

7.11 Genus *Porites*

7.11.1 *Porites horizontalata* Hoffmeister, 1925

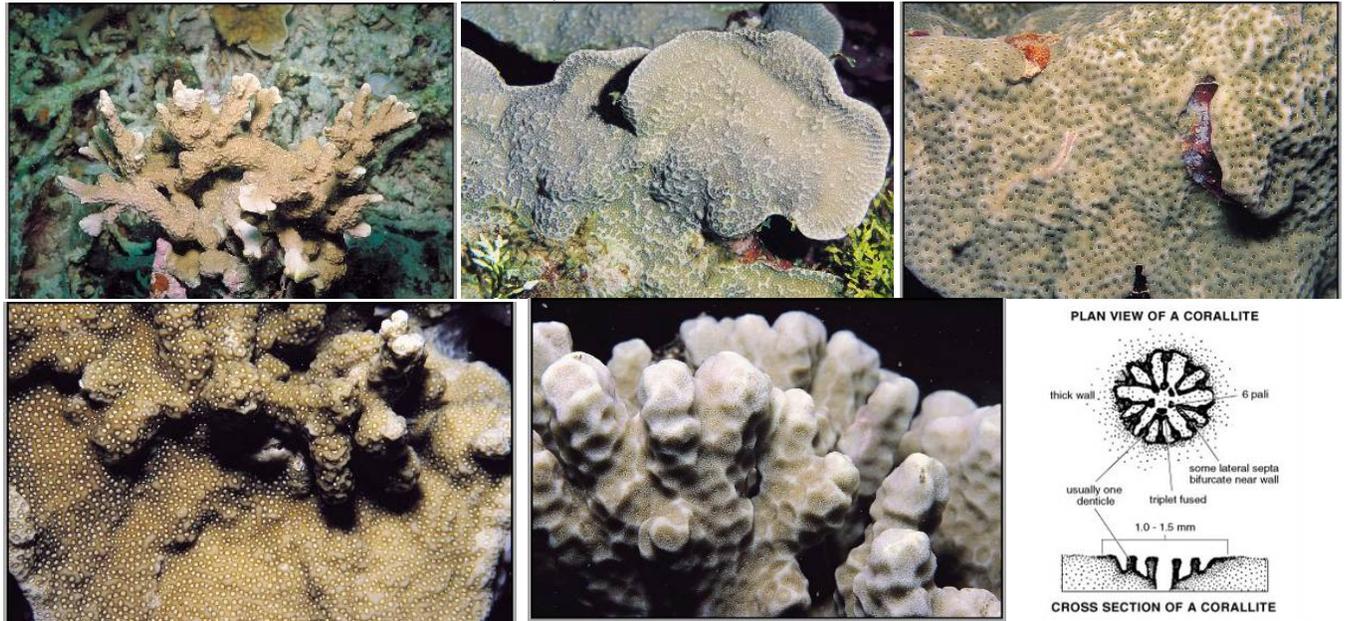


Figure 7.11.1. *Porites horizontalata* photos and corallite plan (Veron, 2000).

Characteristics

Colonies of *Porites horizontalata* are composites of encrusting laminae and contorted anastomosing branches. Corallites are separated into groups by ridges. Colonies are pale brown in color with cream extremities of branches and plates; sometimes they are brightly colored in shallow water (Veron, 2000).

Taxonomy

Taxonomic issues: *Porites* is known to be morphologically plastic and multiple sympatric species frequently exhibit intergradation of skeletal characteristics. Only limited molecular genetic analysis has been performed on the *Porites* thus far. In the most comprehensive, Forsman et al. (2009) identified inseparable clades that contain multiple morphological species, in some cases with morphological species that span more than one clade. However, such genetic work has not been conducted on *Porites horizontalata*. Laminal parts of colonies resemble those of *Porites vaughani*. Branching parts of colonies may have corallites arranged in a *Porites rus*-like pattern. Calice characters are closest to *Porites eridani* branches (Veron, 2000).

Family: Poritidae.

Evolutionary and geologic history: The genus originated in the Eocene and became overwhelmingly dominant in the Miocene Tethys (Veron, 1995). It continues to be the most cosmopolitan of all coral genera (Veron, 2000).

Global Distribution

The range of *Porites horizontalata* is somewhat restricted longitudinally from the Maldives in the west to the central Pacific in the east and latitudinally from south of Japan in the northern hemisphere to New Caledonia in the southern hemisphere.

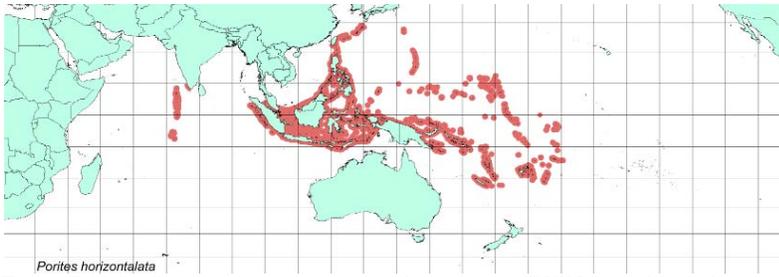


Figure 7.11.2. *Porites horizontalata* distribution from IUCN copied from <http://www.iucnredlist.org>.

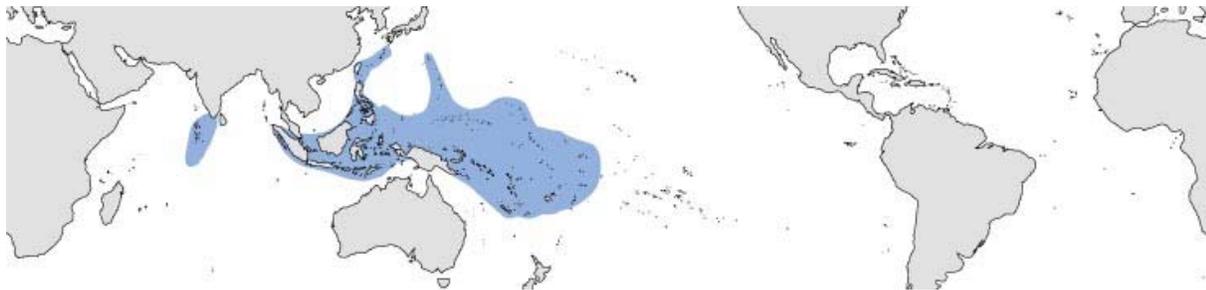


Figure 7.11.3. *Porites horizontalata* distribution from Veron (2000).

U.S. Distribution

According to both the IUCN Species Account and the CITES species database, *Porites horizontalata* has been recorded in American Samoa and the Northern Mariana Islands. The IUCN Species Account also lists this species in the U.S. minor outlying islands.

A search of published and unpublished records of occurrence in U.S. waters indicates *Porites horizontalata* has been reported from Tutuila 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; National Park Service, 2009) and Guam (Burdick, unpubl. data; Randall, 2003). No substantiated published or unpublished records of its occurrence in the U.S. minor outlying islands could be identified.

Within federally protected waters, *Porites horizontalata* has been recorded from the following areas:

- National Park of American Samoa, Tutuila Island unit

Habitat

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

Depth range: *Porites horizontalata* has been reported in water depths ranging from 5 m to 20 m (Carpenter et al., 2008). It is also known to range in depth from moderate to deep water in American Samoa (type location) and in New Caledonia (Veron, 2000).

Abundance

Abundance of *Porites horizontalata* has been reported as sometimes common (Carpenter et al., 2008; Veron, 2000).

Life History

Porites horizontalata is a gonochoric broadcast spawner (Baird et al., 2009). Although specific larval descriptions have not been published for this species, the larvae of all other *Porites* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis (Baird et al., 2009). The minimum size and estimated age at first reproduction have not been determined for this species. However, for two other *Porites* species, the minimum size is < 8 cm (Harriott, 1983). Larval longevity has not been determined in this family.

Threats

Temperature stress: Massive *Porites* has moderate susceptibility to bleaching (Marshall and Baird, 2000; McClanahan et al., 2007) while branching *Porites* seem to have a higher susceptibility, comparable to *Pocillopora* and *Acropora* (Marshall and Baird, 2000; McClanahan et al., 2007), but branching *Porites* had higher mortality than massive *Porites* (Kayanne et al., 2002). *Porites horizontalata* was a bleaching “loser” in Okinawa, disappearing after the 1998 event (Loya et al., 2001). Recent work comparing *Porites lobata* from extreme lagoonal environments with individuals from more benign forereef habitats indicates that thermal history of these corals plays a large part in their reaction to thermal stress (Barshis et al., 2010).

Acidification: While no studies have tested acidification impacts on *Porites horizontalata*, De’ath et al. (De’ath et al., 2009) looked at 328 colonies of massive *Porites* from 69 reefs of the Great Barrier Reef (GBR) and found a decline in calcification by 14.2% since 1990, predominantly because extension declined by 13.3%. This is similar to the estimates of a global decline in aragonite saturation state of 16% since the beginning of global industrialization (De’ath et al., 2009). The De’ath study agreed with earlier, more limited work on *Porites* on the GBR (Cooper et al., 2008) and on laboratory and mesocosm experiments that showed declines in calcification with reduced aragonite saturation state in *Porites cylindrical* (Hii et al., 2009) and *Porites compressa* adults (Langdon and Atkinson, 2005; Marubini et al., 2001), *Porites lutea* adults (Hossain and Ohde, 2006; Ohde and Hossain, 2004), and *Porites astreoides* juveniles (Albright et al., 2008). Work on other corals has shown that impacts are not limited to extension as acidification impairs fertilization and settlement success in *Acropora palmata* (Albright et al., 2010), although it has not been found to interfere with settlement of larvae in *Porites astreoides* (Albright et al., 2008). Acidification also is likely to contribute to reef destruction in the future (Hoegh-Guldberg et al., 2007; Silverman et al., 2009) reducing habitat for corals. 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: Medium number of genus level disease reports of subacute (lesions resulting in slow progressive tissue loss) tissue loss, black band disease, and endolithis hypermycosis (UNEP, 2010). 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).

Predation: *Porites* is susceptible to crown-of-thorns seastar (*Acanthaster planci*) and corallivorous snail predation (B. Vargas-Ángel, CRED, Honolulu, HI, pers. comm., September 2010), including predation of *Coralliphilia violacea* on both massive and branching forms (Zeid et al., 1999). Massive *Porites* are susceptible, but not a preferred prey, of the predatory asteroid *Culcita novaeguineae* (Glynn and Krupp, 1986), and the butterflyfish *Chaetodon unimaculatus* (Cox, 1986). No reference was found to the susceptibility of branching *Porites*.

Land-based sources of pollution (LBSP): McClanahan and Obura (McClanahan and Obura, 1997) identified *Porites* as intermediate for its sediment tolerance in the western Indian Ocean. In contrast, *Porites* is often found in relatively turbid waters in Asia and the eastern Pacific and were considered sediment tolerant by Rogers (1990) and Brown (1997b). 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: According to the CITES Trade Database, UNEP World Conservation Monitoring Centre, 25,000-50,000 pieces of *Porites* spp. per year traded (CITES, 2010).

Risk Assessment

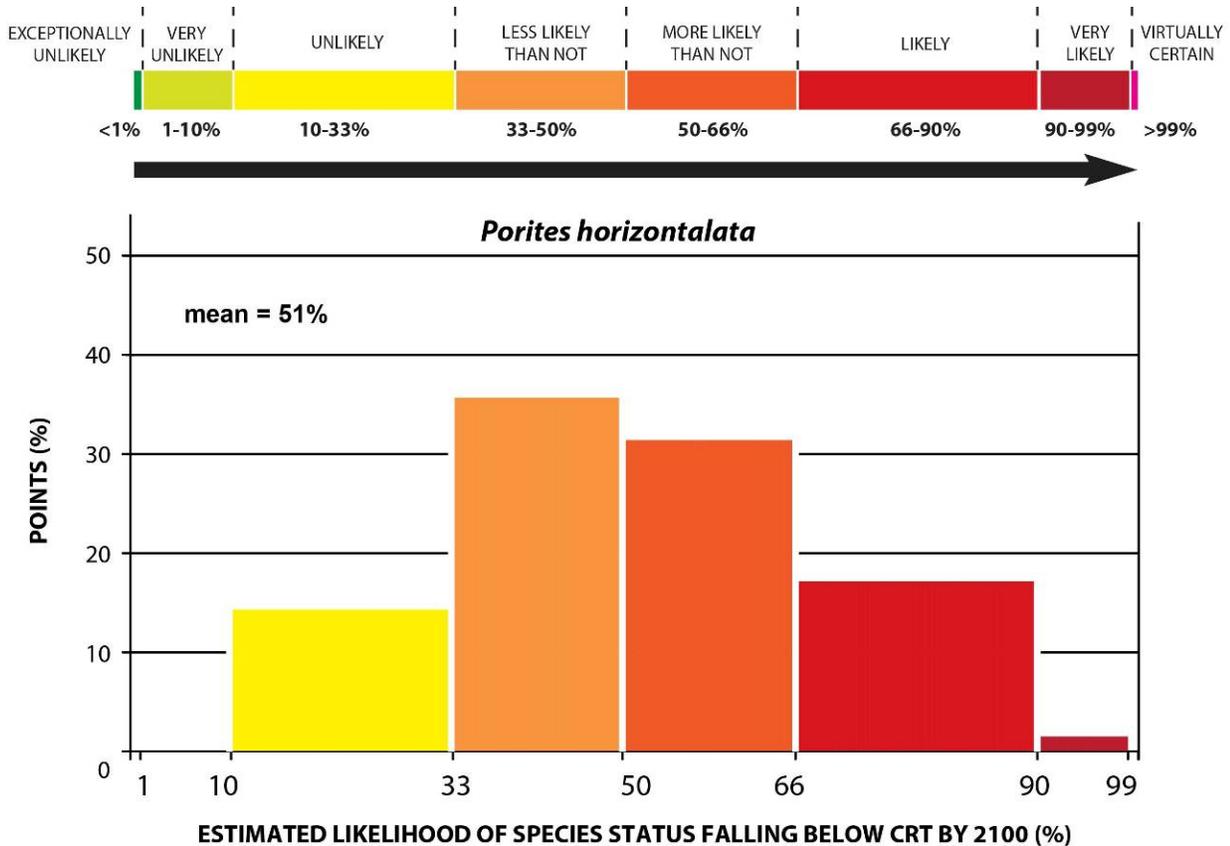


Figure 7.11.4. Distribution of points to estimate the likelihood that the status of *Porites horizontalata* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Porites horizontalata* include the fairly low tolerance to thermal stress and susceptibility to acidification impacts in the genus. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) are the species' broad distribution, the high tolerance of sediment stress and turbid water, and low disease and predation susceptibility of the genus. 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 *Porites horizontalata* 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 51% and a standard error (SE) of 12% (Fig. 7.11.14). 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 wide range of votes of 10%–99% (Fig. 7.11.14) and the average range of likelihood estimates of the seven BRT voters (62%)—the third-highest variability (see Table 8.1).. The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Porites horizontalata*.

7.11.2 *Porites napopora* Veron, 2000

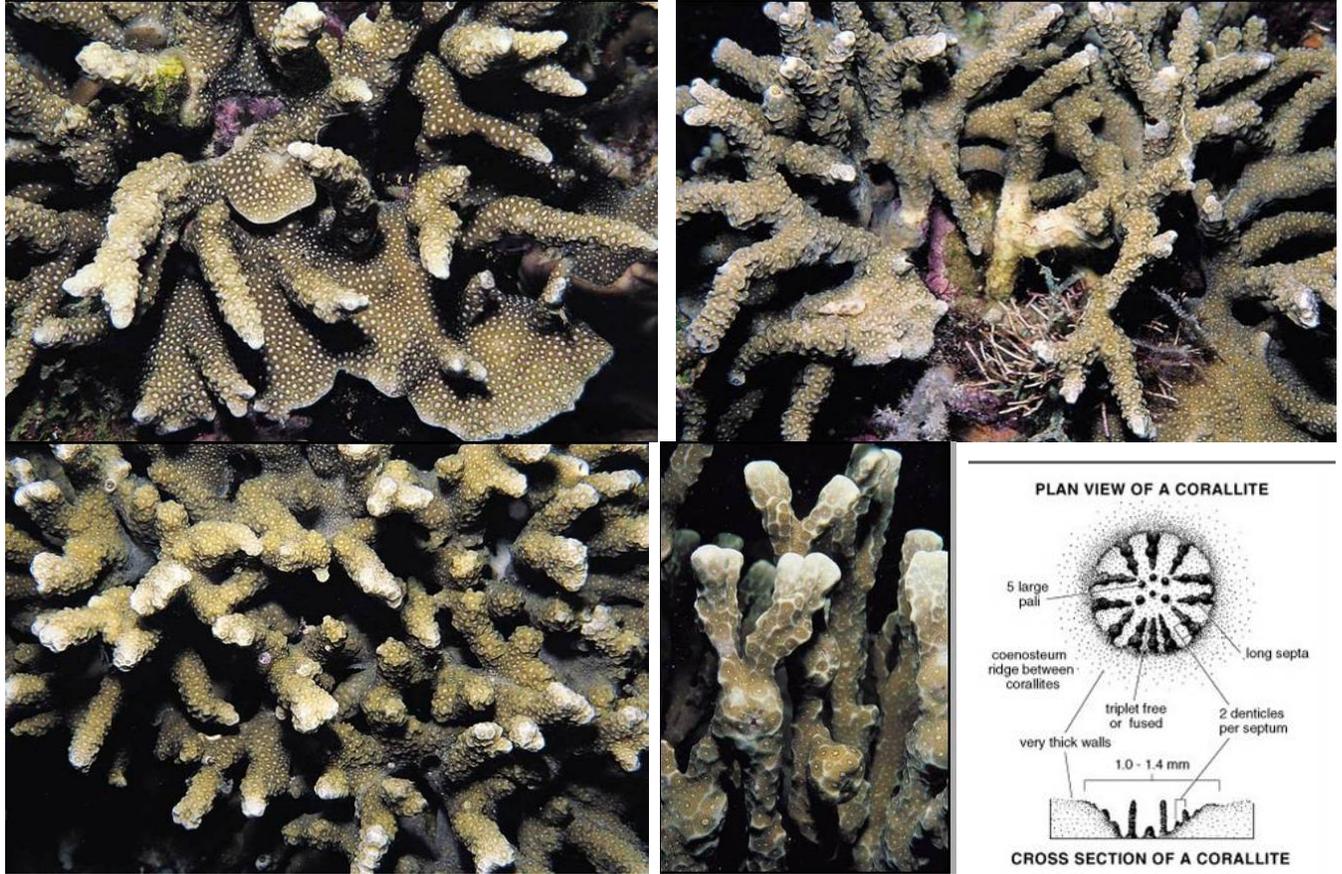


Figure 7.11.5. *Porites napopora* photos and corallite plan from Veron (2000).

Characteristics

Colonies of *Porites napopora* are broad basal laminae with irregular clumps of tapered irregularly fused branches. Corallites are irregularly spaced and are in excavated pits. Those on branches are especially deeply excavated, giving branches a rough surface. Walls between corallites are thin. Colonies are brown in color with white corallite centers (Veron, 2000).

Taxonomy

Taxonomic issues: *Porites* is known to be morphologically plastic and multiple sympatric species frequently exhibit intergradation of skeletal characteristics. Only limited molecular genetic analysis has been performed on the *Porites* so far. In the most comprehensive, Forsman et al. (2009) identified inseparable clades that contain multiple morphological species, in some cases with morphological species that span more than one clade. However, such genetic work has not been conducted on *Porites napopora*. *Porites napopora* is similar to *Porites nigrescens* and *Porites negrosensis*, both of which have similarly excavated corallites. *Porites nigrescens* does not have basal laminae and *Porites negrosensis* has corallites with rounded walls. *Porites horizontalata* has similar corallites but forms primarily explanate plates. See also *Porites flavus* and *Porites tuberculosa* (Veron, 2000).

Family: Poritidae.

Evolutionary and geologic history: The genus originated in the Eocene Era and became overwhelmingly dominant in the Miocene Tethys (Veron, 1995). It continues to be the most cosmopolitan of all coral genera (Veron, 2000).

Global Distribution

Range is somewhat restricted both longitudinally and latitudinally, limited to the west and central Pacific (Veron 2000), particularly the Coral Triangle area.

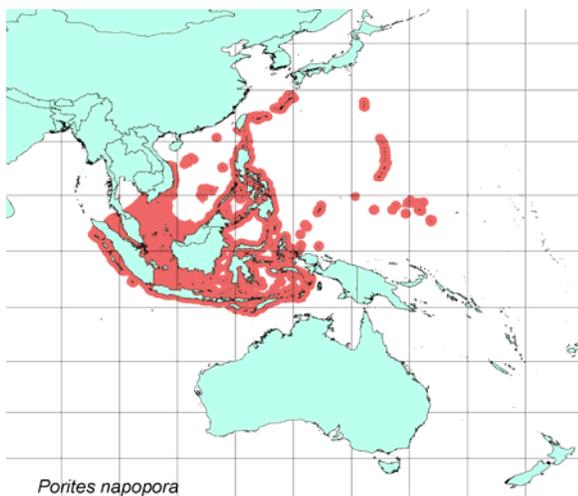


Figure 7.11.6. *Porites napopora* distribution from IUCN copied from <http://www.iucnredlist.org>.



Figure 7.11.7. *Porites napopora* distribution from Veron (2000); however, see “Distribution” paragraphs.

U.S. Distribution

According to the IUCN Species Account, *Porites napopora* occurs in the Northern Mariana Islands, but no supporting reference is given. The CITES species database does not include any record of occurrence in U.S. waters.

In Veron (2000; Volume 3, page 318) the distribution map includes the Mariana Archipelago, with a photo taken by Gustav Paulay labeled “Guam.” However, Veron (2002) indicates “erratum: photograph was taken at Palau, not Guam” (page 182). G. Paulay (University of Florida, Gainesville, FL, pers. comm. to J. Kenyon via email 2/28/2010) indicates photos submitted by him to Veron from Palau, the Cook Islands, and other locations were mistakenly attributed to Guam. Further email communications of J. Kenyon with G. Paulay (3/2/2010) confirm this species has not been observed by G. Paulay in the Mariana Archipelago. There are no other substantiated records of its occurrence in the Mariana Archipelago (J. Veron pers. comm. to J. Kenyon via email 4/23/2010).

Two colonies of *Porites napopora* have been reported at Fagatele Bay, Tutuila, American Samoa at a depth of 10 m based on visual identification (Birkeland, unpubl. data; Fisk and Birkeland, 2002, Table 5, page 31). No other published or unpublished data sources indicate the occurrence of *Porites napopora* elsewhere in U.S. waters.

Within federally protected waters, *Porites napopora* has been recorded from the following areas:

- Fagatele Bay National Marine Sanctuary, Tutuila

Habitat

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

Depth range: *Porites napopora* has been reported in water depths ranging from 3 m to 15 m (Carpenter et al., 2008). The species has no known deep refugia.

Abundance

Abundance of *Porites napopora* has been reported as sometimes common (Carpenter et al., 2008; Veron, 2000).

Life History

The reproductive characteristics of *Porites napopora* have not been determined (Baird et al., 2009). Other species in the genus *Porites* have been described as gonochoric broadcast spawners (10), gonochoric brooders (6), or hermaphroditic brooders (2) (Baird et al., 2009). Although specific observations have not been published for this species, the larvae of all other *Porites* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis (Baird et al., 2009). The minimum size and estimated age at first reproduction have not been determined for this species. However, for two other *Porites* species, the minimum size is < 8 cm (Harriott, 1983). Larval longevity has not been determined in this family.

Threats

Temperature stress: Massive *Porites* has moderate susceptibility to bleaching (Marshall and Baird, 2000; McClanahan et al., 2007) while branching *Porites* seem to have a higher susceptibility comparable to *Pocillopora* and *Acropora* (Marshall and Baird, 2000; McClanahan et al., 2007), but branching *Porites* had higher mortality than massive corals (Kayanne et al., 2002). Recent work comparing *Porites lobata* from extreme lagoonal environments with individuals from more benign forereefs indicates that thermal history of these corals plays a large role in their response to thermal stress (Barshis et al., 2010).

Acidification: While no studies have tested acidification impacts on *Porites napopora*, De'ath et al. (De'ath et al., 2009) looked at 328 colonies of massive *Porites* from 69 reefs of the Great Barrier Reef (GBR) and found a decline in calcification by 14.2% since 1990, predominantly because extension declined by 13.3%. This is similar to the estimates of a global decline in aragonite saturation state of 16% since the beginning of global industrialization (De'ath et al., 2009). The De'ath study agreed with earlier, more limited work on *Porites* on the GBR (Cooper et al., 2008) and on laboratory and mesocosm experiments that showed declines in calcification with reduced aragonite saturation state in *Porites cylindrical* (Hii et al., 2009) and *Porites compressa* adults (Langdon and Atkinson, 2005; Marubini et al., 2001), *Porites lutea* adults (Hossain and Ohde, 2006; Ohde and Hossain, 2004), and *Porites astreoides* juveniles (Albright et al., 2008). Work in other corals has shown that impacts are not limited to extension as acidification impairs fertilization and settlement success in *Acropora palmata* (Albright et al., 2010), although it has not been found to interfere with settlement of larvae in *Porites astreoides* (Albright et al., 2008). Acidification also contributes to reef destruction (Hoegh-Guldberg et al., 2007; Silverman et al., 2009) reducing habitat for corals. 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: Medium number of genus level disease reports of subacute (lesions resulting in slow progressive tissue loss) tissue loss syndrome, black band disease, and endoliths hypermycosis (UNEP, 2010). 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).

Predation: *Porites* is susceptible to crown-of-thorns seastar (*Acanthaster planci*) and corallivorous snail predation (B. Vargas-Ángel, CRED, Honolulu, HI, pers. comm., September 2010), including predation of *Coralliphilia violacea* on both massive and branching forms (Zeid et al., 1999). Massive *Porites* are susceptible, but not a preferred prey, of the predatory asteroid *Culcita novaeguineae* (Glynn and Krupp, 1986) and the butterflyfish *Chaetodon unimaculatus* (Cox, 1986).

Land-based sources of pollution (LBSP): McClanahan and Obura (1997) identified *Porites* as intermediate for its sediment tolerance in the western Indian Ocean. In contrast, *Porites* is often found in relatively turbid waters in Asia and the eastern Pacific and were considered sediment tolerant by Rogers (1990) and Brown (1997b). 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: According to the CITES Trade Database, UNEP World Conservation Monitoring Centre, 25,000-50,000 pieces of *Porites* spp. per year traded (CITES, 2010).

Risk Assessment

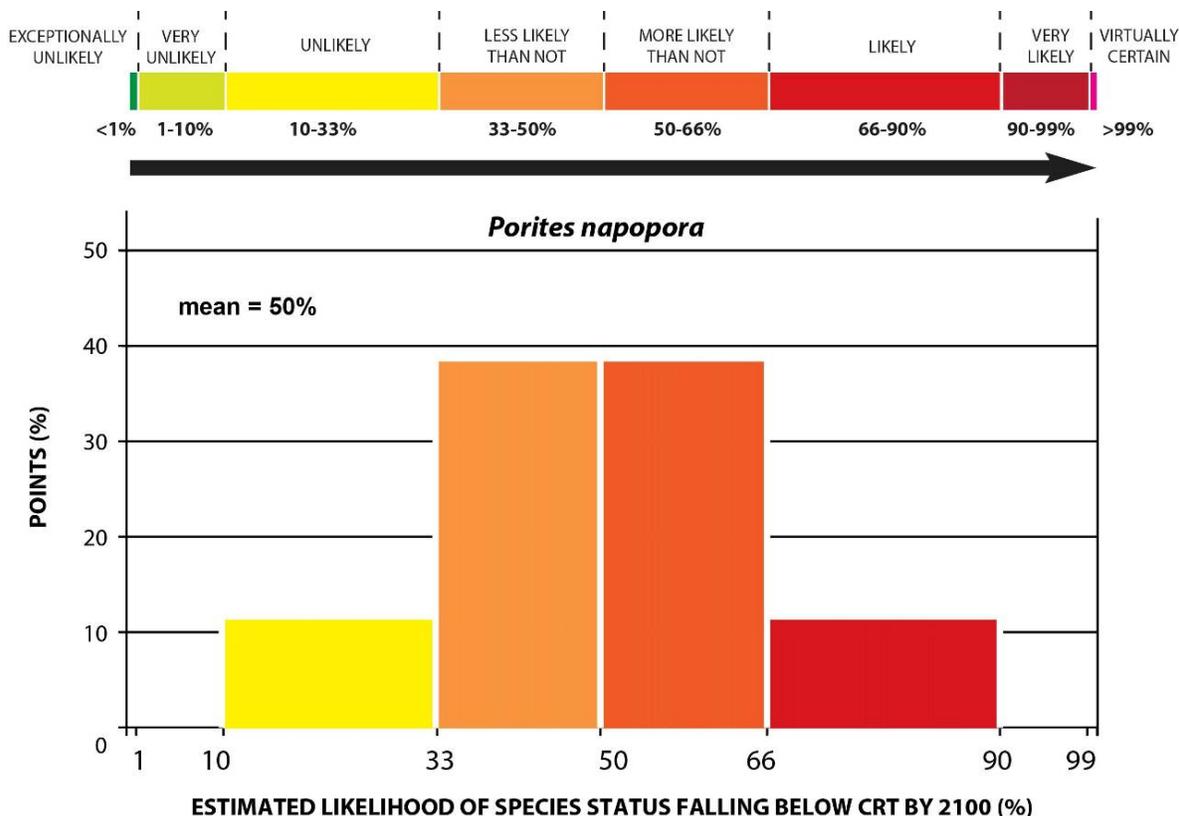


Figure 7.11.8. Distribution of points to estimate the likelihood that the status of *Porites napopora* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Porites napopora* include the species' distribution that is restricted to the western Pacific and the fairly low tolerance to thermal stress and susceptibility to acidification impacts in the genus. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) included the high tolerance of sediment stress and turbid water, and low disease and predation susceptibility of the genus.

The overall likelihood that *Porites napopora* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "as likely as not" risk category with a mean likelihood of 50% and a standard error (SE) of 9% (Fig. 7.11.8). 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%–90% (Fig. 7.11.8) and the average range of likelihood estimates of the seven BRT voters (58%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Porites napopora*.

7.11.3 *Porites nigrescens* Dana, 1846

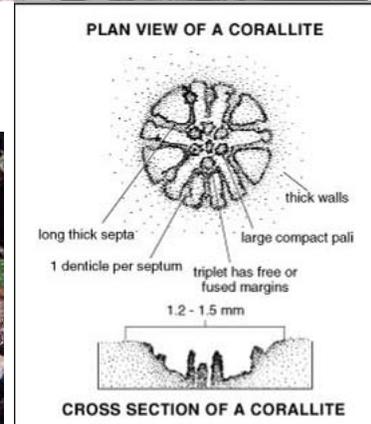
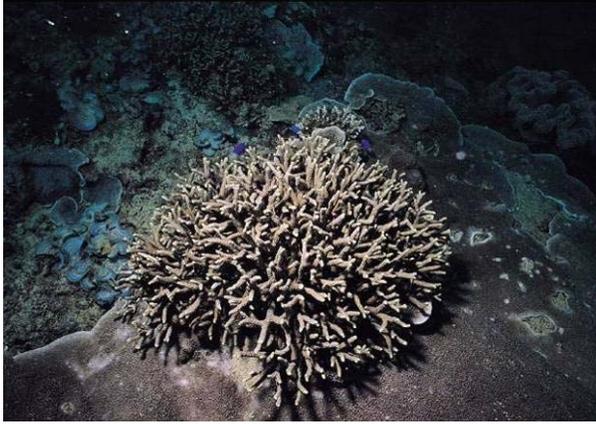


Figure 7.11.9. *Porites nigrescens* photos and corallite plan from Veron (2000).

Characteristics

Colonies of *Porites nigrescens* are branching, sometimes with an encrusting base. Concave calices give the surface a pitted appearance. Tentacles are frequently extended during the day. Colonies are brown or cream in color (Veron, 2000).

Taxonomy

Taxonomic issues: *Porites* is known to be morphologically plastic and multiple sympatric species frequently exhibit intergradation of skeletal characteristics. Only limited molecular genetic analysis has been performed on the *Porites* so far. In the most comprehensive, Forsman et al. (2009) identified inseparable clades that contain multiple morphological species, in some cases with morphological species that span more than one clade. However, such genetic work has not been conducted on *Porites nigrescens*. *Porites nigrescens* is similar to *Porites cylindrica*, which is usually found in the same habitat where it has less excavated corallites and thicker branches (Veron, 2000).

Family: Poritidae.

Evolutionary and geologic history: The genus originated in the Eocene and became overwhelmingly dominant in the Miocene Tethys (Veron, 1995). It continues to be the most cosmopolitan of all coral genera (Veron, 2000).

Global Distribution

The distribution is broad longitudinally, ranging from the east coast of Africa to the central Pacific and broad latitudinally ranging from the Red Sea and south of Japan in the northern hemisphere to halfway down both coastlines of Australia in the southern hemisphere (Veron, 2000).

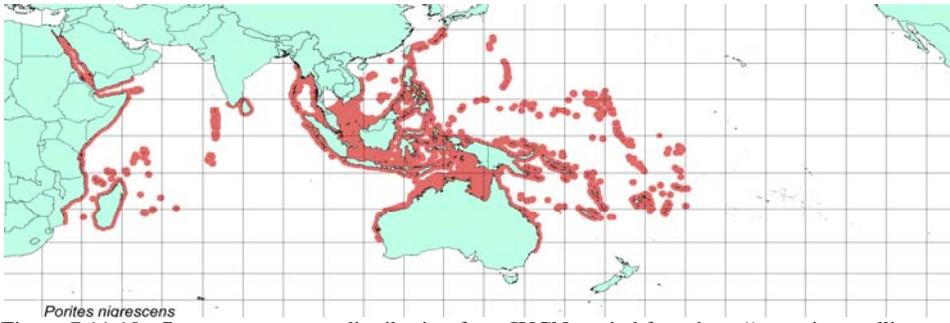


Figure 7.11.10. *Porites nigrescens* distribution from IUCN copied from <http://www.iucnredlist.org>.

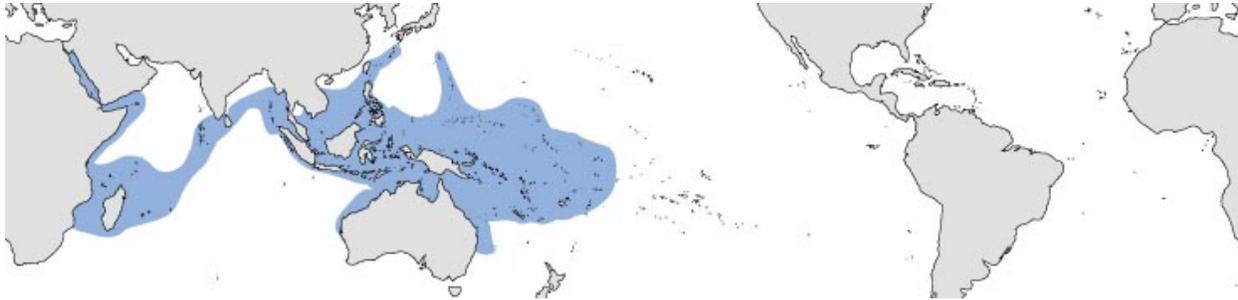


Figure 7.11.11. *Porites nigrescens* distribution from Veron (2000).

U.S. Distribution

According to both the IUCN Species Account and the CITES species database, *Porites nigrescens* has been recorded in American Samoa. The IUCN Species Account also lists this species in the Northern Mariana Islands and the U.S. minor outlying islands.

A search of published and unpublished records of occurrence in U.S. waters indicates *Porites nigrescens* has been reported from Tutuila and Ofu-Olosega in American Samoa (Maragos et al., 1994; Mundy 1996, Lovell and McLardy, 2008; National Park Service, 2009).

No substantiated published or unpublished records of its occurrence in the Northern Mariana Islands or the U.S. minor outlying islands could be identified.

Within federally protected waters, *Porites nigrescens* has been recorded from the following areas:

- National Park of American Samoa, Ofu Island unit

Habitat

Habitat: *Porites nigrescens* has been reported to occupy lower reef slopes and lagoons protected from wave action (Veron 2000).

Depth range: *Porites nigrescens* has been reported at moderate depths ranging from 0.5 m to 20 m (Carpenter et al., 2008).

Abundance

Porites nigrescens has been reported as sometimes common (Veron, 2000). Where found, it can be a part of a locally abundant branching Poritid assemblage (Phongsuwan and Brown, 2007).

Life History

The reproductive characteristics of *Porites nigrescens* have not been determined (Baird et al., 2009). Other species in the genus *Porites* have been described as gonochoric broadcast spawners (10), gonochoric brooders (6), or hermaphroditic brooders (2) (ibid). Although specific observations have not been published for this species, the larvae

of all other *Porites* 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. The minimum size and estimated age at first reproduction have not been determined for this species. However, for two other *Porites* species, the minimum size is < 8 cm (Harriott, 1983). Larval longevity has not been determined in this family.

Threats

Temperature stress: Massive *Porites* have moderate susceptibility to bleaching (Marshall and Baird, 2000; McClanahan et al., 2007) while branching *Porites* seem to have a higher susceptibility comparable to *Pocillopora* and *Acropora* (Marshall and Baird, 2000; McClanahan et al., 2007), but branching *Porites* had higher mortality than massive *Porites* (Kayanne et al., 2002). *Porites nigrescens* had high bleaching rates in East Africa in 1998 (Obura, 2001) and Palau in 2000 (Bruno et al., 2001). Recent work comparing *Porites lobata* from extreme lagoonal environments with individuals from more benign forereefs indicates that thermal history of these corals plays a large role in their response to thermal stress (Barshis et al., 2010).

Acidification: While no studies have tested acidification impacts on *Porites nigrescens*, De'ath et al. (De'ath et al., 2009) looked at 328 colonies of massive *Porites* from 69 reefs of the Great Barrier Reef (GBR) and found a decline in calcification by 14.2% since 1990, predominantly because of an extension decline of 13.3%. This is similar to the estimates of a global decline in aragonite saturation state of 16% since the beginning of global industrialization (De'ath et al., 2009). The De'ath study agreed with earlier, more limited work on *Porites* on the GBR (Cooper et al., 2008) and on laboratory and mesocosm experiments that showed declines in calcification with reduced aragonite saturation state in *Porites cylindrical* (Hii et al., 2009) and *Porites compressa* adults (Langdon and Atkinson, 2005; Marubini et al., 2001), *Porites lutea* adults (Ohde and Hossain, 2004; Hossain and Ohde, 2006), and *Porites astreoides* juveniles (Albright et al., 2008). Work on other corals has shown that impacts are not limited to extension as acidification impairs fertilization and settlement success in *Acropora palmata* (Albright et al., 2010), although it has not been found to interfere with settlement of larvae in *Porites astreoides* (Albright et al., 2008). Acidification also contributes to reef destruction (Hoegh-Guldberg et al., 2007; Silverman et al., 2009) reducing habitat for corals. 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: Medium number of genus level disease reports of subacute (lesions resulting in slow progressive tissue loss) black band disease, and endolithis hypermycosis (UNEP, 2010). 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).

Predation: *Porites* is susceptible to crown-of-thorns seastar (*Acanthaster planci*) and corallivorous snail predation (B. Vargas-Ángel, CRED, Honolulu, HI, pers. comm., September 2010), including predation of *Coralliphilia violacea* on both massive and branching forms (Zeid et al., 1999). Massive *Porites* are susceptible, but not a preferred prey, of the predatory asteroid *Culcita novaeguineae* (Glynn and Krupp, 1986) and the butterflyfish *Chaetodon unimaculatus* (Cox, 1986).

Land-based sources of pollution (LBSP): McClanahan and Obura (McClanahan and Obura, 1997) identified *Porites* as intermediate for its sediment tolerance in the western Indian Ocean. In contrast, *Porites* is often found in relatively turbid waters in Asia and the eastern Pacific and were considered sediment tolerant by Rogers (1990) and Brown (1997b). 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: According to the CITES Trade Database, UNEP World Conservation Monitoring Centre, 25,000-50,000 pieces of *Porites* spp. per year traded (CITES, 2010). CITES data specifically name *Porites nigrescens* but it is uncertain how much of this harvest is of *Porites nigrescens*.

Risk Assessment

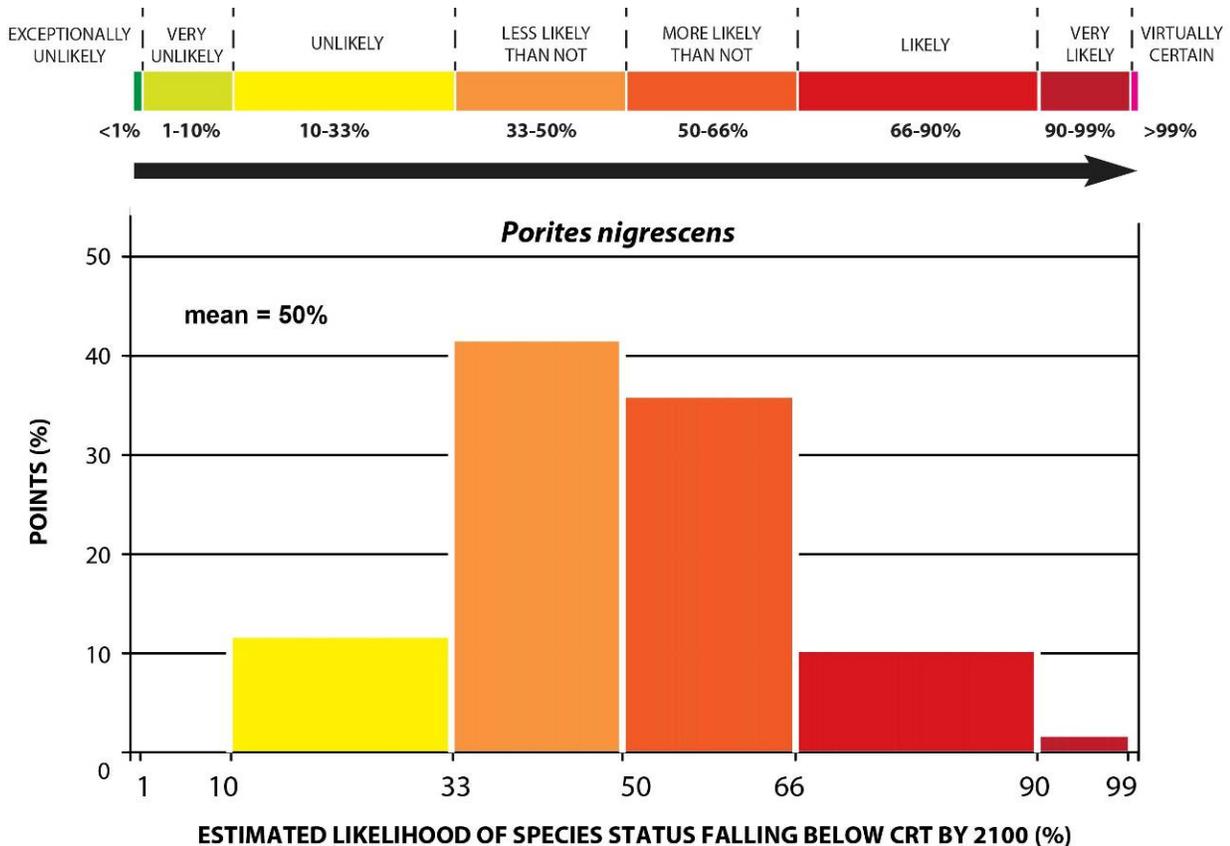


Figure 7.11.12. Distribution of points to estimate the likelihood that the status of *Porites nigrescens* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Porites nigrescens* include the fairly low tolerance to thermal stress and susceptibility to acidification impacts in the genus. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) included the species' broad distribution, the high tolerance of sediment stress and turbid water, and low disease and predation susceptibility of the genus.

The overall likelihood that *Porites nigrescens* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "less likely than not" risk category with a mean likelihood of 50% and a standard error (SE) of 9% (Fig. 7.11.12). 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 10%–99% (Fig. 7.11.12) and the average range of likelihood estimates of the seven BRT voters (58%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Porites nigrescens*.

7.11.4 *Porites pukoensis* Vaughan, 1907

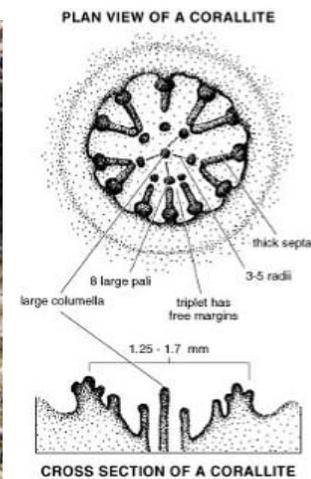


Figure 7.11.13. *Porites pukoensis* photos and corallite plan from Veron (2000).

Characteristics

Colonies of *Porites pukoensis* are massive with a tendency to form columns. Tentacles are usually extended during the day. Colonies are brown or tan in color (Veron, 2000).

Taxonomy

Taxonomic issues: *Porites* is known to be morphologically plastic and multiple sympatric species frequently exhibit intergradation of skeletal characteristics. Only limited molecular genetic analysis has been performed on the *Porites* so far. In the most comprehensive, Forsman et al. (2009) identified inseparable clades that contain multiple morphological species, in some cases, with morphological species that span more than one clade. This is a particular issue for *Porites pukoensis* as it is morphologically very similar to *Porites compressa* and *Porites lobata* that are both part of genetic Clade 1. However, no live *Porites pukoensis* could be found for genetic analysis. According to Veron (2000), *Porites pukoensis* is similar to *Porites evermanni*, which lacks denticles at the bases of septa. See also *Porites nodifera* (Veron 2000). However, according to the original description, it may be indistinguishable from forms of *Porites lobata* and *Porites compressa* (Vaughan, 1907). See “Risk Assessment” below for the BRT determination on taxonomy of the species.

Family: Poritidae.

Evolutionary and geologic history: The genus originated in the Eocene Era and became overwhelmingly dominant in the Miocene Tethys (Veron, 1995). It continues to be the most cosmopolitan of all coral genera (Veron, 2000).

Global Distribution

Porites pukoensis is only found in the Hawaiian Archipelago (Veron, 2000).



Figure 7.11.14. *Porites pukoensis* distribution from IUCN copied from <http://www.iucnredlist.org>.



Figure 7.11.15. *Porites pukoensis* distribution copied from Veron and Stafford-Smith (2002) and agrees with Veron (2000).

U.S. Distribution

According to both the IUCN Species Account and the CITES species database, *Porites pukoensis* has been recorded in Hawai'i. The CITES species database also lists this species in American Samoa.

A search of published and unpublished records of occurrence in U.S. waters indicates *Porites pukoensis* has been reported from Tutuila in American Samoa (Hoffmeister, 1925; Lamberts, 1983), Hawai'i (Veron, 2000), and Kingman Reef (CRED, unpubl. data). *Porites pukoensis* was not been found during recent searches conducted from a reef near Pūko'o, Molokai'i (Z. Forsman, Hawai'i Institute of Marine Biology, Kāne'ohe, HI; E. Brown, marine biologist, National Park Service, Kalaupapa, HI, pers. comm., 21 September 2010).

Within federally protected waters, *Porites pukoensis* has been recorded from the following areas:

- Pacific Remote Islands Marine National Monument (Kingman)

Habitat

Habitat: *Porites pukoensis* has been reported to occupy shallow protected reef environments, especially lagoons (Veron, 2000).

Depth range: *Porites pukoensis* has an unknown depth range.

Abundance

Abundance of *Porites pukoensis* has been reported as usually uncommon (Veron, 2000).

Life History

The reproductive characteristics of *Porites pukoensis* have not been determined, although all similar *Porites* in the central Pacific are gonochoric broadcast spawners (Baird et al., 2009). Although specific larval descriptions have not been published for this species, the larvae of all other *Porites* species studied contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis (Baird et al., 2009). The minimum size and estimated age at first reproduction have not been determined for this species. However, for two other *Porites* species, the minimum size is < 8 cm in diameter (Harriott, 1983). Larval longevity has not been determined in this family.

Threats

Temperature stress: Massive *Porites* have moderate susceptibility to bleaching (Marshall and Baird, 2000; McClanahan et al., 2007), while branching *Porites* seem to have a higher susceptibility comparable to *Pocillopora* and *Acropora* (Marshall and Baird, 2000; McClanahan et al., 2007), but branching *Porites* had higher mortality than massive *Porites* (Kayanne et al., 2002). Recent work comparing *Porites lobata* from extreme lagoonal environments with individuals from more benign fore reefs indicates that thermal history of these corals plays a large part in their reaction to thermal stress (Barshis et al., 2010).

Acidification: De'ath et al. (2009) looked at 328 colonies of massive *Porites* from 69 reefs of the Great Barrier Reef (GBR) and found a decline in calcification by 14.2% since 1990, predominantly because of an extension decline of 13.3%. This is similar to the estimates of a global decline in aragonite saturation state of 16% since the beginning of global industrialization (De'ath et al., 2009). The De'ath study agreed with earlier, more limited work on *Porites* on the GBR (Cooper et al., 2008) and on laboratory and mesocosm experiments that showed declines in calcification with reduced aragonite saturation state in *Porites cylindrical* (Hii et al., 2009) and *Porites compressa* adults (Langdon and Atkinson, 2005; Marubini et al., 2001), *Porites lutea* adults (Hossain and Ohde, 2006; Ohde and Hossain, 2004), and *Porites astreoides* juveniles (Albright et al., 2008). Work in other corals has shown that impacts are not limited to extension as acidification impairs fertilization and settlement success in *Acropora palmata* (Albright et al., 2010), although it has not been found to interfere with settlement of larvae in *Porites astreoides* (Albright et al., 2008). Acidification is also likely to contribute to reef destruction in the future (Hoegh-Guldberg et al., 2007; Silverman et al., 2009) reducing habitat for corals. 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: Medium number of disease reports for the genus *Porites* of subacute (lesions resulting in slow progressive tissue loss) tissue-loss syndrome, black-band disease, edolithic hypermycosis, yellow-band disease, and pigmentation response including pink-line syndrome (UNEP, 2010). 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).

Predation: *Porites* is susceptible to crown-of-thorns seastar (*Acanthaster planci*) and corallivorous snail predation (B. Vargas-Ángel, CRED, Honolulu, HI, pers. comm., September 2010), including predation by *Coralliphilia violacea* on both massive and branching forms (Zeid et al., 1999). Massive *Porites* are susceptible, but not a preferred prey, of the predatory asteroid *Culcita novaeguineae* (Glynn and Krupp, 1986) and the butterflyfish *Chaetodon unimaculatus* (Cox, 1986).

Land-based sources of pollution: McClanahan and Obura (McClanahan and Obura, 1997) identified *Porites* as intermediate for its sediment tolerance in the western Indian Ocean. In contrast, *Porites* is often found in relatively turbid waters in Asia and the eastern Pacific and were considered sediment tolerant by Rogers (Rogers, 1990) and Brown (Brown, 1997b). 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: According to the CITES Trade Database, UNEP World Conservation Monitoring Centre, 25,000-50,000 pieces of *Porites* spp. per year traded (CITES, 2010).

Risk Assessment

The risk assessment for this species was problematic because of questions of both taxonomy and identification of this species. Two risk assessments were voted on by the BRT for this species to cover both extremes of the potential status of the species: (1) *Porites pukoensis* is part of the clade of poritid corals that includes *Porites lobata* and *Porites compressa* (Forsman et al., 2009) and does not represent a separate species, and (2) *Porites pukoensis* is a unique species that is a rare member of coral reef communities where it is found and only exists in a range limited to Hawai'i and potentially a few other islands in the central Pacific.

After consultation with experts and key taxonomic references, including the most recent molecular analysis (Forsman et al., 2009) and the original species description (Vaughan, 1907), it was concluded by the BRT that *Porites pukoensis* does not represent a separate, rare species. The original description of *Porites pukoensis* (Vaughan, 1907) is unconvincing that this is a separate species:

“The calicular characters of *Porites pukoensis* are practically identical with those of *P compressa* forma *angustisepta*. As was remarked in discussing the latter form, it is not at all unlikely that they may be only different growth forms of the same species. However, the specimens at my disposal for study do not show intergradation.”

“*Porites lobata* forma *parvicalyx* (p. 200) is also closely related. ... The three forms, *Porites compressa* forma *angustisepta*, *Porites pukoensis*, and *Porites lobata* forma *parvicalyx* constitute a most interesting series. It may be that they all belong to the same species. Should they do so, they will show that the growth form of corals is of only slight systematic importance.”

Recent work by Forsman et al. (2009) shows that, in fact, Vaughan was probably quite correct in the latter statement made 102 years prior. Molecular genetics have shown that *Porites lobata* and *Porites compressa* are members of a single clade, distinct from others in his analysis. These two works make it most likely that *Porites pukoensis* is only another form within this clade and perhaps genetically indistinct from these two. Forsman was unable to find specimens of *Porites pukoensis* to include it in the genetic analysis (pers. comm. 2010). Based on this determination, *Porites* Clade 1 forma *pukoensis* is part of a clade that includes the hardiest and most widely distributed of the poritids.

Based on this evidence, the BRT concluded that it is most likely that *Porites* Clade 1 forma *pukoensis* is not genetically distinct from the clade containing *Porites lobata* Dana 1846, making it part of a clade of corals that exists commonly from the eastern coast of Africa to the western coast of the Americas (Fig. 7.11.16).



Figure 7.11.16. *Porites lobata* distribution from IUCN copied from <http://www.iucnredlist.org>.

Risk Assessment of *Porites* clade 1 forma *pukoensis*

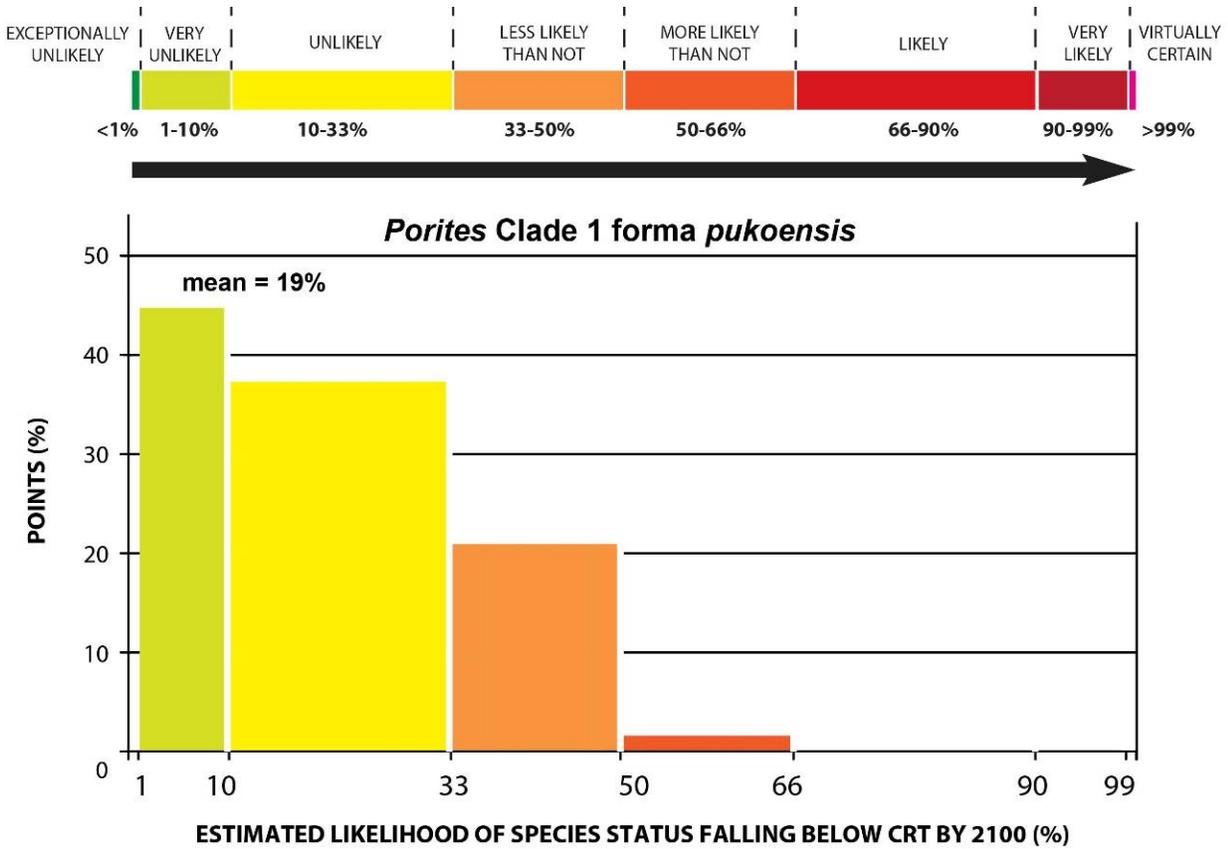


Figure 7.11.17. Distribution of points to estimate the likelihood that the status of *Porites* Clade 1 forma *pukoensis* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

With the conclusion that this coral is not genetically distinct from *Porites lobata*, factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) included the species’ broad distribution, the high tolerance of sediment stress and turbid water, and low disease and predation susceptibility of the genus. Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for this species include the moderate/low tolerance to thermal stress and susceptibility to acidification impacts in the genus.

The overall likelihood that *Porites* Clade 1 forma *pukoensis* will fall below the Critical Risk Threshold by 2100 was estimated to be in the “very unlikely” risk category with a mean likelihood of 19% and a standard error (SE) of 8% (Fig. 7.11.17). 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%–66% (Fig. 7.11.17) and the average range of likelihood estimates of the seven BRT voters (43%). 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.

Risk Assessment of *Porites pukoensis*

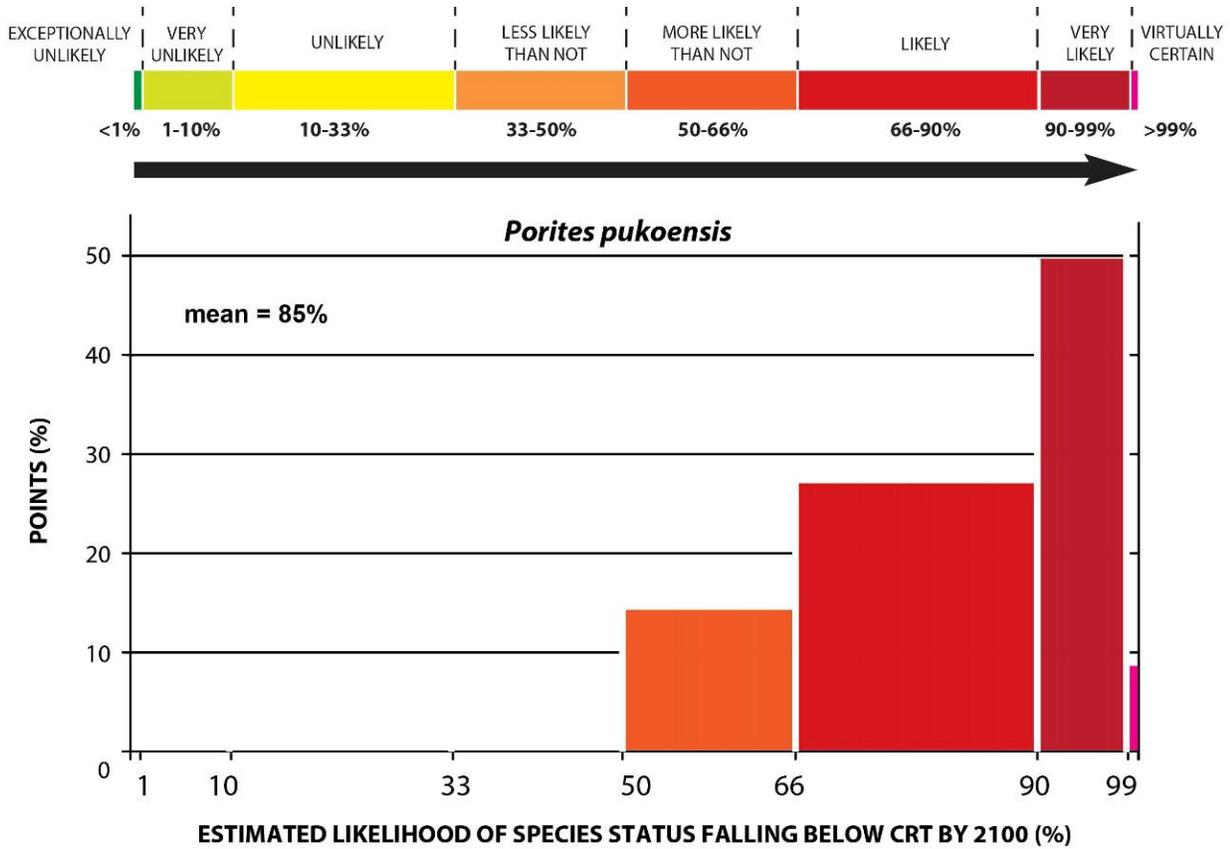


Figure 7.11.18. Distribution of points to estimate the likelihood that the status of *Porites pukoensis* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

If *Porites pukoensis* is in fact a unique species that is a rare member of coral reef communities where it is found and only exists in a range limited to Hawai'i and potentially a few other islands in the central Pacific. Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for this species include the extremely limited distribution and rarity where it occurs. Range may exist in a restricted area of Hawa'i only (off the island of Moloka'i) or be rare but present in American Samoa (Hoffmeister, 1925) and Kingman Reef (CRED, unpubl. data). Either way, any species with such a limited range, and rarity when present, is at high risk of extinction. Factors reducing the potential extinction risk (lower likelihood of falling below the Critical Risk Threshold) include the coral's high tolerance to sediment stress and turbid water and low susceptibility to disease and predation.

The overall likelihood that a unique *Porites pukoensis* species will fall below the Critical Risk Threshold by 2100 was estimated to be in the "likely" risk category with a mean likelihood of 85%, a standard error (SE) of 9%, and included some votes for "virtually certain" (Fig. 7.11.18). 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 50%–100% (Fig. 7.11.18) and the average range of likelihood estimates of the seven BRT voters (40%)—the smallest range of any candidate coral (Table 8.1). 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.

7.12 Genus *Psammocora* (Family Siderastreidae)

7.12.1 *Psammocora stellata* Verrill, 1866



Figure 7.12.1. *Psammocora stellata* photos and corallite plan from Veron (2000).

Characteristics

Colonies of *Psammocora stellata* are submassive or branching, with encrusting bases. Corallites have poorly defined walls. Approximately half of the septo-costae are tear-shaped. Columellae are poorly developed or absent. Colonies are tan, grey or purple in color (Veron, 2000).

Taxonomy

Taxonomic issues: There is some question as to whether the eastern Pacific populations are distinct species (“Additional problematic species include the validity of...three to four species in the genus *Psammocora*” (Glynn and Ault, 2000)). *Psammocora stellata* is similar to *Psammocora obtusangula*, which forms branches and has discernible columellae (Veron, 2000). More recent work (Benzoni et al., 2010) compared genetic relationships among 12 morphologically identified Indo-Pacific *Psammocora* species and found that they represented 5 genetic species. This indicates that problems may exist in the classical identification of *Psammocora* species. However, no particular doubt has been placed on the validity of *Psammocora stellata* (Benzoni et al., 2010; Stefani et al., 2008).

Family: Siderastreidae.

Evolutionary and geologic history: Evolved in the Miocene Era (Edinger and Risk, 1995) and disappeared from the Caribbean in the Pliocene Age (Glynn and Ault, 2000).

Global Distribution

Psammocora stellata has a somewhat restricted and fragmented range. Longitudinally, it stretches from Indonesia to the East Pacific and latitudinally it is only found in the northern hemisphere from Hawai'i and the Northern Mariana Islands to the Galapagos and coast of Ecuador (Veron, 2000).

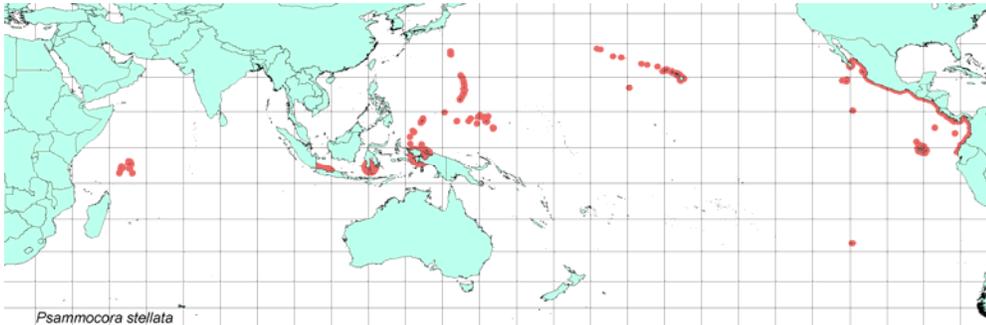


Figure 7.12.2. *Psammocora stellata* distribution from IUCN copied from <http://www.iucnredlist.org>.

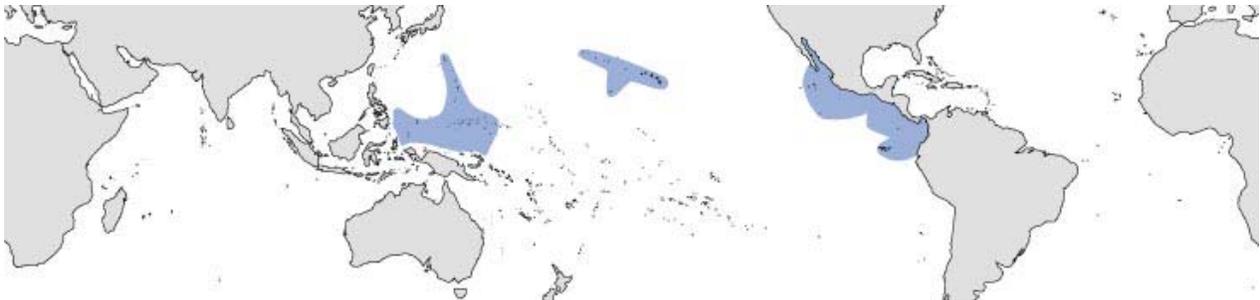


Figure 7.12.3. *Psammocora stellata* distribution from Veron (2000).

U.S. Distribution

According to both the IUCN Species Account and the CITES species database, *Psammocora stellata* has been recorded in the Northern Mariana Islands and the U.S. minor outlying islands. The CITES species database also lists this species in Hawai'i.

A search of published and unpublished records of occurrence in U.S. waters indicates *Psammocora stellata* has been reported from Guam (Burdick, unpubl. data; Randall, 2003), Hawai'i (Aki et al., 1994; Veron, 2000; Maragos et al., 2004; Fenner, 2005), Johnston Atoll, Howland Island and Kingman Reef (CRED, unpubl. data; Maragos and Jokiel, 1986), and Palmyra Atoll (Williams et al., 2008b).

Within federally protected waters, *Psammocora stellata* has been recorded from the following areas:

- Papahānaumokuākea Marine National Monument (Nihoa, French Frigate Shoals, Gardner Pinnacles, Maro Reef, Laysan, Lisianski, Pearl and Hermes, Midway, Kure)
- Pacific Remote Islands Marine National Monument (Johnston, Howland, Palmyra, Kingman)
- Hawaiian Islands Humpback Whale National Marine Sanctuary

Habitat

Habitat: *Psammocora stellata* has been reported to occupy shallow wave-washed rock (Veron, 2000). In the eastern Pacific, it is also found on rubble bottoms adjacent to reefs (Feingold, 1996).

Depth range: *Psammocora stellata* has been reported at depths ranging from 0 m to 20 m (Carpenter et al., 2008).

Abundance

Abundance of *Psammocora stellata* has been reported as usually uncommon (Veron 2000). The species is abundant in the eastern Pacific (Glynn and Ault, 2000).

Life History

In the eastern Pacific, *Psammocora stellata* is a gonochoric spawner (Glynn and Colley, 2008). In Hawai'i, Kolinski and Cox (2003) classified *Psammocora stellata* as a brooder based on the tank collection of swimming coral larvae 45 min after previous examination of secluded colonies on the July full moon between 19:50 to 21:00. The minimum size and estimated age at first reproduction have not been determined for any members of the family Siderastreidae (Harrison and Wallace, 1990). Planula larvae do not contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis (Glynn and Ault, 2000), i.e., they are lecithotrophic. Larval longevity has not been determined in this family.

Asexual reproduction by fragmentation is common in eastern Pacific populations of *Psammocora stellata* (Glynn and Colley, 2009).

Threats

Temperature stress: The genus *Psammocora* has a low bleaching susceptibility on the Great Barrier Reef (Marshall and Baird, 2000). It bleaches but is not highly susceptible in the eastern Pacific (multiple locations cited in (Glynn and Colley, 2001) and Gulf of California (Williams and Bunkley-Williams, 1990).

Acidification: While no studies have been published on acidification impacts on this genus, *Psammocora stellata* is common on eastern Pacific reefs and near-reef habitats where the aragonite saturation state is naturally low due to upwelling (Manzello et al., 2008). This may imply that to some degree, this species can tolerate acidified water but the impact of acidification on growth has not been quantified. However, in most corals studied (Table 3.2.2), acidification impairs growth (Kleypas and Langdon, 2006) 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: None reported 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 evidence show that these impacts are occurring in more taxa and at a broader geographic scale (Sutherland et al., 2004, Green and Bruckner 2000).

Predation: *Psammocora stellata* is susceptible to predation by crown-of-thorns seastar (*Acanthaster planci*) but is not a preferred prey species (Cortés and Guzmán, 1998; Glynn, 1976).

Land-based sources of pollution (LBSP): *Psammocora stellata* is somewhat sediment tolerant in the eastern Pacific as it is frequently found growing on sand and rubble plains (Feingold, 1996), but is not found alive in high-sediment environments (Cortés, 1990). Occupying rubble habitat makes it less susceptible to habitat destruction than reef-dwellers. Algal overgrowth slows colony growth (Fernandez et al., 2008) or kills colonies (Glynn, 1997). 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 trade information for this species was listed on the CITES Trade Database, UNEP World Conservation Monitoring Centre (CITES, 2010).

Risk Assessment

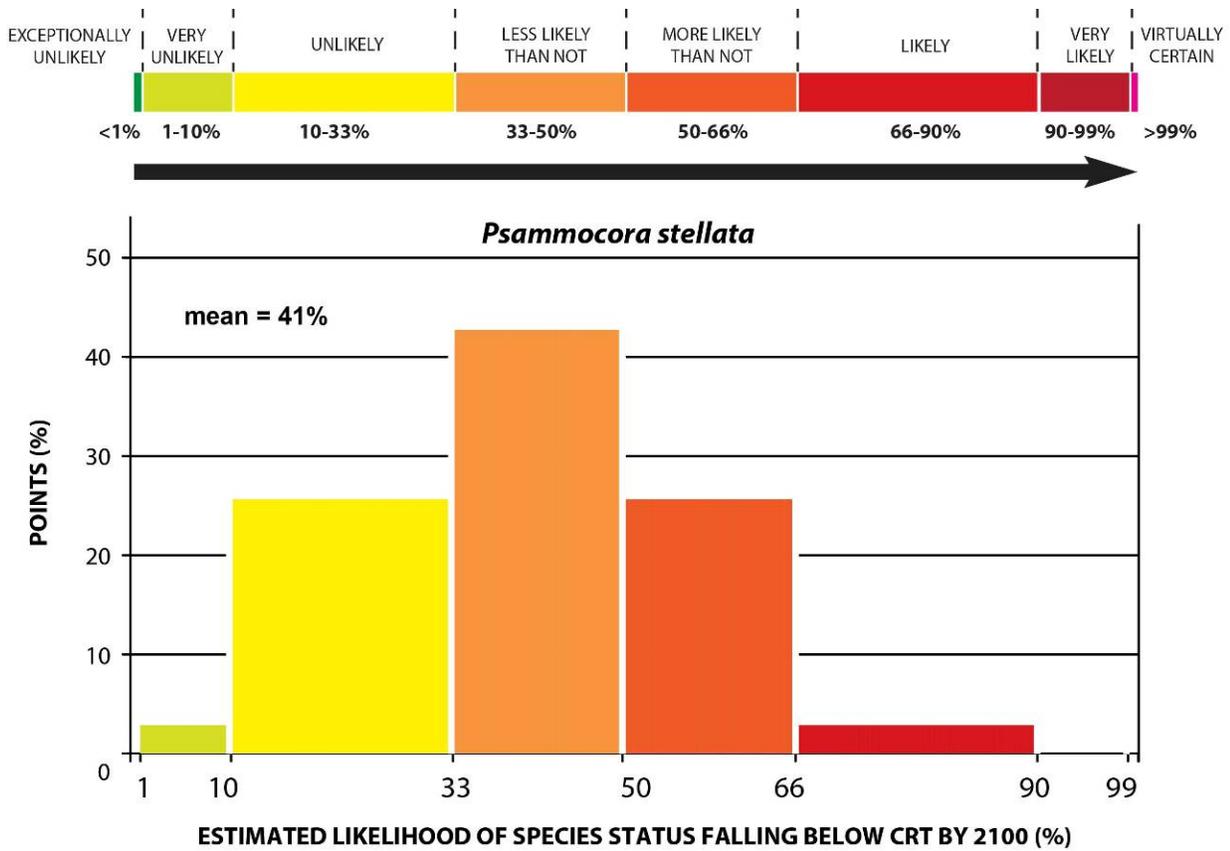


Figure 7.12.4. Distribution of points to estimate the likelihood that the status of *Psammocora stellata* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) for *Psammocora stellata* included the species' broad latitudinal distributions, its wide habitat distribution and free-living growth form (unattached corallith morphology) found on reef and just off reef including high energy zones, and its low susceptibility to bleaching, including high abundance after the 1982-1983 El Niño. Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for this species include susceptibility to algal overgrowth.

The overall likelihood that *Psammocora stellata* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "less likely than not" risk category with a mean likelihood of 41% and a standard error (SE) of 9 (Fig. 7.12.4). 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 1%–90% (Fig. 7.12.4) and the average range of likelihood estimates of the seven BRT voters (58%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Psammocora stellata*.

7.13 Genus *Leptoseris* (Family Agariciidae)

7.13.1 *Leptoseris incrustans* Quelch, 1886

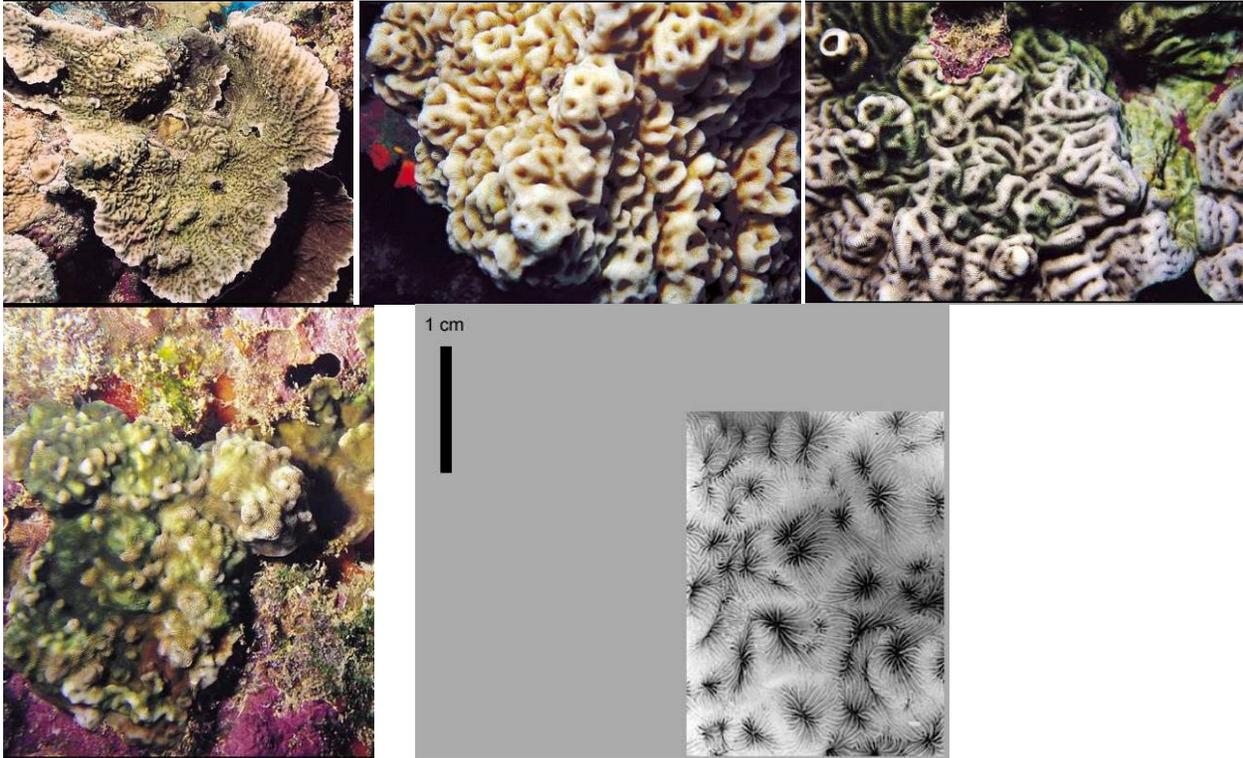


Figure 7.13.1. *Leptoseris incrustans* photos and corallite plan from Veron (2000).

Characteristics

Colonies of *Leptoseris incrustans* are primarily encrusting but may develop broad explanate laminae. These laminae often have radiating ridges. Corallites are small, closely compacted and superficial. The coenosteum commonly has Hydnothora-like monticules. Septo-costae are thin and equal, giving colonies a smooth surface. Columellae are small styles. Colonies are pale to dark brown or greenish-brown in color (Veron, 2000). Maximum colony size is 100 cm.

Taxonomy

Taxonomic issues: None. *Leptoseris incrustans* is similar to *Leptoseris hawaiiensis*, which has larger corallites and no Hydnothora-like projections on the coenosteum. It is also similar to *Leptoseris mycetoseroides*, which has well-developed radiating ridges on laminae (Veron, 2000).

Family: Agariciidae.

Evolutionary and geologic history: The genus is known from the Tethys Sea in the Oligocene Era (Wells and Moore, 1956).

Global Distribution

Leptoseris incrustans has a very broad range. Longitudinally it stretches from the Red Sea to the central Pacific Islands and latitudinally it stretches from the Red Sea and Hawai'i in the northern hemisphere to southern Africa and the Great Barrier Reef in Australia in the southern hemisphere (Veron, 2000).

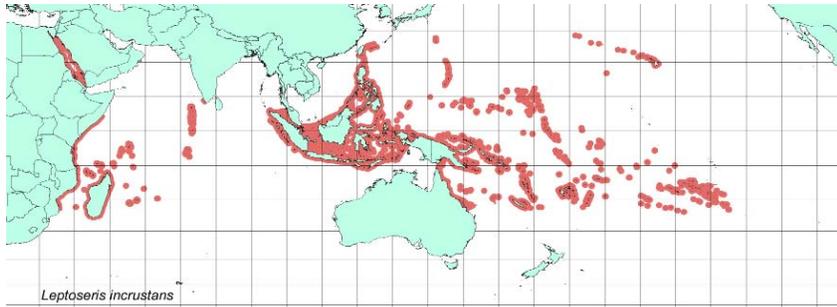


Figure 7.13.2. *Leptoseris incrustans* distribution from IUCN copied from <http://www.iucnredlist.org>.

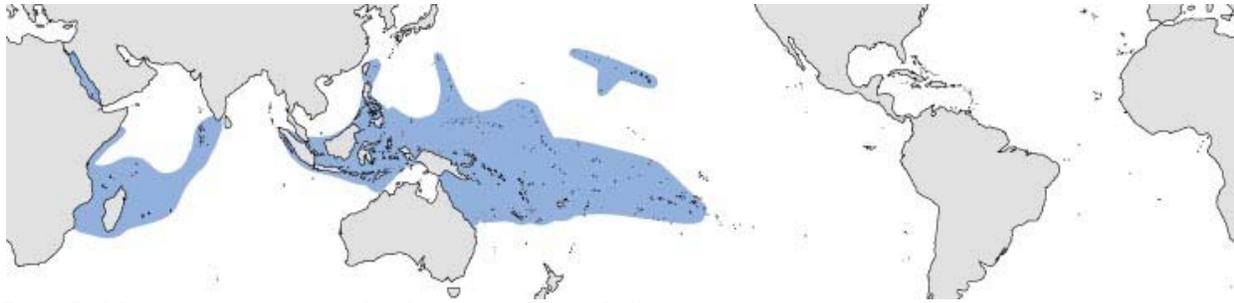


Figure 7.13.3. *Leptoseris incrustans* distribution from Veron (2000).

U.S. Distribution

According to both the IUCN Species Account and the CITES species database, *Leptoseris incrustans* occurs in American Samoa, the Northern Mariana Islands, Hawai'i, and the U.S. minor outlying islands.

A search of published and unpublished records of occurrence in U.S. waters indicates *Leptoseris incrustans* has been reported from Tutuila, Ofu-Olosega, and Rose Atoll in American Samoa (Maragos et al., 1994, Coles et al., 2003, Lovell and McLardy, 2008; Birkeland, unpubl. data; Kenyon et al., 2010a; National Park Service, 2009), Guam (Burdick, unpubl. data; Randall, 2003), Hawai'i (Aki et al., 1994; Beets et al., 2010; Godwin and Bolick, 2006; Maragos et al., 2004; Veron, 2000), Johnston Atoll and Jarvis Island (CRED, unpubl. data; Maragos and Jokiel, 1986).

Within federally protected waters, *Leptoseris incrustans* has been recorded from the following areas:

- Papahānaumokuākea Marine National Monument (French Frigate Shoals, Pearl and Hermes, Midway, Kure)
- Pacific Remote Islands Marine National Monument (Johnston, Jarvis)
- National Park of American Samoa, Ofu Island unit
- Rose Atoll Marine National Monument
- Puuhonua o Hōnauanau National Historic Park, Hawa'i
- Kalaupapa National Historic Park, Moloka'i
- Hawaiian Islands Humpback Whale National Marine Sanctuary

Habitat

Habitat: *Leptoseris incrustans* inhabits shallow reef environments (Veron, 2000).

Depth range: *Leptoseris incrustans* has been reported in water depths ranging from 10 m to 20 m (Carpenter et al., 2008). This species has also been reported in the mesophotic zone between 50 m and 80 m (Rooney et al., 2010), suggesting potential deep refugia.

Abundance

Abundance of *Leptoseris incrustans* has been reported as uncommon (Veron, 2000).

Life History

The reproductive characteristics of *Leptoseris incrustans* have not been determined ((Baird et al., 2009). However, the congener *Leptoseris explanata* is gonochoric (Baird et al., 2009). The minimum size and estimated age at first reproduction have not been determined for any members of the genus *Leptoseris* (Harrison and Wallace, 1990). Larvae in this genus have not been studied to determine whether or not they contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis (Baird et al., 2009), i.e., if they are autotrophic or lecithotrophic. Larval longevity has not been determined in this family.

Threats

Temperature stress: The genus *Leptoseris* is listed as having no bleaching response (0 ± 0 SD) in a compilation of 17 genera in McClanahan et al. (2007). In Hawai'i, *Leptoseris incrustans* contains type C1 zooxanthellae (Lewis, 1989), which may be relatively bleaching tolerant.

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 some evidence show that these impacts are occurring on a trend of increasing taxonomic and geographic scale (Green and Bruckner, 2000; Sutherland et al., 2004). A few disease reports for the family Agariciidae could be found on the global disease database (UNEP, 2010).

Predation: Unknown.

Land-based sources of pollution (LBSP): The effects of LBSP on the genus *Leptoseris* are largely unknown. 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 was found in the CITES Trade Database, UNEP World Conservation Monitoring Centre, Cambridge, UK (CITES, 2010). Collection/trade is not considered to be a significant threat to this species.

Risk Assessment

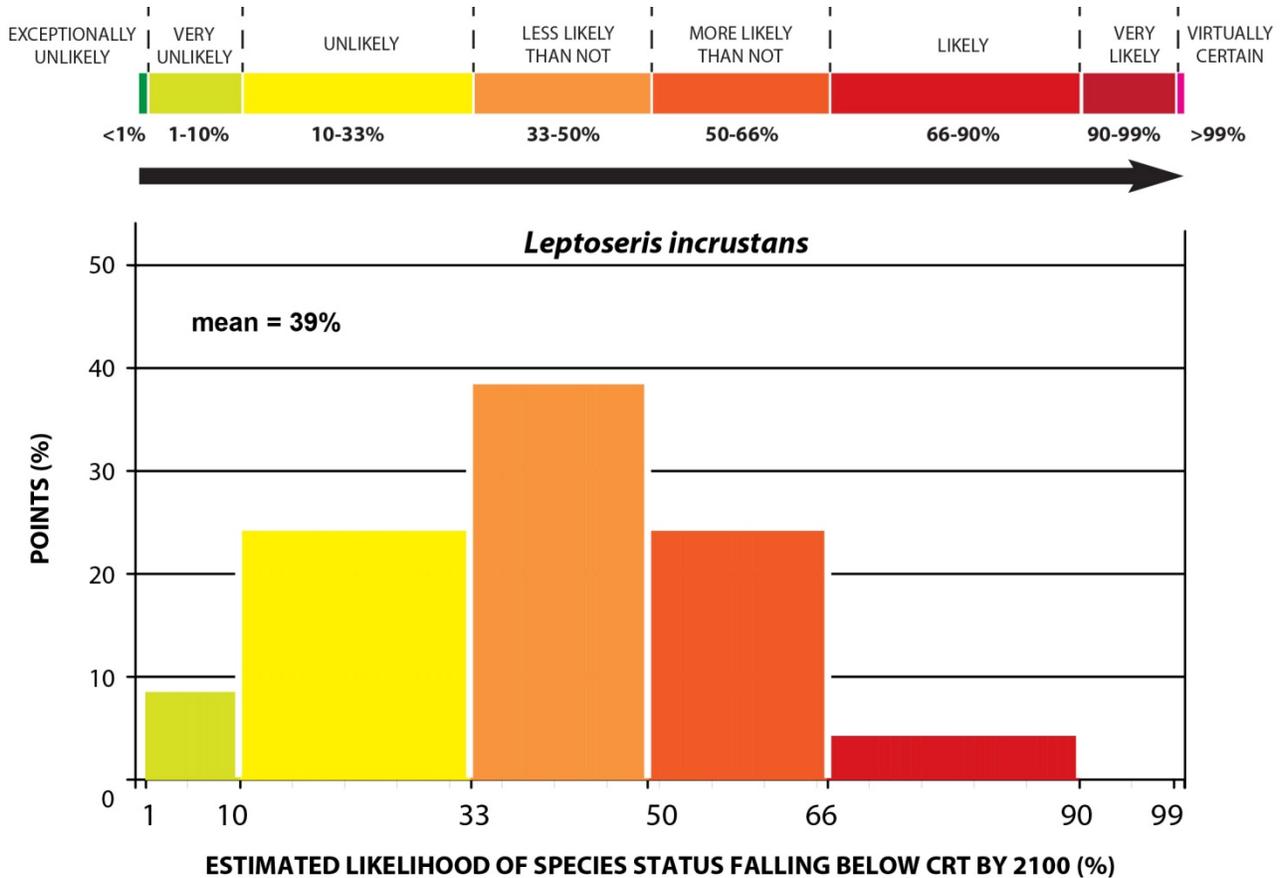


Figure 7.13.4. Distribution of points to estimate the likelihood that the status of *Leptoseria incrustans* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Leptoseria incrustans is considered uncommon; therefore, the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for this species is increased. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) are that *Leptoseria incrustans* occupies a variety of habitat types including mesophotic deep reefs, tolerates murky waters, has low bleaching rates, and is broadly distributed both latitudinally and longitudinally in the Indo-Pacific. Occurrence in mesophotic habitats was considered to reduce extinction risk since these habitats are somewhat buffered from surface-based threats.

The overall likelihood that *Leptoseria incrustans* will fall below the Critical Risk Threshold by 2100 was estimated to be in the “less likely than not” risk category with a mean likelihood of 39% and a standard error (SE) of 10% (Fig. 7.13.4). 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 1%–90% (Fig. 7.13.4) and the average range of likelihood estimates of the seven BRT voters (61%)—the eighth-highest range (Table 8.1). 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.

7.13.2 *Leptoseris yabei* Pillai and Scheer, 1976

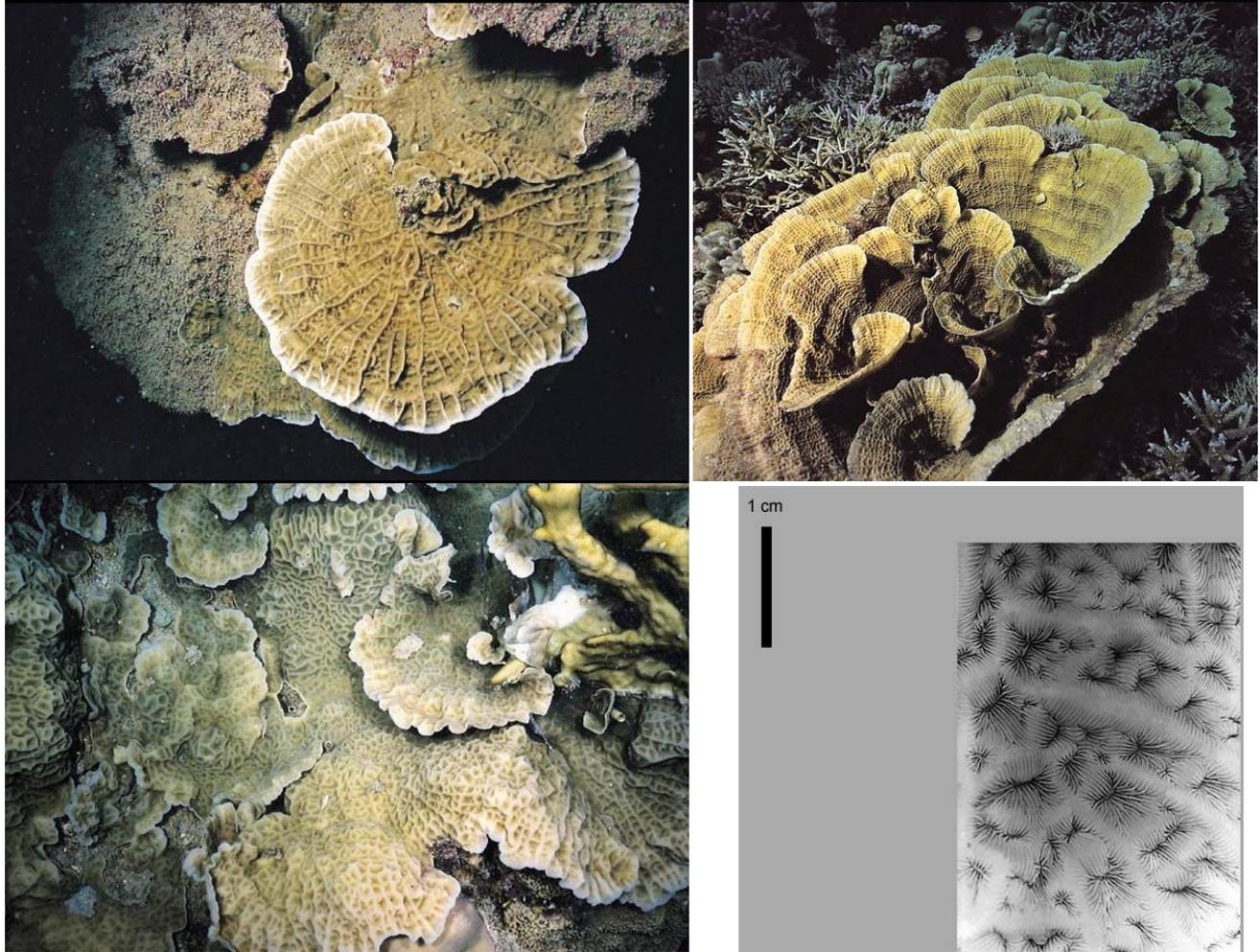


Figure 7.13.5. *Leptoseris yabei* photos and corallite plan from Veron (2000).

Characteristics

Colonies of *Leptoseris yabei* are laminar, in whorls or tiers or vase-shaped. They are commonly over 1 m across. Corallites are enclosed in rectangular pockets formed between radiating ridges and low walls that are parallel to frond margins. Septo-costae are moderately exsert and alternate. Colonies are usually pale brown or yellowish in color, sometimes with white margins (Veron, 2000). Maximum colony size 300 cm (Veron and Pichon, 1980).

Taxonomy

Taxonomic issues: None. *Leptoseris yabei* is closest to *Leptoseris mycetoseroides* but is readily distinguished from all other species by having corallites in rectangular pockets.

Family: Agariciidae.

Evolutionary and geologic history: The genus is known from the Tethys Sea in the Oligocene Era (Wells and Moore, 1956).

Global Distribution

Leptoseris yabei has a relatively broad distribution range, stretching longitudinally from the Red Sea to the east-central Pacific Ocean and latitudinally from Japanese waters in the northern hemisphere across the Great Barrier Reef and south Madagascar in the southern hemisphere (Veron, 2000).

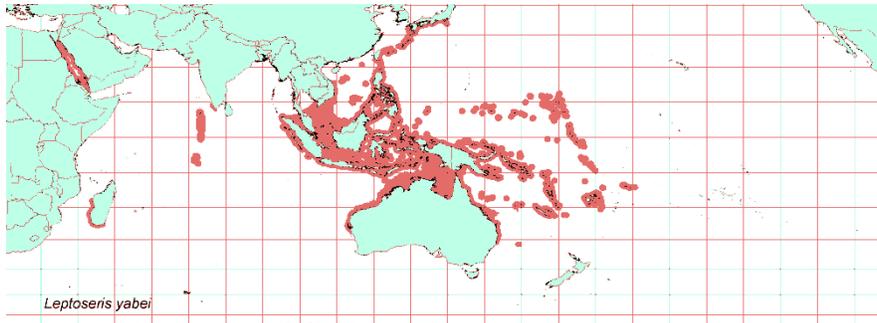


Figure 7.13.6. *Leptoseris yabei* distribution from IUCN copied from <http://www.iucnredlist.org>.

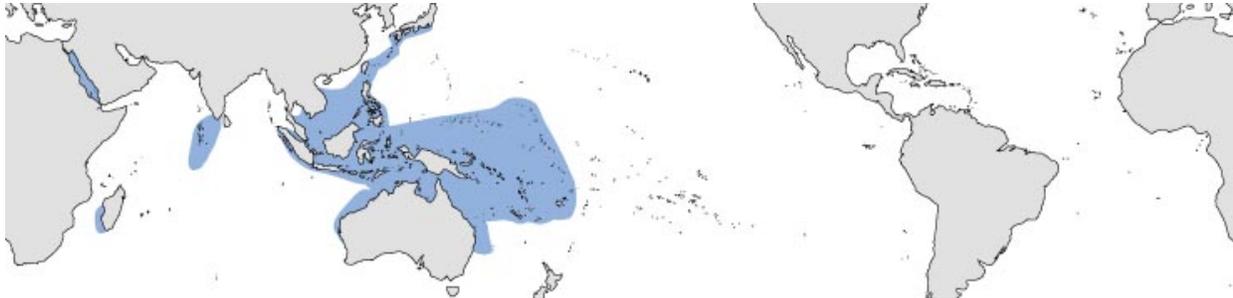


Figure 7.13.7. *Leptoseris yabei* distribution from Veron (2000).

U.S. Distribution

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

A search of published and unpublished records of occurrence in U.S. waters indicates *Leptoseris yabei* has been reported from Tutuila, Ofu-Olosega, and Rose Atoll in American Samoa (Maragos et al., 1994; Lovell and McLardy, 2008; National Park Service, 2009; Kenyon et al., 2010a). Kahng and Maragos (2006) also report *Leptoseris yabei* specimens collected in deep-water surveys off Maui, Lānaʻi, and Kauaʻi in 2001–2004 using submersibles at depths of 70 m to 120 m and showed *Leptoseris* spp. to be dominant on hard substrate below 60 m with benthic cover exceeding 90% in some areas.

Within federally protected waters, *Leptoseris yabei* has been recorded from the following areas:

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

Habitat

Habitat: *Leptoseris yabei* is usually found on flat substrates (Veron, 2000).

Depth range: *Leptoseris yabei* has been reported at water depths ranging from 3 m to 50 m (Carpenter et al., 2008; Kahng et al., 2010; Kahng and Kelley, 2007; Kahng and Maragos, 2006; Rooney et al., 2010). This species has been reported as a dominant one in mesophotic reefs in Hawaiʻi (Kahng and Maragos, 2006), suggesting potential deep refugia. However, preliminary genetic work indicates there is likely unresolved taxonomic diversity among these deepwater *Leptoseris* (Chan et al., 2009) indicating that the species identification of *Leptoseris yabei* within these mesophotic reef communities is problematic.

Abundance

Abundance of *Leptoseris yabei* has been reported as uncommon but conspicuous (Veron, 2000).

Life History

The reproductive characteristics of *Leptoseris yabei* have not been determined (Baird et al., 2009). However, the congener *Leptoseris explanata* is gonochoric (Baird et al., 2009), with colonies found to possess ripe testes or colored eggs on high-latitude reefs in the Houtman Abrolhos Islands, western Australia, when sampled before the main spawning event in March 1987 (Babcock et al., 1994; Baird et al., 2009). Other members of the family Agariciidae (i.e., 6 species of *Pavona*, 3 species of *Pachyseris*) are known to be gonochoric spawners (Baird et al., 2009). The minimum size and estimated age at first reproduction have not been determined for any members of the genus *Leptoseris* (Harrison and Wallace, 1990). Larvae in this genus have not been studied to determine whether or not they contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis (Baird et al., 2009). Larval longevity has not been determined in this family.

Threats

Temperature stress: The genus *Leptoseris* is listed as having no bleaching response (0 ± 0 SD) among the 17 included genera in McClanahan et al. (2007). *Leptoseris yabei* contains clade C zooxanthellae, with the type shifting by depth; in shallower water it contains type C1 (LaJeunesse et al., 2004a), which may be relatively bleaching-resistant (Smith et al., 2004b).

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 family Agariciidae can be found in the global disease database (UNEP, 2010).

Predation: Unknown.

Land-based sources of pollution (LBSP): The effects of LBSP on the genus *Leptoseris* are largely unknown. 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

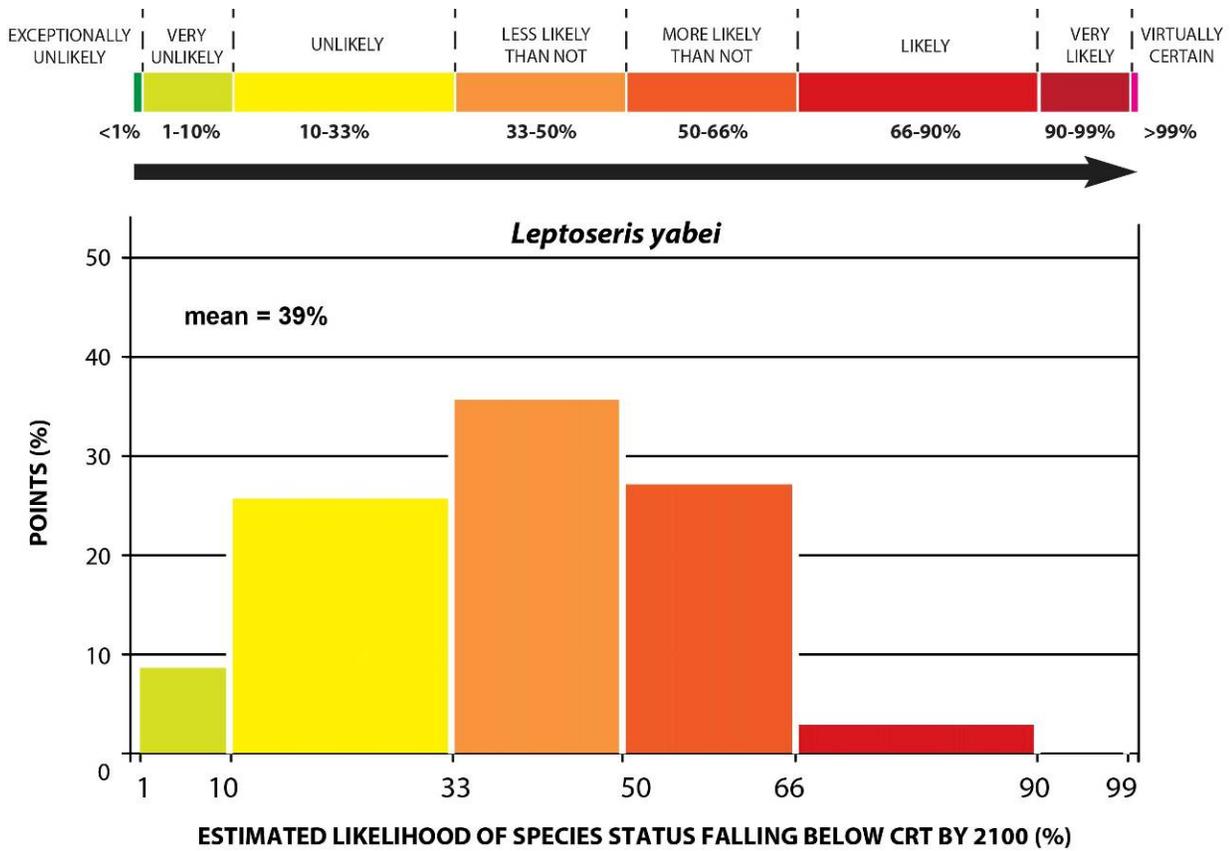


Figure 7.13.8. Distribution of points to estimate the likelihood that the status of *Leptoseris yabei* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Leptoseris yabei is considered uncommon; therefore, the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Leptoseris yabei* is increased. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) are that *Leptoseris yabei* has a broad depth range and occurs in mesophotic environments, tolerates murky water, has low bleaching rates, and occupies a variety of habitat types and is broadly distributed both latitudinally and longitudinally in the Indo-Pacific. Occurrence in mesophotic habitats was considered to reduce extinction risk since these habitats are somewhat buffered from surface-based threats.

The overall likelihood that *Leptoseris yabei* will fall below the Critical Risk Threshold by 2100 was estimated to be in the “less likely than not” risk category with a mean likelihood of 39% and a standard error (SE) of 11% (Fig. 7.13.8). 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 1%–90% (Fig. 7.13.8) 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 *Leptoseris yabei*.

7.14 Genus *Pachyseris*

7.14.1 *Pachyseris rugosa* Lamarck, 1801



Figure 7.14.1. *Pachyseris rugosa* photos from Veron (2000).

Characteristics

Colonies of *Pachyseris rugosa* are upright, irregular, anastomosing bifacial plates. Columellae are wall-like lobes (Veron, 2000). Colonies are often over 1 m across. Colonies are brown or deep blue-grey in color (Veron, 2000).

Taxonomy

Taxonomic issues: None. Similar to *Pachyseris gemmae* and *Pachyseris involuta* (Veron, 2000). An early review of *Pachyseris* taxonomy concluded all species were simply morphs of *Pachyseris speciosa* (Matthai, 1948), but many species are recognized today.

Family: Agariciidae

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

Global Distribution

Pachyseris rugosa has a very widespread distribution, stretching from the western Indian Ocean into the Pacific. The species is found in the Red Sea, Madagascar and the Seychelles, India, Indonesia, Australia, the Philippines, Japan, Micronesia, and the Marianas Archipelago.

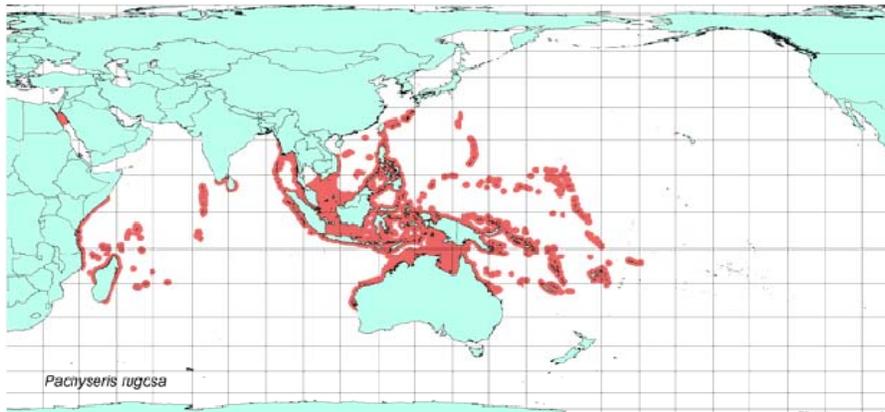


Figure 7.14.2. *Pachyseris rugosa* distribution from IUCN copied from <http://www.iucnredlist.org>.

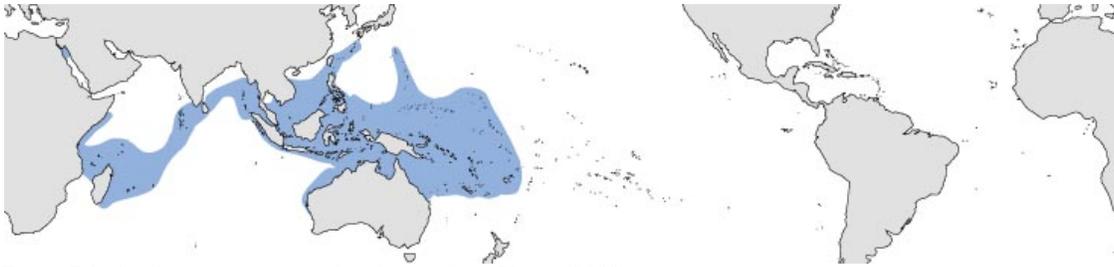


Figure 7.14.3. *Pachyseris rugosa* distribution from Veron (2000).

U.S. Distribution

According to both the IUCN Species Account and the CITES species database, *Pachyseris rugosa* occurs in American Samoa and the Northern Mariana Islands.

A search of published and unpublished records of occurrence in U.S. waters indicates *Pachyseris rugosa* has been reported from Tutuila in American Samoa (Coles et al., 2003; Lamberts, 1983; Maragos et al., 1994). Veron (2000) shows *Pachyseris rugosa* in the Marianas, but that is likely based on inaccurate geographic information of evidence (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*).

Pachyseris rugosa has not been recorded from federally protected U.S. waters.

Habitat

Habitat: *Pachyseris rugosa* may develop into large mound-shaped colonies in shallow water but smaller colonies occur in a wide range of habitats including those exposed to strong wave action (Veron, 2000). Distribution of this genus on the Great Barrier Reef is associated with areas of fine-grained sediments (Uthicke et al., 2010). It could be an indicator of quiet water (Veron et al., 1977) or a moderate energy environment (Cabioch et al., 1998).

Depth range: *Pachyseris rugosa* has been reported in water depths ranging from 5 m to 20 m (Carpenter et al., 2008). The species may be excluded from shallow waters due to excess light (Titlyanov and Latypov, 1991).

Abundance

Abundance of *Pachyseris rugosa* has been reported to be common (Veron, 2000).

Life History

Pachyseris rugosa is a gonochoric broadcast spawner (Babcock and Heyward, 1986; Dai et al., 1992; Willis et al., 1985). The minimum size and estimated age at first reproduction have not been determined for any members of the genus *Pachyseris* (Harrison and Wallace, 1990). Although specific observations have not been published for this species, the larvae of the single *Pachyseris* species studied does 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 this family.

Pachyseris rugosa contains clade C zooxanthellae (Abrego et al., 2009; Dong et al., 2009), with a predominance of clade C3h in areas of greater temperature or turbidity (LaJeunesse et al., 2004a). Congener *Pachyseris speciosa* may be somewhat photophobic and unable to adapt to high light levels (Dinesen, 1983).

Threats

Thermal stress: *Pachyseris* experiences variable but high bleaching (Bruno et al., 2001; Marshall and Baird, 2000; McClanahan et al., 2007; Stimson et al., 2002). In some places it may be bleaching tolerant (Sheppard, pers. comm. in McClanahan et al., 2007)). Congener *Pachyseris speciosa* showed heavy bleaching in Guam in 1994 (Paulay and Benayahu, 1999). Laboratory tests with this species showed a synergistic depression of photosynthetic characteristics

based on elevated temperatures and light (Bhagooli and Hidaka, 2006). As a genus, its high bleaching rate and relative rarity may give it a relatively high extirpation risk in the western Indian Ocean (McClanahan et al., 2007).

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: *Pachyseris rugosa* is vulnerable to a ciliate disease skeletal eroding band (Antonius and Lipscomb, 2000). Although overall disease presence was low during a survey in Indonesia, the black-band progressed across *Pachyseris rugosa* at an average rate of 0.63cm/d (Haapkyla et al., 2009). 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 some evidence show that these impacts are occurring on a trend of increasing taxonomic in more taxa and at a broader geographic scale (Green and Bruckner, 2000; Sutherland et al., 2004).

Predation: Mass mortality of this species on the Great Barrier Reef has been attributed to *Acanthaster planci*, although predation was not observed directly (<http://www.aims.gov.au/pages/research/reef-monitoring/cairns-section-fringing-reefs/>).

Land-based sources of pollution (LBSP): *Pachyseris rugosa* has suffered high partial mortality as a result of dredging (Blakeway, 2005), but its branching structure should make it an efficient sediment-rejecter (Stafford-Smith, 1993). The species disappeared in Jakarta Bay between 1920 and 2005, which was attributed to decreased water quality from coastal development (Van der Meij et al., 2010).

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 this genus is relatively high (CITES, 2010). *Pachyseris rugosa* experiences substantial export, averaging 1195 specimens annually from 1991 to 2008. Quotas from Fiji account for a high proportion of the export, although *Pachyseris rugosa* is also supplied in considerable quantities from the Solomon Islands. A substantial decline in exports recorded in 1997–2003 occurred, but it is not clear whether this was a real decline or exports were reported at the genus level. Exports returned to high levels (2085 *Pachyseris rugosa* annually) in 2004–2008.

Risk Assessment

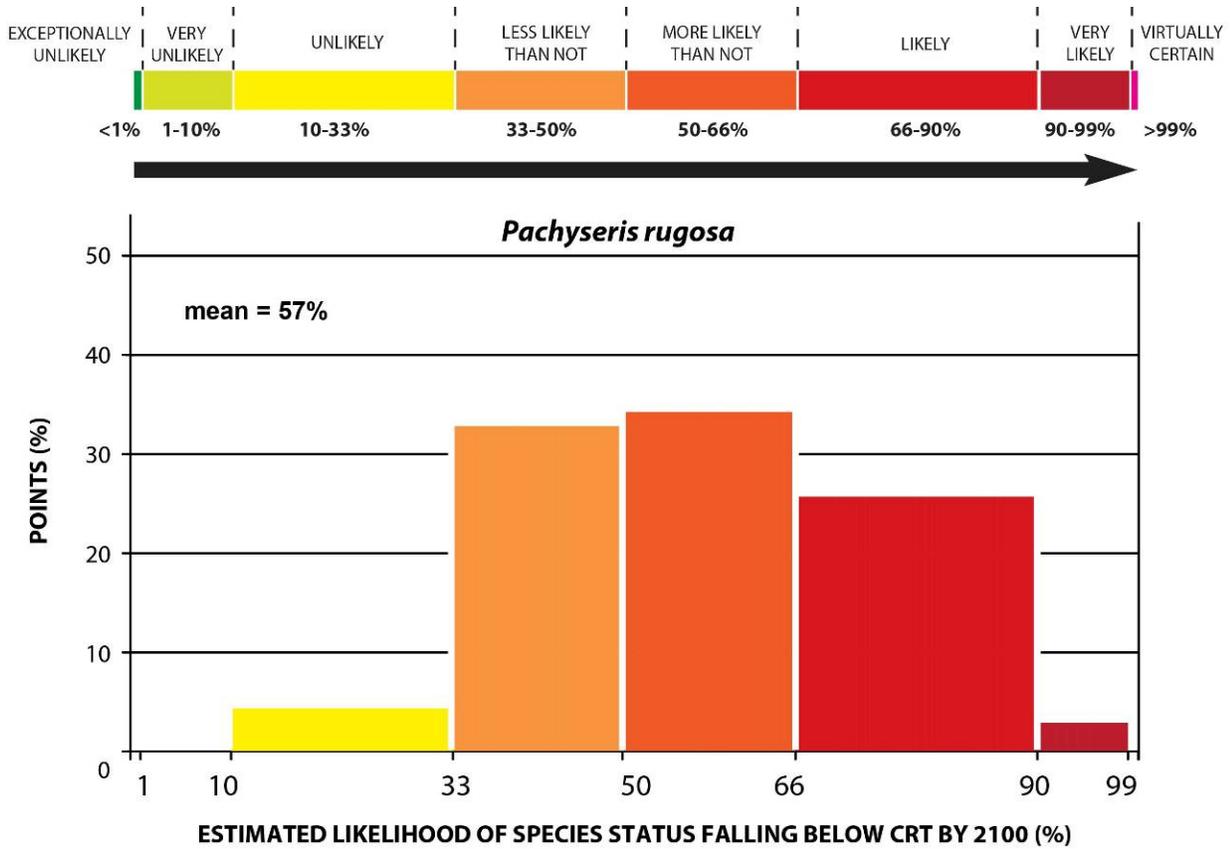


Figure 7.14.4. Distribution of points to estimate the likelihood that the status of *Pachyseris rugosa* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Factors that increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Pachyseris rugosa* are that it has high (but variable) bleaching, has been observed to be susceptible to multiple types of disease, and has been inferred to be susceptible to poor water quality. Substantial collection from the aquarium trade could lead to local extirpation in some areas. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) are that *Pachyseris rugosa* has a widespread distribution from the central Pacific to Africa, and it can have a high local abundance. Wide distribution is considered to lower 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 *Pachyseris rugosa* 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 11% (Fig. 7.14.4). 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. 7.14.4) 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 *Pachyseris rugosa*. The overall wide range of votes also reflects the uncertainty in resolving *Pachyseris rugosa*’s potential stress sensitivity with its widespread distribution and common abundance.

7.15 Genus *Pavona*

7.15.1 *Pavona bipartita* Nemenzo, 1980

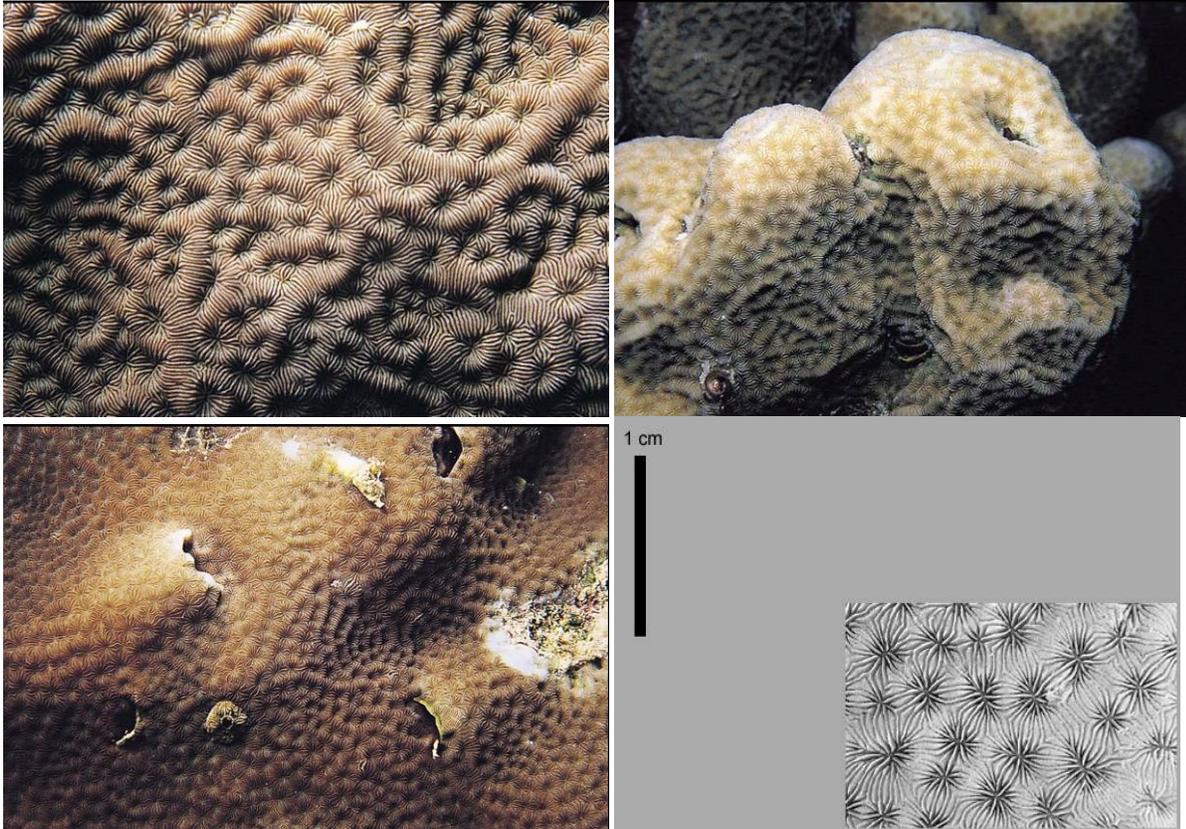


Figure 7.15.1. *Pavona bipartita* photos and corallite plan from Veron (2000).

Characteristics

Colonies of *Pavona bipartita* are submassive or encrusting and may be over 1 m across. Corallites are uniformly distributed but collines are characteristically uneven in height and may form slightly raised ridges several centimeters long. Septo-costae are in two slightly alternating orders. Colonies are uniform pale to dark brown in color (Veron, 2000)

Taxonomy

Taxonomic issues: None. *Pavona bipartita* is similar to *Pavona duerdeni* (Veron, 2000). Two further little-known and undescribed species are close to *Pavona bipartita* (Veron, 2000).

Family: Agariciidae.

Evolutionary and geologic history: The family evolved in the Tethys Sea during the Cenozoic Era, with most genera disappearing from the Caribbean. *Pavona* disappeared from the Caribbean in the Eocene (Veron, 1995).

Global Distribution

Pavona bipartita has a broad longitudinal range; it is found in the Red Sea, the southwest and central Indian Ocean, the central Indo-Pacific, southern Japan and the South China Sea, the oceanic west Pacific, the central Pacific, and the Great Barrier Reef.

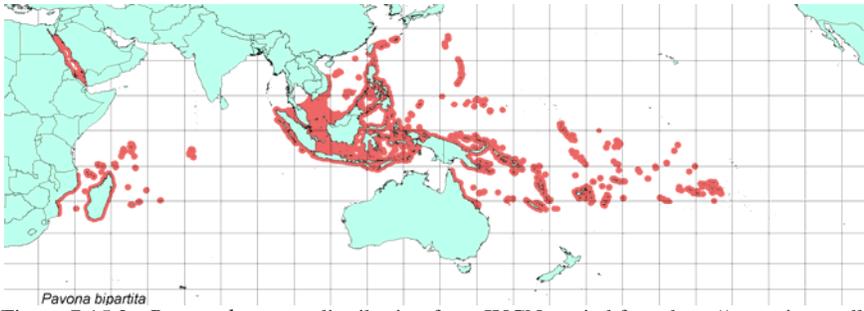


Figure 7.15.2. *Pavona bipartita* distribution from IUCN copied from <http://www.iucnredlist.org>.

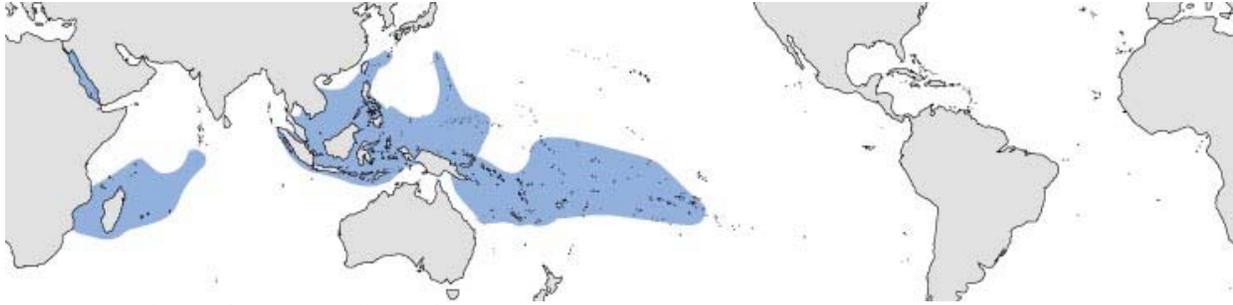


Figure 7.15.3. *Pavona bipartita* distribution from Veron (2000).

U.S. Distribution

According to the IUCN Species Account, *Pavona bipartita* occurs in American Samoa, the Northern Mariana Islands, and the U.S. minor outlying islands. The CITES species database does not list its occurrence in U.S. waters.

A search of published and unpublished records of occurrence in U.S. waters indicates *Pavona bipartita* has been reported from Tutuila in American Samoa (CRED, unpubl. data), Guam (Burdick, unpubl. data) and CNMI (CRED, unpubl. data).

Within federally protected waters, *Pavona bipartita* has been recorded from the following areas:

- Marianas Trench Marine National Monument (Asuncion)

Habitat

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

Depth range: *Pavona bipartita* has been reported in water depths ranging from 3 m to 20 m (Carpenter et al., 2008).

Abundance: *Pavona bipartita* has been reported as uncommon (Carpenter et al., 2008; Veron, 2000).

Life History

The reproductive characteristics of *Pavona bipartita* have not been determined (Baird et al., 2009). However, six congeners (*Pavona cactus*, *Pavona chiriquiensis*, *Pavona clavus*, *Pavona duerdeni*, *Pavona gigantea*, and *Pavona varians*) are known to be gonochoric spawners (Baird et al., 2009); eastern Pacific populations of *Pavona varians* and the sibling agariciid species *Pavona* sp. are also known to be hermaphrodites (Glynn and Ault, 2000; Glynn et al., 2000). The minimum size and estimated age at first reproduction have not been determined for *Pavona bipartita*, but the minimum colony sizes (and ages) at first reproduction were 5 cm (5 years) and 3 cm (2 to 3 years), respectively, in eastern Pacific populations of the congeners *Pavona varians* and *Pavona* sp. (Baird et al., 2009). Although specific larval descriptions have not been published for this species, the larvae of three other *Pavona* species studied 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 this family.

Threats

Temperature stress: *Pavona* has mixed bleaching susceptibility according to Marshall and Baird (2000), and both massive and encrusting *Pavona* have been highly susceptible to bleaching in the eastern Pacific (Glynn et al., 2001; Maté, 2003b).

Acidification: No studies have examined the direct impacts of ocean acidification on *Pavona bipartita*. Marubini (Marubini et al., 2003) found that *Pavona cactus* calcification slowed during the experimental reduction of the aragonite saturation state. In contrast, a recent study compared growth rates of two massive species of *Pavona* in the eastern Pacific and found little change in growth over the past 30 years due to acidification and little evidence of change along a saturation state gradient (Manzello, 2010). However, no comparable studies have been published on encrusting, frondose or branching pavonids. The presence of multiple species of massive *Pavona* in low saturation state environments in the eastern Pacific (Manzello et al., 2008) and the lack of growth change in lower pH environments suggests a degree of tolerance to acidification, although direct experimental studies have not confirmed this and it may suggest that the threshold for response may be lower than levels seen in the eastern Pacific. Work in other corals has shown the potential for impacts other than extension, as acidification impairs fertilization and settlement success in *Acropora palmata* (Albright et al., 2010), and likely will 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: Medium number of genus level disease reports of acute white diseases in the Pacific (B. Vargas-Ángel, CRED, Honolulu, HI, pers. comm., September 2010). 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 some evidence show that these impacts are occurring on a trend of increasing taxonomic and geographic scale (Green and Bruckner, 2000; Sutherland et al., 2004). Overall, a few disease reports for the family Agariciidae were found in the global disease database (UNEP, 2010).

Predation: Members of the genus *Pavona* are susceptible to predation by crown-of-thorns seastar (*Acanthaster planci*), but susceptibility is variable among species in the eastern Pacific (Glynn, 1976). No information is available on the specific susceptibility of *Pavona bipartita*.

Land-based sources of pollution (LBSP): No information is available on the specific susceptibility of *Pavona bipartita*. The genus *Pavona* is generally regarded as moderately tolerant to sediment stress (Blakeway, 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: More than 1000 pieces of *Pavona* spp. (including *Pavona cactus* and *Pavona decussata*, but with no mention of *Pavona bipartita*) per year are reportedly traded according to the CITES Trade Database, UNEP World Conservation Monitoring Centre (CITES 2010). Fiji appears to be the main exporter of *Pavona* spp (CITES, 2010).

Risk Assessment

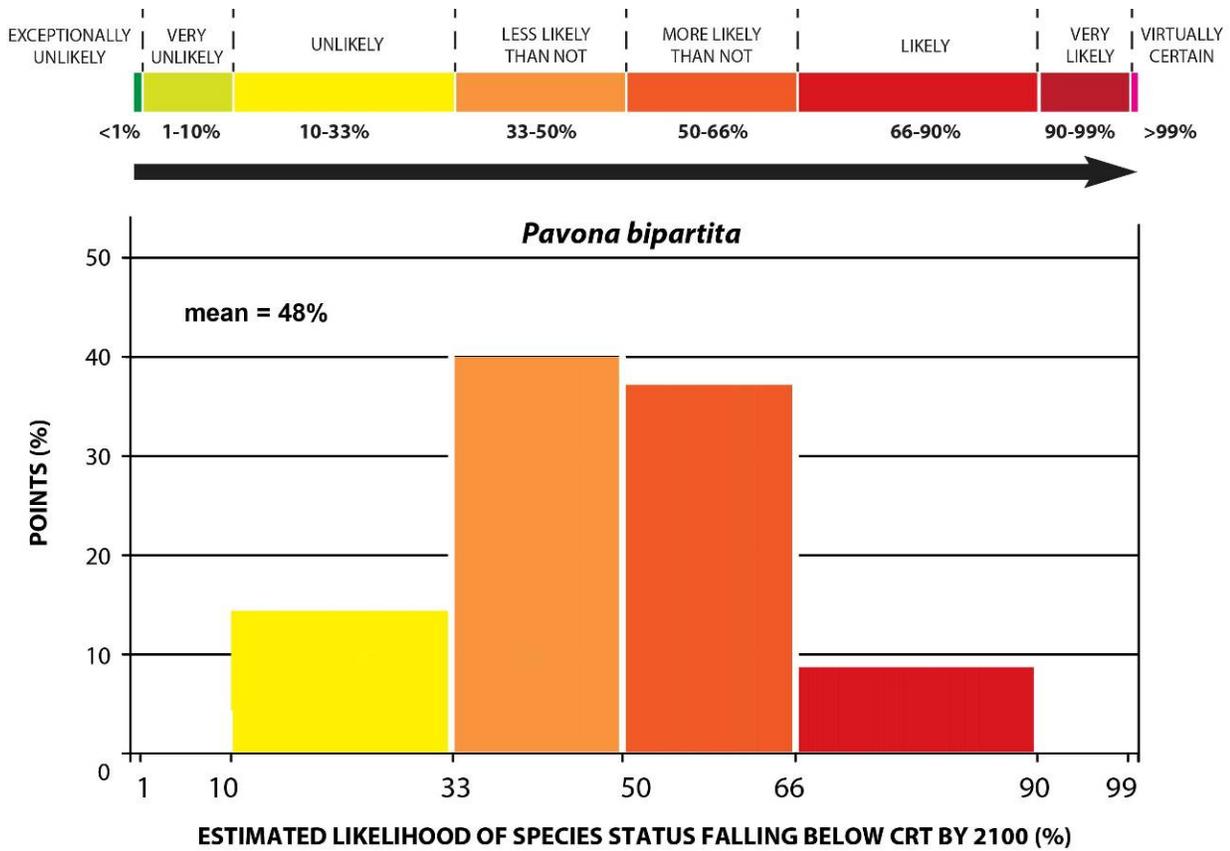


Figure 7.15.4. Distribution of points to estimate the likelihood that the status of *Pavona bipartita* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Pavona bipartita's moderate-to-low tolerance to thermal stress increases the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Pavona bipartita*. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) for *Pavona bipartita* are its broad distribution range, moderate tolerance of sediment stress, and low disease and predation susceptibility of the genus. Wide distribution is considered to lower 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 *Pavona bipartita* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "less likely than not" risk category with a mean likelihood of 48% and a standard error (SE) of 11% (Fig. 7.15.4). 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%–90% (Fig. 7.15.4) and the average range of likelihood estimates of the seven BRT voters (47%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Pavona bipartita*.

7.15.2 *Pavona cactus* Forskål, 1775



Figure 7.15.5. *Pavona cactus* photos and corallite plan from Veron (2000).

Characteristics

Pavona cactus colonies are composed of thin, contorted, bifacial, upright fronds with or without thickened branching bases. Corallites are fine, shallow and are aligned in irregular rows parallel to frond margins. Colonies are pale brown or greenish-brown in color, often with white margins (Veron, 2000).

Taxonomy

Taxonomic issues: None. *Pavona cactus* is similar to *Pavona frondifera* (Veron, 2000).

Family: Agariciidae

Evolutionary and geologic history: The family evolved in the Tethys Sea during the Cenozoic Age, with most genera disappearing from the Caribbean. *Pavona* disappeared from the Caribbean in the Eocene Era (Veron, 1995).

Global Distribution

Pavona cactus has a wide global distribution ranging in longitude from the Red Sea to the central Pacific, in latitude from Japan across the Great Barrier Reef and along the eastern and western coasts of Australia, and from the Red Sea to southern Africa (Veron, 2000). *Pavona cactus* does not have a restricted or highly fragmented range.

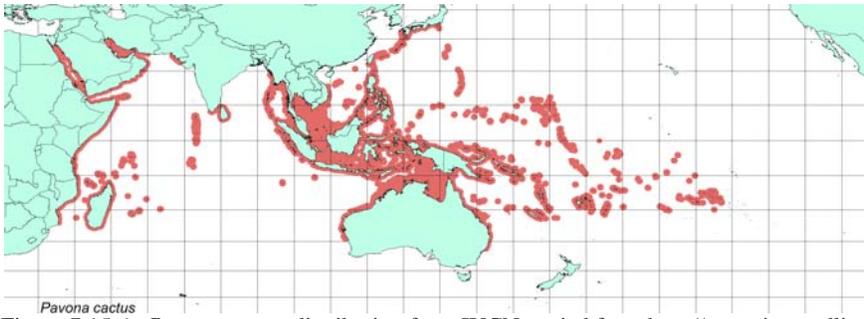


Figure 7.15.6. *Pavona cactus* distribution from IUCN copied from <http://www.iucnredlist.org>.

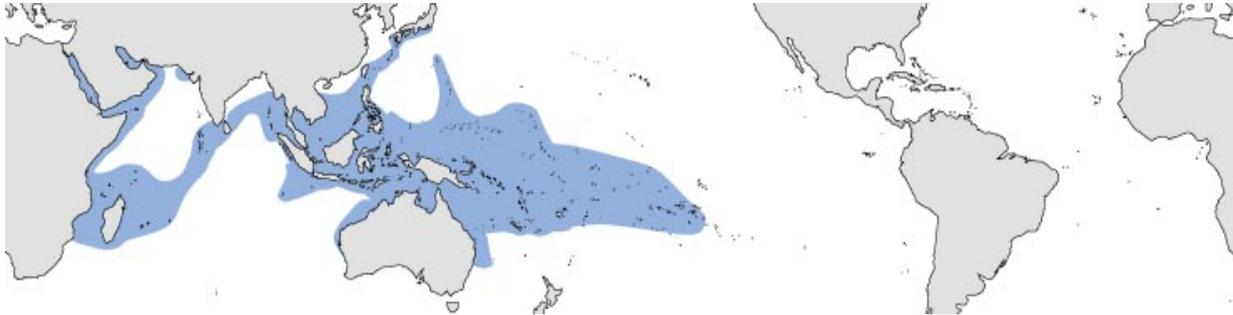


Figure 7.15.7. *Pavona cactus* distribution from Veron (2000).

U.S. Distribution

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

A search of published and unpublished records of occurrence in U.S. waters indicates *Pavona cactus* has been reported from Ofu-Olosega in American Samoa (Lovell and McLardy, 2008; National Park Service, 2009), Guam (Burdick, unpubl. data; Randall, 2003) and Palmyra Atoll (Williams et al., 2008b).

Within federally protected waters, *Pavona cactus* has been recorded from the following areas:

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

Habitat

Habitat: *Pavona cactus* is usually found in lagoons and on upper reef slopes, especially those of fringing reefs, and in turbid waters protected from wave action, where colonies are sometimes greater than 10 meters across (Veron, 2000).

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

Abundance

Abundance of *Pavona cactus* has been reported as common (Veron, 2000).

Life History

Pavona cactus is a gonochoric broadcast spawner (Glynn and Ault, 2000). The minimum size and estimated age at first reproduction have not been determined for *Pavona cactus*, but the minimum colony sizes (and ages) at first reproduction were 5 cm (5 years) and 3 cm (2 to 3 years), respectively, in eastern Pacific populations of the congeners *Pavona varians* and *Pavona* sp. (Glynn et al., 2000). Although specific larval descriptions have not been published for this species, the larvae of three other *Pavona* species studied 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 this family. Its leafy/branching form makes it relatively fragile, and some clones have quite high fragment survival (Willis and Ayre, 1985).

Threats

Temperature stress: *Pavona* has mixed bleaching susceptibility according to Marshall and Baird (2000), and both massive and encrusting *Pavona* have been highly susceptible to bleaching in the eastern Pacific (Glynn et al., 2001; Maté, 2003b).

Acidification: Marubini et al. (2003) found that *Pavona cactus* calcification slowed during the experimental reduction of the aragonite saturation state. This agrees with a recent study that compared growth rates of two massive species of *Pavona* in the eastern Pacific and found little change in growth over the past 30 years because of acidification and little evidence of change along a saturation state gradient (Manzello, 2010). However, no comparable studies have been published on encrusting, frondose or branching pavonids. The presence of multiple species of massive *Pavona* in low saturation state environments in the eastern Pacific (Manzello et al., 2008) and the lack of growth change in lower pH environments suggests a degree of tolerance to acidification, although direct experimental studies have not confirmed this. Work in other corals has shown the potential for impacts other than extension as acidification impairs fertilization and settlement success in *Acropora palmata* (Albright et al., 2010) and likely will 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: Medium number of genus level disease reports of acute white disease in the Pacific (B. Vargas-Ángel, CRED, Honolulu, HI, pers. comm., September 2010). However, ample evidence indicated that diseases can have devastating regional impacts on individual coral species (e.g., Aronson and Precht, 2001; Bruckner and Hill, 2009) and some evidence show that these impacts are occurring on a trend of increasing taxonomic and geographic scale (Green and Bruckner, 2000; Sutherland et al., 2004). Overall, a few disease reports for the family Agariciidae were found on the global disease database (UNEP, 2010).

Predation: Members of the genus *Pavona* are susceptible to predation by crown-of-thorns seastar (*Acanthaster planci*), but susceptibility is variable among species in the eastern Pacific (Glynn, 1976). No information is available on the specific susceptibility of *Pavona cactus*.

Land-based sources of pollution (LBSP): No information is available on the specific susceptibility of *Pavona cactus*. The genus *Pavona* is generally regarded as moderately tolerant to sediment stress (Blakeway, 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: More than 1000 pieces of *Pavona* spp. (including *Pavona cactus* and *Pavona decussata*) per year are reportedly traded according to the CITES Trade Database, UNEP World Conservation Monitoring Centre (CITES, 2010). Fiji appears to be the main exporter of *Pavona* spp. (CITES, 2010).

Risk Assessment

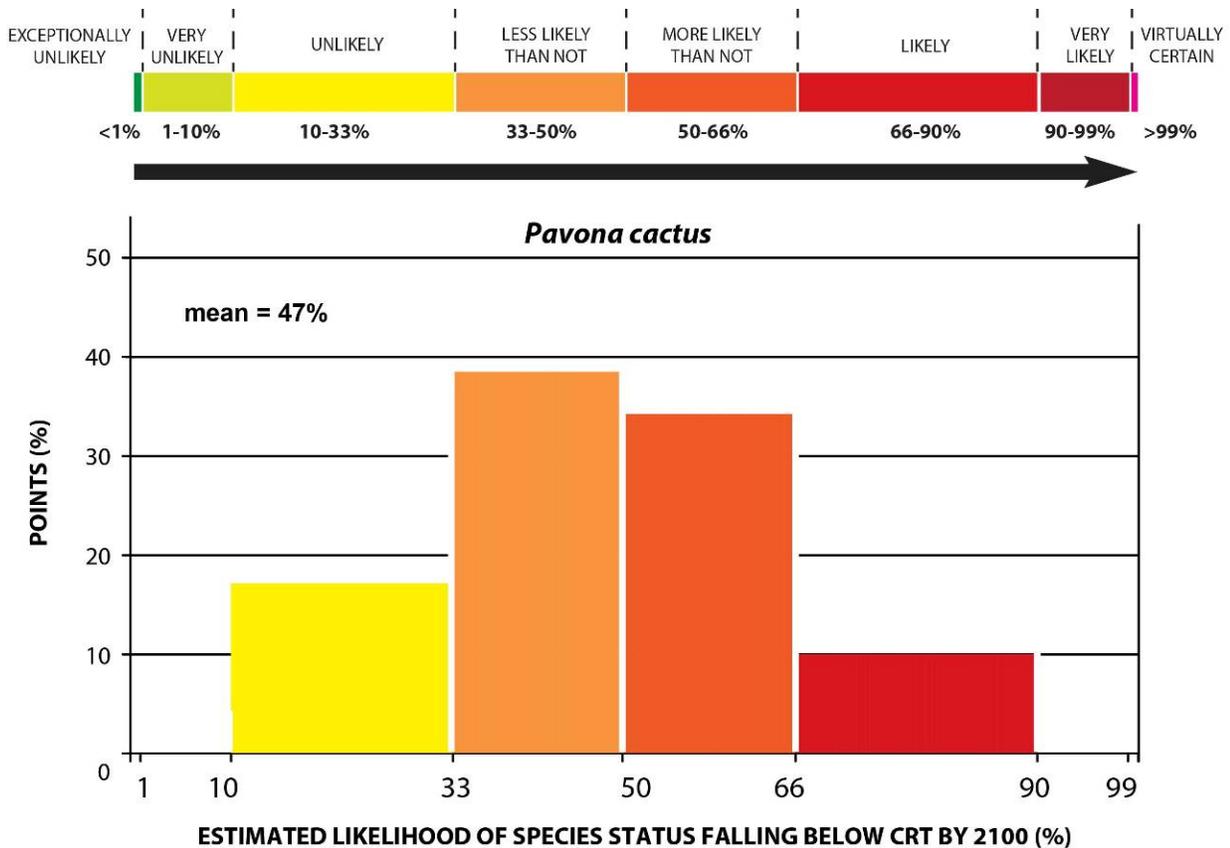


Figure 7.15.8. Distribution of points to estimate the likelihood that the status of *Pavona cactus* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Pavona cactus' moderate-to-low tolerance to thermal stress increases the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Pavona cactus*. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) for *Pavona cactus* are its broad distribution range, use of fragmentation as an important part of its life history, the moderate tolerance of sediment stress, and low susceptibility to disease and predation of the genus. Wide distribution is considered to lower 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 *Pavona cactus* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "less likely than not" risk category with a mean likelihood of 47% and a standard error (SE) of 11% (Fig. 7.15.8). 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%–90% (Fig. 7.15.8) and the average range of likelihood estimates of the seven BRT voters (47%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Pavona cactus*.

7.15.3 *Pavona decussata* Dana, 1846

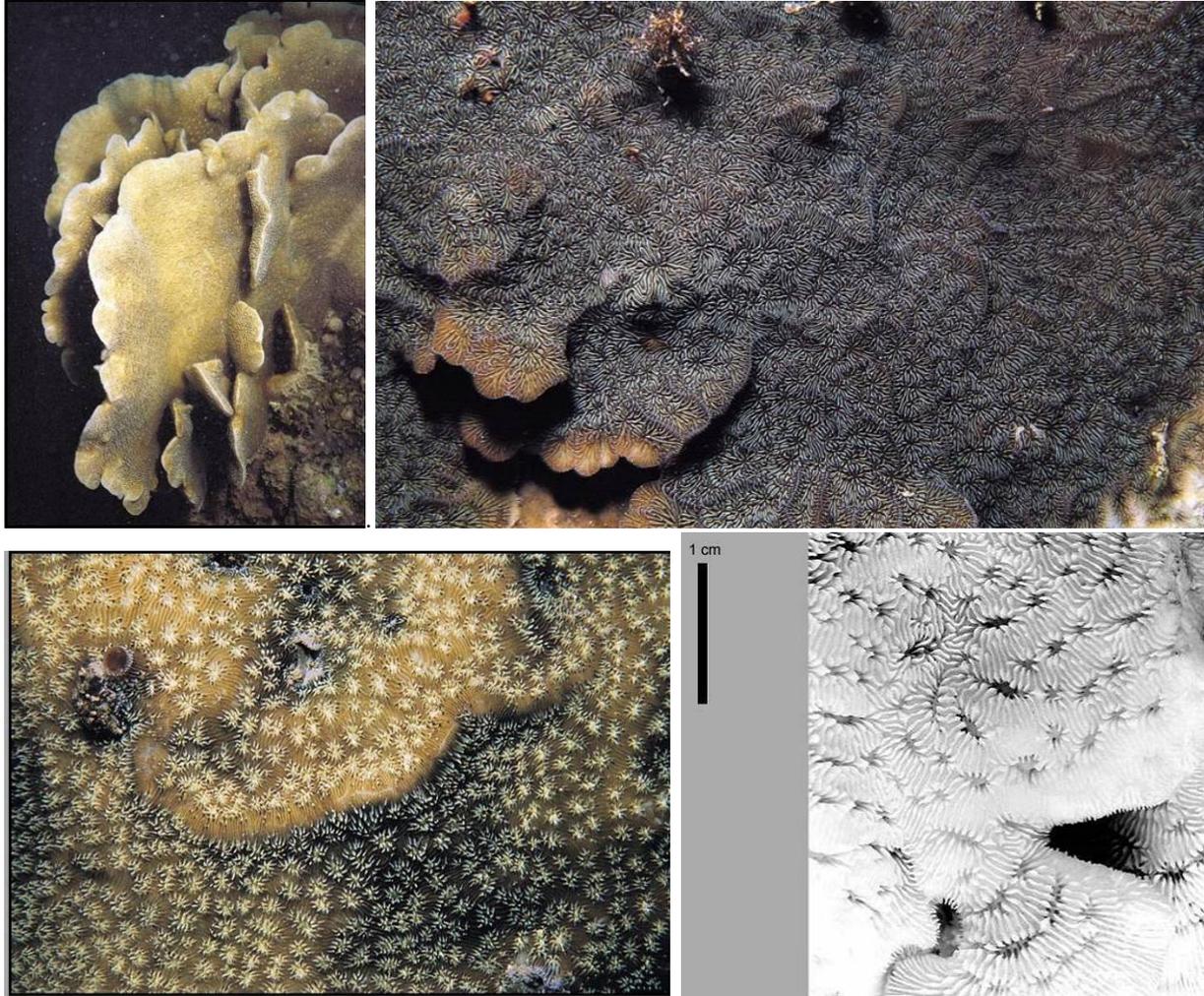


Figure 7.15.9. *Pavona decussata* photos and corallite plan from Veron (2000).

Characteristics

Colonies of *Pavona decussata* are thick interconnecting bifacial upright plates or are submassive, with or without lobed horizontal margins and upright plates. Corallites are irregular, deep seated, and are sometimes aligned parallel to margins or to radiating ridges. Colonies are brown, creamy-yellow or greenish in color (Veron, 2000).

Taxonomy

Taxonomic issues: No significant taxonomic issues. Stunted colonies superficially resemble *Pavona danai* and *Pavona frondifera* (Veron, 2000).

Family: Agariciidae.

Evolutionary and geologic history: The family evolved in the Tethys Sea during the Cenozoic Age, with most genera disappearing from the Caribbean. *Pavona* disappeared from the Caribbean in the Eocene Era (Veron, 1995).

Global Distribution

Pavona decussata has a wide global distribution ranging longitudinally from the Red Sea in the west to the French Polynesia in the east and latitudinally from Japan in the northern hemisphere to halfway up the eastern and western coasts of Australia and around Madagascar in the southern hemisphere (Veron, 2000).

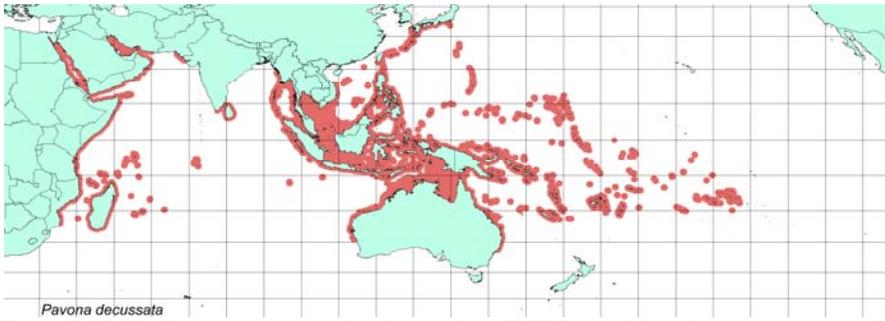


Figure 7.15.10. *Pavona decussata* distribution from IUCN copied from <http://www.iucnredlist.org>.

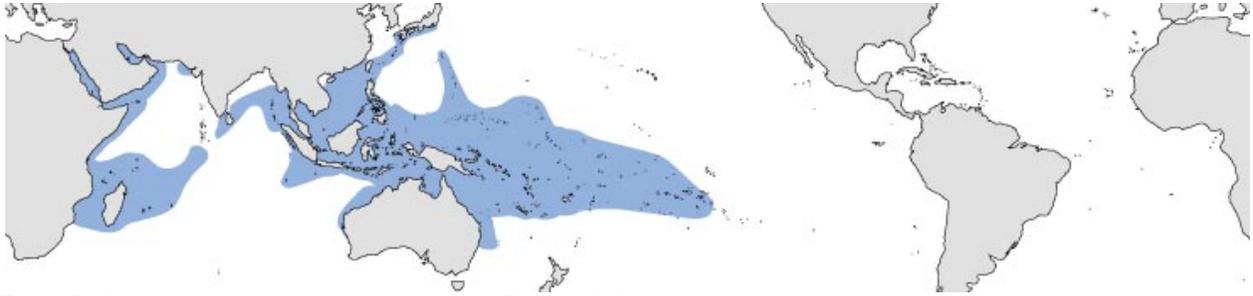


Figure 7.15.11. *Pavona decussata* distribution from Veron (2000).

U.S. Distribution

According to both the IUCN Species Account and the CITES species database, *Pavona decussata* 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 *Pavona decussata* has been reported from Tutuila and Ofu-Olosega in American Samoa (Birkeland, unpubl. data; Coles et al., 2003; Hoffmeister, 1925; Lamberts, 1983; Lovell and McLardy, 2008; Maragos et al., 1994; Mundy, 1996; National Park Service, 2009) and Guam (Amesbury et al., 1999; Burdick, unpubl. data; Randall, 2003). No substantiated published or unpublished record of its occurrence in the U.S. minor outlying islands could be identified.

Within federally protected waters, *Pavona decussata* has been recorded from the following areas:

- National Park of American Samoa, Ofu Island unit
- War in the Pacific National Historical Park, Guam

Habitat

Habitat: *Pavona decussata* can be found in most reef habitats (Veron, 2000).

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

Abundance

Abundance of *Pavona decussata* has been reported as common (Veron, 2000).

Life History

The reproductive characteristics of *Pavona decussata* have not been determined (Baird et al., 2009). However, six congeners (*Pavona cactus*, *Pavona chiriquiensis*, *Pavona clavus*, *Pavona duerdeni*, *Pavona gigantea*, and *Pavona varians*) are known to be gonochoric spawners (Baird et al., 2009); eastern Pacific populations of *Pavona varians* and the sibling agariciid species *Pavona* sp. are also known to be hermaphrodites (Glynn et al., 2000). The minimum size and estimated age at first reproduction have not been determined for *Pavona decussata*, but the minimum colony sizes (and ages) at first reproduction were 5 cm (5 years) and 3 cm (2 to 3 years), respectively, in eastern Pacific populations of the congeners *Pavona varians* and *Pavona* sp. (Baird et al., 2009). Although specific larval descriptions have not been published for this species, the larvae of three other *Pavona* species studied 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 this family.

Threats

Temperature stress: *Pavona* is susceptible to mixed bleaching according to Marshall and Baird (2000) and both massive and encrusting *Pavona* have been highly susceptible to bleaching in the eastern Pacific (Glynn et al., 2001; Maté, 2003b). Yamano et al. (2011) found that *Pavona decussata* has expanded its range northward in Japan as temperatures have warmed. This may provide a northern refugium for the species.

Acidification: No studies have examined the direct impacts of ocean acidification on *Pavona decussata*. Marubini (Marubini et al., 2003) found that *Pavona cactus* calcification slowed during the experimental reduction of the aragonite saturation state. In contrast, a recent study compared growth rates of two massive species of *Pavona* in the eastern Pacific and found little change in growth over the past 30 years because of acidification and little evidence of change along a saturation state gradient (Manzello, 2010). However, no comparable studies have been published on encrusting, frondose or branching pavonids. The presence of multiple species of massive *Pavona* in low saturation state environments in the eastern Pacific (Manzello et al., 2008) and the lack of growth change in lower pH environments suggests a degree of tolerance to acidification, although direct experimental studies have not confirmed this and it may suggest that the threshold for response may be lower than levels seen in the eastern Pacific. Work in other corals has shown the potential for impacts other than extension as acidification impairs fertilization and settlement success in *Acropora palmata* (Albright et al., 2010) and likely will 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: Medium number of genus level disease reports of acute white disease in the Pacific (B. Vargas-Ángel, CRED, Honolulu, HI, pers. comm., September 2010). 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 some evidence show that these impacts are occurring on a trend of increasing taxonomic and geographic scale (Green and Bruckner, 2000; Sutherland et al., 2004). Overall, a few disease reports for the family Agariciidae were found on the global disease database (UNEP, 2010).

Predation: Members of the genus *Pavona* are susceptible to predation by crown-of-thorns seastar (*Acanthaster planci*), but susceptibility is variable among species in the eastern Pacific (Glynn, 1976). No information is available on the specific susceptibility of *Pavona decussata*.

Land-based sources of pollution (LBSP): No information is available on the specific susceptibility of *Pavona decussata*. The genus *Pavona* is generally regarded as moderately tolerant to sediment stress (Blakeway, 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: More than 1000 pieces of *Pavona* spp. (including *Pavona cactus* and *Pavona decussata*) per year are reportedly traded according to the CITES Trade Database, UNEP World Conservation Monitoring Centre (CITES, 2010). Fiji appears to be the main exporter of *Pavona* spp. (CITES, 2010).

Risk Assessment

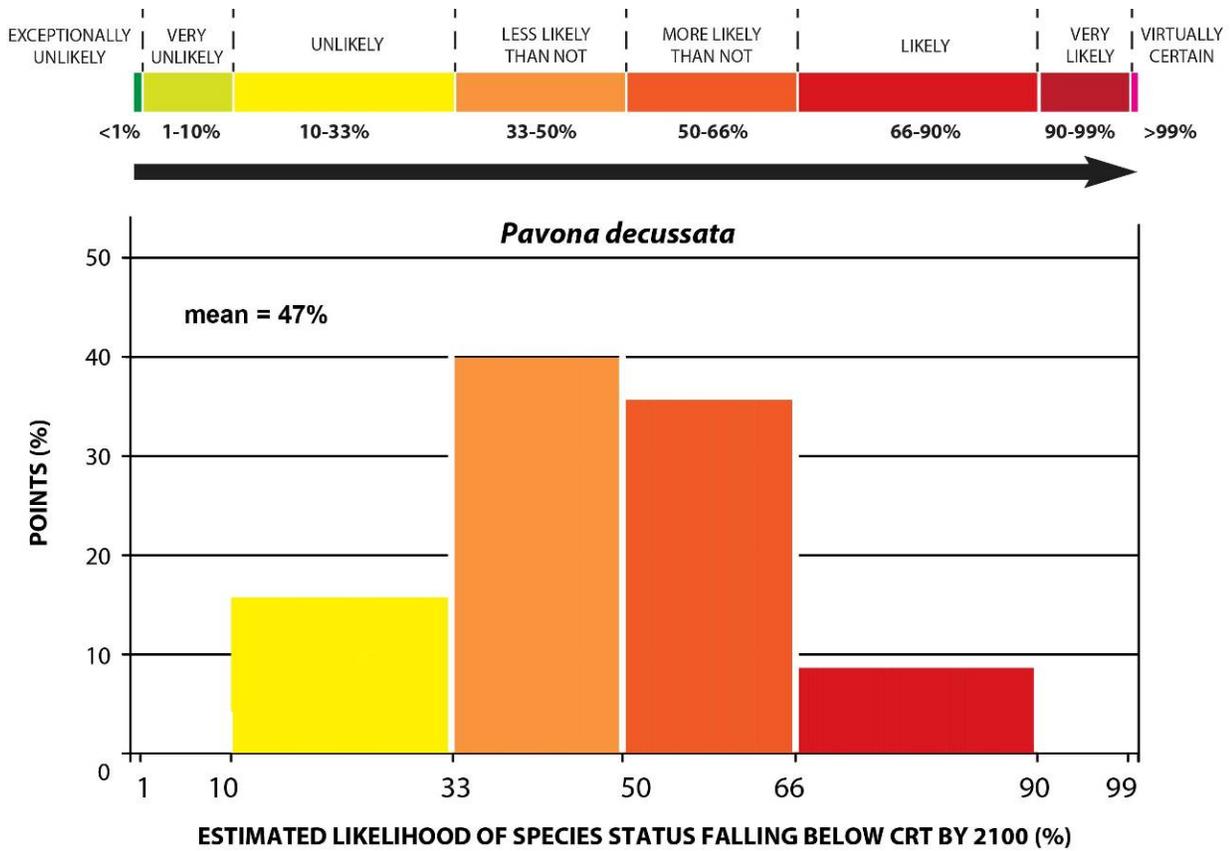


Figure 7.15.12. Distribution of points to estimate the likelihood that the status of *Pavona decussata* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Pavona decussata's moderate-to-low tolerance to thermal stress increases the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Pavona decussata*. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) for *Pavona decussata* are its broad distribution range, the moderate tolerance of sediment stress, and low susceptibility to disease and predation of the genus. Wide distribution is considered to lower 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 *Pavona decussata* will fall below the Critical Risk Threshold by 2100 was estimated to be in the "less likely than not" risk category with a mean likelihood of 47% and a standard error (SE) of 11% (Fig. 7.15.12). 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 10%–90% (Fig. 7.15.12) 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 *Pavona decussata*.

7.15.4 *Pavona diffluens* Lamarck, 1816

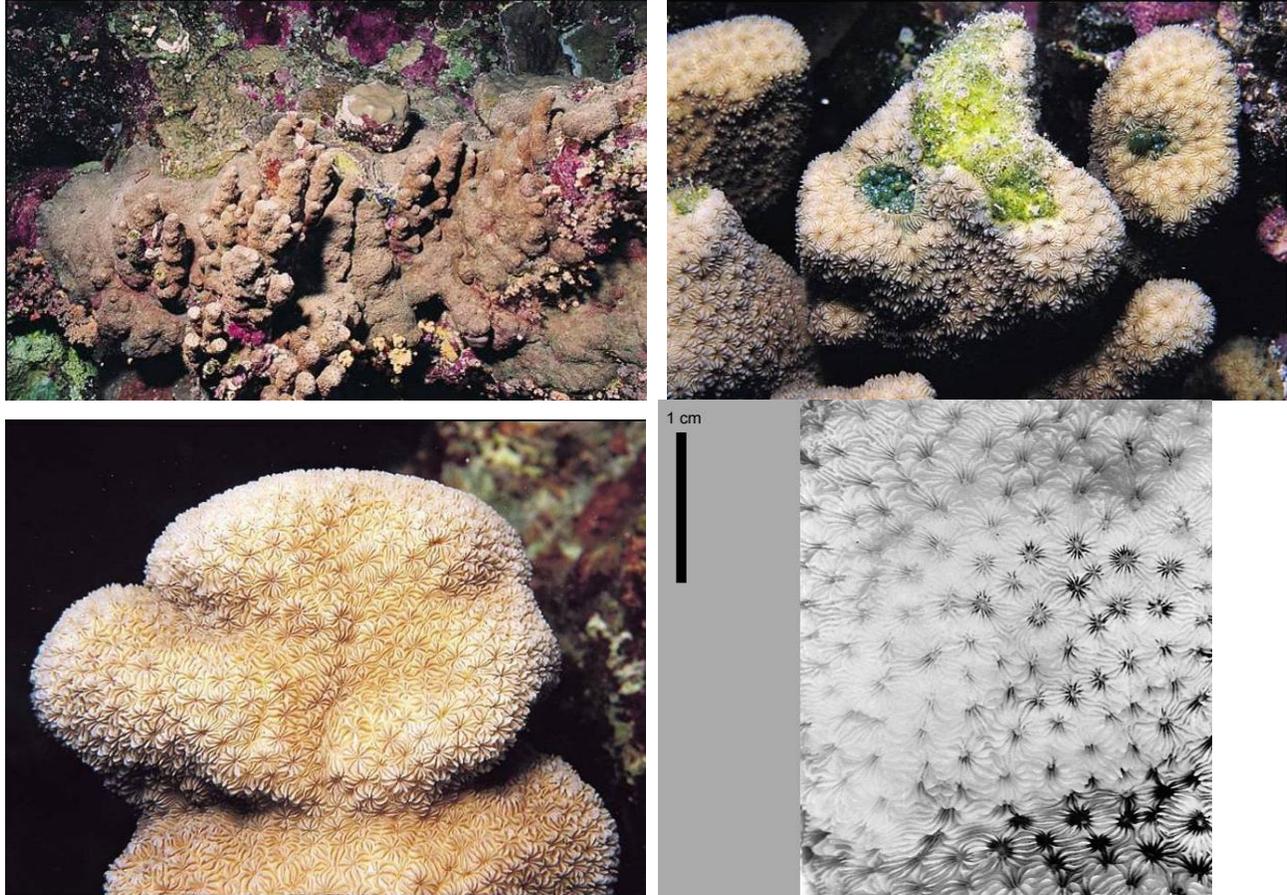


Figure 7.15.13. *Pavona diffluens* photos and corallite plan from Veron (2000).

Characteristics

Colonies of *Pavona diffluens* are submassive. Corallites are deep. Septo-costae strongly alternate with primary septa very exsert. Columellae are peg-like to absent. Colonies are tan colored (Veron, 2000).

Taxonomy

Taxonomic issues: None. *Pavona diffluens* is similar to *Pavona gigantea*, which forms massive colonies, and *Pavona explanulata*, which has a laminar growth-form and corallites with less exsert primary septa (Veron, 2000).

Family: Agariciidae.

Evolutionary and geologic history: The family evolved in the Tethys Sea during the Cenozoic Age, with most genera disappearing from the Caribbean. *Pavona* disappeared from the Caribbean in the Eocene Era (Veron, 1995).

Global Distribution

Pavona diffluens has a very narrow distribution, both latitudinal and longitudinal. It is only found in the region of the Red Sea and Arabian Gulf according to Veron (Veron, 2000) but Carpenter et al. (Carpenter et al., 2008) also record it in the Northern Marianas and American Samoa (but see below).

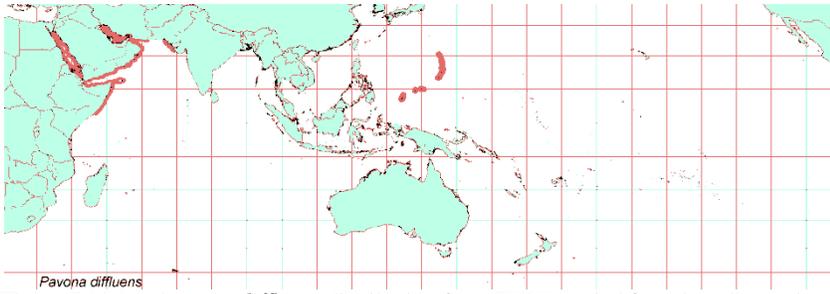


Figure 7.15.14. *Pavona diffluens* distribution from IUCN copied from <http://www.iucnredlist.org>.



Figure 7.15.15. *Pavona diffluens* distribution from from Veron (2000).

U.S. Distribution

According to the IUCN Species Account, *Pavona diffluens* has been recorded in the Northern Mariana Islands, but the records (Randall, 1995) are considered unlikely. The CITES species database lists this species in American Samoa.

A search of published and unpublished records of occurrence in U.S. waters indicates *Pavona diffluens* has been reported from Tutuila, Ofu-Olosega, and Ta'u in American Samoa (Birkeland, unpubl. data; CRED, unpubl. data; Lovell and McLardy, 2008; National Park Service, 2009) and Guam (Burdick, unpubl. data; Randall, 2003).

Within federally protected waters, *Pavona diffluens* has been recorded from the following areas:

- National Park of American Samoa, Tutuila Island unit

Habitat

Habitat: *Pavona diffluens* has been reported to be found in most reef habitats (Veron, 2000).

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

Abundance

Abundance of *Pavona diffluens* has been reported as uncommon (Veron, 2000).

Life History

The reproductive characteristics of *Pavona diffluens* have not been determined (Baird et al., 2009). However, six congeners (*Pavona cactus*, *Pavona chiriquiensis*, *Pavona clavus*, *Pavona duerdeni*, *Pavona gigantea*, and *Pavona varians*) are known to be gonochoric spawners (Baird et al., 2009); eastern Pacific populations of *Pavona varians* and the sibling agariciid species *Pavona* sp. are also known to be hermaphrodites (Glynn et al., 2000). The minimum size and estimated age at first reproduction have not been determined for *Pavona diffluens*, but the minimum colony sizes (and ages) at first reproduction were 5 cm (5 years) and 3 cm (2 to 3 years), respectively, in eastern Pacific populations of the congeners *Pavona varians* and *Pavona* sp. a (ibid). Although specific larval descriptions have not been published for this species, the larvae of all three other *Pavona* species studied 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 this family.

Threats

Temperature stress: *Pavona* is susceptible to mixed bleaching according to Marshall and Baird (2000), and both massive and encrusting *Pavona* have been highly susceptible to bleaching in the eastern Pacific (Glynn et al., 2001; Maté, 2003b).

Acidification: No studies have examined the direct impacts of ocean acidification on *Pavona diffluens*. Marubini (Marubini et al., 2003) found that *Pavona cactus* calcification slowed during the experimental reduction of the aragonite saturation state. In contrast, a recent study compared the growth rates of two massive species of *Pavona* in the eastern Pacific and found little change in growth over the past 30 years because of acidification and little evidence of change along a saturation state gradient (Manzello, 2010). However, no comparable studies have been published on encrusting, frondose or branching pavonids. The presence of multiple species of massive *Pavona* in low saturation state environments in the eastern Pacific (Manzello et al., 2008) and the lack of growth change in lower pH environments suggests a degree of tolerance to acidification, although direct experimental studies have not confirmed this, and it may suggest that the threshold for response may be lower than levels seen in the eastern Pacific. Work in other corals has shown the potential for impacts other than extension as acidification impairs fertilization and settlement success in *Acropora palmata* (Albright et al., 2010) and likely will 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: Medium number of genus level disease reports of acute white disease in the Pacific (B. Vargas-Ángel, CRED, Honolulu, HI, pers. comm., September 2010). 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 some evidence show that these impacts are occurring on a trend of increasing taxonomic and geographic scale (Green and Bruckner, 2000; Sutherland et al., 2004). Overall, few disease reports for the family Agariciidae were found on the global disease database (UNEP, 2010).

Predation: Members of the genus *Pavona* are susceptible to predation by crown-of-thorns seastar (*Acanthaster planci*), but susceptibility is variable among species in the eastern Pacific (Glynn, 1976). No information is available on the specific susceptibility of *Pavona diffluens*.

Land-based sources of pollution (LBSP): No information is available on the specific susceptibility of *Pavona diffluens*. The genus *Pavona* is generally regarded as moderately tolerant to sediment stress (Blakeway, 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: More than 1000 pieces of *Pavona* spp. (including *Pavona cactus* and *Pavona decussata*, but with no mention of *Pavona diffluens*) per year are reportedly traded according to the CITES Trade Database, UNEP World Conservation Monitoring Centre (CITES, 2010). Fiji appears to be the main exporter of *Pavona* spp. (CITES, 2010).

Risk Assessment

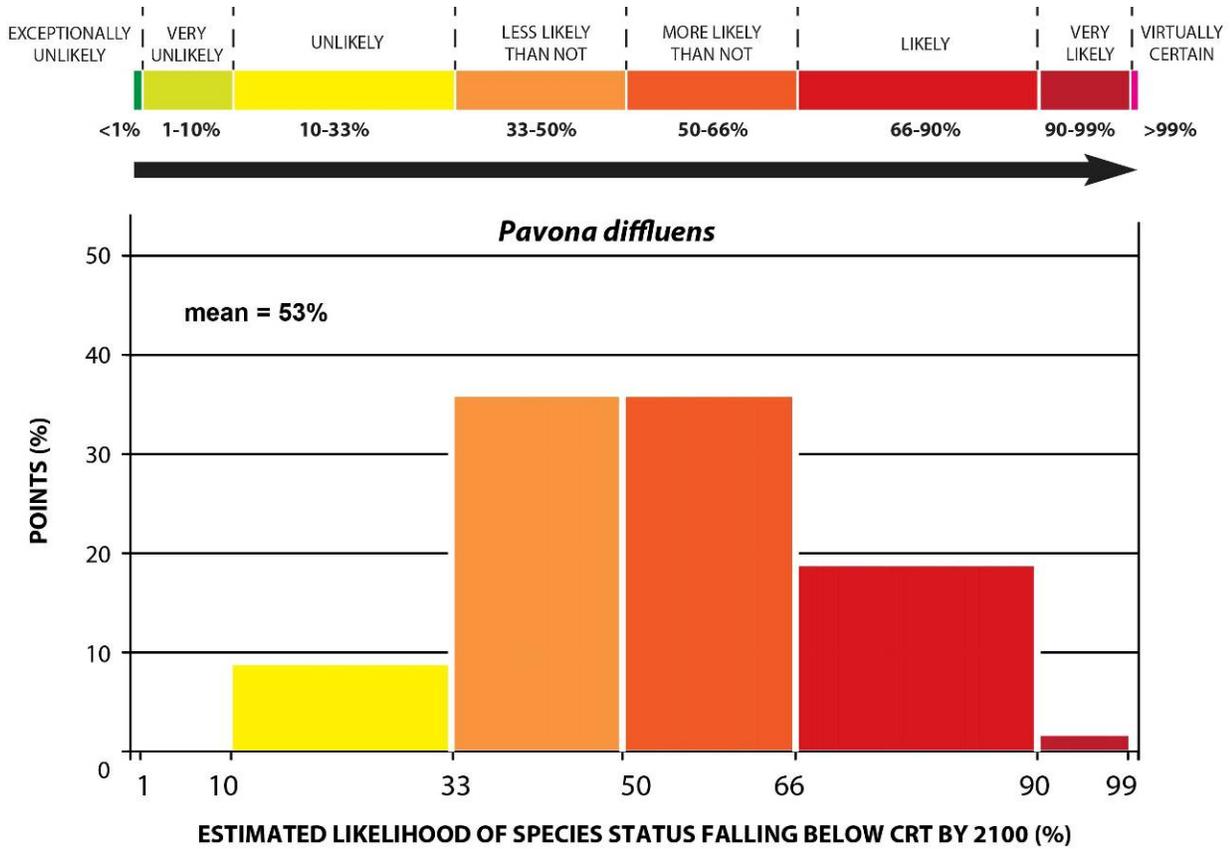


Figure 7.15.16. Distribution of points to estimate the likelihood that the status of *Pavona diffluens* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

Pavona diffluens' fairly moderate-to-low tolerance to thermal stress and the species' narrow distribution range increase the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Pavona diffluens*. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) for *Pavona diffluens* are its moderate tolerance of sediment stress, low susceptibility of the genus to disease and predation, and its restricted and split distribution range.

The overall likelihood that *Pavona diffluens* 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 53% and a standard error (SE) of 12% (Fig. 7.15.16). 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 narrow distribution range was the reason *Pavona diffluens* had a slightly higher mean likelihood compared to the other *Pavona* spp. The uncertainty of the BRT is reflected in the range of votes of 10%–99% (Fig. 7.15.16) and the average range of likelihood estimates of the seven BRT voters (61%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Pavona diffluens*.

7.15.5 *Pavona venosa* (Ehrenberg, 1834)

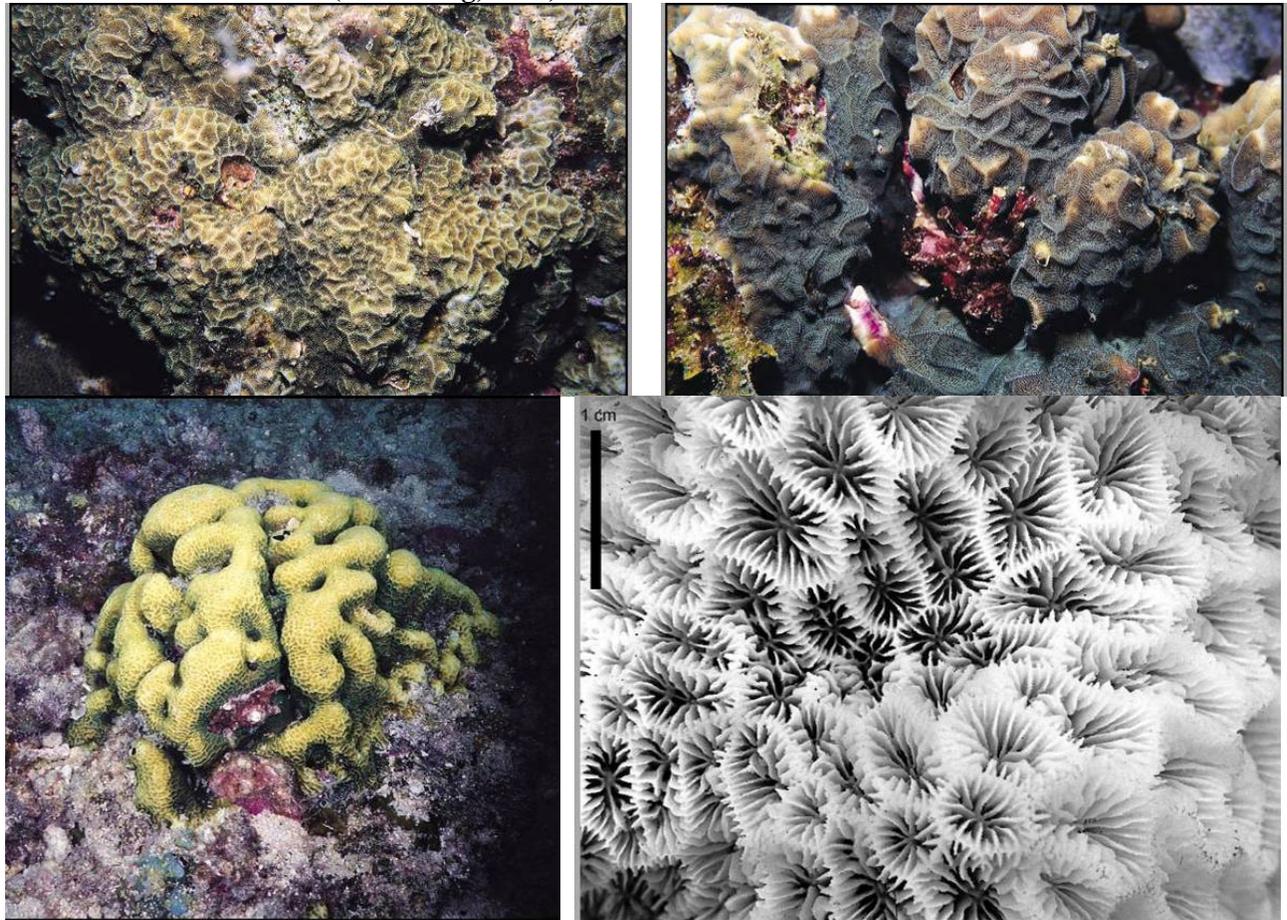


Figure 7.15.17. *Pavona venosa* photos and corallite plan from Veron (2000).

Characteristics

Colonies of *Pavona venosa* are massive to encrusting. Corallites are in short valleys with acute walls. Septo-costae are generally in three orders and are widely spaced. Columellae are poorly developed or absent. Colonies are yellow-brown or pinkish-brown in color, sometimes mottled (Veron, 2000).

Taxonomy

Taxonomic issues: None. *Pavona venosa* is similar to *Pavona varians*, which has less well-developed ridges (collines) and usually two orders of septa (Veron, 2000).

Family: Agariciidae.

Evolutionary and geologic history: The family evolved in the Tethys Sea during the Cenozoic Age, with most genera disappearing from the Caribbean. *Pavona* disappeared from the Caribbean in the Eocene Era (Veron, 1995).

Global Distribution

Pavona venosa has a wide distribution, ranging longitudinally from the Red Sea in the west to possibly the Cook Islands in the east and latitudinally from the Ryukyu Islands (Japan) on the northern hemisphere to South Africa and half way down the eastern and western coasts of Australia in the southern hemisphere.

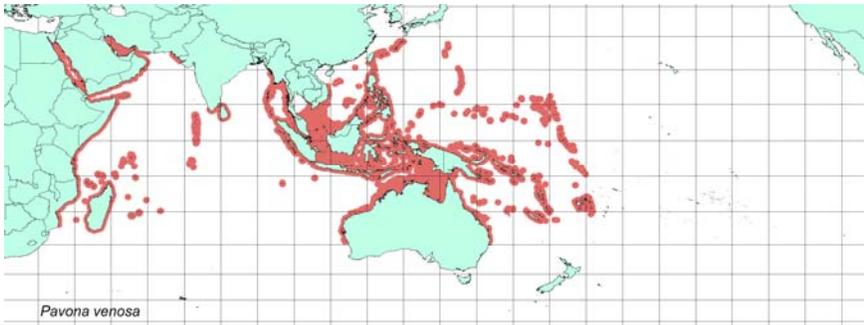


Figure 7.15.18. *Pavona venosa* distribution from IUCN copied from <http://www.iucnredlist.org>.



Figure 7.15.19. *Pavona venosa* distribution from Veron (2000).

U.S. Distribution

According to both the IUCN Species Account and the CITES species database, *Pavona venosa* has been recorded in the Northern Mariana Islands. The CITES species database also lists this species in American Samoa.

A search of published and unpublished records of occurrence in U.S. waters indicates *Pavona venosa* has been reported from Tutuila, Ofu-Olosega, Ta'u, and Rose Atoll in American Samoa (Birkeland, unpubl. data; Coles et al., 2003; Fisk and Birkeland, 2002; Kenyon et al., 2010a; Lovell and McLardy, 2008; National Park Service, 2009), Guam (Amesbury et al., 1999; Burdick, unpubl. data; Randall, 2003), and Kingman Reef (CRED, unpubl. data).

Within federally protected waters, *Pavona venosa* has been recorded from the following areas:

- Pacific Remote Islands Marine National Monument (Kingman)
- National Park of American Samoa, Tutuila and Ofu Island units
- Fagatele Bay National Marine Sanctuary, Tutuila
- Rose Atoll Marine National Monument
- War in the Pacific National Historical Park, Guam

Habitat

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

Depth range: *Pavona venosa* has been reported in water depths ranging from 2 m to 20 m (Carpenter et al., 2008).

Abundance

Abundance of *Pavona venosa* has been reported to be usually uncommon but distinctive (Veron, 2000).

Life History

The reproductive characteristics of *Pavona venosa* have not been determined (Baird et al., 2009). However, six congeners (*Pavona cactus*, *Pavona chiriquiensis*, *Pavona clavus*, *Pavona duerdeni*, *Pavona gigantea*, and *Pavona varians*) are known to be gonochoric spawners (Baird et al., 2009); eastern Pacific populations of *Pavona varians* and the sibling agariciid species *Pavona* sp. are also known to be hermaphrodites (Glynn et al., 2000). The minimum size and estimated age at first reproduction have not been determined for *Pavona venosa*, but the minimum colony sizes (and ages) at first reproduction were 5 cm (5 years) and 3 cm (2 to 3 years), respectively, in eastern Pacific populations of the congeners *Pavona varians* and *Pavona* sp. (Baird et al., 2009). Although specific larval descriptions have not been published for this species, the larvae of three other *Pavona* species studied 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 this family.

Threats

Temperature stress: *Pavona* is susceptible to mixed bleaching according to Marshall and Baird (2000), and both massive and encrusting *Pavona* has been highly susceptible to bleaching in the eastern Pacific (Glynn et al., 2001; Maté, 2003b).

Acidification: No studies have examined the direct impacts of ocean acidification on *Pavona venosa*. Marubini (Marubini et al., 2003) found that *Pavona cactus* calcification slowed during the experimental reduction of the aragonite saturation state. In contrast, a recent study compared the growth rates of two massive species of *Pavona* in the eastern Pacific and found little change in growth over the past 30 years because of acidification and little evidence of change along a saturation state gradient (Manzello, 2010). However, no comparable studies have been published on encrusting, frondose or branching pavonids. The presence of multiple species of massive *Pavona* in low saturation state environments in the eastern Pacific (Manzello et al., 2008) and the lack of growth change in lower pH environments suggests a degree of tolerance to acidification, although direct experimental studies have not confirmed this, and it may suggest that the threshold for response may be lower than levels seen in the eastern Pacific. Work in other corals has shown the potential for impacts other than extension as acidification impairs fertilization and settlement success in *Acropora palmata* (Albright et al., 2010) and likely will 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: Medium number of genus level disease reports of acute white disease in the Pacific (B. Vargas-Ángel, CRED, Honolulu, HI, pers. comm., September 2010). 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 some evidence show that these impacts are occurring on a trend of increasing taxonomic and geographic scale (Green and Bruckner, 2000; Sutherland et al., 2004). Overall, few disease reports for the family Agariciidae were found on the global disease database (UNEP, 2010).

Predation: Members of the genus *Pavona* are susceptible to predation by crown-of-thorns seastar (*Acanthaster planci*), but susceptibility is variable among species in the eastern Pacific (Glynn, 1976). No information is available on the specific susceptibility of *Pavona venosa*.

Land-based sources of pollution (LBSP): No information is available on the specific susceptibility of *Pavona venosa*. The genus *Pavona* is generally regarded as moderately tolerant to sediment stress (Blakeway, 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: More than 1000 pieces of *Pavona* spp. (including *Pavona cactus* and *Pavona decussata*, but with no mention of *Pavona venosa*) per year are reportedly traded according to the CITES Trade Database, UNEP World Conservation Monitoring Centre (CITES, 2010). Fiji appears to be the main exporter of *Pavona* spp. (CITES, 2010).

Risk Assessment

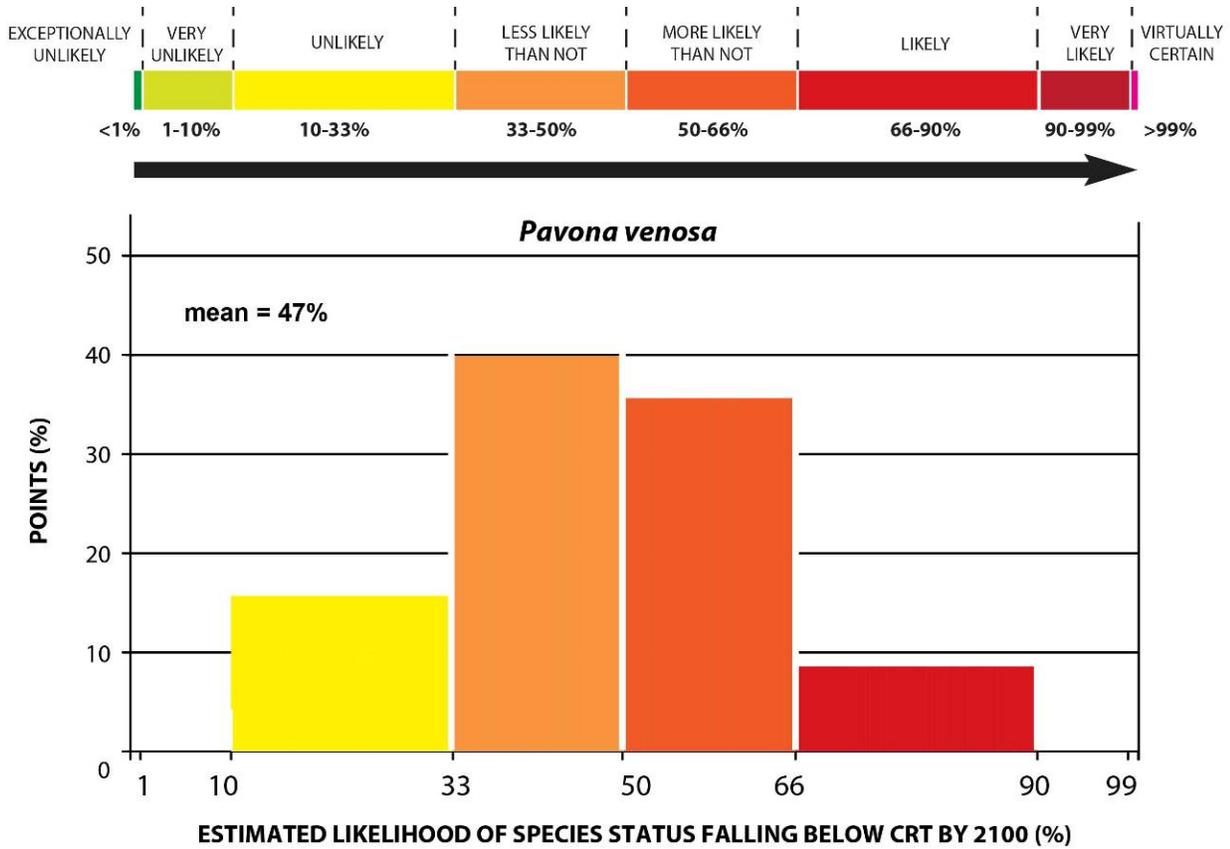


Figure 7.15.20. Distribution of points to estimate the likelihood that the status of *Pavona venosa* falls below the Critical Risk Threshold (the species is of such low abundance, or so spatially fragmented, or at such reduced diversity that extinction is extremely likely) by 2100.

The moderate-to-low tolerance to thermal stress increases the potential extinction risk (higher likelihood of falling below the Critical Risk Threshold) for *Pavona venosa*. Factors that reduce potential extinction risk (decrease the likelihood of falling below the Critical Risk Threshold) of *Pavona venosa* are its broad distribution, the moderate tolerance of sediment stress, and low susceptibility of the genus to disease and predation. Wide distribution is considered to lower 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 *Pavona venosa* will fall below the Critical Risk Threshold by 2100 was estimated to be in the “less likely than not” risk category with a mean likelihood of 47% and a standard error (SE) of 12% (Fig. 7.15.20). 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%–90% (Fig. 7.15.20) and the average range of likelihood estimates of the seven BRT voters (48%). The overall wide range of votes reflects the uncertainty among BRT members inherent in the lack of adequate ecological and demographic information for *Pavona venosa*.