ENDANGERED SPECIES ACT STATUS REVIEW REPORT:

Black Teatfish

(*Holothuria nobilis*)

Figure 1 Holothuria nobilis observed in Réunion by thierrycordenos https://www.inaturalist.org/observations/41710200

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National Marine Fisheries Service

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DISCLAIMER

This document does not represent a decision by the National Marine Fisheries Service (NMFS) regarding whether this species should be proposed for listing as threatened or endangered under the Endangered Species Act of 1973 (ESA).

EXECUTIVE SUMMARY

This report was produced in response to a petition received from the Center for Biological Diversity on May 14, 2020, to list the black teatfish (*Holothuria nobilis*) as an endangered or threatened species under the Endangered Species Act (ESA). On August 10, 2020, the National Marine Fisheries Service (NMFS) announced in the *Federal Register* that the petition presented substantial information indicating the petitioned action may be warranted and that a status review for the species should be conducted (85 FR 48144). This report is the status review for the black teatfish (*Holothuria nobilis*) and summarizes the best available data and information on the species. The report also presents an evaluation of the status and extinction risk of the black teatfish.

The black teatfish, *H. nobilis*, is found in tropical coral reef flats and outer reef slopes at depth of 0 to 40 meters. Its distribution ranges throughout the Indian Ocean; including along the east coast of Africa, the Red and Arabian Seas, as well as the coastal waters of Madagascar and the West coast of India. Actual abundance of *H. nobilis* is largely unknown across most of its geographical range, with no available historical baseline population data.

Of the 25 countries where *H. nobilis* is known to occur, potentially all of them have had or currently have sea cucumber fisheries. Overall, efforts to address overutilization of sea cucumbers through regulatory measures appear inadequate, with evidence of illegal and unregulated fishing of sea cucumbers in countries with fishing moratoriums including Comoros, Egypt, India, Mauritius, Mayotte, Saudi Arabia, Tanzania, and Yemen.

The most significant threat to *H. nobilis* is overutilization through commercial harvest to meet the demand for trade in “bêche-de-mer”. *H. nobilis* is one of the most highly valued sea cucumber species and consequently may be one of the most exploited sea cucumber species in the Indo-Pacific region. However, understanding exploitation levels is difficult because few countries record catches or exports by species, making it difficult to determine the level of utilization of a single species. Additionally there is a lack of data on the current abundance of *H. nobilis* and its habitat needs, recruitment success, and population connectivity. We recognize that a number of sea cucumbers are overfished, but the available data do not support a conclusion that *H. nobilis* is at risk of extinction currently or in the foreseeable future.

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INTRODUCTION

Scope and Intent

This document is the status review in response to a petition[1] to list the black teatfish (*Holothuria nobilis*) as a threatened or endangered species under the Endangered Species Act (ESA). Under the ESA, if a petition is found to present substantial scientific or commercial information that the petitioned action may be warranted, a status review shall be promptly commenced (16 U.S.C. 1533(b)(3)(A)). The National Marine Fisheries Service (NMFS) determined that the petition presented substantial information in support of the petitioned action, such that a status review for the species should be conducted (85 FR 48144, August 10, 2020).

This document is the scientific review of the biology, population status, and future outlook for the Indian Ocean species of black teatfish (*Holothuria nobilis*). It provides a summary of the available data and information on the species.

In 2019, the United States, along with the European Union, Kenya, Senegal, and the Seychelles submitted a proposal for consideration at the 18th meeting of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Conference of the Parties (CoP) to include three species of sea cucumber belonging to the subgenus *Holothuria (Microthele): Holothuria (Microthele) fuscogilva, Holothuria (Microthele) nobilis and Holothuria (Microthele) whitmaei* in Appendix II of CITES. This proposal was comprehensive in its portrayal of the species' biology and ecology as well as its discussion of potential threats to the species. We, therefore, cite extensively to this proposal throughout this status review (through directly quoted excerpts from the proposal, identified as "*Excerpt from CITES (2019)*") and provide updates based on new or missing information we have found since submission of this proposal to the CITES Conference of the Parties. Based on this information, we present an evaluation of the *H. nobilis's* status and extinction risk. This draft status review is based on public and peer-reviewer comments, data, and information reviewed through October 2021.

[1] Center for Biological Diversity to U.S. Secretary of Commerce, acting through the National Oceanic and Atmospheric Administration and the National Marine Fisheries Service, May 14, 2020, "A petition to list black teatfish (*Holothuria nobilis*) as endangered or threatened species under the Endangered Species Act."

LIFE HISTORY AND ECOLOGY

Taxonomy and Distinctive Characteristics

Morphological characteristics were historically used to distinguish between teatfish species, although morphological features alone were determined to be unreliable markers of identification due to high intraspecific variability (Uthicke et al. 2004). The more recent use of molecular analyses resolved the taxonomic confusion between teatfish species in the Indian and Pacific Oceans. From this analysis, three species were distinguished:

1) *Holothuria whitmaei*: black/dark brown specimens found in waters of Australia and the southwest Pacific;
2) *H. fuscogilva*: white/beige specimens with dark markings broadly distributed throughout the tropical Indo-Pacific; and
3) *H. nobilis*: black specimens with white ventro-lateral patches found in the western Indian Ocean (Uthicke et al. 2004).

H. fuscogilva was considered the same species as *H. nobilis* until 1980 (Cherbonnier 1980). *H. whitmaei*, occurring in the Pacific Ocean, was separated from *Holothuria (Microthele) nobilis*, which occurs in the Indian Ocean, in 2004 (Uthicke et al. 2004). The two black teatfish (*H. whitmaei*, with distribution in the Pacific Ocean, and *H. nobilis*, with distribution in the Indian Ocean)[2] appear to be allopatric with a genetic distance of 9.2 percent, implying a divergence during the Pliocene of approximately 1.8-4.6 million years before present (Uthicke et al. 2004). Further molecular analyses support the distinction between *H. nobilis* and *H. fuscogilva*, once considered synonyms, as different species (Ahmed et al. 2016).

The currently accepted taxonomy of black teatfish (*H. nobilis*) is as follows:

Kingdom: Animalia
Phylum: Echinodermata
Class: Holothuroidea
Order: Holothuriida
Family: Holothuriidae
Genus: *Holothuria*
Species: *nobilis*

Life history information can be difficult to assess in sea cucumbers because they have few hard body parts, making it difficult to measure, weigh accurately and tag. Additionally they

[2] In the remainder of this document when the common name “black teatfish” is used we are referring to *H. nobilis*.

can undergo shrinkage and regrowth in body weight as adults (FAO 2019). The following information is what is available for *H. nobilis*.

Excerpt from CITES (2019):

> Teatfish are characterized by a suboval body arched dorsaly (bivium) and a flattened ventrally (trivium), a thick and rigid tegument, a large number of ventral podia arranged tightly and without order, small dorsal papillae, and anal teeth (Purcell *et al.* 2012). The mouth, surrounded by tentacles, is ventral (Purcell *et al.* 2012).
>
> The main characteristic that distinguishes teatfish from other sea cucumber species is the presence of lateral protuberances ("teat-like") on the tegument, visible in their live and processed forms (Purcell *et al.* 2012; Conand pers. comm. 2017).
>
> Teatfish are large size species, which can range from 30 to 70 cm depending on the species. Their color also varies according to species.

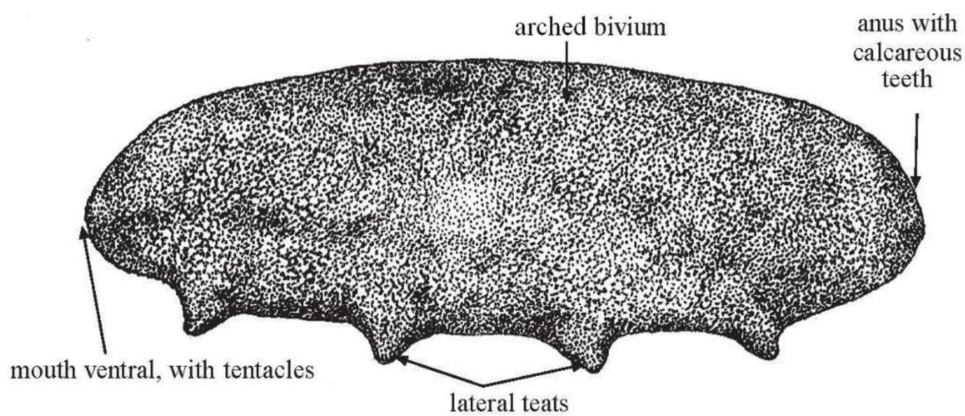


Figure 2 *Teatfish schema modified from Carpenter & Niem (1998) (From CITES 2019).*

Excerpt from CITES (2019):

> *Holothuria (Microthele) nobilis*
>
> Size: Maximum length about 60 cm; average length about 35 cm. Average fresh weight: 230 g (Mauritius), 800–3 000 g (Réunion), 1 500 g (Egypt); average fresh length: 14 cm (Mauritius), 35 cm (Réunion), 55 cm (Egypt).
>
> Morphology: Presence of 6 to 10 characteristic large lateral protrusions ('teats') at the ventral margins. Dorsal podia are sparse and small, while the ventral podia are numerous, short and greyish. The tegument is usually covered by fine sand. The

mouth is ventral, with 20 stout tentacles. Anus surrounded by five small calcareous teeth. Cuvierian tubules absent.

Color: This species is black dorsally with white blotches and spots on the sides of the animal and around the lateral protrusions ('teats'). Juveniles probably differ in color from adults.

LIVE (photo by: R. Aumeeruddy)

PROCESSED (photo by: S.W. Purcell)

Figure 3 Example of a live and processed black teatfish (*H. nobilis*; From FOA 2012).

Juveniles show similarities to other species: *H. fuscogilva* and *H. whitmaei* (Conand 1981) which makes it difficult to identify juveniles in the field. However, Sweet et al. (2016) are believed to have spotted two juveniles within the patch reef off Vavvaru on Lhaviyani Atoll in Maldives in August 2015 (see **Figure 4** below).

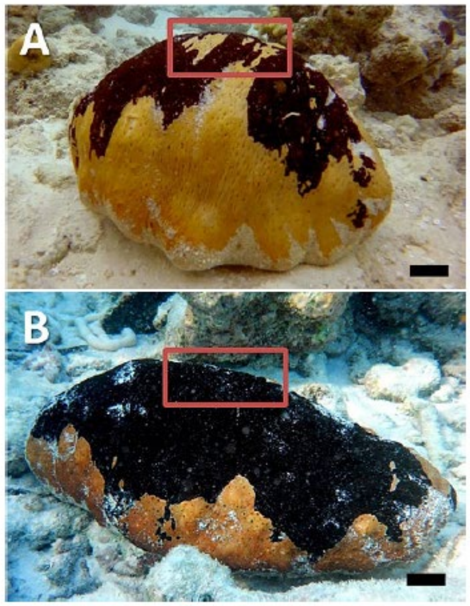


Figure 4 *Possibly two juvenile H. nobilis off Vavvaru on Lhaviyani Atoll in Maldives, August 2015 (Sweet, et al. 2016).*

Range, Distribution, and Habitat Use

H. nobilis occurs in tropical coral reef flats and outer reef slopes at depths between 0 and 40 meters, with a preference for hard substrates (Lawrence et al. 2004; Idreesbabu and Sureshkumar 2017; Eriksson et al. 2012; Conand et al. 2013; CITES 2019). While *H. nobilis* has occasionally been observed in seagrass (Purcell et al. 2012), seagrass is not considered the desired habitat of the species. Lawrence et al. (2004) state that while seagrass beds may be important to most of the main commercial species of sea cucumber, *H. nobilis* is one of the exceptions as it had only been found on coral substrate. Further, *H. nobilis* is considered to be strongly associated with a single habitat variable (i.e. hard substrate; Eriksson et al. 2012). Thus, the primary habitat for *H. nobilis* is widely considered to be coral reefs (flats/slopes; Conand 2008). *H. nobilis* is commonly seen covered by sand, though this species does not bury (Conand 2008). *H. nobilis* is distributed throughout the Indian Ocean, including along the east coast of Africa (Egypt, Sudan, Somalia, Kenya, Eritrea, Djibouti, Tanzania, Mozambique, Zanzibar, and South Africa); the Red and Arabian Seas (Israel, Jordan, Saudi Arabia, Oman, Yemen); and the coastal waters of Madagascar, Mayotte, Mauritius, La Reunion, Seychelles, Comoros, Chagos, Sri Lanka, the Maldives, and the west coast of India (See **Figure 5**)(CITES 2019; Conand et al. 2013; Uthicke et al. 2004). The species does not occur in the waters of the United States or its overseas territories.

Figure 5 Holothuria nobilis range map (Conand et al. 2013).

Feeding and Diet

H. nobilis like other sea cucumbers of the order Holothuriida are deposit and detritus feeders. They digest organic matter in the sediment such as bacteria, cyanobacteria, decaying plant matter, copepods, diatoms, foraminiferans, and fungi. Using retractile tentacles, they ingest the top few millimeters of sediment and excrete less organic rich sediment (Anderson et al. 2011; Purcell et al. 2016; Webster & Hart 2018). In this way the role of sea cucumbers is similar to that of earthworms (CITES 2002). *H. nobilis* primarily inhabit nutrient-sparse coral reef ecosystems, where their role in nutrient cycling can be substantial (Purcell et al. 2011; Purcell et al. 2016). Digestion of nitrogen-rich compounds such as proteins converts organic nitrogen to inorganic forms, which in turn can be utilized by primary producers (Purcell et al. 2011; Purcell et al. 2016).

Reproduction and Growth

Teatfish are gonochoristic (i.e. separate sex) broadcast spawners, meaning males and females release their gametes into the water column and fertilization occurs externally (Conand 1981; Conand 1986; Toral-Granda 2006). With this reproductive strategy, successful fertilization depends upon the density of male and female teatfish in a particular location (CITES 2019; FAO 2019; Purcell et al. 2010; Purcell et al. 2011). *H. nobilis* do not exhibit sexual dimorphism, and sex of individual animals must be determined through microscopic examination of the gonads. Teatfish have slow growth rates, maturing at about 3-7 years, and are thought to live for several decades (Conand et al. 2013, FAO 2019). Conand et al. (2013) reported that *H. nobilis* mature at around 4 years of age. Reproductive fitness is positively correlated with body size, with larger individuals having larger gonads that produce more gametes, thus exhibiting higher fecundity (CITES 2019). As adults, they are non-migratory and relatively sedentary (FAO 2019).

Environmental cues (e.g., tidal conditions, lunar phases, temperature fluctuations) and chemical cues trigger the release of gametes (Purcell *et al.* 2010). *H. nobilis* is believed to reproduce annually during the cold season (Purcell, Samyn & Conand 2012; Conand *et al.* 2013; CITES 2019). Successful fertilization depends upon sufficient population density and proximity of adults (Purcell *et al.* 2010; Purcell *et al.* 2011; CITES 2019; FAO 2019). Minimum population densities for successful reproduction have yet to be determined (Purcell *et al.* 2011). It is unknown if the species can successfully reproduce in deeper waters (Conand *et al.* 2013).

The oocytes of most sea cucumber species are small (< 200 μm in diameter) and are neutrally buoyant in the water column (Purcell *et al.* 2010). Fertilized *H. nobilis* eggs quickly develop into free-swimming larvae—sometimes within a day (Purcell *et al.* 2010). These larvae spend 50-90 days in the plankton stage feeding on algae and may be widely dispersed by ocean currents (Conand 2009; Purcell *et al.* 2010; CITES 2019). One breeding trial found that the planktonic period of *H. nobilis* ranged from 44-51 days (Minami 2011). After metamorphosis, sea cucumbers settle on the seafloor (Conand 2009; Purcell *et al.* 2010). Mortality of pelagic larvae is believed to be quite high, while natural mortality rates of adults is believed to be low (CITES 2019; FAO 2019).

Juvenile sea cucumbers tend to have morphological differences when compared to their adult forms and as such have the potential to be misidentified in the field. Additionally, juvenile sea cucumbers may also occupy different habitats or be obscured from view by sediment or crevices within the coral habitat (Shiell 2004). As such, juvenile sea cucumbers are rarely observed in the field (Conand 1989; Sweet et al. 2016).

Genetics and Population Structure

Apart from the genetic data indicating separation of *H. nobilis* and *H. whitmaei* (Uthicke et al. 2004), there is limited additional species-specific information regarding the population structure or genetics of *H. nobilis* populations.

ABUNDANCE AND TRENDS

Few standardized datasets documenting changes in teatfish species densities exist for any range countries. This is due mostly to a lack of detailed historical data on early harvests (Friedman et al. 2011). Sea cucumber fisheries are largely made up of artisanal fishers living in remote locations far removed from the enforcement of centralized fisheries management agencies and therefore have generally not been monitored long-term. Additionally, few countries record catches or exports by species, making it difficult to determine the utilization of a single species. Despite sea cucumbers high commercial value, there have been no obvious extirpations of teatfish species at the national scale; however, declines in densities of teatfish (individuals per hectare) are reported from time series and snap-shot studies and depletion of stocks have been observed (Kinch et al. 2008; Hasan and El-Rady, 2012; Friedman et al. 2011; Lane and Limbong, 2013; Ducarme 2016; FAO 2019). It is also important to note that similar to other teatfish species, *H. nobilis* is thought to be naturally rare when compared to other species of sea cucumber (Purcell, pers. comm. 2019 in CITES 2019; CITES 2019; Conand et al. 2013; Uthicke et al. 2004).

While data on abundance and population trends for teatfish are lacking, they are even more sparse for *H. nobilis* (Anderson *et al.* 2011). Conand et al. (2013) states that the available data indicate that the species has declined by 60-70 percent across at least 80 percent of its range since the 1960s, and that the species is continuing to decrease. These percentages, however, appear to be extrapolations based on observed declines in a single site survey in Eritrea, non-species specific catch data from the Maldives, India, Mozambique, Tanzania, Kenya, and Chagos, as well as anecdotal data from Madagascar and Egypt. The mean density of *H. nobilis* in areas where the species has been observed (e.g., Chagos, Egypt, Eritrea, Madagascar, Mayotte, Saudi Arabia, Seychelles, Sri Lanka, and Zanzibar) ranges from approximately 0.12 to 10 individuals per hectare (CITES 2019). It is thought that *H. nobilis* once occurred at much greater densities (Conand 2018), with anecdotal reports from sea cucumber collectors indicating that sea cucumbers, in general, were historically larger in size and more abundant (Mmbaga 2013).

In Madagascar and Egypt, very few individuals of the species have been observed and stocks are considered depleted due to overexploitation (Bruckner 2006; Conand et al. 2013; CITES 2019). As commercially important sea cucumbers along the coasts of Madagascar became more difficult to find due to scarcity, fishers started to explore potential fishing grounds further away. As a result, more distant sites that had been relatively protected from fishing, including marine protected areas, are starting to experience the effects of fishing pressures (Mulochau 2018a). As an example, due to the overexploitation occurring in Madagascar and the Comoros, harvesting of sea cucumbers in now seen in parts of Mayotte, which is a Natural Marine Park (Mulochau 2018b). Illegal harvest appeared in Mayotte in 2016 in spite of a ban on collection. Because this harvest is illegal, park agents have difficulty determining the quantities and species involved (Mulochau 2018b).

In Tanzania, where *H. nobilis* once dominated the catch, the species now makes up a very small percentage of sea cucumber species harvested (CITES 20129; Conand et al. 2013; Mmbaga 2013; Conand & Muthiga 2007). According to Mmbaga (2013) observations of *H. nobilis* in Tanzanian waters that do occur are more common in deeper water (4-5m vs. 2-3m). This may suggest over harvest of the species in shallow reef areas. However, due to the lack of knowledge about population structure, distribution, and specific exploitation levels of sea cucumbers in Tanzania, Tanzanian natural resource managers have struggled with implementing a management plan (Mmbaga 2013, Conand 2018).

In Chagos, located in the central Indian Ocean, populations of sea cucumbers had declined from 2005-2010 due to illegal fishing (Price et al. 2010; CITES 2019). However, in April 2010 Chagos was designated as the world's largest marine protected area. This may help in the recovery of sea cucumber populations in this area. Such recovery of sea cucumber populations has occurred in marine reserves in the Seychelles. However, this requires increased monitoring and enforcement (Price et al. 2013).

Throughout the rest of the range of *H. nobilis*, they are considered less abundant relative to previous surveys or anecdotal data and their status is uncertain or unknown based on a lack of data. Abundance information by country is summarized in **Table 1**. Additionally, observations of *H. nobilis* during surveys are generally almost exclusively adults, as juvenile teatfish are rarely seen in the field (Conand & Muthinga 2013; Conand 2018; CITES 2019).

Table 1 *Available abundance trends for H. nobilis throughout its range. Rows highlighted in grey indicate that we were unable to find any species-specific abundance data for the particular range country. * Note that sampling methodologies used may vary across study periods and areas.*

Location	Trend	Data/Observations	Data Type	Time Frame	Reference
Comoros	Unknown				

Location	Trend	Data/Observations	Data Type	Time Frame	Reference
Chagos (Salomon Atoll and Peros Atoll)	Possible Population Declines	Mean density reported for Salomon atoll: 83 ind. ha-1 in 2002 and 10 ind. ha-1 in 2006. Not recorded at the Peros Banhos Atoll in either 2002 or 2006.	Underwater Visual Transect Surveys (snorkeling)	2002 & 2006	Price et al. 2010
Djibouti	Unknown				
Egypt (Wadi Quny and Eel Garden in the Gulf of Aqaba)	Possible Population Declines	Densities reported for Wadi Quny and Eel Garden in the Gulf of Aqaba : 16.7 ind. ha^{-1} and 6.7 ind. ha^{-1} in 1995; 0.7 ind. ha^{-1} and 1.3 ind. ha^{-1} in 2002. *H. nobilis* was not observed in 2003 and 2006 surveys at these locations. Observed off Pharoan Island: April & September 2013; February & July 4014; and April 2015 Lawrence et al. (2004) surveyed 116 sites from Taba (border of Israel) to Shalatein, (border of Sudan) from July 2002 to August 2003 and reported a population density of 0.66 ind. ha^{-1}. *H. nobilis* has been reported to be commonly seen by divers as recently as 2019.	Underwater Visual Transect Surveys, Anecdotal Observations	1995-2019	(Lawrence et al. 2004) (Hasan & El-Rady, 2012)(Hasan & Johnson 2019) (FAO 2019)
Eritrea	Unknown	91 sites were surveyed: 60 sites in the central fishing grounds, 15 sites in the southern fishing grounds, and 16 sites in the northern fishing grounds *H. nobilis* densities for Eritrea were recorded at 1 ind ha^{-1}	Underwater Visual Transect Surveys down the cost of Eritrea	2008	(Kalaeb et al. 2008)
India	Unknown				
Israel	Unknown				
Jordan	Unknown				

Location	Trend	Data/Observations	Data Type	Time Frame	Reference
Kenya (Kiunga Marine Reserve)	Unknown	Considered common in 2000; up to 20 specimens were observed during survey of Kiunga Marine Reserve. In 2007, *H. nobilis, Thelenota ananas and B. argus* comprised approximately 10% of the catch (smallest portion of the catch). While, *H. fuscogilva* made up approximately 50% of the catch (largest portion of the catch).	Collection of specimens by hand via snorkeling or by SCUBA. Catch data is based on composition of species at Gazi and Shimoni, the main landing beaches in northern Kenya.	2000 & 2007	(Samyn & Berghe 2000) (Conand & Muthiga 2007)
La Reunion	Unknown	Only a few dispersed specimens have been seen on Réunion reefs.	Anecdotal Observations	unknown	(Conand 2008) (Conand & Muthiga 2007)
Madagascar French Islands off the coast (Lys Island & Juan de Nova Island)	Possible Population Declines	Stocks are assumed to be depleted as very few specimens have been seen the past several years especially in areas that have been heavily fished. **French Islands off the Coast:** **Lys Island** (North West off the northern tip of Madagascar) Recorded abundance of 0.3 ind. ha ± 2.6 **Juan de Nova Island** (Off the West Coast of Madagascar) Observed in 7 out of 25 sampling locations	Anecdotal Observations **Lys Island:** Visual Transect Surveys (Shallow water) Manta Tow Method (Deeper water). **Juan de Nova Island:** Underwater visual census method during SCUBA dives	2010; 2013; 2015	(Conand pers. comm. 2010 in Conand et al. 2013) (Mulochau and Gigou 2017) (Mulochau et al. 2014)

Location	Trend	Data/Observations	Data Type	Time Frame	Reference
Maldives (North Male Atoll, Baa atoll, and Ari Atoll)	Unknown	Survey in north Male Atoll, from the early 2000s, found abundances of *H. nobilis* to be 0.4% relative to the total number of individuals encountered at all sites from eight islands. In 2014, no *H. nobilis* were found during surveys at Baa atoll. However, there are no previous records of *H. nobilis* at Baa atoll either. In 2015, *H. nobilis* was not found at survey sites at Ari Atoll; however, we do not have previous survey data for this site.	Underwater Visual Transect Surveys	2000-2015	(Muthiga, 2008) (Ducame, 2015) (FAO 2019)
Mauritius	Unknown	One individual observed in 2013 after surveying 16 sites in the west and south shallow lagoons of Mauritius. One individual observed in 2014 after surveying 23 sites in the north, west, south and eastern shallow lagoons of Mauritius	Underwater Visual Transect Surveys	2013	(Lampe 2013)(Lampe-Ramdoo et al. 2014)
Mayotte	Possible Population Declines	*H. nobilis*, was observed less frequently in a 2016 study (3 out of 8 sites around Mayotte) than in previous studies (2005, 2012, 2015). Eriksson et al. (2012) recorded a mean density of 10 ind. ha-1 on Mayotte reefs in 2010 and it was considered one of the most abundant species. **Geyser Bank** (northeast of Mayotte) – Observed one individual in 2007, but was not observed in 2015 or 2016.	Sites were surveyed using the Manta Tow Method. **Geyser Bank:** Underwater Visual Transect Surveys	2005-2016	(Eriksson et al. 2012) (Mulochau 2018b)(FAO 2019) (Mulochau 2007) (Mulochau 2018a)
Mozambique	Unknown				

Location	Trend	Data/Observations	Data Type	Time Frame	Reference
Oman	Unknown	*H. nobilis* was observed at 2 of the 11 locations surveyed around the Sultanate of Oman. Each location had a minimum of 3 sites surveyed. *H. nobilis* was only observed at locations in the Arabian Sea.	Underwater visual census method during SCUBA dives	2007–2009	(Claereboudt & Al-Rashdi 2011)
Saudi Arabia	Possible Population Declines	*H. nobilis* was present and harvested in the Red Sea off Saudi Arabia from 1999-2003. It was not documented in 2004's harvested species. However, in 2006 *H. nobilis* was observed at 3 of 18 surveyed sites along the coast of Saudi Arabia. Densities ranged between 0.0 and 0.2 individuals 100 m^{-2}.	Data were obtained from the Jeddah Fishery Research Centre and directly from fishermen Underwater Visual Transect Surveys	1999-2004; 2006-2008	(Hasan 2008) (Hasan 2009)
Seychelles	Stable	Densities of *H. nobilis* were recorded at 2.0 ind. ha^{-1}. *H. nobilis* was considered under-exploited at the time and the second most abundant species of sea cucumber.	Underwater Visual Transect Surveys and Video surveys for deeper water	2003-2004	(Aumeeruddy & Skewes 2005) (Aumeeruddy & Conand, 2008) (FAO 2019)
Somalia	Unknown				
South Africa	Unknown				
Sri Lanka	Unknown	Surveys were conducted on the eastern and northwestern coast of Sri Lanka with densities of *H. nobilis* being recorded as < 1 ind. ha^{-1}	Underwater Visual Transect Surveys	2008	(Dissanayake & Stefansson, 2010) (FAO 2019)
Sudan	Unknown				
Tanzania	Possible Population Declines	Previously dominated the sea cucumber fishery, now reported to comprise a very small percentage of total catch and individuals caught are small	Anecdotal Observations	unknown	(Conand & Muthiga 2007)
Yemen	Unknown				

Location	Trend	Data/Observations	Data Type	Time Frame	Reference
Zanzibar	Unknown	Surveys (269 manta tows and 258 line transects) were unable to find any *H. nobilis* in the fished areas and densities of 1.2 ind. ha^{-1} were observed at the marine reserve site.	Visual Transect Surveys (Shallow water) Manta Tow Method (Deeper water).	2009	(FAO 2019) (Eriksson et al. 2010) (Eggertsen et al. 2020)

As indicated by **Table 1**, in 18 of the 25 countries where *H. nobilis* is reported to occur, the abundance of the species and trends in abundance is very limited or unknown. The information available for the other seven range countries (i.e, Chagos, Egypt, Madagascar, Mayotte, Saudi Arabia, Seychelles, and Tanzania) indicate that there are possible declines in abundance with one exception – the Seychelles where it is reported to be stable (Conand et al. 2013, FAO 2019, CITES 2019). Overall, while some quantitative data are available, the abundance and density trends of *H. nobilis* across their range are poorly understood.

ANALYSIS OF ESA SECTION 4(A)(1) FACTORS

The ESA requires NMFS to determine whether a species is endangered or threatened because of any of the factors specified in section 4(a)(1) of the ESA. The following provides information on each of these five factors as they relate to the status of the black teatfish (*H. nobilis*).

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

H. nobilis occurs in coral reef areas of the Indian Ocean and has a strong affinity for hard substrates (CITES 2019; Conand et al. 2013; Eriksson et al. 2012; Idreesbabu and Sureshkumar 2017; Lawrence et al. 2004). As stated above in the **Range, Distribution, and Habitat Use** section *H. nobilis* has occasionally been observed in seagrass, but seagrass is not considered the desired habitat of the species. The primary habitat for *H. nobilis* is coral reefs and while we do not have data on why *H. nobilis* is found in this specific habitat type, whether it be for protection or for the organic matter found in the sediment, it is known that sea cucumbers are important for supporting overall coral reef health. *H. nobilis* like other sea cucumbers of the order Holothuriida are deposit and detritus feeders. They digest organic matter in the sediment. They ingest the top few millimeters of sediment and excrete less organic rich sediment (Anderson et al. 2011; Purcell et al. 2016; Webster & Hart 2018). Digestion of nitrogen-rich compounds such as proteins converts organic nitrogen to inorganic forms, which in turn can be utilized by other primary producers inhabiting the respective coral reef system (Purcell et al. 2011; Purcell et al. 2016). Further, the role of sea cucumbers in the breakdown of calcium carbonate sediment provides an important source of alkalinity and may, at a local scale, play a role in buffering ocean acidification on coral reefs (Schneider et al. 2011; Purcell et al. 2016). Additional studies on habitat selectivity may provide insight into juvenile and adult utilization of these coral habitats.

As the available data does not provide us with an understanding of *H. nobilis's* habitat usage, it is difficult to identify any specific present or future threats that may affect the features of the habitat on which the species' relies. As an alternative, we focus our discussion on threats to coral reef habitat as a whole.

Coral reefs have been and are currently impacted by human activities, including destructive fisheries, pollution, sedimentation, and changes in water temperature and pH. Threats to coral reef habitat within the range of *H. nobilis* are discussed below and the likely impacts on the status of the species are evaluated.

In a comprehensive status review of 82 reef-building corals conducted by NMFS in 2011, Brainard et al. (2011) identified a total of 19 threats to the world's reef-building corals. Of those threats, the potential impacts most likely to affect reef-building coral species and thus coral reef habitat are ocean warming, ocean acidification, trophic effects of fishing, and impacts of land-based sources of pollution (LBSP; i.e., sedimentation and nutrients). Likewise, the NOAA Coral Reef Conservation Program has identified climate change, LBSP, and overfishing as the three primary threats to focus on in their strategic plan for coral reef conservation. The sections below focus on these major threats applicable to coral reef habitat within the range of *H. nobilis* from both natural and anthropogenic sources.

Climate Change Impacts to Coral Reefs

Because of the thermal limitations of reef-building corals, tropical coral reefs occur in waters that range between 25°C–30°C (Brainard et al. 2011). Although the thermal requirements for *H. nobilis* are not well known, the species only occurs in coral reef areas of the Indian Ocean. Corals exhibit high sensitivity to temperature changes and are therefore subject to bleaching (i.e., the expulsion of their symbiotic zooxanthellae) during elevated temperature events. It is well documented that temperature increases have already caused dramatic declines in many coral species and changes to the composition and structure of coral reefs around the world due to bleaching and disease (Hughes et al. 2018; Hughes et al. 2017; Brainard et al. 2011).

Additionally, evidence suggests that coral bleaching events will continue to occur and become more severe and frequent over the next few decades (IPCC 2014; van Hooidonk et al 2016; Hughes et al. 2018). Even on the most remote coral reefs in the Indo-Pacific, a

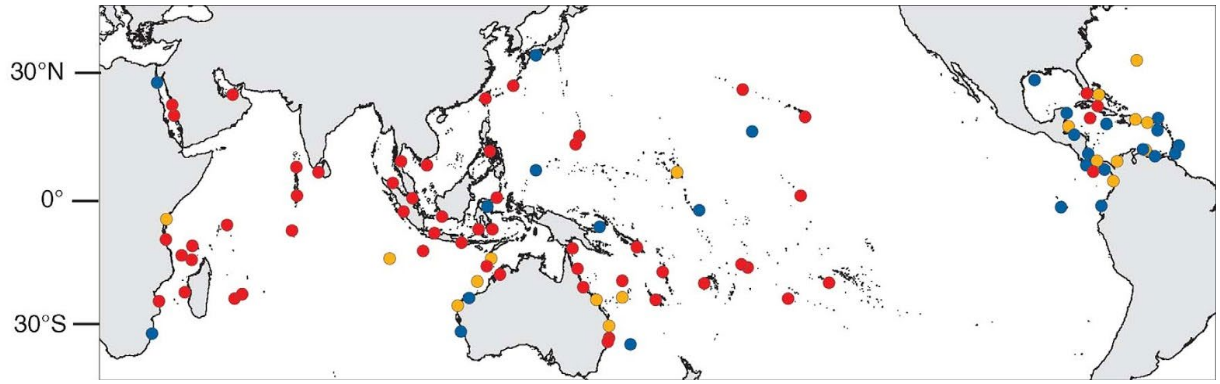


Figure 6 *The global extent of mass bleaching of corals in 2015 and 2016. Symbols show 100 reef locations that were assessed: red circles, severe bleaching affecting >30% of corals; orange circles, moderate bleaching affecting <30% of corals; and blue circles, no substantial bleaching recorded (Source: Hughes et al. 2018).*

Coral reefs in the Indian Ocean experienced extensive bleaching and mortality in 2015 and 2016, including in the Maldives (Perry and Morgan 2017) and Chagos (Sheppard et al. 2017) archipelagos, where *H. nobilis* occurs. However, even before this bleaching event these areas experienced extensive coral mortality due to other ocean warming events (Lindén *et al.* 2002; Obura 2001; Obura 2017). For example, the reefs of the Lakshadweep Islands off India lost 43-87% of their live coral cover, and certain colonies in the Seychelles suffered 95-100% mortality (Ahamada *et al.* 2002; Lindén *et al.* 2002; Obura 2001; Obura 2017; Payet & Agricole 2006; Collier & Humber 2007). These reefs likely provide habitat for *H. nobilis* populations.

Although the years 2014 to 2017 were some of the worst on record for coral reefs, the next few decades will likely be even worse due to the increasing frequency and severity of bleaching events, leading to higher coral mortality and shorter recovery time in between bleaching events. Other broad threats such as ocean acidification are also simultaneously increasing. Consequently, the overall decline of Indo-Pacific coral reef communities is predicted to accelerate (Maynard et al. 2015; Hughes et al 2017; UNEP 2017). A recent study suggests that those coral reefs that have remained unscathed thus far from severe bleaching are likely to decline further in number; additionally, the size of spatial refuges for coral reefs will diminish, with impacts already underway (Hughes et al. 2018).

As previously noted, ocean acidification is also increasing. Increasing carbon dioxide (CO_2) concentrations in the atmosphere (given as partial pressures, pCO_2, in μatm) cause CO_2 levels to rise in the surface ocean resulting in reduced pH of the water or what is commonly referred to as acidification (Watson et al. 2009; Brainard et al. 2011; Gattuso et al. 2014; Pörtner et al. 2014). In terms of impacts to coral reefs, Brainard et al. (2011) and the final rule to list 20-reef building corals (79 FR 53851, September 10, 2014) explained that ocean acidification has the potential to substantially reduce coral calcification and reef cementation. Ocean acidification may also interact with ocean warming by lowering the bleaching threshold for some coral species (Anthony et al. 2008).

The consequences of repeated bleaching events and subsequent mortality, along with added pressure from disease and acidification, are that coral reef habitats will likely undergo substantial changes in structure and/or composition. These physical and ecological changes due to bleaching events affect the entire coral reef community since corals make up the majority of the habitat's physical structure. This continued degradation will likely have negative implications for *H. nobilis*, which predominately rely on coral reefs for habitat. Because the specific habitat requirements of *H. nobilis* are still unclear, the nature and extent of impacts on *H. nobilis* as a consequence of coral reef degradation in the Indian Ocean is unknown. Therefore, it is difficult to predict how changes in structure and/or composition of its habitat may affect its extinction risk and to what degree.

Summary

While there is clear evidence that coral reefs (i.e., *H. nobilis* habitat) will undergo substantial changes due to impacts from ocean warming, acidification, and a variety of other threats, it is unclear whether and to what degree the changes in coral reef composition and ecological function will affect the extinction risk of this sea cucumber species throughout its range. As mentioned above, reduced densities of sea cucumbers may also have considerable effects on the reef ecosystem as sea cucumbers have important functions in the breakdown of organic matter on coral reefs (CITES 2002, Uthicke 2004). Thus, while the habitat complexity provided by the morphological structure of many corals may change due to selective elimination of certain coral species, there is no information to suggest which features of the coral reef or species of coral *H. nobilis* may be dependent on. Consequently, it is difficult to predict how the loss of coral reef habitat or changes in coral reef composition will affect extinction risk for *H. nobilis*. We recognize that the changes in coral reef habitat predicted over the next several decades will likely negatively affect sea cucumber populations; but whether these impacts will significantly increase the extinction risk of *H. nobilis* is unclear.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

H. nobilis is one of the most highly valued sea cucumber species (Uthicke, O'Hara & Byrne 2004; Bruckner 2006; Conand & Muthinga 2007; Muthiga & Conand 2013; Conand 2018; Purcell, Williamson & Ngaluafe 2018). Since the 1990s, the global sea cucumber fishery has dramatically increased in terms of the number of producing countries, number of exploited species, fishing effort, and fishing areas, leading to overexploitation and depletion of teatfish in most of their range countries (CITES 2019). Due to high demand that is not being met by current bêche-de-mer (i.e., the processed form of sea cucumbers, either boiled, dried, and smoked) production, fisheries pressure on the species is expected to continue (Conand et al. 2013; FAO 2019; Muthiga & Conand 2013).

Below, we discuss the main forms of potential overutilization:

- Small-Scale and Artisanal Fisheries;
- Illegal Unregulated and Unreported (IUU) Fisheries;
- Trade in bêche-de-mer; and
- Medicinal use and Research.

Small-Scale and Artisanal Fisheries

Teatfish species, including *H. nobilis,* are largely exploited in small-scale and artisanal fisheries throughout their range. Harvest at these scales has proven difficult to manage, with booms in fishing typically followed by closures or moratoriums on fishing once stocks have been depleted. Overall, there is little international or regional coordination in management of these fisheries (FAO 2019).

Because sea cucumbers are very slow moving and often visible from the surface, they can be harvested by these fishers through hand collection (i.e., gleaning) in shallow waters. Artisanal fishers may also use small wooden or fibre-glass boats, or they may dive using hookahs or SCUBA tanks to collect sea cucumbers using spears, hooks, or dip nets (Bruckner 2006; Toral-Granda, Lovatelli & Vasconcellos 2008; Anderson et al. 2011; Purcell et al. 2011; Conand et al. 2013; CITES 2019; FAO 2019). However, in areas where overharvest has driven fishers into deeper waters, small trawlers may be used (Bruckner 2006; Anderson et al. 2011; CITES 2019).

Once the larger individuals are fished out, fishers then start to collect larger numbers of individuals of a smaller size, along with medium and low-value species. As high-value species become less prominent in trade, medium-value species move up the value chain (Eriksson and Byrne, 2015; Purcell et al. 2011). Once an area is no longer economical to fish, fishers move on to other reefs. High-value species, such as *H. nobilis* will continue to be collected opportunistically as they are encountered (Purcell et al. 2011).

In the 1980s and 1990s, world production of sea cucumbers increased significantly as more countries began to export sea cucumbers (Purcell et al. 2011; **Figure 7**). Between 1985 and 1986, global harvests dramatically increased and then between 1987 and 1989 doubled again in response to increased demand in Asian markets for bêche-de-mer. The global catch of sea cucumbers was estimated at 25,000 tonnes in 1983 and increased to 90,000 tonnes by 1989 (Purcell et al 2011, CITES 2019). Conand 2018 reports landings of sea cucumbers for the western Indian Ocean as 1,759 tonnes from 1986-1996, 2244 tonnes from 1992-2001, 956 tonnes from 2004-2008, and 1555 tonnes from 2009-2014.

As global catches have continued to increase it is difficult to say whether catches are just being better reported than before and/or that more species are being harvested (Conand 2017, CITES 2019).

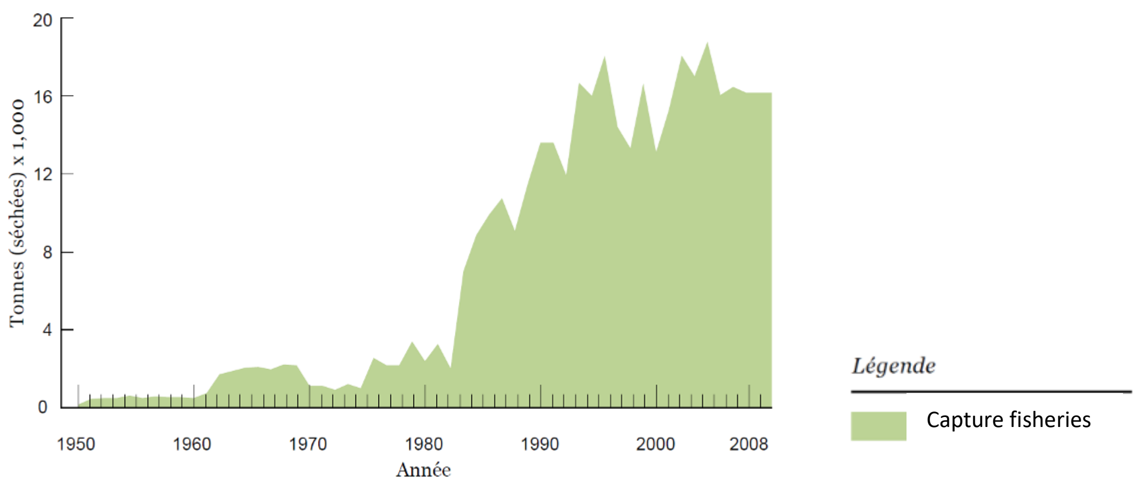


Figure 7 *Global wild captures of sea cucumbers over time; in metric tonnes (adapted from Purcell* et al. *2011 - Source FAO Fishstat (CITES 2019))*

Many of the harvested populations of sea cucumbers, including across the range of *H. nobilis*, are considered either to be fully exploited, overexploited or depleted (See **Figure 8**; Purcell et al. 2011).

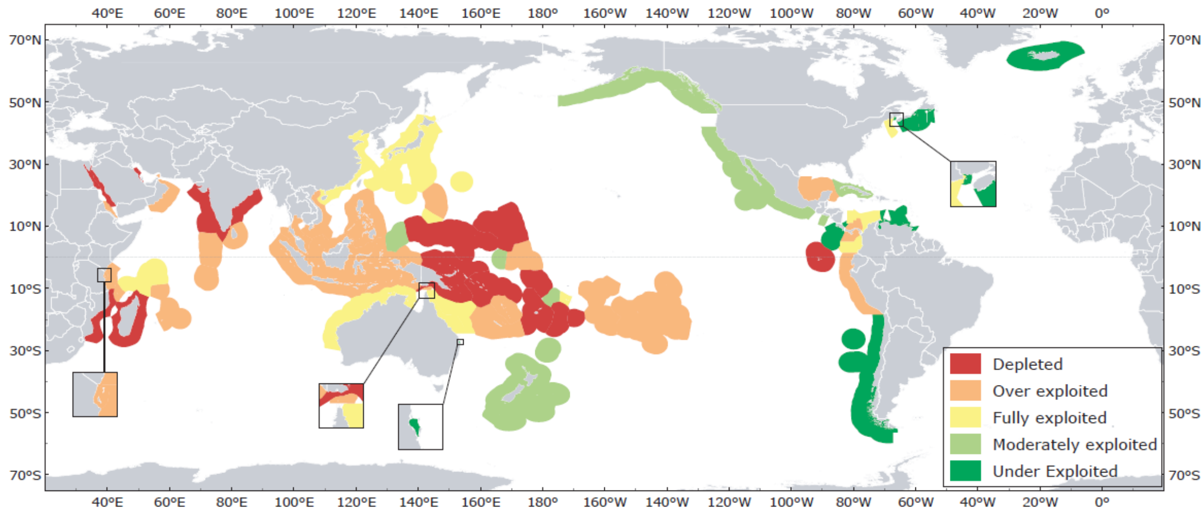


***Figure 8** Current status of sea cucumber fisheries in global fisheries (Purcell et al. 2011) *This figure is not specific to H. nobilis.*

Under-exploited: Undeveloped; believed to have a significant potential for expansion in total production. Average recent annual catches (usually based on exports) at least 50% of the peak maximum potential catch, which is not yet realized. Population abundance is at least 90% of virgin abundance.
Moderately exploited: Exploitation rate is sustainable for medium- and high-value species, with some potential for increased yields without diminishing the reproductive capacity of stocks. Annual catches are at least 50% of the peak maximum potential catch, which is not yet realized. Population abundance is between 60% and 90% of virgin abundance.
Fully exploited: The fishery is operating at or close to a maximum sustainable yield, with no expected room for further expansion. Catches are increasing or stable and not expected to be able to increase sustainably. Population abundance is between 30% and 60% of virgin abundance.
Over-exploited: The fishery is, or has been, exploited at above a level that is believed to be sustainable in the long term, with no potential room for further expansion and a higher risk of stock depletion/collapse. Annual catch of high- and medium-value species is between 10% and 50% of the historical maximum catch, or their abundance is between 10% and 30% of virgin abundance.
Depleted: Catches, and/or stocks, are well below historical levels, irrespective of the amount of fishing effort exerted. Catch of medium and high-value species is below 10% of historical maximum catch, or their abundance is <10% of virgin abundance (sensu Worm et al. 2009).

Within the range *of H. nobilis*, the following can be noted:

In Oman, the sea cucumber fishery dates back to 1960s, but the fishery was discontinued in the 1970s, due to lack of demand. However, the fishery re-opened in 2003 due to the demand of bêche-de-mer from traders in the United Arab Emirates. This fishery was completely unregulated (Conand 2008). Interviews with local fishers revealed that in 2005, about 100 sea cucumbers per fisher per trip could be collected, while in 2007, fewer than 20 sea cucumbers per fisher per trip were collected, indicating that there had been significant harvesting pressure on the resource (Al-Rashdi and Claereboudt 2010). Harvest in Oman originally targeted *H. scabra* (sandfish) another 'high value' species (FAO 2013). We do not have data that suggests that *H. nobils* was specifically targeted, but we do know that *H. nobilis* is also considered a 'high value' species in international trade.

The main signs of over-exploitation of sea cucumbers in Madagascar is an observed shift in species composition (i.e., from high value species to lower value species) in the catch and a decrease in product size (Pouget 2004). However, according to Conand and Muthiga (2007) *H. nobilis* was only 'limitedly harvested' in the 1990s but became more 'moderately harvested' in 1996. *H. nobilis* went back to being 'limitedly harvested' in 2002. The available literature suggests that fishers in Madagascar are mainly targeting the white teatfish (*H. fuscogilva*) and pentard teatfish (*H. sp. "pentard"*, FAO 2013).

The sea cucumber fishery in the Seychelles for a long time was considered relatively unimportant. It was small-scale, with fishers harvesting sea cucumbers either by hand in shallow areas or by using SCUBA/snorkel gear. Because of the low importance attributed to the fishery, it was unregulated and open access. As a result, no data on harvests was collected. However, with the increased demand of bêche-de-mer on the international market and higher prices offered, there was an incentive to develop the fishery (Aumeeruddy and Payet 2005). By 1999, there were already signs of stock depletion. The Seychelles national fisheries authority implemented limited management measures in 1999, but due to a lack of data and limited financial and human resources, stock assessments were not conducted that could help inform the development of a more comprehensive management plan (Aumeeruddy and Payet 2005). Between 2001–2006, the numbers of sea cucumbers harvested in the Seychelles increased significantly from 41,935 to 281,209 individuals. During this same period, the numbers of *H. nobilis* harvested only slightly increased from 7,794 to 8,753 (Aumeeruddy and Conand 2008), however, the catch per unit effort (CPUE) for *H. nobilis* decreased (**Figure 9**; Aumeeruddy and Conand 2008). In 2007 and 2008 harvests of *H. nobils* fell to 5,687 individuals. The fishery however is considered to not be depleted and is still actively fished (FAO 2019; Conand et al. 2013).

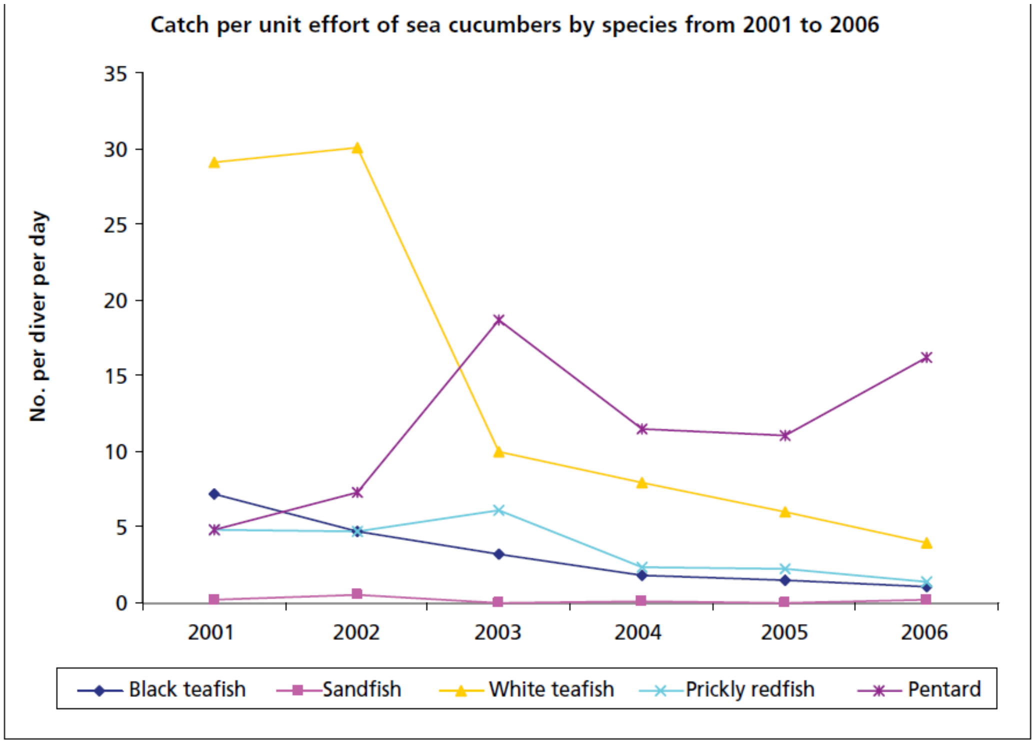


Figure 9 CPUE in the Seychelles expressed in numbers of sea cucumbers collected per diver per day during 2001-2006 (from Aumeeruddy and Conand 2008).

Throughout the rest of the *H. nobilis* range, there is a lack of recent fisheries-dependent data as many of the countries have banned sea cucumber fishing, including Comoros, Egypt, India, Mauritius, Mayotte, Saudi Arabia, Tanzania, and Yemen. However, despite these bans, there is evidence of continued fishing pressure on sea cucumbers through IUU fisheries.

Illegal Unregulated and Unreported Fisheries

According to Conand (2018), illegal sea cucumber fishing mostly takes place in countries where there is a permanent ban on exports; in countries where management plans and regulations for export are weak; in less developed countries where poverty drives poachers to smuggle illegal catches to nearby ports where they can be sold legally; and in countries with remote fishing areas where enforcement is difficult. **Figure 10** below shows how widespread IUU fisheries (purple) are in the range of *H. nobilis,* as well as the rest of the world.

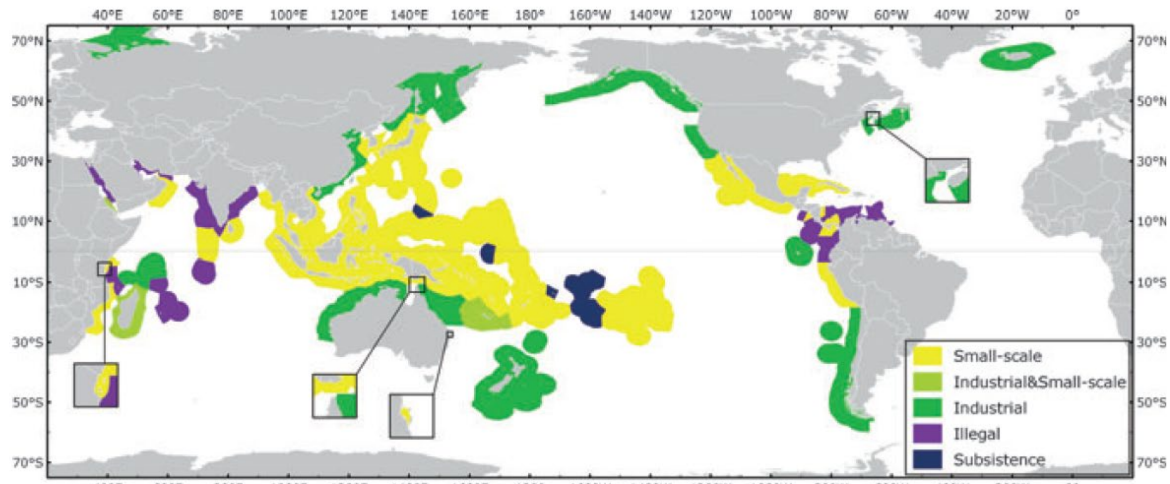


Figure 10 Scale of fishing in global sea cucumber fisheries (Purcell et al. 2011). *This figure is not specific to *H. nobilis*.

Evidence of illegal fishing has specifically been documented in Saudi Arabia, Mayotte, Yemen, Egypt, Mauritius and Tanzania.

In Saudi Arabia, the harvesting of sea cucumbers started in 1999 and by 2004, a ban was put in place. However, based on the results from Hasan's (2009) survey, it is evident that illegal fishing has continued, especially in the southern and northern sections of the coastline.

Illegal harvesting of sea cucumbers has also been observed in Mayotte. It was believed to have started in 2016 because of lack of supply of sea cucumbers in the neighboring waters of Comoros and Madagascar. Because this harvest is illegal, park agents have difficulty determining the quantities and species involved (FAO 2013; Mulochau 2018b).

In Yemen, the fishery and the export of sea cucumbers are both banned by the Minister of Fish Wealth, but illegal catches and collection of sea cucumbers is still considered to be occurring (FOA 2013).

Sea cucumber fishing is currently banned in Egypt. However, there continues to be a problem with IUU fishing for sea cucumbers which has led to dramatic declines in the population abundance and species diversity of sea cucumbers in Egyptian waters (FAO 2013).

In Mauritius, the Ministry of Fisheries instituted a two-year moratorium on sea cucumber collection, later extending the moratorium through 2016 to prevent fishery collapse (Conand et al. 2016). These moratoria have sometimes given rise to illegal harvesting (Conand 2008).

Tanzania, has maintained a fishery closure since 2006 (Eriksson et al. 2012). However, illegal fishing and export has continued.

The above information is for sea cucumber fisheries in general and not specific to *H. nobilis*. However, IUU fisheries are common in the range of *H. nobilis* (see **Figure 10)**. Additionally, countries like Egypt, Mayotte, and Saudi Arabia that have dealt with illegal and unregulated fisheries have documented possible population declines of *H. nobilis* (see **Table 1**).

Trade in bêche-de-mer

Overall and country-specific trade data for *H. nobilis* are unknown. The trade value chains and fishery to market traceability do not identify down to the species level. As such, the information below presents the trade of all sea cucumber species.

An estimated 10,000 tons of bêche-de-mer are traded internationally each year, corresponding to about 200 million individuals harvested (Purcell et al. 2016). Bêche-de-mer, including *H. nobilis,* are sold primarily to Asian markets in Hong Kong SAR (Special Administrative Region), Singapore, Taiwan, People Republic of China, Korea and Malaysia (CITES 2019; Purcell et al. 2012). *H. nobilis* is sold for 20 USD to 80 USD/kg dry weight, depending on size and condition; prices in Hong Kong retail markets range from106 USD to 139 USD/kg dried (Purcell et al. 2012). However, this product may now have a higher retail price. Purcell et al. 2018 report that demand, and hence prices of most beche-de-mer species appear to have steadily increased since 2011, however, this study did not cover the value of *H. nobilis*. Being of high value, teatfish species, including *H. nobilis*, are preferentially targeted by fishers and exporters.

In Sri Lanka, exports of sea cucumbers appeared to peak in the late 1990s, at nearly 300 tonnes, worth approximately 3 million USD and then decreased by almost half in the early 2000s (Kumara et al. 2005; Conand 2008). All exports went to Singapore, Taiwan and the People Republic of China (Kumara et al. 2005). According to the FAO (2013) import of bêche-de-mer commenced in 1996 but accurate information on import quantities and the source of imports have not been established (Kumara et al. 2005). Information on the annual exports have been poorly documented and there were no records on catch and effort. This has made it very difficult to quantify the historical and current production trends of sea cucumber species in Sri Lanka (FAO 2013).

In Kenya, the fisheries department data shows a declining trend in production of sea cucumbers (Conand & Muthiga, 2007). For example, fishers sell to 'middlemen' who then accumulate and sell to an exporting agent (Eriksson et al. 2010). This system is common for sea cucumber fisheries globally (Conand 1989). Therefore, monitoring trade chains and sales of bêche-de- mer is very difficult in much of this region (Purcell et al. 2011).

While trends in the documented flows of trade are not necessarily evidence of corresponding decreases of species' in-water abundances, they are likely indicative of potential overexploitation. While we do not have species-specific sea cucumber trade data, the high market value is a concern for *H. nobilis* (Uthicke, O'Hara & Byrne 2004; Bruckner 2006; Muthinga & Conand, 2013; Conand 2018; Purcell et al. 2018).

Medicinal Research and Use
Excerpt from CITES (2019):

> Since the late 1990s, additional markets have emerged for biomedical research. Bioprospectors have been interested in sea cucumbers for the research and development of natural products. Sea cucumbers harbor various chemical compounds used to prevent anemia, combat certain forms of cancer, strengthen immune defenses and alleviate arthritis pain (Chen 2004). Sea cucumbers contain chondroitin and glucosamine, which are important components for cartilage formation, as well as other bio-active substances that have anti-inflammatory and anti-tumor properties (Mindell 1998). In China, sea cucumbers are considered a traditional remedy and a drug, and their use dates back to the Ming dynasty (1368-1644 AC) (Chen 2004). This has led to the development of ancestral traditions, particularly in coastal communities, where the consumption of sea cucumber is part of the usages and customs (Chen 2004).

While *H. nobilis* may be used for medical research, there are no data on the level at which *H. nobilis* is specifically targeted or used in medical research. Thus, we cannot assess whether this form of utilization is affecting the status of the species.

Summary
The combination of extensive small-scale and artisanal harvest of sea cucumbers, and illegal poaching across the Indian Ocean for the purpose of supplying bêche-de-mer has resulted in depleted stocks of sea cucumbers in certain parts of the range of *H. nobilis*. While *H. nobilis* may be following similar trends to other high-value species, the lack of species-specific data makes it difficult to know to what extent. Given the information above, albeit limited and focused on sea cucumber fisheries in general, overutilization may be a threat to *H. nobilis*.

Disease or Predation

The extent to which disease and parasites result in sea cucumber mortality in the wild is largely unknown. The impact of predation on *H. nobilis* also remains unknown. However, approximately 30 species of fish, 19 species of sea star, 17 species of crustacean, and several gastropods have been known to prey on sea cucumbers in general (Purcell *et al.* 2010; Purcell *et al.* 2016; Conand 2018; Webster & Hart 2018; CITES 2019). Birds, sea turtles, and marine mammals may also prey on sea cucumbers on occasion (Purcell *et al.* 2010). Overall, the threat presented to *H. nobilis* specifically by predation remains unknown.

Inadequacy of Existing Regulatory Mechanisms

International Regulations

CITES governs the international trade of CITES-listed species. Because international trade is one of the driving forces of the exploitation of *H. nobilis*, in August 2019, the CITES CoP added the three species of teatfish to Appendix II of CITES - including *H. nobilis* (the listing went into effect August 2020). This listing allows legal and sustainable trade in *H. nobilis* , but it is to be regulated. Exports of *H. nobilis* now require CITES export permits or re-export certificates that certify the beche-de-mer from *H. nobilis* was legally acquired and that the Scientific Authority of the State of export has advised that such export will not be detrimental to the survival of that species (i.e., a 'non-detriment finding'). Given that international trade is one of the main threats to the species (i.e., overutilization), this listing may provide *H. nobilis* some safeguards against future depletion of populations. However, due to the limited information on the present abundance of the species throughout its range, it is likely difficult for Scientific Authorities of exporting countries to determine what level of trade is sustainable.

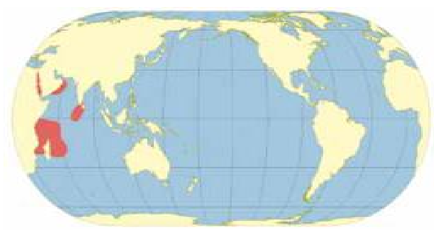
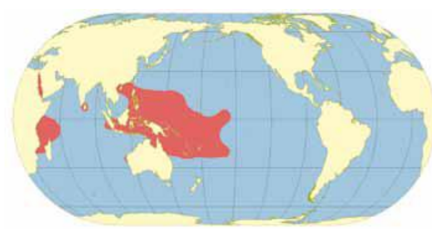
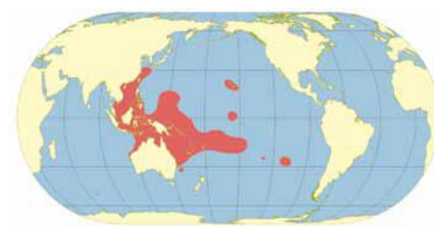
The Food and Agriculture Organization of the United Nations (FAO) establishes an expert Panel in advance of each CITES CoP to review marine species proposals. This Expert Panel is, tasked with assessing proposals from a scientific perspective and in accordance with CITES biological listing criteria (FAO 2008-2021). The assessment of this proposal concluded that:

- *H. whitmaei* met the CITES Appendix II listing criteria,
- *H. fuscogilva* did not meet the CITES Appendix II listing criteria, and
- *H. nobilis* the panel was unable to make a determination due to insufficient data.

However, due to potential confusion in identification between dried *H. fuscogilva*, *H. nobilis* and *H. whitmaei* in trade, all three species were listed in Appendix II of CITES under its 'look-alike' provision.

H. nobilis and *H. whitmaei* ranges do not overlap, but *H. fuscogilva's* range overlaps with both species (see **Figure 11 below**).

Figure 11 *Range Maps and CITES determinations for H. nobilis, H. fuscogilva,* and *H. whitmaei (CITES 2019)*

H. nobilis	*H. fuscogilva*	*H. whitmaei*
		
Insufficient evidence of declines to make a determination	Available data did not meet the CITES Appendix II listing criteria	Available data did meet the CITES Appendix II listing criteria

The FAO panel noted, based on previous cases for species listed under Appendix II with similar circumstances, the following outcomes are likely to occur:

1) International trade ceases;
2) International trade continues but without proper CITES documentation ("illegal trade"); and/or
3) international trade continues with inadequate non-detriment findings (FAO 2019).

Because this listing only recently went into effect (August 2020), it is too soon to evaluate the effectiveness of the CITES listing.

Regulations to Address Climate Change

In order to ensure consistency in the application of climate change science to ESA decisions, in 2016 NMFS issued "Guidance for Treatment of Climate Change in NMFS Endangered Species Act Decisions" (Climate Guidance, NMFS 2016). The Climate Guidance indicates that when addressing the adequacy of existing regulatory mechanisms in status reviews, listing decisions, and recovery plan analyses, NMFS will cite to or draw from previous NMFS findings, updated as appropriate in light of developments in this area, to describe the adequacy of existing global and national climate change regulatory mechanisms." (NMFS 2016).

In the coral final management report, which accompanied the 2014 final rule to list 20 species of coral (79 FR 53851, September 10, 2014), NMFS identified existing regulatory mechanisms that were relevant to the threats to coral species (NMFS 2012). In that report and in the final listing rule NMFS concluded that existing regulatory mechanisms were insufficient in their ability to prevent widespread impacts with regard to the effects of Green House Gas (GHG) emissions on coral reefs. Since the publication of the final management report and the coral listing final rule, the Paris Agreement on climate change went into effect. The agreement was signed by 197 countries and the European Union (EU) and entered into force on November 4, 2016. To date, 179 countries and the EU have ratified or acceded to the Agreement. The Paris Agreement set a goal of limiting global temperature increase to below 2 °C, and optimally keeping it to 1.5 °C. Each of the countries have made pledges to decrease GHG emissions to meet this goal (United Nations Framework Convention on Climate Change 2018).

The United States currently accounts for a fifth of the world's emissions and had pledged to cut its emissions by 26-28%. However, in November 2020, the United States withdrew from the Paris Agreement. Due to this withdrawal, it had seemed unlikely the United States' pledge would be met, but the United States officially rejoined the Paris Agreement on January 20, 2021, when U.S. President Biden took office. The United States plans to discuss its recommitment to its pledge at the UN climate conference in November 2021. If the agreement's pledges are not met, projected GHG emissions will be similar to that of emissions scenario RCP 8.5 by 2030. If all countries are able to achieve their pledges, projected emissions will fall somewhere between scenarios RCP 4.5 and RCP 8.5. According to van Hooidonk et al. (2016), GHG reduction pledges would have to be 150% greater on average for emissions in 2030 to be under the RCP 4.5 scenario. Even if the RCP 4.5 scenario is realized, more than 75% of reefs would still experience annual severe bleaching before 2070 (van Hooidonk et al. 2016). In fact, an analysis of the responses of coral reefs to increased warming and acidification under all four pathways found that only RCP 2.6 would allow the current downward trend in coral reefs to stabilize, and that RCP 4.5 would likely drive the elimination of most coral reefs by 2040–2050 (Hoegh-Guldberg *et al.* 2017). As such, regardless of whether pledges under the Paris Climate Agreement are met, impacts to coral reefs (i.e., *H. nobilis* habitat) will still be widespread and severe.

As described above in the section discussing **Climate Change Impacts to Coral Reefs,** while there is clear evidence that sea cucumber habitat (i.e., coral reefs) will undergo substantial changes due to impacts from ocean warming and acidification due to an increase in GHG emissions, it is unclear whether and to what degree the changes in coral reef composition and ecological function will affect the extinction risk of *H. nobilis*. It is likely that coral degradation with affect some of the biological needs of *H. nobilis*, but the extent is uncertain. As such, we conclude that ocean warming and acidification are likely to negatively affect *H. nobilis* habitat; while the current magnitude of this impact remains unclear as does the effect of climate change on *H. nobilis* themselves, the best available information indicates threats as a result of climate change will worsen into the future. Given the foregoing information, we conclude that regulatory mechanisms to control for climate change are likely inadequate and may contribute to the increased extinction risk of *H. nobilis*.

Local Regulations

The establishment of management strategies for *H. nobilis* has been and still is hindered by a lack of basic biological and ecological information as well as limited information on existing and historic sea cucumber fisheries (Bruckner 2006). The regulatory measures most common in sea cucumber fisheries for the Indo-Pacific are minimum legal size limits, gear restrictions (bans on the use of scuba), requirements for exporters to submit logbooks, and no-take reserves (FAO 2013; Purcell et al. 2011).

In Yemen, the sea cucumber fishery and the export of beche-de-mer are both banned by the Minister of Fish Wealth, but illegal catches and collection of sea cucumbers still occurs (FOA 2013).

Fishing is currently banned in Egypt. The ban was originally put in place in 2001 and was lifted in 2002. However, observations of sea cucumber stocks showed rapid decline, so a new ban was established in 2003 (Conand 2008). There continues to be a problem with IUU fisheries in Egypt (FAO 2013).

In Mauritius, there is a Sea cucumber Management Plan that restricts sea cucumber fishing during the month of March each year to enable reproduction of most sea cucumber species (Purcell et al. 2012). In 2010, the Ministry of Fisheries instituted a two-year moratorium on sea cucumber collection, later extending the moratorium through 2016 (Conand et al. 2016). These moratoria have sometimes given rise to illegal harvesting (Conand 2008). The Fishery was again closed starting March 2020 through December 2023[3].

In Saudi Arabia, sea cucumber fishing was banned in 2004 (Hasan 2009). Despite this ban, enforcement has been weak and illegal fishing is occurring and data in **Table 1** indicates that there are still possible population declines for *H. nobilis*.

Tanzania, has maintained a fishery closure since 2006 (Eriksson et al. 2012). However, illegal fishing and export has continued. There have been exports that falsely claim that the beche-de-mer is from Mozambique and in transit to Zanzibar (FAO 2013). Zanzibar's sea cucumber and beche-de-mer trade is open access and largely unregulated (Eggertsen et al.

[3] https://blueconomy.govmu.org/Pages/Legislation/Regulations.aspx

2020) and sea cucumber catches are continuing to decline in most of the shallow coastal waters around Unguja Island and Mkenda (FAO 2013).

Mayotte's fishery has been closed since 2004 and the exclusive economic zone of Mayotte is now a Natural Marine Park (FAO 2013). As stated earlier, due to the overexploitation occurring in Madagascar and the Comoros, illegal fishing has spread to parts of Mayotte (Mulochau 2018b).

Madagascar's sea cucumber fisheries are managed under several Fisheries regulations. They regulate the minimum legal size of capture to 11cm body length. They also prohibit the use of scuba[4] for the collection of sea cucumbers. However, the size limits put in place may not be appropriate for all species. For example, different species of sea cucumber reach different sizes at sexual maturity. In addition, while the use of scuba is forbidden, enforcement is weak and harvesting using scuba is still commonly carried out in Madagascar (FAO 2013).

India has banned the export of all wild taken specimens of species listed under CITES Appendix I, II, and III[5] and heavy fines and imprisonment can be imposed (FAO 2013). However, India still deals with issues in enforcement due to poaching and illegal trade of both fresh sea cucumbers and beche-de-mer to neighboring countries (FAO 2013).

The Seychelles have a licensing program that was started in 1999. This program requires an annual sea cucumber fishing and processing license be purchased. Since 2001 there has been a maximum of 25 license distributed each year (Aumeeruddy and Conand 2008). As such, the Seychelles is considered to have strong enforcement capacity because it only needs to monitor the use of 25 licensed fishers. Additionally, fishers logbooks are required to be submitted regularly. Non-compliance can result in non-renewal of their fishing license. Sales receipt books are also required for sales between fishers and the processor/exporters, and random inspections are carried out at processing facilities (Aumeeruddy and Conand 2008).

Overall, many of these management measures for sea cucumber species have not performed well due to the artisanal nature of these fisheries; shortcomings in stock monitoring, catch reporting, and enforcement (Conand & Muthiga 2007; Toral-Granda et al. 2008; Purcell et al. 2010; Conand and Muthinga 2013; FAO 2019). In addition, the lack of biological and ecological information on harvested species, like *H. nobilis*, hinders the development of sustainable sea cucumber harvest plans (Bruckner 2006; Purcell et al. 2011; FAO 2019). Subsequently, while local sea cucumber regulations (e.g., moratoriums

[4] The name "scuba", an acronym of "Self-Contained Underwater Breathing Apparatus"
[5] https://cites.org/eng

and fishing bans) throughout the range of *H. nobilis* may be adequate to protect the species from legal overutilization, the enforcement of these regulations is inadequate as evidenced by the continued illegal, unregulated and unreported fishing that occurs in many parts of the species' range and may be contributing to declines in populations.

Other Natural or Manmade Factors Affecting its Continued Existence

We considered factors including bycatch and effects of climate change on *H. nobilis*. However, as the primary habitat of *H. nobilis* is coral reefs, bycatch by trawlers that mainly trawl seagrass habits are not likely to have an effect on the extinction risk of *H. nobilis*. Additionally, the available literature does not indicate that *H. nobilis* has been observed as bycatch in these fisheries (Bruckner 2006). While climate change is a concern, there is a lack of data on how the effects of climate change (warming waters, acidification, and sea level rise) may affect *H. nobilis*. At this time, we were unable to find any information on other natural or manmade factors that may be affecting the continued existence of *H. nobilis*.

Summary of Threats and Conclusion

The primary threat facing sea cucumber species is overutilization for international trade (Bruckner 2006; Conand 2008; Purcell et al. 2010; Conand et al. 2014; CITES 2019; FAO 2019). Supply and demand for international trade to Asian markets has contributed to extensive harvest and stock depletions of sea cucumbers at various locations across the Western Indian Ocean. Sea cucumbers are easily collected given their shallow distribution, their large size, and limited mobility (Uthicke et al. 2004; Bruckner 2006; Anderson et al. 2011; Purcell et al. 2011; CITES 2019). In addition to their easy collection, their late sexual maturity (Conand 1989; Conand et al. 2013) and reproductive method of broadcast spawning combine to increase their vulnerability to stock depletion (Uthicke et al. 2004; Bruckner 2006; Al-Rashdi & Claereboudt 2010; Anderson et al. 2011; Purcell et al. 2011; CITES 2019; FAO 2019).

Overutilization and the inadequate enforcement of regulatory mechanisms are likely the most significant threats to *H. nobilis*. However, the impacts of these threats has largely been inferred based on available data on general sea cucumber populations as species-specific data are limited. In addition to these threats, climate change related threats (i.e., ocean warming and acidification) are also of concern, especially because these threats negatively affect sea cucumber habitat. However, because of the scarcity of information and uncertainties associated with how climate change related threats may affect *H. nobilis* populations in the future, we cannot determine the significance of this threat in terms of its impact on *H. nobilis* at this time.

EXTINCTION RISK ANALYSIS

In determining the extinction risk of a species, it is important to consider both the demographic risks facing the species as well as current and potential threats that may affect the species' status. To this end, a demographic analysis was conducted for *H. nobilis* and considered alongside the information presented on threats as detailed in this report.

A demographic risk analysis is an assessment of the manifestation of past threats that have contributed to the species' current status and informs the consideration of the biological response of the species to present and future threats. This analysis evaluated the population viability characteristics and trends available for *H. nobilis*, such as abundance, growth rate/productivity, spatial structure, connectivity, and diversity to determine the potential risks these demographic factors pose to the species. The information from this demographic risk analysis in conjunction with the available information on the section 4(a)(1) factors was then synthesized to determine an overall risk of extinction for *H. nobilis*.

The appropriate time horizon for evaluating whether a species is more likely than not to be at a high level of risk in the "foreseeable future" depends on various case-and species-specific factors. For example, the time horizon may reflect certain life history characteristics (e.g., long generational time or late age-at-maturity) and may also reflect the time frame or rate over which identified threats are likely to impact the biological status of the species (e.g., the rate of disease spread). The appropriate time horizon coincides with the period of time over which reliable projections can be made as to the specific threats facing the species as well as the species' response, but it is not limited to the period that status can be quantitatively modeled or predicted within predetermined limits of statistical confidence. Reliable projections may be qualitative in nature.

The "foreseeable future" for this extinction risk analysis was considered to extend out several decades (>30 years). Given the species' life history traits, with longevity estimated to be several decades, age of sexual maturity ranging from three to seven years, density-dependent reproduction and potentially low rates of recruitment, it would likely take more than a few decades (i.e., multiple generations) for any recent management actions to be realized and reflected in population abundance. Similarly, the impact of present threats to the species could be realized in the form of noticeable population declines within this timeframe, as demonstrated in the available survey and fisheries data (see **Populations and Abundance** section). As the main potential operative threats to the species are overutilization and the inadequacy of existing regulatory mechanisms, this timeframe would allow for reliable predictions regarding the impact of current levels of fishery-related mortality on the biological status of the species. Additionally, this time frame allows for consideration of the previously discussed impacts on habitat from climate change while the significance of these effects are still uncertain.

Demographic Risk Analysis

Threats to a species' long-term persistence, such as those evaluated in the **Analysis of the ESA Section 4(A)(1) Factors** section of this review, are manifested demographically as risks to its abundance, productivity, spatial structure, connectivity, genetic and ecological diversity. These demographic risks thus provide the most direct indices or proxies of extinction risk. In this section, the current status of each of these risks is assessed by evaluating the species demographic factors adapted from McElhany et al. (2000). These demographic factors are based on general conservation biology principles applicable to a wide variety of species.

Abundance

As discussed in the **Abundance and Trends** section of this status review, throughout the range of *H. nobilis,* the species is either considered less abundant, or its status is unknown based on a lack of data, with the exception of the Seychelles (see **Table 1**). In fact, in 18 of the 25 countries where *H. nobilis* is reported to occur, the abundance of the species and trends in abundance are unknown due to a lack of data. Based on the available data, *H. nobilis* occurs throughout the Indian Ocean, including along the east coast of Africa, the Red and Arabian Seas, the coastal waters of Madagascar and the west coast of India. Similar to other teatfish species, *H. nobilis* is thought to be naturally rare when compared to other species of sea cucumber (Purcell, pers. comm. 2019 in CITES 2019; CITES 2019; Conand et al. 2013; Uthicke et al. 2004).

H. nobilis has not been reported to be extirpated from any range countries but has been observed to no longer occur at several survey locations across its range, including Geyser Bank in Mayotte and Eel Garden in Egypt (see **Table 1**; CITES 2019; Conand et al. 2013; Uthicke et al. 2004). Throughout the species range, the historical abundance of *H. nobilis* is uncertain, but the abundance of other sea cucumber species have declined (Kinch et al. 2008; Hasan and El-Rady, 2012; Friedman et al. 2011; Lane and Limbong, 2013; Ducarme 2016; FAO 2019). The available data indicates population declines or possible population declines of *H. nobilis* in Chagos, Egypt, Madagascar, Mayotte, Saudi Arabia, and Tanzania. In Chagos at Salomon atoll, there was a decrease in density from 83 ind. ha^{-1} to 10 ind. ha^{-1} from 2002-2006 (Price et al. 2010). In Egypt, at Wadi Quny and Eel Garden in the Gulf of Aqaba the species was observed at densities of 0.7 ind. ha^{-1} and 1.3 ind. ha^{-1} respectively in 2002, but were not observed at these locations in 2006 (Hasan & El-Rady, 2012). However, confirmed reports of the species were made off Pharoan Island in April 2015 (Hasan & Johnson 2019) and *H. nobilis* has been reported to be commonly seen by divers as recently as 2019 in Egypt's waters (FAO 2019). For Madagascar, there are anecdotal reports that *H.*

nobilis is assumed to be depleted as very few specimens have been seen in the past several years (Conand pers. comm. 2010 in Conand et al. 2013). In Mayotte, the species was reported to be observed less frequently in 2016 than in 2005, 2012, and 2015, however, we do not have reported density numbers (Mulochau 2018; FAO 2019). Off the coast of Saudi Arabia, *H. nobilis* was not documented in 2004's harvested species but had been present in the harvest record from 1999-2003. However, in 2006 *H. nobilis* was observed at 3 of 18 surveyed sites along the coast of Saudi Arabia (Hasan 2008; Hasan 2009). For Tanzania, there are anecdotal reports that *H. nobilis* once previously dominated the sea cucumber fishery, but now it is reported to comprise a very small percentage of the total catch (Conand & Muthiga 2007). The abundance of *H. nobilis* in the Seychelles is reported to be stable (Conand et al. 2013, FAO 2019, CITES 2019).

Adult density is critical to the species' persistence because the species needs a sufficient density to successfully reproduce (Conand & Muthiga 2007; Purcell et al. 2010; Purcell et al. 2011). However, due to the limited species-specific information on *H. nobilis* throughout its range it is not possible to determine whether current densities are adequate to allow for successful reproduction. Research is required to determine minimum population densities for positive rates of population growth (Friedman et al. 2011). Overall, while some quantitative data are available, the abundance and density trends of *H. nobilis* across their range are poorly understood.

Productivity

Teatfish generally exhibit low natural mortality rates, low to moderate population growth rates, and variable success of larval survival and recruitment, resulting in generally low productivity (CITES 2019; FAO 2019). While larger individuals may be considered highly fecund, teatfish experience high levels of larval mortality (Uthicke, 2004; FAO 2019). Additionally, successful reproduction is highly dependent on adult density (Conand & Muthiga 2007; Purcell et al. 2010; Purcell et al. 2011). How productivity may affect the extinction risk of *H. nobilis* specifically is challenging to determine given the lack of species-specific information. As stated above, there have been documented abundance declines (see **Table 1**) in Chagos (Saloman Atoll), Mayotte, Egypt (Wadi Quny and Eel Gardens in the Gulf of Aqaba), however, divers have reported commonly seeing *H. nobilis* in Egypt's waters. The remaining 22 range countries do not have species-specific abundance or population growth data. While population declines due to overharvest could negatively affect the species' reproduction and survival, we do not have the data to determine if this is currently affecting *H. nobilis*, as minimum population densities for successful reproduction have yet to be determined (Purcell et al. 2011).

Spatial Distribution and Population Structure

H. nobilis has a relatively large range, occurring throughout the Indian Ocean, including along the east coast of Africa, the Red and Arabian Seas, the coastal waters of Madagascar and the west coast of India (CITES 2019; Conand et al. 2013; Uthicke et al. 2004). While there have been reports of population declines, no widespread extirpations or a reduction of range have been reported. Additionally, no information is available on the population structure of *H. nobilis* within its range or the connectivity of populations throughout its range. We considered using other species of teatfish as a reference for connectivity. Skillings et al. 2014, discussed the connectivity of *H. whitmaei* and *H. atra* in the Hawaiian Islands and showed that species with similar range sizes do not predict relative dispersal ability. Both species appeared to share similar life history traits, similar minimum larval duration, occupy the same habitats, are both wide ranging, and are closely related, yet they did not have similar levels of population structuring based on analyses of their genetic data. Thus, differences in population structure may stem from subtle, species-specific differences in habitat usage, population size, or life history that also have large impacts on genetic structure (Skillings et al 2014). Given these species-dependent results, it would be inappropriate to use another species of teatfish as a proxy for determining if current spatial structure and connectivity of populations are contributing to the extinction risk of *H. nobilis*.

Genetic Diversity

As noted previously in the *Genetics and Population* section above, we could not find any information regarding *H. nobilis* specific genetic diversity. Without any genetic analyses to determine diversity or effective population size, we are unable to conclude whether low genetic diversity is a threat contributing to the species' risk of extinction.

Threats Assessment

According to Section 4 of the ESA and NMFS' implementing regulations, the Secretary (of Commerce or the Interior) determines whether a species is threatened or endangered as a result of any one or a combination of the following section 4(a)(1) factors: (A) destruction or modification of habitat, (B) overutilization, (C) disease or predation, (D) inadequacy of existing regulatory mechanisms, or (E) other natural or man-made factors. Collectively, we refer to these Section 4(a)(1) factors and the demographic risk factors discussed in the preceding section as "threats." Below, we summarize the impact of each threat identified in terms of its contribution to the extinction risk of the species using the following qualitative risk definitions:

- Low risk
    - Based on the best available information, it is unlikely this threat is causing negative impacts to the species at the population level throughout its range, such that it is not likely to be affecting extinction risk for the species.

- Moderate risk
    - Based on the best available information, this threat is likely causing negative impacts to the species at the population level in at least some portion of its range, such that it may be affecting extinction risk for the species.
- High risk
    - Based on the best available information, this threat is likely causing negative impacts to the species at the population level throughout its range, such that it is likely affecting extinction risk for the species.

Additionally, where the risk to the species is unknown due to lack of data the risk section will have a (U) for "Unknown."

Uncertainty

A confidence rating (CR) was given to the impact of each threat based on the available information. Below are the definitions of the confidence rating scores (adapted from the confidence ratings in Lack et al. (2014)):

- 0 (no confidence) = No information.
- 1 (low confidence) = Very limited information.
- 2 (medium confidence) = Some reliable information available, but reasonable inference and extrapolation required.
- 3 (high confidence) = Reliable information with little to no extrapolation or inference required.

Those threats where little to no information was available on the impact on the status of the species (e.g., where CR = 0 to 1), indicating significant uncertainty regarding the risk to the species, are highlighted in gray.

Individually, these threats may not significantly contribute to the extinction risk of the species. However, in combination with other threats that, for example, decrease the abundance of the species (e.g., overutilization) or potentially affect important life history functions, these threats may exacerbate the impact of the other threats on the status of the species. We discuss how the combination of the identified threats are affecting the overall extinction risk of the species in the following section of this report.

Table 1 Assessment of demographic and threat factors for H. nobilis.

Factor	Threat	Risk	Confidence Rating
Demographic Factors	Abundance	U	1
	Productivity	U	1
	Spatial Distribution/Spatial Connectivity	U	1
	Genetic Diversity	U	0
Factor A	Destruction and Modification of Habitat	U	1
Factor B	Overutilization	Moderate	2
Factor C	Disease/Predation	U	0
Factor D	Inadequate Regulatory Mechanisms	Moderate	2
Factor E	Other Natural or Manmade Factors	U	0

Overall Risk of Extinction

Guided by the results of the demographic risk analysis and the Section 4(a)(1) factors above, we analyzed the overall risk of extinction of *H. nobilis* throughout its range. In this process, we considered the best available scientific and commercial information regarding *H. nobilis* across its range, including associated uncertainties, and analyzed the collective condition of its populations to assess the species' overall extinction risk.

Despite much uncertainty due to limited information, it is likely that *H. nobilis* will continue to experience declining trends in its abundance and productivity in the foreseeable future, specifically due to continued overutilization and the lack of enforcement of existing regulatory mechanisms.

Information on the status of teatfish stocks in general does not indicate any wide-spread extirpations or a reduction of range, although declines in densities of teatfish were reported from time series and snap-shot studies (Kinch et al. 2008; Hasan and El-Rady, 2012; Friedman et al. 2011; Lane and Limbong, 2013; Ducarme 2016; FAO 2019). For *H. nobilis* specifically, declines were recorded in several locations, including Chagos, Egypt, Madagascar, Mayotte, Saudi Arabia, and Tanzania. Additionally, a few site-specific surveys within these countries' waters noted an absence of the species; however, the species was still present in other survey locations within those countries. For example, while *H. nobilis* was not found during surveys at Eel Gardens, Egypt, in 2003 or 2006 (Hasan & Abd El-Rady, 2012), the species was recorded as having a population density of 0.66 ind. ha-1 for Egypt in 2004 (Lawrence et al. 2004) and there is current anecdotal data that state the species is still commonly seen by divers (FAO 2019). Thus, where there are available species-specific data, they are largely insufficient to draw any firm conclusions regarding the species' status within these locations.

Most of the available data only provide snap shots of the species (e.g, density at a certain location and point in time) and do not allow for species-specific trend analyses across most of *H. nobilis'* range. Additionally, where data do indicate species decline, there are insufficient data on what *H. nobilis* densities should be to ensure reproductive success and sustainable populations. For example, in Chagos, the mean density of *H. nobilis* reported for Salomon atoll declined from 83 ind. ha^{-1} in 2002 to 10 ind. ha^{-1} in 2006, with the authors of the survey indicating concern for the species. Yet, the mean density for the Seychelles was reported as 2.0 ind. ha^{-1}, with this population considered to be under exploited (Aumeeruddy & Conand 2008). However, for most of the range, specifically 18 of the 25 countries where *H. nobilis* is reported to occur, species-specific information on the current as well as historical densities are unknown.

Although *H. nobilis* is considered a 'high value' species, reliable catch or trade data for *H. nobilis* are limited. Most of the available data are not species specific but pertain to sea cucumbers, in general, which includes approximately 1700 extant species, making it difficult to parse out or determine the impacts of threats on *H. nobilis*, the species' response, and current status. Additionally, we could not find catch or trade data that show *H. nobilis* is the main species targeted throughout its range. In the Maldives and Mozambique, it is reported that *H. nobilis* is one of the top three fished sea cucumber species. In Oman, *H. scabra* was the main targeted sea cucumber species, and in Madagascar *H. nobilis* is only thought to be 'limitedly harvested' with *H. fuscogilva* the targeted species.

Furthermore, our ability to make reliable predictions of the impacts of threats and *H. nobilis*' response into the future is limited by the variability in not only the quantity and quality of available data across the species' range regarding its occurrence and the potential impacts to the species from ongoing and predicted threats, but also by the high amount of uncertainty in how *H. nobilis* may respond to those threats, given that the demographic information for this species is severely limited. We recognize that a number of sea cucumber species are overfished, but being overfished is not necessarily equivalent to being at risk of extinction.

Due to the limitations of the available data, including sparse species-specific information hindering status and trend analyses, significant uncertainty regarding the identification and magnitude of potential threats to the species throughout most of its range, and a lack of demographic data to assess how *H. nobilis* is or may respond to these threats, we are unable to determine, with any confidence, the impact of identified potential threats on the status of the species presently or in the foreseeable future. Thus, we find that the best available commercial and scientific data available do not support a conclusion that *H. nobilis* is at moderate or high risk of extinction currently or in the foreseeable future.

Significant Portion of its Range (SPR) Analysis

Under the ESA, a species may be listed if it is in danger of extinction or likely to become so within the foreseeable future throughout all or a significant portion of its range. Although the available data do not support a conclusion that *H. nobilis* is at risk of extinction currently or in the foreseeable future based on the rangewide assessment, we examined whether there are any portions of the species' range where *H. nobilis* may be facing elevated extinction risk, and whether any such portions qualify as "significant portions" in order to determine whether the species may qualify for listing on the basis of its status within a portion of its range.

The Final Policy on Interpretation of the Phrase ''Significant Portion of Its Range'' in the Endangered Species Act's Definitions of ''Endangered Species'' and ''Threatened Species''("SPR Policy,"79 FR 37578, July 1, 2014), has partially guided this assessment. Under the SPR Policy, we must determine whether there is substantial information indicating that (1) any portions may be "significant" and (2) the species may be in danger of extinction in those portions or likely to become so within the foreseeable future. The order in which these determinations are made is flexible and typically determined based on the nature of the available information or circumstances for the particular species.

With respect to *H. nobilis*, we first examined information relevant to making the second determination by considering whether there may be a concentration of threats in portions of the range and whether the species is at risk of extinction within those portions. When evaluating the threats that *H. nobilis* faces we considered overutilization for international trade in bêche-de-mer and the lack of enforcement of existing regulatory mechanisms. These two factors are considered the main threats likely causing negative impacts to *H. nobilis* at the population level in at least some portions of its range (see **Table 4**).

Based on our review of the available data, these main threats appear to be largely widespread throughout *H. nobilis*' range. Sea cucumbers in general face the threats of overutilization and illegal harvest for the purpose of supplying bêche-de-mer to Asian markets. This demand is ubiquitous throughout the western Indian Ocean (i.e. the range of *H. nobilis;* see **Figures 8 and 10**). Given the wide-spread nature of these threats, we next considered whether the species may be responding differently in certain portions of its range to the point where it may be at risk of extinction from these threats within those portions.

Where species-specific information is available, the data show potential negative responses, as evidenced by population declines, in Chagos, Egypt, Madagascar, Mayotte, Saudi Arabia, and Tanzania. However, as stated previously in the extinction risk analysis, where data do indicate species-specific declines there is insufficient data to indicate the species is facing a risk of extinction in those locations. For example, in Chagos the mean density reported for Salomon atoll in 2002 was 83 ind. ha-1 and in 2006 was reported as 10 ind. ha-1. Although this decline to 10 ind. ha-1 could potentially be a cause for concern, in the nearby Seychelles, a mean density of 2.0 ind. ha-1, reported during a 2003-2004 survey, was considered to represent an under exploited *H. nobilis* population. Additionally, there are only anecdotal data for declines in Tanzania and Madagascar. Without additional information on minimum density thresholds or the reproductive potential or current productivity of *H. nobilis*, the available information does not allow us to conclude that these populations may be in danger of extinction. Furthermore, sea cucumber fishing is currently prohibited in Egypt (first in 2001-2002 and reinstated in 2003), Mayotte (since 2004), Saudi Arabia (since 2006), and Tanzania (since 2006). While illegal and unregulated fishing is an issue for sea cucumbers, these fishing bans are likely reducing fishing pressure on the species, and, thus, potentially decreasing the species' risk of extinction in these areas.

While there are limited data for the locations listed above, demographic data to determine how *H. nobilis* may be responding to these threats are largely lacking. As a result, we are unable to determine the extinction risk of *H. nobilis* in any portion of its range. Thus, we are unable to conclude that the species may be at a moderate or high risk of extinction in any portion of its range or likely to become so within the foreseeable future. Because we have made this determination, we did not separately examine whether any portions qualify as "significant." Furthermore, such an analysis would likely be challenged by the same type of data limitations, such as lack of understanding of population structure, population connectivity, and species-specific abundance data, and as a result, prevent a conclusion regarding whether any portions are biologically important such that they qualify as "significant portions" of the species' range.

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