rates in coral reefs worldwide, leading to reef bioerosion and dissolution.[192] Acidification coupled with elevated temperatures also reduces coral larval survival and settlement.[193]

Climate change also exacerbates coral disease, leading to widespread declines of threatened and endangered species.[194] For example, white-band disease led to precipitous declines (on the order of 92-97%) of once-abundant Caribbean elkhorn and staghorn corals. Research indicates that these disease outbreaks were driven by heat stress from rising ocean temperatures.[195] Pillar corals (*Dendrogyra cylindrus*), which have suffered catastrophic declines in Florida in recent years, succumbed to black band disease that first emerged following bleaching events in 2014 and 2015 spurred by abnormally high water temperatures.[196]

In sum, climate change is degrading and destroying coral reef habitat in the western Indian Ocean through elevated temperatures, which lead to bleaching events and the spread of coral disease, as well as through ocean acidification, which reduces larval survival and impedes reef formation and maintenance. Local stressors including overfishing, destructive fishing practices (*e.g.,* dynamiting/blast fishing, poisoning, seine netting, trapping, breaking, trampling), anchor damage, boat grounding, industrial and agricultural wastes (leading to eutrophication, chemical pollution, and bacterial pollution), increased freshwater inputs, sedimentation, storm events including cyclones (and associated siltation, flooding, and wave damage), urbanization, tourism, coral extraction, sand mining, dredging, maritime shipping and associated pollution (including oil spills), and seaweed farming compound these harms. All of these stressors, in turn, put coral reef-reliant species including *H. nobilis* at increased risk of extinction.

B. Seagrass Beds

The loss of seagrass beds also threatens black teatfish with extinction. In certain areas, black teatfish use seagrass beds as their preferred habitat. Seagrasses include ~55-60 species of vascular plants that grow in clear, shallow, sheltered, estuarine and coastal waters in the tropics, temperate zones, and subarctic.[197] The tropical Indo-Pacific bioregion provides home for the largest number of seagrass species worldwide, as well as a high biodiversity of associated flora and fauna.[198] The extensive seagrass beds of the Western Indian Ocean, in particular, harbor at least 13 seagrass species.[199] Biophysical parameters including temperature, salinity,[200] depth, wave and current activity, substrate, light,[201] and

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[192] Albright *et al.* (2016); Heron *et al.* (2017); Eyre *et al.* (2018). Eyre *et al.* (2018) predict that "reef sediments globally will transition from net precipitation to net dissolution when seawater Ω_{ar} reaches 2.92 ± 0.16 (expected circa 2050 CE)."
[193] Pitts (2018).
[194] Randall & van Woesik (2017).
[195] 71 Fed. Reg. 26,852, 26,872 (May 9, 2006); Randall & van Woesik (2015); van Woesik & Randall (2017).
[196] Lewis *et al.* (2017).
[197] Waycott *et al.* (2007) at 194; Nakamura (2009) at 39; Coles *et al.* (2011) at 225.
[198] Coles *et al.* (2011) at 227.
[199] Gullström *et al.* (2002) at 588.
[200] Seagrasses are believed to grow best in salinities of 35 ppt (range 4-65 ppt), with species-specific differences in tolerance. Waycott *et al.* (2007) at 200.
[201] Seagrasses must get enough light to photosynthesize, but not enough to overheat the water or to allow competitors (*e.g.,* epiphytic algae) to overtake the system. *Id.* at 199; Coles *et al.* (2011) at 228.

nutrients, in addition to anthropogenic pressures (including climate change), all determine whether seagrasses can grow in a given location.[202]

In the Western Indian Ocean, seagrass bed research has been conducted primarily along the East African coast (Kenya, Tanzania, Mozambique).[203] Even there, such research is in its infancy.[204] Less has been done in the island states (Comoros, Seychelles, Reunion, Madagascar, Mauritius).[205] In general, scientists know that seagrass beds are rich, productive ecosystems serving important ecological roles including water quality regulation, nutrient cycling, oxygen production, carbon sequestration,[206] sediment stabilization, nursery habitat provision (including for sea cucumbers), and fisheries production.[207] They also provide food for a wide variety of species including fish, echinoderms, sea turtles, and dugongs.[208]

Sea cucumbers, in turn, provide a variety of benefits to seagrass communities. Exclusion of the commercially important holothurian *H. scabra* from seagrass beds was found to lower seagrass growth and biomass and increase macroalgae biomass and organic matter.[209] Such findings suggest that overfishing of sea cucumbers from seagrass beds could detrimentally affect these important ecosystems.[210]

Seagrass beds have come under threat from a variety of stressors including overfishing, destructive fishing methods (*e.g.,* bottom trawling), aquaculture, pollution (*e.g.*, herbicides, pesticides, heavy metals, petrochemicals, sedimentation/turbidity), shipping traffic (*e.g.*, scars from propellers, breakage from anchor chains), changes in salinity gradients flowing from water diversion or storm events, invasive species, shoreline development, dredging, seaweed farming, and climate change.[211] Losses of coral reefs and mangroves also can harm seagrass beds by altering sedimentation regimes and energy flow.[212] On a global scale, seagrasses are reported to have undergone catastrophic losses flowing largely from anthropogenic activity: on the order of 18-29% of total area across 40 locations.[213] They may be losing an additional 1.5-7% of their global area annually.[214] This destruction, degradation, and fragmentation

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[202] Waycott *et al.* (2007) at 199; Coles *et al.* (2011) at 228; Telesca *et al.* (2015) at 12513.
[203] Gullström *et al.* (2002) at 588.
[204] Bandeira & Björk (2001) at 420.
[205] Gullström *et al.* (2002) at 588.
[206] One study reports that Indo-Pacific seagrass meadows are largely autotrophic, resulting in an average net sink of 155 $gC/m^2/year$. Unsworth *et al.* (2012) at 024026. *See also* Rasheed & Unsworth (2011) at 93 (noting seagrass beds' important role as a carbon sink).
[207] Bandeira & Björk (2001) at 420; Gullström *et al.* (2002) at 588, 592; Waycott *et al.* (2007) at 196; Nakamura (2009) at 39; Coles *et al.* (2011) at 225, 226; Rasheed & Unsworth (2011) at 93, 99; Unsworth *et al.* (2012) at 024026; Conand & Muthinga (2013) at 19; Telesca *et al.* (2015) at 12505; *see generally* Dorenbosch *et al.* (2005).
[208] Nakamura (2009) at 39.
[209] Wolkenhauer *et al.* (2010) at 215.
[210] *Id*.
[211] Francour, Ganteaume & Poulain (1999) at 391; Gullström *et al.* (2002) at 588, 594; de la Torre-Castro (2006) at 30, 31; Kenworthy *et al.* (2006) at 608; Ralph *et al.* (2006) at 567, 568, 578-84; Nakamura (2009) at 41-42; Coles *et al.* (2011) at 229, 230, 231; Telesca *et al.* (2015) at 12505, 12514.
[212] Gullström *et al.* (2002) at 592.
[213] Green & Short (2003) at 286; Kenworthy *et al.* (2006) at 603; Ralph *et al.* (2006) at 567; Coles *et al.* (2011) at 225; Rasheed & Unsworth (2011) at 94; Telesca *et al.* (2015) at 12505, 12506.
[214] Coles *et al.* (2011) at 226; Telesca *et al.* (2015) at 12505.

"become especially perilous in developing nations as coastal states attempt to increase revenue through activities that elevate stress levels in seagrass ecosystems"—such as sea cucumber harvest.[215]

Of all human impacts, scientists believe eutrophication (*i.e*., nutrient enrichment, primarily of nitrogen and phosphorus) has the greatest detrimental impact on seagrass beds.[216] While nutrient enhancement has a positive effect on seagrass growth to a certain point, too much can be toxic or promote excessive growth of phytoplankton and epiphytic macroalgae.[217] Such algae overgrowth can prevent light from reaching seagrasses, hindering their growth. Increased sedimentation or turbidity can have a similar effect.[218]

Climate change, too, exerts stress on seagrass beds. Seagrass ecosystems are considered at high risk from climate change through three primary mechanisms: increased thermal stress,[219] changes in freshwater flows, and increased storm incidence and severity.[220] Regression modeling relating 16 years' worth of seagrass biomass to climatic data in northeast Australia confirmed this sensitivity, with significant negative correlations between seagrass biomass and both elevated temperature and reduced river flows.[221] Elevated temperatures can "super-heat" waters, making them inhospitable to seagrass species.[222] Both laboratory and field data suggest that tropical seagrass species undergo thermal stress at temperatures exceeding 35°C.[223] Increased thermal stress also occurs when seagrasses are exposed to warmer air during low tide events, which can lead to desiccation.[224] Finally, reduced river flows also can increase water temperatures as well as alter salinity regimes and reduce nutrient influx.[225]

The effects of other climate change-related phenomena on seagrasses, including reduced pH and increased dissolved CO_2, appear to be species-specific.[226] Climate change-associated sea level rise may create or destroy seagrass habitat, depending on location and impacts to light penetration.[227] Increasing storm events and storm surge, flooding, coastal erosion, and infrastructure development may be harmful, damaging or smothering seagrass ecosystems.[228]

Climate change is acting synergistically with multiple other stressors to affect seagrass beds, though such interactions have not been well-studied.[229] The interaction of global climate change, fishing (including fishing for sea cucumbers), and increasing human development near the coasts may be particularly influential.[230]

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[215] Kenworthy *et al.* (2006) at 606.
[216] Gullström *et al.* (2002) at 588, 592; Ralph *et al.* (2006) at 568, 571; Waycott *et al.* (2007) at 199.
[217] Ralph *et al.* (2006) at 568, 569, 573.
[218] *Id.* at 568, 573, 575-77.
[219] *See generally* Waycott *et al.* (2007) at 201-204.
[220] *Id.* at 226; Rasheed & Unsworth (2011) at 93, 101.
[221] Rasheed & Unsworth (2011) at 93, 99.
[222] *Id.* at 94.
[223] *Id.* at 100.
[224] *Id.* at 100.
[225] Waycott *et al.* (2007) at 201.
[226] *Id.* at 200, 219-21.
[227] *Id.* at 204-08
[228] *Id.* at 201, 208-15.
[229] Ralph *et al.* (2006) at 568; Waycott *et al.* (2007) at 223; Coles *et al.* (2011) at 234; Telesca *et al.* (2015) at 12505.
[230] Kenworthy *et al.* (2006) at 607.

In sum, while the Indo-Pacific is the center of seagrass diversity, such habitats are subject to numerous significant stressors including overfishing, destructive fishing methods (*e.g.,* bottom trawling), aquaculture, pollution (*e.g.*, herbicides, pesticides, heavy metals, petrochemicals, sedimentation/turbidity), shipping traffic (*e.g.*, scars from propellers, breakage from anchor chains), changes in salinity gradients flowing from water diversion or storm events, invasive species, shoreline development, dredging, seaweed farming, climate change, and coral reef and mangrove loss. Seagrass beds in the region also are fragmented across numerous jurisdictions making cohesive, science-based management and conservation difficult.[231] Without such management, seagrass beds and their associated communities will continue to decline. Such habitat degradation and destruction places the black teatfish at increasing risk of extinction.

2. OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC, OR EDUCATIONAL PURPOSES

Overfishing for international trade is the primary threat facing the black teatfish and placing it at risk of extinction.[232] Catch of sea cucumbers has increased at least 500% since the 1950s, with the largest growth since the 1980s.[233] This growth has been characterized by an increasing number of harvesting countries, an increasing number of harvested species, and expansion of sea cucumber fisheries into more remote waters and/or deeper fishing grounds.[234] Despite this increase in effort and harvest, worldwide production remains insufficient to meet demand.[235]

While total volume of global harvest is difficult to estimate with any precision (because, *e.g.*, some countries do not parse out sea cucumbers in their trade statistics on marine invertebrates; some countries both import and re-export sea cucumbers; animals exported salted, frozen, or dried have different weights (each of which differs from fresh weight); some countries underreport exports; and illegal fishing and trade are rampant),[236] current extraction approximates 200 million sea cucumbers weighing 10,000 tons (dried) per year.[237]

Sea cucumbers are harvested in over 70 nations,[238] but sea cucumbers typically are not consumed in the nations in which they are caught and processed.[239] The majority of harvested sea cucumbers are exported to Asia for the luxury seafood market which has grown alongside increasing wealth in the region.[240] Hong Kong, Taiwan, and Singapore represent the primary global markets for dried sea cucumber, called bêche-de-mer or trepang;[241] much of this product is then redistributed to mainland

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[231] Coles *et al.* (2011) at 234. *See also* Waycott *et al.* (2007) at 226 (discussing management needs).
[232] Bruckner (2006) at 2, 41; Conand (2008) at 184; Purcell *et al.* (2010) at 149; Conand *et al.* (2014) at 6; CITES (2019a) at 9, 14; CITES (2019c) at 1; FAO (2019) at 62, 64.
[233] Bruckner (2006) at 2; Purcell *et al.* (2011) at 36; CITES (2019c) at 3.
[234] Bruckner (2006) at 2.
[235] Conand & Muthinga (2013) at iii.
[236] Bruckner (2006) at 75; Toral-Granda, Lovatelli & Vasconcellos (2008) at 4; Purcell *et al.* (2010) at 16-17; Anderson *et al.* (2011) at 319, 329, 333; Purcell *et al.* (2011) at 36, 42; CITES (2019a) at 2, 13; FAO (2019) at 76.
[237] Purcell *et al.* (2016) at 367.
[238] Purcell *et al.* (2012) at iv.
[239] *Id.*; Conand (2018) at 591.
[240] Toral-Granda, Lovatelli & Vasconcellos (2008) at 1; Purcell, Hair & Mills (2012) at 69; Purcell *et al.* (2014) at 2; Conand (2017) at S1; Conand (2018) at 590; Purcell *et al.* (2018) at 127; Purcell, Williamson & Ngaluafe (2018) at 58, 59, 61; CITES (2019a) at 9.
[241] Sea cucumbers are also known in the trade “Hoi Sum” and “Hai Shen” (roughly translated to “ginseng of the sea”) in Hong Kong and mainland China. To & Shea (2012), at 66.

China and other secondary markets including Malaysia.[242] The dried product is typically rehydrated before consumption.[243] Chinese consume sea cucumbers as a delicacy and for medicinal benefits, as sea cucumber is considered one of the eight culinary treasures from the sea.[244] Sea cucumbers also are consumed raw or pickled in Japan and Korea,[245] and boiled and salted in other nations.[246]

The growing luxury seafood market in China has led to dramatic increases in international market prices for sea cucumbers since the late 1980s, putting increasing pressure on sea cucumber stocks.[247] Between 2011 and 2016, average retail prices for sea cucumbers in Hong Kong and Guangzhou increased more than 16% and maximum prices by over 50%.[248] High-value stocks have come under the most pressure and are at highest risk of localized extinction.[249] *Holothuria nobilis* and other teatfish are among the highest-value species in trade, fetching US$106-270 per kg (dried) in Hong Kong.[250] Teatfish thus are at particular risk from overfishing, and overall harvest has been unsustainable.[251] Black teatfish are estimated to have declined by 60-70% across 80% of their range.[252] Despite their depletion, fishery pressure on high-value species including *H. nobilis* is expected to continue.[253]

While the primary market for sea cucumbers is in Asia, the United States also imports sea cucumbers, including *H. nobilis*.[254] According to the U.S. Law Enforcement Management Information System (LEMIS) database, in 2014 alone the United States imported over 3.6 million kg of sea cucumbers (both live and dried) plus an additional 382,000 individual specimens from 22 different sea cucumber species.[255] U.S. sea cucumber imports, both in terms of quantity and number of species, have vastly increased over the last decade: in 2007, the United States imported only around 99,000 kg of sea cucumbers (both live and dried) and an additional 1300 individual specimens with only four different sea cucumber species identified.[256]

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[242] Toral-Granda, Lovatelli & Vasconcellos (2008) at 2; Anderson *et al.* (2011) at 322; Purcell, Hair & Mills (2012) at 69; Conand (2017) at S5; Purcell *et al.* (2018) at 127; Purcell, Williamson & Ngaluafe (2018) at 58; CITES (2019a) at 2, 10, 30.
[243] Purcell (2014), at 1.
[244] To & Shea (2012) at 66; Purcell *et al.* (2018) at 128. Sea cucumbers also are consumed to a lesser extent as an aphrodisiac. (Purcell *et al.* (2010) at 12.)
[245] Conand (2009) at 4.
[246] Bruckner (2006), at 64; Conand (2009) at 224.
[247] Purcell, Patrois & Fraisse (2006) at 515; Conand & Muthiga (2007) at iii; Anderson *et al.* (2011) at 318; Purcell *et al.* (2018) at 127; Purcell, Williamson & Ngaluafe (2018) at 58-59; CITES (2019a) at 9.
[248] Purcell, Williamson & Ngaluafe (2018) at 61.
[249] Purcell *et al.* (2018) at 130.
[250] Uthicke, O'Hara & Byrne (2004) at 837; Bruckner (2006) at 4, 76; Toral-Granda (2007) at 39-41; Conand (2008) at 170; Conand (2009) at 226; Purcell, Hair & Mills (2012) at 69; Purcell, Samyn & Conand (2012) at 71; Conand *et al.* (2013) at 1, 5; Conand *et al.* (2014) at 5; Conand (2017) at S2; CITES (2019a) at 2, 30.
[251] Ahmed (2015) at 85; FAO (2019) at 62.
[252] Conand *et al.* (2013) at 1, 4; Conand *et al.* (2014) at 5; CITES (2019a) at 8.
[253] Conand *et al.* (2013) at 5.
[254] *See also* Bruckner (2006), at 64 (noting minor markets in North America (USA and Canada).
[255] *See* Ex. A (Excel spreadsheet of all sea cucumber imports from LEMIS database, 2014).
[256] *See* Ex. B (Excel spreadsheet of all sea cucumber imports from LEMIS database, 2007); *see also* Ex. C (Excel spreadsheet of "*Holothuria species*" imports from LEMIS database, 2004-2014, documenting zero kilograms of *Holothuria species* (imports sea cucumbers from the genus *Holothuria* with species-level identification) in 2004 to a maximum of 693,716 in 2012).

The United States has imported *H. nobilis*. The LEMIS database documents the 2014 import of 391 kg of likely dried *H. nobilis* purportedly from a captive breeding facility in Haiti.[257] While documented shipments to the United States identified as *H. nobilis* are limited, many sea cucumber imports only are identified to the genus level. Indeed, in 2007, over 80 percent of sea cucumber shipments into the United States were not identified to species level.[258] Between 2004 and 2014, over 2.37 million kg of sea cucumbers identified only as "*Holothurian species*" were imported into the United States, plus an additional 82,000 individual specimens.[259] Thus it is unknown but possible that additional imports of black teatfish into the United States have occurred and continue to occur.[260]

Sea cucumbers including *H. nobilis* also are available for online sale in the United States. An online search in English revealed several companies advertising *H. nobilis* for sale, including on eBay.[261] There also are increasing reports of sea cucumber smuggling through the United States to Asia.[262]

No CITES trade data on black teatfish is currently available. The Parties voted to include *H. nobilis* under CITES Appendix II at their 18th Conference of the Parties in 2019, and the listing will require Parties to track and report imports and exports in the species. However, the Parties delayed the effectiveness of the listing until August 28, 2020.[263] Thus the first full year of trade data will not be reported until October 2022.[264]

In addition to trade for seafood markets, other markets for sea cucumbers have emerged since the late 1990s. One is for the private aquarium trade.[265] Other markets exist for biomedical and pharmaceutical research as well as nutritional supplements and traditional medicines.[266] Sea cucumbers have been used in traditional Chinese medicine since the Ming Dynasty (1368-1644 AC) and have been found to produce various chemical compounds (*e.g.*, mucopolysaccharides, chondroitin, glucosamine, saponins) used to treat anemia, combat cancer, strengthen the immune system, and alleviate arthritis pain.[267] In Malaysia, consumption of sea cucumbers is also believed to have medicinal benefits.[268] Sea cucumber byproducts also can be found in cosmetics including toothpastes, body lotions, soaps, shampoos, balms, and liniments.[269] They also are used as plant fertilizer.[270]

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257 *See* Ex. A Excel spreadsheet of all sea cucumber imports from LEMIS database, 2014).
258 *See* Ex. B (Excel spreadsheet of all sea cucumber imports from LEMIS database, 2007). Identification to species-level of imported sea cucumbers in trade has improved: as of 2014, around 10 percent of sea cucumber imports lacked species identification. *See* Ex. A (Excel spreadsheet of all sea cucumber imports from LEMIS database, 2014).
259 Ex. C (Excel spreadsheet of "*Holothuria species*" imports from LEMIS database, 2004-2014).
260 More recent U.S. import statistics are not available, because the LEMIS database to the public in 2014.
261 *See* https://www.ebay.com/itm/Wild-sea-cucumber-Lechi-Holothuria-Nobilis-1-Lb-/202638072453 (advertising "Wild sea cucumber Lechi, Holothuria Nobilis 1 Lb" for $109USD, shipped from Flushing, NY); https://pricepoper.com/products/sea-cucumber-nobilis-tincture-alcohol-free-extract-sea-cucumber-holothuria-nobilis-2-oz (offering tincture containing "Holothuria nobilis").
262 *See* Rohrlich (2019); Repard (2018).
263 CITES Appendices I, II, III.
264 CITES, *National Reports* Resolution Conf. 11.17 (Rev. CoP18); CITES (2019c).
265 Toral-Granda, Lovatelli & Vasconcellos (2008) at 2; CITES (2019a) at 10.
266 Bruckner (2006) at 41, 75; Toral-Granda, Lovatelli & Vasconcellos (2008) at 2; Purcell *et al.* (2014) at 7; CITES (2019a) at 10.
267 Purcell *et al.* (2010) at 12; Anderson *et al.* (2011) at 332-33; CITES (2019a) at 10, 12.
268 Bruckner (2006) at 65.
269 *Id.* at 41; Conand (2008) at 184; Purcell *et al.* (2010) at 13; CITES (2019a) at 12.
270 Bruckner (2006) at 75.

In sum, overfishing for international trade threatens the black teatfish with extinction. Because of their high value black teatfish have been targeted heavily in a variety of countries, leading to depletion and local extirpation.[271] Quantifying the extent of black teatfish decline across harvesting countries is challenging because of a lack of baseline and historical harvest data.[272] However, for most countries where data exist, black teatfish fishing expanded rapidly and depleted the species. The countries harvesting black teatfish include (but are not limited to) those falling in FAO zone 51, *see* Fig. J.[273] Country- or jurisdiction-specific summaries of sea cucumber fishing histories and regulatory schemes, to the extent they are available from the scientific literature, are presented below:

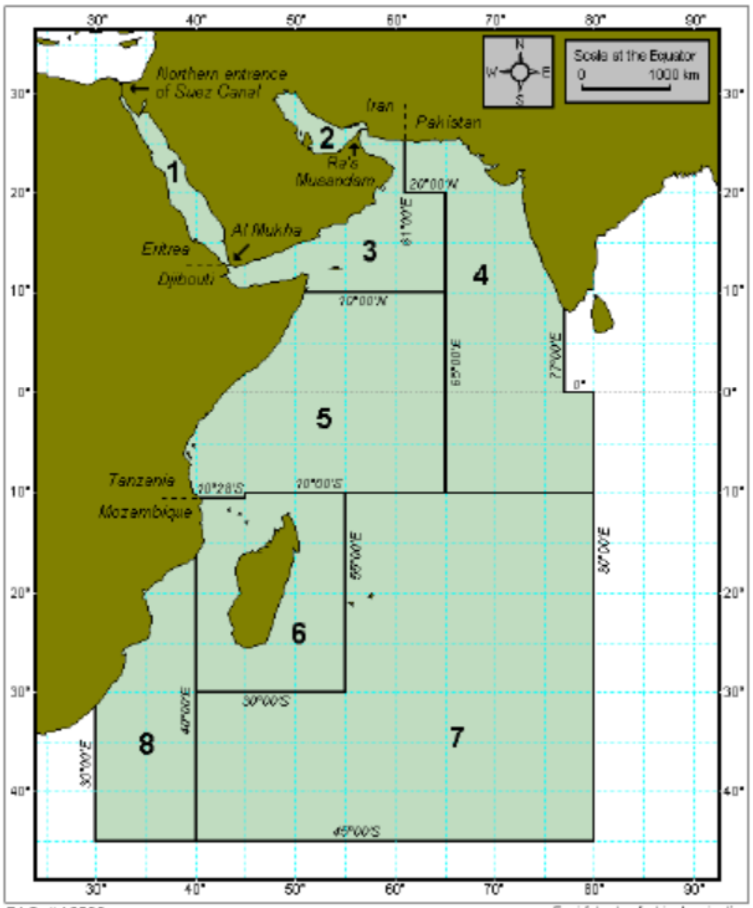

Fig. J. FAO Fishing Zone 51, Western Indian Ocean. (FAO.)

Chagos Archipelago/Marine Protected Area: Despite this area's protection, populations of *H. nobilis* have decreased in since ~2010 due to illegal fishing.[274]

Egypt: Overharvest led to dramatic declines and local extirpations of black teatfish off the coast of Egypt in an extremely short period of time. The Red Sea sea cucumber fishery in Egypt began on a small scale

[271] FAO (2019) at 64.
[272] *Id*.
[273] *See also* Conand (2017) at S4, Table 2; Conand (2018) at 593.
[274] Conand (2008) at 164; Conand *et al.* (2013) at 4.

in 1998, with fishermen primarily using benthic trawling[275] in the south and Gulf of Suez and SCUBA in the central Red Sea and Gulf of Aqaba.[276] Some hand collection also occurred.[277] The fishery preferentially targeted high-value species including *H. nobilis*.[278] Fishery catch increased dramatically between 1998 and 2000, with a concomitant increase in fishing geography to encompass the entire Egyptian coast of the Red Sea.[279]

This increase in fishing effort led to rapid depletion of stocks including *H. nobilis* and a fishery ban by the Red Sea Governorate in 2000.[280] The neighboring Suez Governorate failed to institute a parallel ban, however, leading to further stock depletion as well as the development of an illegal fishery in area of the Red Sea Governorate's jurisdiction.[281]

Between 1998 and 2001, total landed catch per trip fell from three million animals to 400,000, despite an increase in fishing vessel operation.[282] Further evidencing local depletion of desired stocks, the number of fished species went from two to 14 between 1998 and 2002.[283] *H. nobilis* has been lost almost completely.[284] A license-based fishery was reopened in Red Sea Governorate in 2002, but ongoing resource depletion led to a new ban in 2003.[285] Illegal fishing continues.[286]

Ahmed & Lawrence (2007) conducted surveys to consider whether recovery was evident subsequent to the 2003 fishery ban. They found evidence of a very limited recovery, with *H. nobilis* returning to one site (Small Magawish in the islands off the Hurghada coast).[287] However, *H. nobilis* has been almost completely lost off the Egyptian coast due to overfishing.[288]

Eritrea: Fishing has led to a reduction in *H. nobilis* in easily accessible waters off the Eritrean coast.

Sea cucumber harvesting in Eritrea has occurred for less than 50 years.[289] Intensive exploitation and a move to deeper waters began in 2000, with a dramatic increase in catch and export rates.[290] In 2007, the fishery temporarily was closed to prevent illegal fishing and export.[291]

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[275] Trawling not only leads to the reduction of sea cucumbers directly via harvest, but also indirectly through habitat degradation and destruction (*e.g.,* reduced habitat complexity, changed sediment structure, reduced species diversity). (Lawrence *et al.* (2004) at 87.) Such detrimental effects tend to be greatest in sensitive, stable, and complex areas like coral reefs and seagrass beds. (*Id*.)
[276] *Id.* at 80, 82; Bruckner (2006) at 95, 205-06; Ahmed & Lawrence (2007) at 14.
[277] Lawrence *et al.* (2004) at 82; Bruckner (2006) at 95, 205-06.
[278] Lawrence *et al.* (2004) at 84.
[279] *Id.* at 82, 86; Bruckner (2006) at 95, 205-06; Ahmed & Lawrence (2007) at 14.
[280] Lawrence *et al.* (2004) at 82, 86, 87; Bruckner (2006) at 95, 205-06; Ahmed & Lawrence (2007) at 14; Ahmed (2015) at 81, 82; FAO (2019) at 70.
[281] Lawrence *et al.* (2004) at 82-83; Bruckner (2006) at 95, 205-06; Ahmed & Lawrence (2007) at 14.
[282] Lawrence *et al.* (2004) at 83.
[283] *Id.*; Bruckner (2006) at 95, 205-06.
[284] Bruckner (2006) at 95, 205-06; Ahmed (2015) at 84, 85; Ahmed & Lawrence (2007) at 15-17.
[285] Lawrence *et al.* (2004) at 83; Bruckner (2006) at 95, 205-06; Ahmed & Lawrence (2007) at 14.
[286] Ahmed (2015) at 81, 82, 85.
[287] Ahmed & Lawrence (2007) at 15-17.
[288] Conand *et al.* (2013) at 4; Ahmed (2015) at 84, 85; FAO (2019) at 70-71.
[289] Kalaeb *et al.* (2008) at 8.
[290] *Id*.
[291] *Id*. at 8-9.

Scientists since have conducted baseline surveys to assess sea cucumber stock status in Eritrea's waters.[292] They recorded 16 sea cucumber species including *H. nobilis*.[293] Average abundance of sea cucumber species was markedly higher in unfished versus fished areas.[294] Commercial species including *H. nobilis* were found in areas characterized by greater depth, remoteness, and exposure to strong winds and rough seas (all of which make fishing more difficult).[295]

No legislation specific to the sea cucumber fishery is currently in effect in Eritrea, though a seasonal closure (October-February) applies to all fisheries.[296] A cooperative agreement between the National Fisheries Corporation and fishermen engaged in the sea cucumber fishery imposes a total allowable catch of 500 tons and minimum size limit of 5 cm wet length.[297] Illegal fishing continues.[298]

Geyser Bank: Black teatfish have declined in the waters off of Geyser Bank, a coral atoll in the Western Indian Ocean.[299]

Located west of Madagascar and between Mayotte and the Glorioso Islands, Geyser Bank is part of the Glorioso Islands marine nature park and has been protected since 2012.[300] While fishing is prohibited in territorial waters and regulated in the exclusive economic zone, these regulations remain difficult to enforce due to the atoll's remoteness.[301]

Surveys for sea cucumbers off Geyser Bank found few individuals, suggesting that they have been fished.[302] *H. nobilis* was observed in surveys conducted off Geyser Bank in 2006 and 2007 but not in 2015 or 2016.[303] Overall abundances of commercially important sea cucumber species on Geyser Bank were low compared to nearby sites including Mayotte and the Gloriosos.[304]

Illegal harvest of sea cucumbers by fishermen from neighboring countries is believed to occur regularly off Geyser Bank.[305] The remoteness and isolation of the atoll makes control efforts rare.[306] Estimation of illegal harvest remains difficult and scientists stress that poaching must be halted to conserve sea cucumber species in this area.[307]

Iles Eparses: While *H. nobilis* can be found off the Iles Eparses (French Scattered Islands), illegal fishing threatens the species' continued existence in this area.

The Iles Eparses are located in the Southwest Indian Ocean off the coast of Madagascar. These islands are governed as a strict Nature Reserve and encompass 207 km^2 of coral reefs (163 km^2 of reef flats and

[292] *Id*. at 9.
[293] *Id*. at 10.
[294] *Id*.
[295] *Id*. at 11-12.
[296] *Id*. at 12.
[297] *Id*.
[298] *Id*.
[299] Mulochau (2018) at 15.
[300] *Id*.
[301] *Id*.
[302] Conand (2008) at 161.
[303] Mulochau (2018) at 17-18.
[304] *Id*. at 18.
[305] *Id*. at 19.
[306] *Id*.
[307] *Id*. at 15, 19.

lagoons and 43 km^2 of barrier reef).[308] Despite their protection, illegal fisheries target sea cucumbers off these islands.[309] For example, in 2013 and 2014, French authorities seized foreign vessels in the Iles Eparses exclusive economic zone that contained diving gear and one ton of sea cucumbers.[310]

Scientists conducted studies in the waters off the Iles Eparses from 2011-2013 to asses echinoderm abundance and diversity.[311] While *H. nobilis* was not found off of Europa, it was found at approximately 1/3 of reef flat sites off Juan de Nova, and approximately 2/3 of reef flat and 1/3 of outer reef slopes off of Glorieuses.[312] Moluchau *et al.* (2014) also reported that *H. nobilis* frequently was sampled on the reef flats and lagoonal reef patch off Juan de Nova, occurring at just over a third of these sampled sites.[313] These studies suggest that protected areas can provide a safe haven for commercially targeted species, assuming this protection is adequately enforced.[314]

India: *H. nobilis* has been depleted in Indian waters.[315] While harvest of all sea cucumber species was prohibited in India in the early 2000s (when they were added to Schedule I of the Wildlife Protection Act), illegal fishing continues and other fisheries contribute to sea cucumber depletion through habitat destruction and bycatch.[316]

In coral reefs of the Lakshadweep Archipelago, *H. nobilis* has been found on the outer reef slope and in rocky areas (specifically on Agatti, Kavaratti, and Kalpeni atolls).[317] Sea cucumber diversity and species richness on the eastern side of the atolls and outer reef slopes are comparatively higher due to less human disturbance.[318] While there is no commercial fishing of sea cucumbers in Lakshadweep waters, poaching has been reported and presents a significant concern for sea cucumber conservation in the region.[319]

Kenya: Stocks of sea cucumbers including *H. nobilis* off the Kenyan coastline have been heavily fished and, consequently, depleted.[320]

The sea cucumber fishery in Kenya has existed since the early 1900s. It is primarily artisanal with harvest done by hand, snorkel, SCUBA, or spear.[321] Currently, most harvesting is done in a few villages in the Lamu (northern Kenya) and Kwale (southern Kenya) districts.[322] Overall documentation on Kenyan sea cucumber fishing and trade is poor.[323] However, reduced production, reduced size of valuable species,

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[308] *Id*. at 23.
[309] Conand *et al.* (2016a) at 53.
[310] *Id*. at 58.
[311] *See generally* Mulochau *et al.* (2014), Conand *et al.* (2016a).
[312] Conand *et al.* (2016a) at 55.
[313] Moluchau *et al.* (2014) at 26, 27.
[314] *Id*. at 28; *see also* Conand & Muthinga (2013) at 20 (noting that protected reefs generally have higher densities of sea cucumbers than fished reefs).
[315] Conand *et al.* (2013) at 4.
[316] Bruckner (2006) at 95; Conand (2008) at 163.
[317] Idreesbabu & Sureshkumar (2017) at 569, 571, 572, 574.
[318] *Id*. at 573.
[319] *Id*. at 574.
[320] Samyn (2000) at 12.
[321] Muthinga, Ochiewo & Kawaka (2007) at 8; Conand (2008) at 159.
[322] Muthinga, Ochiewo & Kawaka (2007) at 8.
[323] *Id*. at 8, 15-16.

reduced catch per unit effort, and a turn toward catch of less valuable species all indicate that the Kenyan sea cucumber fishery "is overexploited and on the verge of becoming unviable."[324]

Collection and export of the ~17 harvested species (including *H. nobilis*) increased from the late 1980s to 1992 followed by a steep decline (≥ 50% since 1994).[325] By 2007, *H. nobilis* comprised only 10% of the reported catch.[326] Scientific surveys conducted between 2005-2007 did not record any incidences of *H. nobilis* on reef sites along the Kenyan coastline.[327]

The sea cucumber fishery in Kenya has evolved without much management despite the fact that concerns about overfishing arose as far back as 1918.[328] While licenses technically are required for sea cucumber collection and trade, most fishermen do not hold them.[329] The level and type of management intervention undertaken by the Fisheries Department is undocumented.[330] Outside of marine parks, no effective regulations exist for sea cucumber harvest.[331] Even within marine parks, enforcement of regulations (*e.g.,* a SCUBA ban) has been challenging.[332]

Multiple factors contribute to sea cucumber overexploitation in Kenya. First, sea cucumber fisheries continue to be, in effect, an open access resource which has led to a "tragedy of the commons"[333] scenario.[334] Insufficient knowledge of regional sea cucumber biology and ecology also has precluded the development of effective management plans.[335] The Fisheries Department lacks sufficient financial and human resources to adequately monitor and enforce its functions.[336] Increasing international demand and prices for sea cucumber products, coupled with local poverty and ease of sea cucumber collection and processing, foster continued resource exploitation.[337] A lack of knowledge among fishermen about fishery regulations compounds management challenges.[338]

Madagascar: Sea cucumber fisheries in Madagascar have depleted local *H. nobilis* populations.

Export fishing for sea cucumbers in Madagascar began in 1921 and began to increase dramatically in the late 1980s or early 1990s.[339] Exports peaked between 1991 and 1994 and declined through 2004 (with the exception of an uptick in 2002).[340] Annual exports have declined overall by > 85% from the historical peak due to systemic depletion, and catch is now mostly small, low-value species.[341] Sea cucumber

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[324] *Id*. at 18.
[325] Samyn (2000) at 96; Bruckner (2006) at 96; Muthinga, Ochiewo & Kawaka (2007) at 8, 10, 12, 16-17; Conand (2008) at 159; Conand *et al.* (2013) at 4; FAO (2019) at 73.
[326] Conand *et al.* (2013) at 4.
[327] Conand & Muthinga (2013) at 14-15.
[328] Muthinga, Ochiewo & Kawaka (2007) at 8, 15.
[329] *Id*. at 15; Conand & Muthinga (2013) at 43.
[330] Muthinga, Ochiewo & Kawaka (2007) at 17.
[331] Samyn (2000) at 13; Muthinga, Ochiewo & Kawaka (2007) at 15.
[332] Muthinga, Ochiewo & Kawaka (2007) at 17-18; Conand & Muthinga (2013) at 43.
[333] *See generally* Hardin (1968).
[334] Muthinga, Ochiewo & Kawaka (2007) at 18.
[335] *Id*.
[336] *Id*.
[337] *Id*.
[338] *Id*.
[339] Rasolofonirina, Mara & Jangoux (2004) at 135, 147; Bruckner (2006) at 96; Rasolofonirina (2007) at 30; Conand (2008) at 159.
[340] Rasolofonirina (2007) at 37; FAO (2019) at 73.
[341] Purcell *et al.* (2011) at 39.

fisheries in the country are considered depleted, with declines of medium- and high-value species upwards of 90% from virgin abundance.[342]

Heavy harvest occurs in the southwest portion (Toliara region) and along the west coast of the island.[343] Over 30 species are harvested, including species of high commercial value like *H. nobilis*.[344] Stocks of high-value species including *H. nobilis* are believed to be depleted since very few individuals have been seen in recent years, especially in heavily fished areas.[345] For example, a recent scientific survey at sites adjacent to Ankilibe village (which has an active sea cucumber fishery) did not find any individuals of the species *H. nobilis*.[346] Other evidence of overexploitation in the sea cucumber fishery more broadly include declining product quality, decreasing size and collection of juveniles, an increase in the use of illegal harvesting methods, increasing competition between fishermen, and a move to fish in deeper waters and outside Malagasy waters (*e.g.*, Seychelles).[347]

Historically, collection of sea cucumbers was done by family groups using hand-harvest and traditional gear.[348] As international demand for bêche-de-mer increased, the fishery shifted to an artisanal or semi-industrial enterprise using motorized boats and special equipment.[349] While some fishermen continue to collect sea cucumbers on the reef flat during low tide, they also engage in destructive fishing methods including intentional breaking of coral to find sea cucumbers.[350]

Management of the sea cucumber fishery is shared between government resource managers and the Madagascar National Trepang traders group.[351] While regulations (*e.g.,* licensing requirement) do exist, they do not cover all exploited species and are not applied effectively.[352] For example, fishing with SCUBA is illegal, but this restriction has proven difficult to enforce and use of the method continues to increase.[353] Regulation is challenging given the high value of the sea cucumber fishery, which brought in the equivalent of US$3.1 million in 2002—representing about 2% of the total export value of marine resources for the country.[354] Overall catch statistics are poor, as exporters frequently underreport to avoid paying taxes.[355]

Maldives: Maldives' short-lived sea cucumber fishery followed the typical boom-and-bust pattern.[356] *H. nobilis* and two other species were targeted for a fishery that began around 1986.[357] Exports increased

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[342] *Id*.
[343] Rasolofonirina, Mara & Jangoux (2004) at 134; McVean *et al.* (2005) at 15; Rasolofonirina (2007) at 30; Conand (2008) at 159.
[344] Rasolofonirina, Mara & Jangoux (2004) at 136-37; Rasolofonirina (2007) at 30, 32, 33, 34; Conand (2008) at 160.
[345] Conand (2008) at 160; Conand *et al.* (2013) at 4.
[346] Conand & Muthinga (2013) at 15-16.
[347] Rasolofonirina, Mara & Jangoux (2004) at 134, 135, 145; McVean *et al.* (2005) at 18; Rasolofonirina (2007) at 30-31, 36.
[348] Rasolofonirina (2007) at 35.
[349] McVean *et al.* (2005) at 18; Rasolofonirina (2007) at 35.
[350] Rasolofonirina, Mara & Jangoux (2004) at 145; Rasolofonirina (2007) at 30.
[351] Bruckner (2006) at 96.
[352] Rasolofonirina, Mara & Jangoux (2004) at 145; Conand (2008) at 172; Conand & Muthinga (2013) at 43.
[353] Rasolofonirina, Mara & Jangoux (2004) at 145; Bruckner (2006) at 96; Rasolofonirina (2007) at 36; Conand & Muthinga (2013) at 43.
[354] Rasolofonirina, Mara & Jangoux (2004) at 148; Rasolofonirina (2007) at 37.
[355] Rasolofonirina (2007) at 36.
[356] Conand (2008) at 163.
[357] Bruckner (2006) at 96; FAO (2019) at 70.

from 3 mt in 1986 to 740 mt in 1990. Because of overfishing, a ban on SCUBA fishing was implemented in 1996.[358] Sea cucumber surveys conducted over the years from 1991 through 2015 evidenced the depletion of *H. nobilis* in Maldivian waters.[359]

Mauritius: Sea cucumbers including *H. nobilis* have been under fishing pressure in Mauritius since the fishery began in the mid-2000s.[360] Surveys conducted by the Ministry of Fisheries in 2010 evidenced a decrease in sea cucumber abundance, size, and diversity compared to data collected in 2007-08.[361] To reduce pressure, the Ministry of Fisheries instituted a two-year moratorium on sea cucumber collection in 2010, later extending the moratorium through 2016 to prevent fishery collapse.[362] Following stock assessment surveys, the moratorium was extended for another five years.[363]

Stock surveys in 2009 (at Balaclava Marine Park) and 2012 (Blue Bay Marine Park) attempted to assess sea cucumber biodiversity to inform management measures.[364] Lagoon terraces in Blue Bay Marine Park were found to host several species including *H. nobilis*.[365] However, additional surveys conducted in 2011 and 2013 in the shallow lagoons of Mauritius found *H. nobilis* to be among the least abundant of 19 species found (three individuals found in 2011 and one individual found in 2013).[366] Overall sea cucumber densities and absolute abundance of commercially valued species were higher in more remote areas.[367]

Mayotte: Scientific surveys suggest that Mayotte's black teatfish populations have declined over time.

Mayotte is the oldest of the four main island groups comprising the Comoros Archipelago.[368] Lying at the northern end of the Mozambique Channel between East Africa and Madagascar, Mayotte includes two main islands (Petite Terre and Grande Terre) and 30 smaller islands spread across a lagoon.[369] Mayotte's coral reefs have been subject to increasing human pressure and decimated by coral bleaching (90% of corals destroyed in 1998).[370]

Historical records suggest that fishermen were employed by Chinese communities to harvest sea cucumbers from Mayotte as early as 1916.[371] It was not until the mid-1990s or early 2000s, however, that Mayotte experienced a period of unregulated harvest.[372] *H. nobilis* represented the species caught

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[358] Bruckner (2006) at 96.
[359] Conand *et al.* (2013) at 4; FAO (2019) at 70.
[360] Lampe-Ramdoo, Pillay & Conand (2014) at 17; Conand *et al.* (2016b) at 15.
[361] Lampe-Ramdoo, Pillay & Conand (2014) at 17.
[362] *Id*.; Conand *et al.* (2016b) at 15.
[363] Conand *et al.* (in prep.) (20xx).
[364] Conand *et al.* (2016b) at 16.
[365] *Id*. Scientists have stated that it is vital to protect sea cucumber species in marine parks from illegal harvest to ensure their long-term conservation. Conand *et al.* (2016b) at 18.
[366] Lampe (2013) at 26; Lampe-Ramdoo, Pillay & Conand (2014) at 18-19.
[367] Lampe (2013) at 27.
[368] Conand, Quod & Rolland (2005) at 19.
[369] *Id*. at 19, 22.
[370] *Id*. at 19.
[371] Eriksson, Byrne & de la Torre-Castro (2012) at 160.
[372] Pouget (2005) at 22; Pouget (2008) at 35; Eriksson, Byrne & de la Torre-Castro (2012) at 160; Mulochau (2018) at 21.

most frequently during the height of the fishery.[373] Commercial species still remained common on the main islands' fringing reefs in 2003, and the fishery was closed in 2004.[374]

Scientists have conducted several studies to assess the abundance and diversity of sea cucumber species in Mayotte. Studies on Grande Terre's fringing reef conducted in 2003 revealed nine species including *H. nobilis*, which represented 4% of the total abundance of holothurians observed.[375] The mean density for *H. nobilis* in fringing reef flat and barrier reef areas surveyed in 2012 was 10-20 individuals/hectare (density was highest in the outer barrier reefs); this is believed to approach the "natural" density of this species.[376] In 2016, a total of 15 commercially important sea cucumber species including *H. nobilis* were observed across eight monitoring stations, though at low relative abundance (1.94%).[377] It appears that populations of *H. nobilis* declined between these two studies.[378]

Though fishing for *H. nobilis* is banned in Mayotte, the effectiveness of this ban has not yet been determined and scientists have expressed "concern with regards to the present, rather blind, overexploitation of sea cucumbers in the Comoros."[379] Illegal fishing appears to have developed in 2016 in certain reef areas and is difficult to quantify.[380]

Mozambique: *H. nobilis* has been depleted in Mozambique's waters. The black teatfish is one of 11 preferred sea cucumber species targeted for harvest in the country.[381] Catch fluctuated between 17.7 to 110 mt from 1979 through the mid-1990s and dropped precipitously in 1997 (to 2.9 mt) due to overharvest of targeted species.[382] Closed seasons and areas, licensing requirements, and size limits have not deterred exploitation.[383]

Réunion: Although sea cucumbers have not been exploited in Réunion, the reefs are so small that depletion would occur in days or weeks.[384] *H. nobilis* has been found at Saint Gilles on Réunion Island in sandy-detrital areas with sparse live coral cover.[385] Overall, valuable species including *H. nobilis* are not abundant, suggesting that despite the lack of exploitation Réunion does not serve as a refuge for this species.[386]

Saudi Arabia: Sea cucumber species including *H. nobilis* were depleted in Saudi Arabia after a short harvest period that began in in 1999 and ended (due to a ban) in 2004.[387]

Following the ban, Hasan (2009) surveyed three areas in the Red Sea waters off Saudi Arabia and documented significant depletion of sea cucumbers at all sites.[388] Twelve species including *H. nobilis*

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[373] Pouget (2005) at 25; Pouget (2008) at 37.
[374] Eriksson, Byrne & de la Torre-Castro (2012) at 160.
[375] Pouget (2005) at 23.
[376] Eriksson, Byrne & de la Torre-Castro (2012) at 163-64, 167; FAO (2019) at 72.
[377] Mulochau (2018) at 23-25.
[378] *Id*. at 26.
[379] Conand (2008) at 161; Conand *et al.* (2013) at 5.
[380] Pouget (2008) at 35-36; Mulochau (2018) at 21, 26.
[381] Bruckner (2006) at 97.
[382] *Id*.; Conand (2008) at 161.
[383] Bruckner (2006) at 97; Conand & Muthinga (2013) at 43.
[384] Conand & Frouin (2007) at 22; Conand (2008) at 159.
[385] Bourjon & Morcel (2016) at 42.
[386] Conand & Frouin (2007) at 22; Conand (2008) at 159.
[387] Hasan (2009) at 34-35.
[388] *Id*. at 34.

were observed.[389] *H. nobilis* was recorded at Shaab Al-Jaziera in the Al-Wajh area (14 individuals), and at Bousti (7 individuals) and Tallah (18 individuals) in the Thowal area.[390] All surveyed sites exhibited low sea cucumber diversity; the density of *H. nobilis* was 0.1-0.2 individuals per 100 m^2 in the Al-Wajh area, and the species also was at a very low density in the Thowal area.[391] Total biomass of *H. nobilis* was 24.95 kg across all sites.[392] Illegal fishing appears to be a continuing problem, especially on the northern and southern portions of the coastline.[393] Hasan (2009) concluded that remaining populations are insufficient to maintain a reliable fishery or contribute to recovery in the near future.[394]

Seychelles: Despite some management, stock assessments have revealed that high-value, shallow-water species including *H. nobilis* have been overexploited or show signs of significant local depletion in the Seychelles.[395] Continued exploitation risks stock collapse.[396]

Artisanal fishermen have harvested sea cucumbers in the Seychelles since the late 1800s, generally by hand (wading and snorkel gear).[397] Historically the sea cucumber fishery was open access.[398] Harvest remained relatively stable in the early 2000s, with *H. nobilis* harvest increasing from 7,794 tons to 8,753 tons in that time frame.[399] In 2006, black teatfish represented 4.9% of the total catch.[400] Over the same time frame, catch per diver appeared to decrease. *See* Table 2. Overall harvest began declining in 2007.[401] Historical export data is unreliable because sea cucumbers often were grouped with shark fins by customs officials.[402] Even more recent export data is questionable, as amounts exported often differ from amounts imported by Hong Kong.[403]

Year	Black Teatfish
2001	7,15
2002	4,75
2003	3,22
2004	1,82
2005	1,52
2006	1,05

Table 2. Number of black teatfish collected daily by one diver in the Seychelles between 2001-2006. (Conand (2008).)

[389] *Id*. at 32.
[390] *Id*. at 32-33.
[391] *Id*. at 32-33.
[392] *Id*. at 34.
[393] *Id*.
[394] *Id*. at 35-36.
[395] Aumeeruddy (2007) at 48.
[396] *Id*.
[397] Aumeeruddy & Payet (2004) at 240, 241; Bruckner (2006) at 98; Aumeeruddy (2007) at 39; Aumeeruddy & Conand (2007) at 19; Aumeeruddy & Conand (2008) at 195, 196; Conand (2008) at 160.
[398] Aumeeruddy & Payet (2004) at 240, 241; Aumeeruddy (2007) at 47.
[399] Aumeeruddy & Conand (2008) at 199; Conand *et al.* (2013) at 4; FAO (2019) at 73.
[400] Aumeeruddy & Conand (2008) at 197.
[401] Aumeeruddy & Conand (2008) at 199; Conand *et al.* (2013) at 4; FAO (2019) at 73.
[402] Aumeeruddy & Payet (2004) at 241.
[403] *Id*. at 242.

After harvest began to increase, fishery authorities started gathering information on sea cucumber stock status and biology.[404] They focused on two of the main sea cucumber fishing grounds: the Mahé Plateau and Amirantes Plateau.[405] Surveys revealed *H. nobilis* densities of two individuals/hectare and an estimated standing biomass of 11,589 tons.[406] Higher densities persist in areas closed to fishing.[407]

As for management, licensing requirements were instituted in 1999, but stock depletion and a shift to less valuable species have been reported nonetheless.[408] Enforcement capacity is limited, and poaching[409] represents a continuing concern that stymies efforts to sustainably manage these fisheries.[410] Six species (including black teatfish) now form the primary targets for an export market which began in the late 1970s, expanded in the 1990s, and today operates at an industrial scale.[411] SCUBA divers harvest most of the sea cucumbers from Seychelles' waters since the high-value species have been depleted from the accessible shallows.[412]

South Africa: Uncontrolled exploitation of sea cucumber species is believed to be widespread.[413]

Sri Lanka: Sea cucumber exports appeared to peak in the late 1990s and decreased significantly in the early 2000s.[414] *H. nobilis* is depleted in Sri Lankan waters, with densities of < 1 individual per hectare.[415]

Sultanate of Oman: *H. nobilis* is relatively rare in the Sultanate of Oman.[416] The coastline of the Sultanate of Oman extends more than 3,500 km along three connected water bodies: the Arabian Sea, Sea of Oman, and Persian Gulf.[417] Of these, *H. nobilis* has been recorded in the coral reefs of the Arabian Sea.[418]

Sea cucumber exploitation in the Sultanate of Oman is relatively recent.[419] Yet only five years after the start of commercial exploitation, some easily-accessible areas already showed evidence of

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[404] Aumeeruddy (2007) at 39; Aumeeruddy & Conand (2008) at 197.
[405] Aumeeruddy (2007) at 39; Aumeeruddy & Conand (2008) at 198.
[406] Aumeeruddy (2007) at 40; Aumeeruddy & Conand (2008) at 198; FAO (2019) at 72; *see also* Aumeeruddy & Conand (2007).
[407] Aumeeruddy (2007) at 41-42; Aumeeruddy & Conand (2008) at 198; FAO (2019) at 72.
[408] Aumeeruddy & Payet (2004) at 240-42; Bruckner (2006) at 98; Aumeeruddy (2007) at 39, 47; Aumeeruddy & Conand (2007) at 19; Conand (2008) at 160; Conand & Muthinga (2013) at 43.
[409] For example, in 2001, a Malagasy vessel with several tons of sea cucumber on board was apprehended in Farquhar atoll. (Aumeeruddy (2007) at 48.)
[410] Aumeeruddy & Payet (2004) at 243; Aumeeruddy (2007) at 48.
[411] Aumeeruddy & Payet (2004) at 241; Bruckner (2006) at 98; Aumeeruddy (2007) at 39, 42, 48; Aumeeruddy & Conand (2007) at 19; Aumeeruddy & Conand (2008) at 195-97; Conand (2008) at 160; FAO (2019) at 72.
[412] Aumeeruddy & Payet (2004) at 242; Aumeeruddy (2007) at 39; Aumeeruddy & Conand (2007) at 19; Aumeeruddy & Conand (2008) at 195, 196; Conand (2008) at 160.
[413] Conand (2008) at 164.
[414] FAO (2019) at 73.
[415] Conand *et al.* (2013) at 4; FAO (2019) at 71.
[416] Claereboudt & Al Rashdi (2011) at 29.
[417] *Id*. at 25.
[418] *Id*. at 27.
[419] Al-Rashdi & Claereboudt (2010) at 10.

overfishing.[420] For example, sea cucumber populations in Mahout Bay showed rapid decline between 2005 and 2008.[421]

Tanzania—Mainland: The sea cucumber fishery in Tanzania expanded rapidly and without baseline biological or monitoring data.[422] Landings began increasing in the late 1980s through the mid-1990s; they subsequently have declined and highly valued species including *H. nobilis* are considered depleted or overexploited along much of the Tanzanian coastline.[423] *H. nobilis* now comprises only a miniscule portion of total catch.[424] Other evidence of depletion and overexploitation includes the harvest of juveniles, a reduction in the size of individuals harvested, and few species persisting in shallow waters.[425]

The sea cucumber fishery in Tanzania is open-access and largely unregulated due to lack of monitoring and enforcement capacity.[426] The fishery, which primarily is artisanal with some small commercial operations, targets 22 species of which *H. nobilis* historically was one of the most important.[427] Sea cucumbers are harvested by hand, free diving, SCUBA, and as trawling bycatch.[428] Fishing occurs on sheltered nearshore reefs year-round, with peaks in March-May and September-December when winds are light.[429]

Sea cucumber harvest is almost entirely for export.[430] Traders must have licenses and exports are taxed.[431] To evade these duties, bêche-de-mer sometimes has been exported as fish offal or fish maw.[432] While exports have declined alongside the resource base, IUU fishing poses an ongoing problem in terms of harvest and export tracking.[433]

Legislation in Tanzania does not specifically address fishing of sea cucumbers.[434] Even if political will were sufficient to develop legislation, however, the country faces challenges in terms of education and enforcement of the regulatory mandates.[435]

Tanzania—Zanzibar: Underwater surveys performed in 2009 found no *H. nobilis* in fished reef areas near Mkokotoni, Uroa, and Fumba, and low density (1.2 individuals/hectare) in the marine reserve site of Chumbe Coral Park.[436]

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[420] *Id*. at 10, 11.
[421] *Id*. at 12.
[422] Mgaya & Mmbaga (2007) at 51, 53.
[423] Jiddawi & Öhman (2002) at 519, 523, 524; Mmbaga & Mgaya (2004) at 194; Bruckner (2006) at 99; Mgaya & Mmbaga (2007) at 51; Conand (2008) at 160-61; Mmbaga (2013) at 1100, 1121.
[424] Conand *et al.* (2013) at 4.
[425] Mgaya & Mmbaga (2007) at 54; Mmbaga (2013) at 1115.
[426] Jiddawi & Öhman (2002) at 519; Mmbaga & Mgaya (2004) at 195, 201; Bruckner (2006) at 99.
[427] Jiddawi & Öhman (2002) at 519; Mmbaga & Mgaya (2004) at 194, 195; Bruckner (2006) at 99; Mgaya & Mmbaga (2007) at 51, 54; Conand (2008) at 160.
[428] Bruckner (2006) at 99; Mgaya & Mmbaga (2007) at 51.
[429] Mmbaga & Mgaya (2004) at 194; Bruckner (2006) at 99; Mgaya & Mmbaga (2007) at 51.
[430] Jiddawi & Öhman (2002) at 521.
[431] Bruckner (2006) at 99; Conand & Muthinga (2013) at 43.
[432] Mmbaga & Mgaya (2004) at 194.
[433] *Id*. at 194; Mgaya & Mmbaga (2007) at 54; Conand (2008) at 161.
[434] Mgaya & Mmbaga (2007) at 53.
[435] *Id*. at 55.
[436] FAO (2019) at 72; *see also* Conand & Muthinga (2013) at 18-19 (not listing *H. nobilis* among species reported from stock assessment analysis).

3. *DISEASE OR PREDATION*

A. Disease

The extent to which disease and parasites result in sea cucumber mortality is largely unknown. While *H. nobilis* is not yet cultured commercially, recent reports from other cultured sea cucumber species list the following afflictions:

- Outbreaks of dipteran flies ("bloodworms") which compete with juvenile sea cucumbers for resources;
- Internal parasitisation of juvenile sea cucumbers by protozoans, leading to disease;
- Highly contagious bacterial infections of the body wall of juvenile and adult sea cucumbers, which can cause skin lesions and body wall breakdown;
- Competition for food by copepods.[437]

Overall, disease presents a possible but unquantified threat to *H. nobilis*.

B. Predation

The impact of predation on *H. nobilis* also remains unknown. Many sea cucumbers produce chemical defenses (*e.g.,* saponins, terpenes), which reduce predation to some degree.[438] However, predators of at least seven phyla have overcome these defenses and prey on holothuroids (perhaps especially juveniles).[439] These include ~30 species of fish, 19 species of sea star, 17 species of crustacean, and several gastropods.[440] Birds, sea turtles, and marine mammals may prey on sea cucumbers on occasion as well.[441] The literature demonstrates the importance of sea cucumbers in food webs, as they provide energy transfer to a high number of benthic and benthopelagic species.[442]

Overall, the threat presented to *H. nobilis* by predation remains unknown.

4. *INADEQUACY OF EXISTING REGULATORY MECHANISMS*

Existing regulatory mechanisms do not adequately protect black teatfish from existential threats including trade, fisheries, and climate change.

A. Inadequate Regulatory Mechanisms Addressing Trade Threaten the Black Teatfish with Extinction

Regulatory mechanisms addressing trade remain inadequate to protect the black teatfish from extinction. As described above, the CITES Parties included *H. nobilis* on CITES Appendix II in 2019 but delayed the effectiveness of the listing until August 2020. While inclusion of black teatfish under CITES

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[437] Purcell, Hair & Mills (2012) at 72.
[438] Conand (2009) at 224; Purcell *et al.* (2010) at 12; Purcell *et al.* (2016) at 377; Webster & Hart (2018) at 7.
[439] Purcell *et al.* (2011) at 38; Purcell *et al.* (2016) at 377-79; Conand (2018) at 591; Webster & Hart (2018) at 7; CITES (2019a) at 6, 8.
[440] Purcell *et al.* (2010) at 12; Purcell *et al.* (2016) at 368, 377-79; Conand (2018) at 591; Webster & Hart (2018) at 7; CITES (2019a) at 6.
[441] Purcell *et al.* (2010) at 12.
[442] *Id*. at 379.

Appendix II provides important protections for the species, these protections alone are not sufficient to combat the threat of overfishing and trade and ensure the survival of black teatfish.

First, commercial trade in species listed under Appendix II is still allowed; CITES only requires an export permit for international trade.[443] By listing a species as "endangered" or issuing a 4(d) rule that bans the import and sale of *H. nobilis*, NMFS will halt the trade of black teatfish into and within the United States. Commercial trade in species that are threatened with extinction should be banned, not just regulated.

Second, for species listed under Appendix II, exporting nations must certify that black teatfish exports will not be detrimental to the species' survival and that the exported specimens were legally acquired.[444] This is an important protection; however, CITES does not require the importing country (here, the United States) to verify that certification or independently evaluate whether the trade is detrimental. Indeed, CITES does not currently require exporting nations' to even document or provide any basis for their non-detriment findings.[445] By listing black teatfish under the ESA, NMFS will either ban import and U.S. trade (which is needed) or, with a 4(d) rule, must independently ensure that import and trade indeed is not detrimental. CITES protections are helpful but not sufficient to protect the black teatfish.

B. Inadequate Regulatory Mechanisms Addressing Fishing Threaten the Black Teatfish with Extinction

Regulatory mechanisms addressing fishing likewise are inadequate to protect the black teatfish from extinction. Extant regional, national, and local fishery management plans are either nonexistent or inadequate, which has allowed overexploitation of black teatfish populations.[446] *See* Part III.2, *infra* (describing several jurisdictions' approaches to sea cucumber fishery management and challenges faced). Regulation of sea cucumber fisheries is challenging because they "are largely a diffuse activity … mainly by artisanal fishers living in remote locations far removed from the presence of centralized fisheries management agencies, and in countries that often have fiscal and governance problems."[447] As a result, many commercial sea cucumber fisheries are open access—which inevitably leads to overharvest.[448] According to Bruckner (2006), open-access sea cucumber fisheries typically pass through four phases:

(1) Targeting dense, easily accessed sea cucumber populations in nearshore, shallow environments;
(2) Growing catch as fishery effort increases and the industry flourishes;
(3) Catch staying constant alongside increasing effort as the industry matures;
(4) Expansion to more remote areas and deeper waters as target species are locally depleted.[449]

When fishery management regimes do develop, they often are reactive, put in place after massive depletion of local stocks.[450]

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[443] CITES, Mar. 3, 1973, 27 U.S.T. 1087, at Art. IV.
[444] *Id.*
[445] CITES, Res. Conf. 16.7 (Rev. CoP17).
[446] Bruckner (2006) at 22, 75; Conand & Muthiga (2007) at iii; Toral-Granda, Lovatelli & Vasconcellos (2008) at iv, 2; Anderson *et al.* (2011) at 333; FAO (2019) at 62, 73-74.
[447] FAO (2019) at 64; *see also id.* at 73.
[448] CITES (2019a) at 15. *See generally* Hardin (1968).
[449] Bruckner (2006) at 81.
[450] *Id.* at 90.

Despite efforts by the IUCN and Secretariat of the Pacific, regional-scale management measures are lacking.[451] To the extent they do exist, fishery management measures for sea cucumber species, including teatfish, are national or local and vary by country and type.[452] Local, community-based tenure systems characteristic of artisanal and subsistence fisheries often were used prior to development of commercial fisheries.[453] To the extent management measures for commercial fisheries exist, they may include open and closed areas (*e.g.*, marine protected areas),[454] licensing, quotas, seasonal or rotational harvests, gear restrictions, size limits, logbook requirements, and prohibitions on harvesting particular species.[455] Many management measures for sea cucumber species have not performed well due to the artisanal nature of these fisheries; socioeconomic pressure; shortcomings in stock monitoring, catch reporting, and enforcement; the inability to communicate closures once quotas are reached; and a general lack of political will to manage these fisheries sustainably.[456] In addition, the lack of even basic biological and ecological information on harvested species hinders the development of sustainable sea cucumber harvest plans.[457]

Effective conservation measures must be instituted if sea cucumber populations are to be conserved.[458] While local-level regulatory measures must form part of the solution, many scientists have noted that international regulations that control trade are necessary to conserve sea cucumber species.[459] In response to these calls, the Parties to CITES voted to include *H. nobilis* on CITES Appendix II in 2019; the listing will be effective August 28, 2020.[460] The United States was a co-proponent on the proposal to include the species on CITES.[461] Inclusion on CITES Appendix II requires exporting nations to certify that sea cucumber exports will not be detrimental to the species' survival and that the specimen was legally acquired.[462] The listing should help curb illegal trade and harvest and promote more sustainable management of sea cucumber harvest.[463]

However, importing nations also must be part of the solution.[464] The United States imports sea cucumbers including the black teatfish. According to the U.S. Fish and Wildlife Service's LEMIS database, the U.S. imported at least 391 kg of *H. nobilis* in 2014, as well as over 2.73 million kg of sea cucumbers

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451 Toral-Granda, Lovatelli & Vasconcellos (2008) at 2; FAO (2019) at 74.
452 *See* Conand & Muthinga (2013) at 42-45.
453 Bruckner (2006) at 74, 75; CITES (2019a) at 15; FAO (2019) at 75.
454 Given their sedentary nature, marine protected areas hold promise for sea cucumber conservation. (Purcell *et al.* (2010) at 11.) For example, no-take zones in the Great Barrier Reef, Australia, have 3-4 times higher densities of *H. whitmaei* than fished reefs. (Purcell *et al.* (2011) at 51.) However, the efficacy of marine protected areas depends on whether they are properly sited, whether fishing bans are enforced, and the degree to which they suffer from external pressures including land-based pollution or coastal development. (Conand & Muthiga (2007) at 60; Anderson *et al.* (2011) at 333; CITES (2019a) at 17.)
455 Bruckner (2006) at 82; Toral-Granda, Lovatelli & Vasconcellos (2008) at 2; Anderson *et al.* (2011) at 333; CITES (2019a) at 15-16, 17-18; FAO (2019) at 74.
456 Conand & Muthiga (2007) at iii; Toral-Granda, Lovatelli & Vasconcellos (2008) at 2, 4; Purcell *et al.* (2010) at 15, 134; Conand & Muthinga (2013) at 45; FAO (2019) at 74.
457 Bruckner (2006) at 41, 82; Purcell *et al.* (2011) at 49-54; FAO (2019) at 74.
458 Toral-Granda, Lovatelli & Vasconcellos (2008) at 1.
459 Lawrence *et al.* (2004) at 88; Anderson *et al.* (2011) at 333; Purcell *et al.* (2014) at 8.
460 CITES Appendices I, II, III.
461 CITES (2019a) at 1.
462 Convention on International Trade in Endangered Species of Wild Fauna and Flora, Mar. 3, 1973, 27 U.S.T. 1087, 993 U.N.T.S. 243 (entered into force July 1, 1975), Art. IV; Anderson *et al.* (2011) at 333.
463 Bruckner (2006) at 2, 5.
464 Purcell *et al.* (2014) at 7.

identified only as "*Holothurian species*" (which may include *H. nobilis*) between 2004 and 2014.[465] Protection under the U.S. Endangered Species Act would provide important, additional benefits to black teatfish. The ESA generally bans the import, export, and sale of endangered species in interstate and foreign commerce[466] and requires NMFS to issue regulations deemed "necessary and advisable" for the conservation of threatened species.[467] The ESA also provides for "international cooperation" in the conservation of foreign species.[468] ESA listing increases awareness of listed species and their threats; stimulates research efforts to address conservation needs; and increases funding for conservation of species in their range countries, including habitat conservation. Under the ESA, NMFS and the U.S. Fish and Wildlife Service provide financial assistance for programs to conserve listed species in foreign countries, encourage conservation programs for such species, and offer other related assistance, such as personnel and training.[469]

In sum, existing regulatory mechanisms inadequately protect the black teatfish from threats including fishing and associated trade. Listing under the ESA would further conservation efforts and help prevent the black teatfish's extinction.

C. Inadequate Regulatory Mechanisms Addressing Climate Change Threaten the Black Teatfish with Extinction

Finally, national and international regulatory mechanisms do not adequately protect the black teatfish from the existential threat posed by climate change. These mechanisms are non-binding and, even if adhered to by all parties, fail to mandate greenhouse gas emission reductions sufficient to protect the black teatfish from climate change-related effects including coral reef degradation associated with ocean warming, ocean acidification, and coral disease.

NMFS repeatedly has acknowledged that regulatory mechanisms are inadequate to regulate greenhouse gas emissions at levels protective of species. For example, in its proposed listing rule for the bearded seal, NMFS stated that

> there are currently no effective mechanisms to regulate [greenhouse gas (GHG)] emissions, which are contributing to global climate change and associated modifications to bearded seal habitat. The risk posed to bearded seals due to the lack of mechanisms to regulate GHG emissions is directly correlated to the risk posed by the effects of these emissions.[470]

In a recent synthesis of the literature on point, NMFS stated that "existing regulatory mechanisms with the objective of reducing GHG emissions were inadequate to prevent … climate-related threats."[471] NMFS conducted "an in-depth analysis of international agreements to curb GHG emissions and their respective progress" and concluded that it was "unlikely that Parties would be able to collectively

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[465] *See* Ex. A (Excel spreadsheet of all sea cucumber imports from LEMIS database, 2014); Ex. C (Excel spreadsheet of "*Holothuria species*" imports from LEMIS database, 2004-2014).
[466] 16 U.S.C. § 1538(a).
[467] *Id.* § 1533(d).
[468] *Id*. § 1537.
[469] *See* USFWS, Foreign Species/Overview.
[470] 75 Fed. Reg. 77,496, 77,508 (Dec. 10, 2010); *see also* 77 Fed. Reg. 76,706, 76,712 (Dec. 28, 2012) (noting that "[c]urrent mechanisms do not effectively regulate GHG emissions, which are contributing to global climate change and associated modifications to ringed seal habitat.").
[471] 79 Fed. Reg. 53,852, 53,903 (Sept. 10, 2014).

achieve, in the near term, climate change avoidance goals outlined via international agreements."[472] In addition, "none of the major global initiatives appeared to be ambitious enough, even if all terms were met, to reduce GHG emissions to the level necessary to" avoid impacts to imperiled species.[473] To make matters worse, the United States—one of the world's biggest GHG emitters—withdrew from the most recent international climate agreement, the Paris Agreement.[474]

As detailed below, the continued failure of the U.S. government and the international community to implement effective and comprehensive greenhouse gas reduction measures places black teatfish at ever-increasing risk of extinction.

i. International Climate Change Agreements Are Insufficient to Protect the Black Teatfish from Extinction

The primary international agreement on climate action is the United Nations Framework Convention on Climate Change (UNFCCC). Adopted at the Rio Earth Summit in 1992, it has to date been ratified by 195 countries. The most recent agreement covering UNFCCC countries, the Paris Agreement, was ratified in 2016 and will take effect this year. According to the UNFCCC,

> [t]he Paris Agreement builds upon the Convention and for the first time brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects.[475]

The "central aim" of the Agreement "is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius."[476]

Scientists predict increases of 2°C or more would result in "'dangerous' [to] 'extremely dangerous' climate change."[477] Projected impacts include the disappearance of Arctic summer sea ice, irreversible melting of the Greenland ice sheet, an increased risk of extinction for 20-30% of species on Earth, and "rapid and terminal" declines of coral reefs worldwide.[478] The Paris Agreement seeks to avoid such dangerous harms by aiming to limit warming to 1.5°C. Humans already have warmed the planet 1.0°C over the pre-industrial level, and at the current rate we likely will reach 1.5°C of warming between 2030 and 2052.[479]

This warming occurs largely due to rising atmospheric CO_2 levels. Last year, the global annual atmospheric concentration of CO_2 exceeded 415 parts per million (ppm) for the first time.[480] This carbon dioxide level—a dramatic increase over the preindustrial level of 280 ppm—has not been seen for 3

[472] *Id.*
[473] *Id.*
[474] Pompeo (2019).
[475] UNFCCC (2020).
[476] *Id.*
[477] Anderson and Bows (2011).
[478] Veron *et al.* (2009); *see also* Jones *et al.* (2009); TEEB (2009); Hare *et al.* (2011); Warren *et al.* (2011); Frieler *et al.* (2012).
[479] IPCC (2018); UNFCCC (2020).
[480] Harvey (2019).

million years.[481] Atmospheric CO_2 has been rising at a rate of nearly 3 ppm per year, and this rate is accelerating.[482] But as climate scientists have warned: "[i]f humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO_2 will need to be reduced … to at most 350 ppm [equivalent to ~1.5°C], but likely less than that."[483] This 350 ppm target must be achieved within decades to prevent dangerous tipping points and "the possibility of seeding irreversible catastrophic effects."[484]

Despite its adoption of the 1.5°C threshold, the Paris Agreement does not do enough to shield the black teatfish from the harmful effects of climate change, including impacts to its one of its primary habitats: coral reefs.[485] *See* Part III.1.A, *supra*. Additionally, signatories have not yet effected the changes necessary to achieve the Agreement's goals.[486] Finally, the withdrawal of the United States—one of the world's primary contributors of atmospheric CO_2—from the Paris Agreement will hamper global efforts to rein in the devastating effects of climate change.[487]

ii. National Climate Change Law Is Insufficient to Protect the Black Teatfish

To date, federal agencies have failed to fully capitalize on existing authority under domestic law to reduce greenhouse gas emissions to levels that would be protective of species. The U.S. government repeatedly has acknowledged that its rules do not go far enough to notably reduce the nation's greenhouse gas emissions.[488] The government's refusal to utilize existing laws such as the Clean Air Act and Energy Policy and Conservation Act to force needed greenhouse gas reductions renders them inadequate mechanisms to protect the black teatfish and its habitats from the effects of climate change.

5. OTHER NATURAL OR MANMADE FACTORS AFFECTING THE BLACK TEATFISH'S CONTINUED EXISTENCE

Several other threats contribute to the black teatfish's risk of extinction, including a lack of basic biological and ecological information, risks of rarity, and bycatch.

A. Lack of Basic Biological & Ecological Information

As noted in Part I, *supra*, basic biological and ecological characteristics of black teatfish remain largely unknown.[489] According to one prominent study, "[i]t is now apparent that there is hardly any information on the ecology of the 'real' *H. nobilis*." (Uthicke, O'Hara & Byrne (2004) at 846.) The lack of

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481 *Id.*
482 Raupach *et al.* (2007); Friedlingstein *et al.* (2010); Harvey (2019); NOAA (2019a).
483 Hansen *et al.* (2008).
484 *Id.*
485 *See* UNEP (2019).
486 *See id*.
487 *See generally id.*
488 *See, e.g.,* NHTSA (2011) ("these reductions in emissions are not sufficient by themselves to reduce total [commercial medium-heavy duty on-highway vehicle and work truck] emissions below their 2005 levels by 2020"); 77 Fed. Reg. 22,392, 22,401 (April 13, 2012) (conceding that this new power plant rule on greenhouse gas emissions "will not have direct impact on U.S. emissions of greenhouse gases under expected economic conditions"
489 Mmbaga & Mgaya (2004) at 199; Bruckner (2006) at 6, 34, 36, 41; Conand (2007) at 1-5; Conand (2009) at 225; Hasan (2009) at 31; Anderson *et al.* (2011) at 319, 333; Purcell *et al.* (2011) at 37; Eriksson, Byrne & de la Torre-Castro (2012) at 159-60; CITES (2019a) at 9.

basic biological and ecological information on *H. nobilis* poses a threat because, without this information, conservation-based fishery management plans cannot be developed.[490] Further, without baseline information about pre-fishing abundances and densities as well as ongoing monitoring (both of which generally are lacking) it is challenging to gauge historical and ongoing depletion of this species.

B. Risks of Rarity

As overfishing depletes black teatfish populations, making them both smaller and more isolated, the species becomes particularly vulnerable to disturbances including stochastic perturbations (*e.g.,* variations in vital rates, environmental fluctuations, genetic drift) and environmental catastrophes.[491] In particular, overexploitation of black teatfish, which are broadcast spawners, means there often do not exist enough individuals in close enough proximity to successfully reproduce. Modeling has shown that individuals separated by only a few meters do not contribute to larval production because of gamete dilution in the water column.[492] Thus as breeding populations become depleted, natural replenishment of populations becomes less likely and this represents an "incipient threat" to the species.[493] Such populations likely suffer from an Allee effect, in some instances causing population collapse and preventing recovery.[494]

C. Bycatch

Bycatch in other fisheries also poses a threat to sea cucumber species including black teatfish.[495] Indiscriminate fishing methods including trawling and dredging can impact both sea cucumber populations and their habitat.[496] Bycatch is known to contribute to sea cucumber depletion in India and Tanzania.[497]

6. SUMMARY OF FACTORS

Overfishing to supply the luxury food market in Asia represents the greatest threat to the black teatfish. The increasing demand for bêche-de-mer, in conjunction with non-existent or inadequate regulatory mechanisms and management measures, has led to a precipitous decline in the global population of *H. nobilis*. If capture of black teatfish for international trade is not substantially curbed, the species' decline will continue and the global population will spiral towards extinction.

The threat posed by climate change to important black teatfish habitats, particularly coral reefs, also threatens this species with extinction. Likewise, continued degradation of seagrass beds by eutrophication and other threats poses an increasing threat to both juvenile and adult black teatfish. Without sufficient high-quality habitat, black teatfish will not be able to persist into the future. Existing regulatory mechanisms are inadequate to sufficiently ameliorate these threats.

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490 Bruckner (2006) at 6; Toral-Granda, Lovatelli & Vasconcellos (2008) at 3; Anderson *et al.* (2011) at 333; CITES (2019a) at 9.
491 *See* 68 Fed. Reg. 13,370 13,387 (Mar. 19, 2003) ("Semi-isolated populations are more vulnerable to the effects of demographic and environmental population fluctuations.")
492 Al-Rashdi & Claereboudt (2010) at 13, *citing* Claereboudt (1999).
493 Bruckner (2006) at 41, 43; Toral-Granda, Lovatelli & Vasconcellos (2008) at 4.
494 Al-Rashdi & Claereboudt (2010) at 13; Anderson *et al.* (2011) at 319, 332, 333.
495 Bruckner (2006) at 2.
496 *Id.* at 44.
497 *Id.* at 95, 99; Mgaya & Mmbaga (2007) at 51; Conand (2008) at 163.

Finally, the lack of basic biological and ecological information on black teatfish, in conjunction with the species' rarity and its catch in other fisheries, put this species at risk of local extirpation and broader extinction. Without knowing basic life history characteristics, it is impossible to develop science-based, sustainable harvesting plans (whether for direct catch or for bycatch). Without sustainable harvesting plans, overfishing (both directed catch and bycatch) will continue to deplete this species to the point where it does not exist at densities sufficient to support successful reproduction and, hence, species recovery. Listing under the U.S. ESA will provide the black teatfish with essential protection from key threats, namely trade, and help prevent this species' extinction.

PART IV. 4(d) RULE

Should NMFS determine after conducting a status review that listing of the black teatfish as "threatened" is warranted, the Center hereby petitions the agency to simultaneously issue a 4(d) rule outlining necessary and advisable regulations for the species' conservation.[498]

The Center urges NMFS to extend to the black teatfish all prohibitions of ESA Section 9, including the bans on taking, imports, exports, sale in interstate or foreign commerce, and transport (applying the existing limited exceptions to promote science and restoration as provided in ESA Section 10) and to promulgate additional protective regulations needed for survival and recovery of the black teatfish. Specifically, we petition NMFS to issue regulations addressing trade and greenhouse gas emissions (specifically as they affect ocean warming and acidification).

CONCLUSION

Listing under the U.S. Endangered Species Act provides a critical mechanism for effectively shielding the black teatfish from threats to the species' continued existence. The black teatfish is in danger of extinction, or likely to become so within the foreseeable future, due to overfishing/trade, climate change, and inadequate regulatory mechanisms. The species' rarity presents an additional risk to the black teatfish's continued existence because the species needs sufficient density—currently lacking in many places—to successfully reproduce. Lack of basic biological and ecological information as well as bycatch pose additional threats.

The black teatfish's precipitous decline began when the bêche-de-mer market exploded alongside rising prosperity in Asia in the late 1980s and early 1990s. Scientists estimate the black teatfish has declined by 60-70% across 80% of the species' range and its global population continues to decrease. Because the species lives in shallow water habitats and is large and slow moving, it makes an easy—and lucrative—target for capture. The black teatfish remains at high risk due to increasing demand in the international marketplace and inadequate fisheries management regimes in the countries in whose jurisdiction the species is found.

Habitat degradation and destruction also pose an increasing threat to the black teatfish. Most black teatfish live in coral reef habitats, which continue to deteriorate due to warming ocean waters, ocean acidification, and associated disease. Degradation of seagrass beds, another habitat utilized by the black teatfish and one that may be particularly important for juveniles, further threatens the species' continued existence.

[498] 16 U.S.C. § 1533(d).

Protection of the black teatfish under the U.S. Endangered Species Act is both urgent and warranted: urgent due to the threats described in this petition, particularly overfishing to supply international trade in bêche-de-mer, and warranted because black teatfish constitute a listable entity (*i.e.*, species) under the ESA. As described throughout this petition, the black teatfish faces high-magnitude and growing threats to its continued existence. NMFS must promptly make a positive 90-day finding on this petition, initiate a status review, and expeditiously proceed toward listing and protecting this sea cucumber species.

LITERATURE CITED

Cited references can be found at the following Google Drive link: https://drive.google.com/open?id=178F_8m7R0qpS8cxQNWz8Fypkla6SZXvA. A USB drive with cited sources also will be submitted for the record. Please consider these references along with the Petition and include them in the administrative record for the 90-Day Finding on the Petition.

Statutes & Treaties

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United States Endangered Species Act, 16 U.S.C. §§ 1531 *et seq.*; 1532(6), (16); 1533(a), (b)(1)(A) , (b)(3)(A), (B), (d); 16 U.S.C. § 1538(a).

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