7.6 Genus *Anacropora*

7.6.1 Anacropora puertogalerae Nemenzo, 1964

Figure 7.6.1. *Anacropora puertogalerae* photos from Veron (2000).

Characteristics

Colonies of *Anacropora puertogalerae* have compact branches, typically less than 13 mm in diameter and tapering. They have widely-spaced corallites, often with thin spines underneath. Colonies are pale brown in color, occasionally with white tips (Veron, 2000).

Taxonomy

Taxonomic issues: None. *Anacropora puertogalerae* is morphologically similar to *Anacropora spinosa* and *Anacropora forbesi* which has rounded branch tips and less developed spines (Veron, 2000).

Family: Acroporidae.

Evolutionary and geologic history: Morphologic taxonomy has been unable to resolve whether *Anacropora* are recently derived from *Montipora* or from *Acropora*, but genetic evidence supports the former view (Fukami et al., 2000).

Global Distribution

Anacropora puertogalerae has been reported throughout the Indo-Pacific, on the Great Barrier Reef in Australia, Fiji, Indonesia, Japan, and other areas.

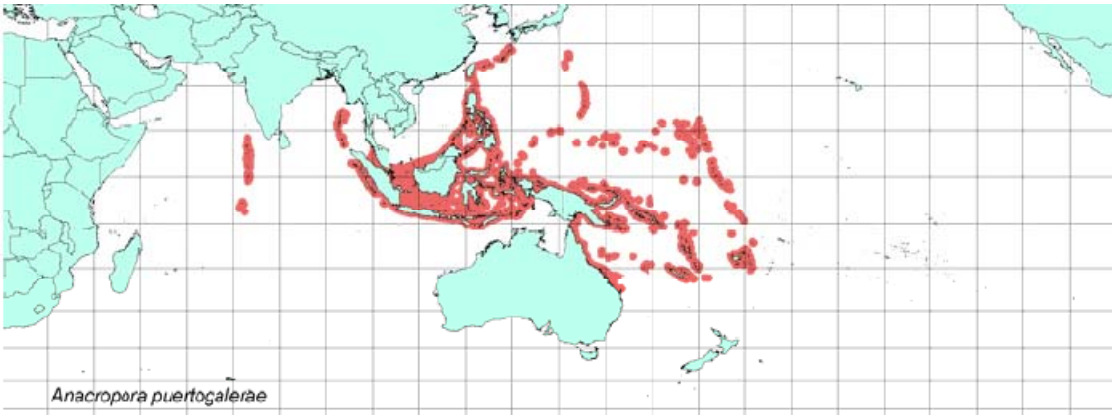

Figure 7.6.2. *Anacropora puertogalerae* distribution from IUCN copied from http://www.iucnredlist.org.

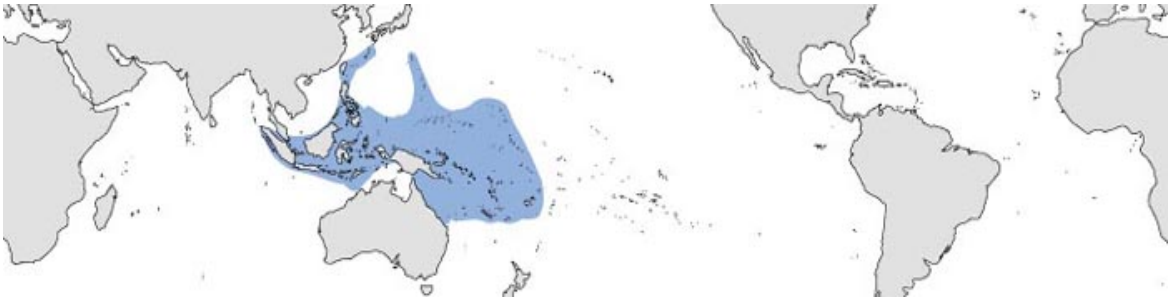

Figure 7.6.3. *Anacropora puertogalerae* distribution from Veron (2000).

U.S. Distribution

According to the IUCN Species Account, *Anacropora puertogalerae* has been reported to occur in the Northern Mariana Islands, but no supporting references were given. The CITES species database does not include any record of occurrence in U.S. waters. However, the Marianas record is likely an error based on a geographical error regarding photographic records (Kenyon et al., 2010b). G. Paulay (University of Florida, Gainesville, FL. pers. comm., 28 February 2010) indicates a number of photos submitted by him to Veron from Palau, the Cook Islands, and other locations in the Pacific were mistakenly attributed to Guam (similar to the *errata* later acknowledged by Veron (2002) for *Acanthastrea regularis* and *Porites napopora*).

Anacropora puertogalerae has not been recorded in federally protected U.S. waters.

Habitat

Habitat: *Anacropora puertogalerae* has been reported to occupy shallow reef environments (Veron, 2000), though it has also been found separated from reefs (Veron, 1995).

Depth range: *Anacropora puertogalerae* has been reported in water depths ranging from 5 m to 20 m (Carpenter et al., 2008).

Abundance

Abundance of *Anacropora puertogalerae* has been reported as uncommon (Veron, 2000) but can form large thickets in the Philippines (IUCN, 2010).

Life History

Anacropora puertogalerae has been reported to be a simultaneous hermaphrodite (Bermas, 1996) and a broadcast spawner. Clonal structure suggests the species also reproduces by fragmentation (Ablan et al., 1997). No observations of the time of spawning have been reported in published literature. The minimum size and age of first reproduction have not been determined for any members of the genus *Anacropora* (Harrison and Wallace, 1990). Planula larvae contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis (Baird et al., 2009), i.e., they are autotrophic. Larval longevity has not been determined in the genus *Anacropora*.

Growth of *Anacropora puertogalerae* has been reported to be primarily via linear extension (Bermas, 1996), although colonies can reach a maximum size of 300 cm diameter (Veron and Wallace, 1984).

Threats

Thermal stress: Although there is not much species-specific information about the response of *Anacropora puertogalerae* to thermal stress, the bleaching susceptibility in the genus *Anacropora* seems to be variable. In 1998 in Palau, the genus had total mortality in some areas but was unaffected in others (Bruno et al., 2001). However, as a family acroporids are generally bleaching-susceptible.

Acidification: No specific research has addressed the effects of acidification on the genus *Anacropora*. However, experiments on acidification impacts have demonstrated negative effects on other members of the family Acroporidae, including reduced *Acropora* calcification (Anthony et al., 2008; Renegar and Riegl, 2005; Schneider and Erez, 2006)

and productivity (Anthony et al., 2008) and, in *Acropora palmata,* impaired fertilization and settlement success (Albright et al., 2010). In general, most corals studied have shown negative relationships between acidification and growth (Table 3.2.2), and acidification 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 have caused 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 *Anacropora puertogalerae* are not known. However, ample evidence indicate that 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: *Anacropora puertogalerae* have been reported to be preyed on by wrasses, in proportion to availability (Cole et al., 2010). However, population-level effects remain unknown.

Land-based sources of pollution (LBSP): Some *Anacropora* species appear resistant to sediment and nutrients while others are susceptible (Mohammed and Mohammed, 2005). LBSP-related stresses (nutrients, sediment, toxins, and salinity) often act in concert rather than individually and are influenced by other biological (e.g., herbivory) and hydrological factors. Collectively, LBSP stresses are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales (particularly important for species with limited range) and reduce the resilience of corals to bleaching (Carilli et al., 2009a; Wooldridge, 2009b).

Collection/Trade: Trade in the genus *Anacropora* has been reported to be negligible, with only 14 pieces reported in export over the last decade (CITES, 2010). No species-specific export records exist for *Anacropora puertogalerae*.

Risk assessment

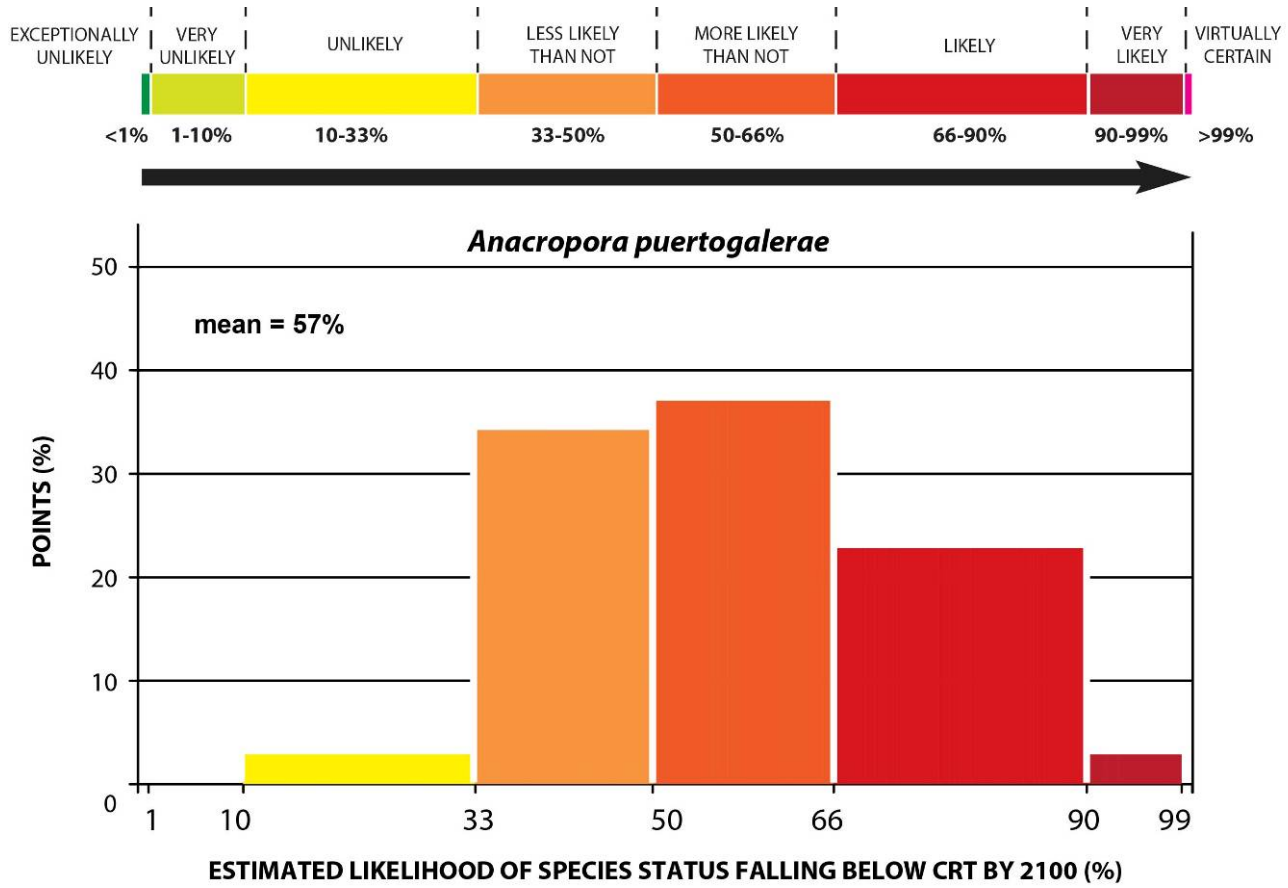

Figure 7.6.4. Distribution of points to estimate the likelihood that the status of *Anacropora puertogalerae* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below Critical Risk Threshold) for *Anacropora puertogalerae* are that the high susceptibility to threats common to members of the genus *Acropora* (bleaching, disease, and predation) are generally considered appropriate to species in the confamilial genus *Anacropora* as well. A factor that reduces potential extinction risk (decrease the likelihood of falling below Critical Risk Threshoild) was that *Anacropora puertogalerae* has a somewhat broad range.

The overall likelihood that *Anacropora puertogalerae* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "more likely than not" risk category with a mean likelihood of 57% and a standard error (SE) of 8% (Fig. 7.6.4). 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 10%–99% (Fig. 7.6.4) and the average range of likelihood estimates of the seven BRT voters (60%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for this *Anacropora puertogalerae*.

7.6.2 *Anacropora spinosa* Rehberg, 1892

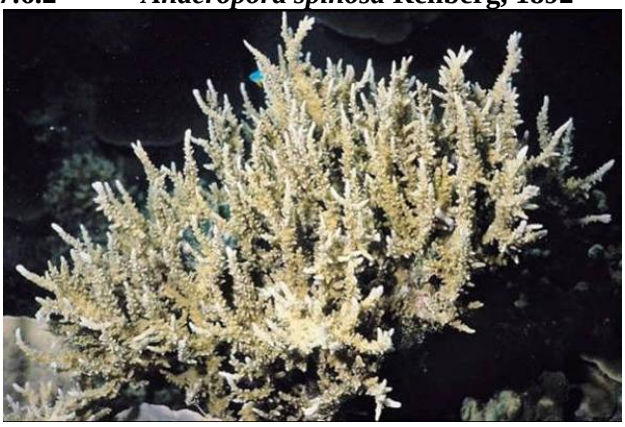

Figure 7.6.5. *Anacropora spinosa* photos from Veron (2000).

Characteristics

Colonies of *Anacropora spinosa* have compact branches, less than 10 mm in diameter and tapering. They have elongate, crowded, irregular corallites that are not strongly tapered but still have spines beneath. Colonies are pale brown in color, occasionally with white tips (Veron, 2000).

Taxonomy

Taxonomic issues: None. *Anacropora spinosa* is morphologically similar to *Anacropora puertogalerae,* which has thicker branches and more elongate, is less crowded, and has tapered spines (Veron, 2000).

Family: Acroporidae.

Evolutionary and geologic history: Morphologic taxonomy has been unable to resolve whether *Anacropora* were most recently derived from *Montipora* or from *Acropora*, but genetic evidence supports the former view (Fukami et al., 2000).

Global Distribution

Anacropora spinosa has been reported primarily in the Indo-Pacific, in Indonesia, Japan, and the Philippines. Unlike *Anacropora puertogalerae*, it has not been reported in Australia. However, there have been reports of *Anacropora spinosa* from Egypt (Mohammed and Mohammed, 2005).

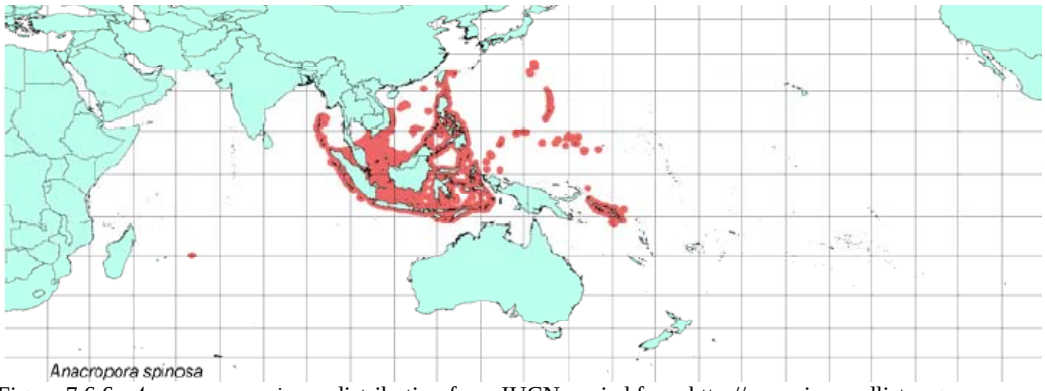

Figure 7.6.6. *Anacropora spinosa* distribution from IUCN copied from http://www.iucnredlist.org.

Figure 7.6.7. *Anacropora spinosa* distribution from Veron (2000).

U.S. Distribution

The CITES database does not list *Anacropora spinosa* in U.S. waters, although the IUCN species account lists it in the Northern Marianas. Veron (Veron, 2000) also lists it in the Marianas; however, the Marianas record is likely an error based on a geographical error regarding photographic records (Kenyon et al., 2010). G. Paulay (University of Florida, Gainesville, FL, pers. comm., 28 February 2010) indicates a number of photos submitted by him to Veron from Palau, the Cook Islands, and other locations in the Pacific were mistakenly attributed to Guam (similar to the *errata* later acknowledged by Veron (2002) for *Acanthastrea regularis* and *Porites napopora*).

Anacropora spinosa has not been recorded in federally protected U.S. waters.

Habitat

Habitat: *Anacropora spinosa* has been reported to occupy shallow reef environments (Veron, 2000), generally in clear or slightly turbid water and on soft substrates of lower reef slopes (IUCN, 2010). *Anacropora spinosa* has also been found separated from reefs (Veron, 1995).

Depth range: *Anacropora spinosa* has been reported in water depths ranging from 5 m to 15 m (Carpenter et al., 2008).

Abundance

Abundance of *Anacropora spinosa* has been reported as uncommon (Veron, 2000) but may occur in extensive tracts in certain areas (Wood, 1983).

Life History

Anacropora spinosa has been reported to be a simultaneous hermaphrodite that broadcast spawns mature gametes (Baird et al., 2009). No observations of the time of spawning have been reported in published literature. The minimum size and age of first reproduction have not been determined for any members of the genus *Anacropora* (Harrison and Wallace, 1990). Planula larvae contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis (Baird et al., 2009), i.e., they are autotrophic. Larval longevity has not been determined in this genus.

Threats

Thermal stress: Although there is not much species-specific information about the response of *Anacropora spinosa* to thermal stress, the bleaching susceptibility in the genus *Anacropora* seems to be variable. In 1998 in Palau, the genus had total mortality in some areas but was unaffected in others (Bruno et al., 2001). However, as a family, acroporids are generally bleaching-susceptible.

Acidification: No specific research has addressed the effects of acidification on the genus *Anacropora*. However, experiments on acidification impacts have demonstrated negative effects on other members of the family Acroporidae, including reduced *Acropora* calcification (Anthony et al., 2008; Renegar and Riegl, 2005; Schneider and Erez, 2006) and productivity (Anthony et al., 2008) and, in *Acropora palmata,* impaired fertilization and settlement success (Albright et al., 2010). In general, most corals studied have shown negative relationships between acidification and growth (Table 3.2.2), and acidification 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 have caused 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 *Anacropora spinosa* are not known. However, ample evidence indicates that 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: *Anacropora spinosa* have been reported to be preyed on by wrasses, in proportion to availability (Cole et al., 2010). However, population-level effects remain unknown.

Land-based sources of pollution (LBSP): *Anacropora spinosa* was found in Egypt to be not vulnerable to sedimentation or macroalgal interactions, in contrast to congener *Anacropora forbesi* (Mohammed and Mohammed, 2005). LBSP-related stresses (nutrients, sediment, toxins, and salinity) often act in concert rather than individually and are influenced by other biological (e.g., herbivory) and hydrological factors. Collectively, LBSP stresses are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales (particularly important for species with limited range) and reduce the resilience of corals to bleaching (Carilli et al., 2009a; Wooldridge, 2009b).

Collection/Trade: Trade in the genus *Anacropora* has been reported to be negligible, with only 14 pieces reported in export over the last decade (CITES, 2010). The only known export of *Anacropora spinosa* was a single specimen from Indonesia in 2005.

Risk Assessment

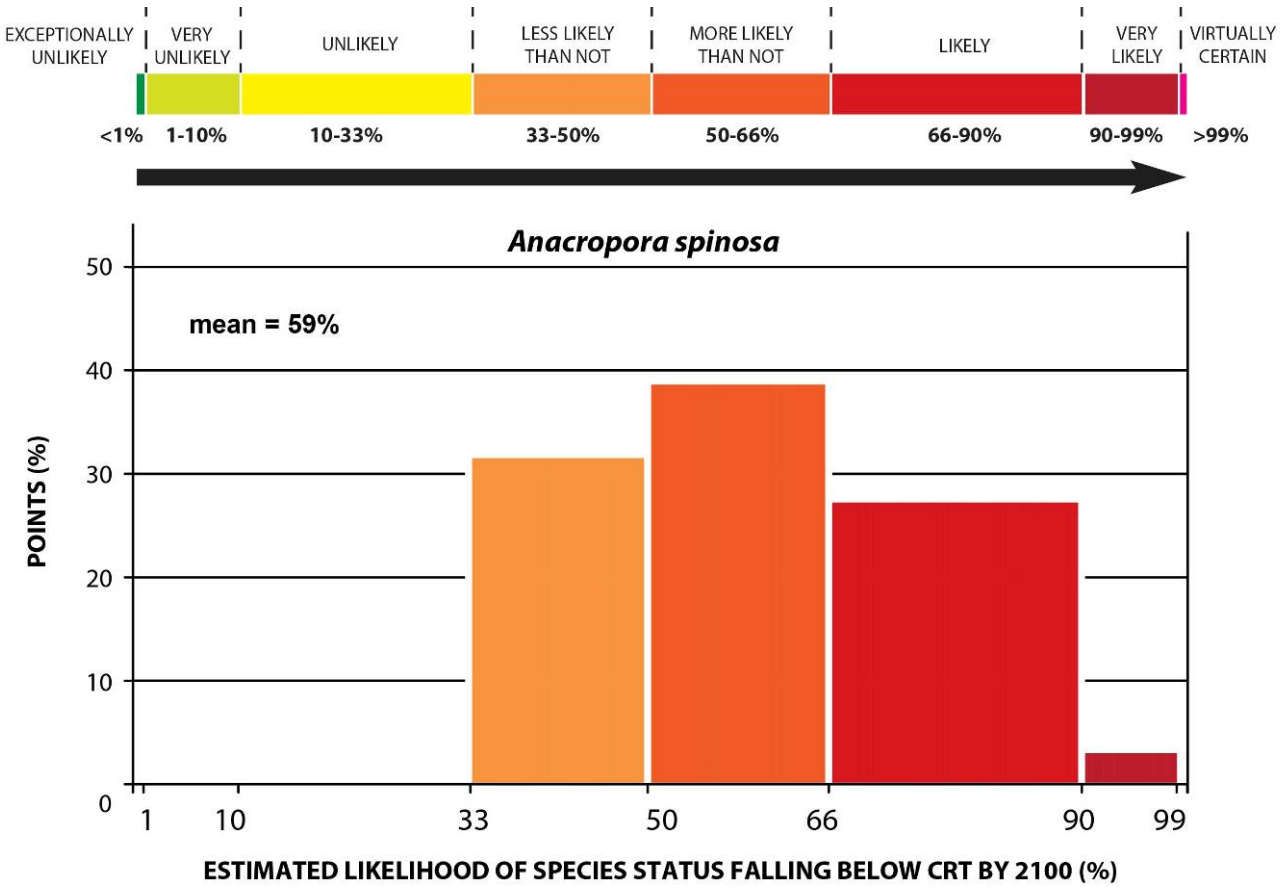

Figure 7.6.8. Distribution of points to estimate the likelihood that the status of *Anacropora spinosa* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below Critical Risk Threshold) for *Anacropora spinosa* are that the high susceptibility to threats common to members of the genus *Acropora* (bleaching, disease, and predation) are generally considered appropriate to species in the confamilial genus *Anacropora* as well. A factor that reduces potential extinction risk (decrease the likelihood of falling below Critical Risk Threshold) was that *Anacropora spinosa* has a moderately broad range, although it is more restricted and disjunct that its congener *Anacropora puertogalerae*.

The overall likelihood that *Anacropora spinosa* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "more likely than not" risk category with a mean likelihood of 59% and a standard error (SE) of 8% (Fig. 7.6.8). 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 33%–99% (Fig. 7.6.8) and the average range of likelihood estimates of the seven BRT voters (55%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Anacropora spinosa*.

7.7 Genus *Astreopora*

7.7.1 *Astreopora cucullata* Lamberts, 1980

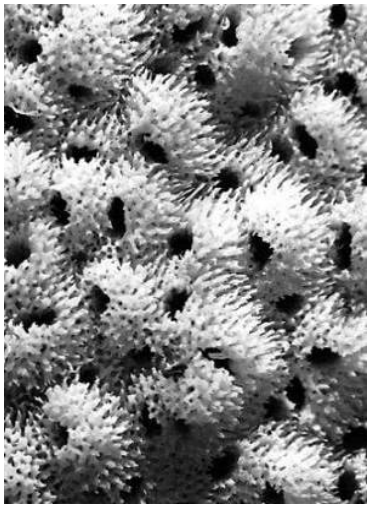

Figure 7.7.1. *Astreopora cucullata* photos from Veron (2000).

Characteristics

Astreopora cucullata has thick or encrusting platy colonies. They have irregular corallites that are immersed on concave surfaces but exsert on convex surfaces. The corallites are inclined, often with elliptical openings, and have papillae that may form a hood over the opening (Veron, 2000). Coenosteum forms distinctive hoods that can obscure parts of the calices (Lamberts, 1982). Colonies are pale brown or cream in color (Veron, 2000), tan or rust-colored (Lamberts, 1980).

Taxonomy

Taxonomic issues: None. *Astreopora cucullata* is similar to *Astreopora scabra* (Veron, 2000). Type specimen collected from Aua, Tutuila, American Samoa, on a slope at 3 m depth (Lamberts, 1980).

Family: Acroporidae.

Evolutionary and geologic history: *Astreopora* was the first of the genera in this family to occur, first appearing in the late Cretaceous (about 70 Ma) (Wells and Moore, 1956). The genus was formerly present in the Caribbean (Budd et al., 1992) but is now extinct.

Global Distribution

Astreopora cucullata has a broad distribution. Primarily it is found in the Indo-Pacific, including eastern Australia, Fiji, Indonesia, Japan, the Philippines, and Papua New Guinea. It may also be found in the Red Sea (IUCN, 2010).

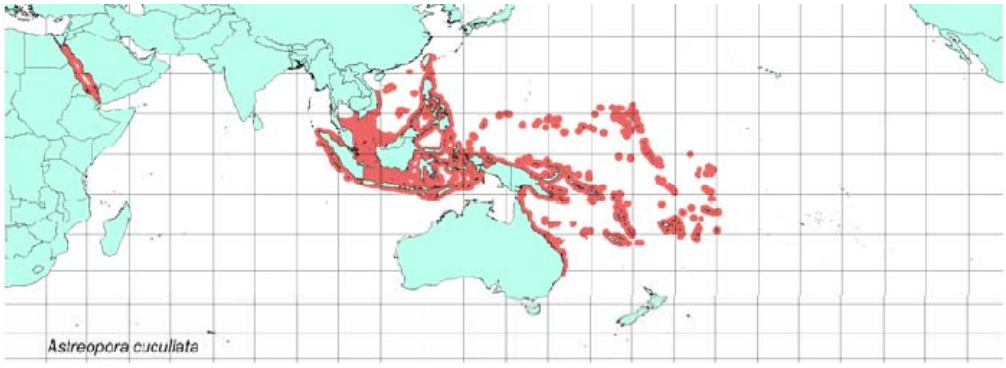

Figure 7.7.2. *Astreopora cucullata* distribution from IUCN copied from http://www.iucnredlist.org.

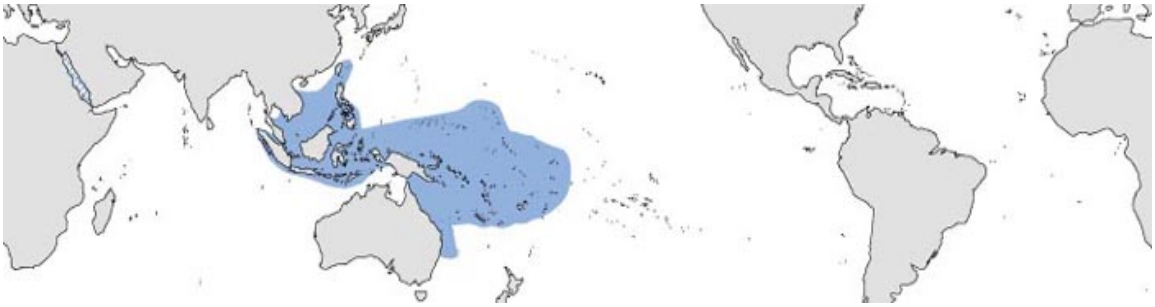

Figure 7.7.3. *Astreopora cucullata* distribution from Veron (2000).

U.S. Distribution

According to both the IUCN Species Account and the CITES species database, *Astreopora cucullata* occurs in American Samoa. The IUCN Species account lists it occurrence in the U.S. minor outlying islands, but the CITES species database does not.

A search of published and unpublished records of occurrence in U.S. waters indicates *Astreopora cucullata* has been reported from Tutuila, Ofu-Olosega, Ta′u, and Rose Atoll in American Samoa (Birkeland, unpubl. data; Coles et al., 2003; CRED, unpubl. data; Kenyon et al., 2010a; Lamberts, 1983; Maragos et al., 1994).

Within federally protected waters, *Astreopora cucullata* has been recorded from the following areas (Kenyon, 2010):

- National Park of American Samoa, Ofu Island unit
- Rose Atoll Marine National Monument

Habitat

Habitat: *Astreopora cucullata* has been reported to occupy protected reef environments (Veron, 2000).

Depth range: *Astreopora cucullata* has been reported in water depths ranging from 5 m to 15 m (Carpenter et al., 2008). The original species description noted it was only found at reef edges (Lamberts, 1980).

Abundance

Abundance of *Astreopora cucullata* has been reported as rare (Veron, 2000).

Life History

Reproductive characteristics of *Astreopora cucullata* have not been determined (Baird et al., 2009). However, the congeners *Astreopora gracilis*, *Astreopora myriophthalma*, and *Acropora listeri* are hermaphroditic broadcast spawners (Babcock et al., 1986; Babcock et al., 1994; Dai et al., 1992). The minimum size and age of first reproduction have not been determined for any members of the genus *Astreopora* (Harrison and Wallace, 1990). Although observations of larvae have not been published for this species, the larvae of *Astreopora myriophthalma* do not contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis (Baird et al., 2009), i.e., they are lecithotrophic. Larval longevity has not been determined in the genus *Astreopora*.

Growth rates are unknown, but colonies can be as large as 1 m across (Lamberts, 1980).

Threats

Thermal stress: Although there is not much species-specific information about the response of *Astreopora cucullata* to thermal stress, the genus Congeners can be bleaching-susceptible (ex: Goreau and Hayes, 1994), although overall *Astreopora* are less susceptible to bleaching than other genera within the acroporid family (Marshall and Baird, 2000) and often survive when they do bleach (McClanahan et al., 2004a).

Acidification: No specific research has addressed the effects of acidification on the genus *Astreopora*. However, most corals studied have shown negative relationships between acidification and growth (Table 3.2.2), and acidification 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 have caused 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 *Astreopora cucullata* are not known. Congeners have contracted a fungal disease in Kenya (McClanahan et al., 2004b), and *Astreopora myriophthalma* was infected with black-band disease at a polluted site in Jordan (Al-Moghrabi, 2001). Ample evidence indicate that 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: The specific effects of predation are unknown for *Astreopora cucullata*.

Land-based sources of pollution (LBSP): The specific effects of LBSP stresses are largely unknown for *Astreopora cucullata*. LBSP-related stresses (nutrients, sediment, toxins, and salinity) often act in concert rather than individually,and are influenced by other biological (e.g., herbivory) and hydrological factors. Collectively, LBSP stresses are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales (particularly important for species with limited range) and reduce the resilience of corals to bleaching (Carilli et al., 2009a; Wooldridge, 2009b).

Collection/Trade: Trade in the genus *Astreopora* has been reported to be light and sporadic (CITES, 2010). A single *Astreopora cucullata* export was reported from Saudia Arabia in 1999.

Risk Assessment

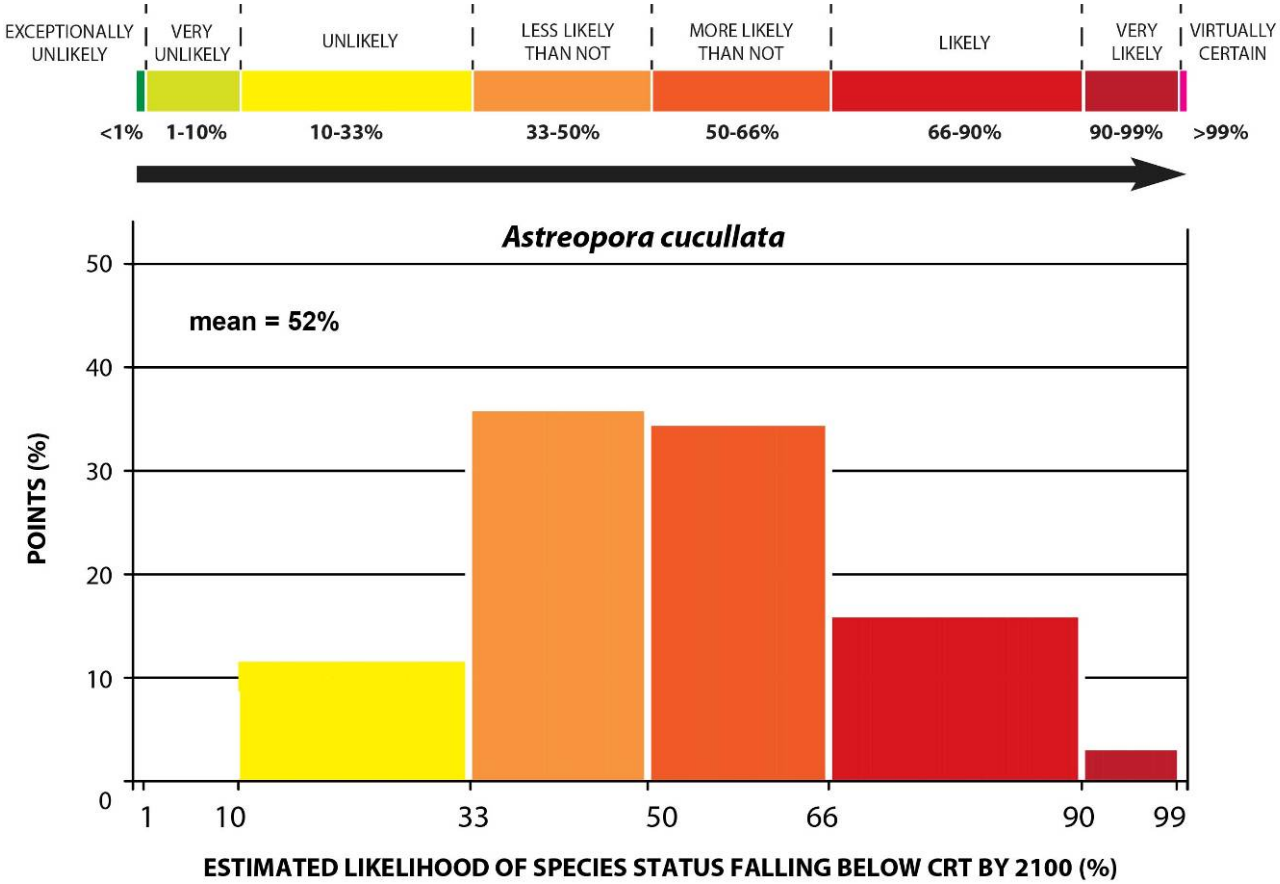

Figure 7.7.4. Distribution of points to estimate the likelihood that the status of *Astreopora cucullata* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Astreopora cucullata* are its rarity and that it belongs to a family that is highly susceptible to stress (bleaching, acidification, disease, predation, and pollution). Factors that reduce the potential extinction risk (lower likelihood of falling below the Critical Risk Threshold) are that is has a widespread distribution and appears to be less vulnerable to bleaching than other species in its family. The genus also survived the Cretaceous extinction.

The overall likelihood that *Astreopora cucullata* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "more likely than not" risk category with a mean likelihood of 52% and a standard error (SE) of 9% (Fig. 7.6.8). 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 10%–99% (Fig. 7.7.4) and the average range of likelihood estimates of the seven BRT voters (59%).

7.8 Genus *Isopora*

7.8.1 *Isopora crateriformis* Gardiner, 1898

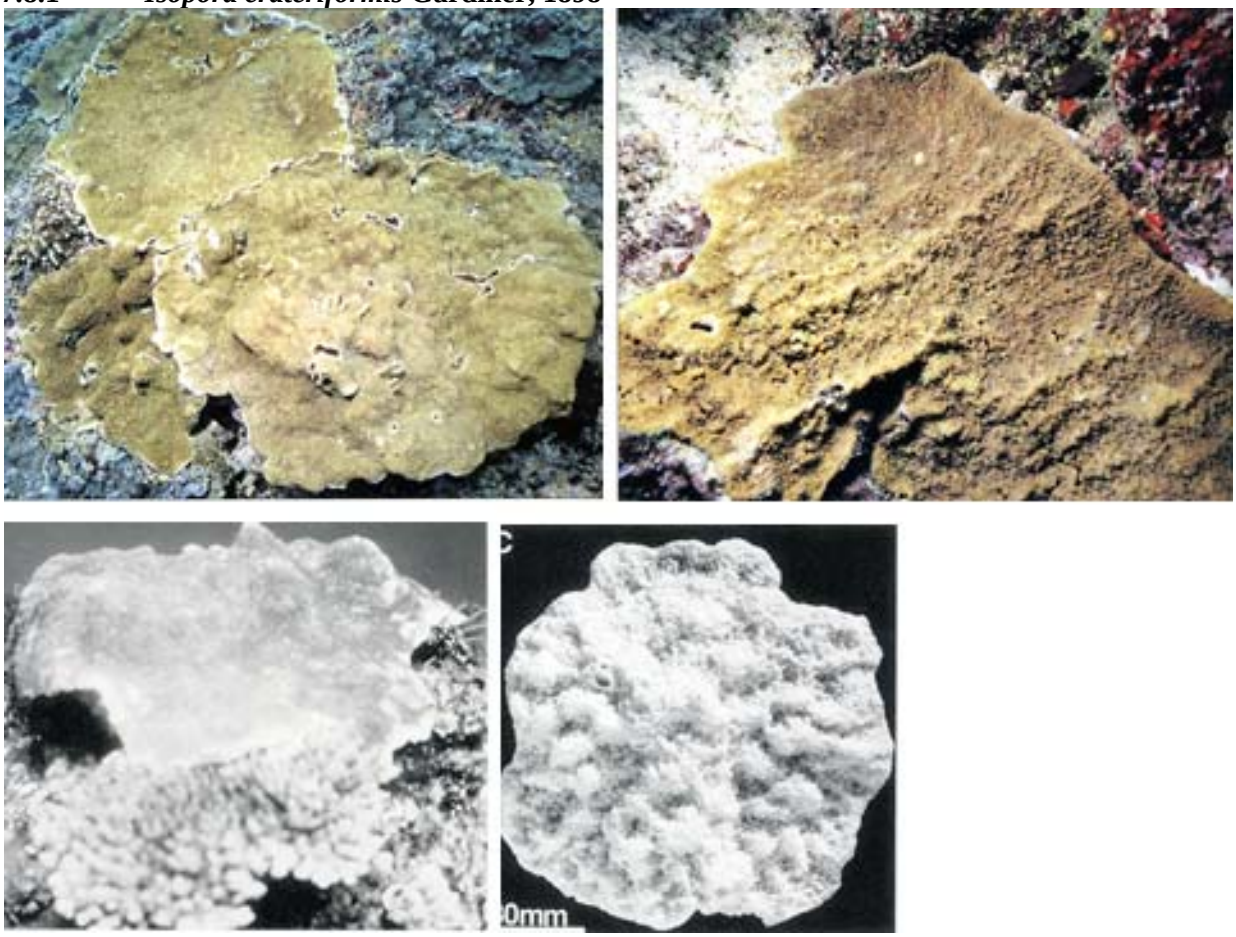

Figure 7.8.1. *Isopora crateriformis* copied from (*upper two photos*) Veron (2000) and (*lower two photos*) Wallace (1999). Note in lower left photo that *Isopora crateriformis* is overgrowing and outcompeting the alcyonacean (soft coral) *Sinularia* sp.

Characteristics

Isopora crateriformis forms flattened solid encrusting plates sometimes referred to as "cowpies." They can sometimes be over a meter in diameter. Colonies are brown in color (Veron, 2000).

Taxonomy

Taxonomic issues: None.

Family: Acroporidae.

Evolutionary and geologic history: Two extinct species of *Isopora* first appeared in the southern Caribbean fossil records about 5.9–4.6 Ma at the Miocene-Pliocene boundary, co-occurring with the extinct *Acropora saludensis* (Budd and Wallace, 2008). *Acropora palmata* first appeared in the early Pliocene (5.6–3 Ma) where it was found to co-occur with the two *Isopora* species and *Acropora cervicornis*. The *Isopora* species and two *Acropora* species were found in roughly equal numbers. *Isopora* also appeared in the fossil record in the Pacific in the Pliocene. *Isopora* went extinct in the Caribbean about 3–1 Ma (Budd and Wallace, 2008).

Isopora was formerly classified as a subgenus of *Acropora* based on morphology, but *Isopora* is thought to have evolved from *Astreopora* (Randall, 1981). Although it was formerly classified as a subgenus of *Acropora,* based on morphology,

Isopora has recently been considered a separate genus (Wallace et al., 2007), based on its significant genetic distance from *Acropora* (Fukami et al., 2000) and differences in its reproductive strategy (Kojis, 1986).

Global Distribution

Wallace (1999, cf Fig.7.8.3) and Veron (2000, cf Fig. 7.8.4) consider *Isopora crateriformis* to be found in areas stretching from Sumatra to American Samoa. Although *Isopora crateriformis* and *Isopora cuneata* are definitely distinct species, the two species can be very difficult to distinguish in the field when they are in the form of flat encrusting plates. One wonders if distributional records for *Isopora crateriformis* on the African coast and offshore islands based on field surveys might need to be confirmed.

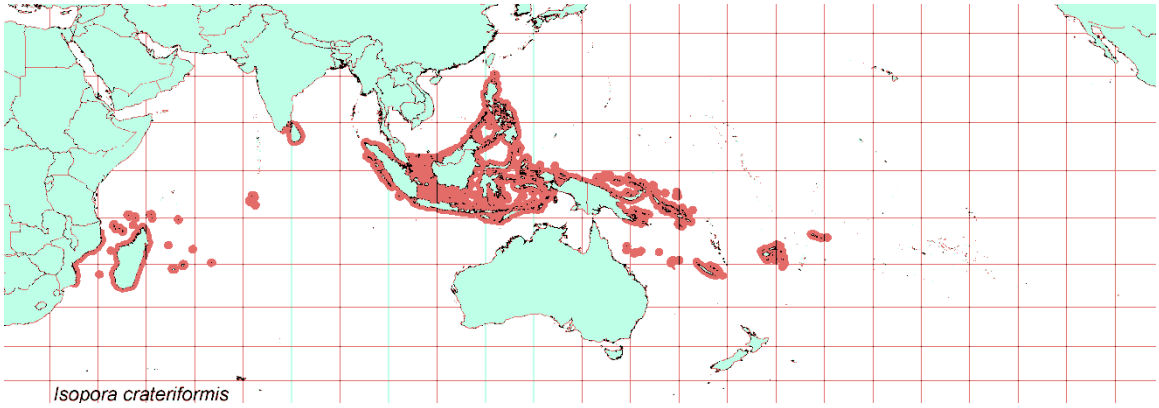

Figure 7.8.2. *Isopora crateriformis* distribution from IUCN copied from http://www.iucnredlist.org.

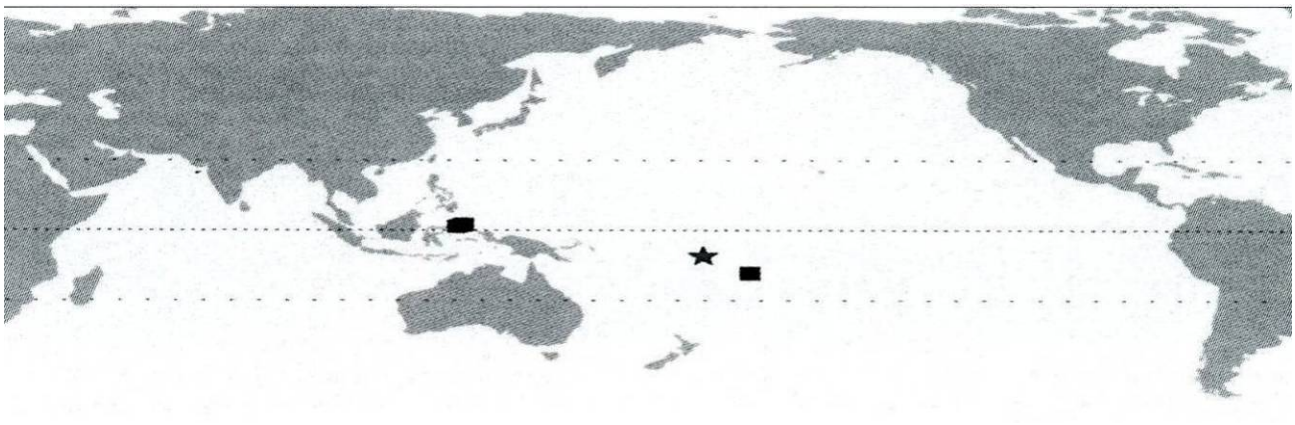
Figure 7.8.3. *Isopora crateriformis* distribution from Wallace (1999).

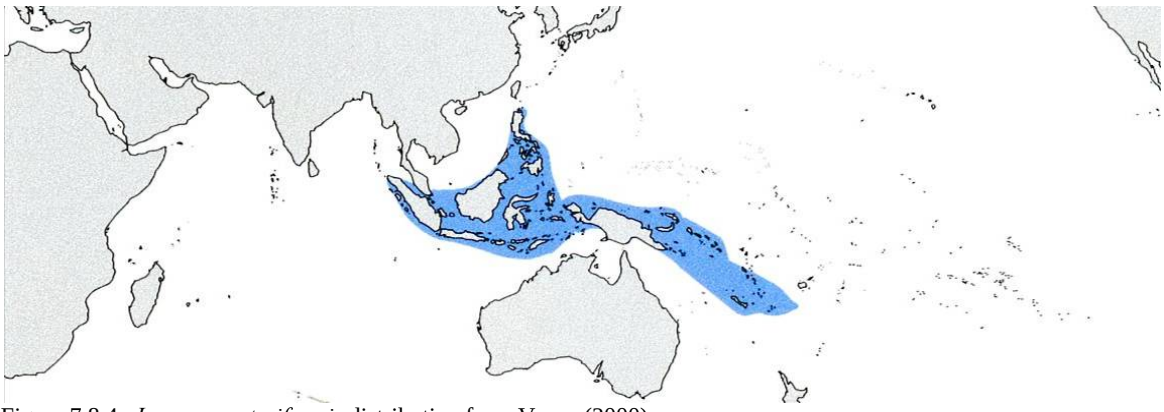
Figure 7.8.4. *Isopora crateriformis* distribution from Veron (2000).

U.S. Distribution

According to both the IUCN Species Account and the CITES species database, *Isopora crateriformis* occurs in American Samoa.

A search of published and unpublished records of occurrence in U.S. waters indicates *Isopora crateriformis* has been reported from Tutuila, Ofu-Olosega, and Ta′u in American Samoa (Birkeland, unpubl. data; Coles et al., 2003; CRED, unpubl. data; Fisk and Birkeland, 2002; Hoffmeister, 1925; Lamberts, 1983; Lovell and McLardy, 2008; Maragos, 1994; Mundy, 1996; National Park Service, 2009).

Within federally protected waters, *Isopora cratiformis* has been recorded from the following areas (Kenyon et al., 2010b):

- National Park of American Samoa, Tutuila, and Ofu Island units
- Fagatele Bay National Marine Sanctuary, Tutuila

Habitat

Isopora crateriformis is found most commonly in shallow, high-wave energy environments.

Depth range: *Isopora craterformis* has been reported in water depths ranging from low tide commonly to at least 12 m (Birkeland, 1987). The species was recently reported (as *Acropora crateriformis*) on mesophotic reefs (< 50 m depth) in American Samoa (Bare et al., 2010).

Abundance

Abundance of *Isopora craterformis* has been reported as sometimes common and occasionally locally abundant. *Isopora craterformis* has been reported as common in Indonesia (Veron, 2000) and as one of the most prevalent corals in American Samoa (Birkeland, 1987).

Life History

Isopora crateriformis is most likely a simultaneous hermaphroditic brooder as is the closely related *Isopora cuneata* (Bothwell, 1981). *Isopora cuneata* planulae lack zooxanthellae, and in some areas the species can undergo several seasonal cycles of larval production (Kojis, 1986). Its brooding life history allows *Isopora* spp. to locally dominate recruitment at Lord Howe Island, Australia; colonies of this genus also dominate the adult population there, suggesting brooding may drive community structure in remote areas (Harriott, 1992; 1995). *Isopora cuneata* is not prone to asexual reproduction via fragmentation, based on its semi-encrusting morphology (Bothwell, 1981). The species shows moderate gene flow (Mackenzie et al., 2004) but little potential for large-scale dispersal (Ayre and Hughes, 2004),

For additional family level information, see Section 7.5: Genus *Acropora*.

Threats

For each of these possible threats, see also Section 7.5: Genus *Acropora* for additional family level information.

Thermal stress: Although there is not much species-specific information about the response of *Isopora craterformis* to thermal stress, members of the family Acroporidae are consistently ranked among the coral genera as most severely susceptible to bleaching (Marshall and Baird, 2000; McClanahan et al., 2007; McClanahan et al., 2005a). However, the genera may have differential responses across regions during mass bleaching mortalities (McClanahan et al., 2004a). *Isopora crateriformis* tolerates high temperatures in shallow back-reef pools in American Samoa (Craig et al., 2001), but it is not abundant and acroporids do bleach in these habitats (Fenner and Heron, 2008). Although *Isopora crateriformis* was relatively resistant to bleaching in Fiji in 2000 (Lovell, 2000), bleaching poses a high risk to this family at a global scale.

Acidification: No specific research has addressed the effects of acidification on *Isopora crateriformis*. However, experiments on acidification impacts have all demonstrated negative effects on other members of the family Acroporidae, including reduced *Acropora* calcification (Anthony et al., 2008; Marubini et al., 2003; Renegar and Riegl, 2005; Schneider and Erez, 2006) and productivity (Anthony et al., 2008) and, in *Acropora palmata*, impaired fertilization and settlement success (Albright et al., 2010) In general, most corals studied have shown negative relationships between acidification and growth (Table 3.2.2), and acidification 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 have already caused appreciable declines in coral populations so far, the BRT considers it to be a significant threat to corals by 2100.

Disease: There is no species-specific information, although in general acroporid species are moderately to highly susceptible to disease. The ecological and population impacts of disease have not been established for this species. However, ample evidence indicate that diseases can have devastating regional impacts on individual coral species (e.g., (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 (Sutherland et al., 2004; Green and Bruckner, 2000).

Predation: Susceptibility of *Isopora crateriformis* to predation is inferred from the fact that most acroporids have been reported to be preferentially consumed by crown-of-thorns seastars, fish, and gastropods.

Land-based sources of pollution: (LBSP): The specific effects of LBSP stresses are largely unknown for *Isopora crateriformis*. LBSP-related stresses (nutrients, sediment, toxins, and salinity) often act in concert rather than individually and are influenced by other biological (e.g., herbivory) and hydrological factors. Collectively, LBSP stresses are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales (particularly important for species with limited range) and reduce the resilience of corals to bleaching (Carilli et al., 2009a; Wooldridge, 2009b).

C**ollection/Trade:** CITES treats *Isopora* as *Acropora* and has included data on export under the genus *Acropora*. As a whole, this genus is heavily involved in international trade with 50,000–270,000 reported exported pieces per year from Indonesia (CITES, 2010).

Risk Assessment

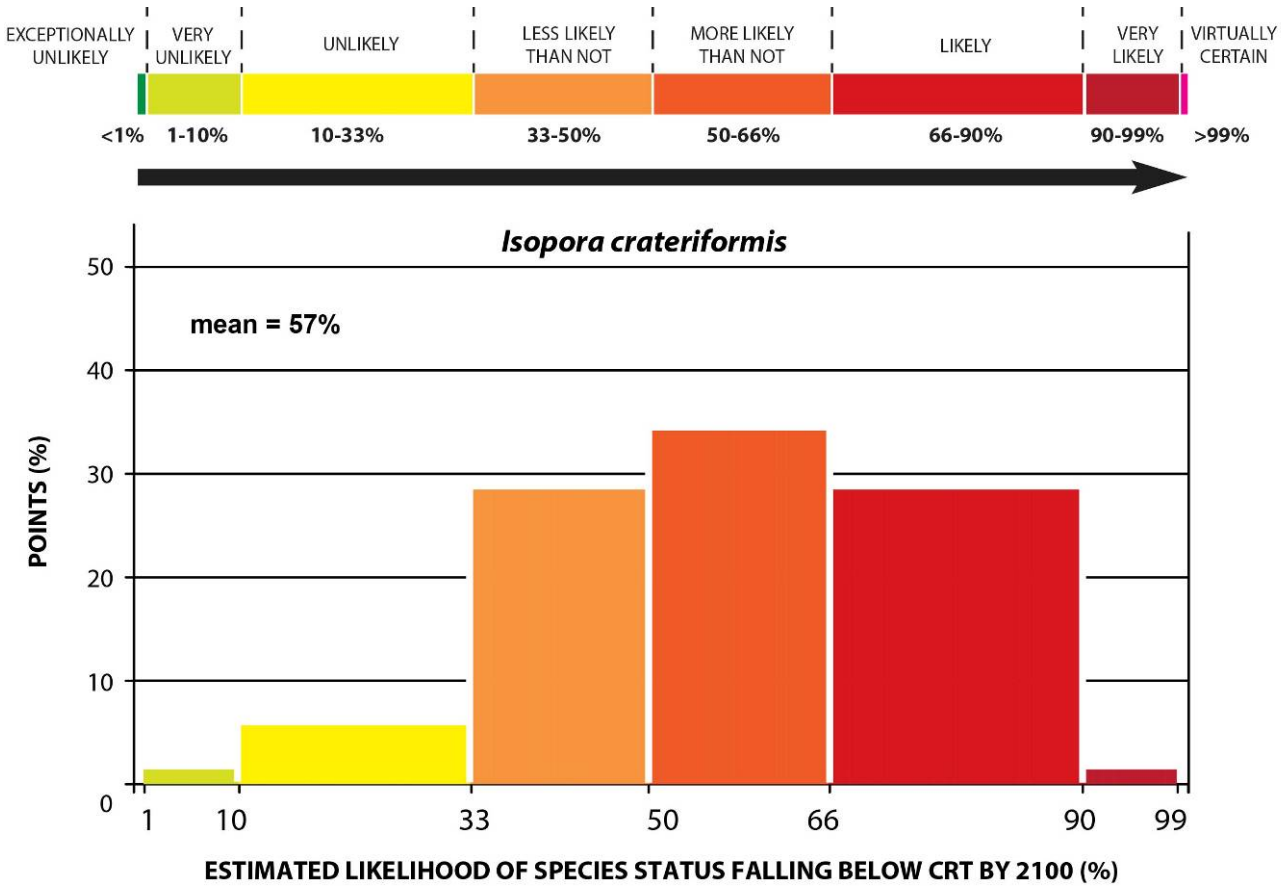

Figure 7.8.5. Distribution of points to estimate the likelihood that the status of *Isopora crateriformis* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors influencing the voting results towards a higher likelihood of falling below Critical Risk Threshold were the high susceptibility to threats inferred to be common to members of the family Acroporidae, which includes special attractiveness to corallivores, vulnerability to bleaching from unusually warm water, and susceptibility to disease. Factors that reduce the potential extinction risk (lower likelihood of falling below Critical Risk Threshold) were its prevalence in areas of heavy wave action, as water motion can reduce bleaching vulnerability. Reduced risk also indicates that *Isopora crateriformis* is often common and sometimes the dominant coral or at least the dominant acroporid coral (Birkeland et al., 1987). It is also found across a wide depth range from just below low tide to mesophotic depths, which allows the potential for buffering from surface-based threats.

The overall likelihood that *Isopora crateriformis* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "more likely than not" risk category with a mean likelihood of 57% and a standard error (SE) of 14% (Fig. 7.8.5). 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 1%–99% (Fig. 7.8.5) and the average range of likelihood estimates of the seven BRT voters (51%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for this species.

7.8.2 *Isopora cuneata* Dana, 1846

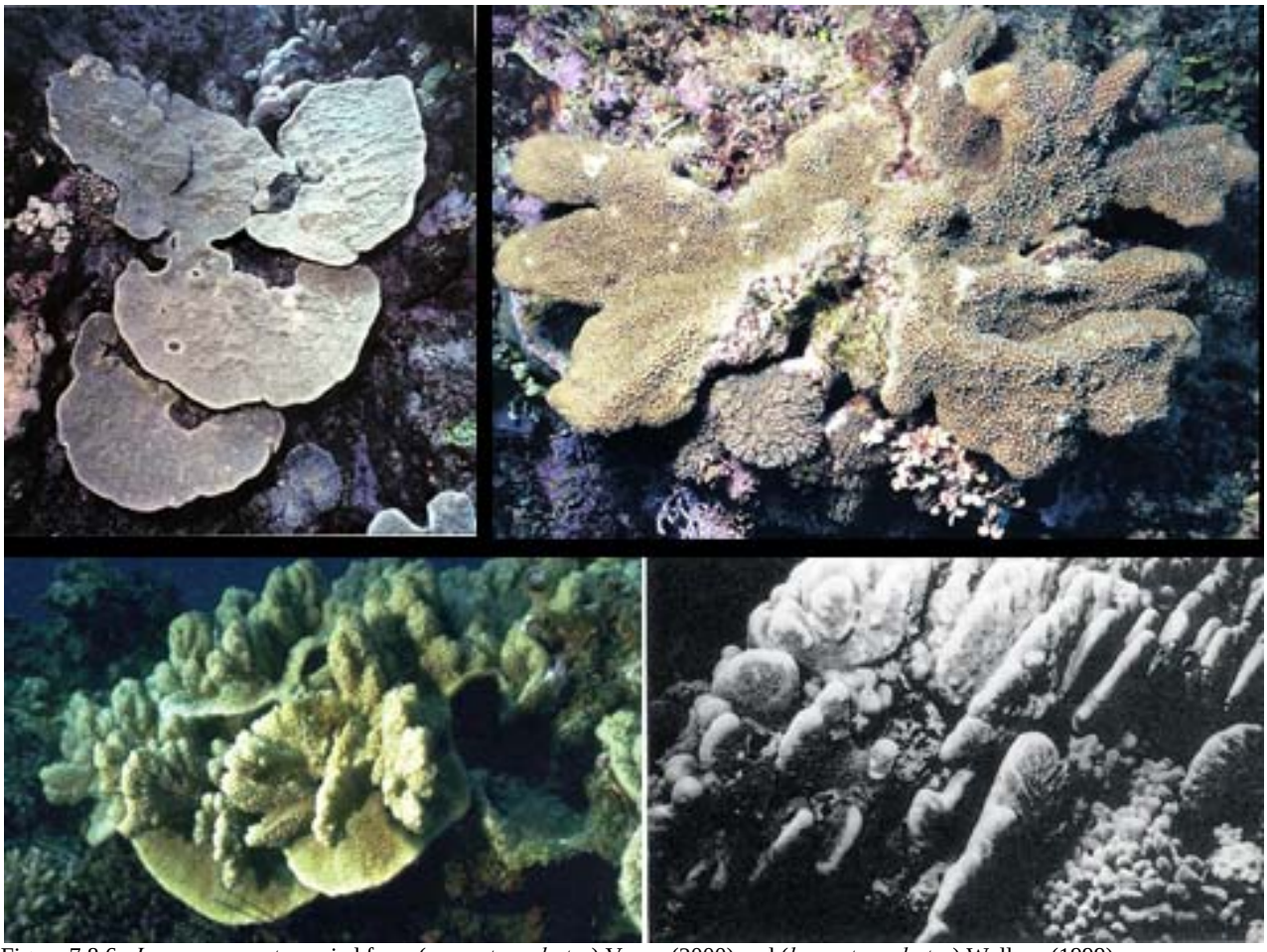

Figure 7.8.6. *Isopora cuneata* copied from (*upper two photos*) Veron (2000) and (*lower two photos*) Wallace (1999).

Characteristics

Isopora cuneata can form flattened solid encrusting plates like *Isopora crateriformis* but usually also forms "Mohawk" ridges parallel to the main wave motion or short flattened blades. Colonies are brown or pale cream (Veron, 2000).

Taxonomy

Taxonomic issues: None.

Family: Acroporidae.

Evolutionary and geologic history: Two extinct species of *Isopora* first appeared in the southern Caribbean fossil records about 5.9–4.6 Ma at the Miocene-Pliocene boundary, co-occurring with the extinct *Acropora saludensis* (Budd and Wallace, 2008). *Acropora palmata* first appeared in the early Pliocene (5.6–3 Ma), where it was found to co-occur with the two Isopora species and Acropora cervicornis. The *Isopora* species and two *Acropora* species were found in roughly equal numbers. *Isopora* also appeared in the fossil record in the Pacific in the Pliocene. *Isopora* went extinct in the Caribbean about 3–1 Ma (Budd and Wallace, 2008).

Isopora was formerly classified as a subgenus of *Acropora* based on its morphology. *Isopora* is thought to have evolved from *Astreopora* (Randall, 1981). Although it was formerly classified as a subgenus of *Acropora,* based on morphology, *Isopora* has recently been considered a separate genus (Wallace et al., 2007), based on its significant genetic distance from *Acropora* (Fukami et al., 2000) and differences in its reproductive strategy (Kojis, 1986).

Global Distribution

The IUCN (Fig. 7.8.7) and Veron (2000, cf Fig. 7.8.8 below) consider *Isopora cuneata* to be found from the coast of eastern Africa to the central Pacific. Although *Isopora cuneata* is definitely a distinct species from *Isopora palifera*, the two species can be very difficult to distinguish in the field, especially if they are not both present together at a site (Ayre et al., 1991; Veron, 2000; Wallace, 1999). One wonders if distributional records for *Isopora cuneata* on the African coast and offshore islands, based on field surveys, might need to be confirmed (cf. Fig. 6.13.8). *Isopora palifera* exists at Bassas da India and on the southeast African mainland down to northern KwaZulu Natal. *Isopora cuneata* is not proven to exist there (Riegl, 1995).

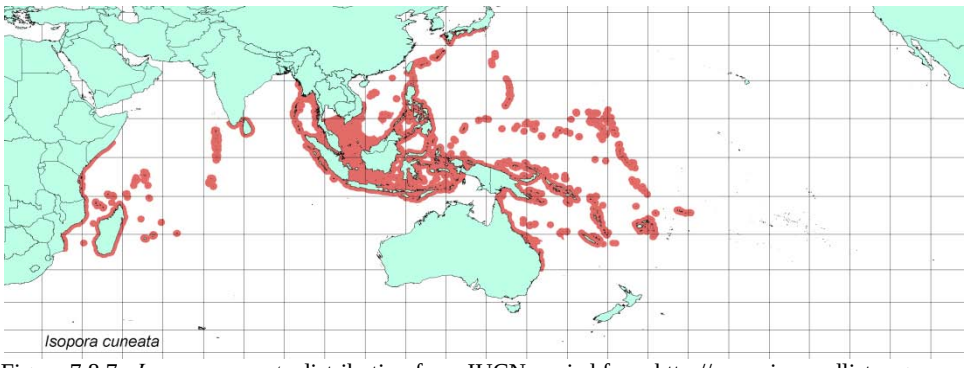

Figure 7.8.7. *Isopora cuneata* distribution from IUCN copied from http://www.iucnredlist.org.

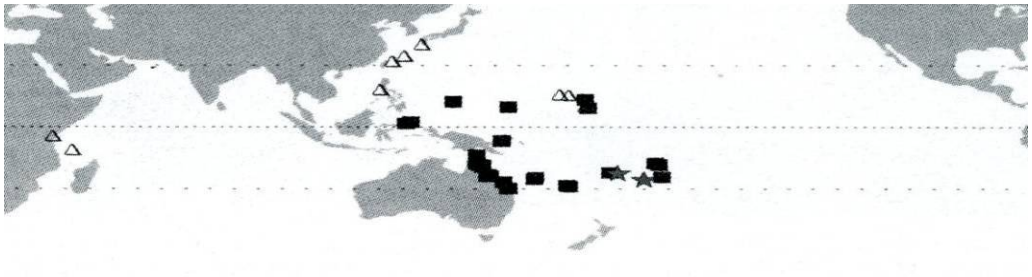

Figure 7.8.8. *Isopora cuneata* distribution from Wallace (1999). The black squares are specimen-based records in the *Acropora* database at the Museum of Tropical Queensland, the stars are type localities of senior and junior synonyms, and the black triangles are taken from records in the literature. When the triangles are open (not black), the records from the literature are possibly misidentifications.

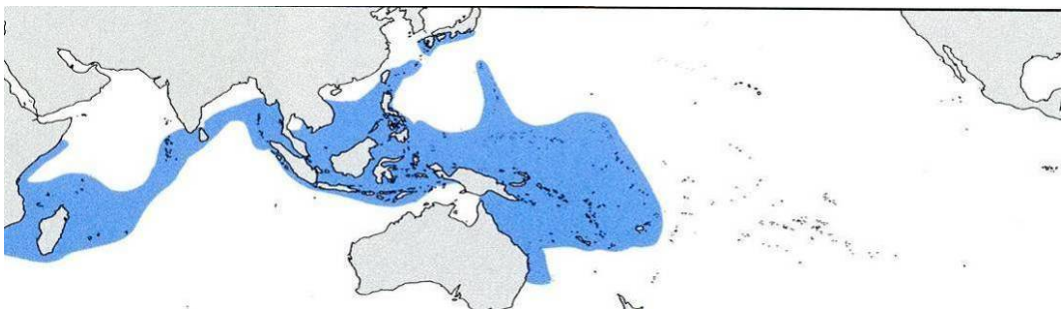

Figure 7.8.9. *Isopora cuneata* distribution from (Veron, 2000).

U.S. Distribution

According to both the IUCN Species Account and the CITES species database, *Isopora cuneata* occurs in American Samoa and the Northern Mariana Islands. The CITES species database also lists it for the U.S. minor outlying islands.

A search of published and unpublished records of occurrence in U.S. waters indicates *Isopora cuneata* has been reported from Tutuila and Ofu-Olosega in American Samoa (Birkeland, unpubl. data; Coles et al., 2003; CRED, unpubl. data; Lovell and McLardy, 2008; Maragos et al., 1994; National Park Service, 2009), and Palmyra Atoll (Williams et al., 2008b).

In Veron (2000) (Volume 1, page 185) the distribution map for this species includes a photo taken by Gustav Paulay labeled "Guam." However, G. Paulay (Univ. of Florida, Gainesville, FL, pers. comm., 28 February 2010) indicates a number of photos submitted by him to Veron from Palau, the Cook Islands, and other locations in the Pacific were mistakenly attributed to Guam (similar to the *errata* later acknowledged by Veron (2002) for *Acanthastrea regularis* and *Porites napopora*). Consequently, there are no substantiated records of its occurrence in the Mariana Archipelago.

Within federally protected waters, *Isopora cuneata* has been recorded from the following areas (Kenyon, 2010):

- Pacific Remote Islands Marine National Monument (Howland, Palmyra)
- National Park of American Samoa, Ofu Island unit

Habitat

Isopora cuneata is found most commonly in shallow, high-wave energy environments. Although it is occasionally found on sheltered reef slopes and backreef lagoons, it is more typical of reef crests and inner reef flats (Ayre et al., 1991).

Depth range: *Isopora cuneata* has been reported in water depths ranging from low tide to 15 m (Wallace, 1999).

Abundance

Abundance of *Isopora cuneata* has been reported as generally common and occasionally locally abundant (Veron, 2000). *Isopora cuneata* is by far the most predominant of acroporids on some areas of the Great Barrier Reef (Ayre et al., 1991; Bradbury and Young, 1983).

Life History

Isopora cuneata is a simultaneous hermaphroditic brooder (Bothwell, 1981). The planulae lack zooxanthellae, and in some areas the species can undergo several seasonal cycles of larval production (Kojis, 1986). Its brooding life history allows *Isopora* spp. to locally dominate recruitment at Lord Howe Island, Australia; colonies of this genus also dominate the adult population there, suggesting brooding may drive community structure in remote areas (Harriott, 1992; 1995). *Isopora cuneata* is not prone to asexual reproduction via fragmentation, based on its semi-encrusting morphology (Bothwell, 1981). The species shows moderate gene flow (Mackenzie et al., 2004) but little potential for large-scale dispersal (Ayre and Hughes, 2004). For additional information regarding the confamilial genus *Acropora*, see Section 7.5: Genus *Acropora*.

Threats

For each of these possible threats, see also Section 7.5: Genus *Acropora* for additional information on confamilial genus *Acropora*.

Thermal stress: Although there is not much species-specific information about the response of *Isopora cuneata* to thermal stress, members of the family Acroporidae are consistently ranked among the corals most severely susceptible to bleaching (Marshall and Baird, 2000; McClanahan et al., 2007; McClanahan et al., 2005a). However, the genera may have differential responses across regions during mass bleaching mortalities (McClanahan et al., 2004a). *Isopora cuneata* has intermediate bleaching susceptibility relative to other acroporids (Done et al., 2003) but showed severe losses in a 2006 mass bleaching event in the Marshall Islands, with only shaded bases of colonies surviving (Beger et al., 2008). *Isopora cuneata* was a common species in the *Acropora palifera* zone of the Chagos, but *Isopora cuneata* was nearly completely eliminated in 1998 and has not yet regenerated (Sheppard et al., 2002). Bleaching poses a high risk to this species at a global scale.

Acidification: No specific research has addressed the effects of acidification on *Isopora cuneata*. However, experiments on acidification impacts have all demonstrated negative effects on other members of the family Acroporidae, including reduced *Acropora* calcification (Anthony et al., 2008; Marubini et al., 2003; Renegar and Riegl, 2005; Schneider and Erez, 2006) and productivity (Anthony et al., 2008) and, in *Acropora palmata,* impaired fertilization and settlement success (Albright et al., 2010). In general, most corals studied have shown negative relationships between acidification and growth (Table 3.2.2), and acidification 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 have already caused appreciable declines in coral populations so far, the BRT considers it to be a significant threat to corals by 2100.

Disease: There is no species-specific information, although in general acroporid species are moderately to highly susceptible to disease. The ecological and population impacts of disease have not been established for this species. However, ample evidence indicate that 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 (Sutherland et al., 2004; Green and Bruckner, 2000).

Predation: Susceptibility of the family Acroporidae to predation stems from reports that most *Acropora* spp. have been preferentially consumed by crown-of-thorns seastars (COTS). In addition to COTS, *Acropora* spp. have been reported to be favored prey of the gastropods *Drupella* spp. and other corallivorous snails.

Land-based sources of pollution: Nutrient enrichment and sedimentation pose a low threat, but contaminant effects are unknown. Competition with algae significantly reduces growth rates of *Isopora cuneata* (Tanner, 1995). At high-latitude Lord Howe Island, *Isopora cuneata* was found to host five types of C zooxanthellae, with an ability to host specialized types in turbid environments (Wicks et al., 2010). The species is also capable of photo-adapting to low light environments by increasing zooxanthellae density altering photosynthetic mechanisms (dark reaction enzymes or electron transport rates) (Thinh, 1991).

LBSP-related stresses (nutrients, sediment, toxins, and salinity) often act in concert rather than individually and are influenced by other biological (e.g., herbivory) and hydrological factors. Collectively, LBSP stresses are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales (particularly important for species with limited range) and reduce the resilience of corals to bleaching (Carilli et al., 2009a; Wooldridge, 2009b).

C**ollection/Trade:** CITES treats *Isopora* as *Acropora* and has included data on export under the genus *Acropora*. As a whole, this genus is heavily involved in international trade with 50,000–270,000 reported exported pieces per year from Indonesia (CITES, 2010).

Risk Assessment

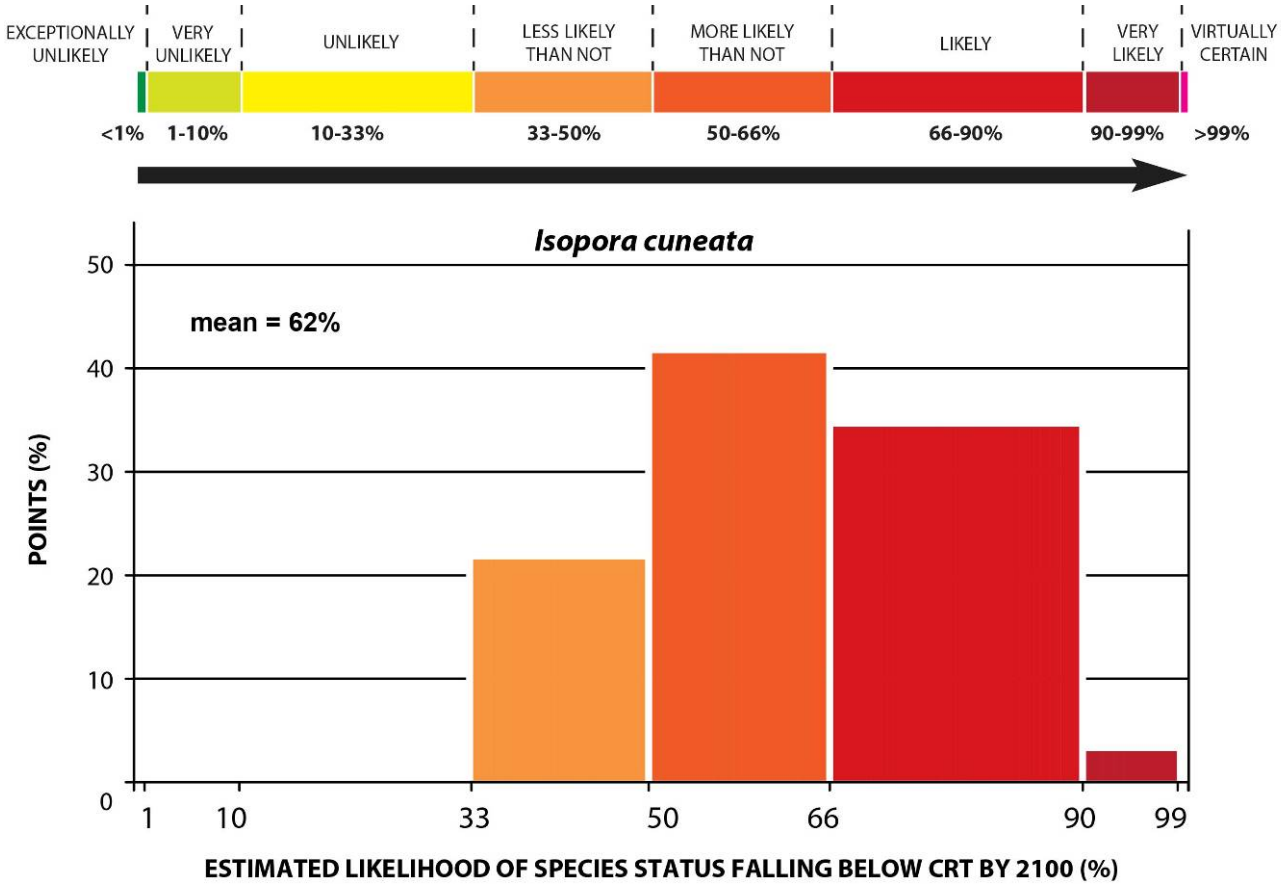

Figure 7.8.10. Distribution of points to estimate the likelihood that the status of *Isopora cuneata* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Isopora cuneata* are the high susceptibility to threats inferred to be common to members of the family Acroporidae, which includes special attractiveness to corallivores, vulnerability to bleaching from unusually warm water, and susceptibility to disease. Factors that reduce the potential extinction risk (lower likelihood of falling below the Critical Risk Threshold) were its prevalence in areas of heavy wave action, as water motion may reduce bleaching vulnerability. Reduced risk also indicates that *Isopora cuneata* is often common and sometimes the dominant coral or at least the dominant acroporid coral Bradbury, 1983 #1509; Ayre, 1991 #1508}. These characteristics tend toward species persistence (Richards, 2009).

The overall likelihood that *Isopora cuneata* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "more likely than not" risk category with a mean likelihood of 62% and a standard error (SE) of 8.5% (Fig. 7.8.10). 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 33%–99% (Fig. 7.8.10) and the average range of likelihood estimates of the seven BRT voters (51%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Isopora cuneata*.

7.9 Genus *Montipora*

Taxonomic Issues

Taxonomy within the genus *Montipora* has long been challenging, with species designations based largely on the arrangement and size of protrusions between corallites (e.g., "papillae" are smaller than corallites while "verrucae" are larger) and by colony form (laminar, encrusting, massive, and branching); Veron (2000) categorizes the 75 *Montipora* species into 12 "growth groups" according to these characters. Van Oppen et al. (2004) note that there is often little congruence between these morphological groups and clades derived from nuclear and/or mitochondrial genetic sequencing which they attribute to interspecific hybridization, phenotypic plasticity, and/or homoplasy of growth characteristics. Recent work by Forsman et al. (2010) presents detailed genetic and morphometric analyses of seven Hawaiian *Montipora* species that demand careful evaluation relative to the status and consequent estimated extinction risk of several of the candidate *Montipora* species. Specifically, results of this recent study provide important information that the BRT has deemed to alter the species status and, hence, the estimates of extinction risk for *Montipora dilatata, Montipora flabellata,* and *Montipora patula*.

Forsman et al. (2010) analyzed genetic and microskeletal characteristics from 71 colonies representing seven *Montipora* species collected from throughout the Hawaiian Archipelago, including specimens of three of the candidate species and with a special focus on the endemic and very rare *Montipora dilatata*. They sequenced a suite of genetic markers including five mitochondrial and two nuclear genes. Analyses of the mitochondrial Control Region (mtCR) yielded four strongly supported clades, each separated from the others by 3–7 fixed nucleotide differences. One of these clades included the two rare endemic species *Montipora dilatata* and *Montipora flabellata*, along with the widely distributed *Montipora turgescens;* a second clade grouped *Montipora patula* with *Montipora verrilli;* while *Montipora capitata* and *Montipora incrassata* each formed a distinct clade. The additional mitochondrial markers and the ITS (multicopy nuclear) markers all resolved the same four clades, while the single copy ATPs ß gene yielded a discordant tree based on high allelic diversity among individuals. A classification of 19 micromorphological measurements also failed to find any distinctions amongst *Montipora dilatata, Montipora flabellata*, and *Montipora turgescens*, or between *Montipora patula* and *Montipora verrilli*. Forsman et al. (2010) also compared the mtCR sequences from the Hawaiian corals in their study to those from other *Montipora* species collected from Indonesia and the Great Barrier Reef (Van Oppen et al., 2004) and suggest that their four clades likely include additional *Montipora* species from outside Hawai`i. For example, the Hawaiian *Montipora patula/verrilli* samples shared their identical mtCR haplotype with non-Hawaiian species, including *Montipora altasepta*, *Montipora hispida*, *Montipora peltiformis*, and *Montipora aequituberculata*. These authors conclude that concurrence of the mitochondrial and ITS trees with the micromorphological groupings provide strong support for several species complexes. The nominal species within these clades represent either morphological variants of the same species or some degree of incipient speciation.

Given that the best available information indicates a lack of discernible genetic differentiation, a lack of distinction in microskeletal morphology, and considerable potential for phenotypic plasticity in color, colony growth form, and skeletal structures, the BRT has chosen to evaluate extinction risk for these respective clades (i.e., *Montipora dilatata/flabellata/turgescens* and *Montipora patula/verrilli*) rather than for the nominal species. The BRT will treat these two "clades" as "species" for purposes of U.S. Endangered Species Act status evaluation. This would require reconsideration on potential future studies that would provide either improved genetic resolution or reproductive studies (e.g., testing hybridization within and between these clades). Indeed, if these nominal species are indeed distinct (i.e., the determination to "lump" nominal species within these two indistinguishable clades is in error), the extinction risk of each would be equal to or, most likely, be higher than that currently estimated for each of the two larger clades.

Evolutionary and geologic history: The age of most species of *Montipora* is unknown as a result of their delicate skeletons and poor preservation in the fossil record. Nevertheless, the genus as a whole is old, likely diverging from the genus *Acropora* about 54 Ma (Fukami et al., 2000). Based on genetic divergence estimates, the main diversification of *Montipora* species is estimated to have occurred around 6.6 Ma (Fukami et al., 2000).

Life History

Of the 35 species of *Montipora* for which reproductive mode has been described, all are hermaphroditic broadcast spawners (Baird et al., 2009). Numerous species of *Montipora* have been observed to participate in multispecies spawning events that have been documented throughout the Indo-Pacific (Baird et al., 2009). The larvae of all 30 examined *Montipora* species contain zooxanthellae that can supplement maternal provisioning with energy sources provided by photosynthesis (Baird et al., 2009). Larval longevity has not been determined for *Montipora* nor has age at first reproduction, although their fast growth rates suggest early maturity and short generation times (Van Oppen et al., 2004)

Threats

Temperature increase: *Montipora* species have relatively high bleaching response/impact (just below *Millepora* and *Acropora*) according to published rankings in both Australia and eastern Africa (Marshall and Baird, 2000; McClanahan et al., 2007; respectively).

Acidification: While the candidate species of *Montipora* have not been directly investigated for effects of ocean acidification, a congener, *Montipora capitata*, showed 15%–20% reduction in colony growth rate in mesocosm treatments of anticipated CO_2 levels within this century, although gamete production was not affected (Jokiel et al., 2008). In general, most corals studied have shown negative relationships between acidification and growth (Table 3.2.2) and acidification 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: *Montipora* species have moderate susceptibility/impact from disease. The genus has been susceptible to black-band disease in Australia (Sato et al., 2009) and the Red Sea (Al-Moghrabi, 2001), growth anomalies in Hawai`i (Aeby, 2006; Wolanski and Delesalle, 1995), and white syndromes in Australia and Hawai`i (Aeby, 2006; Willis et al., 2004).

Land-Based Sources of Pollution (LBSP): *Montipora* is characterized as a "sediment-intolerant" genus by McClanahan and Obura (1997), although some species have been found to be relatively sediment tolerant (Hodgson, 1990). Clearly, some *Montipora* are more sediment susceptible than others (Ferrier-Pagès et al., 2010; Jokiel et al., 2007). Elevated nutrients have also had no effect on fecundity or fertilization success in *Montipora* (Abramovitch-Gottlib et al., 2003; Cox and Ward, 2002). Competition with algae reduced settlement and survival of *Montipora* larvae but the impact was reversed with antibiotics, suggesting the recruitment inhibition was caused by indirect microbial interactions (Vermeij et al., 2009).

Predation: The crown-of-thorns seastar (*Acanthaster planci*) has been observed preferentially preying on members of this genus, with predator outbreaks resulting in substantial population impacts to *Montipora* spp. (Colgan, 1987). *Montipora verrucosa*, however, was avoided in experiments on feeding by the pillow seastar *Culcita novaeguineae* (Glynn and Krupp, 1986).

7.9.1 *Montipora angulata* Lamarck, 1816

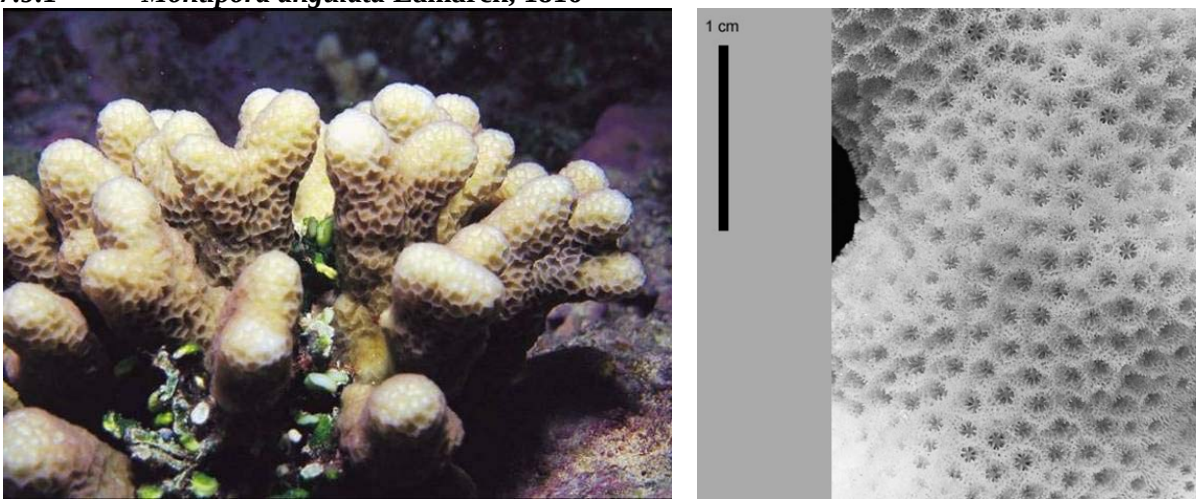

Figure 7.9.1. *Montipora angulata* photos and corallite plan from Veron (2000).

Characteristics

Colonies of *Montipora angulata* are pale brown and have extensive encrusting bases with short branches that form a compact clump. Corallites are slightly foveolate (funnel shaped) and immersed in the coenosteum. The coenosteum is smooth or forms thin ridges between corallites. Colonies are pale brown in color (Veron, 2000).

Taxonomy

Taxonomic issues: Genetic evidence places *Montipora angulata* in a clade with other species, but the specific composition depends on whether mitochondrial DNA or the *Pax*-C intron is used (Van Oppen et al., 2004). In the absence of additional genetic work or reproductive crosses that test hybridization potential, we will treat *Montipora angulata* as a valid species.

Family: Acroporidae.

Evolutionary and geologic history: See Section 7.9: Genus *Montipora*.

Global Distribution

Montipora angulata is somewhat widely distributed from the south Indian coast throughout the central Pacific. It also has wide latitudinal range from central Japan to the midsection of both coasts of Australia. It is absent from Hawai`i, the eastern Indian Ocean, and the Red and Arabian Seas.

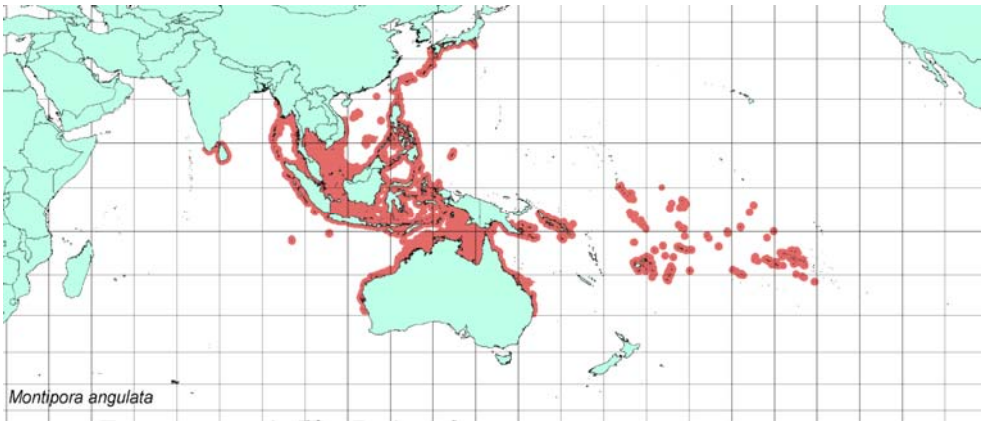

Figure 7.9.2. *Montipora angulata* distribution from IUCN copied from http://www.iucnredlist.org.

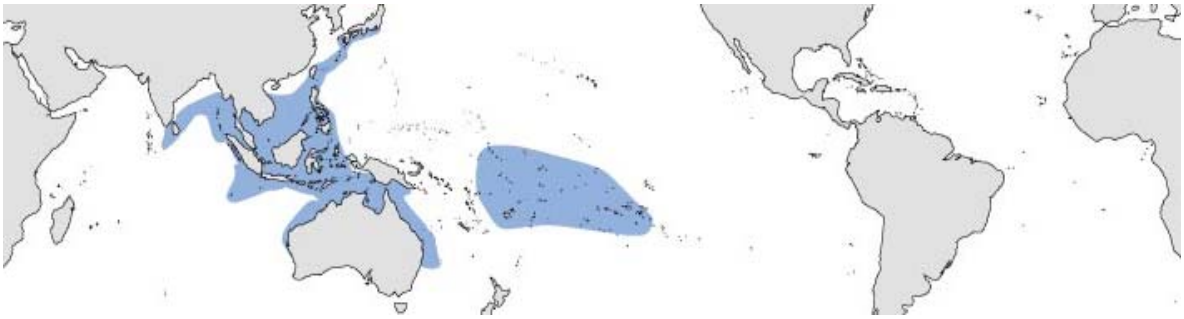

Figure 7.9.3. *Montipora angulata* distribution from Veron (2000).

U.S. Distribution

According to the IUCN Species Account, *Montipora angulata* occurs in American Samoa and the U.S. minor outlying islands. The CITES species database does not list this species in U.S. waters. A search of published and unpublished records of occurrence in U.S. waters indicates *Montipora angulata* has been reported from Rose Atoll in American Samoa (Kenyon et al., 2010a). No substantiated published or unpublished reference supporting its occurrence in the U.S. minor outlying islands could be identified.

Within federally protected waters, *Montipora anuglata* has been recorded from the following areas:

- Rose Atoll National Monument

Habitat

Habitat: *Montipora angulata* has been reported to be found on fringing reefs and reef flats (Veron, 2000).

Depth range: *Montipora angulata* has been reported in water depths ranging from at least 1 m to 20 m (Carpenter et al., 2008).

Abundance

Abundance of *Montipora angulata* has been reported mostly as rare (Veron, 2000).

Life History

The reproductive characteristics of *Montipora angulata* have not been determined (Baird et al., 2009). However, sexuality and reproductive mode have been determined for 35 other species of *Montipora*, all of which are hermaphroditic broadcast spawners. Although specific observations have not been published for this species, the larvae of all other *Montipora* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis.

Threats

Thermal stress: Branching *Montipora* spp. have relatively high bleaching response according to published rankings in both Australia and east Africa (Marshall and Baird, 2000; McClanahan et al., 2007). *Montipora angulata* contains Clade C zooxanthellae (Good et al., 2005); this clade varies in its thermal tolerance (LaJeunesse et al., 2003) but is generally less resistant to bleaching than Clade D. The congeneric species *Montipora capitata* copes with bleaching by relying more heavily on heterotrophic input, allowing it to rebuild lipid stores (Rodrigues et al., 2008) and maintain fecundity after bleaching (Cox, 2007).

Acidification: While not studied in this species, a congener, *Montipora capitata*, showed 15%–20% reduction in colony growth rate in mesocosm treatments of anticipated CO_2 levels within this century, although gamete production was not affected (Jokiel et al., 2008). Similarly, experiments on acidification impacts have all demonstrated negative effects on other members of the family Acroporidae, including reduced *Acropora* calcification (Anthony et al., 2008; Marubini et al., 2003; Renegar and Riegl, 2005; Schneider and Erez, 2006) and productivity (Anthony et al., 2008) and, in *Acropora palmata,* impaired fertilization and settlement success (Albright et al., 2010) and reduced growth in the field from Curaçao (Bak et al., 2009). In general, most corals studied have shown negative relationships between acidification and

growth (Table 3.2.2) and acidification 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 have caused appreciable declines in coral populations so far, the BRT considers it to be a significant threat to corals by 2100.

Disease: *Montipora* species have moderate susceptibility/impact from disease. The genus has been susceptible to black-band disease in Australia (Sato et al., 2009) and the Red Sea (Al-Moghrabi, 2001), growth anomalies in Hawai`i (Aeby et al., 2006) and white syndromes in Australia and Hawai`i (Aeby, 2006; Willis et al., 2004). Ample evidence indicate that 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: *Montipora* species are preferred prey of crown-of-thorns seastar (*Acanthaster planci)*.

Land-based sources of pollution (LBSP): The effects of LBSP on *Montipora angulata* are largely unknown. *Montipora* is characterized as a "sediment-intolerant" genus by McClanahan and Obura (1997), while other congeners have been found to be relatively sediment tolerant (Hodgson, 1990; Stafford-Smith, 1993). Clearly, some *Montipora* are more sediment susceptible than others (Jokiel et al., 2007). Elevated nutrients have also had no effect on fecundity or fertilization success in *Montipora* (Cox and Ward, 2002). Competition with algae reduced settlement and survival of *Montipora* larvae but was reversed with antibiotics, suggesting the recruitment inhibition was caused by indirect microbial interactions (Vermeij et al., 2009).

LBSP-related stresses (nutrients, sediment, toxins, and salinity) often act in concert rather than individually and are influenced by other biological (e.g., herbivory) and hydrological factors. Collectively, LBSP stresses are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales (particularly important for species with limited range) and reduce the resilience of corals to bleaching (Carilli et al., 2009a; Wooldridge, 2009b).

Collection/Trade: The genus *Montipora* is heavily involved in the international aquarium trade, with substantial exports reported (in the thousands of pieces per year) from Indonesia, Malaysia, Tonga, Solomon Islands, and Fiji—regions for which *Montipora angulata* likely comprise a portion. Of concern, both Malaysia and Indonesia report increasing exports over the period from 2000 to 2008 (less than 5000 to over 35,000 for Indonesia).

Risk Assessment

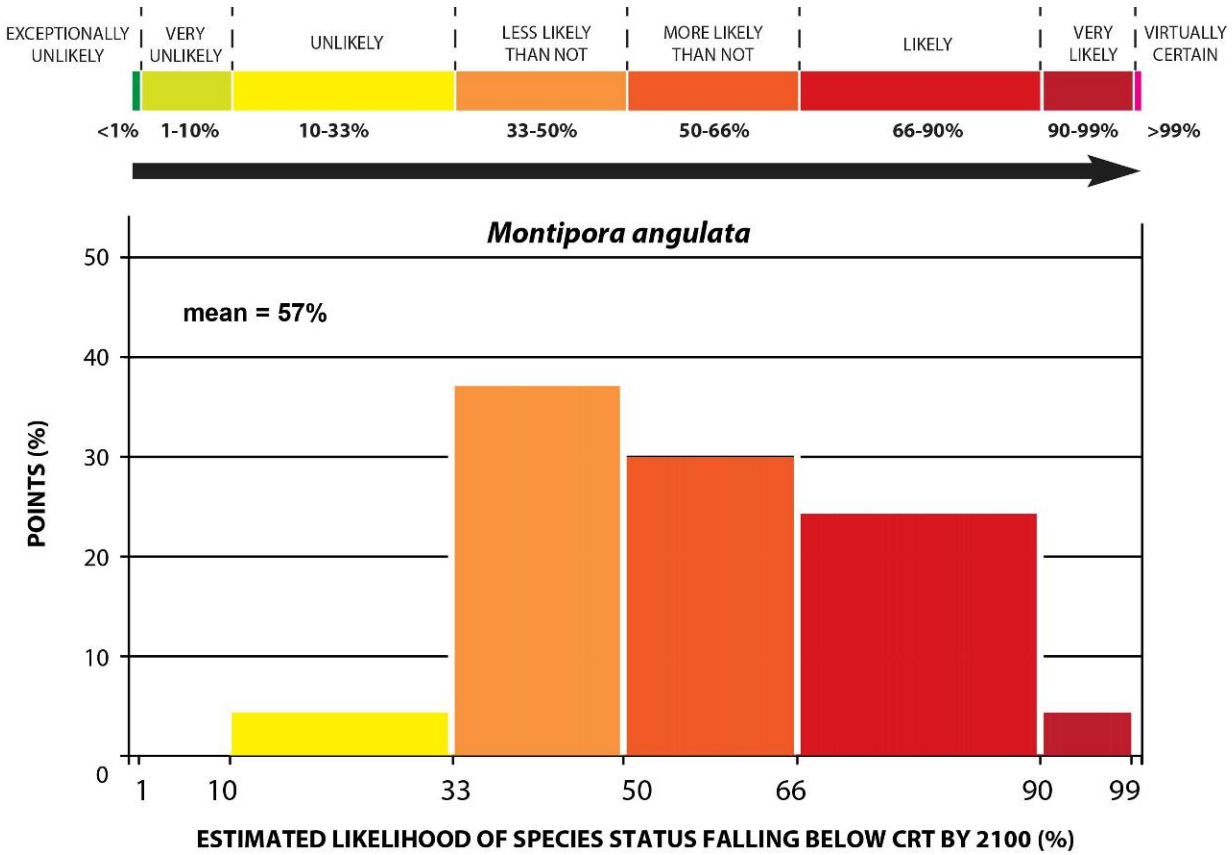

Figure 7.9.4. Distribution of points to estimate the likelihood that the status of *Montipora angulata* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for this species include its rare abundance combined with presumed generic vulnerability to a range of threats including disease, bleaching, and predation as well as potentially increasing threats from collection/trade. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) are its relatively wide geographic distribution, making it more likely a species will be able to escape the impacts of threats and catastrophes in at least some locations. The BRT also considered wide latitudinal distribution to indicate broader tolerance to environmental condtions and hence, greater potential for surviving changing environmental regimes.

The overall likelihood that *Montipora angulata* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "more likely than not" risk category with a mean likelihood of 57% and a standard error (SE) of 12% (Fig. 7.9.4). This SE was calculated by taking the standard deviation of the seven mean voting scores of the BRT members and its relatively high value (among the 82 candidates) shows a somewhat lower coherence among the BRT. The uncertainty of the BRT is reflected in the wide range of votes of 10%–99% (Fig. 7.9.4) and the average range of likelihood estimates of the seven BRT voters (54%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Montipora angulata*.

7.9.2 *Montipora australiensis* Bernard, 1897

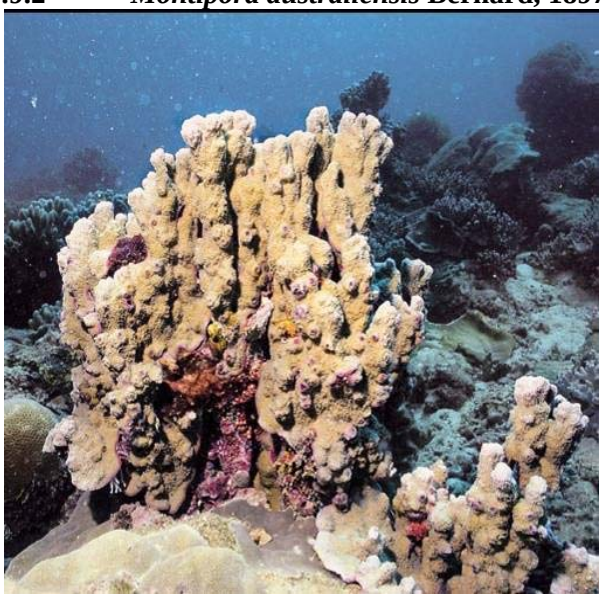

Figure 7.9.5. *Montipora australiensis* photos and corallite plan from Veron (2000).

Characteristics

Colonies of *Montipora australiensis* are pale brown, forming thick plates and irregular columns. Corallites are both immersed and exsert, the latter having a prominent ring of fused thecal papillae. Fine ridges of coenosteum, which are mostly vertical on branches, join corallites forming a network (Veron, 2000).

Taxonomy

Taxonomic issues: None.

Family: Acroporidae.

Evolutionary and geologic history: See Section 7.9: Genus *Montipora.*

Global Distribution

Montipora australiensis is widely distributed longitudinally, occurring widely throughout east Africa and through to the east-central Pacific from the south Indian coast throughout the central Pacific. It also has wide latitudinal range from central Japan to the midsection of both coasts of Australia. It is absent from Hawai`i, the northeastern Indian Ocean, and the Red and Arabian Seas.

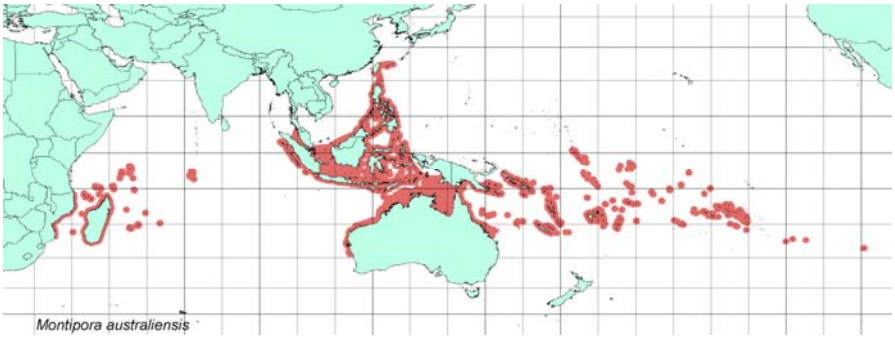

Figure 7.9.6. *Montipora australiensis* distribution from IUCN copied from http://www.iucnredlist.org.

Figure 7.9.7. *Montipora australiensis* distribution from Veron (2000).

U.S. Distribution

The only record of occurrence of *Montipora australiensis* in federally protected waters is

- National Park of American Samoa, Ofu unit (Birkeland, unpubl. data).

Habitat

Habitat: *Montipora australiensis* has been reported to occupy shallow reef environments with high wave action (Veron, 2000).

Depth range: The shallow reef environment described by Veron above seems at odds with the IUCN description of a 2 m–30-m depth range for *Montipora australiensis* (Carpenter et al., 2008).

Abundance

Montipora australiensis has most often been reported as rare (Veron, 2000).

Life History

The reproductive characteristics of *Montipora australiensis* have not been determined (Baird et al., 2009). However, sexuality and reproductive mode have been determined for 35 other species of *Montipora*, all of which are hermaphroditic broadcast spawners. Although specific observations have not been published for this species, the larvae of all other *Montipora* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis.

Threats

Thermal stress: Branching *Montipora* spp. have relatively high bleaching response according to published rankings in both Australia and east Africa (Marshall and Baird, 2000; McClanahan et al., 2007; respectively). The congeneric species *Montipora capitata* copes with bleaching by relying more heavily on heterotrophic input, allowing it to rebuild lipid stores (Rodrigues et al., 2008) and maintain fecundity after bleaching (Cox, 2007).

Acidification: While not studied in this species, a congener, *Montipora capitata*, showed 15%–20% reduction in colony growth rate in mesocosm treatments of anticipated CO_2 levels within this century, though gamete production was not affected (Jokiel et al., 2008). Similarly, experiments on acidification impacts have all demonstrated negative effects on other members of the family Acroporidae, including reduced *Acropora* calcification (Anthony et al., 2008; Marubini et al., 2003; Renegar and Riegl, 2005; Schneider and Erez, 2006) and productivity (Anthony et al., 2008) and, in *Acropora palmata,* impaired fertilization and settlement success (Albright et al., 2010), and reduced growth in the field from Curaçao (Bak et al., 2009). In general, most corals studied have shown negative relationships between acidification and growth (Table 3.2.2) and acidification 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: *Montipora* spp. have moderate susceptibility/impact from disease. The genus has been susceptible to black-band disease in Australia (Sato et al., 2009) and the Red Sea (Al-Moghrabi, 2001), growth anomalies in Hawai`i (Aeby et al., 2006) and white syndromes in Australia and Hawai`i (Aeby, 2006; Willis et al., 2004). Also ample evidence

indicate that 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: *Montipora* spp. are preferred prey of crown-of-thorns seastar (*Acanthaster planci)*.

Land-based sources of pollution (LBSP): The effects of LBSP on *Montipora australiensis* are largely unknown. *Montipora* is characterized as a "sediment-intolerant" genus by McClanahan and Obura (1997), while other congeners have been found to be relatively sediment tolerant (Hodgson, 1990; Stafford-Smith, 1993). Clearly some *Montipora* are more sediment susceptible than others (Jokiel et al., 2007). Elevated nutrients showed no effect on fecundity or fertilization success in *Montipora* (Cox and Ward, 2002). Competition with algae reduced settlement and survival of *Montipora* larvae but was reversed with antibiotics, suggesting the recruitment inhibition was caused by indirect microbial interactions (Vermeij et al., 2009).

LBSP-related stresses (nutrients, sediment, toxins, and salinity) often act in concert rather than individually and are influenced by other biological (e.g., herbivory) and hydrological factors. Collectively, LBSP stresses are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales (particularly important for species with limited range) and reduce the resilience of corals to bleaching (Carilli et al., 2009a; Wooldridge, 2009b).

Collection/Trade: The genus *Montipora* is heavily involved in the international ornamental trade, with substantial exports reported (in the thousands of pieces per year) from Indonesia, Malaysia, Tonga, Solomon Islands, and Fiji. Of particular concern, both Malaysia and Indonesia report increasing exports over the 2000 to 2008 period (less than 5000 to over 35,000 for Indonesia).

Risk Assessment

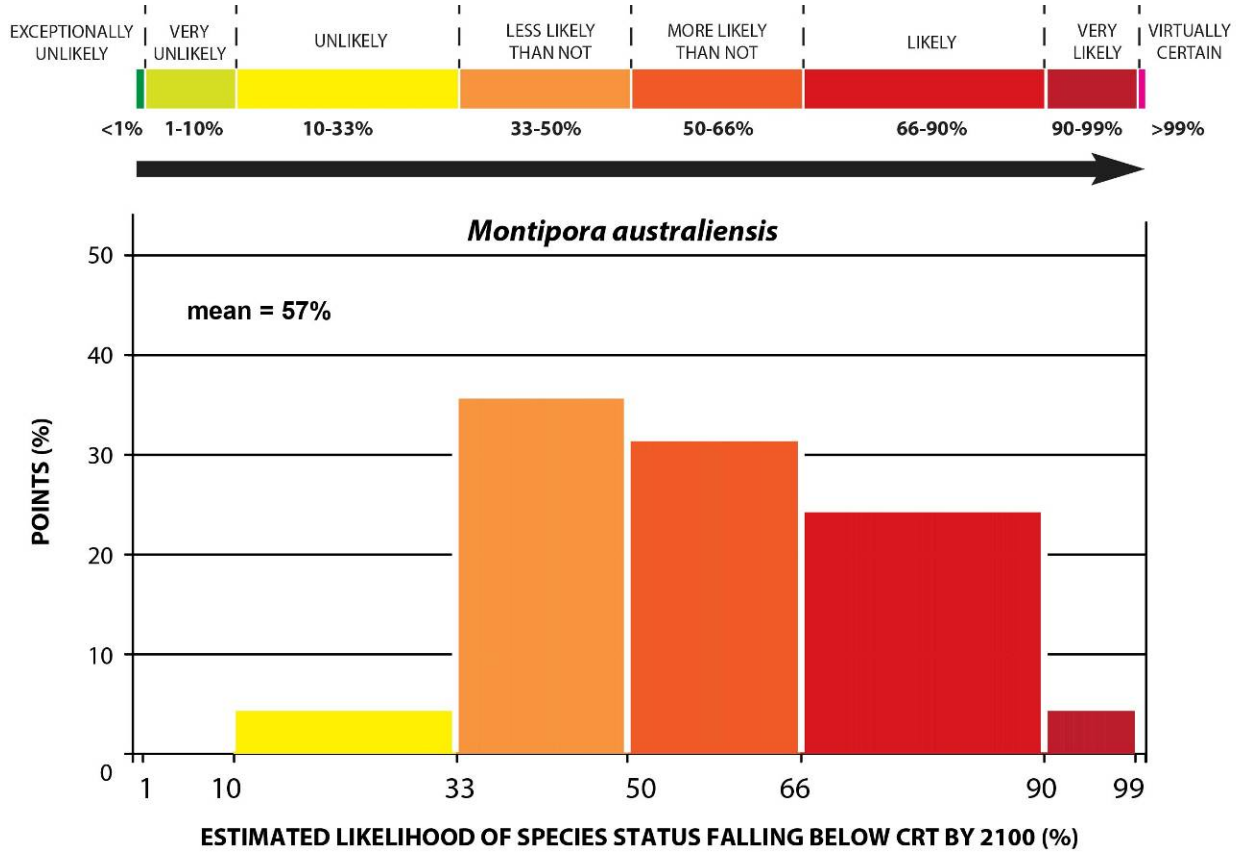

Figure 7.9.8. Distribution of points to estimate the likelihood that the status of *Montipora australiensis* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold for *Montipora australiensis* include its rare abundance combined with presumed generic vulnerability to a range of threats including disease, bleaching, and predation as well as potentially increasing threats from collection/trade. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) are its relatively wide geographic distribution, making it more likely a species will be able to escape the impacts of threats and catastrophes in at least some locations.

The mean likelihood that *Montipora australiensis* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "more likely than not" risk category with a mean likelihood of 57% and a standard error (SE) of 12% (Fig. 7.9.8). This SE was calculated by taking the standard deviation of the seven mean voting scores of the BRT members and its relatively high value (among the 82 candidates) shows a somewhat lower coherence among the BRT. The uncertainty of the BRT is reflected in the wide range of votes of 10%–99% (Fig. 7.9.8) and the average range of likelihood estimates of the seven BRT voters (54%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Montipora australiensis*.

7.9.3 *Montipora calcarea* Bernard, 1897

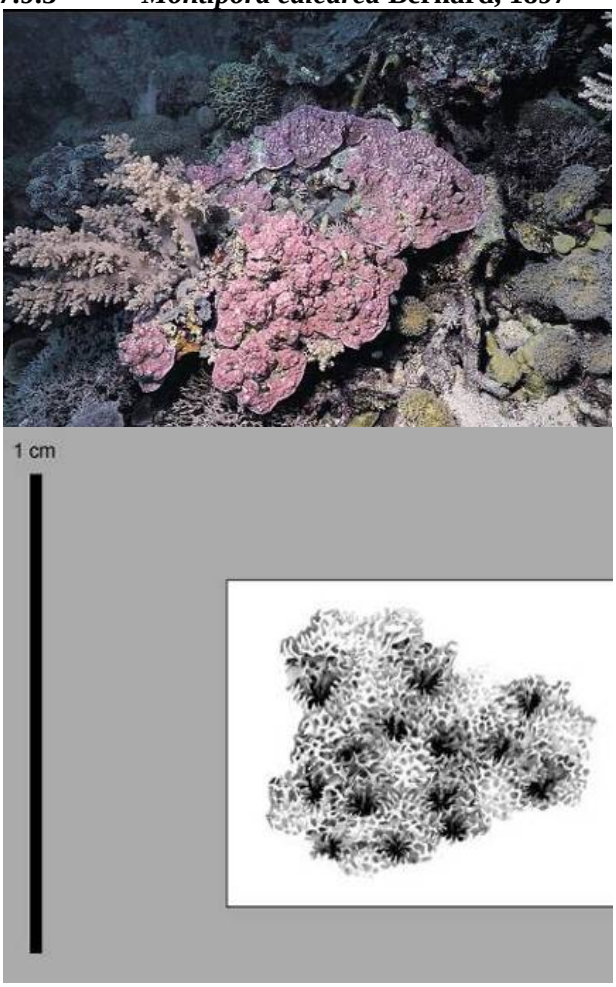

Figure 7.9.9. *Montipora calcarea* photos and corallite plan from Veron (2000).

Characteristics

Colonies of *Montipora calcarea* are pale brown or blue, which may photograph purple. Colonies are irregular thick plates with columnar upgrowths. Corallites are crowded and immersed; those on upgrowths have a slight formation of a lower lip. The coenosteum is coarse, with a light texture (Veron, 2000).

Taxonomy

Taxonomic issues: None.

Family: Acroporidae.

Evolutionary and geologic history: See Section 7.9: Genus *Montipora*.

Global Distribution

Global distribution of *Montipora calcarea* is fairly wide but somewhat discontinuous. It is present throughout the Red Sea and east Africa, but limited occurrences are reported across the Indian Ocean and the bulk of Southeast Asia. It is reported to occur along the west but not the east coast of Australia and has limited occurrence in the west-central Pacific.

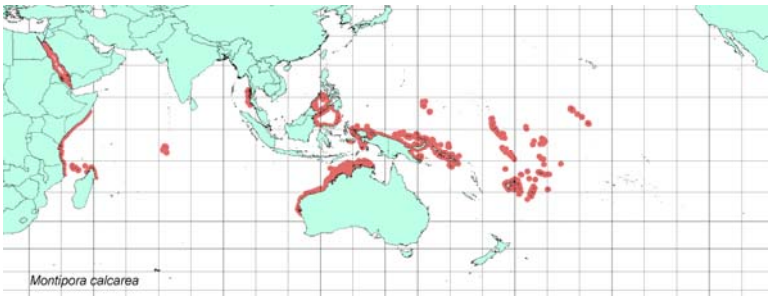

Figure 7.9.10. *Montipora calcarea* distribution from IUCN copied from http://www.iucnredlist.org.

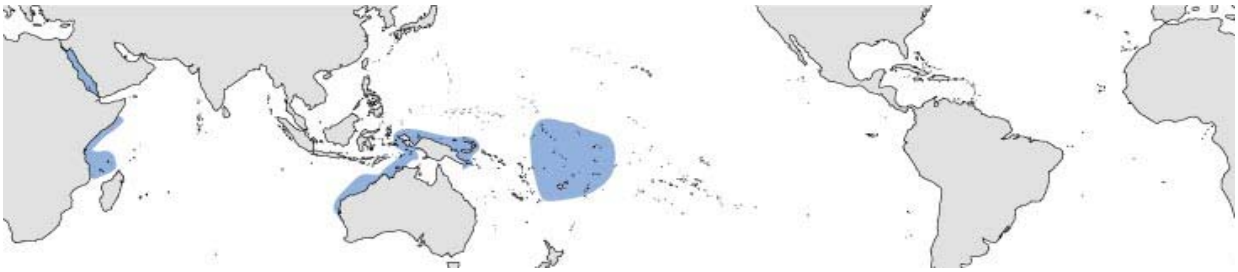

Figure 7.9.11. *Montipora calcarea* distribution from Veron (2000).

U.S. Distribution

According to both the IUCN Species Account and the CITES species database, *Montipora calcarea* occurs in American Samoa. The IUCN Species Account also lists its occurrence in the U.S. minor outlying islands. A search of published and unpublished records of occurrence in U.S. waters indicates *Montipora calcarea* has been reported from Tutuila, Ta′u, and Rose Atoll in American Samoa (Birkeland, unpubl. data; Fisk and Birkeland, 2002; Kenyon et al., 2010a; Lovell and McLardy, 2008; National Park Service, 2009), including areas under federal protection in these regions. No substantiated published or unpublished reference supporting its occurrence in the U.S. minor outlying islands could be identified.

Within federally protected waters, *Montipora calcarea* has been recorded from the following areas:

- National Park of American Samoa, Tutuila Island unit
- Fagatele Bay National Marine Sanctuary, Tutuila
- Rose Atoll Marine National Monument

Habitat

Habitat: *Montipora calcarea* has been reported to occur in shallow reef environments (Veron, 2000).

Depth range: *Montipora calcarea* has been reported in water depths ranging from 0 to 20 m (Carpenter et al., 2008).

Abundance

Montipora calcarea has most often been reported to be rare (Veron, 2000) but may be locally abundant.

Life History

The reproductive characteristics of *Montipora calcarea* have not been determined (Baird et al., 2009). However, sexuality and reproductive mode have been determined for 35 other species of *Montipora*, all of which are hermaphroditic broadcast spawners. Although specific observations have not been published for this species, the larvae of all other *Montipora* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis.

Threats

Thermal stress: Plating *Montipora* spp. have relatively high bleaching response according to published rankings in both Australia and east Africa (Marshall and Baird, 2000; McClanahan et al., 2007; respectively). The congeneric species *Montipora capitata* copes with bleaching by relying more heavily on heterotrophic input, allowing it to rebuild lipid stores (Rodrigues et al., 2008) and maintain fecundity after bleaching (Cox, 2007).

Acidification: While not studied in this species, a congener, *Montipora capitata*, showed 15%–20% reduction in colony growth rate in mesocosm treatments of anticipated CO_2 levels within this century, although gamete production was not affected (Jokiel et al., 2008). Similarly, experiments on acidification impacts have all demonstrated negative effects on other members of the family Acroporidae, including reduced *Acropora* calcification (Anthony et al., 2008; Marubini et al., 2003; Renegar and Riegl, 2005; Schneider and Erez, 2006) and productivity (Anthony et al., 2008) and, in *Acropora palmata,* impaired fertilization and settlement success (Albright et al., 2010) and reduced growth in the field from Curaçao (Bak et al., 2009). In general, most corals studied have shown negative relationships between acidification and growth (Table 3.2.2) and acidification 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 have caused appreciable declines in coral populations so far, the BRT considers it to be a significant threat to corals by 2100.

Disease: *Montipora* spp. have moderate susceptibility/impact from disease. The genus has been susceptible to black-band disease in Australia (Sato et al., 2009) and the Red Sea (Al-Moghrabi, 2001), growth anomalies in Hawai`i (Aeby et al., 2006) and white syndromes in Australia and Hawai`i (Aeby, 2006; Willis et al., 2004).

Predation: *Montipora* spp. are preferred prey of crown-of-thorns seastar (*Acanthaster planci)*.

Land-based sources of pollution (LBSP): The effects of LBSP on *Montipora calcarea* are largely unknown. *Montipora calcarea* was not susceptible to algal or sediment impacts in anthropogenically impacted waters in Egypt (Mohammed and Mohammed, 2005; Wellington, 1982). *Montipora* is characterized as a "sediment-intolerant" genus by McClanahan and Obura (1997), while other congeners have been found to be relatively sediment-tolerant (Hodgson, 1990; Stafford-Smith, 1993). Clearly, some *Montipora* are more sediment susceptible than others (Jokiel et al., 2007). Elevated nutrients have also had no effect on fecundity or fertilization success in *Montipora* (Cox and Ward, 2002). Competition with algae reduced settlement and survival of *Montipora* larvae but was reversed with antibiotics, suggesting the recruitment inhibition was caused by indirect microbial interactions (Vermeij et al., 2009).

LBSP-related stresses (nutrients, sediment, toxins, and salinity) often act in concert rather than individually, and are influenced by other biological (e.g., herbivory) and hydrological factors. Collectively, LBSP stresses are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales (particularly important for species with limited range) and reduce the resilience of corals to bleaching (Carilli et al., 2009a; Wooldridge, 2009b).

Collection/Trade: The genus *Montipora* is heavily involved in the international aquarium trade, with substantial exports reported (in the thousands of pieces per year) from Indonesia, Malaysia, Tonga, Solomon Islands, and Fiji. Of concern, both Malaysia and Indonesia report increasing exports over the 2000−2008 period (less than 5000 to over 35,000 for Indonesia).

Risk Assessment

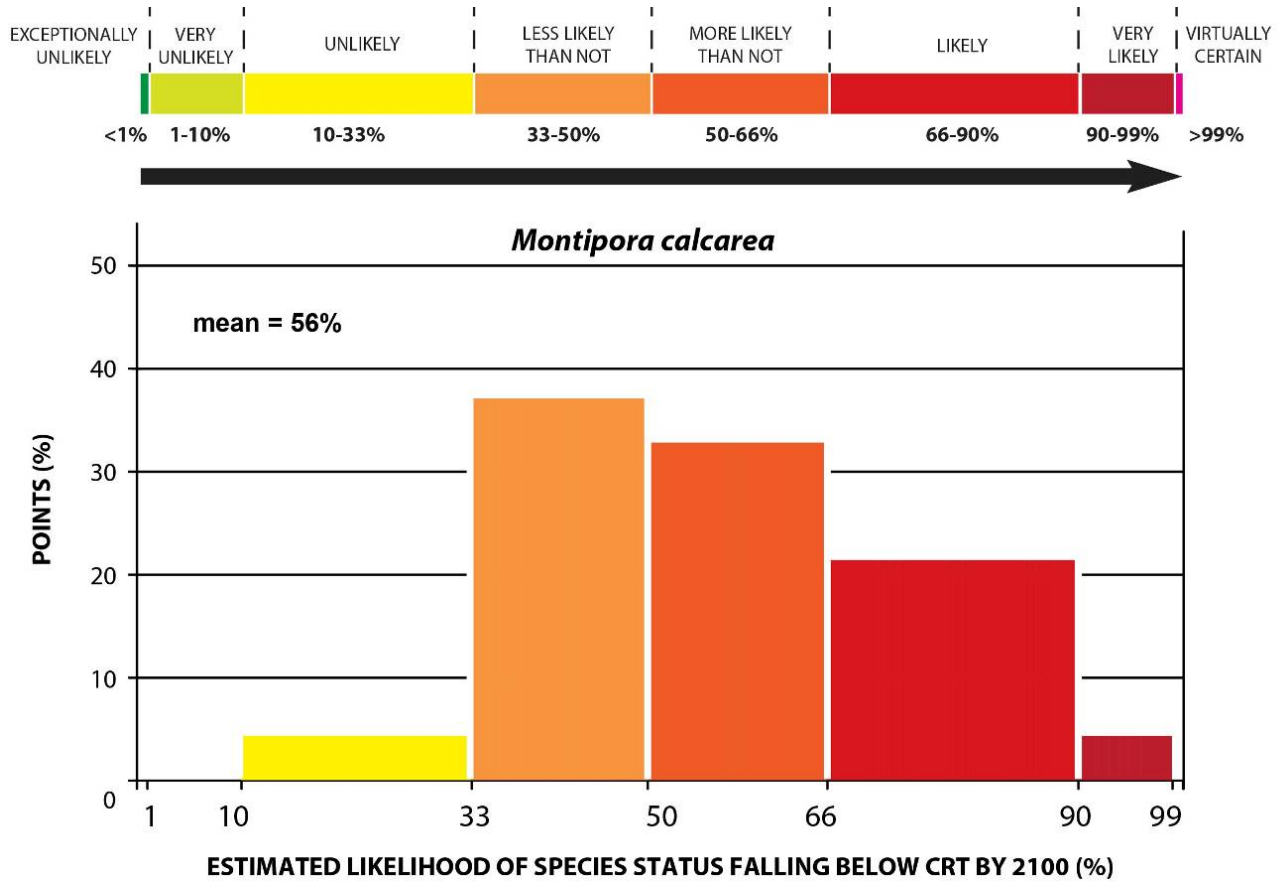

Figure 7.9.12. Distribution of points to estimate the likelihood that the status of *Montipora calcarea* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Montipora calcarea* include its rare abundance combined with presumed generic vulnerability to a range of threats including disease, bleaching, and predation as well as potentially increasing threats from collection/trade. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) are its relatively wide geographic distribution, making it more likely a species will be able to escape the impacts of threats and catastrophes in at least some locations.

The mean likelihood that *Montipora calcarea* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "more likely than not" risk category with a mean likelihood of 56% and a standard error (SE) of 12% (Fig. 7.9.12). This SE was calculated by taking the standard deviation of the seven mean voting scores of the BRT members and its relatively high value (among the 82 candidates) shows a somewhat lower coherence among the BRT. The uncertainty of the BRT is reflected in the wide range of votes of 10%–99% (Fig. 7.9.12) and the average range of likelihood estimates of the seven BRT voters (54%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Montipora calcarea*.

7.9.4 *Montipora caliculata* Dana, 1846

Figure 7.9.13. *Montipora caliculata* photos and corallite plan from Veron (2000).

Characteristics

Montipora caliculata colonies are brown or blue and massive. Corallites are a mixture of immersed and foveolate (funnel shaped), the latter usually having wavy rims. Individual corallites typically have all or part of their wall missing so that adjacent corallites form short valleys. Parts of walls that remain may be tuberculae-like (Veron, 2000).

Taxonomy

Taxonomic issues: None.

Family: Acroporidae.

Evolutionary and geologic history: See Section 7.9: Genus *Montipora*.

Global Distribution

Montipora caliculata has a wide distribution, though IUCN reports its existence in east Africa/Madegascar which is not supported by (Veron, 2000). Otherwise, it ranges from western Sumatra through the Pitcairn Islands. It also has fairly wide latitudinal range from Taiwan to mid-Australia.

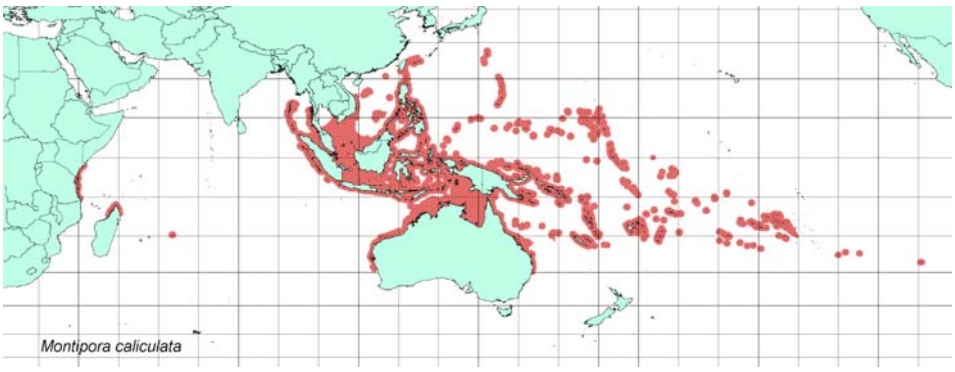

Figure 7.9.14. *Montipora caliculata* distribution from IUCN copied from http://www.iucnredlist.org.

Figure 7.9.15. *Montipora caliculata* distribution from Veron (2000).

U.S. Distribution

According to both the IUCN Species Account and the CITES species database, *Montipora caliculata* occurs in American Samoa and the Northern Mariana Islands. The IUCN Species Account also lists its occurrence in the U.S. minor outlying islands. A search of published and unpublished records of occurrence in U.S. waters indicates *Montipora caliculata* has been reported from Tutuila, Ofu-Olosega, Ta′u, and Swains in American Samoa (Birkeland, unpubl. data; Coles et al., 2003; CRED, unpubl. data; Fisk and Birkeland, 2002; Kenyon et al., 2010b; Lamberts, 1983; Lovell and McLardy, 2008; Maragos, 1994; National Park Service, 2009), the Mariana Islands (CRED, unpubl. data; Randall, 2003), Howland and Baker Islands, Jarvis Island and Kingman Reef (CRED, unpubl. data), and Palmyra Atoll (Williams et al., 2008b).

Within federally protected waters, *Montipora caliculata* has been recorded from the following areas:

- Pacific Remote Islands Marine National Monument (Howland, Baker, Jarvis, Palmyra, Kingman),
- National Park of American Samoa (Tutuila and Ofu Island units),
- Fagatele Bay National Marine Sanctuary,
- Marianas Trench Marine National Monument (Asuncion, Maug).

Habitat

Habitat: *Montipora caliculata* are found in most reef environments (Veron, 2000).

Depth range: *Montipora caliculata* are found at depths of up to 20 m.

Abundance

Montipora caliculata are most often reported to be uncommon (Veron, 2000).

Life History

The reproductive characteristics of *Montipora caliculata* have not been determined (Baird et al., 2009). However, the sexuality and reproductive mode have been determined for 35 other species of *Montipora*, all of which are hermaphroditic broadcast spawners. Although specific observations have not been published for this species, the larvae of all other *Montipora* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis.

Threats

Thermal stress: *Montipora* spp. have relatively high bleaching response according to published rankings in both Australia and east Africa (Marshall and Baird, 2000; McClanahan et al., 2007). *Montipora caliculata* is known to contain mycosporine-like amino acids (Teai et al., 1997), which can play a role in reducing bleaching exposure. However, *Montipora caliculata* was the 7th most susceptible to bleaching of the 18 *Montipora* listed on the Great Barrier Reef (Done et al., 2003), but showed only moderate bleaching (~ 20%, or less than half as susceptible as congener *Montipora tuberculosa*) in French Polynesia during the 2002 bleaching event (Hughes et al., 2003).

The congeneric species *Montipora capitata* copes with bleaching by relying more heavily on heterotrophic input, allowing it to rebuild lipid stores (Rodrigues et al., 2008) and maintain fecundity after bleaching (Cox, 2007).

Acidification: While not studied in this species, a congener, *Montipora capitata*, showed 15%–20% reduction in colony growth rate in mesocosm treatments of anticipated CO_2 levels within this century, although gamete production was not affected (Jokiel et al., 2008). Similarly, experiments on acidification impacts have all demonstrated negative effects on other members of the family Acroporidae, including reduced *Acropora* calcification (Anthony et al., 2008; Marubini et al., 2003; Renegar and Riegl, 2005; Schneider and Erez, 2006) and productivity (Anthony et al., 2008) and, in *Acropora palmata,* impaired fertilization and settlement success (Albright et al., 2010) and reduced growth in the field from Curaçao (Bak et al., 2009). In general, most corals studied have shown negative relationships between acidification and growth (Table 3.2.2) and acidification 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 have caused appreciable declines in coral populations so far, the BRT considers it to be a significant threat to corals by 2100.

Disease: *Montipora* spp. have moderate susceptibility/impact from disease. The genus has been susceptible to black-band disease in Australia (Sato et al., 2009) and the Red Sea (Al-Moghrabi, 2001), growth anomalies in Hawai`i (Aeby et al., 2006), and white syndromes in Australia and Hawai`i (Aeby, 2006; Willis et al., 2004). Also, ample evidence indicate that 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: *Montipora* spp. are preferred prey of crown-of-thorns seastar (*Acanthaster planci)*.

Land-based sources of pollution (LBSP): The effects of LBSP on *Montipora caliculata* are largely unknown. *Montipora* is characterized as a "sediment-intolerant" genus by McClanahan and Obura (1997), although there is clearly substantial variation in sediment tolerance among species (Hodgson, 1990; Jokiel et al., 2007; Stafford-Smith, 1993). Elevated nutrients have shown no effect on fecundity or fertilization success in *Montipora* (Cox and Ward, 2002). Competition with algae reduced settlement and survival of *Montipora* larvae but was reversed with antibiotics, suggesting the recruitment inhibition was caused by indirect microbial interactions (Vermeij et al., 2009).

LBSP-related stresses (nutrients, sediment, toxins, and salinity) often act in concert rather than individually and are influenced by other biological (e.g., herbivory) and hydrological factors. Collectively, LBSP stresses are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales (particularly important for species with limited range) and reduce the resilience of corals to bleaching (Carilli et al., 2009a; Wooldridge, 2009b).

Collection/Trade: The genus *Montipora* is heavily involved in the international aquarium trade, with substantial exports reported (in the thousands of pieces per year) from Indonesia, Malaysia, Tonga, Solomon Islands, and Fiji. Of particular concern, both Malaysia and Indonesia report increasing exports over the 2000−2008 period (less than 5000 to over 35,000 for Indonesia).

Risk Assessment

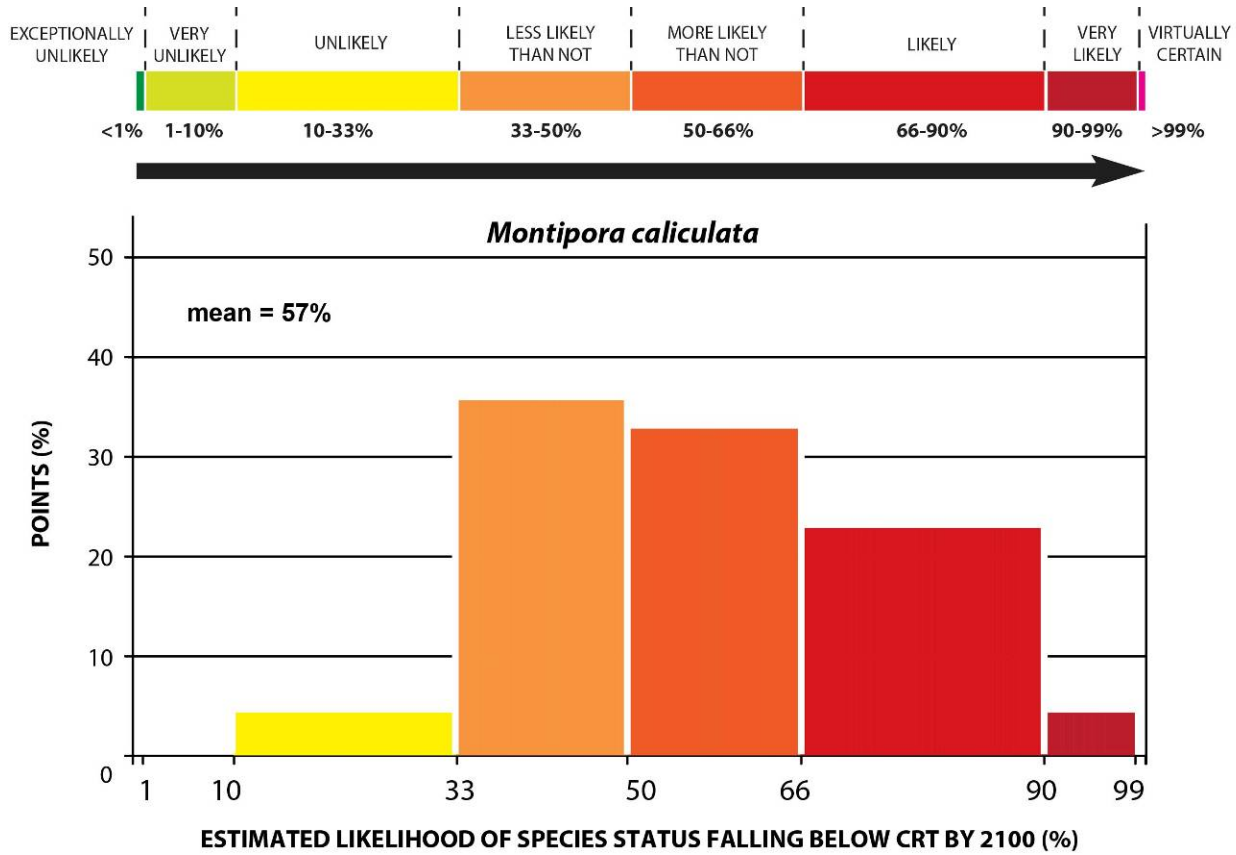

Figure 7.9.16. Distribution of points to estimate the likelihood that the status of *Montipora caliculata* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Montipora caliculata* include its presumed generic vulnerability to a range of threats including disease, bleaching, and predation as well as potentially increasing threats from collection/trade. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) are its relatively wide geographic distribution, making it more likely a species will be able to escape the impacts of threats and catastrophes in at least some locations.

The mean likelihood that *Montipora caliculata* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "more likely than not" risk category with a mean likelihood of 57% and a standard error (SE) of 12% (Fig. 7.9.16). This SE was calculated by taking the standard deviation of the seven mean voting scores of the BRT members and its relatively high value (among the 82 candidates) indicates a somewhat lower coherence among the BRT. The uncertainty of the BRT is reflected in the wide range of votes of 10%–99% (Fig. 7.9.16) and the average range of likelihood estimates of the seven BRT voters (54%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Montipora caliculata*.

7.9.5 *Montipora dilatata* Dana, 1846, *Montipora flabellata* Dana, 1846, and *Montipora turgescens* Bernard, 1897

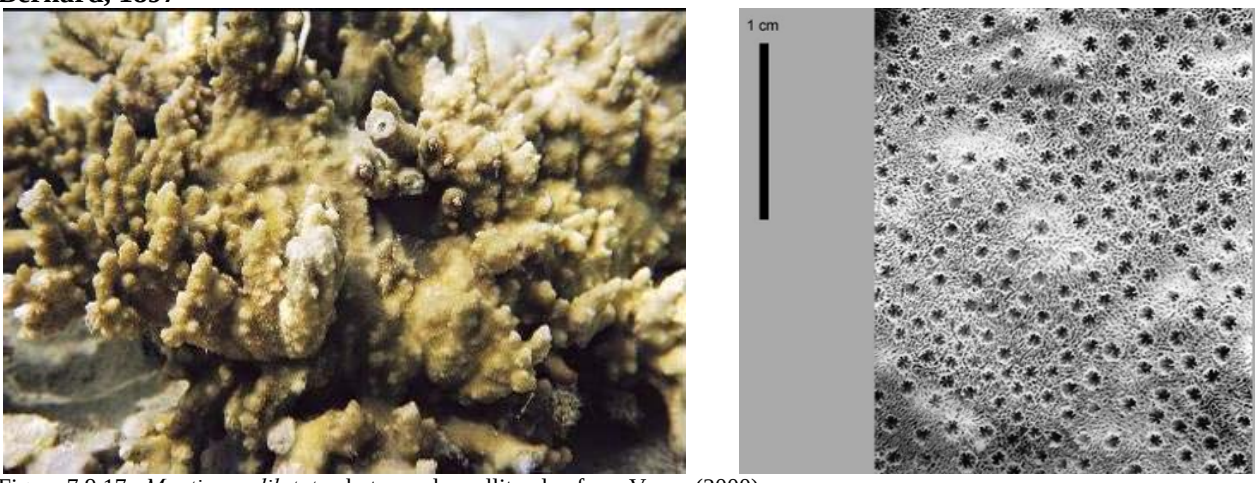

Figure 7.9.17. *Montipora dilatata* photos and corallite plan from Veron (2000).

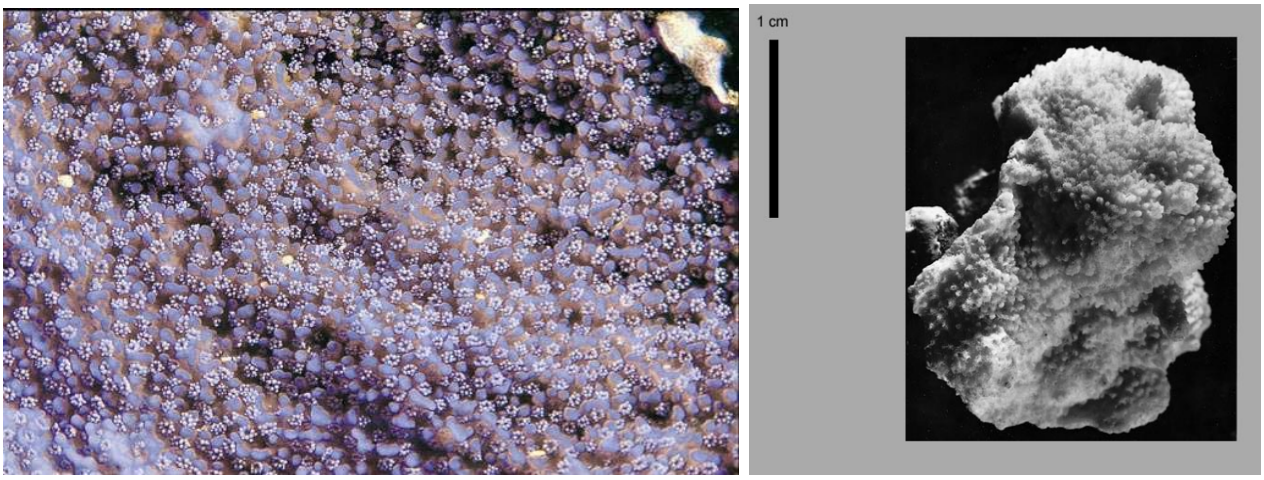

Figure 7.9.18. *Montipora flabellata* photos and corallite plan from Veron (2000).

Characteristics

Montipora dilatata: Colonies are encrusting to submassive and up to 0.3 m across, with irregular branch-like upgrowths up to 100 mm thick which become flattened near their ends. Coenosteum papillae are inconspicuous. Corallite walls are well defined. Colonies are pale to dark brown in color (Veron, 2000).

Montipora flabellata: Colonies are encrusting, with irregular lobes. Corallites are small (0.5 mm diameter). Papillae cover the colony surface and are sometimes fused into ridges. Septa are poorly developed. Colonies are usually blue (which may photograph pink), also brown or purple (Veron, 2000).

Montipora turgescens: Colonies are massive, flat, hemispherical or columnar. In habitats exposed to strong wave action the surface is usually mounded. Corallites are immersed. The coenosteum has no elaborations. Colonies are brown, cream or purple (Veron, 2000).

Note: Forsman et al (2010) show that the development of coenosteum elaborations is pheontypically plastic.

Taxonomy

Taxonomic issues: Important, see Section 7.8: Genus *Montipora*. In considering implications of recent results, the BRT has decided to assess extinction risk on this "species complex" as a single unit since the specimens examined from Hawai`i are indistinguishable on genetic or microskeletal characteristics and colony morphology is known to be highly plastic.

Family: Acroporidae.

Evolutionary and geologic history: See Section 7.9: Genus *Montipora*.

Global Distribution

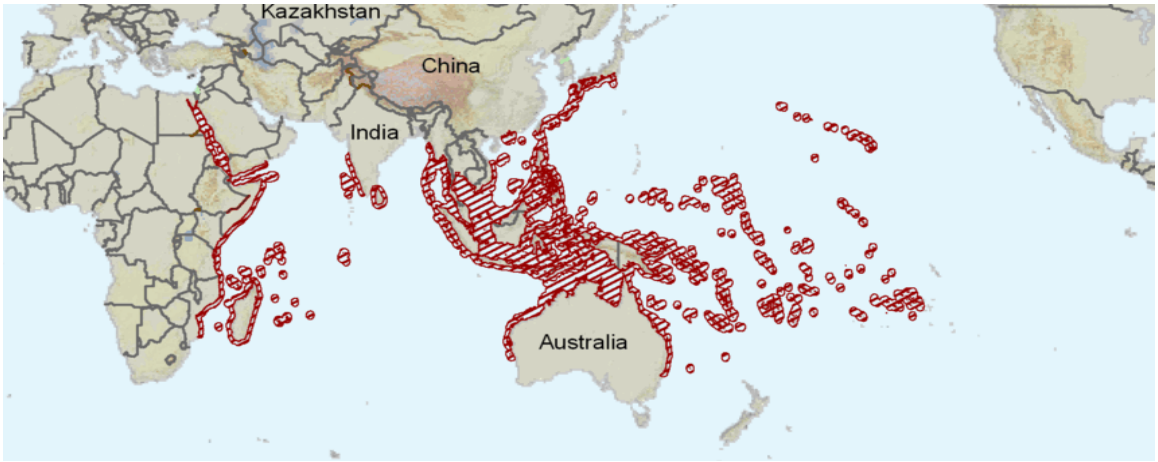

Figure 7.9.19. *Montipora dilatata/flabellata/turgescens* distribution (subsumed as distribution of *Montipora turgescens* as *Montipora dilatata* and *Montipora flabellata* are described as Hawaiian endemics) from IUCN copied from http://www.iucnredlist.org.

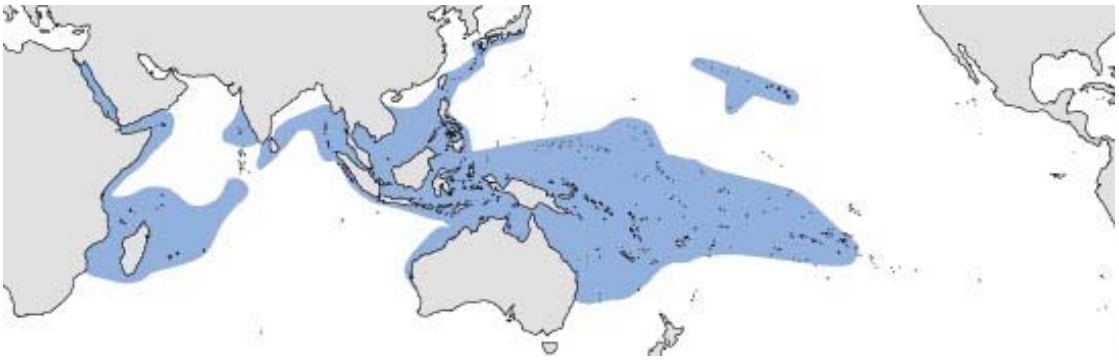

Figure 7.9.20. *Montipora dilatata/flabellata/turgescens* distribution (subsumed as distribution of *Montipora turgescens* as *Montipora dilatata* and *Montipora flabellata* are described as Hawaiian endemics) from Veron (2000).

U.S. Distribution

The rare components (*Montipora dilatata* and/or *Montipora flabellata*) of this complex have been recorded from the following federally protected areas (Godwin and Bolick, 2006; Maragos et al., 2004; Williams et al., 2008b):

- Papahānaumokuākea Marine National Monument (Necker, French Frigate Shoals, Gardner Pinnacles, Maro Reef, Laysan, Lisianski, Pearl and Hermes, Midway, Kure)
- Pacific Remote Islands Marine National Monument (Johnston, Palmyra, Kingman)
- Kalaupapa National Historic Park, Moloka'i
- Hawaiian Islands Humpback Whale National Marine Sanctuary

Habitat

Habitat: *Montipora dilatata/flabellata/turgescens* has been reported to occupy most reef environments (Veron, 2000).

Depth range: *Montipora dilatata/flabellata/turgescens* has been reported to depths of 30 m (Carpenter et al., 2008).

Abundance

The nominal *Montipora dilatata* is extremely rare while *Montipora flabellata* is the fifth most common coral in Hawai`i (statewide average 2.2% cover; http://cramp.wcc.hawaii.edu/LT_Montoring_files/Coral_Species.htm). There have likely been declines in these nominal species over the recent past, particularly *Montipora dilatata* (http://www.nmfs.noaa.gov/pr/pdfs/species/hawaiianreefcoral_detailed.pdf). However, the nominal *Montipora turgescens* is described as widespread and common and no evidence of overall declines has been found.

Life History

Montipora dilatata/flabellata/turgescens are hermaphroditic broadcast spawners (Baird et al., 2009; Kolinski and Cox, 2003). Although specific observations have not been published for this species, the larvae of all other *Montipora* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis.

Threats

Montipora dilatata has previously been identified as a Species of Concern under the Endangered Species Act (National Marine Fisheries Service, 2004). A "species of concern" identifies species about which NMFS has some concerns regarding status and threats, but for which insufficient information is available to indicate a need to list the species under the Endangered Species Act. *Montipora dilatata* was identified as a Species of Concern in 2004 based on the species being very rare, endemic to a small geographic area (Hawai`i), and subject to the following factors for decline: (1) vulnerability to coral bleaching; (2) fresh water kills and exposure at extreme low tide; (3) habitat degradation and modification as a result of sedimentation, pollution, and alien alga invasion; and (4) damage by anchors, fish pots, swimmers, and divers.

Thermal stress: The nominal *Montipora dilatata* and *Montipora flabellata* are highly susceptible to bleaching (Jokiel and Brown, 2004; Kenyon and Brainard, 2006) with substantial local declines of *Montipora dilatata* in Kāne`ohe Bay, Hawai`i, from bleaching mortality (Jokiel and Brown, 2004) (http://www.nmfs.noaa.gov/pr/pdfs/species/hawaiianreefcoral_detailed.pdf). The congeneric species *Montipora capitata* copes with bleaching by relying more heavily on heterotrophic input, allowing it to rebuild lipid stores (Rodrigues et al., 2008) and maintain fecundity after bleaching (Cox, 2007).

Acidification: While not studied in this species, a congener, *Montipora capitata*, showed 15%–20% reduction in colony growth rate in mesocosm treatments of anticipated CO_2 levels within this century, although gamete production was not affected (Jokiel et al., 2008). Similarly, in most corals studied (Table 3.2.2), 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: *Montipora* spp. are generally described as medium susceptibility to disease. Nominal *Montipora turgescens* is specifically described with mortality from a rapid tissue-loss ("white") syndrome in the Northwestern Hawaiian Islands and this condition affected more than 21% of *Montipora* spp. colonies in a 2003 survey (Aeby, 2006). Also, ample evidence indicate that diseases can have devastating regional impacts on individual coral species (e.g., Aronson and Precht, 2001; Bruckner and Hill, 2009) and evidence show that these impacts are occurring in more taxa and at a broader geographic scale (Green and Bruckner, 2000; Sutherland et al., 2004).

Predation: *Montipora* spp. are preferred prey of crown-of-thorns seastar (*Acanthaster planci*) and susceptible to snail predation.

Land-based sources of pollution (LBSP): The effects of LBSP on *Montipora dilatata/flabellata/turgescens* are largely unknown. *Montipora* was characterized as a "sediment-intolerant" genus by McClanahan and Obura (1997), while other congeners have been found to be relatively sediment tolerant (Hodgson, 1990; Stafford-Smith, 1993). Clearly, some *Montipora* are more sediment susceptible than others (Jokiel et al., 2007). Elevated nutrients have shown no effect on fecundity or fertilization success in *Montipora* (Cox and Ward, 2002). Competition with algae reduced settlement and survival of *Montipora* larvae but was reversed with antibiotics, suggesting the recruitment inhibition was caused by indirect microbial interactions (Vermeij et al., 2009).

LBSP-related stresses (nutrients, sediment, toxins, and salinity) often act in concert rather than individually and are influenced by other biological (e.g., herbivory) and hydrological factors. Collectively, LBSP stresses are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales (particularly important for species with limited range) and reduce the resilience of corals to bleaching (Carilli et al., 2009a; Wooldridge, 2009b).

Collection: *Montipora* spp. are substantially involved in international trade, but there are no records at the species level. Substantial exports are reported (in the thousands of pieces per year) from Indonesia, Malaysia, Tonga, Solomon Islands, and Fiji. Of concern, both Malaysia and Indonesia report increasing exports over the 2000−2008 period (less than 5000 to over 35,000 for Indonesia).

Risk Assessment

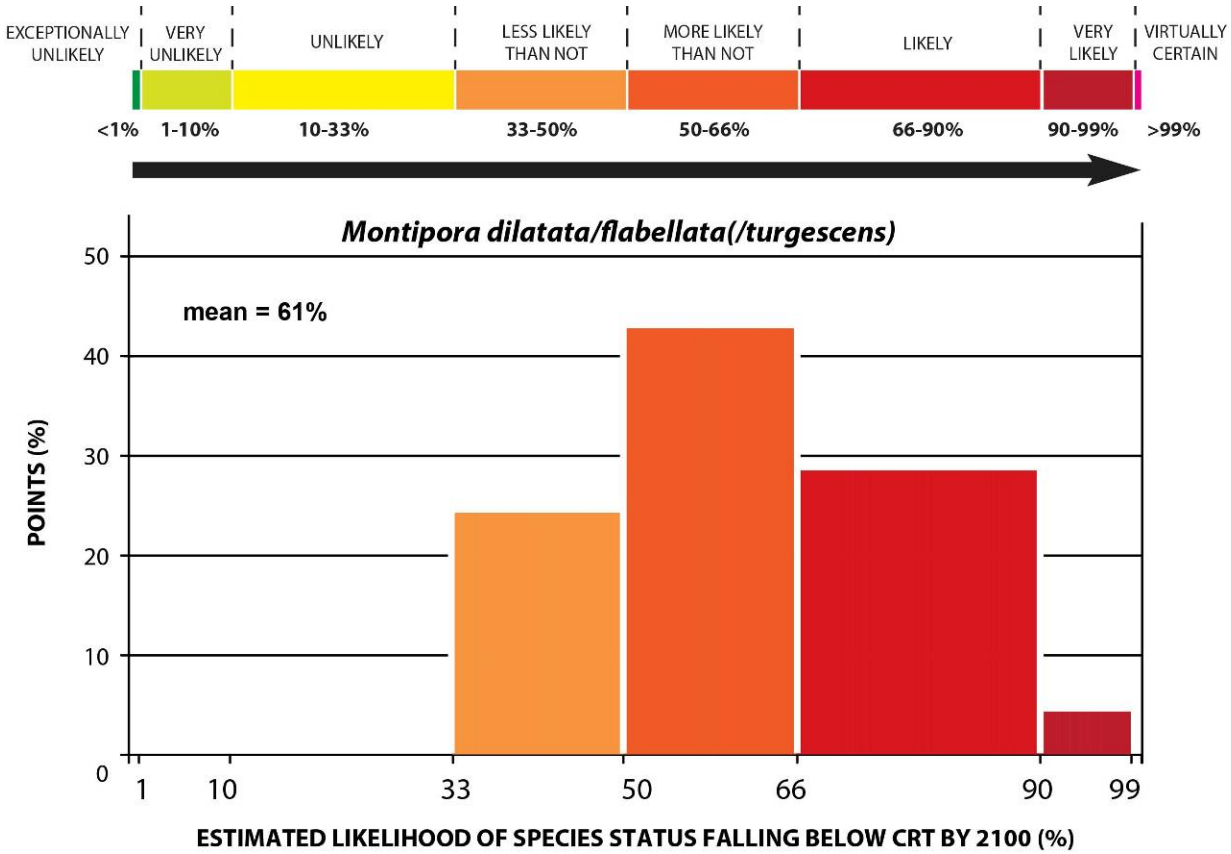

Figure 7.9.21. Distribution of points to estimate the likelihood that the status of *Montipora dilatata/flabellata/turgescens* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Montipora dilatata/flabellata/turgescens* include its presumed generic vulnerability to a range of threats including disease, bleaching, predation and potentially increasing threats from collection/trade, as well as documented declines in Hawai`i of the *Montipora dilatata* component. Factors that reduce potential extinction risk (decrease the likelihood of

falling below the Critical Risk Threshold) are the common occurrence and relatively wide geographic distribution of the *Montipora turgescens* component, making it more likely a species will be able to escape the impacts of threats and catastrophes in at least some locations.

The overall likelihood *Montipora dilatata/flabellata/turgescens* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "more likely than not" risk category with a mean likelihood of 61% and a standard error (SE) of 7% (Fig. 7.9.21). This SE was calculated by taking the standard deviation of the seven mean voting scores of the BRT members and its relatively high value (among the 82 candidates) shows a somewhat lower coherence among the BRT. The uncertainty of the BRT is reflected in the range of votes of 33%–99% (Fig. 7.9.21) and the average range of likelihood estimates of the seven BRT voters (56%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Montipora dilatata/flabellata/turgescens*, but was partly attributed to taxonomic uncertainties in this group.

7.9.6 *Montipora lobulata* Bernard, 1897

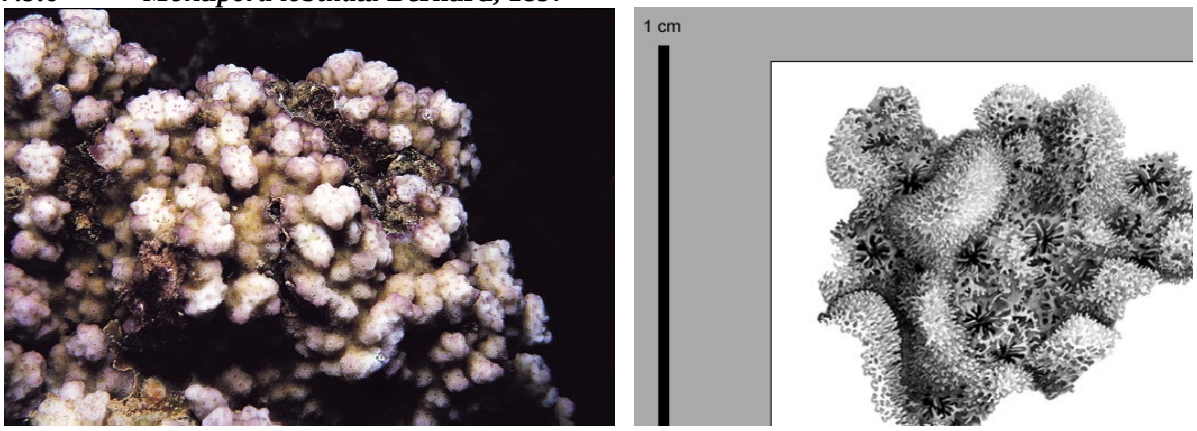

Figure 7.9.22. *Montipora lobulata* photos and corallite plan from Veron (2000).

Characteristics

Colonies of *Montipora lobulata* are mottled brown or white and submassive. Colony surfaces consist of irregular mounds covered by irregular tuberculae. There is complete continuity in size between the mounds and tuberculae. Corallites are distributed irregularly although they are less common in tuberculae. The coenosteum is irregularly coarse (Veron, 2000).

Taxonomy

Taxonomic issues: None.

Family: Acroporidae.

Evolutionary and geologic history: See Section 7.9: Genus *Montipora*.

Global Distribution

Montipora lobulata has a disjoint distribution, with occurrence in the western and central Indian Ocean and the central Pacific, but absence from Australia and the Coral Triangle region. It appears that Veron (2000) does not support its occurrence in the Northern Marianas.

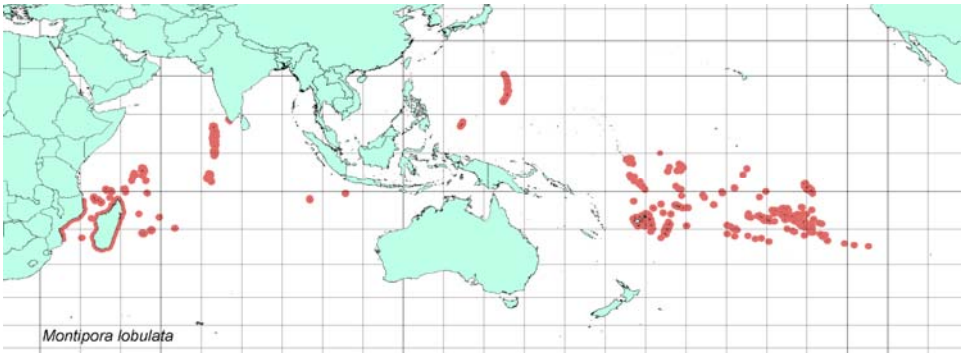

Figure 7.9.23. *Montipora lobulata* distribution from IUCN copied from http://www.iucnredlist.org.

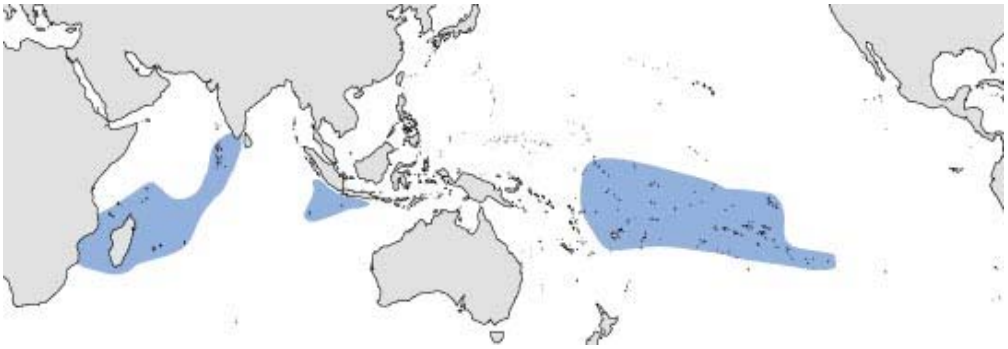

Figure 7.9.24. *Montipora lobulata* distribution from Veron (2000).

U.S. Distribution

According to both the IUCN Species Account and the CITES species database, *Montipora lobulata* occurs in American Samoa and the Northern Mariana Islands. The IUCN Species Account also lists its occurrence in the U.S. minor outlying islands.

A search of published and unpublished records of occurrence in U.S. waters indicates *Montipora lobulata* has been reported from Tutuila, Ta′u, and Rose Atoll in American Samoa (Coles et al., 2003; Kenyon et al., 2010a), Guam and CNMI (Burdick, unpubl. data; CRED, unpubl. data; Randall, 2003), and Wake Atoll (CRED, unpubl. data).

Montipora lobulata has been reported to occur in the following federally protected waters:

- Pacific Remote Islands Marine National Monument (Wake)
- Fagatele Bay National Marine Sanctuary, Tutuila
- Rose Atoll Marine National Monument

Habitat

Habitat: *Montipora lobulata* has been reported to inhabit shallow reef environments (Veron, 2000).

Depth range: *Montipora lobulata* has been reported at depths of up to 20 m.

Abundance

Abundance of *Montipora lobulata* has been reported as rare (Veron 2000).

Life History

The reproductive characteristics of *Montipora lobulata* have not been determined (Baird et al., 2009). However, the sexuality and reproductive mode have been determined for 35 other species of *Montipora*, all of which are hermaphroditic broadcast spawners. Although specific observations have not been published for this species, the larvae of all other *Montipora* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis.

Threats

Thermal stress: *Montipora* spp. have relatively high bleaching response according to published rankings in both Australia and east Africa (Marshall and Baird, 2000; McClanahan et al., 2007). The congeneric species *Montipora capitata* copes with bleaching by relying more heavily on heterotrophic input, allowing it to rebuild lipid stores (Rodrigues et al., 2008) and maintain fecundity after bleaching (Cox, 2007).

Acidification: While not studied in this species, a congener, *Montipora capitata*, showed 15%−20% reduction in colony growth rate in mesocosm treatments of anticipated CO_2 levels within this century, although gamete production was not affected (Jokiel et al., 2008). Similarly, in most corals studied (Table 3.2.2), acidification impairs growth (Langdon and Atkinson, 2005; Manzello, 2010) and, in the case of *Acropora palmata,* 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: *Montipora* spp. have moderate susceptibility/impact from disease. The genus has been susceptible to black-band disease in Australia (Bourne, 2005; Sato et al., 2009) and the Red Sea (Al-Moghrabi, 2001), growth anomalies in Hawai`i (Aeby, 2006) and white syndromes in Australia and Hawai`i (Aeby, 2006; Willis et al., 2004). Also, ample evidence indicate that diseases can have devastating regional impacts on individual coral species (e.g., Aronson and Precht, 2001; Bruckner and Hill, 2009), and evidence show that these impacts are occurring in more taxa and at a broader geographic scale (Green and Bruckner, 2000; Sutherland et al., 2004).

Predation: *Montipora* spp. are preferred prey of crown-of-thorns seastar (*Acanthaster planci*).

Land-based sources of pollution (LBSP): The effects of LBSP on *Montipora lobulata* are largely unknown. *Montipora* is characterized as a "sediment-intolerant" genus by McClanahan and Obura (1997), while other congeners have been found to be relatively sediment tolerant (Hodgson, 1990; Stafford-Smith, 1993). Clearly, some *Montipora* are more sediment susceptible than others (Jokiel et al., 2007). Elevated nutrients have shown no effect on fecundity or fertilization success in *Montipora* (Cox and Ward, 2002). Competition with algae reduced settlement and survival of *Montipora* larvae but was reversed with antibiotics, suggesting the recruitment inhibition was caused by indirect microbial interactions (Vermeij et al., 2009).

LBSP-related stresses (nutrients, sediment, toxins, and salinity) often act in concert rather than individually and are influenced by other biological (e.g., herbivory) and hydrological factors. Collectively, LBSP stresses are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales (particularly important for species with limited range) and reduce the resilience of corals to bleaching (Carilli et al., 2009a; Wooldridge, 2009b).

Collection/Trade: The genus *Montipora* is heavily involved in the international aquarium trade, with substantial exports reported (in the thousands of pieces per year) from Indonesia, Malaysia, Tonga, Solomon Islands, and Fiji. Of concern, both Malaysia and Indonesia report increasing exports over the 2000−2008 period (less than 5000 to more than 35,000 for Indonesia).

Risk Assessment

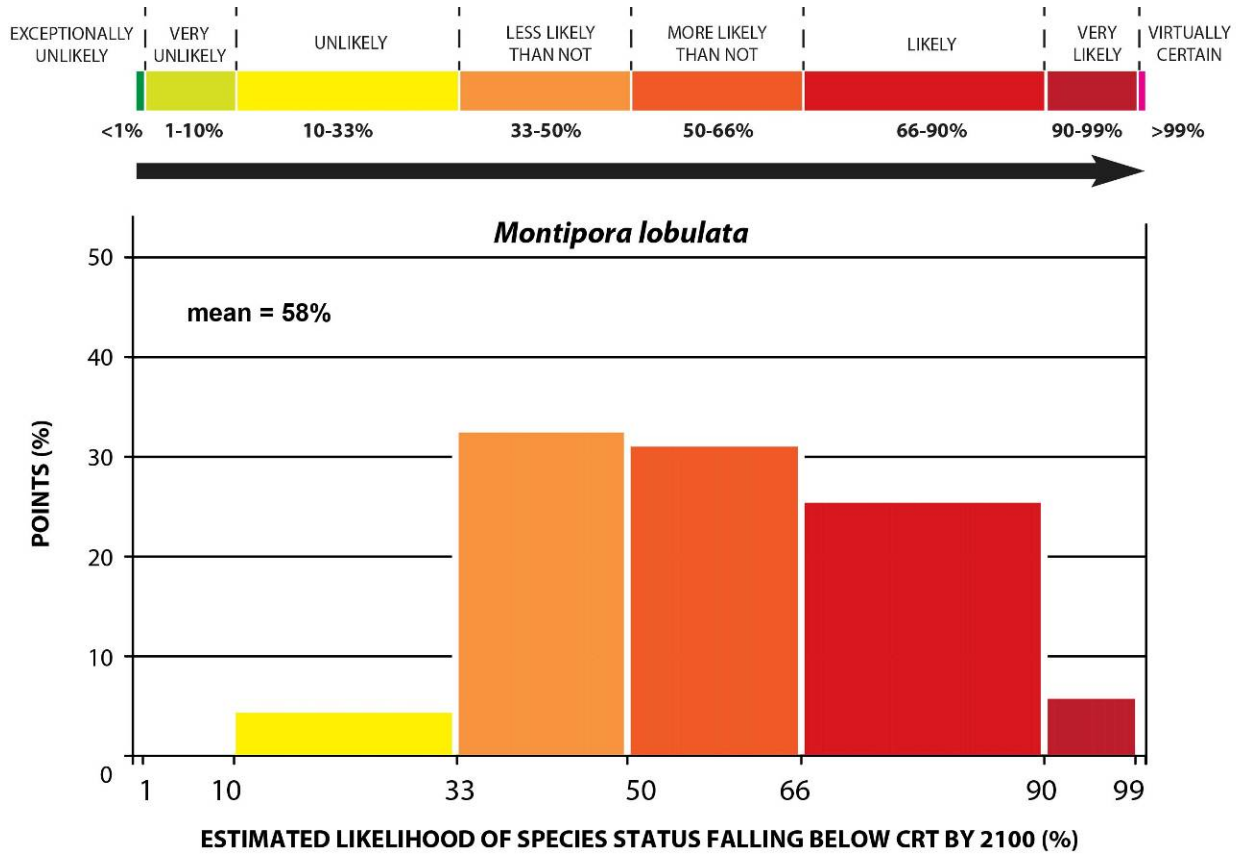

Figure 7.9.25. Distribution of points to estimate the likelihood that the status of *Montipora lobulata* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold for *Montipora lobulata* include its rare occurrence combined with presumed generic vulnerability to a range of threats including disease, bleaching, and predation as well as potentially increasing threats from collection/trade. *Montipora lobulata* has a wide but seemingly more vulnerable disjunct longitudinal distribution (reducing connectivity and making "rescue" of extirpation less likely) and rather limited latitudinal distribution (suggesting less environmental tolerance). Wide distribution lowers extinction risk by making it more likely a species will be able to escape the impacts of threats and catastrophes in at least some locations.

The overall likelihood that *Montipora lobulata* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "more likely than not" risk category with a mean likelihood of 58% and a standard error (SE) of 12% (Fig. 7.9.25). This SE was calculated by taking the standard deviation of the seven mean voting scores of the BRT members and its relatively high value (among the 82 candidates) indicates a somewhat lower coherence among the BRT. The uncertainty of the BRT is reflected in the wide range of votes of 10%–99% (Fig. 7.9.25) and the average range of likelihood estimates of the seven BRT voters (57%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Montipora lobulata*.

7.9.7 *Montipora patula (/verrili)* Bernard, 1897

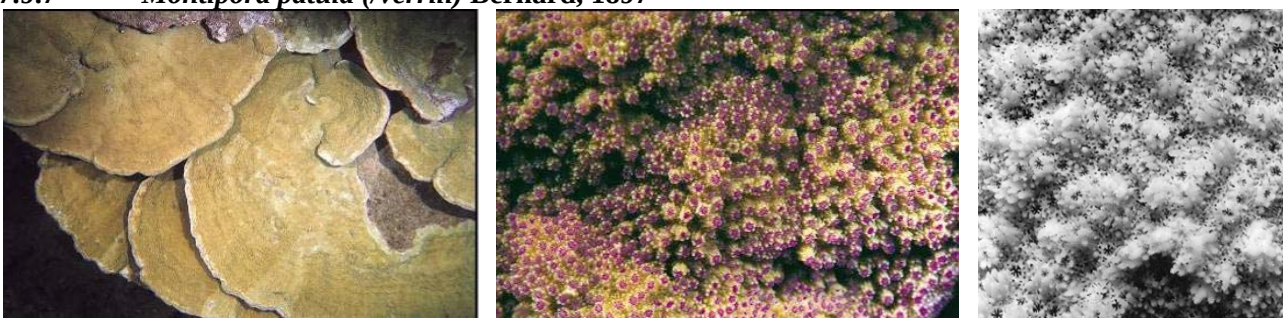

Figure 7.9.26. *Montipora patula* photos and corallite plan from Veron (2000).

Characteristics

Montipora patula colonies are tan, most often with purple polyps and are encrusting or tiered plates, sometimes over two meters across. Plates usually have free edges. Corallites are small and irregular in height. Papillae are concentrated around the corallites (Veron, 2000).

(Nominal *Montipora verrilli* described similarly but as only encrusting)

Taxonomy

Taxonomic issues: See Section 7.9: Genus *Montipora*. Given results of recent genetic and micro-morphological analyses, the BRT has chosen to evaluate extinction risk of *Montipora patula/verrilli* as a single unit since they are indistinguishable genetically and micro-morphologically (Forsman et al., 2010).

Family: Acroporidae.

Evolutionary and geologic history: See Section 7.9: Genus *Montipora*."

Global Distribution

Montipora patula/verrilli has a very restricted range, centered in the main and Northwestern Hawaiian Islands. IUCN includes Palau, Marianas Islands, Phoenix Islands, French Polynesia, and Johnston Atoll for the nominal *Montipora verrilli,* but this is not supported by Veron (2000).

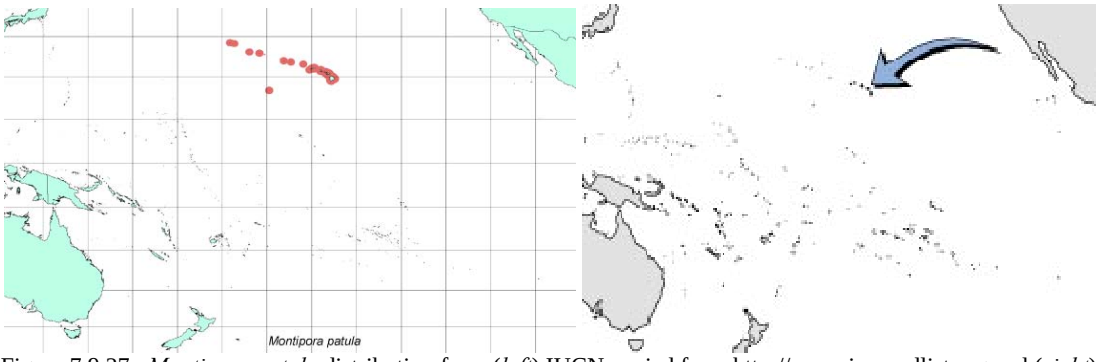

Figure 7.9.27. *Montipora patula* distribution from (*left*) IUCN copied from http://www.iucnredlist.org and (*right*) Veron (2000).

Figure 7.9.28. *Montipora verrilli* distribution from (*left*) IUCN copied from http://www.iucnredlist.org and (*right*) Veron (2000).

U.S. Distribution

As described above, and within federally protected waters, nominal *Montipora patula* has been recorded from the following areas:

- Papahānaumokuākea Marine National Monument (Nihoa, Necker, French Frigate Shoals, Gardner Pinnacles, Maro Reef, Laysan, Lisianski, Pearl and Hermes, Midway, Kure)
- Pacific Remote Islands Marine National Monument (Johnston, Palmyra, Kingman)
- Kaloko-Honokōhau National Historic Park, Hawai`i
- Puukoholā Heiau National Historic Site, Hawai`i
- Puuhonua o Hōnaunau National Historic Park, Hawai`i
- Kalaupapa National Historic Park, Moloka`i
- Hawaiian Islands Humpback Whale National Marine Sanctuary

Habitat

Habitat: *Montipora patula* has been reported to occupy shallow reef environments and reef flats (Veron, 2000). *Montipora patula* is common in wave-swept environments but less tolerant of sediment-impacted areas (Jokiel et al., 2007).

Depth range: IUCN describes both these nominal species as restricted to shallow reef flats, up to 10 m. However, Kuhlmann (1983) describes *Montipora verrilli* as occurring up to 40 m, including a photo at 25-m depth. This suggests the potential for deep refugia.

Abundance

Abundance of *Montipora patula* has been reported as sometimes common (Veron 2000). The nominal *Montipora patula* is the most abundant of the three Hawaiian endemic (nominal) *Montipora* with overall statewide mean cover of 3.3%, making it the 4th most abundant coral in Hawai`i (http://cramp.wcc.hawaii.edu/LT_Montoring_files/Coral_Species.htm). The nominal *Montipora verrilli* is less abundant in Hawai`i. Dollar and Grigg (Dollar and Grigg, 2004) show substantial declines of *Montipora patula* on a subset of their transects over 12 years, but other transects within sites show high variability between surveys and/or similar cover between the beginning and end of the study.

Life History

Montipora patula and *Montipora verrilli* are both documented as hermaphroditic broadcast spawners (Heyward, 1986). Release of packaged egg and sperm bundles has been observed in the months of July through September at Coconut Island, O`ahu, Hawai`i, during two moon phases: new to first quarter, and full to third quarter (Heyward, 1986; Hodgson, 1988; Kolinski and Cox, 2003). Although specific larval descriptions have not been published for this species, the larvae of all other *Montipora* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis.

Threats

Thermal stress: *Montipora* spp. have relatively high bleaching response according to published rankings in both Australia and east Africa (Marshall and Baird, 2000; McClanahan et al., 2007). *Montipora patula* is among the most bleaching-susceptible species in the Northwestern Hawaiian Islands (Kenyon and Brainard, 2006) and may be moderately susceptible in the main Hawaiian Islands (Jokiel and Brown, 2004). What ultimately became known as the stress-tolerant zooxanthellae clade D was first documented in shallow-water *Montipora patula* in Hawa`ʻi (Rowan and Powers, 1991), though the species also hosts clade C in deeper waters (LaJeunesse et al., 2004b).

Acidification: While not studied in this species, a congener, *Montipora capitata*, showed 15%–20% reduction in colony growth rate in mesocosm treatments of anticipated CO_2 levels within this century, although gamete production was not affected (Jokiel et al., 2008). Similarly, in most corals studied (Table 3.2.2), 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 have caused appreciable declines in coral populations so far, the BRT considers it to be a significant threat to corals by 2100.

Disease: *Montipora* spp. have moderate susceptibility/impact from disease. Both nominal *Montipora patula* and *Montipora verrilli* are specifically noted with acute disease conditions (involving tissue loss/partial mortality) with high frequency of occurrence (over 20% of surveyed sites where the taxa was observed showed disease signs) and high prevalence (over 7% in some sites) in the Northwestern Hawaiian Islands (Aeby, 2006). This author points out that the high prevalence sites had suffered severe bleaching in the previous year. Also, ample evidence indicate that diseases can have devastating regional impacts on individual coral species (e.g., Aronson and Precht, 2001; Bruckner and Hill, 2009), and evidence show that these impacts are occurring in more taxa and at a broader geographic scale (Green and Bruckner, 2000; Sutherland et al., 2004).

Predation: *Montipora* spp. are preferred prey of crown-of-thorns seastar (*Acanthaster planci)*.

Land-based sources of pollution (LBSP): The effects of LBSP on *Montipora patula* are largely unknown for this species. *Montipora patula* may be less sediment tolerant than other *Montipora* species (Jokiel et al., 2007), and it did disappear from survey stations in Pelekane Bay, Hawai`i between 1977 and 1996 as the bay became more sediment impacted (Tissot, 1998). Elevated nutrients have also had no effect on fecundity or fertilization success in *Montipora* (Cox and Ward, 2002). Competition with algae reduced settlement and survival of *Montipora* larvae but was reversed with antibiotics, suggesting the recruitment inhibition was caused by indirect microbial interactions (Vermeij et al., 2009).

LBSP are largely unknown for this genus. LBSP-related stresses (nutrients, sediment, toxins, and salinity) often act in concert rather than individually and are influenced by other biological (e.g., herbivory) and hydrological factors. Collectively, LBSP stresses are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales (particularly important for species with limited range) and reduce the resilience of corals to bleaching (Carilli et al., 2009a; Wooldridge, 2009b).

Collection/Trade: The genus *Montipora* is heavily involved in the international ornamental trade. However, collection for the ornamental trade is likely of a low overall impact in the geographic areas where this species is located, as compared to many of its congeners.

Risk Assessment

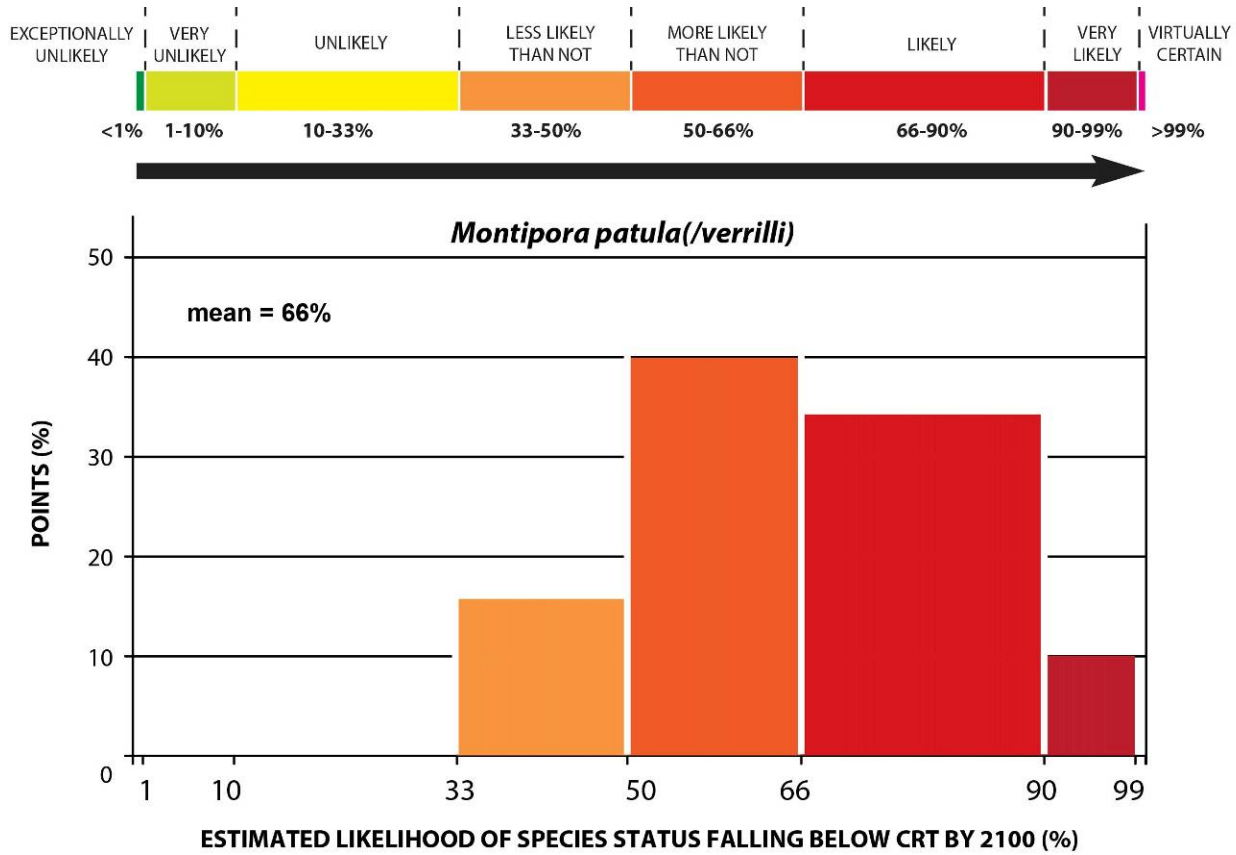

Figure 7.9.29. Distribution of points to estimate the likelihood that the status of *Montipora patula/verrilli* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Montipora patula/verrilli* include its combined very narrow geographic distribution, restriction to shallow habitats,and its generic high susceptibility to a range of threats (bleaching, predation) and documented species-specific impacts from disease. Narrow geographic distribution (and narrow habitat range) increases the likelihood that changing conditions or a local impact in a particular location can push the species below the Critical Risk Threshold. No known characteristics of this species noted that reduced expectations of extinction risk were noted.

The overall likelihood that *Montipora patula/verrilli* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "more likely than not/likely" risk categories with a mean likelihood of 66% and a standard error (SE) of 10% (Fig. 7.9.29). This SE was calculated by taking the standard deviation of the seven mean voting scores of the BRT members and its moderate value (among the 82 candidates) indicates the degree of coherence among the BRT. The uncertainty of the BRT is reflected in the range of votes of 33%–99% (Fig. 7.9.29) and the average range of likelihood estimates of the seven BRT voters (50%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Montipora patula/verrilli*.

7.10 Genus *Alveopora* (Family Poritidae)

7.10.1 *Alveopora allingi* Hoffmeister, 1925

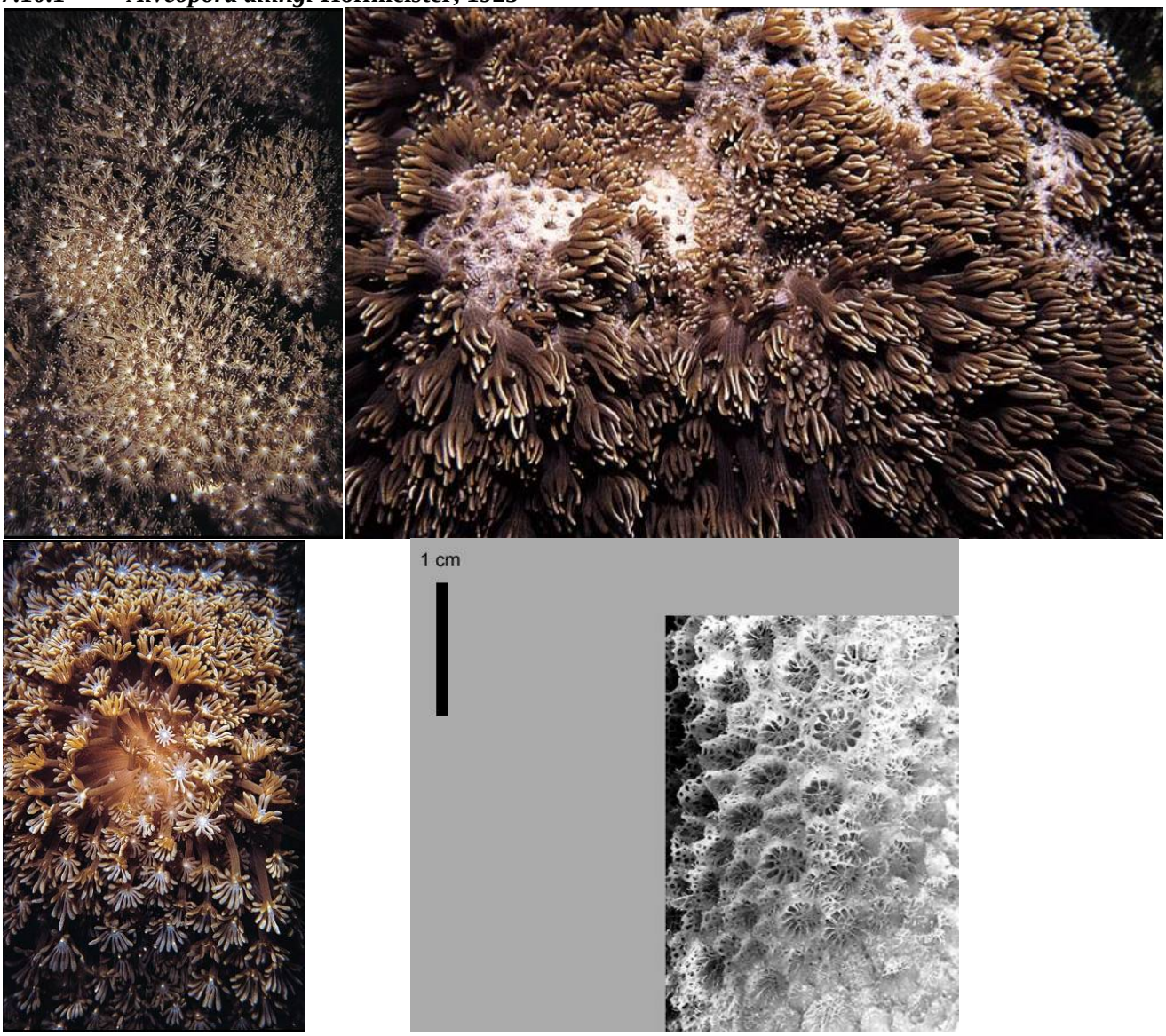

Figure 7.10.1. *Alveopora allingi* photos and corallite plan from Veron (2000).

Characteristics

Colonies of *Alveopora allingi* are encrusting or have short irregular lobes with rounded surfaces or are columnar. Corallites have walls composed of interconnected rods and spines and long spine-like septa. Columellae are usually present and are sometimes well developed. Polyps are tightly compacted and are long, usually with slightly expanded tentacle tips. Colonies are usually yellow, green or brown in color with white oral cones (Veron, 2000).

Taxonomy

Taxonomic issues: None. *Alveopora allingi* is similar to *Alveopora catalai*, which has larger corallites and a branching growth-form. *Alveopora marionensis* has smaller corallites but a similar growth-form (Veron, 2000).

Family: Poritidae.

Evolutionary and geologic history: The genus is known from the Tethys Sea in the Eocene, but is extinct in the Caribbean (Wells and Moore, 1956).

Global Distribution

Alveopora allingi has a very broad range, extending from the Red Sea and East Africa to the central Pacific. It extends latitudinally from the Japanese Ryukyu Islands and Red Sea in the northern hemisphere across the Great Barrier Reef and down both coastlines of Australia and South Africa in the southern hemisphere (Veron, 2000).

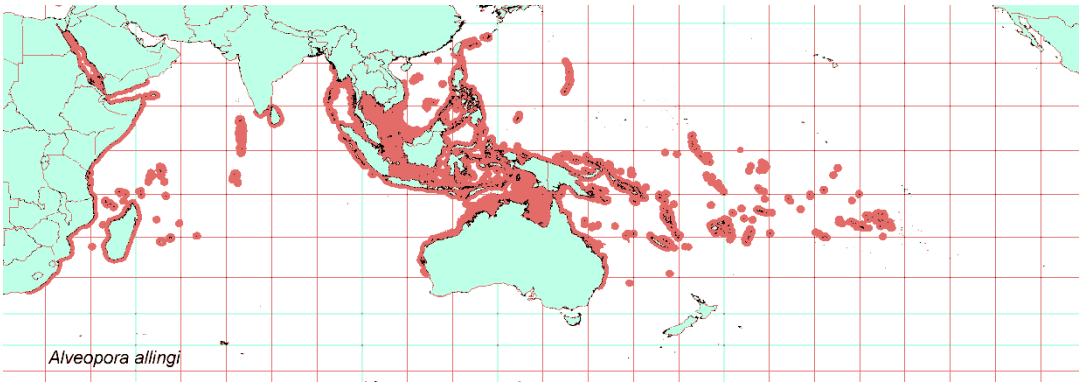

Figure 7.10.2. *Alveopora allingi* distribution from IUCN copied from http://www.iucnredlist.org.

Figure 7.10.3. *Alveopora allingi* distribution from Veron (2000).

U.S. Distribution

According to both the IUCN Species Account and the CITES database, *Alveopora allingi* occurs in American Samoa. The IUCN Species Account lists its occurrence in the Northern Mariana Islands and U.S. minor outlying islands, but the CITES database does not.

A search of published and unpublished records of occurrence in U.S. waters indicates *Alveopora allingi* has been reported from Tutuila in American Samoa (Coles et al., 2003; Hoffmeister, 1925; Lovell and McLardy, 2008; Maragos et al., 1994; Mundy, 1996; National Park Service, 2009) and the Mariana Islands (Randall, 2003).

Within federally protected waters, *Alveopora allingi* has been recorded from the following areas:

- National Park of American Samoa, Tutuila Island unit.

Habitat

Habitat: *Alveopora allingi* has been reported to occupy protected reef environments (Veron, 2000).

Depth range: *Alveopora allingi* has been reported in water depths ranging from 5 m to 10 m (Carpenter et al., 2008; Veron and Pichon, 1980).

Abundance

Abundance of *Alveopora allingi* has been reported as usually uncommon (Veron, 2000).

Life History

Reproductive characteristics of *Alveopora allingi* have not been determined (Baird et al., 2009). The congeners *Alveopora gigas, Alveopora verrilliana, and Alveopora tizardi* are hermaphroditic broadcast spawners (Babcock et al., 1994; Baird et al., 2009). The congeners *Alveopora daedalea* and *Alveopora japonica* have been reported as hermaphroditic brooders in the Red Sea (Shlesinger and Loya, 1985) and Japan (Harii et al., 2001), respectively. The minimum age of first reproduction for the congener *Alveopora japonica* in Tokyo Bay, where the annual sea temperature ranges from 13°C to 27°C, is 3 years (Harii et al., 2001).

On temperate-latitude reefs (28°–29°S) in the Houtman Abrolhous Islands, western Australia, two colonies of *Alveopora allingi* were sampled before the main mass spawning nights in late March 1987, but there was no indication of developed gametes (Babcock et al., 1994).

Although specific observations have not been published for this species, the larvae of two other *Alveopora* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis (Baird et al., 2009), i.e., they are autotrophic. Larval longevity has not been determined in this family.

Threats

Temperature stress: The genus *Alveopora* is listed as having the highest bleaching response from the 17 included genera in McClanahan et al. (2007) table for the Indian Ocean. *Alveopora* had high bleaching in Guam in 1994 (Paulay and Benayahu, 1999) and South Africa in 2000 but had little bleaching or mortality in Palau in the 2001 event (Bruno et al., 2001). Low-to-moderate bleaching of *Alveopora allingi* was observed in East Africa during the 1997-1998 event (Obura, 2001).

Acidification: Unknown for this genus. However, in most corals studied (Table 3.2.2), acidification impairs growth (Langdon and Atkinson, 2005; Manzello, 2010) and, in the case of *Acropora palmata,* 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 have caused 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, ample evidence indicate that diseases can have devastating regional impacts on individual coral species (e.g., (Aronson and Precht, 2001; Bruckner and Hill, 2009), and evidence show that these impacts are occurring in more taxa and at a broader geographic scale (Green and Bruckner, 2000; Sutherland et al., 2004). A few disease reports for the genus *Alveopora* can be found in the Global Disease Database (UNEP, 2010; B. Vargas-Ángel, CRED, Honolulu, HI, pers. comm., September 2010).

Predation: Unknown.

Land-based sources of pollution (LBSP): The effects of LBSP on *Alveopora allingi* are largely unknown, for both the species and the genus. LBSP-related stresses (nutrients, sediment, toxins, and salinity) often act in concert rather than individually and are influenced by other biological (e.g., herbivory) and hydrological factors. Collectively, LBSP stresses are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales (particularly important for species with limited range) and reduce the resilience of corals to bleaching (Carilli et al., 2009a; Wooldridge, 2009b).

Collection/Trade: No export data for this species in CITES Trade Database, UNEP World Conservation Monitoring Centre, Cambridge, UK (CITES, 2010). Collection and trade are not considered to be a significant threat to this species.

Risk Assessment

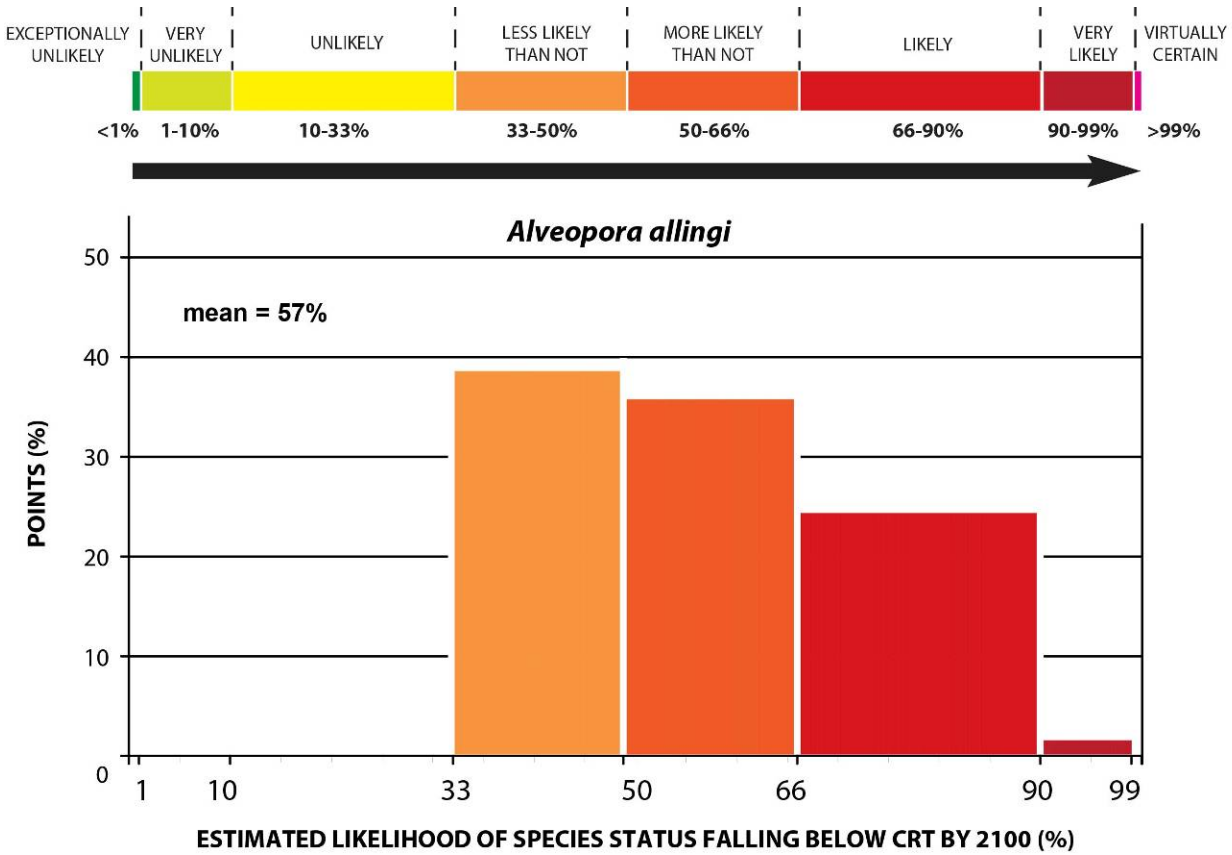

Figure 7.10.4. Distribution of points to estimate the likelihood that the status of *Alveopora allingi* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Alveopora allingi* include bleaching. The high bleaching rate is the primary known threat of extinction for *Alveopora allingi*. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) are that *Alveopora allingi* occupies a variety of habitat types and is broadly distributed both latitudinally and longitudinally in the Indo-Pacific. Wide geographic and habitat distribution lowers extinction risk by making it more likely a species will be able to escape the impacts of threats and catastrophes in at least some locations.

The overall likelihood that *Alveopora allingi* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "more likely than not" risk category with a mean likelihood of 57% and a standard error (SE) of 9% (Fig. 7.10.4). 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 33%–99% (Fig. 7.10.4) and the average range of likelihood estimates of the seven BRT voters (52%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Alveopora allingi*.

7.10.2 *Alveopora fenestrata* Lamarck, 1816

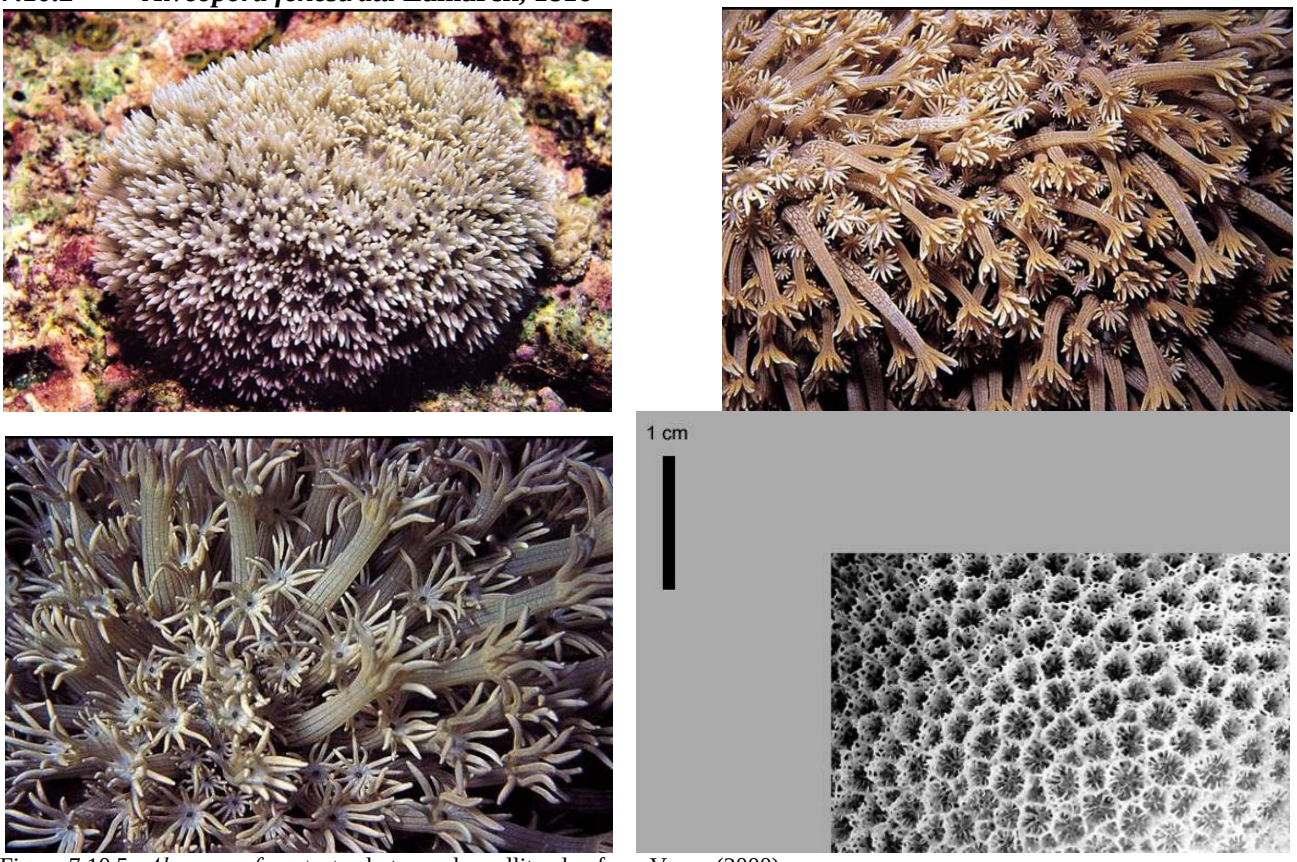

Figure 7.10.5. *Alveopora fenestrata* photos and corallite plan from Veron (2000).

Characteristics

Colonies of *Alveopora fenestrate* are generally hemispherical with the surface divided into lobes. Corallites have walls composed of compacted rods and spines. Septa are composed of tapered spines which are connected low in the corallite. Polyps are long, with long tentacles giving a ragged appearance. Colonies are grey or greenish-brown in color, sometimes with white oral cones (Veron, 2000). Maximum colony size is 30 cm.

Taxonomy

Taxonomic issues: None. *Alveopora fenestrata* is similar to *Alveopora marionensis* and *Alveopora verrilliana* (Veron, 2000).

Family: Poritidae.

Evolutionary and geologic history: The genus is known from the Tethys Sea in the Eocene but is extinct in the Caribbean (Wells and Moore, 1956).

Global Distribution

Alveopora fenestrata has a relatively broad range. Longitudally it stretches from the Red Sea to the oceanic west Pacific and latitudinally from the Red Sea and the Northern Mariana Islands on the northern hemisphere to southern Africa and across both coasts of Australia in the Southern hemisphere (Veron, 2000).

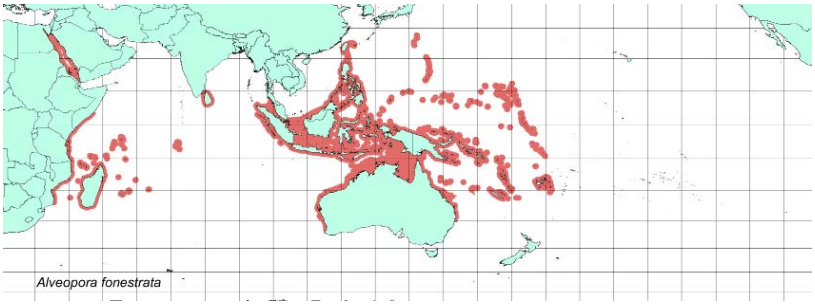

Figure 7.10.6. *Alveopora fenestrata* distribution from IUCN copied from http://www.iucnredlist.org.

Figure 7.10.7. *Alveopora fenestrata* distribution from Veron (2000).

U.S. Distribution

According to the IUCN Species Account, *Alveopora fenestrata* occurs in the Northern Mariana Islands. The CITES database does not list its occurrence in U.S. waters.

A search of published and unpublished records of occurrence in U.S. waters indicates *Alveopora fenestrata* has been reported from Guam (Randall, 2003).

Alveopora fenestrata has not been recorded from federally protected waters.

Habitat

Habitat: *Alveopora fenestrata* has been reported to occupy shallow reef environments (Veron, 2000).

Depth range: *Alveopora fenestrata* has been reported in water depths ranging from 3 m to 30 m (Carpenter et al., 2008).

Abundance

Abundance of *Alveopora fenestrata* has been reported as uncommon (Veron, 2000).

Life History

Reproductive characteristics of *Alveopora fenestrata* have not been determined (Baird et al., 2009). The congeners *Alveopora gigas, Alveopora verrilliana, and Alveopora tizardi* are hermaphroditic broadcast spawners (Babcock et al., 1994; Baird et al., 2009). The congeners *Alveopora daedalea* and *Alveopora japonica* have been reported as hermaphroditic brooders in the Red Sea (Shlesinger and Loya, 1985) and Japan (Harii et al., 2001), respectively. The minimum age of first reproduction for the congener *Alveopora japonica* in Tokyo Bay, where the annual sea temperature ranges from 13 to 27°C, is 3 years (Harii et al., 2001).

Although specific observations have not been published for this species, the larvae of two other *Alveopora* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis (Baird et al., 2009), i.e., they are autotrophic. Larval longevity has not been determined in this family.

Threats

Temperature stress: The genus *Alveopora* is listed as having the highest bleaching response from the 17 included genera in McClanahan et al. (2007) table for the Indian Ocean. *Alveopora* had high bleaching in Guam in 1994 (Paulay and Benayahu, 1999) and South Africa in 2000 but had little bleaching or mortality in Palau in the 2001 event (Bruno et al., 2001).

Acidification: Unknown for this genus. However, in most corals studied (Table 3.2.2), 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 have caused 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, ample evidence indicate that 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). A few disease reports for the genus *Alveopora* can be found in the global disease database (UNEP, 2010).

Predation: Effects from predation on *Alveopora fenestrata are u*nknown.

Land-based sources of pollution (LBSP): The effects of LBSP are largely unknown for the genus *Alveopora*. LBSP-related stresses (nutrients, sediment, toxins, and salinity) often act in concert rather than individually and are influenced by other biological (e.g., herbivory) and hydrological factors. Collectively, LBSP stresses are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales (particularly important for species with limited range) and reduce the resilience of corals to bleaching (Carilli et al., 2009a; Wooldridge, 2009b).

Collection/Trade: No export data on CITES Trade Database, UNEP World Conservation Monitoring Centre, Cambridge, UK (CITES, 2010). Collection/trade is not considered a significant threat to this species.

Risk Assessment

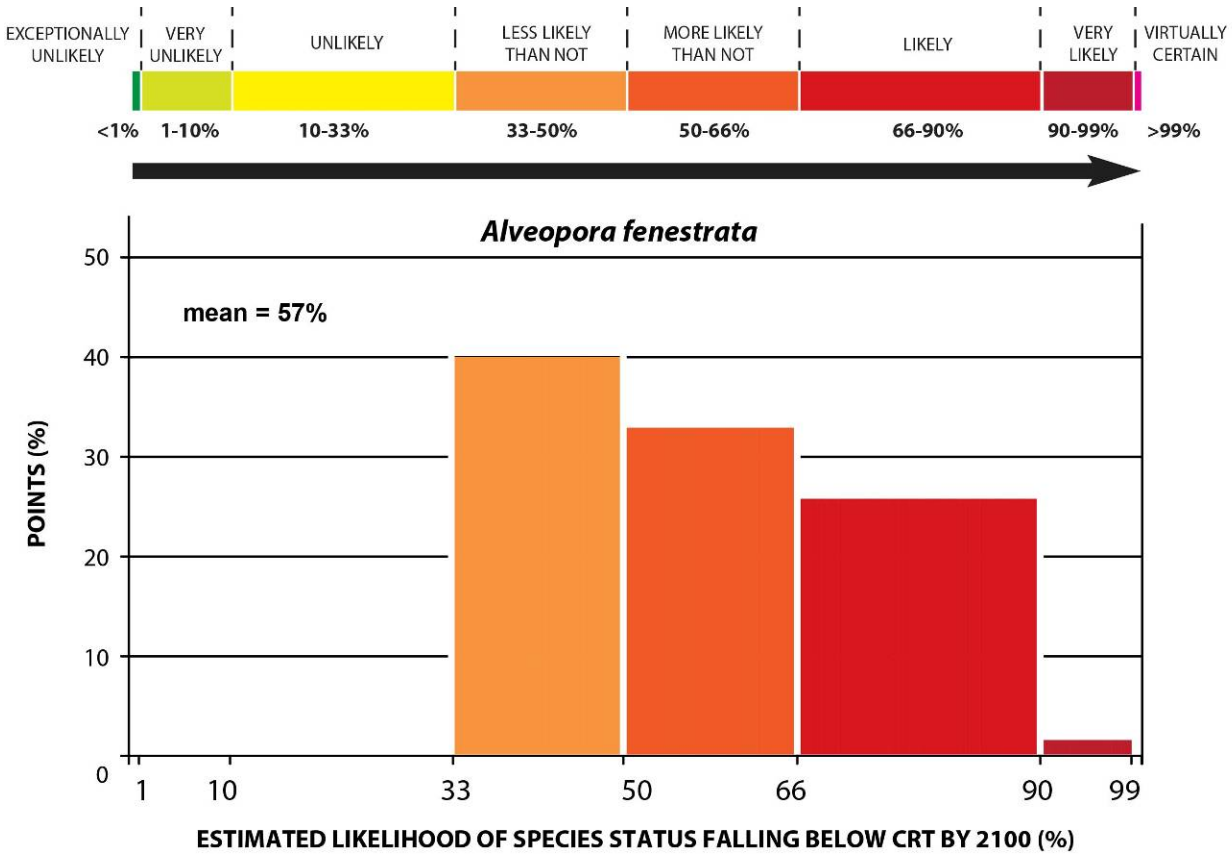

Figure 7.10.8. Distribution of points to estimate the likelihood that the status of *Alveopora fenestrata* falls below the Critical Risk Threshold (Critical Risk Threshold; the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Alveopora fenestrata* include bleaching. The high bleaching rate is the primary known threat of extinction for *Alveopora fenestrata*. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) are that *Alveopora fenestrata* occupies a range of depths and is broadly distributed both latitudinally and longitudinally in the Indo-Pacific. Wide geographic and habitat distribution lowers extinction risk by making it more likely a species will be able to escape the impacts of threats and catastrophes in at least some locations.

The overall likelihood that *Alveopora fenestrata* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "more likely than not" risk category with a mean likelihood of 57% and a standard error (SE) of 9% (Fig. 7.10.8). 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 33%–99% (Fig. 7.10.8) and the average range of likelihood estimates of the seven BRT voters (52%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Alveopora fenestrata*.

7.10.3 *Alveopora verrilliana* Dana, 1872

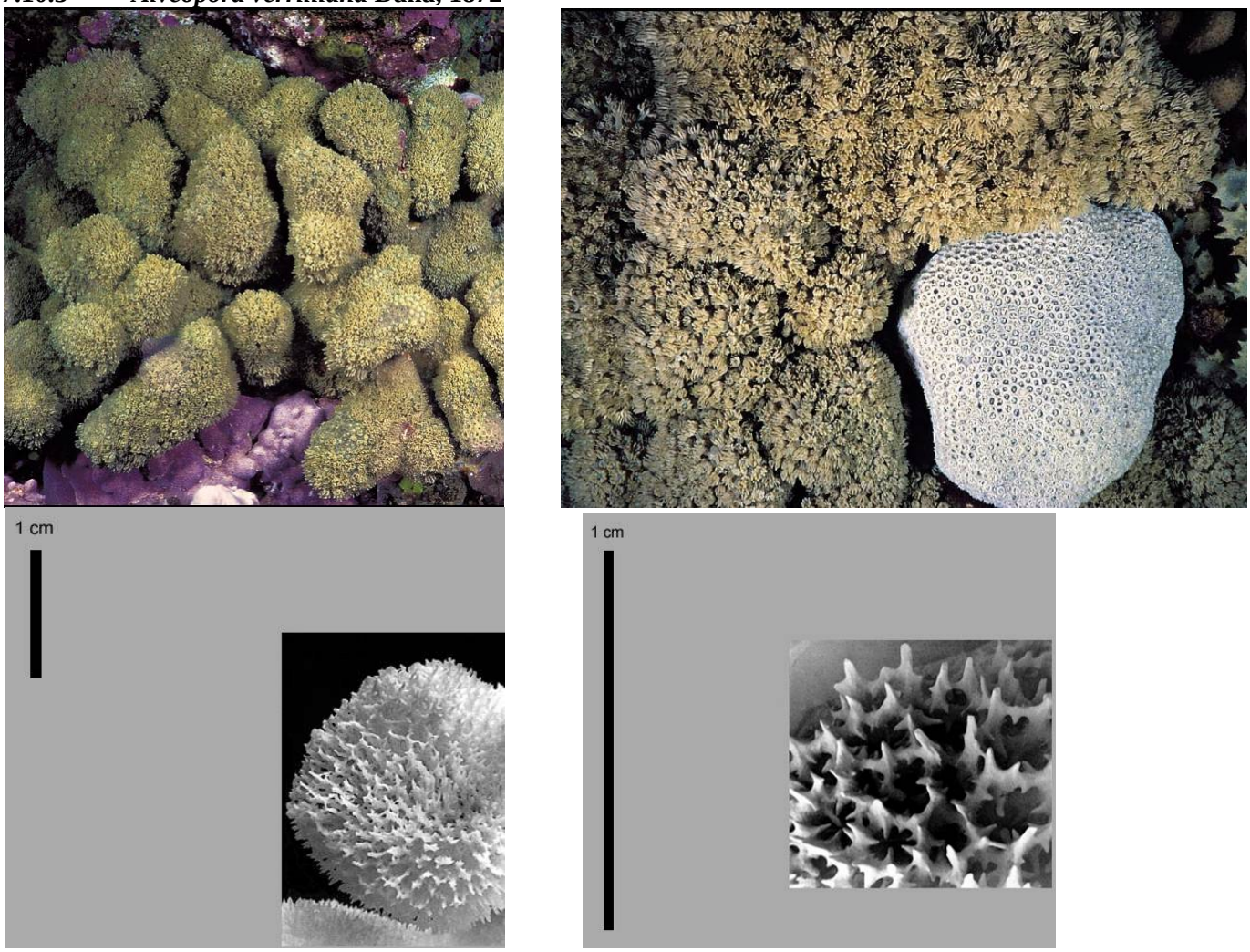

Figure 7.10.9. *Alveopora verrilliana* photos and corallite plan from Veron (2000).

Characteristics

Colonies of *Alveopora verrilliana* are composed of short irregularly dividing knob-like branches. Corallites have short blunt septal spines and a palisade of vertical spines above the wall. Polyps are long when extended. Colonies are dark greenish-brown, grey or chocolate in color, sometimes with white oral cones and/or tentacle tips (Veron, 2000). Maximum colony size is 100 cm.

Taxonomy

Taxonomic issues: None. *Alveopora verrilliana* is similar to *Alveopora fenestrata,* which is distinguished by growth-form, lack of spines around the corallites and larger corallites.

Family: Poritidae.

Evolutionary and geologic history: The genus is known from the Tethys Sea in the Eocene but is extinct in the Caribbean (Wells and Moore, 1956).

Global Distribution

Alveopora verrilliana has a broad range. It stretches from the Red Sea to the central Pacific Ocean longitudinally and latitudinally from the Japanese Ryukyu Islands in the northern hemisphere and midway along both Australian coasts in the southern hemisphere (Veron, 2000). Veron (2000) also reports it in Hawai`i but the IUCN does not.

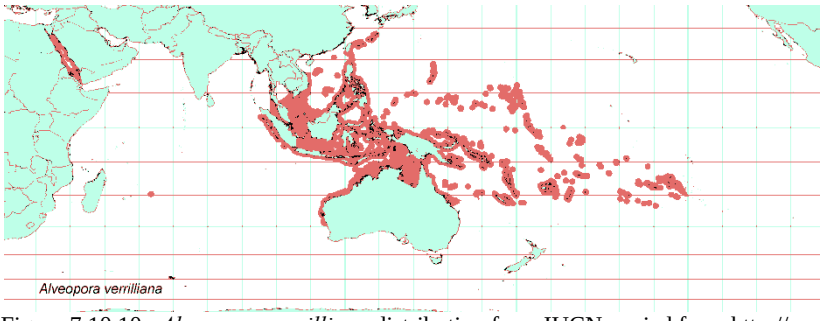

Figure 7.10.10. *Alveopora verrilliana* distribution from IUCN copied from http://www.iucnredlist.org.

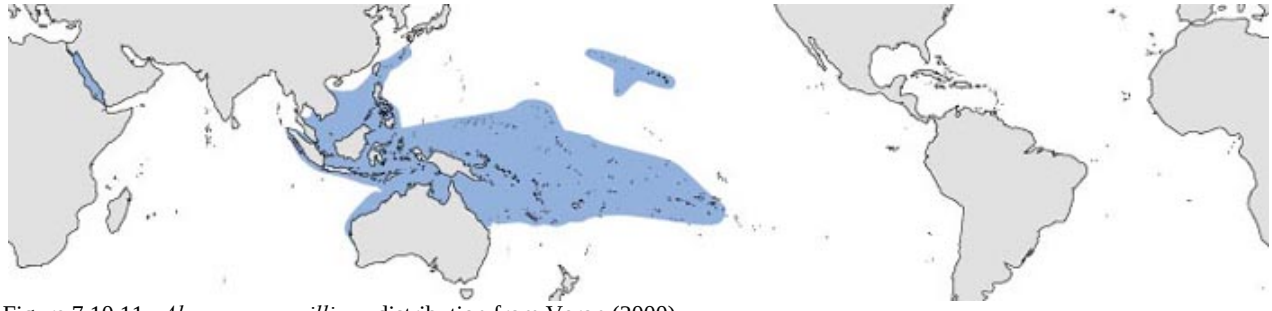

Figure 7.10.11. *Alveopora verrilliana* distribution from Veron (2000).

U.S. Distribution

According to both the IUCN Species Account and the CITES species database, *Alveopora verrilliana* occurs in American Samoa, the Northern Mariana Islands, and minor outlying islands.

A search of published and unpublished records of occurrence in U.S. waters indicates *Alveopora verrilliana* has been reported from Tutuila, Ta′u, and Rose Atoll in American Samoa (Hoffmeister, 1925; Kenyon et al., 2010a; Lamberts, 1983), the Mariana Islands (Randall, 2003). Palmyra Atoll (Williams et al., 2008b) and Kingman Reef (CRED, unpubl. data).

Within federally protected waters, *Alveopora verrilliana* has been recorded from the following areas:

- Pacific Remote Islands Marine National Monument (Palmyra, Kingman)
- Rose Atoll Marine National Monument

Habitat

Habitat: *Alveopora verrilliana* has been reported to occupy shallow reef environments (Veron, 2000).

Depth range: *Alveopora verrilliana* has been reported in water depths ranging from 3 m to 40 m (Carpenter et al., 2008). Kuhlman (1983) reported that *Alveopora verrilliana* occurs on outer steep slopes from 20 m to 80 m deep in the Red Sea, suggesting the potential for deep refugia.

Abundance

Abundance of *Alveopora verrilliana* has been reported to be uncommon (Veron, 2000).

Life History

Alveopora verrilliana is a hermaphroditic broadcast spawner (Babcock et al., 1994; Baird et al., 2009). On temperate-latitude reefs (28°–29° S) in the Houtman Abrolhous Islands, western Australia, 7 of 12 colonies sampled had ripe gametes, and spawning was inferred during the time of mass spawning for this region (Babcock et al., 1994). The minimum age of first reproduction for the congener *Alveopora japonica* in Tokyo Bay, where the annual sea temperature ranges from 13°C to 27°C, is 3 years (Harii et al., 2001).

Although specific observations have not been published for this species, the larvae of two other *Alveopora* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis (Baird et al. 2009), i.e., they are autotrophic. Larval longevity has not been determined in this family.

Threats

Temperature stress: The genus *Alveopora* is listed as having the highest bleaching response from the 17 included genera in McClanahan et al. (2007) table for the Indian Ocean. *Alveopora* had high bleaching in Guam in 1994 (Paulay and Benayahu, 1999) and South Africa in 2000 but had little bleaching or mortality in Palau in the 2001 event (Bruno et al., 2001).

Acidification: Unknown for this genus. However, in most corals studied (Table 3.2.2), acidification impairs growth (Langdon and Atkinson, 2005; Manzello, 2010) and, in the case of *Acropora palmata*, 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 have caused 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, ample evidence indicate that diseases can have devastating regional impacts on individual coral species (e.g., Aronson and Precht, 2001; Bruckner and Hill, 2009) and evidence show that these impacts are occurring in more taxa and at a broader geographic scale (Green and Bruckner, 2000; Sutherland et al., 2004). In the global disease database, there are a low number of disease reports for the genus *Alveopora* (UNEP, 2010).

Predation: Unknown.

Land-based sources of pollution (LBSP): The effects of LBSP are largely unknown for the genus *Alveopora*. LBSP-related stresses (nutrients, sediment, toxins, and salinity) often act in concert rather than individually and are influenced by other biological (e.g., herbivory) and hydrological factors. Collectively, LBSP stresses are unlikely to produce extinction at a global scale; however, they may pose significant threats at local scales (particularly important for species with limited range) and reduce the resilience of corals to bleaching (Carilli et al., 2009a; Wooldridge, 2009b).

Collection/Trade: No export data of this species reported in CITES Trade Database, UNEP World Conservation Monitoring Centre, Cambridge, UK (CITES, 2010). Collection/Trade is not considered a significant threat for this species.

Risk Assessment

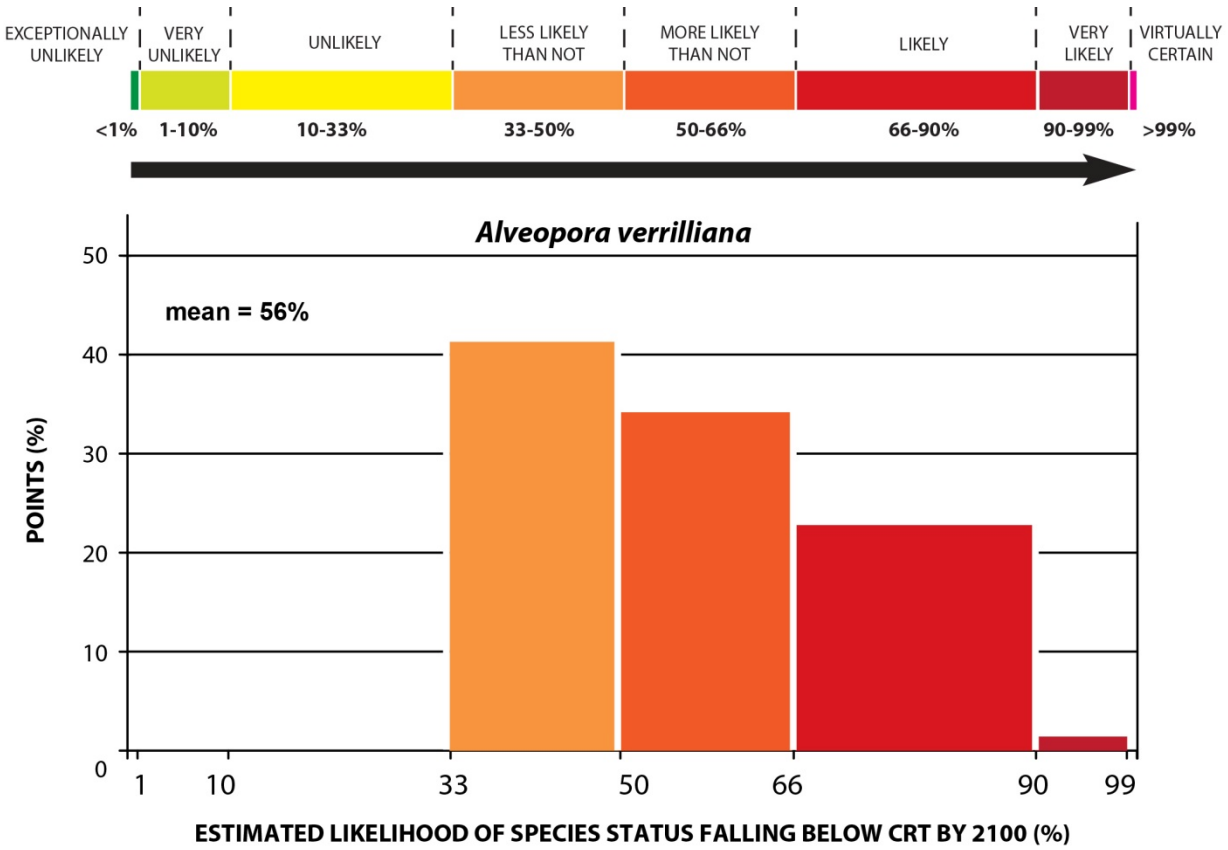

Figure 7.10.12. Distribution of points to estimate the likelihood that the status of *Alveopora verrilliana* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Alveopora verrilliana* include bleaching. The high bleaching rate is the primary known threat of extinction for *Alveopora verrilliana*. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) are that *Alveopora verrilliana* occupies a variety of habitat types and is broadly distributed both latitudinally and longitudinally in the Indo-Pacific. Wide distribution lowers extinction risk by making it more likely a species will be able to escape the impacts of threats and catastrophes in at least some locations.

The overall likelihood that *Alveopora verrilliana* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "more likely than not" risk category with a mean likelihood of 56% and a standard error (SE) of 9% (Fig. 7.10.12). 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 33%–90% (Fig. 7.10.12) and the average range of likelihood estimates of the seven BRT voters (49%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Alveopora verrilliana*.