APPENDIX: *Millepora boschmai* (De Weerdt and Glynn, 1991)

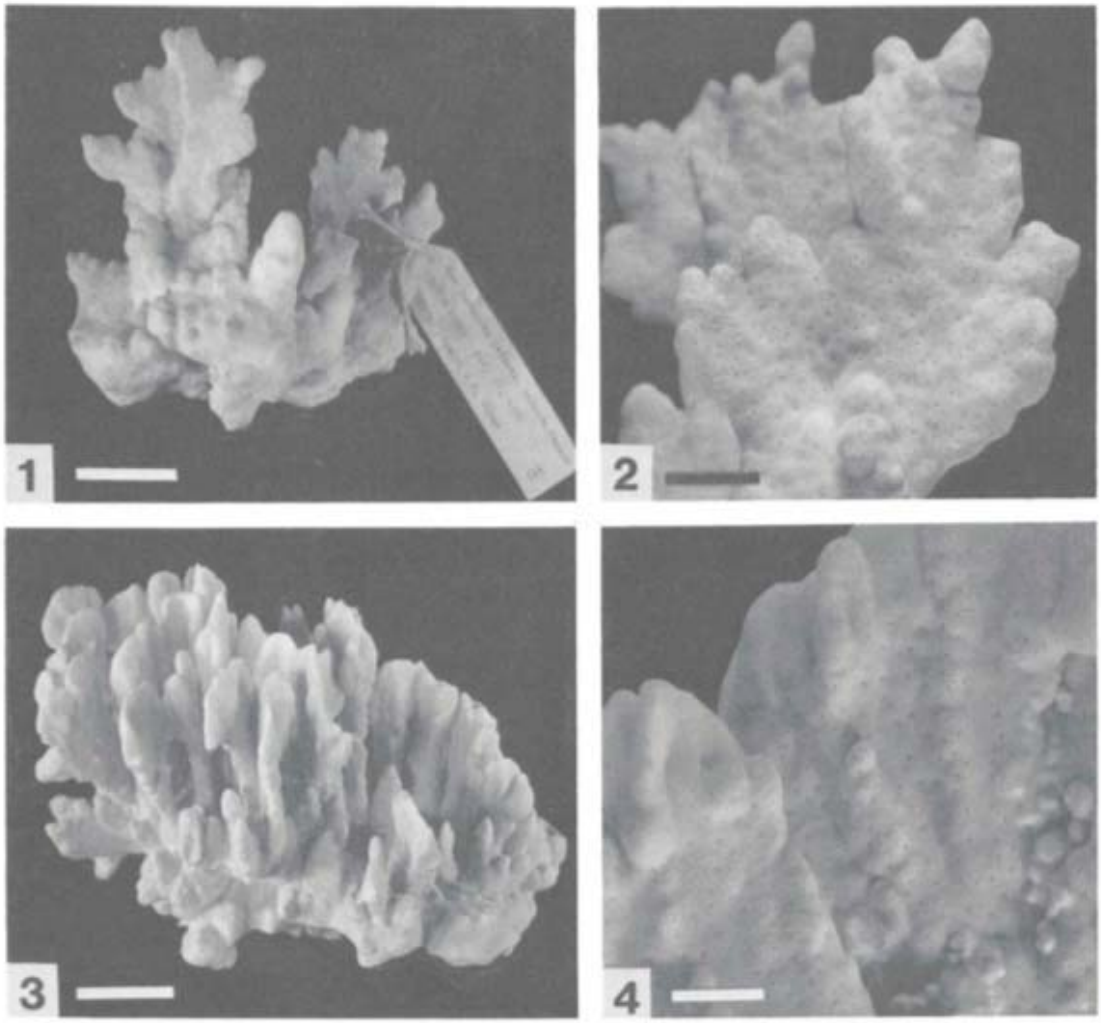

Figure A.1. Photos of *Millepora boschmai* skeletons used in the description of the species (de Weerdt and Glynn, 1991).

Millepora boschmai is a species of hydrocoral in the eastern Pacific that may have already gone extinct as a result of thermal-stress induced bleaching. While not a candidate species, the BRT determined that it would be valuable to assess the degree of extinction risk in this species to provide context for interpreting the voting results of the candidate species.

Characteristics

Shape and size: irregularly encrusting base from which arise plate-like outgrowths to 12 cm high and 0.5–1 cm thick. The plates are somewhat irregular in outline and usually increase in width distally, where they are irregularly, sometimes rather deeply, indented. Lateral plate-like extensions occasionally develop in between the plates, forming weakly developed box-like frameworks. Coralla of intermediate size, probably not exceeding 30 cm in overall height, 30 cm in length and 17 cm in width. Surface is generally smooth, sometimes a little warty (de Weerdt and Glynn, 1991).

Taxonomy

Taxonomic issues: Six specimens collected in Sumba and South Sulawesi, Indonesia were recently attributed to this species (Razak and Hoeksema, 2003). Such an anomalous distribution requires taxonomic follow up to confirm or refute conspecific status.

Class: Hydrozoa, Order Milleporina, Family Milleporidae

Evolutionary and geologic history: De Weerdt and Glynn (1991) first described this species from the eastern Pacific where it is one of only a few milleporid species, almost all of which are most closely related to Indo-Pacific forms. They identified this strong affinity with the Indo-pacific as being either due massive Eocene and Pleistocene extinctions in the eastern Pacific followed by reintroduction of Indo-West Pacific species by long-distance dispersal, or survival of some coral populations in eastern Pacific refugia after the closure of the Isthmus of Panama, providing the source for recolonization of places close enough to these refugia (see Rosen (1988) for a review of the different theories).

Global Distribution

This species was only found in the Gulf of Chiriquí, Panama (de Weerdt and Glynn, 1991), and most recently specimens from Indonesia were identified as *Millepora boschmai* (Razak and Hoeksema 2003). Its range is very restricted and highly fragmented.

Before 1983, the species was also reported to occur at Contreras Islands, Secas Islands, Coiba Island and Bahía Honda, Panama (de Weerdt and Glynn, 1991). No confirmed living animals are known, although animals possibly conspecific with this species have recently been reported from Indonesia. The species was initially recorded from a single location at Coiba Island, Panama and known only from the Gulf of Chiriqui; that subpopulation was regarded as extinct following the 1982/83 El Niño; however, a second subpopulation was later found off Uva Island. With the subsequent extinction of the Uva Island subpopulation following the 1997/98 El Niño, this species may now be extinct. Despite intensive searches no further living specimens have been found within the region. Observed population decline since 1982 in the eastern Pacific region is therefore estimated as 100% (IUCN 2008). According to Razak and Hoeksema (2003), *Millepora boschmai* may so far have been overlooked in Indonesia and the Indo-West Pacific because it is relatively rare or because it is not well known (Razak and Hoeksema, 2003). However, many milleporids are easily confused and separated by relatively small morphological characteristics. With a lack of living material in the eastern Pacific it may never be known for certain if the Panama and Indonesian corals are the same species.

Figure A.2. *Millepora boschmai* distribution from IUCN copied from http://www.iucnredlist.org.

Habitat

Habitat: *Millepora* species are generally found in inshore areas characterized by turbidity, and exhibit a tolerance for siltation. *Millepora boschmai* in Panama were found in clear to moderately-sedimented bays protected from high surge.

Depth range: *Millepora boschmai* was reported from the upper forereef slope (2 m) to deep, sand and rubble slopes (18 m); however, it was most abundant at the reef base (5–6 m) and deeper outer slope to 12–15 m (de Weerdt and Glynn, 1991). No known deep refugia.

Abundance

This species was uncommon prior to 1982 and extremely rare between 1983 and 1997. It has not been found alive since 1998.

According to de Weerdt and Glynn (1991), *Millepora boschmai* was the least abundant of the three *Millepora* species known from the Gulf of Chiriquí. De Weerdt and Glynn (1991) reported the elimination of *Millepora boschmai* following the 1982/83 El Niño event. Detailed searches from 1984 through 1990 across the former range revealed only dead colonies (Glynn and Feingold, 1992). However, in the early 1990s eight live colonies were found in the Gulf of Chiriquí; five colonies at Uva Island (Glynn and Feingold, 1992), and three colonies at the north end of Coiba Island (Anonymous, 1993; Glynn and Colley, 2001; Glynn et al., 2001). However, after the 1997/98 ENSO event, all known colonies were dead (Glynn et al., 2001). Since then, no live colonies have been observed, despite targeted searches throughout the former distribution. The only species-specific population information available for this species is an estimate of a pre-1982 total population in the 100s (Glynn, 1997). However, there is evidence that overall coral reef habitat has declined, and this is used as a proxy for population decline for this species. This species is particularly susceptible to bleaching, disease, and other threats and therefore population decline is based on both the percentage of destroyed reefs and critical reefs that are likely to be destroyed within 20 years (Wilkinson, 2004). We assume that most, if not all, mature individuals will be removed from a destroyed reef and that on average, the number of individuals on reefs are equal across its range and proportional to the percentage destroyed reefs. Reef losses throughout the species' range have been estimated over three generations, two in the past and one projected into the future. (IUCN, 2010).

Life History

The reproductive characteristics of this species are unknown.

Threats

Thermal stress: *Millepora* are listed as having a severe susceptibility to bleaching (Marshall and Baird, 2000). This was borne out by the potential extinction during the 1997/98 El Niño.

Acidification: While no studies have been published on acidification impacts on this genus, *Millepora boschmai* is common on eastern Pacific reefs and near-reef habitats where the aragonite saturation state is naturally low due to upwelling (Abramovitch-Gottlib et al., 2003). This may imply that to some degree, this species can tolerate acidified water but the impact of acidification on growth has not been quantified. However, in most corals studied, acidification impairs growth (Langdon and Atkinson, 2005; Manzello, 2010) and, in the case of *Acropora palmate*, impairs fertilization and settlement success (Albright et al., 2010) and is likely to contribute to reef destruction in the future (Hoegh-Guldberg et al., 2007; Silverman et al., 2009). While ocean acidification has not been demonstrated to cause appreciable declines in coral populations so far, the BRT considers it to be a significant threat to corals by 2100.

Disease: Susceptibility and impacts of disease on this species are not known. However, there is ample evidence that emerging diseases can have devastating regional impacts on individual coral species (e.g., (Aronson and Precht, 2001; Bruckner and Hill, 2009) and there is evidence that these impacts are occurring in more taxa and at a broader geographic scale (Green and Bruckner, 2000; Sutherland et al., 2004).

Predation: Genus not particularly susceptible to predation by crown-of-thorns seastars (*Acanthaster planci*).

Land-based sources of pollution (LBSP): The effects of LBSP on the genus *Millepora* are largely unknown. LBSP-related stresses often act in concert rather than individually, and are influenced by other biological (e.g., herbivory) and hydrological factors. Excess nutrients can disrupt corals physiologically (Dubinsky and Stambler, 1996; Fabricius, 2005), but community-level effects on corals are often indirect through competition with algae (McCook et al., 2001; Szmant, 2002). Toxic contaminants are capable of producing coral mortality, as well as disrupting cellular and reproductive processes (Peters et al., 1997). Hyposaline runoff can lead to bleaching and mortality (Coles and Jokiel, 1992). Sediment stress is a complicated response; most sediment impacts are negative (Rogers, 1990; Fabricius, 2005) though some corals are sediment-tolerant. Collectively, LBSP stresses are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales and reduce the resilience of corals to bleaching (Carilli et al., 2009; Wooldridge, 2009).

Collection/Trade: No trade information for this species was listed on the CITES Trade Database, UNEP World Conservation Monitoring Centre (CITES, 2010).

Risk assessment

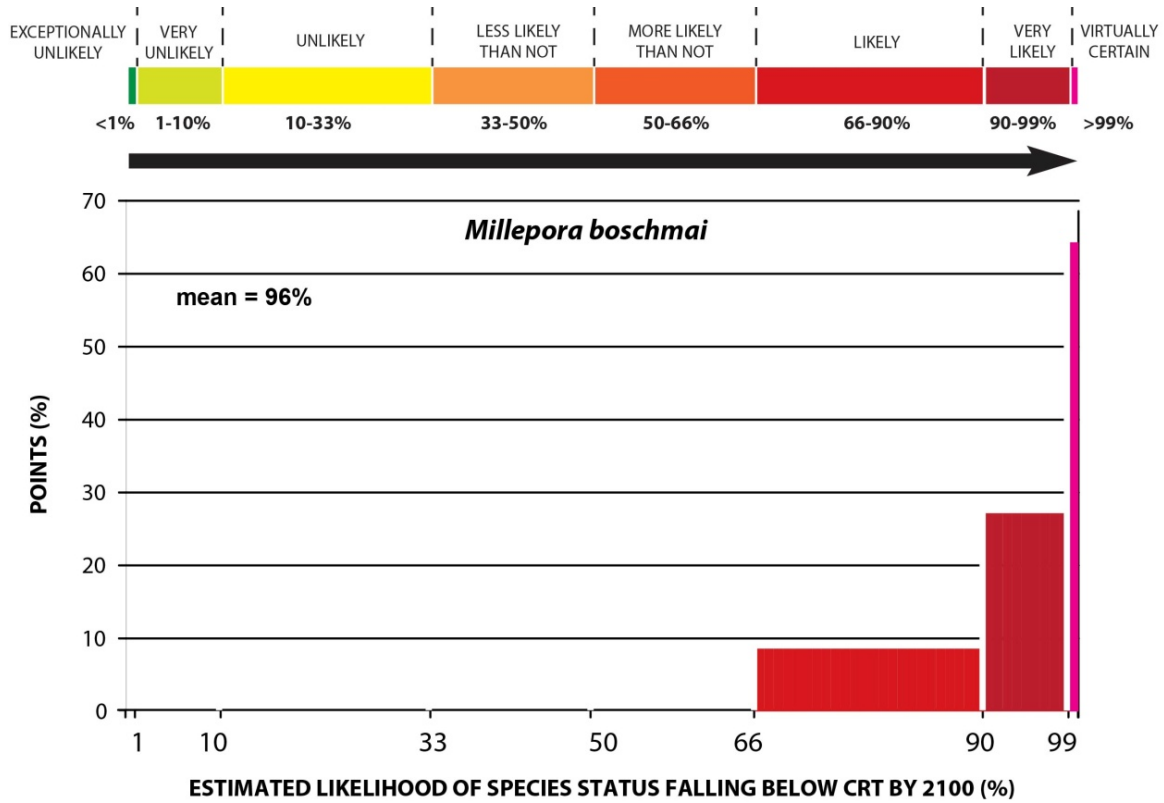

Figure A.3: Distribution of points to estimate the likelihood that the status of *Millepora boschmai* falls below the Critical Risk Threshold (CRT; the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

The BRT was not able to identify factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) for *Millepora boschmai*. Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Millepora boschmai* include its bleaching susceptibility, its extremely limited distribution, and the fact that, when it is found, it is always extremely rare.

In the discussion of this species, de Weerdt and Glynn (1991) discussed the risk posed to any coral endemic to the eastern Pacific:

> "Elements of the eastern Pacific reef coral fauna, consisting of several small, geographically isolated populations in a highly varying environment, would seem to be especially vulnerable to extinction (Wiebe et al., 1975; D'elia et al., 1981; Wolanski and Delesalle, 1995; Leichter et al., 1996; Lewis, 2006; Paytan et al., 2006; Carilli et al., 2010). ENSO events, which started about 2.8 million years ago after the rise of the Panama Isthmus (Ferrier-Pagès et al., 2010), and have since then occurred continuously but un-predictably (Glynn, 1990; Ferrier-Pagès et al., 2010), probably contribute to the poor development of eastern Pacific coral reefs (Glynn, 1990). Range reductions, which affected the hydrocoral *M. platyphylla* and possibly three scleractinian species (Glynn, 1990; Ferrier-Pagès et al., 2010), may therefore have occurred regularly in the eastern Pacific since the onset of said events. If *M. boschmai* was endemic to the Gulf of Chiriqui prior to its disappearance, recovery of the species seems highly unlikely, but this can only be ascertained in due time."

It is very likely that this species is already extirpated from the eastern Pacific, if not extinct, due to its susceptibility to bleaching events. Surveys around Uva and Coiba Island in Panama's Gulf of Chiriqui within the last two years turned up no living specimens (Glynn pers. comm.).

The overall likelihood that *Millepora boschmai* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "very likely" risk category with a mean likelihood of 96% and a standard error (SE) of 5% (Fig. A.3). This SE was calculated by taking the standard deviation of the seven mean voting scores of the BRT members and shows the coherence among the BRT. The uncertainty of the BRT is reflected in the range of votes of 66%-100% (Fig. A.3) and the average range of likelihood estimates of the seven BRT voters (14%).

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