DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Parts 223 and 224

[Docket No. 170117082–7082–01]

RIN 0648–XF174

Endangered and Threatened Wildlife; 90-Day Finding on a Petition To List 10 Species of Giant Clams as Threatened or Endangered Under the Endangered Species Act

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: 90-day petition findings, request for information, and initiation of status review.

SUMMARY: We, NMFS, announce our 90-day findings on a petition to list ten species of giant clam as endangered or threatened under the U.S. Endangered Species Act (ESA). We find that the petition presents substantial scientific or commercial information indicating that the petitioned action may be warranted for seven species (*Hippopus hippopus, H. porcellanus, Tridacna costata, T. derasa, T. gigas, T. squamosa, and T. tevoroa*). Accordingly, we will initiate status reviews of these seven giant clam species. To ensure that the status reviews are comprehensive, we are soliciting scientific and commercial information regarding these species. We find that the petition did not present substantial scientific or commercial information indicating that the petitioned action may be warranted for the other three petitioned giant clam species (*T. crocea, T. maxima,* or *T. noae*).

DATES: Information and comments on the subject action must be received by August 25, 2017.

ADDRESSES: You may submit comments, information, or data, by including ''NOAA–NMFS–2017–0029'' by either of the following methods:

- *Federal eRulemaking Portal:* Go to *www.regulations.gov/#!docketDetail;D=NOAA-NMFS-2017-0029,* click the ''Comment Now'' icon, complete the required fields, and enter or attach your comments.
- *Mail or hand-delivery:* Office of Protected Resources, NMFS, 1315 East-West Highway, Silver Spring, MD 20910. Attn: Lisa Manning.

Instructions: NMFS may not consider comments if they are sent by any other method, to any other address or individual, or received after the comment period ends. All comments received are a part of the public record and NMFS will post for public viewing on *http://www.regulations.gov* without change. All personal identifying information (*e.g.,* name, address, etc.), confidential business information, or otherwise sensitive information submitted voluntarily by the sender will be publicly accessible. NMFS will accept anonymous comments (enter ''N/A'' in the required fields if you wish to remain anonymous).

FOR FURTHER INFORMATION CONTACT: Lisa Manning, NMFS, Office of Protected Resources (301) 427–8403.

SUPPLEMENTARY INFORMATION:

Background

On August 7, 2016, we received a petition from a private citizen, Dr. Dwayne W. Meadows, Ph.D., requesting that we list the Tridacninae giant clams (excluding *Tridacna rosewateri*) as endangered or threatened under the ESA. The ten species of giant clams considered in this finding are the eight *Tridacna* species, including: *T. costata, T. crocea, T. derasa, T. gigas, T. maxima, T. noae, T. squamosa,* and *T. tevoroa* (also known as *T. mbalavauna*); and the two *Hippopus* species: *H. hippopus* and *H. porcellanus.* The petitioner also requested that critical habitat be designated for Tridacninae species that occur in U.S. waters concurrent with final ESA listing. The petition states that Tridacninae giant clams merit listing as endangered or threatened species under the ESA because of the following: (1) Loss or curtailment of habitat or range; (2) historical and continued overutilization of the species for commercial purposes; (3) inadequacy of existing regulatory mechanisms to safeguard the species; (4) other factors such as global climate change; and (5) the species' inherent vulnerability to population decline due to their slow recovery and low resilience to threats.

ESA Statutory Provisions and Policy Considerations

Section 4(b)(3)(A) of the ESA of 1973, as amended (16 U.S.C. 1531 *et seq.*), requires, to the maximum extent practicable, that within 90 days of receipt of a petition to list a species as threatened or endangered, the Secretary of Commerce make a finding on whether that petition presents substantial scientific or commercial information indicating that the petitioned action may be warranted, and promptly publish the finding in the **Federal Register** (16 U.S.C. 1533(b)(3)(A)). When we find that substantial scientific or commercial information in a petition and in our files indicates the petitioned action may be warranted (a ''positive 90-day finding''), we are required to promptly commence a review of the status of the species concerned, which includes conducting a comprehensive review of the best available scientific and commercial information. Within 12 months of receiving the petition, we must conclude the review with a finding as to whether, in fact, the petitioned action is warranted. Because the finding at the 12-month stage is based on a significantly more thorough review of the available information, a ''may be warranted'' finding at the 90-day stage does not prejudge the outcome of the status review and 12-month finding.

Under the ESA, a listing determination may address a ''species,'' which is defined to also include subspecies and, for any vertebrate species, any distinct population segment (DPS) that interbreeds when mature (16 U.S.C. 1532(16)). A joint NMFS-U.S. Fish and Wildlife Service (USFWS) policy clarifies the agencies' interpretation of the phrase ''distinct population segment'' for the purposes of listing, delisting, and reclassifying a species under the ESA (''DPS Policy''; 61 FR 4722; February 7, 1996). A species, subspecies, or DPS is ''endangered'' if it is in danger of extinction throughout all or a significant portion of its range, and ''threatened'' if it is likely to become endangered within the foreseeable future throughout all or a significant portion of its range (ESA sections 3(6) and 3(20), respectively; 16 U.S.C. 1532(6) and (20)). Pursuant to the ESA and our implementing regulations, the determination of whether a species is threatened or endangered shall be based on any one or a combination of the following five section 4(a)(1) factors: The present or threatened destruction, modification, or curtailment of habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; inadequacy of existing regulatory mechanisms; and any other natural or manmade factors affecting the species' existence (16 U.S.C. 1533(a)(1), 50 CFR 424.11(c)).

ESA-implementing regulations issued jointly by NMFS and USFWS (50 CFR 424.14(b)) define ''substantial information'' in the context of reviewing a petition to list, delist, or reclassify a species as the amount of information that would lead a reasonable person to believe that the measure proposed in the petition may be warranted. When evaluating whether substantial information is contained in a petition, we must consider whether the petition: (1) Clearly indicates the administrative measure recommended and gives the scientific and any common name of the species involved; (2) contains detailed narrative justification for the recommended measure, describing, based on available information, past and present numbers and distribution of the species involved and any threats faced by the species; (3) provides information regarding the status of the species over all or a significant portion of its range; and (4) is accompanied by the appropriate supporting documentation in the form of bibliographic references, reprints of pertinent publications, copies of reports or letters from authorities, and maps (50 CFR 424.14(b)(2)).

At the 90-day stage, we evaluate the petitioner's request based upon the information in the petition including its references, and the information readily available in our files. We do not conduct additional research, and we do not solicit information from parties outside the agency to help us in evaluating the petition. We will accept the petitioner's sources and characterizations of the information presented, if they appear to be based on accepted scientific principles, unless we have specific information in our files that indicates the petition's information is incorrect, unreliable, obsolete, or otherwise irrelevant to the requested action. Information that is susceptible to more than one interpretation or that is contradicted by other available information will not be dismissed at the 90-day finding stage, so long as it is reliable and a reasonable person would conclude that it supports the petitioner's assertions. Conclusive information indicating the species may meet the ESA's requirements for listing is not required to make a positive 90-day finding. We will not conclude that a lack of specific information alone negates a positive 90-day finding, if a reasonable person would conclude that the unknown information itself suggests an extinction risk of concern for the species at issue.

To make a 90-day finding on a petition to list a species, we evaluate whether the petition presents substantial scientific or commercial information indicating the subject species may be either threatened or endangered, as defined by the ESA. First, we evaluate whether the information presented in the petition, along with the information readily available in our files, indicates that the petitioned entity constitutes a ''species'' eligible for listing under the ESA. Next, we evaluate whether the information indicates that the species at issue faces extinction risk that is cause for concern; this may be indicated in information expressly discussing the species' status and trends, or in information describing impacts and threats to the species. We evaluate any information on specific demographic factors pertinent to evaluating extinction risk for the species at issue (*e.g.,* population abundance and trends, productivity, spatial structure, age structure, sex ratio, diversity, current and historical range, habitat integrity or fragmentation), and the potential contribution of identified demographic risks to extinction risk for the species. We then evaluate the potential links between these demographic risks and the causative impacts and threats identified in ESA section 4(a)(1).

Information presented on impacts or threats should be specific to the species and should reasonably suggest that one or more of these factors may be operative threats that act or have acted on the species to the point that it may warrant protection under the ESA. Broad statements about generalized threats to the species, or identification of factors that could negatively impact a species, do not constitute substantial information that listing may be warranted. We look for information indicating that not only is the particular species exposed to a factor, but that the species may be responding in a negative fashion; then we assess the potential significance of that negative response.

Many petitions identify risk classifications made by non-governmental organizations, such as the International Union for the Conservation of Nature (IUCN), the American Fisheries Society, or NatureServe, as evidence of extinction risk for a species. Risk classifications by other organizations or made under other Federal or state statutes may be informative, but such classification alone may not provide the rationale for a positive 90-day finding under the ESA. For example, as explained by NatureServe, their assessments of a species' conservation status do ''not constitute a recommendation by NatureServe for listing under the U.S. Endangered Species Act'' because NatureServe assessments ''have different criteria, evidence requirements, purposes and taxonomic coverage than government lists of endangered and threatened species, and therefore these two types of lists should not be expected to coincide'' (*http://www.natureserve.org/prodServices/statusAssessment.jsp*). Thus, when a petition cites such classifications, we will evaluate the source of information that the classification is based upon in light of the standards on extinction risk and impacts or threats discussed above.

Analysis of the Petition

General Information

The petition clearly indicates the administrative measure recommended and gives the scientific and, in some cases, the common names of the species involved. The petition also contains a narrative justification for the recommended measures and provides limited information on the species' geographic distribution, habitat use, and threats. Limited information is also provided on population status and trends for all but a couple of species. The introduction of the petition emphasizes that giant clam species have not been evaluated by the IUCN since 1996, and more recent information provides evidence of significant population declines of all giant clam species range-wide, with increasing threats. The petition then provides general background information on giant clams as well as some limited species-specific information where available. Topics covered by the petition include giant clam taxonomy, natural history, descriptions of *Tridacna* species (descriptions of *Hippopus* species are absent), geographic range, habitat descriptions, life history (including growth and reproduction), ecology (including their symbiotic relationship with zooxanthellae and their ecological role on coral reefs), population structure and genetics, and abundance and trends. A general description of threats categorized under the five ESA Section 4(a)(1) factors is provided and is meant to apply to all of the petitioned clam species. This section discusses the following threats: Coral reef habitat degradation (including sedimentation, pollution, and reclamation), subsistence and commercial harvest by coastal and island communities for local consumption as well as sale and export for the meat, aquarium and curio trades, inadequacy of existing regulatory mechanisms to safeguard the species, and impacts of climate change (including bleaching and ocean acidification). A synopsis of and our analysis of the information provided in the petition and readily available in our files is provided below.

Species Description

Giant clams are a small but conspicuous group of large bivalves that are members of the cardiid bivalve subfamily Tridacninae (Su *et al.,* 2014). They are the largest living marine bivalves found in coastal areas of the Indo-Pacific region, and are frequently regarded as important ecological components of coral reefs, especially as providers of substrate and contributors to overall productivity (Neo and Todd 2013). The most recent information suggests there are 13 extant species of giant clams, 10 of which are considered in this 90-day finding, including 8 species in the genus *Tridacna—T. crocea, T. derasa, T. gigas, T. maxima, T. noae, T. squamosa, T. costata* (formerly *T. squamosina*) and *T. tevoroa* (formerly *T. mbalavauna*), and 2 species in the genus *Hippopus—H. hippopus* and *H. porcellanus.*

Taxonomy

Giant clam taxonomy (family Cardiidae, subfamily Tridacninae) has seen a surge in new species descriptions in recent decades (Borsa *et al.,* 2015a), and there is some disagreement in the literature regarding the validity of some species. Two giant clam species considered in this 90-day finding have been only recently described (*T. tevoroa* and *T. costata*), but have been shown to be junior synonyms of species described decades before (*i.e., T. mbalavuana* and *T. squamosina,* respectively; Borsa *et al.,* 2015a). Another species, *T. noae,* has been the subject of debate in terms of its validity as a species. However, *T. noae* has been recently resurrected from synonymy with the small giant clam, *T. maxima,* after additional molecular and morphological evidence supported the taxonomic separation of the two species (Su *et al.,* 2014).

Range and Distribution

Modern giant clams are distributed along shallow shorelines and on reefs in the Indo-West Pacific in the area confined by 30° E and 120° W (*i.e.,* from South Africa to beyond French Polynesia) and between 36° N and 30° S (*i.e.,* from Japan in the North to Australia in the South; Neo *et al.,* 2015) and excluding New Zealand and Hawaii, although there are reports that at least two species have been introduced in Hawaii (*T. derasa* and *T. squamosa;* bin Othman *et al.,* 2010). Although most extant giant clams mainly occur within the tropical Indo-Pacific region, three species (*T. maxima, T. squamosa* and *T. costata*) are found as far west as East Africa or the Red Sea (Soo and Todd 2014). Of all the giant clam species, *T. maxima* has the most cosmopolitan distribution, which encompasses nearly the entire geographical range of all the other giant clam species. On the other side of the spectrum, the more recently described *T. costata, T. tevoroa,* and *H. porcellanus* have the most restricted geographical ranges (bin Othman *et al.,* 2010).

Anecdotal reports by SCUBA divers and data from Reef Check (an international non-governmental organization that trains volunteers to carry out coral reef surveys) include records of giant clams beyond previously defined geographical boundaries, extending their known occurrence to near Cape Agulhas, South Africa. Giant clam distribution is not uniform, with greater diversity found in the central Indo-Pacific (Spalding *et al.,* 2007). A couple of recent sources have extended the known ranges of a couple of species. For example, Gilbert *et al.* (2007) documented the first observation of *T. squamosa* in French Polynesia, extending the species' range farther east than previously reported. Likewise, in our files, we found evidence that *T. tevoroa* has recently been observed in the Loyalty Islands of New Caledonia, whereas it was previously thought to be restricted to Tonga and Fiji (Kinch and Teitelbaum 2009). The petition claims that several of the species occur (or historically occurred) in the United States and its territories or possessions, including: *T. derasa, T. gigas, T. maxima, T. squamosa,* and *H. hippopus.* The rest of the petitioned clam species have strictly foreign distributions. The NMFS Coral Reef Ecosystem Program (CREP) conducts routine Reef Assessment and Monitoring Program surveys in U.S. territories, but their comprehensive monitoring reports only include general information on *Tridacna* clams, not at the species level.

Habitat

The petition cites Soo and Todd (2014), stating that giant clams are markedly stenothermal (*i.e.,* they are able to tolerate only a small range of temperature) and thus restricted to warm waters. Based on the broad latitudinal and depth ranges of some giant clam species, they each likely have varying ranges of temperature tolerance, possibly similar to that of other coral reef associated species. Although giant clams are typically associated with and are prominent inhabitants of coral reefs, this is not an obligate relationship (Munro 1992). Giant clams are typically found living on sand or attached to coral rock and rubble by byssal threads (Soo and Todd 2014), but they can be found in a wide variety of habitats, including live coral, dead coral rubble, boulders, sandy substrates, seagrass beds, macroalgae zones, etc. (Gilbert *et al.,* 2006; Hernawan 2010).

Life History

The exact lifespan of tridacnines has not been determined; although it is estimated to vary widely between eight to several hundred years (see original citations in Soo and Todd 2014). Little information exists on the size at maturity for giant clams, but size and age at maturity vary by species and geographical location (Ellis 1997). In general, giant clams appear to have relatively late sexual maturity, a sessile, exposed adult phase and broadcast spawning reproductive strategy, all of which can make giant clams vulnerable to depletion and exploitation (Neo *et al.,* 2015). All giant clam species are classified as protandrous functional hermaphrodites, meaning they mature first as males and develop later to function as both male and female (Chambers 2007); but otherwise, giant clams follow the typical bivalve mollusc life cycle. At around 5 to 7 years of age (Kinch and Teitelbaum 2009), giant clams reproduce via broadcast spawning, in which several million sperm and eggs are released into the water column where fertilization takes place. Giant clam spawning can be seasonal; for example, in the Central Pacific, giant clams can spawn year round but are likely to have better gonad maturation around the new or full moon (Kinch and Teitelbaum 2009). In the Southern Pacific, giant clam spawning patterns are seasonal and clams are likely to spawn in spring and throughout the austral summer months (Kinch and Teitelbaum 2009). Once fertilized, the eggs hatch into free-swimming trochophore larvae for around 8 to 15 days (according to the species and location) before settling on the substrate (Soo and Todd 2014; Kinch and Teitelbaum 2009). During the pediveliger larvae stage (the stage when the larvae is able to crawl using its foot), the larvae crawl on the substrate in search of suitable sites for settlement and metamorphose into early juveniles (or spats) within 2 weeks of spawning (Soo and Todd 2014). Growth rates after settlement generally follow a sigmoid (''S'' shaped) curve, beginning slowly, then accelerating after approximately 1 year and then slowing again as the animals approach maturity (Ellis 1997). These rates are usually slow and vary amongst species.

Feeding and Nutrition

According to Munro (1992), giant clams are facultative planktotrophs, in that they are essentially planktotrophic (*i.e.,* they feed on plankton) but they can acquire all of the nutrition required for maintenance from their symbiotic algae, *Symbodinium.* Nutritional requirements and strategies vary significantly by species. For example, *T. derasa* is able to function as a complete autotroph in its natural habitat (down to 20 m), whereas *T. tevoroa* only achieves this in the shallower parts of its distribution (10 to 20 m). *Tridacna gigas* shows a different strategy, comfortably satisfying all apparent carbon requirements from the combined sources of filter-feeding and phototrophy (Klumpp and Lucas 1994). In fact, Klumpp *et al.* (1992) showed that *T. gigas* is an efficient filter-feeder and that carbon derived from filter-feeding in Great Barrier Reef waters supplies significant amounts of the total carbon necessary for its respiration and growth.

Giant Clam Status and Abundance Trends

The petition does not provide historical or current global abundance estimates for any of the petitioned clam species; rather, the petition cites a number of studies that document local extirpations of various giant clam species in particular areas to demonstrate that all species of giant clams are currently declining, or have declined historically, within their ranges. We assess the information presented in the petition, and information in our files, regarding each of the petitioned species in individual species accounts later in this finding.

ESA Section 4(a)(1) Factors

The petition indicates that giant clam species merit listing due to all five ESA section 4(a)(1) factors: Present or threatened destruction, modification, or curtailment of its habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; inadequacy of existing regulatory mechanisms; and other natural or manmade factors affecting its continued existence. We first discuss each of these threats to giant clams in general, and then discuss these threats as they relate to each species, based on information in the petition and the information readily available in our files.

Threats to Giant Clams

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

The petition contends that all giant clam species are at risk of extinction due to habitat destruction. The petitioner cites Foster and Vincent (2004) and states that: ''Giant clams inhabit shallow coastal waters which are highly vulnerable to habitat degradation caused by various anthropogenic activities.'' While we agree that highly populated coastal areas are subject to anthropogenic impacts (*e.g.,* land-based sources of pollution, sedimentation, nutrient loading, etc.), the reference provided by the petitioner refers to habitat degradation as a threat to seahorse populations, with no information provided in this reference specific to giant clams. The petition also asserts that because giant clams are associated with coral reefs, that all species of giant clams face all of the ''regular'' threats that coral reefs generally face, including coral reef habitat degradation, sedimentation and pollution. The petition cites Brainard *et al.* (2011), a status review report that was prepared by NMFS for 82 coral species under the ESA, as evidence of habitat destruction issues throughout the range of the petitioned giant clam species. While this status review report thoroughly describes issues related to coral reef habitat degradation in general, it does not discuss giant clams, nor does it provide any substantial evidence regarding a link between coral reef habitat degradation and negative population-level impacts to any of the petitioned giant clam species throughout their ranges. Further, the petition itself notes that while giant clam species are generally associated with coral reefs, it is not an obligate relationship. In fact, surveys in many areas suggest that adults of most species of giant clams can live in most of the habitats available in coralline tropical seas (Munro 1992), with observations of giant clam species inhabiting a diverse variety of habitats (*e.g.,* live coral, dead encrusted coral, coral rubble, seagrass beds, sandy substrates, boulders, macroalgae zones, etc.; Gilbert *et al.,* 2006; Hernawan 2010). Additionally, while the petition describes the ecological importance of giant clams to coral reefs, the petition does not provide any information demonstrating the importance of pristine coral reef habitat to the survival of giant clam species.

Finally, the petitioner also notes evidence from the South China Sea that 40 square miles (104 sq km) of coral reefs have been destroyed as a result of giant clam poaching, with an additional 22 square miles (57 sq km) destroyed by island-building and dredging activities. The petitioner notes that the main target during these poaching activities is *T. gigas,* because its large shell is considered a desirable luxury item in mainland China. Although directed poaching of giant clams would fall under the threat of overutilization, the means of poaching (*e.g.,* explosives, tools of various sorts, and/or dragging and pulling to remove giant clams from the surrounding habitat) clearly has impacts to coral reef habitat as well. However, it is unclear how the loss of coral reefs in the South China Sea may impact the status of giant clams throughout their ranges, and aside from *T. gigas,* the petition provides no species-specific information regarding habitat destruction for the other nine petitioned species.

Therefore, while the information in the petition suggests concern for the status of coral reef habitat generally, its broadness, generality, and speculative nature, and the lack of connections between the threats discussed and the status of the giant clam species specifically, means that we cannot find that this information reasonably suggests that habitat destruction is an operative threat that acts or has acted on each of the species to the point that they may warrant protection under the ESA. Broad statements about generalized threats to the species, or identification of factors that could negatively impact a species, do not constitute substantial information that listing may be warranted. We look for information indicating that not only is the particular species exposed to a factor, but that the species may be responding in a negative fashion; then we assess the potential significance of that negative response and consider the significance within the context of the species' overall range. In this case, generalized evidence of declining coral reef habitat is not evidence of a significant threat to any of the individual petitioned species to infer extinction risk such that the species may meet the definition of either threatened or endangered under the ESA.

In addition to habitat degradation as a result of various anthropogenic activities, the petition contends that climate change related threats, including ocean warming and ocean acidification, are operative threats to all giant clam species and the coral reef habitat they rely on. The petitioner cites Brainard *et al.* (2011) and NMFS' proposed and final rules to list numerous reef-building corals under the ESA (77 FR 73219; December 7, 2012 and 79 FR 53852; September 10, 2014) as substantial information to support these claims. While we agree with the petitioner that coral bleaching events have been increasing in both intensity and geographic extent because of climate change, and the information in the petition suggests concern for coral reef ecosystems, we disagree with the petitioner's broad and generalized application of this information to the status of giant clams.

With regard to climate change related threats to coral reef habitat, NMFS' final rule to list 20 species of reef-building corals (79 FR 53852; September 10, 2014) explains that exposure and response of coral species to global threats varies spatially and temporally, based on variability in the species' habitat and distribution. The vast majority of coral species occur across multiple habitat types, or reef environments, and have distributions that encompass diverse physical environmental conditions that influence how that species responds to global threats. Additionally, the best available information, as summarized in Brainard *et al.* (2011) and the coral final rule (79 FR 53852; September 10, 2014), shows that adaptation and acclimatization to increased ocean temperatures are possible; there is intra-genus variation in susceptibility to bleaching, ocean acidification, and sedimentation; at least some coral species have already expanded their ranges in response to climate change; and not all species are seriously affected by ocean acidification. In fact, some studies suggest that coral reef degradation resulting from global climate change threats alone is likely to be an extremely spatially, temporally, and taxonomically heterogeneous process. These studies indicate that coral reef ecosystems, rather than disappear entirely as a result of future impacts, will likely persist, but with unpredictable changes in the composition of coral species and ecological functions (Hughes *et al.,* 2012; Pandolfi *et al.,* 2011). We have additional information regarding climate change impacts and predictions for coral reefs readily available in our files, which indicates a highly nuanced and variable pattern of exposure, susceptibility, resilience, and recovery over regionally and locally different spatial and temporal scales, with much uncertainty remaining. The literature underscores the multitude of factors contributing to coral response to thermal stress, including taxa, geographic location, biomass, previous exposure, frequency, intensity, and duration of thermal stress events, gene expression, and symbiotic relationships (Pandolfi *et al.,* 2011; Putman *et al.,* 2011; Buddemeier *et al.,* 2012; Sridhar *et al.,* 2012; Teneva *et al.,* 2012; van Hooidonk and Huber, 2012). Evidence suggests that coral bleaching events will continue to occur and become more severe and more frequent over the next few decades (van Hooidonk 2013). However, newer multivariate modeling approaches indicate that traditional temperature threshold models may not give an accurate picture of the likely outcomes of climate change for coral reefs, and effects and responses will be highly nuanced and heterogeneous across space and time (McClanahan *et al.,* 2015).

In addition to bleaching, the petitioner similarly implies that ocean acidification is a threat to giant clam habitat (*i.e.,* corals and coral reefs). The petition cites Brainard *et al.* (2011) and states: ''ocean acidification threatens to slow or halt coral growth and reef building entirely if the pH of the ocean becomes too low for corals to form their calcite skeletons.'' The petition further states that bioerosion of coral reefs is likely to accelerate as skeletons become more fragile because of the effects of acidification. However, aside from these broad and generalized statements regarding the potential impacts of ocean acidification to giant clam habitat (based largely on information regarding ocean acidification impacts to corals and coral reefs), the petition provides very limited information regarding species-specific impacts of ocean acidification for most of the petitioned giant clam species. Additionally, as with coral bleaching, Brainard *et al.* (2011) and the coral final rule (79 FR 53852; September 10, 2014) show that adaptation and acclimatization to ocean acidification are possible, there is intra-genus variation in susceptibility to ocean acidification, and not all species are seriously affected. The previous discussion regarding spatial and temporal variability regarding how coral species respond to increasing temperature also applies to how corals respond to impacts of ocean acidification. Despite the generally high-ranking global threats from climate change, including coral bleaching and acidification and considerations of how these threats may act synergistically, only 20 of the 83 petitioned coral species ultimately warranted listing under the ESA. This underscores the fact that reef-building corals exist within a wide spectrum of susceptibility and vulnerability to global climate change threats. Thus, at the broad level of coral reefs, the information in the petition and in our files does not allow us to conclude that coral reefs generally are at such risk from ocean acidification effects as to threaten the viability of the petitioned giant clam species.

Finally, the petition provided no information or analysis regarding how changes in coral reef composition and function because of climate change pose an extinction risk to any of the petitioned giant clam species. This is particularly important given that giant clams do not have an obligate relationship to coral reefs and, like corals, occur in a wide variety of habitats that encompass diverse physical environmental conditions that influence how a particular species responds to global threats. Broad generalizations regarding climate change related threats and their impacts cannot be applied as an equivalent threat to corals and coral reef associated species. In cases where the petitioner provided relevant species-specific information regarding climate change impacts, we consider this information in further detail below in the individual species accounts.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The petition describes several activities that may be contributing to the overutilization of giant clams in general. The petition notes that harvest of giant clams is for both subsistence purposes (*e.g.,* giant clam adductor, gonad, muscle, and mantle tissues are all used for food products and local consumption), as well as commercial purposes for global international trade (*e.g.,* giant clam shells are used for a number of items, including jewelry, ornaments, soap dishes).

The petition discusses a number of commercial fisheries that operated historically, including long-range Taiwanese fishing vessels and some local fisheries that developed in the 1970s and 1980s (*e.g.,* Papua New Guinea, Fiji, Maldives). According to Munro (1992), historical commercial fisheries appear to have been limited to long-range Taiwanese fishing vessels, which targeted the adductor muscles of larger species (*e.g., T. gigas* and *T. derasa*). This activity reached its peak in the mid-1970s and then subsided in the face of depleted stocks, strong international pressures, and improved surveillance of reef areas (Munro 1992). In response to declining activities by the Taiwanese fishery and continuing demand for giant clam meat, commercial fisheries developed in Papua New Guinea, Fiji, and the Maldives. For example, the Fijian fishery, which was exclusively for *T. derasa,* landed over 218 tons over a 9-year period, with the largest annual harvest totaling 49.5 tons in 1984. The petition cites Lewis *et al.* (1998) in stating this level of harvest is ''thought to have removed most of the available stock,'' but the authors actually stated that in 1984–85 there were still abundant populations on various reefs in the windward (Lau, Lomaiviti) islands but subsequent commercial harvest has considerably reduced these numbers. Because of these rapidly depleting local stocks, government authorities closed the fisheries (Munro 1992). The petition also noted historical commercial overutilization of giant clams (*i.e., T. gigas* and *T. derasa*) in Palau. Hester and Jones (1974) recorded densities of 50 *T. gigas* and 33 *T. derasa* per hectare at Helen Reef, Palau, before these stocks were ''totally decimated by distant-water fishing vessels'' (Munro 1992), although no further information or citations are provided to better describe the decimation. The petition discusses a few other studies that document historical overutilization of giant clams in various locations, including Japan, Philippines, Malaysia, and Micronesia (Okada 1997; Villanoy *et al.,* 1988; Tan and Yasin 2003; and Lucas 1994, respectively). Thus, it is clear that in some locations, giant clams, particularly the largest species (*T. gigas* and *T. derasa*), have likely experienced historical overutilization as a result of commercial harvest. However, it should be noted that the large majority of the information provided in the petition points to selective targeting of the largest giant clam species, with limited information on many of the other petitioned giant clam species. Therefore, we cannot conclude that overutilization is contributing equally or to the same extent to the extinction risk of all giant clam species. Thus, any individual studies and species-specific information are discussed and analyzed in further detail in the individual species accounts below.

In terms of current and ongoing threats of overutilization to giant clams, the petition emphasizes the threat of the growing giant clam industry in China, largely the result of improved carving techniques, increased tourism in Hainan, China, the growth in e-commerce, and the domestic Chinese wholesale market (Larson 2016). The petition also cites McManus (2016) to note concerns that stricter enforcement of the trade in ivory products has diverted attention to giant clam shells. The petition points out that the giant clam (*T. gigas*) is the main target for international trade, as this species' shell is considered a desirable luxury item, with a pair of high quality shells (from one individual) selling for upwards of US $150,000. Therefore, the high value and demand for large *T. gigas* shells may be a driving factor contributing to ongoing overutilization of the species. However, aside from *T. gigas,* the petition provides very limited information regarding the threat of international trade to the other nine petitioned giant clam species. Based on the information presented in the petition and in our files, we acknowledge that international trade may be a threat to some species (*e.g., T. gigas*), but we cannot conclude that international trade is posing an equivalent threat to all of the petitioned species, as it is clear that some giant clam species are more desirable and targeted more for international trade than others. A more detailed analysis of available species-specific trade information presented in the petition and in our files can be found in the individual species accounts in later sections of this notice.

Although the petition does not mention aquaculture and hatchery programs, we found some information in our files on numerous giant clam aquaculture and hatchery programs throughout the Indo-Pacific, with several species being cultured in captivity for the purpose of international trade and restocking/reseeding programs to enhance wild populations. Currently, a variety of hatchery and nursery production systems are being utilized in over 21 Indo-Pacific countries (Teitelbaum and Friedman 2008), with several Pacific Island Countries and Territories (PICTs) across the Pacific using giant clam aquaculture and restocking programs to help enhance wild populations and culture clams for commercial use/trade. For example, the Cook Islands cultures giant clams at the Aitutaki Marine Research Center and exported 30,000 giant clams from 2003 to 2006 for the global marine aquarium trade (Kinch and Teitelbaum 2009). In 2005, the Palau National Government established the Palau Maricultural Demonstration Center Program to conduct research on giant clam culture and to establish community-based giant clam grow-out farms. This program has helped establish 46 giant clam farms throughout Palau, with over two million giant clam 'seedlings' distributed (Kinch and Teitelbaum 2009). At least 10 percent of all giant clams from each farm are also kept aside to spawn naturally in their own ranched enclosures, thus reseeding nearby areas. In addition to being used to reseed areas in Palau, the program exported approximately 10,000 cultured giant clams each year from 2005 to 2008 to France, Germany, Canada, the United States (including Guam and the Federated States of Micronesia (FSM)), Korea, and Taiwan. Other major producers of cultured giant clams for export include the Republic of the Marshall Islands, Tonga, and the FSM, producing an approximate average of 15–20,000 pieces of clams per year (Kinch and Teitelbaum 2009). Therefore, the international trade of giant clams is complex, with many facets to consider, including the increasing influx of cultured giant clams into the trade. We acknowledge that the success of these restocking programs have been variable and limited in some locations (Teitelbaum and Friedman 2008); however, given the foregoing information, we cannot conclude that international trade poses an equal extinction risk to all of the petitioned giant clam species. In cases where the petition did provide species-specific information regarding commercial trade, we consider this information, as well as what is in our files, in the individual species accounts below.

Disease and Predation

The petition states that predation is not likely a threat to giant clam species, as there is no evidence to suggest that levels of predation have changed or are unnaturally high and affecting the status of giant clam populations. We could also find no additional information in our files regarding the threat of predation for any of the petitioned clam species.

The petition asserts that because diseases have been documented in a number of species and have likely increased in concert with climate change, they cannot be ruled out as a threat. The petition presented some limited information on diseases (*e.g.,* impacts of protozoans and parasitic gastropods on giant clams and other bivalves on the Great Barrier Reef of Australia), but did not provide any species-specific information regarding how diseases may be impacting giant clam populations to the point that disease poses an extinction risk to any of the petitioned clam species. We could also not find any additional information in our files regarding the threat of disease for any of the petitioned clam species. Therefore, we conclude that the petition does not provide substantial information that disease or predation is a threat contributing to any of the species' risk of extinction, such that it is cause for concern.

Inadequacy of Existing Regulatory Mechanisms

The petition claims existing regulatory mechanisms at the international, federal, and state level to protect giant clams or the habitat they need to survive are inadequate. The petitioner asserts that not only are local and national laws inadequate to protect giant clams, but that international trade and greenhouse gas regulations are also inadequate. We address each of these topics separately below.

Local and National Giant Clam Regulations

The petitioner notes that there are some laws for giant clams on the books in certain locations, but only discusses regulations from the Philippines and Malaysia and a separate issue of illegal clam poaching in disputed areas of the South China Sea. The petition acknowledges that all species of giant clam in the Philippines are protected as endangered species under the Philippine's Fisheries Administrative Order No. 208 series of 2001 (Dolorosa and Schoppe 2005), but states that despite this law, declines of giant clams continue. However, the only study presented on abundance trends since the law was implemented in 2001 was conducted on one reef (Tubbataha Reef; Dolorosa and Schoppe 2005). Dolorosa and Schoppe (2005) specifically stated that they could not conclude a continuous decline of tridacnids was occurring because the much lower density observed in their study was based on data taken from a single transect. Prior to the study conducted by Dolorosa and Schoppe (2005), the only quantitative information presented was from studies conducted in the 1980s and 1990s (Villanoy *et al.,* 1988; Salazar *et al.,* 1999). Therefore, based on the foregoing information, we cannot conclude that the aforementioned fisheries law is inadequate for mitigating local threats to giant clams and slowing or halting population declines in the Philippines. However, illegal poaching for some species does seem to be an issue in some areas of the Philippines, notably in the protected area of Tubbataha Reef National Marine Park. For example, hundreds of giant clams (*T. gigas*) were confiscated from Chinese fishermen who poached in the Park in the early 2000s (Dolorossa and Schoppe 2005), indicating that regulatory mechanisms (*e.g.,* the protected area) may not be adequate to protect that highly sought after species.

The petitioner also notes that Malaysia's Department of Fisheries has listed giant clams as protected species, but cites Tan and Yasin (2003) as evidence that giant clams continue to decline despite this protective regulation. The petition provides no details regarding when this law was implemented or what specific protections it affords giant clams in Malaysian waters, nor could we find these details in the reference provided (Tan and Yasin 2003). Given that Malaysia represents a different proportion of each of the petitioned species' overall range, the potential inadequacy of regulatory mechanisms in Malaysia will be assessed and considered for each of the petitioned species in the individual species accounts below.

Overall, the discussion of inadequate regulatory mechanisms for giant clams at the national/local level by the petitioner focuses on Southeast Asia, without any information regarding regulatory mechanisms throughout large portions of the rest of the ranges of the species. However, we found regulations in our files in numerous countries throughout the tropical Pacific (*e.g.,* PICTs) and Australia regarding the harvest of giant clams. For example, size limits and complete bans on commercial harvest are the most commonly used fisheries management tools for giant clams throughout the PICTs (Kinch and Teitelbaum 2009). Several countries, including French Polynesia, Niue, Samoa, and Tonga, have size limits imposed for certain species. Some PICTs, such as Fiji and New Caledonia, both of which have active high volume tourist trades, allow up to three giant clam shells (or six halves) not weighing more than 3 kg to be exported with Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES) permits. Other PICTs, such as Guam and New Caledonia, have imposed bag-limits on subsistence and commercial harvest of giant clams. Papua New Guinea has imposed a ban on the use of night lights to harvest giant clams. There are also community-based cultural management systems in many PICTs like the Cook Islands where a local village or villages may institute *rahui,* or closed areas, for a period of time to allow stocks to recover (Chambers 2007). Finally, the following PICTs have complete bans on commercial harvest and export, with the exception of aquacultured species: FSM, Fiji, French Polynesia, Kiribati, Palau, Solomon Islands, and Vanuatu (Kinch and Teitelbaum 2009). Therefore, without any information or analysis as to how these regulatory measures are failing to address local threats to giant clams, we cannot conclude that there is substantial information indicating that regulatory mechanisms for all of the petitioned giant clam species are equally inadequate such that they may be posing an extinction risk to the species. Where more specific information is available for a particular species, we consider this information in the individual species accounts later in this finding.

Trade Regulations

The petition asserts that international regulations, specifically the CITES, are inadequate to control commercial trade of giant clam species. The petition explains that although all members of the Tridacninae family are listed under Appendix II of CITES, implementation and enforcement are likely not adequate and thus illegal shipments are not necessarily intercepted. However, the assertions regarding illegal shipments were made broadly about wildlife shipments in general, without providing any specific information or clear linkages regarding how CITES is failing to regulate international trade of each of the petitioned giant clam species. The petition cites a number of CITES documents and states that these documents ''show wide disparities in yearly giant clam trade figures,'' which suggest that some countries have failed to exert control on the clam trade (bin Othman *et al.,* 2010). However, the petition did not provide any additional details explaining how these trade figures demonstrate a risk of extinction to any particular species.

Overall, the discussion of the inadequacy of CITES is very broad and does not discuss how the inadequacy of international trade regulations is impacting any of the petitioned species to the point that it is contributing to an extinction risk, with the exception of *T. gigas* and the growing giant clam industry in China. For example, the petition points out that the shape of the large giant clam shells (*T. gigas*) makes them highly desirable for making large, intricately carved scenes. In fact, the petition itself emphasizes that *T. gigas* is the main giant clam species targeted and poached in the South China Sea for this particular trade. Therefore, from the information in the petition and our files, it is clear that some giant clam species are more desirable and targeted for the international trade than others, and thus require more restrictive regulations to ensure their sustainability. As discussed previously in the *Overutilization for Commercial, Recreational, Scientific, or Educational* section above, we concluded that, for giant clams in general, the information in the petition and our files does not constitute substantial information that international trade is posing an equivalent threat to all of the petitioned giant clam species. Therefore, while we acknowledge that international trade may be a threat to some species, and existing regulations may be inadequate and warrant further investigation, the assertion that inadequate regulations for international trade is an equivalent threat to all of the petitioned giant clam species is not supported.

Greenhouse Gas Regulations

The petition claims that regulatory mechanisms to curb greenhouse gas emissions and reduce the effects of global climate change are inadequate to protect giant clams from the threats climate change poses to the species and their habitat. The petition goes on to explain that climate change threats, including bleaching and ocean acidification, represent the most significant long-term threat to the future of global biodiversity. Information in our files and from scientific literature indeed indicates that greenhouse gas emissions have a negative impact to reef building corals (NMFS 2012). However, as we discussed in detail previously, beyond this generalized global threat to coral reefs, we do not find that the petition presents substantial information indicating that the effects of greenhouse gas emissions are negatively affecting the petitioned species or their habitat such that they may warrant listing under the ESA. In particular, the information in the petition and in our files does not indicate that the loss of coral reef habitat or the direct effects of ocean warming and acidification is contributing to the extinction risk of the petitioned species (refer back to the *Present or Threatened Destruction, Modification or Curtailment of its Habitat or Range* section above and the *Other Natural or Manmade Factors* section below). Therefore, with the exception of species for which species-specific information is available regarding negative responses to ocean warming or acidification, inadequate regulatory mechanisms controlling greenhouse gas emissions are not considered a factor that may be contributing to the extinction risk of the petitioned species.

Other Natural or Manmade Factors Affecting Its Continued Existence

Ocean Warming and Giant Clam Bleaching

The petitioner discusses the climate change-related impacts of ocean warming and giant clam bleaching as an extinction risk to all the petitioned giant clam species. In terms of giant clam bleaching, the petitioner argues that giant clams are like stony corals, in that the *Symbodinium* zooxanthellae in giant clams are subject to bleaching and other effects from high temperature. The petitioner provides a number of studies documenting giant clam bleaching in various locations, including the Great Barrier Reef in Australia and Southeast Asia. The petition then describes several studies on the physiological effects to giant clams from bleaching and ocean acidification, with the large majority of these studies conducted on *T. gigas*. However, while the petition provides some evidence that giant clams experience bleaching as a result of increased temperature, there is no discussion regarding how giant clams tolerate bleaching or the extent to which bleaching leads to mortality for the majority of the petitioned species. For example, the petition discusses a study by Leggat *et al.* (2003), in which the symbiotic zooxanthellae in *T. gigas* declined 30-fold during the 1998 global coral bleaching event, leading to a loss of the nutrition provided by zooxanthellae in ways very similar to the effects on stony corals; however, the petition failed to present any discussion or analysis as to how this stressor is linked to mortality of giant clams or population declines. In fact, the main conclusion of the Leggat *et al.* (2003) study states:

> Despite this significant reduction in symbiont population, and the consequent changes to their carbon and nitrogen budgets, the clams are able to cope with bleaching events significantly better than corals. During the recovery of clams after an artificial bleaching event only three out of 24 clams died, and personal observations at Orpheus Island indicated that survival rates of bleached clams were greater than 95 percent under natural conditions. This is in contrast to reports indicating coral mortality in some species can be as great as 99 percent.

Therefore, although giant clams and stony corals can experience similar bleaching of their symbiotic zooxanthellae, this does not necessarily equate to analogous impacts of widespread bleaching-induced mortality from ocean warming. As discussed for another reef-dwelling organism in the orange clownfish 12-month finding (80 FR 51235), anemones also have symbiotic zooxanthellae, but literature on the effects of ocean warming on anemones show results that are not necessarily analogous with corals either, and in fact show high variability between and within species. Even individual anemones can show varying responses across different bleaching events. Although observed anemone bleaching has thus far been highly variable during localized events, the overall effect of bleaching events on anemones globally (*i.e.,* overall proportion of observed anemones that have shown ill effects) has been of low magnitude at sites across their ranges. In fact, only 3.5 percent of the nearly 14,000 observed anemones were recorded as bleached across 19 study sites and multiple major bleaching events (Hobbs *et al.,* 2013). Based on this example, generalized statements about bleaching impacts to all organisms that have symbiotic dinoflagellates being analogous are not supported by the best available information.

Without species-specific information on how ocean warming-induced bleaching affects each of the petitioned giant clam species (*e.g.,* mortality rates and evidence of negative population level effects), we cannot conclude that bleaching caused by ocean warming may be acting equally on all of the petitioned species to the point that the petitioned action may be warranted. Where the petition provides some species-specific information regarding the effects of temperature-induced bleaching, we consider this information in more detail in the individual species accounts below.

Ocean Acidification

Similar to the effects of ocean warming, the petitioner discusses ocean acidification as a threat contributing to the extinction risk of all of the petitioned giant clam species. The petitioner asserts that the effects of ocean acidification will likely accelerate the bioerosion of giant clam shells and lead to their increased fragility. To support this assertion, the petition cites two studies. One study (Waters 2008) looked at cultured specimens of *T. maxima* in a lab experiment and found that *T. maxima* juveniles exposed to pCO_2 concentrations approximating glacial (180 ppm), current (380 ppm) and projected (560 ppm and 840 ppm) levels of atmospheric CO_2 (per the IPCC IS92a scenario) suffered decreases in size and dissolution, and this occurred below thresholds previously considered detrimental to other marine organisms in similar conditions. We discuss these results and implications in further detail in the *T. maxima* species account below.

The second study (Lin *et al.,* 2006) did not specifically evaluate impacts of ocean acidification but instead involved mechanical tests on the shells of conch (*Strombus gigas*), giant clam (*T. gigas*), and red abalone (*Haliotis rufescens*) for a comparison of strength with respect to the microstructural architecture and sample orientation. The study found that although the structure of the *T. gigas* shell had the lowest level of organization of the three shells, its sheer size results in a strong overall system (Lin *et al.,* 2006). The petitioner claims that because *T. gigas* has the lowest flexural shell strength relative to the two other types of shells tested, that any loss of shell material or strength from the effects of ocean acidification may have a greater negative effect on giant clams than on other large molluscs. However, this statement is speculative, and no additional information or references were provided to support this claim.

Overall, while we agree that ocean acidification is likely to continue and increase in severity over time within the ranges of the giant clam species, resulting in various detrimental impacts, additional information in our files also underscores the complexity and uncertainty associated with the various specific effects of ocean acidification across the ranges of giant clams. There are numerous complex spatial and temporal factors that compound uncertainty associated with projecting effects of ocean acidification on coral reef associated species such as giant clams. Further, as explained in the final rule to list 20 reef-building coral species under the ESA (79 FR 53852; September 10, 2014), projecting species-specific responses to global threats is complicated by several physical and biological factors that also apply to the petitioned giant clam species. First, global projections of changes to ocean acidification into the future are associated with three major sources of uncertainty, including greenhouse gas emissions assumptions, strength of the climate's response to greenhouse gas concentrations, and large natural variations. There is also spatial and temporal variability in projected environmental conditions across the ranges of the species. Finally, species-specific responses depend on numerous biological characteristics, including (at a minimum) distribution, abundance, life history, susceptibility to threats, and capacity for acclimatization.

In this case, the petition did not provide sufficient information regarding the likely impacts of ocean acidification on specific giant clam species or their populations. Without any analysis of how ocean acidification may be negatively impacting each of the petitioned giant clam species (with the exception of *T. maxima* and *T. squamosa*), we cannot conclude that substantial information was provided to indicate effects of ocean acidification may be acting on all of the petitioned species to the point that the petitioned action may be warranted. In cases where the petition did provide species-specific information, we consider this information in further detail in the individual species accounts below.

Individual Species Accounts

Based on the information presented in the petition and in our files, we made 10 separate 90-day findings, one for each of the petitioned giant clam species. We first address the seven species for which we have determined that the information presented in the petition and in our files constitutes substantial information that the petitioned action may be warranted (*i.e.,* positive 90-day finding). Because we will be addressing all potential threats to these species in forthcoming status reviews, we will only provide summaries of the main threat information in these species accounts as opposed to addressing every ESA (4)(a)(1) factor. Then, we address the remaining three species for which we determined that the information presented in the petition and in our files does not constitute substantial information that the petitioned action is warranted (*i.e.,* negative 90-day finding). In these species accounts, we address every ESA (4)(a)(1) factor individually.

Hippopus hippopus

Species Description

The petition does not provide any descriptive information for *H. hippopus.* We found some information in our files describing this species. Its shell exterior is off-white with a yellowish orange coloring and reddish blotches arranged in irregular concentric bands; the shell interior is porcelaneous white, frequently flushed with yellowish orange on the ventral margin, and the mantle ranges from a yellowish-brown, dull green, or grey (Kinch and Teitelbaum 2009). Maximum shell length for *H. hippopus* is 40 cm, but it is commonly found at lengths up to 20 cm. It can be found on sandy bottoms of coral reefs in shallow water to a depth of 6 m. Smaller specimens (up to about 15 cm in length) are often attached to coral rubble by their byssal strings, while large and heavy specimens are unattached and lack a byssus (Kinch and Teitelbaum 2009).

Life History

The petitioner provides some information on life history specific to this species. He cites Shelley (1989) who found second sexual maturity in *H. hippopus* at Orpheus Island, Great Barrier Reef, at a shell size of 145mm which equated to 2 years of age for males and 4 years of age for hermaphrodites of the species from the study area. He cites Stephenson (1934) and Shelley (1989) who reported that *H. hippopus* spawns in the austral summer months of December to March on the Great Barrier Reef, which is also supported by Munro (1992) who found spawning of *H. hippopus* to be restricted to a short summer season in the central region of the Great Barrier Reef. In Palau, Hardy and Hardy (1969) reported that *H. hippopus* spawned in June. In a detailed study of early life history in Guam, fertilized eggs of *H. hippopus* had a mean diameter of 130.0 µm (micrometers; 13 cm; Jameson 1976). According to the same study, settlement in Guam occurred 9 days after fertilization at a mean shell length of 202.0 µm (20.2 cm) for *H. hippopus.* Juveniles of *H. hippopus* in Guam first acquired zooxanthellae after 25 days and juvenile shells showed first signs of becoming opaque after 50 days (Jameson 1976).

Range, Habitat, and Distribution

The petition includes a range map for *H. hippopus* that was excerpted from bin Othman *et al.* (2010). bin Othman *et al.* (2010) note that data from Reef Check (*www.reefcheck.org*) indicate that there are populations of giant clams beyond the species-specific boundaries described by the references on which the range maps within bin Othman *et al.* (2010) are based, although no further detail is provided for any species. This applies to all species for which range maps based on bin Othman *et al.* (2010) are provided in this finding. The range map for *H. hippopus* provided in the petition does include several U.S. Pacific areas including Guam, Commonwealth of the Northern Mariana Islands (CNMI), and Wake Atoll. According to the petition, *H. hippopus* also historically occurred in Singapore (Neo and Todd 2012b and 2013) and the United States, although locations in the United States are not specified and no reference is provided.

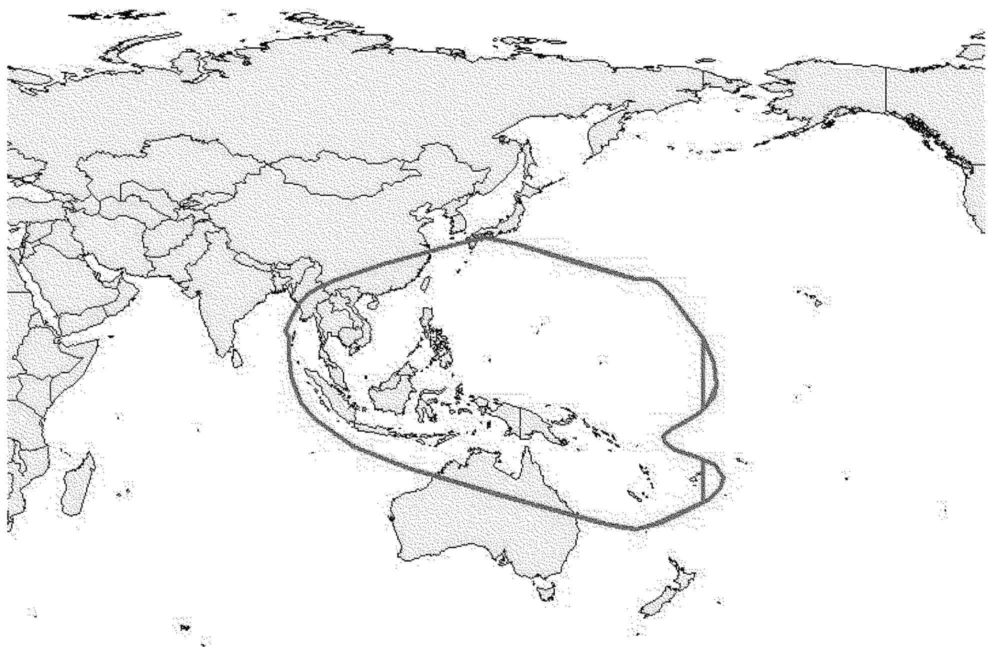

Figure 1: Range map for *Hippopus hippopus*, extracted from compilation of species ranges provided by bin Othman *et al.,* 2010.

According to Munro (1992), *H. hippopus* occurs in the widest range of habitat types of all the Tridacninae species. This species is seemingly equally comfortable on sandy atoll lagoon floors or exposed intertidal habitats, and similar to *T. gigas,* which is found in many habitats (*e.g.,* high or low islands, lagoons, or fringing reefs; Munro 1992).

Population Status and Abundance Trends

Although an overall population abundance estimate or population trends for *H. hippopus* are not presented, the petitioner does provide some limited abundance information from various locations within the species' range. For example, the petition cites Tan and Yasin (2003) who state that giant clams of all species but *T. crocea* are considered endangered in Malaysia. The authors mention underwater surveys that reveal the ''distribution of giant clams are widespread but their numbers are very low,'' but there are no references provided by the authors to provide any more detail or support for this information, which makes it difficult to interpret this information for individual species. The only species-specific information for *H. hippopus* in this reference is that it occurs in Malaysian waters. The petition states that Brown and Muskanofola (1985) found that *H. hippopus* was locally extinct in Indonesia. Upon review of this reference, more specifically, the authors found many small shells of *H. hippopus* but no living specimens in their survey area of seven island transects in Central Java, Indonesia. The authors noted that because of time constraints, it was not possible to cover more than a very small proportion of the total area suitable for clam growth in Karimun Jawa. Thus, confining the survey to such a small area could have affected the results. Hernawan (2010) found small populations and evidence of recruitment failure in the six species found during a survey of Kei Kecil, Southeast-Maluku, Indonesia, including *H. hippopus.* The authors conducted giant clam surveys in nine sites out of the many thousands of islands that make up Indonesia. At another site in Indonesia, Eliata *et al.* (2003) reported an 84 percent decline in *H. hippopus* based on surveys of Pari Island from 1984 and 2003. This species is presumed nationally extinct in Singapore (Neo and Todd 2012a, 2013) and has been reported as extirpated from Fiji, Tonga, Samoa and American Samoa, Guam, the Mariana Islands, and Taiwan (Wells 1996a, Skelton *et al.* 2002, Teitelbaum and Friedman 2008).

The petition presents three references from the Philippines on *H. hippopus.* Villanoy *et al.* (1988) states this species has been overexploited based on the export volumes of giant clam shells. The petitioner claims densities of *H. hippopus* declined by 97 percent in Tubbataha Reef Park in the Philippines from 1995–2005 based on a survey by Dolorosa and Schoppe (2005). However, upon closer review of this reference, the data in Dolorosa and Schoppe (2005) indicating a substantial decline in *H. hippopus* density was taken from a single transect; as such, the authors concluded that a continuous decline of the Tridacnids (including *H. hippopus*) could not be confirmed. Finally, Salazar *et al.* (1999) did a stock assessment of giant clams (including *H. hippopus*) in the Eastern Visayas of the Philippines and found most of the populations were made up of juveniles with insufficient numbers of breeders to repopulate the region, although this reference was unavailable for review. Notably, the petition cites Thamrongnavasawat (2001) as reporting that *H. hippopus* is considered extinct in Mo Ko Surin National Park in Thailand, although the bibliographic information provided for this reference did not allow us to access it for review.

While individually and collectively the studies discussed in this section represent a small portion of *H. hippopus'* total geographic range, localized declines and potential extirpations of this species in small areas are spread throughout its range and not confined to one area that may be disproportionately affected by some negative impact. Thus, the number and spatial distribution of localized severe declines or extirpations in the context of the species' range may be contributing to an elevated extinction risk for this species such that it warrants further investigation.

Threats to *Hippopus hippopus*

The petition presents three studies with species-specific information regarding threats to *H. hippopus.* Some historical information indicates that shells of *H. hippopus* (long extirpated in Fiji) occur in shell middens at the Lapita-era (1100–550 B.C.) settlements (Bourewa and Qoqo) along the Rove Peninsula in Fiji; the valve size and weight increase with depth (*i.e.,* age) in the midden, suggesting that human consumption contributed to its local disappearance (Seeto *et al.* 2012). While this one piece of evidence does not constitute substantial information that overharvest may be acting or may have acted on *H. hippopus* as a species to the extent that it needs protection under the ESA, the threat of overexploitation will be evaluated in the status review. Blidberg *et al.* (2000) studied the effect of increasing water temperature on *T. gigas, T. derasa,* and *H. hippopus* at a laboratory in the Philippines. *Hippopus hippopus* experienced increased respiration and production of oxygen in elevated temperatures and was therefore more sensitive to higher temperature than the two other species tested. After 24 hours at ambient temperature plus 3 °C, however, no bleaching was observed for any of the species. While we acknowledge the potential for ocean warming to have an effect on this species, this was a limited experiment, the results of which are difficult to interpret in terms of the potential species-level or even localized impacts of physiological stress due to elevated ocean temperatures in the wild in the context of this assessment. While this one study does not constitute substantial information that climate change may be acting on *H. hippopus* as a species to the extent that it needs protection under the ESA, the impacts of ocean warming will be further evaluated for *H. hippopus* in the status review based on the best available information.

Finally, Norton *et al.* (1993) found two incidences of mortality in *H. hippopus* from rickettsiales-like organisms in cultured clams in the western Pacific, one in the Philippines and one in Kosrae. However, it is not uncommon among individuals cultured in close proximity to be afflicted with parasites or diseases that spread quickly (Norton *et al.,* 1993). While this does not constitute substantial information that disease or parasites may be acting on *H. hippopus* as a species to the extent it needs the protections of the ESA, the threats of disease and parasites will be further evaluated in a forthcoming status review.

Conclusion

In conclusion, the information provided on threats for this species is limited and the individual studies by themselves are not substantial information indicating the petitioned action may be warranted for the species. However, the evidence presented of localized declines or extirpations in different parts of the species' range does suggest that one or more threats may be acting on the species throughout all or a significant portion of its range and the petitioned action may be warranted. The number and spatial distribution of localized severe declines or extirpations in the context of the species' range may be contributing to an elevated extinction risk for this species such that it warrants further investigation. The best available information on the species' overall status and all potential threats will be evaluated in a forthcoming status review to determine what has potentially caused these declines and extirpations.

Hippopus porcellanus

Species Description

The petition does not provide any descriptive information for *H. porcellanus.* We found some information in our files describing this species. Commonly known as the China clam, *H. porcellanus* grows to a maximum of 40 cm, but is commonly found up to 20 cm in shell length. The shell exterior is off-white, occasionally with scattered weak reddish blotches. The shell interior is porcelaneous white, more or less flushed with orange on the ventral margin, and the mantle ranges from a yellowish-brown, dull green or grey (Kinch and Teitelbaum 2009). This species can be distinguished from its congener, *H. hippopus,* by its smoother and thinner shells and presence of fringing tentacles at its incurrent siphon (Neo *et al.,* 2015).

Life History

Aside from the information already discussed previously in the *Giant Clam Life History* section, the petition did not provide any life history information specific to *H. porcellanus,* nor could we find any additional information in our files on the life history of this species.

Range, Habitat, and Distribution

Hippopus porcellanus has one of the most restricted geographic ranges of the petitioned giant clam species. The petition notes that the species only occurs in Palau, Indonesia, and the Philippines based on the IUCN assessment (Wells 1996); however, in the population abundance and trends section, the petition notes the endangered status of *H. porcellanus* in Malaysia, placing its occurrence there as well.

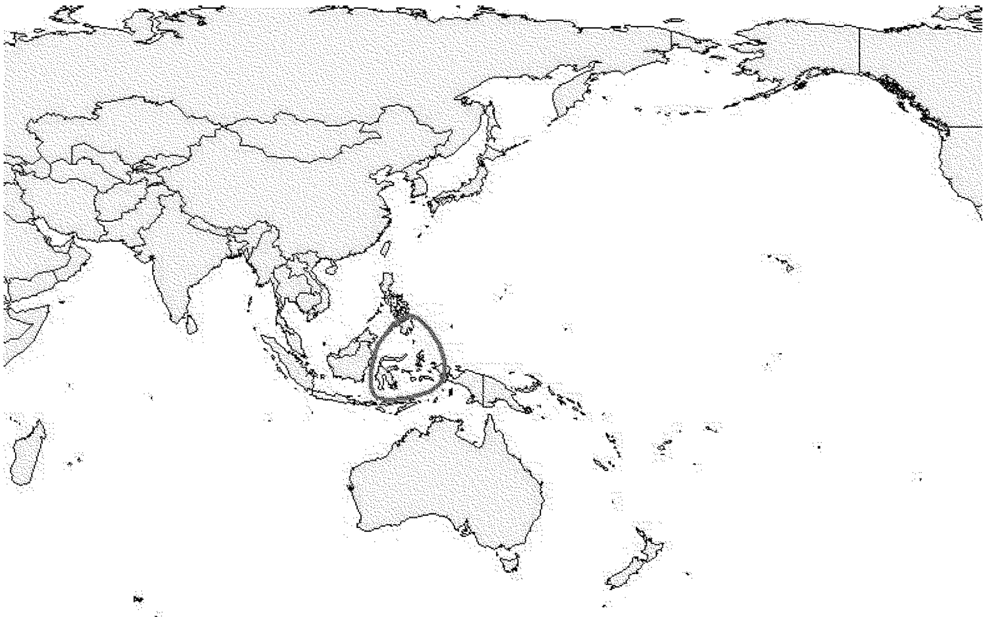

Figure 2: Geographic range of *Hippopus porcellanus*, extracted from bin Othman *et al.* (2010).

H. porcellanus can be found in shallow waters on sandy bottoms of coral reefs. Young specimens are often attached to coral heads via their byssus, whereas mature individuals lack a byssus and lay unattached on the substrate (Rosewater 1982).

Population Status and Abundance Trends

The petition does not provide an overall population abundance or trend estimate for *H. porcellanus* as a species throughout its range. The petition does, however, provide limited, localized information on the population status and abundance trends of *H. porcellanus,* with some information from Malaysia and the Philippines, but no species-specific information from other parts of the species' range, including Indonesia and Palau. As discussed in other species accounts, the petitioner cites Tan and Yasin (2003), who state that giant clams of all species but *T. crocea* are considered endangered in Malaysia. As noted previously, the authors mention underwater surveys that reveal that the ''distribution of giant clams are widespread but their numbers are very low,'' but the authors do not provide any references with any more detail or support for this information, which makes it difficult to interpret this information for individual species. The only species-specific information for *H. porcellanus* in this reference is that it is restricted to Sabah, Eastern Malaysia.

The petition asserts that *H. porcellanus* is overexploited and depleted in the Philippines based on Villanoy *et al.,* (1988) and Rubec *et al.,* (2001). Villanoy *et al.,* (1988) examined average size frequency distributions of giant clams harvested from the Sulu Archipelago and Southern Palawan areas from 1978 to1985, and determined that *H. porcellanus* was overexploited in the Philippines as early as the 1980s. The authors note that these findings have serious implications given that the Sulu Archipelago and Southern Palawan may be the last strongholds of all giant clam species occurring in Philippine waters. Rubec *et al.* (2001) more recently described *H. porcellanus* as ''depleted,'' but they did not provide any references or additional detail to help us determine what they meant by ''depleted'' or how this current information relates to historical abundance of the species in Philippine waters. Without any quantitative information on abundance trends of *H. porcellanus* in the Philippines since the 1980s, it is difficult to determine what the present status of the species is in this portion of its range. However, we note that because *H. porcellanus* has an extremely restricted geographic range, occurring in only three countries, overexploitation in the Philippines gives cause for concern and warrants further investigation.

While *H. porcellanus* also occurs in Indonesia and Palau, the petition did not provide any additional information regarding the species' status or abundance trends in these locations. The information provided by the petitioner for giant clams in Indonesia is from a location where *H. porcellanus* is not known to occur (*i.e.,* Kei Kecil, Indonesia). We could not otherwise find any information in our files from Indonesia or Palau regarding the status of *H. porcellanus* in these locations.

Overall, while the information presented in the petition is very limited regarding the species' current status and abundance trends throughout its range and would not in and of itself constitute substantial information, the species' range is significantly restricted. Therefore, given that the species only occurs in four countries, the information presented in the petition from the Philippines, albeit limited, gives cause for concern that the species may have an elevated extinction risk that warrants further investigation.

Threats to *H. porcellanus*

The only species-specific information provided by the petition regarding threats to *H. porcellanus* is related to overutilization in the Philippines. As described in the *Population Status and Abundance Trends* section above, the petitioner cited Villanoy *et al.* (1988) as evidence of overutilization of *H. porcellanus.* Villanoy *et al.* (1988) notes that giant clams have long been harvested by subsistence fishermen in the Indo-Pacific Region as a supplementary source of protein. Additionally, in some areas of the Philippines (*e.g.* Sulu Archipelago, Southern Palawan), giant clams are also harvested commercially for their shells. After examining average size frequency distributions of giant clams harvested from the Sulu Archipelago and Southern Palawan areas from 1978–1985, Villanoy *et al.* (1988) determined that *H. porcellanus* was overexploited in the Philippines as early as the 1980s, and is no longer commercially harvested. As noted previously, the Sulu Archipelago and Southern Palawan areas are thought to be the last strongholds of giant clams in Philippine waters. Therefore, the overexploitation of *H. porcellanus* as of the 1980s and its restricted range could have serious implications regarding the species' extinction risk. More recently, Rubec *et al.* (2001) similarly document that *H. porcellanus* has been depleted to such an extent that it is no longer commercially viable for harvesting in the Philippines.

Conclusion

In conclusion, the information provided on population abundance and threats for this species is limited and by itself would not be considered substantial information indicating the petitioned action may be warranted. The individual studies presented are not compelling evidence of species level concerns for reasons discussed above. However, given the species' extremely restricted range, combined with evidence of localized declines and historical overutilization in the Philippines, we find the information compelling enough to conclude that the petitioned action may be warranted. The best available information on the species' overall population status and all potential threats will be evaluated in a forthcoming status review.

Tridacna costata (T. squamosina)

Species Description

Tridacna costata has been described only recently (Richter *et al.,* 2008; bin Othman *et al.,* 2010), but it has been shown to be a junior synonym of the previously described *T. squamosina* (Borsa *et al.,* 2015a). This species of giant clam grows to 32 cm (Neo *et al.,* 2015) and features 5–7 deep rib-like vertical folds, resulting in a zig-zag dorsal shell margin. According to Richter *et al.,* (2008), the mantle is most commonly a subdued brown mottled pattern; mantle margins are green with prominent ''wart-like'' protrusions and pale striations following mantle contour. These features (the pronounced rib-like vertical folds and the prominent wart-like protrusions on the mantle tissue) are the main diagnostic features that separate *T. costata* from its sympatric congeners. These features are conservatively present even in small clams <10 cm shell length (Richter *et al.,* 2008).

Life History

The petition itself does not describe any species-specific life history information for *T. costata,* but we found some limited information in one of the references provided that suggests a narrow reproductive period. Richter *et al.* (2008) found marked differences in the seasonal times of reproduction between *T. costata* and its Red Sea congeners (*T. maxima* and *T. squamosa*). Specifically, *T. costata'*s reproductive period appears to be an early and brief period in spring, coinciding with the seasonal planktonic bloom (Richter *et al.,* 2008). This narrow reproductive window may make *T. costata* particularly vulnerable to overfishing. The timing of *T. costata'*s reproduction combined with the small diameter of the ova (75 ±2 [SEM] µm) suggests a planktotrophic (*i.e.,* feeding on plankton) development of the larvae. This contrasts with the lecithotrophic (*i.e.,* yolk-feeding) and hence food-independent larval development in the summer-spawning *T. squamosa* and *T. maxima,* which also have much larger eggs (35 percent ±1 percent and 41 percent ±2 percent by volume, respectively; Richter *et al.,* 2008).

Range, Habitat, and Distribution

Among giant clam species, *T. costata* has one of the most restricted geographical ranges, occurring only in the Red Sea. Richter *et al.* (2008) describes the species as occurring throughout the northeastern Gulf of Aqaba (type locality), Sinai coast, western Gulf of Aqaba, northern Red Sea, and Egyptian mainland down to Hurghada and Safaga.

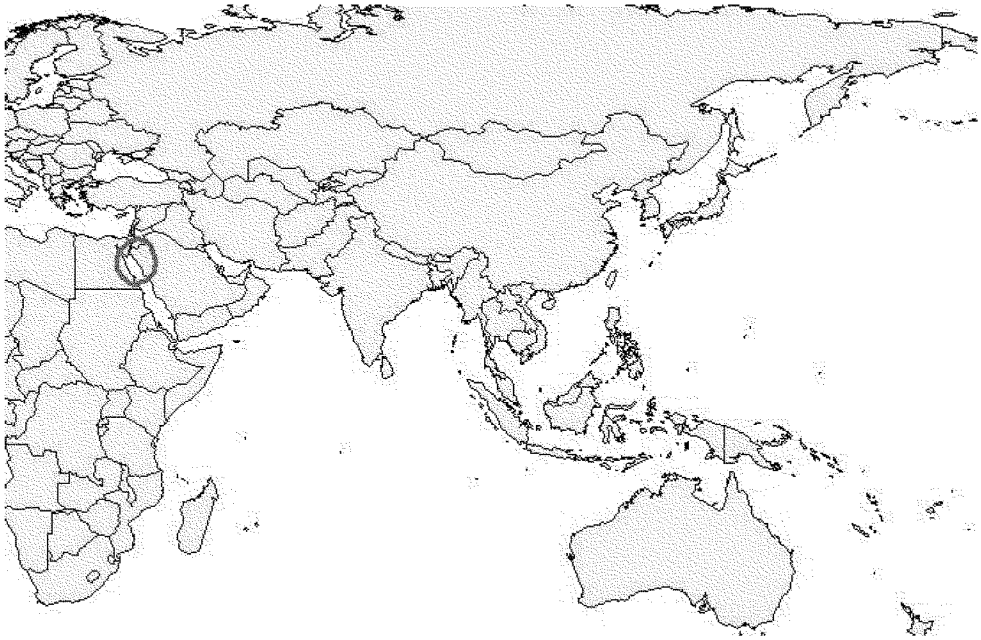

Figure 3: Geographic range of *Tridacna costata*, extracted from bin Othman *et al.* (2010).

In a survey of giant clams in the Red Sea, Richter *et al.* (2008) noted that live specimens of *T. costata* were found exclusively in very shallow water including reef flats, seagrass beds, sandy-rubble flats, on slight depressions in barren rocky flats, or under branching corals or coral heads shallower than 2m. All clams were weakly attached to the substrate. Thus, unlike its Red Sea congeners *T. maxima* and *T. squamosa,* which have broad vertical ranges of distribution, *T. costata* is restricted to the reef top (Richter *et al.,* 2008).

Population Status and Abundance Trends

Given the recent description of this species, information on its current population status and abundance trends is limited. However, one available study suggests a significant historical decline of the species. Results of surveys along the shores and well-dated emerged reef terraces of Sinai and Aqaba show that *T. costata* comprised >80 percent of giant clam stocks prior to the last interglacial period (122,000 to 125,000 years ago). Subsequently, the proportion of *T. costata* plunged to <5 percent in freshly discarded shell middens (Richter *et al.,* 2008). Currently, the species is thought to represent less than one percent of the present giant clam stocks in the Red Sea. For example, in underwater surveys conducted in the Gulf of Aqaba and northern Red Sea, only 6 out of 1,000 live specimens belonged to the new species, with densities averaging 0.9 ±0.4 individuals per 1,000 m^2. The highest numbers for the species occurred on offshore shoals in the Red Sea proper; however, adult broodstock was below detection in much of the study area (Richter *et al.,* 2008). In fact, only 13 live individuals of *T. costata* were observed along the entire Jordanian Red Sea coast, which prevented collection of paratypes (Richter *et al.,* 2008).

Threats to *T. costata*

Based on the limited information in the petition, we determined that historical and ongoing overutilization may be a threat contributing to an elevated extinction risk for this species that warrants further investigation, particularly given the species' restricted geographic range and shallow depth distribution. In general, *Tridacna* stocks in the Red Sea have declined to less than 5 percent of their sizes in the 1980s and 1990s, largely due to artisanal reef-top gathering for meat and shells (Richer *et al.,* 2008). Richter *et al.* (2008) notes that modern humans have likely been exploiting Red Sea mollusks for at least 125,000 years. Although natural disturbances may be responsible for variable rates of recruitment and mortality among the three Red Sea giant clam species, the substantial reduction in *Tridacna* size (equivalent to ~20-fold decrease in individual body mass and fecundity accompanying the species shift) strongly indicates overfishing (Richter *et al.,* 2008). Further, given that *T. costata* is restricted to the shallow reef top (and thus more accessible to reef top gathering), it is likely that overutilization of the species has contributed to its significant decline. Therefore, we conclude that the petition presents substantial information that overutilization may be a threat contributing to an elevated extinction risk for this particular species.

Conclusion

Based on the above information, we find that the petition presents substantial scientific and commercial information indicating that the petitioned action of listing *T. costata* as threatened or endangered may be warranted. Its highly restricted range, reduced abundance, low productivity (due to its narrow reproductive periodicity), and the threat of overutilization for commercial purposes may be contributing to an elevated risk of extinction such that the petitioned action may be warranted. The best available information on the species' overall population status and all potential threats will be evaluated in a forthcoming status review.

Tridacna derasa

Species Description

The petition itself does not provide any descriptive information for *T. derasa.* Neo *et al.* (2015) report that *T. derasa* is the second largest species, growing up to 60 cm with heavy and plain shells, with no strong ribbing. According to Lewis *et al.* (1998), the maximum size recorded in Fiji, 62 cm, is well above that recorded by

Rosewater (1965, 51.4 cm) who, however, had access to only few specimens. Specimens greater than 50 cm in length are relatively common.

Life History

The petition presents very limited life history information for *T. derasa.* The optimal reproductive season for *T. derasa* sampled from Michaelmas Cay was from September/October to November/December (Braley 1988). Simultaneous hermaphroditism was found in 0 to 28 percent of sampled *T. derasa.* We found no additional life history information for this species in our files.

Range, Habitat, and Distribution

The petition does not provide a description of the geographic range for *T. derasa,* but it was included in the range map provided for most of the petitioned species. The map includes all of Malaysia, but Tan & Zulfigar (2003) report that *T. derasa* is restricted to Sabah, Eastern Malaysia. Wells (1996) noted that *T. derasa* has been introduced during various mariculture efforts in areas including the United States (*e.g.,* Hawaii) and the Federated States of Micronesia. bin Othman *et al.* (2010) reports *T. derasa* from Australia, Palau, Papua New Guinea (PNG), and the Philippines. *Tridacna derasa* is noted as an introduced species in the Cook Islands and Samoa (introduced for aquaculture purposes) and also reported from Fiji, FSM, the Marshall Islands, New Caledonia, Solomon Islands, Tonga, and Vanuatu (CITES 2009).

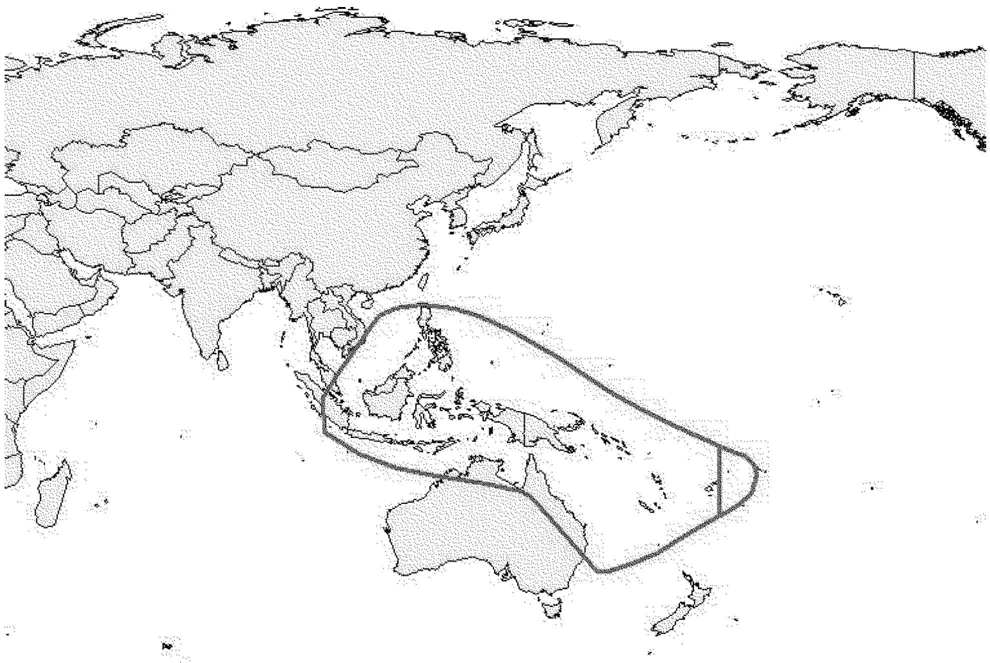

Figure 4: Geographic range of *Tridacna derasa*, extracted from bin Othman *et al.* (2010).

Tridacna derasa preferentially inhabits clear offshore or oceanic waters away from high islands with significant run-off of freshwater (Munro 1992). For example, it is not recorded from the Papuan Barrier Reef running along the south coast of PNG, nor from the fringing reefs of the north coast, but it does occur within a few miles of the southeast point of mainland PNG (Munro 1992). Large *T. derasa* were also commonly found at 10 to 20 m depth in the clear oceanic conditions of the windward islands and barrier reefs of eastern Fiji (Adams *et al.,* 1988). Lewis *et al.* (1988) reported that:

> *T. derasa* has a curious NW–SE distribution across the Indo-Malayan region, and is not found east of Tonga or in equatorial areas east of Solomon Islands. In Fiji, the species is generally confined to clear oceanic outer lagoon areas, within the protection of well-developed barrier or fringing reefs. Occurring near the surface down to 25 m, *T. derasa* occurs in greatest density in the windward (eastern) islands of the Fiji group. Very high numbers (hundreds/hectare) are occasionally noted. It is rare or absent from high island fringing reefs and lagoons where salinity and water clarity are reduced by freshwater runoff, and from unprotected areas. Until a size of typically 30 cm is reached, the species is weakly byssally attached to coral pieces or rubble.

Population Status and Abundance Trends

The petition does not provide estimates of population abundance or trends for *T. derasa;* however, the petition does provide some information on population status or trends from individual locations within the species' range. A small population of *T. derasa* (initial baseline survey counted 44 individuals) showed an annual mortality of 4.4 percent at Michaelmas Cay on the Great Barrier Reef between 1978 and 1985 (Pearson and Munro 1991). Rubec *et al.* (2001) notes that *T. derasa,* among other species, was depleted and no longer commercially harvestable in the Philippines, although the authors do not provide an original source of that information. Teitelbaum and Friedman (2008) refer to the extirpation of *T. derasa* in Vanuatu but do not provide a reference for that information. The authors also report that Vanuatu has a restocking program that includes *T. derasa.* Teitelbaum and Friedman (2008) report that the reintroduction of approximately 25,000 *T. derasa* to Yap from neighboring Palau in 1984 resulted in only approximately 8 percent survival of the introduced stock. However, these *T. derasa* matured, reproduced, and re-established viable populations on nearby reefs (Lindsay 1995). Surveys conducted by the Secretariat of the Pacific Community (PROC-Fish/C–CoFish programmes) noted the continued presence of *T. derasa* in Yap in low numbers in mid-2006.

The petitioner cites Tan and Yasin (2003), stating giant clams of all species but *T. crocea* are considered endangered in Malaysia. The authors mention underwater surveys that reveal ''distribution of giant clams are widespread but their numbers are very low,'' but the authors did not provide any references with any more detail or support for this information, which makes it difficult to interpret this information for individual species. Brown and Muskanofola (1985) found only one individual of *T. derasa* during a survey carried out in Karimun Jawa, a group of islands off the north coast of Central Java, Indonesia, surmising the species was essentially functionally extinct in this area. At another site in Indonesia, the petition cites Hernawan (2010), stating that they found small populations and evidence of recruitment failure in the six species found during a survey of Kei Kecil, Southeast-Maluku, including *T. derasa.* The authors conducted giant clam surveys in nine sites in this area. However, Indonesia encompasses thousands of islands and *T. derasa* occurs in other locations throughout Indonesia (Hernawan 2010). Therefore, these two studies represent a small sample of *T. derasa* abundance in Indonesian waters.

Hardy and Hardy (1969) did a seminal study of ecology of *Tridacna* in Palau in the 1960s where *T. derasa* and *T. gigas* made up the largest proportion of the standing crop biomass because of their size. Hester and Jones (1974) recorded densities of 50 *T. gigas* and 33 *T. derasa* per hectare at Helen Reef, Palau; the petition notes that this study was conducted before these stocks were ''totally decimated by distant-water fishing vessels,'' but provides no information or references to document this ''decimation.''

While individually and collectively, the studies discussed in this section represent a small portion of *T. derasa'*s total geographic range, the small population sizes and extirpations of this species in small areas are spread throughout its range and are not confined to one or few areas that may be disproportionately affected by some negative impact. Therefore, the number and spatial distribution of small populations or local extirpations in the context of the species' range may be contributing to an elevated extinction risk for this species such that it warrants further investigation.

Threats to *T. derasa*

Beyond the generalized threats to all giant clam species discussed above, the petition presents little information on threats to *T. derasa* specifically. According to Munro (1992), historical commercial fisheries appear to have been confined to long-range Taiwanese fishing vessels, which targeted the adductor muscles of the larger species (*e.g., T. gigas* and *T. derasa*). There are anecdotal claims in several of the references discussed above that harvest led to low population levels at certain study sites (*e.g.* Rubec *et al.,* 2001, Teitelbaum and Friedman 2008, Tan and Yasin 2003, Brown and Muskanofola 1985, and Hernawan 2010), but none of those studies provide empirical evidence of declining trends or of potential causes of low population numbers. The petition cites Lewis *et al.* (1988), stating that the Fijian fishery for *T. derasa* landed over 218 tons over a 9-year period, with the largest annual harvest totaling 49.5 tons and which is ''thought to have removed most of the available stock.'' We find this to be a slight mischaracterization of what Lewis *et al.* (1988) state about *T. derasa* in Fiji based on 26 surveys between 1984–1987:

> Tridacna derasa: Widespread throughout the group, but generally rare on the fringing reefs of the main islands where terrestrial influence is strong, and in the leeward islands (yasawas) where sheltered oceanic lagoons are generally wanting. In 1984–85, there were still abundant populations on various reefs in the windward (Lau, Lomaiviti) islands, but subsequent commercial harvest has considerably reduced these numbers. Isolated pockets still remain and should be protected. Densities on inhabited windward islands generally low, with remaining individuals in deeper water (10 m plus). Further commercial harvests for export should be prohibited.

According to CITES documents, commercial harvest for export is now prohibited in Fiji and the fisheries department cultures clams, including *T. derasa,* for restocking programs. Wild populations have been improving; currently reseeding occurs mostly in marine protected areas with 200 sites reseeded annually (CITES 2009). However, challenges remain for poaching at night.

A 2004 CITES trade review for *T. derasa* indicates that out of 11 countries where *T. derasa* is traded, one was assessed as ''Urgent Concern'' (Tonga), two as ''Possible Concern,'' and the remaining eight as ''Least Concern.'' The review also notes that international trade in *T. derasa* was reported from an additional 14 countries not selected for review and that for most countries no population monitoring seems to be in place and harvest and use of giant clams are inadequately regulated or not at all.

The petition cites Bliderg (2000), who studied the effect of increasing water temperature by 3 °C on cultured *T. derasa,* and several other species, for 24 hours. Results showed reduced gross production and decreased respiration of oxygen in response to the temperature increase however, different species of clams demonstrated different results, indicating different strategies for dealing with heat stress. None of the treated specimens exhibited any bleaching during the experiment. We acknowledge these results, but note they are not easily interpreted to determine potential individual or species level effects over time and/or space for *T. derasa.* The clams used in the experiment were cultured and not harvested from the wild. Cultured specimens are likely to experience much more uniform environments and are likely not acclimated to the common daily fluctuations in many environmental parameters experienced in the wild. As such, their responses to abrupt changes in their environment may differ from those of wild specimens. Given the heterogeneity of the species' habitat and current environmental conditions across its range, these results are not compelling evidence of a threat related to increased water temperature that is acting or will act on *T. derasa* to the extent that the petitioned action may be warranted.

Conclusion

In conclusion, the information provided on threats for this species is limited and by itself would not be considered substantial information indicating the petitioned action may be warranted. The individual studies presented are not compelling evidence of species level concerns for reasons discussed above, however, taken together they provide sufficient evidence such that further investigation is warranted. The evidence presented of small, localized populations or extirpations in different parts of the species range is compelling enough to conclude that the petitioned action may be warranted. The best available information on all potential threats to the species will be evaluated in a forthcoming status review to determine what has potentially caused the observed declines and extirpations, and the extent to which such declines have occurred.

Tridacna gigas

Species Description

Tridacna gigas is the largest of all the giant clam species, growing to a maximum shell length of 137 cm, with weights in excess of 200 kg. However, the species is most commonly found at lengths up to 80 cm (Neo *et al.,* 2015; Kinch and Teitelbam 2009). The shell exterior is off-white and is often strongly encrusted with marine growths. The shell interior is porcellaneous white, and the mantle is yellowish brown to olive green, with numerous, small, brilliant blue-green rings, particularly along the lateral edges (Kinch and Teitelbaum 2009). This species may be readily identified by its size and by the elongate, triangular projections of the upper margins of the shells (Lucas 1988).

Life History

In addition to the *Life History* section above on giant clams in general, the petition provided some species-specific life history information for *T. gigas.* The petition cited Braley (1988), who found that the optimal reproductive season for *T. gigas* sampled from Michaelmas Cay and Myrmidon Reef in Australia was October to February. Munro (1992) noted that spawning of *T. gigas* is restricted to a short summer season in the central region of the Great Barrier Reef. For *T. gigas,* von Bertalanffy growth parameter estimates include an asymptotic length (L_∞) of 80 cm, growth coefficient (K) of 0.105, and a theoretical date of 'birth' (t0) of 0.145 (Neo *et al.,* 2015). According to Branstetter (1990), growth coefficients (K) falling in the range of 0.05–0.10/yr are for slow-growing species; 0.1–0.2 for a moderate-growing species; and 0.2–0.5 for a fast-growing species. Under these parameters, the giant clam *T. gigas* is considered a moderate-growing species. However, the petition notes that there are major differences between typical non-symbiotic bivalves and *T. gigas* regarding the relative allocations of energy to respiration and growth. For example, Klumpp *et al.* (1992) showed that *T. gigas* is an efficient filter-feeder and that carbon derived from filter-feeding in Great Barrier Reef waters supplies substantial proportions of the total carbon needed for respiration and growth.

Range, Habitat, and Distribution

Prior to the rapid escalation of the aquarium trade, *T. gigas* could be found throughout the shallow tropical waters of the Indian and Pacific oceans; however, the recent fossil record, together with historical accounts show that the range of *T. gigas* has been dramatically reduced (see the *Population Status and Abundance Trends* section below; Munro 1992; bin Othman *et al.,* 2010). The species' range once extended from East Africa to Micronesia and Australia to Japan. Like other giant clam species, *T. gigas* is typically associated with coral reefs and can be found in many habitats, whether high- or low-islands, lagoons or fringing reefs (Munro 1992).

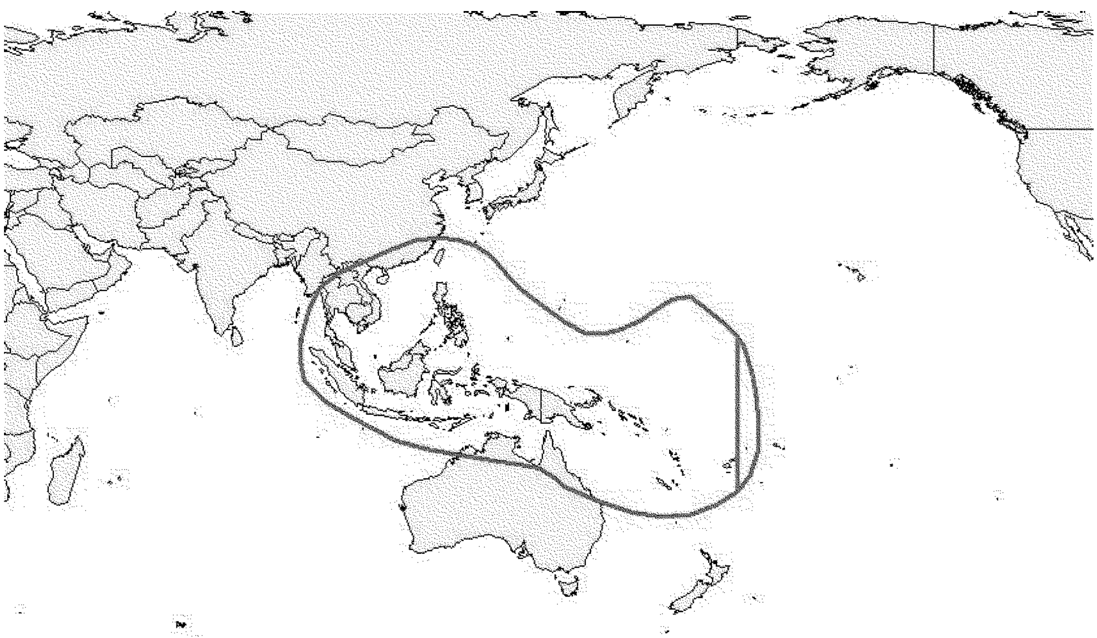

Figure 5: Geographic range of *Tridacna gigas*, extracted from bin Othman *et al.* (2010).

Population Status and Abundance Trends

The petition does not provide overall estimates of population abundance or trends for *T. gigas.* The petition does provide several lines of evidence that *T. gigas* has experienced a number of local extirpations in various locations throughout its range. Munro (1992) reports that while relict stocks of *T. gigas* occur in Indonesian, Malaysian, and Philippines waters and possibly on the west coast of Thailand and in southern Burma, in most cases it appears that these stocks are functionally extinct because of the wide dispersal of the survivors, making successful fertilization unlikely. In a more recent survey from Indonesian waters, *T. gigas* was surprisingly found in Ohoimas, where it was previously believed to be extinct (Hernawan 2010). However, only four individuals were found in only one of nine sites surveyed. Additionally, several sources (Munro 1992; Teitelbaum and Friedman 2008; Kinch and Teitelbaum 2009) note local extirpations of *T. gigas* have occurred in the Commonwealth of the Northern Mariana Islands, Federated States of Micronesia (Yap, Chuuk, Pohnpei, and Kosrae), Fiji, Guam, New Caledonia, Taiwan, Ryuku Islands (Japan), and Vanuatu. Neo and Todd (2012a, 2013) report that *T. gigas* is also nationally extinct in Singapore. In Australia, the *T. gigas* population from the Great Barrier Reef is essentially a relict population, consisting primarily of large adult clams; the lack of younger, faster-growing *T. gigas* clams is likely the reason for the species' low annual production of new biomass (Neo *et al.,* 2015). Further, Kinch and Teitelbaum (2009) also report declining stocks of *T. gigas* across the three main island groups in Kiribati.

Thus, while quantitative abundance estimates are unavailable for *T. gigas* throughout its range, the numerous local extirpations of *T. gigas* documented across a large portion of its range may be contributing to an elevated extinction risk for this species such that it warrants further investigation.

Threats to *T. gigas*

As noted previously, giant clams in general are considered a valuable fishery target in many countries, with uses for both local consumption and commercial trade. Based on information in the petition and our files, it is clear that *T. gigas* is the most heavily exploited species of all giant clams, which has likely led to its substantial declines and extirpations in a number of locations throughout its range. As discussed previously in the general threats section for giant clams, the petition emphasizes the threat of the growing giant clam industry in China, largely the result of improved carving techniques, tourism in Hainan, China, the growth in e-commerce, and the domestic Chinese wholesale market (Larson 2016). The petition also raises concerns that stricter enforcement of the trade in ivory products has diverted attention to giant clam shells (McManus 2016). The petition points out that the giant clam (*T. gigas*) is preferentially targeted for international trade due to its large size and because it is considered a desirable luxury item in China thought to confer supernatural powers and improve health. As noted previously, a pair of high quality shells (from one individual) can fetch up to US $150,000. Therefore, the high value and demand for large *T. gigas* shells may be a driving factor contributing to overutilization of the species.

Conclusion

Overall, we conclude that the information presented in the petition and our files provides substantial evidence that the petitioned action for *T. gigas* may be warranted. This species has likely experienced significant population declines and local extirpations in several locations throughout its range, likely due to historical and ongoing overutilization for commercial purposes and further investigation is warranted. The best available information on its overall status and all potential threats to the species will be evaluated in a forthcoming status review.

Tridacna squamosa

Species Description

Although the petition notes that *T. squamosa,* also known as the fluted clam, grows to 19 cm based on Neo *et al.* (2015), we find this information is in error. Neo *et al.* (2015) report shell lengths of up to 40 cm for the species, and information in our files suggests it is most commonly found at lengths up to 30 cm (Kinch and Teitelbaum 2009). The shell exterior is described as ''greyish white, often with different hues of orange, yellow, or pink to mauve, and with the blade-like scales commonly of different shades or color'' (Kinch and Teitelbaum 2009). The shell interior is porcelaneous white, occasionally tinged with orange, and the mantle is mottled in various mixes of green, blue, brown, orange, and yellow (Kinch and Teitelbaum 2009).

Life History

Aside from the general giant clam life history information already discussed previously in the *Giant Clam Life History* section, the petition provided little information specific to *T. squamosa. Tridacna squamosa* is a mixotroph whose photoautotrophic range is extended by heterotrophy. We found that *T. squamosa* reaches sexual maturity at sizes of 6 to 16 cm, which equates to a first year of maturity at approximately 4 years old (CITES 2004a).

Range, Habitat, and Distribution

Tridacna squamosa has a widespread distribution across the Indo-Pacific, but is slightly more restricted than *T. maxima* (Munro 1992). Its range extends from the Red Sea and East African coast across the Indo-Pacific to the Pitcairn Islands. It has also been introduced in Hawaii (CITES 2004a). The species' range also extends north to southern Japan, and south to Australia and the Great Barrier Reef (bin Othman *et al.,* 2010). This range description reflects the recent range extension of *T. squamosa* to French Polynesia as a result of observations by Gilbert *et al.* (2007). The petition notes that *T. squamosa* occurred in Singapore and the United States historically; however, there is no supporting reference or evidence provided of the species' occurrence in the United States or its territories.

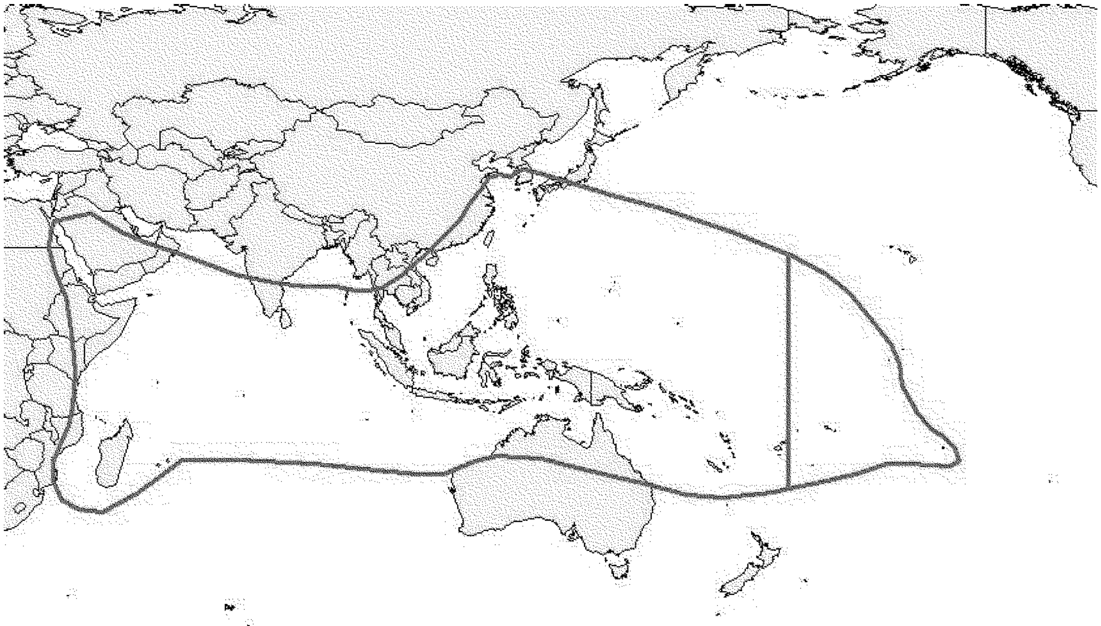

Figure 9: Geographic range of *Tridacna squamosa*, extracted from bin Othman *et al.* (2010).

Tridacna squamosa is usually found near reefs or on sand; it is found attached by its byssus to the surface of coral reefs, usually in moderately protected areas such as reef moats in littoral and shallow water to a depth of 20 m (Kinch and Teitelbaum 2009). This species tends to prefer fairly sheltered lagoon environments next to high islands; however, *T. squamosa* appears to be excluded by *T. maxima* in the closed atoll lagoons of Polynesia (Munro 1992). Neo *et al.* (2009) found that *T. squamosa* larvae, like many reef invertebrates, prefer substrate with crustose coralline algae. *Tridacna squamosa* is also commonly found amongst branching corals (staghorn, *Acropora* spp.; CITES 2004a)

Population Status and Abundance Trends

The petition provides limited some information regarding the species' population status and trends from Singapore, Samoa, and individual sites in Malaysia, Philippines, Indonesia, and Thailand.

The petitioner states that *T. squamosa* is functionally extinct in Samoa based on a study from western Samoa (Zann and Mulipola 1995). This study relied on a range of low technology methods developed for rapid environmental and fisheries assessments. Fisheries surveys were conducted via interviews and surveys of fishermen and households, and results were compared with commercial market landings from the Apia municipal fish market on the island of Upolu. From 1985 to1990, annual landings of all giant clams dropped from 10 metric tons to 0.1 metric tons and field surveys indicated that *T. squamosa* was so rare it was functionally extinct. The authors note that fishing effort also declined around 35 percent between 1983 and 1991, which is considered to be partially responsible for the declines in landings, although other factors likely contributed (*e.g.,* overfishing of inshore stocks, use of destructive fishing techniques, etc.). Information in our files suggests that this species has been the subject of restocking efforts in Samoa. Since 1988, *T. squamosa* has been trans-located from Palau, Tokelau, and Fiji to restock populations in Samoa under the Samoan Community-based Fisheries Management program (Kinch and Teitelbaum 2009).

In Singapore, Neo and Todd (2012a) surveyed 29 reefs, covering an estimated 87,515 m^2 and observed 28 *T. squamosa* individuals, which was double the number observed in a 2003 survey of only 7 reefs and a little over 9,000 m^2 by Guest *et al.* (2008). However, Neo and Todd (2012a) estimate *T. squamosa* density to be 0.032 per 100 m^2, which is five times lower than the 0.16 per 100 m^2 measured in 2003 (Guest *et al.,* 2008). They go on to propose that habitat loss, exploitation, and or sediment have synergistically led to the endangered status of *T. squamosa* in Singapore's waters. Neo and Todd (2013) make a similar conclusion, stating that "the low density and scattered distribution of the remaining *T. squamosa* in Singapore are likely to significantly inhibit any natural recovery of local stocks." However, the authors specifically make the point that the status of a species at a small scale (individual country or an island as may be the case for Singapore) is most often not representative of its global status. Any species, especially one with a large range like *T. squamosa,* will have variable statuses at smaller scales in different habitats due to a variety of factors. Singapore is a small and densely populated island nation known for particularly high anthropogenic impacts in its nearshore waters. The information in Neo and Todd (2012a 2012b and 2013) is informative for resource managers in Singapore and indicates a very low population and density of *T. squamosa.* However, it is unclear how the current information relates to historical abundance of this species at this location. In addition, it is not necessarily useful for assessing the global status of *T. squamosa* because Singapore is a very small proportion of the overall species' range and is not a representative environment of the rest of the species' range.

The petitioner cites Tan and Yasin (2003), stating that giant clams of all species but *T. crocea* are considered endangered in Malaysia. As discussed previously, the authors of this study mention underwater surveys that reveal that the ''distribution of giant clams are widespread but their numbers are very low.'' However, there are no references provided by the authors to provide any more detail or support for this information, which makes it difficult to interpret this information for individual species. The only species-specific information for *T. squamosa* in this reference is that it occurs in Malaysian waters.

The petitioner cites Thamrongnavasawat *et al.* (2001) as saying *T. squamosa* are now considered ''scarce'' throughout Thailand. However, the link provided in the bibliography to access this reference was not functional, and we were otherwise unable to obtain and review this reference to determine what the authors meant by ''scarce'' or on what evidence this statement was based. However, the petitioner provides other studies from Thailand indicating that the species has likely undergone significant declines in this area. For example, Chantrapornsyl *et al.* (1996) documented heavy exploitation and local extirpation of *T. squamosa* in the Andaman Sea. Kittiwattanawong (1997) also concluded that *T. squamosa* was rare in the same area. *Tridacna squamosa* was also deemed ''near extinct'' in Mo Ko Surin National Park in Thailand (Dolorsa and Schoppe 2005).

Villanoy *et al.* (1988) examined average size frequency distributions of *T. squamosa* harvested from the Sulu Archipelago and Southern Palawan areas in the Philippines from 1978 to 1985, and determined that estimates of exploitation rates indicate that populations of these species are overexploited. The petitioner asserts that these findings have serious implications given that the Sulu Archipelago and Southern Palawan are thought to be the last strongholds of giant clams species occurring in Philippine waters. Dolorosa and Schoppe (2005) also report that *T. squamosa* had very low densities in surveys conducted in Tubbataha Reef National Marine Park in the Philippines. The authors note that because of the species' low settlement, survival and growth on live coral substrate, it would take hundreds of years for the stock to be re-established, particularly in isolated areas. However, the authors also note that the numbers seen at Tubbataha Marine Park are significantly lower than in other areas of the Philippines; therefore, the situation in the marine park may not be representative of the species' status across the Philippines as a whole (Dolorosa and Schoppe 2005). The petitioner also cited a stock assessment conducted in Eastern Visayas, in the Philippines (Salazar *et al.,* 1999), which showed that while *T. squamosa* are common in the Samar Sea and San Pedro Bay, most of the giant clams surveyed were in the juvenile stage with no breeders left to repopulate the area. However, the Marine Science Institute (MSI) at the University of the Philippines has a long and successful record of rearing, having cultured giant clams to restore depleted supplies for the last 20 years. In fact, more than 40 sites have received cultured clams and MSI promotes giant clam farming as a sustainable livelihood with restocking activities occurring in collaboration with local groups (bin Othman *et al.,* 2010).

As discussed previously, the petition also broadly states that all six giant clam species occurring in Indonesia, including *T. squamosa,* are experiencing recruitment failure based on a single study from Kei Kecil, Southeast-Maluku, Indonesia (Hernawan 2010). Hernawan (2010) conducted giant clam surveys in 9 sites; however, Indonesia encompasses thousands of islands and *T. squamosa* occurs in several other locations throughout Indonesia (Hernawan 2010). Thus, this study represents a very small sample of *T. squamosa* abundance in Indonesian waters, with no evidence provided to suggest that recruitment failure of *T. squamosa* is occurring throughout Indonesia.

Overall, given the extensive range of *T. squamosa,* the information provided in the petition is limited regarding the population status and abundance trends of the species throughout its range. While we acknowledge that in some locations (primarily Southeast Asia), abundance and/or density of *T. squamosa* may be low, the petition did not provide any information regarding the species' status from a large majority of its range. For example, in addition to countries in Southeast Asia, *T. squamosa* can be found throughout Oceania (*e.g.,* Australasia, Melanesia, Micronesia and Polynesia). The species also inhabits coastlines of the Indian Ocean and has a relatively cosmopolitan distribution in this region (bin Othman *et al.,* 2010). Thus, no information was presented in the petition for an entire two thirds or more of the species' range (*i.e.,* Oceania (with the exception of Samoa), eastern Africa, and the Indian Ocean). However, a lack of information on its own does not mean the action may not be warranted if the lack of information itself may be considered a risk to the species. In this case, given that the only information we have indicates historical declines, low population levels, and notably local extirpations in some locations, we conclude that the information presented in the petition regarding the species' abundance and population trends is compelling enough to warrant further investigation in a forthcoming status review.

Threats to *T. squamosa*

Given that *T. squamosa* is a large, free-living species of giant clam, it is easier to remove from the reef (Neo and Todd 2013), which makes it more susceptible to harvest for local consumption and/or commercial purposes. Some information (albeit limited) provided by the petition suggests that *T. squamosa* may be overexploited in some locations. As discussed earlier in the *Population Status and Abundance Trends* section for *T. squamosa,* estimates of exploitation rates from the Sulu Archipelago and Southern Palawan areas of the Philippines from 1978 to 1985 indicate that populations of *T. squamosa* were overexploited.

Information in our files indicates that *T. squamosa* is important in the subsistence fishery of Papua New Guinea. A commercial fishery for giant clams previously operated in the Milne Bay Province, whereby approximately 150 tonnes of giant clam adductor muscle were exported, as well as one large shipment of 16 tonnes of giant clam shells. However, this fishery has been closed since 2000 and we could not find any additional information in our files regarding the utilization of *T. squamosa* in Papua New Guinea. We also found some information regarding the reported functional extinction of this species in Samoan waters, and acknowledge that the significantly low density of *T. squamosa* in Samoa is largely attributed to overfishing (Kinch and Teitelbaum 2009); however, as noted previously, to mitigate low populations, restocking efforts have been underway in Samoa since the 1980s, and from 1998 to 2000, Samoa has seen the importation of several giant clam species, both larvae and 'yearlings,' for restocking purposes under the Samoan Community-based Fisheries Management program (Kinch and Teitelbaum 2009). Nevertheless, we cannot confirm whether this restocking program has been successful for *T. squamosa.*

In terms of commercial trade, a significant trade review was conducted in 2004 for 27 countries that trade in *T.*

squamosa to identify potential areas of concern. Of the 27 countries reviewed, 24 were deemed to be of ''least concern'' for various reasons; the respective countries had either not reported any trade, or trade levels were minimal or export numbers were low. Two countries (Marshall Islands and Tonga) were deemed to be of ''possible concern'' and only one country (Vietnam) was categorized as ''urgent concern.'' These designations were made largely because trade of the species continues despite export bans or because, in the case of Vietnam, significant trade was occurring (*e.g.,* 74,579 live *T. squamosa* clams were exported from 1994 to 2003) with a lack of information on population monitoring or the basis for non-detriment findings under CITES. Additionally, in the case of the Marshall Islands, where trade seems to continue despite export bans, the review also notes that several small-scale operations were producing farmed (*i.e.,* captive-bred) *T. squamosa* in the 1990s for the aquarium trade and for reseeding depleted areas, and that records of trade in wild rather than captive-bred specimens may be a result of misreporting by importing parties (CITES 2004a). Based on the information presented in the petition and in our files summarized here, we cannot conclude that there is sufficient evidence to suggest that trade of *T. squamosa* is an operative threat that acts or has acted on the species to the point that the petitioned action may be warranted.

Overall, the species-specific information in the petition and in our files to support the claim that *T. squamosa* is experiencing overutilization to the point that the petitioned action may be warranted is limited, particularly given the broad geographic range of the species. While there are anecdotal claims in several of the references that are discussed above that low population levels at certain study sites are due to harvest (*i.e.,* Teitelbaum and Friedman 2008, Tan and Yasin 2003, and Hernawan 2010), none of those studies provide empirical evidence of declining trends.

In addition to overutilization, the petitioner also claims that *T. squamosa* is at risk of extinction due to climate change-related threats, including ocean warming and acidification. In Singapore, local bleaching of *T. squamosa* was observed during a high sea surface temperature event in June 2010 (Neo and Todd 2013); however, no other information was provided regarding the extent of bleaching that occurred nor whether the species experienced significant mortality as a result. In a lab experiment using cultured clams, short-term temperature increases of 3 °C resulted in *T. squamosa* clams maintaining a high photosynthetic rate but displaying increased respiratory demands (Elfwing *et al.,* 2001). Finally, Watson *et al.* (2012) showed that a combination of increased ocean CO_2 and temperature are likely to reduce the survival of *T. squamosa.* Specifically, in a lab experiment, *T. squamosa* juvenile survival rates decreased by up to 80 percent with increasing pCO_2 and decreased with increasing seawater temperature for a range of temperatures and pCO_2 combinations that mimic those expected in the next 50 to 100 years.

We acknowledge these results, but they are not easily interpreted into potential species level effects over time and/or space for *T. squamosa.* First, the clams used in the experiments were cultured and not harvested from the wild. Cultured specimens are likely to experience much more uniform environments and are likely not acclimated to the common daily fluctuations in many environmental parameters experienced in the wild. As such, they may react differently than wild specimens to abrupt changes in their environment. Additionally, information and references in our files acknowledge that there are limitations associated with applying results from laboratory studies to the complex natural environment where impacts will be experienced gradually over the next century at various magnitudes in a non-uniform spatial pattern. In general, lab experiments presented do not reflect the conditions the petitioned species will experience in nature; instead of experiencing changes in levels of ocean warming and acidification predicted for the end of the century within a single generation, species in nature are likely to experience gradual increases over many generations. However, we recognize that because giant clam species are likely long-lived, they likely have longer generation times, and thus, giant clams born today could potentially live long enough to experience oceanic conditions predicted late this century (Watson *et al.,* 2012). Overall, the information regarding negative species-specific impacts from climate change to *T. squamosa* is limited; however, we will thoroughly review climate change related threats and their potential impacts to *T. squamosa* in a forthcoming status review.

Conclusion

In conclusion, the information provided on threats for this species is limited and by itself would not be considered substantial information indicating the petitioned action may be warranted. However, combined with the evidence presented of small, localized populations or extirpations in different parts of the species' range, we conclude the information presented in the petition is compelling enough to conclude that the petitioned action may be warranted. Therefore, we conclude that the number and spatial distribution of localized severe declines or extirpations in the context of the species' range may be contributing to an elevated extinction risk for this species such that it warrants further investigation. Thus, the best available information on overall status and potential threats to the species will be evaluated in a forthcoming status review to determine what has potentially caused these declines and extirpations and the overall extinction risk for the species.

Tridacna tevoroa

Species description

Tridacna tevoroa is another recently described species that has been shown to actually be a junior synonym of a previously described species, *T. mbalavauna* (Borsa *et al.,* 2015a). The petition notes that *T. tevoroa* looks most like *T. derasa* in appearance, but can be distinguished by its rugose mantle, prominent guard tentacles present on the incurrent siphon, thinner valves, and colored patches on shell ribbing (Neo *et al.,* 2015). *T. tevoroa* has an off-white shell exterior, often partially encrusted with marine growths. The shell interior is porcellaneous white, with a yellowish brown mantle (Kinch and Teitelbaum 2009). It can grow to just over 50 cm long (Neo *et al.,* 2015).

Life History

Aside from what has already been discussed in terms of life history information for giant clams in general (refer back to the *Giant Clam Life History* section above), the petition did not describe any species-specific life history information for *T. tevoroa.* However, in one of the references cited by the petitioner we found some additional information related to spawning of *T. tevoroa* clams. During a study of spawning and larval culture of *T. tevoroa* (Ledua *et al.,* 1993), successful spawning of *T. tevoroa* at the Tonga Fisheries Department in late October 1991 indicates that this species has a breeding season that may be similar to that of *T. derasa.* Ledua *et al.* (1993) describe that the breeding season of *T. derasa* on the Great Barrier Reef in Australia is from late winter-early spring to early summer and virtually all individuals are spent by mid-December. In Fiji, the breeding program for this species is from July to October and in Tonga from September to late November (Ledua *et al.,* 1993). It must be noted that the examples of the breeding season of *T. derasa* given here are from higher latitudes within the tropics (17°-21°S), while there is evidence from hatchery spawnings at lower latitudes (Palau, 7°N) that *T. derasa* has an almost full year breeding season (Heslinga *et al.,* 1984 cited in Ledua *et al.,* 1993).

Range, Habitat, and Distribution

Tridacna tevoroa appears to have a restricted distribution. Although the petition says that *T. tevoroa* is restricted to Tonga and Fiji, information in our files indicates that this species was recently observed in the Loyalty Islands of New Caledonia as well (Kinch and Tietelbam 2009). *Tridacna tevoroa* can typically be found on sand in coral reef areas. In Fiji, *T. tevoroa* live along outer slopes of leeward reefs, in very clear, oceanic water at 9–33 m depth (Ledua *et al.,* 1993). Based on the distribution of adults in Fiji and Tonga, it appears that juveniles settle on slopes of off-shore reefs in deep (down to 33 m) oceanic waters. However, juvenile *T. tevoroa* have never been found in nature (Klump and Lucas 1994).

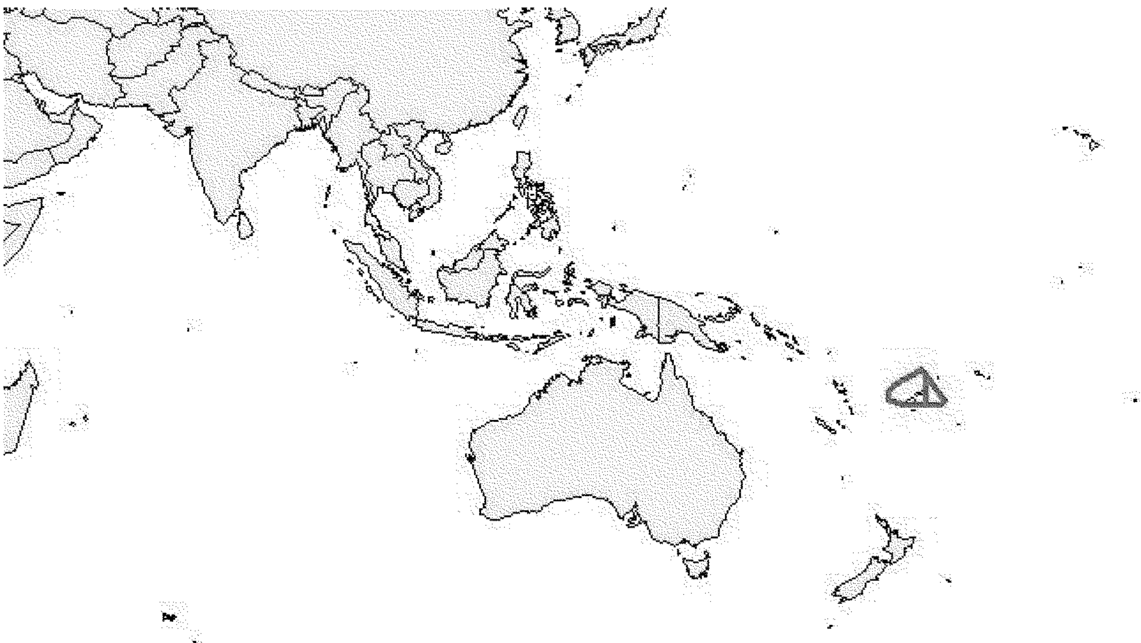

Figure 6: Geographic range of *Tridacna tevoroa*, extracted from bin Othman *et al.* (2010). Note this does not reflect the more recent observation of the species in New Caledonia.

Tridacna tevoroa has a unique depth distribution among the giant clam species; it is the only species to occur in depths below 20 m. In order to better understand how *T. tevoroa* survives in deeper waters, Klumpp and Lucas (1994) compared nutrition of *T. tevoroa* with *T. derasa* in Tonga, where rates of filter-feeding, respiration and the photosynthesis-irradiance response were measured in clams of a wide size range (ca 20 mm to ca 500 mm). Only *T. tevoroa* significantly increased its photosynthetic efficiency with increasing depth. In a study on spawning and larval culture of *T. tevoroa* clams, individuals were collected from waters of Fiji and Tonga (Ledua *et al.,* 1993). The mean depth of clams collected in Fiji was 27.4 m, with samples collected from depths ranging from 20 to 33 m. All specimens were found on the leeward side of reefs and islands. Ledua *et al.,* (1993) notes that: ''Many of the clams found in Tonga were adjacent to the edge of a sand patch and cradled against rocky outcrops, rubble or bare rock with steep slopes.'' During the SCUBA search in February 1992 in Ha'apai (Tonga), two of the authors notably found a considerable number of *T. tevoroa* on live coral (whereas in Fiji, these clams have not been found on live coral, possibly because little live coral was found at this depth in the Lau Islands group). About half of the clams in Tonga were found on the leeward and half on the windward side of reefs. However, windward sides of reefs were still somewhat protected within barrier islands or reefs, and no search has yet been made on outer windward reefs (Ledua *et al.,* 1993). Overall, spatial distribution of *T. tevoroa* appears to be very sparse, with single individuals being found at most locations, although clumps of four individuals were seen twice and other smaller clumps were seen in Tonga, which could represent small breeding groups for this species (Ledua *et al.,* 1993). Given the large areas of suitable reefs and shoals with typical habitat for *T. tevoroa,* Ha'apai, Tonga may be the center of distribution and largest repository of this newly-described species (Ledua *et al.,* 1993).

Population Status and Abundance Trends

The petition provides only one reference for *T. tevoroa* with regard to its population status or abundance trends. Ledua *et al.* (1993) describes *T. tevoroa* as a rare species and notes that few specimens have been found live in Fiji, and only recently larger numbers of this species have been found in Tongan waters. Anecdotal reports from one diver from Uiha Island, Ha'apai, Tonga note that the species was historically more abundant in shallow waters during the 1940s (Ledua *et al.,* 1993). Based on this limited information, the petitioner speculates that *T. tevoroa* has declined significantly in accessible waters and states that the species' current abundance is likely lower than historical levels. However, the petitioner did not provide any additional references or supporting information to substantiate the claim regarding the species' current population status. The petitioner also provided no additional information regarding the species' population status or abundance trends from other portions of its range (*i.e.,* Fiji or New Caledonia). Nonetheless, given that the species is described as rare, has one of the most restricted ranges of the giant clam species, and has likely undergone some level of population decline in its potential center of distribution (*i.e.,* Tonga), we find this information may indicate an elevated extinction risk for this species, and is compelling enough to warrant further investigation.

Threats to *Tridacna tevoroa*

Very little species-specific information on threats is presented in the petition for *T. tevoroa.* Aside from what has already been discussed regarding the threat of overutilization of giant clams in general (refer back to the *Threats to Giant Clams* section above), the petition provides very limited species-specific information regarding overutilization of *T. tevoroa* for commercial, recreational, scientific, or educational purposes. As noted previously in the *Abundance and Population Trends* section, anecdotal reports from one diver from Uiha Island, Ha'apai, Tonga note that the species was historically more abundant in shallow waters during the 1940s. Evidence of former greater abundance and distribution in shallow water in Ha'apai may indicate that fishing pressure has likely contributed to the rarity of this species (Ledua *et al.,* 1993). This is extremely limited information to suggest that overutilization is a threat to the species, particularly given the lack of information from Fiji and New Caledonia; however, given that Ha'apai Tonga is likely the center of distribution and largest repository for this particular species, we find that this information, combined with the species' rarity throughout its range, may be contributing to an elevated risk of extinction for this species.

Conclusion

In conclusion, the information provided on threats for this species is limited and by itself would not be considered substantial information indicating the petitioned action may be warranted. Anecdotal evidence from one location of a species' range would generally not be compelling evidence of species level concerns throughout its range for reasons discussed above. However, the combined evidence on the species' restricted range, sparse distribution and rarity, and anecdotal evidence of population decline in the center of the species' distribution, is compelling enough to conclude that the petitioned action may be warranted. The best available information on its overall status and all potential threats to the species will be evaluated in a forthcoming status review.

Tridacna crocea

Species description

Tridacna crocea is the smallest species of giant clam, reaching only 15 cm (Neo *et al.,* 2015; Copland and Lucas 1988). The species is similar to *T. maxima* but smaller, less asymmetrical and with its scutes worn away except near the upper edge of the shell (Copland and Lucas 1988). The shell exterior is: ''greyish white, often covered with yellow or pinkish orange and frequently encrusted with marine growths near the dorsal margins of valves, but clean and nearly smooth ventrally'' (Kinch and Teitelbaum 2009). The shell interior is porcellaneous white, sometimes with yellow to orange hues on margins. The mantle is often brightly colored and variable in both pattern and color, including shades of green, blue, purple, brown, and orange (Kinch and Teitelbaum 2009).

Life History

The petition provided some species-specific information regarding *T. crocea's* life history. The petition noted that spawning of *T. crocea* in the central region of the Great Barrier Reef is thought to be restricted to a short summer season (Munro 1992), and *T. crocea* has been observed spawning during July in Palau (Hardy and Hardy 1969). In a detailed study of early life history in Guam, fertilized eggs of *T. crocea* had a mean diameter of 93.1µm (Jameson 1976). This same study noted that settlement of *T. crocea* larvae occurred approximately 12 days after fertilization.

We found a limited amount of additional information in our files on the life history of this species. *Tridacna crocea* has the smallest size for adult giant clams and reaches full sexual maturity (hermaphroditism) at approximately 5 to 6 years of age. With reports that *T. crocea* individuals of approximately 8 to 9 cm shell length produce 3 to 4 million eggs (Tisdell 1994), this species has extremely high fecundity. As such, even with relatively high mortality rates, tridacnid populations like *T. crocea* can be rapidly increased by artificial breeding and culture programs (Tisdell 1994).

Range, Habitat, and Distribution

Tridacna crocea has a large range, with distribution ranging from southern Japan to Australia, but not extending eastward into Oceana beyond Palau and the Solomon Islands (Munro 1992). The petition provides information on this species from Singapore, Malaysia, Philippines, Indonesia, Thailand, and Palau. We also found additional information in our files for *T. crocea* from Australia, Solomon Islands, Vanuatu, New Caledonia, Papua New Guinea, and Tonga.

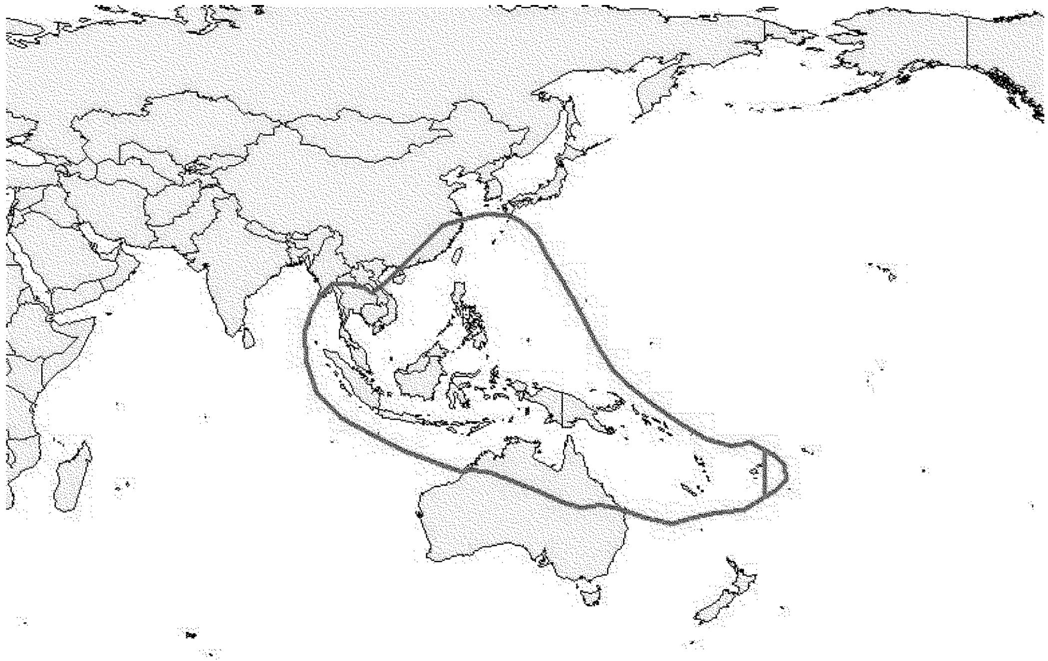

Figure 7: Geographic range of *Tridacna crocea*, extracted from bin Othman *et al.* (2010).

Tridacna crocea is unusual among other giant clam species in that it burrows deeply in coral masses of reef flats and coral heads (with the free valve margins nearly flush with the substrate surface) in shallow water to a depth of about 20 m (when the water is clear; Copland and Lucas 1988; Kinch and Teitelbaum 2009; Neo *et al.,* 2015). According to Hamner and Jones (1974), *T. crocea* burrows as it grows, eroding the surfaces of coral boulders and producing structures that superficially resemble micro-atolls. In a study conducted in Indonesia, *T. crocea* individuals were mostly embedded in dead coral boulders covered by algae (82 percent), with a few living in *Porites* spp., coral rubble, and live coral substrate (only 1 percent; Hernawan 2010). This species remains attached to the substrate throughout its life (Copland and Lucas 1988). The species also appears to aggregate, though the mechanism is unclear. Aggregation (*i.e.,* clumping) may enhance physical stabilization, facilitate reproduction, or provide protection from predators (Soo and Todd 2014).

Population Status and Abundance Trends

The petition does not provide overall estimates of population abundance or trends for *T. crocea*. The petition does provide limited pieces of information regarding the species' population status and trends from Singapore, Malaysia, Philippines, Indonesia, Thailand, and Palau. The petitioner cites Neo and Todd (2012; 2013) to assert that *T. crocea* is likely functionally extinct in Singapore, as the species is reproductively isolated and unlikely to fertilize conspecifics. In the most recent status reassessment of giant clams, Neo *et al.* (2013) note that *T. crocea* surveys in Singapore from 2009/2010 put their density at a low 0.035 per 100 m², but emphasize that abundance estimates for this species may be conservative as its burrowing behavior and cryptic coloration can lead to underestimates of abundance. Nonetheless, the species' population is considered to be small in Singapore, resulting in an endangered status locally. However, the authors specifically make the point that the status of a species at a small scale (individual country or an island as may be the case for Singapore) is not necessarily representative of its global status. Any species, especially one with a large range like *T. crocea,* will have variable statuses at smaller scales in different habitats due to a variety of factors. Singapore is a small and densely populated island nation known for particularly high anthropogenic impacts in its nearshore waters. The information in Neo and Todd (2012a 2012b and 2013) is informative for resource managers in Singapore and indicates a very low population and density of *T. crocea.* However, it is unclear how the current information relates to historical abundance of this species at this location. In addition, it is not necessarily useful for assessing the global status of *T. crocea* because Singapore is a very small proportion of the overall species' range and is not a representative environment of the rest of the species' range.

The petition also asserts that *T. crocea* has declined by 94 percent in the Tubbataha Reef Park in the Philippines since the early 1990s based on a decline from 2,200,000 clams/km² in 1993 (Calumpong and Cadiz 1993) to 133,330 clams/km² in 2005 (Dolorosa and Schoppe 2005). It should be noted that these numbers were derived from transects taken within the ''intertidal area'' of the park. Dolorosa and Schoppe (2005) characterized *T. crocea* as the most abundant and dense giant clam species in the study area, with 133,330 individuals per km² in the intertidal area, and averaging 30,480 individuals per km² in the shallow area (5 m). Dolorosa and Schoppe (2005) also noted that the much lower density observed in their study (as compared to the previous study by Calumpong and Cadiz (1993)) in the intertidal area is not enough to conclude that there is a continuous decline of tridacnids (including *T. crocea*) because the data were only taken from a single transect. Thus, their study is not likely representative of the entire intertidal area, let alone the entire Tubbataha Reef Park. Therefore, the petition's inference of a 94 percent decline in *T. crocea* abundance in Tubbataha Reef Park based on a single transect is not supported. Additionally, Rubec *et al.* (2001) characterizes *T. crocea* as one of the most abundant giant clam species across the Philippines.

The petition also broadly states that all six giant clam species occurring in Indonesia, including *T. crocea,* are experiencing recruitment failure based on one study from Kei Kecil, Southeast-Maluku (Hernawan 2010). Hernawan (2010) conducted giant clam surveys in nine sites throughout Kei Kecil waters. Results showed *T. crocea* to be the dominant species with the highest population density in each of the nine study sites. Similar results have been documented in other areas of Indonesia, including the Andaman Sea, Upanoi and Banchungmanee, Adang Islands and Seribu Islands, Raja Ampat (Hernawan 2010) and Pari Island (Eliata *et al.,* 2003). Additionally, Indonesia is comprised of thousands of islands; thus, the Hernawan (2010) study cited by the petitioner represents a very small sample of *T. crocea* abundance in Indonesian waters, with no evidence provided to suggest that recruitment failure of *T. crocea* is occurring throughout Indonesia. Hernawan (2010) also noted that due to *T. crocea*'s small size and burrowing behavior, fishermen find this particular species more difficult and less desirable to harvest. Thus, this species is not the main target for Indonesian fishermen, leading to it having the highest relative population density throughout the study area (Hernawan 2010).

Finally, the petition notes that *T. crocea* was the only giant clam with a stable population in Malaysia and not considered ''endangered'' by the early 2000s and that the species was still abundant in Thailand's Mo Ko Surin National Park in the late 1990s (Tan and Yasin 2003; Thamrongnavasawat 2001). Additionally, Hardy and Hardy (1969) described *T. crocea* as the most frequent and abundant giant clam species in Palau in the 1960s. No additional information could be found in the petition or in our files pertaining to more recent trends for *T. crocea* in these locations to indicate low abundance or declining population trends.

In our own files, we found that *T. crocea* is one of the most abundant species of giant clam in New Caledonia (Kinch and Teitelbaum 2009). In Papua New Guinea, information on stock status is limited with the exception of Milne Bay, where *T. crocea* was also considered the most abundant species. *T. crocea* is also found in Vanuatu, where, although all stocks of giant clam are generally regarded as declining, improvements have been noted in specific localities (Kinch and Teitelbam 2009); however, we could find no additional information specific to *T. crocea.* In a 2004 CITES assessment of international trade of the species, *T. crocea* was described in general as ''still reasonably abundant'' (CITES 2004b).

Overall, the information regarding *T. crocea*'s population status and abundance trends throughout its range is extremely limited, with most characterizations of this species' abundance being qualitative. Nonetheless, it appears, based on the information presented in the petition and in our files, that *T. crocea* is often the dominant giant clam species wherever it occurs, has some of the highest population densities of any species, and is the only species of giant clam with a stable population in Malaysia. Although information suggests *T. crocea* likely experienced a localized abundance decline in Okinawa, Japan, which represents a very small portion of the species' range, we could not otherwise find any information to indicate that the species' overall abundance or density is so low or declining so significantly that the petitioned action is warranted. Thus, we find the petition insufficient in terms of presenting substantial information that *T. crocea*'s population status or abundance trends indicate that the petitioned action may be warranted.

Threats to *Tridacna crocea*

Factor A: Present or Threatened Destruction Modification, or Curtailment of Range

The petition asserts that all species of giant clam, including *T. crocea,* are at risk of extinction throughout their ranges due to the threat of habitat destruction, largely as a result of threats related to climate change and coral reef habitat degradation. However, the petition does not provide any species-specific information with regard to how habitat destruction is negatively impacting *T. crocea* populations. As described previously, *T. crocea* does not appear to have an obligate relationship to a pristine, live coral reef habitat. In fact, *T. crocea* has been observed in a number of habitat types, including dead coral rubble covered in algae. Thus, and as noted previously, while the information in the petition is otherwise largely accurate and suggests concern for the status of coral reef habitat generally, its broadness, generality, and speculative nature, and the lack of reasonable connections between the threats discussed and the status of *T. crocea* specifically, means that we cannot find that this information reasonably suggests that habitat destruction is an operative threat that acts or has acted on the species to the point that the petitioned action may be warranted.

Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The petition contends that *T. crocea* warrants listing as a result of overutilization for commercial purposes, but only notes three locations in which overfishing of *T. crocea* is reportedly occurring (Fiji, Japan, and Vietnam) based on bin Othman *et al.* (2010). In a market evaluation conducted in the mid-1990s in Japan, *T. crocea* was considered a preferred species for use as sashimi and sushi dishes in Okinawa; in contrast, giant clams were unknown as a food source in mainland Japan. From 1975 to 1995, giant clam catches in Okinawa, Japan declined from 578 tons to 28 tons, likely due to stock depletion (Okada 1998). Given that *T. crocea* comprises approximately 90 percent of the giant clams landed in Okinawa, it is likely that the species experienced historical overfishing in this location. Although overfishing of *T. crocea* may have occurred historically in Okinawa waters, mass seed culture and production of *T. crocea* have been undertaken in Japan to ensure natural stock enhancement, with 44,000–459,000 seeds of *T. crocea* distributed to the fishermen's cooperatives annually from 1987 to 1995 for release into Okinawa waters (Okada 1998). Survival of clams ranged up to 56 percent 3 years after release (Teitelbaum and Friedman 2008). Without any data since 1995, it is difficult to determine whether this fishery is ongoing, the success rate of the local restocking efforts, or the current status of *T. crocea* stocks in Okinawa. Nonetheless, Okinawa, Japan represents a very small portion of the species' overall range and it appears Japan has implemented some regulations and conservation efforts to help safeguard giant clam populations from overfishing.

Aside from Japan, no other information or data is provided in the petition from Fiji or Vietnam to support the broad statement that overfishing of *T. crocea* is occurring in those locations, although we did find some trade data to indicate that *T. crocea* is subject to commercial trade in these areas (CITES 2004b). From 1994 to 2003, exports of *T. crocea* were recorded for 24 countries and territories. However, only ten of the 24 countries were selected for a significant CITES trade review, of which only two were categorized as ''possible concern'' (Fiji and Vanuatu) and only one country (Vietnam) was categorized as ''urgent concern.'' The remaining countries were described as having no or minimal trade, and consequently designated as ''least concern.'' Of the 16 countries not selected for review and recording exports, only the Solomon Islands appeared to be trading in significant quantities (CITES 2004b).

In Fiji, *T. crocea* is not recorded as naturally occurring but it has been reported as ''introduced.'' Between 1997 and 2000, significant quantities of *T. crocea* imports (~15,000 live specimens) were reported from Fiji, of which two-thirds were reported as being of wild origin. Reported imports from captive bred sources have virtually ceased since 2000, and those from wild sources have declined significantly. However, the CITES review regarding trade of *T. crocea* in Fiji concluded that: ''Without information on the status of introduced stocks and harvest levels for domestic consumption, it is not possible to assess whether or not current export levels are detrimental to the species' survival in Fiji'' (CITES 2004b).

In Vietnam between 1998 and 2003, gross live exports of wild-sourced *T. crocea* peaked at 61,674 specimens in 2001 and otherwise ranged between 35,000 and 46,000. Since 2001, much lower levels, albeit still substantial (*i.e.,* from 2,500 to 7,500 specimens annually) of live *T. crocea* reported as captive-bred have been exported. The ''Urgent Concern'' designation was given to Vietnam because of the large quantities reported as exports from the wild during the review period and because of a lack of information on stocks and management activities (CITES 2004b). However, the review did not make any conclusions as to the status of *T. crocea* in Vietnam or whether trade was causing negative population level effects.

Overall, while it appears that some countries have traded *T. crocea* in potentially significant quantities, we could not find any information to suggest that these quantities are contributing to the overutilization of the species, such that the petitioned action may be warranted. Therefore, we conclude that the available information presented in the petition and in our files does not constitute substantial information that international trade is a significant threat posing an extinction risk to *T. crocea* throughout its range.

In most locations where information is available, *T. crocea* does not appear to be a highly sought after giant clam species due to its small size and burrowing behavior, as these characteristics make it more difficult for fishermen to harvest the species. For example, Hester and Jones (1974) noted that *T. crocea* was the only giant clam species that did not likely have commercial value in Palau, and that the species is seldom utilized for any purpose. bin Othman *et al.* (2010) also generally characterize *T. crocea* as ''more difficult and less economical to harvest'' because this species burrows into substrates and is relatively small. In New Caledonia, *T. crocea* is not listed among the preferably harvested species there (Kinch and Teitelbaum 2009). As previously discussed in the *Population Status and Trends* section above, Hernawan (2010) attributed *T. crocea*'s relatively high population densities in survey sites in Indonesia to the fact that Indonesian fishermen do not target this species because of its small size and burrowing behavior. This echoes the general characterization of commercial utilization of this species by bin Othman *et al.* (2010). Finally, Dolorosa and Shoppe (2005) note that ''*T. crocea* is little if at all exploited'' in the Philippines.

Overall, most of the information provided in the petition and in our files suggest that overutilization is not likely a significant threat to *T. crocea* because its small shell is not economically desirable and its burrowing behavior makes it more difficult to harvest relative to other species of clams that are much larger in size and more easily accessible to fishermen. While it is clear that *T. crocea* fulfills a local market niche and may have experienced historical overharvest in Okinawa, Japan, this location represents a very small portion of the species' overall range, and we have no additional information to suggest that this level of utilization is occurring elsewhere, such that the petitioned action may be warranted. Additionally, it appears that reseeding efforts and fishing regulations have been implemented in Japan to help safeguard giant clam populations, including *T. crocea,* from overfishing. Further, the available trade data for *T. crocea* does not indicate that international trade is causing negative population level effects to the species to the point that the petitioned action may be warranted. Therefore, we conclude that the information in the petition and in our files does not constitute substantial information that overutilization is an operative threat that acts or has acted on the species to the point that the petitioned action may be warranted.

Factor C: Disease or Predation

The petition did not provide any species-specific information regarding how diseases may be affecting *T. crocea* populations throughout its range. In fact, none of the information provided in the petition discusses diseases or parasites affecting *T. crocea,* specifically. We could also not find any additional information in our files regarding the threats of disease or predation to *T. crocea.* Therefore, we conclude that the petition does not provide substantial information that disease or predation is an operative threat that acts or has acted on the species to the point that the petitioned action may be warranted.

Factor D: Inadequacy of Existing Regulatory Mechanisms

The petition did not present species-specific information regarding inadequate regulatory mechanisms for *T. crocea.* As discussed above, the petitioner notes that there are some laws for giant clams on the books in certain locations, but only discusses regulations from the Philippines and Malaysia and illegal clam poaching in disputed areas of the South China Sea. These areas represent a small portion of the range of *T. crocea.* We found additional regulations in our files regarding the harvest of giant clams, including *T. crocea,* in several countries. Numerous PICTs and Australia implement size limits, bag limits, bans on commercial harvest, bans on night light harvest, promotion of aquaculture, and community-based cultural management systems for giant clams (more detail provided above; Chambers 2007; Kinch and Teitelbaum 2009). For *T. crocea* specifically, state-set and self-imposed regulations prevail in the fishing areas throughout Japan to protect the giant clam stock (Okada 1997).

In terms of trade regulations, the discussion in the petition was not species-specific. Additionally, we determined above in the *Overutilization for Commercial, Recreational, Scientific, or Educational Purposes* section for *T. crocea,* that international trade is not an operative threat that acts or has acted on the species to the point that the petitioned action may be warranted.

With regard to regulations of greenhouse gas emissions, the discussion in the petition was also not species-specific. The petitioner did not provide species-specific information regarding the negative response to ocean warming or acidification. In addition, the information in the petition, and in our files, does not indicate that *T. crocea* may be at risk of extinction that is cause for concern due to the loss of coral reef habitat or the direct effects of ocean warming and acidification. This is discussed in more detail for *T. crocea* specifically above under Factor A and below under Factor E. Therefore, we conclude that the petition does not provide substantial information that inadequate regulatory mechanisms controlling greenhouse gas emissions is an operative threat that acts or has acted on the species to the point that listing may be warranted.

Factor E: Other Natural or Manmade Factors

Aside from the information previously discussed for giant clams in general in the *Other Natural or Manmade Factors* section, the petition did not provide any species-specific information regarding how climate change related threats, including ocean warming and acidification, are negatively impacting *T. crocea* populations throughout its range. We could also not find any additional information in our files regarding these threats to the species. Therefore, we conclude that the information presented in the petition and in our files does not constitute substantial information that other natural or manmade factors, including climate change related threats, acts or has acted on the species to the point that the petitioned action may be warranted.

Conclusion

Based on the foregoing information, we do not agree that the petition provides substantial information to indicate that the *T. crocea* may warrant listing as threatened or endangered under the ESA. Particularly, in the context of the species' overall range, there is no indication that *T. crocea* has undergone significant population declines or local extirpations such that the species' risk of extinction is elevated to a point that is cause for concern. In contrast, it is the only clam species that is still described as abundant and even dominant in many locations where it is found. Given the species' small size and unique burrowing behavior, the available information does not indicate that *T. crocea* is highly sought after or targeted by fishermen in most locations. Overall, the information presented in the petition and our files does not indicate that any identified or unidentified threats may be acting on *T. crocea* to the point that the species may warrant listing as threatened or endangered under the ESA. After evaluating the population status and threat information presented in the petition and in our files in the context of the species' overall range, we conclude that the petition did not provide substantial information indicating that the petitioned action may be warranted for this species.

Tridacna maxima

Species Description

The petition provided very little information regarding a general description of *T. maxima.* The petition notes that *T. maxima* has close-set scutes and grows to a maximum size of 35 cm. We found additional information in our files describing this species. Although maximum shell length is 35 cm, it is commonly found at lengths up to 25 cm (Kinch and Teitelbaum 2009). *Tridacna maxima* has a grayish-white shell exterior, often suffused with yellow or pinkish orange and strongly encrusted with marine growths. The shell interior is porcellaneous white, sometimes with yellow to orange hues on the margins. *Tridacna maxima* often has a brightly colored mantle, variable in color and pattern (Kinch and Teitelbaum 2009), from brilliant to subdued grayish yellow, bluish green, blackish blue, to purple and brown. These colors occur medially on the mantle and are sometimes spotted and streaked with other colors (Su *et al.,* 2014). The shell of *T. maxima* usually has four to five ribs with round projections on the upper margins (Su *et al.,* 2014).

Life History

The petition presents the majority of life history information for *T. maxima* from Jameson (1976) as cited in Munro (1992). This reference studied samples from Guam and reports fecundity (F) of *T. maxima* as $F = 0.00743\ L^3$ (a ripe gonad of a 20 cm specimen would therefore contain about 20 million eggs), fertilized eggs of *T. maxima* had a mean diameter of 104.5 µm, and settlement occurred 11 days after fertilization at a mean shell length of 195.0 µm. Metamorphosis was basically complete about one day after settlement. Jameson (1976) also reports that juveniles of *T. maxima* first acquire zooxanthellae after 21 days and juvenile shells show the first signs of becoming opaque after 47 days. The petition states that male *T. maxima* in the Cook Islands begin to reach sexual maturity at approximately 6 cm; 50 percent of both males and females were sexually mature at 10 cm and 100 percent were sexually mature at 14 cm and larger. The species was also very slow growing and took 5 years to reach 10 cm in length, 10 years to reach 15 cm and 15 to 20 years to reach 20 cm and above. Because only 21.5 percent of the population were fully sexually mature, the petitioner asserts that overfishing of this species is likely (Chambers 2007). In Guam and Fiji, *T. maxima* spawned during the winter months (LaBarbera 1975). Findings by Jantzen *et al.* (2008) suggest *T. maxima* in the Red Sea is a strict functional photoautotroph limited by light.

Range, Habitat, and Distribution

Among members of the subfamily Tridacninae, *T. maxima* is the most common and widely distributed species in the Indo-Pacific. This species ranges from the Red Sea, Madagascar, and East Africa to the Tuamotu Archipelago and Pitcairn Island in the South Pacific, as well as from southern Japan in the north to Lord Howe Island, off the coast of New South Wales, Australia in the south (bin Othman *et al.,* 2010).

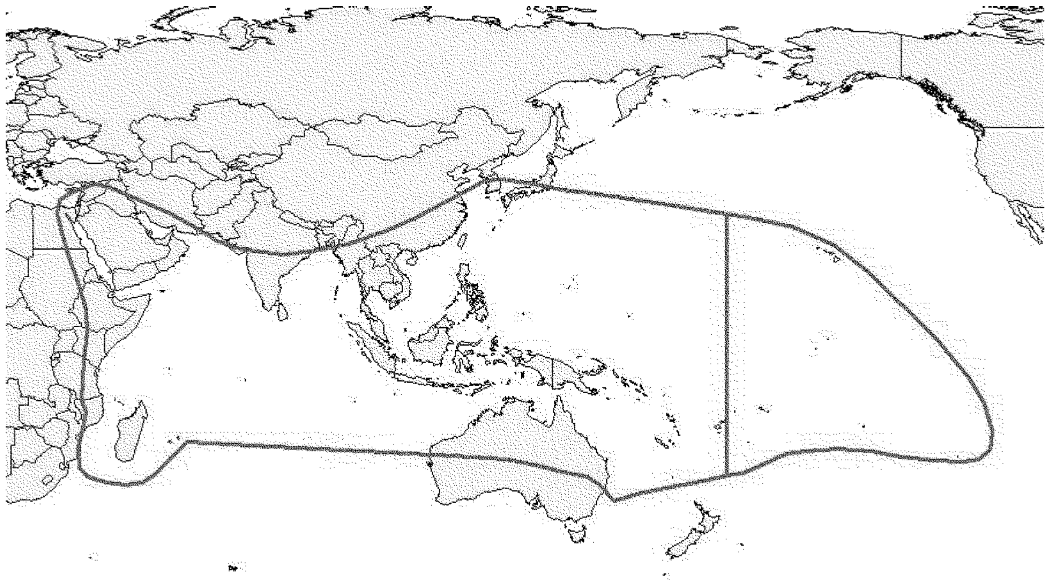

Figure 8: Geographic range of *Tridacna maxima*, extracted from bin Othman *et al.* (2010).

In terms of habitat, *T. maxima* is a reef-top inhabitant, living on the surface of the reef or sand and is usually seen with its colored mantle exposed (Su *et al.,* 2014). This species can be found on reefs, partially embedded in corals in littoral and shallow water, to a depth of 20 m (Kinch and Teitelbaum 2009). In Indonesia, *T. maxima* was found living in dead coral rubble covered in algae, Porites corals, and coral rubble (Hernawan 2010).

Population Status and Abundance Trends

For *T. maxima* specifically, the petition provides limited information regarding the species' population status and trends from Singapore and individual sites in Malaysia, the Philippines, Indonesia, Thailand, French Polynesia, and the Cook Islands.

Neo and Todd (2012a) surveyed 87,515 m^2 in Singapore and did not observe *T. maxima,* despite the observation of one individual in a 2003 survey of a little over 9,000 m^2 by Guest *et al.* (2008). The authors acknowledge that no historical abundance data for *T. maxima* in Singapore exist, nor any precise information on their exploitation. They go on to propose that habitat loss, exploitation, and/or sediment have synergistically led to the extirpation of *T. maxima* in Singapore's waters. Neo and Todd (2013) make a similar conclusion stating that *T. maxima* is ''probably already functionally extinct (in Singapore) as they are reproductively isolated and unlikely to fertilise [sic] conspecifics.'' However, the authors specifically make the point that the status of a species at a small scale (individual country or an island as may be the case for Singapore) is not necessarily representative of its global status. Any species, especially one with a large range like *T. maxima,* will have variable statuses at smaller scales in different habitats due to a variety of factors. Singapore is a small and densely populated island nation known for particularly high anthropogenic impacts in its nearshore waters. The information in Neo and Todd (2012a 2012b and 2013) is informative for resource managers in Singapore and indicates a very low population and density of *T. maxima.* However, it is unclear how the current information relates to historical abundance of this species at this location. In addition, it is not necessarily useful for assessing the global status of *T. maxima* because Singapore is a very small proportion of the overall species' range and is not a representative environment of the rest of the species' range.

As described in earlier species accounts, the petitioner cites Tan and Yasin (2003), stating giant clams of all species but *T. crocea* are considered endangered in Malaysia. The authors mention underwater surveys that reveal that the ''distribution of giant clams are widespread but their numbers are very low.'' However, there are no references provided by the authors to provide any more detail or support for this information, which makes it difficult to interpret this information for individual species. The only species-specific information for *T. maxima* in this reference is that it occurs in Malaysian waters.

The petition cites Salazar *et al.* (1999) who did a stock assessment of *T. crocea, T. maxima, T. squamosa* and *H. hippopus* in the Eastern Visayas of the Philippines and found most of the populations were juveniles with insufficient numbers of breeders to repopulate the region. As noted previously, this reference was unavailable for review so it is unclear if the authors were able to attribute these results to environmental changes, overharvest, or some other type of influence.

As previously discussed in other species accounts, the petition states that Hernawan (2010) found small populations and evidence of recruitment failure in the six species found during a survey of Kei Kecil, Southeast-Maluku, Indonesia, including *T. maxima.* The author conducted giant clam surveys in nine sites; however, Indonesia encompasses thousands of islands and *T. maxima* occurs in other locations throughout Indonesia (Hernawan 2010). Thus, this study represents a very small sample of *T. maxima* abundance in Indonesian waters, with no evidence provided to suggest that recruitment failure of *T. maxima* is occurring throughout Indonesia.

The petitioner cites Thamrongnavasawat *et al.* (2001) as saying *T. maxima* are now considered ''scarce'' throughout Thailand; however the link provided in the bibliography to access this reference was not functional, and we were otherwise unable to obtain and review this reference to determine what the authors meant by ''scarce'' or on what evidence this statement was based.

The only references with species-specific information on abundance and trends for *T. maxima* that show evidence for their conclusions are from Rose Atoll, two atolls and an island in French Polynesia, and Tongareva Lagoon in the Cook Islands. Neo and Todd (2012a) reference another study that reports up to 225 *T. maxima* individuals per square meter at Rose Atoll (Green and Craig 1999). The estimated population size for Rose Atoll (615ha) was approximately 27,800 *T. maxima* individuals based on surveys from 1994 to 95.

In French Polynesia, Gilbert *et al.* (2006) report that several lagoons in two archipelagos are characterized by enormous populations of *T. maxima.* They report densities of 23.6 million clams in 4.05 km^2 at Fangatau atoll, 88.3 million clams in 11.46 km^2 at Tatakoko, and 47.5 million in 16.3 km^2 in Tubuai. At the time of publication, the authors noted these were the largest giant clam densities observed anywhere in the world. The authors also note that a small scale but growing fishery in these areas should be actively managed to avoid decimating these pristine stocks. They list several existing management efforts in French Polynesia including a minimum shell length for capture, development of clam aquaculture capacity, and the establishment of no-take areas (Gilbert *et al.,* 2006). The first no-take area dedicated to the conservation of *T. maxima* was implemented in 2004 at Tatakoto Atoll, one of the study areas in French Polynesia. Six years after the Gilbert *et al.* (2006) study, a stock assessment survey revealed a dramatic decrease in the *T. maxima* population within the no-take area and elsewhere throughout the atoll (83 percent overall reduction in density), an anomaly the authors attribute to temperature variations 3 years prior to the survey, but the cause could not be determined definitively (Andrefouet *et al.,* 2013). The authors note that mortality events of this scale are not uncommon for bivalves and there are other reports of massive die-offs of clams related to environmental variables like ENSO-related temperature increases or lowered mean sea level in certain areas, which leaves clams exposed to unfavorable conditions for long periods. Within a geographic range as vast as *T. maxima*'s, one anomalous event that may have been due to temperature changes does not constitute substantial information that climate change may be affecting the species such that it needs protection under the ESA. As noted above in the *Threats to Giant Clams* section, there is huge heterogeneity across space and time in terms of current and future impacts of climate change on giant clams species.

The petition cites Chambers (2007) and notes that *T. maxima* was overharvested in the southern Cook Islands and the capital was now receiving them from the northern part of the country, but the specific aim of this study was to assess the size distribution, abundance, and density of *T. maxima* in Tongareva lagoon. The author found variation within the lagoon with higher densities occurring in the south, farther from villages. The overall density recorded was 0.42 clams per square meter, with a total population of 28,066 individuals; however, the author notes that these numbers were based on extrapolating over the whole lagoon, all of which is not necessarily suitable clam habitat. The authors suggest that a more accurate extrapolation should be based on the area of available suitable habitat to fully account for areas where *T. maxima* occurs in high numbers. While this study indicates some areas of lower abundance near population centers (*i.e.,* harvest pressure), it also reports high numbers and densities of *T. maxima* at several sites (Chambers 2007).

Finally, a CITES trade review of *T. maxima* characterizes the species as still reasonably abundant in some countries, being ''widespread and abundant'' in Australia, and ''common'' with stable stocks in Vanuatu (CITES 2004c). Overall, the information regarding abundance and population trends for *T. maxima* is limited, particularly given the species' enormous geographic range. As noted previously, any species, especially one with a large range like *T. maxima,* will have variable statuses at smaller scales in different habitats due to a variety of factors. The limited information in the petition and our files, however, does not indicate that *T. maxima*'s overall population status or abundance trends are contributing to an elevated extinction risk, such that the species may be threatened or endangered throughout all or a significant portion of its range.

Threats to *T. maxima*

Factor A: Present or Threatened Destruction Modification, or Curtailment of Range

The petition asserts that all species of giant clam, including *T. maxima,* are at risk of extinction throughout their ranges due to the threat of habitat destruction, largely because of threats related to climate change and coral reef habitat degradation. However, the petition does not provide any species-specific information regarding how habitat destruction is negatively affecting *T. maxima.* While the information in the petition is otherwise [largely] accurate and suggests concern for the status of coral reef habitat generally, its broadness, generality, and speculative nature, and the lack of reasonable connections between the threats discussed and the status of *T. maxima* specifically, means that we cannot find that this information reasonably suggests that habitat destruction is an operative threat that acts or has acted on the species to the point that the petitioned action may be warranted.

Factor B: Overutilization for Commercial, Recreational, or Scientific Purposes

Species-specific information on overharvest of *T. maxima* in the petition is limited. The petitioner cites Bodoy (1984), stating the authors found that harvesting decreased the size of *T. maxima* in Saudi Arabia. However, the authors only surveyed four sites with varying degrees of accessibility and found that the harder-to-access sites, as well as deeper depths at all sites, appear to provide some refuge from collection as they observed either more or larger clams (or both) there.

The study by Shelley (1989) discussed above in the *Life History* section documented likely overfishing of *T. maxima* in the Cook Islands based on a very low proportion of mature individuals in the population. Chambers (2007) notes that *T. maxima* was overharvested in the southern Cook Islands and the capital was now receiving them from the northern part of the country. In the Cook Islands, only cultured clams are exported, and wild harvest is for local consumption. Traditional cultures in individual villages institute a *rahui* system to impose closures of certain areas for a period of time to allow stocks to regenerate (Chambers 2007). While Chambers (2007) indicates some level of harvest pressure on *T. maxima,* they also report areas of high numbers and densities of *T. maxima* in several sites.

We found additional trade information for *T. maxima* in some CITES documents cited by the petitioner, although the trade information therein was not presented in the petition. Out of 31 countries listed in a trade review for this species, one was listed as ''Urgent Concern'' (Tonga), seven were assessed as ''Possible Concern, and ''Least Concern'' was reserved for the remaining 23 countries (CITES 2004c). Countries reported as ''Least Concern'' were assessed as such for the following reasons: either there was no trade reported over the period under review (1994–2003) (n=10), recorded trade during the last 5 years of the period under review was at a low level (n=10), or trade was primarily or entirely of captive bred specimens.

Based on the foregoing information, the species-specific information presented in the petition and in our files on overharvest of *T. maxima* is not substantial. Given the broad geographic range of the species and when considered in combination with all other information presented for this species, we find that the petition does not provide sufficient information to demonstrate that overutilization is an operative threat that acts or has acted on the species to the point that the petitioned action may be warranted.

Factor C: Disease or Predation

The petition does not present any species-specific information indicating disease or predation are factors acting on populations of *T. maxima* to the extent that the species may warrant protection under the ESA. The generalized information in the petition does not constitute substantial information for individual species as discussed above. We found some generalized information indicating that *T. maxima* has some known non-human predators (*e.g.,* large triggerfish, octopi, eagle rays, and pufferfish) and is vulnerable to predation during the juvenile stage (<10 cm); Chambers 2007), but we do not have any additional information in our files on the effects of disease or predation on *T. maxima.*

Factor D: Inadequacy of Existing Regulatory Mechanisms

The petition does not present species-specific information regarding inadequate regulatory mechanisms for *T. maxima.* As discussed above, the petitioner notes that there are some laws for giant clams on the books in certain locations, but only discusses regulations from the Philippines and Malaysia and only discusses illegal clam poaching in disputed areas of the South China Sea. These areas represent a small portion of the range of *T. maxima.* We found additional regulations in our files regarding the harvest of giant clams in several countries. Numerous PICTs and Australia implement size limits, bag limits, bans on commercial harvest, bans on night light harvest, promotion of aquaculture, and community-based cultural management systems for giant clams (more detail provided above in the general *Inadequacy of Existing Regulatory Mechanisms* section of this notice; Chambers 2007; Kinch and Teitelbaum 2009).

In terms of international trade and greenhouse gas regulations, the discussion in the petition was again not species-specific. The petitioner did not provide species-specific information regarding the negative response to ocean warming or acidification. However, we evaluated the information in the petition that may apply to all the petitioned species. Above in the *Threats to Giant Clams* section, we determined that overall, the entire discussion of the inadequacy of CITES is very broad and does not discuss how the inadequacy of international trade regulations is impacting any of the petitioned species to the point that it is contributing to an extinction risk, with the exception of *T. gigas* and the growing giant clam industry in China. In addition, the information in the petition, and in our files, does not indicate that the petitioned species may be at risk of extinction that is cause for concern due to the loss of coral reef habitat or the direct effects of ocean warming and acidification. This is discussed in more detail for *T. maxima* specifically above under Factor A and below under Factor E. Therefore, we conclude that the petition does not provide substantial information that inadequate regulatory mechanisms controlling greenhouse gas emissions is an operative threat that acts or has acted on the species to the point that the petitioned action may be warranted.

Factor E: Other Natural or Manmade Factors

The petition presents limited information in terms of other natural or manmade factors affecting the status of *T. maxima.* The petitioner cites Waters (2008) who found that *T. maxima* juveniles exposed to pCO_2 concentrations approximating glacial (180 ppm), current (380 ppm) and projected (560 ppm and 840 ppm) levels of atmospheric CO_2 (per the IPCC IS92a scenario) suffered decreases in size and dissolution with increased levels of atmospheric CO_2 and this occurred below thresholds previously considered detrimental to other marine organisms in similar conditions. We acknowledge these results however, they are not easily interpreted into potential species level effects over time and/or space for *T. maxima.* First, the clams used in the experiment were cultured and not harvested from the wild. Cultured specimens are likely to experience much more uniform environments and are likely not acclimated to the common daily fluctuations in many environmental parameters experienced in the wild. As such, they may react differently than wild specimens to abrupt changes in their environment. As discussed in more detail in our 12-month finding for orange clownfish (80 FR 51235; August 24, 2015), the acute nature of the exposure and lack of acclimation in this study is noteworthy because most species will not experience changes in acidification so acutely in their natural habitats. Rather, they are likely to experience a gradual increase in average CO_2 levels over several generations, and therefore a variety of factors could come into play over time to aid in adaptation (or may not—there is high uncertainty). We recognize that because giant clam species are likely long-lived, they likely have longer generation times, and thus, giant clams born today could potentially live long enough to experience oceanic conditions predicted late this century (Watson *et al.,* 2012). However, given the disconnect between these experimental results and what can be expected to occur in the wild over time, the uncertainty in future ocean acidification rates, and the heterogeneity of the species' habitat and current environmental conditions across its large range, these results are not compelling evidence that elevated levels of atmospheric CO_2 is an operative threat that acts or has acted on *T. maxima* to the extent that the petitioned action may be warranted.

The work by Andrefouet *et al.* (2013) on *T. maxima* discussed above in the section on *Population status and Trends* documents mortality at Tatakoto Atoll in French Polynesia likely due to a temperature anomaly; however, again the authors did not definitively identify the cause of the observed decline. Further, a single anomaly in one location is not indicative of an ongoing threat that contributes to an elevated extinction risk for *T. maxima.* While we acknowledge the potential for both ocean warming and ocean acidification to have impacts on *T. maxima,* the petition did not present substantial information indicating the species may warrant listing due to these threats, nor do we have additional information in our files that would indicate this.

Conclusion

It is common for all species, especially those with very expansive geographic ranges like *T. maxima,* to experience different impacts and variable population statuses throughout different areas within their range. In evaluating the information presented in the petition, we consider the information itself as well as the scope of the information presented as it relates to the range of the species. The petition presented species-specific information indicating high densities and robust populations in the Cook Islands, French Polynesia, and Rose Atoll. It also provided citations with generalized statements of rarity of *T. maxima* in Singapore and individual study sites in Malaysia, Indonesia, and Thailand. In the case of *T. maxima,* areas where the species may be in poor status are not compelling evidence of the global status of this species compared to its overall range because the information is not outside of what is commonly expected in terms of variability in species status across such a large range as *T. maxima's*. There is an entire one third or more of the species' range for which no information was presented at all in the petition (eastern Africa and the Indian Ocean) with the exception of one study from one site in Saudi Arabia within the Red Sea. Thus, the petition did not present substantial information to indicate either poor population status globally or operative threats acting on the species such that the petitioned action may be warranted for *T. maxima.*

Tridacna noae

Species Description

Tridacna noae, also known as Noah's giant clam, is most like *T. maxima* in appearance, but live *T. noae* specimens can be distinguished by the sparsely distributed hyaline organs, and by the large, easily recognizable, ocellate spots with a thin, white contour on the mantle's edge (Neo *et al.,* 2015; Su *et al.,* 2014). Shell lengths range between 6 and 20 cm (Neo *et al.,* 2015).

Life History

Aside from what has already been discussed in the general life history information applicable to all giant clams (refer back to the *Giant Clam life history* section above), the petition did not provide any species-specific life history information for *T. noae.* We could also not find any other life history information in our files specific to *T. noae.*

Range, Habitat, and Distribution

The petition did not provide a range map for this species, nor was it included in bin Othman *et al.* (2010). *Tridacna noae*'s distribution overlaps with *T. maxima's* distribution, but generally occurs in lower abundances (Neo *et al.,* 2015). Based on the information provided in the petition, *T. noae* has a widespread distribution across the Indo-Pacific, occurring from the Ryuku archipelago of Japan to Western Australia, and from the Coral Triangle (as defined by Veron *et al.,* 2009) to the Coral Sea and to the Northern Line Islands (Borsa *et al.,* 2015b). *Tridacna noae* is thus known from Taiwan, Japan, Dongsha (northern South China Sea), Bunaken (Sulawesi Sea), Madang and Kavieng (Bismarck Sea), the Alor archipelago (Sawu Sea), Kosrae (Caroline Islands), New Caledonia, the Loyalty Islands and Vanuatu (Coral Sea), Viti-Levu (Fiji), Wallis Island, and Kiritimati (Northern Line Islands) (Borsa *et al.,* 2015b). Mitochondrial DNA data also indicate its presence in the Philippines (eastern Negros), Western Australia (in the Molucca Sea at Ningaloo Reef) and in the Solomon Islands (Borsa *et al.,* 2015b). Individuals are attached by a byssus and bore into coral, living in littoral and shallow waters to a depth of 20 m. Borsa *et al.* (2015b) notes that: ''It may occur naturally on the same reef habitats as *T. maxima,* and also *T. crocea* as reported from the Solomon Islands (Huelsken *et al.,* 2013), and as observed at Bunaken and in New Caledonia (this survey).''

Population Status and Abundance Trends

The petition does not provide any species-specific information for *T. noae* concerning its population status or abundance trends. The only statement in the petition with regard to *T. noae*'s status and abundance is: ''Given the threats discussed elsewhere in this report for Asia and here for the South China Sea, it is likely that *T. noae* has also declined severely.'' The petitioner did not provide any references or additional supporting information to substantiate this claim. Given that the species' geographic range extends far beyond Southeast Asia, simply inferring a severe abundance decline throughout the species' large geographic range based on generalized threats discussed for one part of the range (and without providing any link that these threats are specifically acting on *T. noae* to reduce its abundance) is erroneous. Generalized evidence of declining habitat or declining populations per se are not evidence of declines large enough to infer extinction risk that may meet the definition of either threatened or endangered under the ESA. Therefore, we conclude that the information presented in the petition on the species' population status and abundance trends does not constitute substantial information that the species may warrant listing under the ESA. We could also not find any information in our files on the population abundance or tends of the species.

Threats to *Tridacna noae*

Factor A: Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range

The petition does not provide any species-specific information regarding how habitat destruction is negatively impacting *T. noae.* As discussed previously, while the information in the petition is otherwise largely accurate and suggests concern for the status of coral reef habitat generally, its broadness, generality, and speculative nature, and the lack of reasonable connections between the threats discussed and the status of *T. noae* specifically means that we cannot find that this information reasonably suggests that habitat destruction is an operative threat that acts or has acted on the species to the point that the petitioned action may be warranted.

Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Aside from what has already been discussed regarding the threat of overutilization for giant clams in general, we could not find any species-specific information in the petition or in our files regarding overutilization of *T. noae* for commercial, recreational, scientific, or educational purposes. As such, we cannot conclude that the petition presented substantial information that overutilization is an operative threat that acts or has acted on the species to the point that the petitioned action may be warranted.

Factor C: Disease or Predation

Aside from what has already been discussed regarding the threats of disease and predation for giant clams in general (refer back to the *Threats to Giant Clams* section above), we could find no additional information regarding disease or predation specific to *T. noae.* Therefore, we conclude that the petition does not provide substantial information that disease or predation is an operative threat that acts or has acted on the species to the point that the petitioned action may be warranted.

Factor D: Inadequacy of Existing Regulatory Mechanisms

The petition did not present species-specific information regarding inadequate regulatory mechanisms for *T. noae.* As discussed above, the petitioner notes that there are some laws for giant clams on the books in certain locations, but only discusses regulations from the Philippines and Malaysia and illegal clam poaching in disputed areas of the South China Sea. These areas represent a small portion of the range of *T. noae.* We found additional regulations in our files regarding the harvest of giant clams in several countries. Numerous PICTs and Australia implement size limits, bag limits, bans on commercial harvest, bans on night light harvest, promotion of aquaculture, and community-based cultural management systems for giant clams (more detail provided above; Chambers 2007; Kinch and Teitelbaum 2009).

In terms of international trade and greenhouse gas regulations, the discussion in the petition was again not species-specific. The petitioner did not provide species-specific information regarding the negative response to ocean warming or acidification. However, we evaluated the information in the petition that may apply to all the petitioned species. In the general *Threats to Giant Clams* section above, we determined that overall, the entire discussion of the inadequacy of CITES is very broad and does not discuss how the inadequacy of international trade regulations is impacting any of the petitioned species to the point that it is contributing to an extinction risk, with the exception of *T. gigas* and the growing giant clam industry in China. In addition, the information in the petition, and in our files, does not indicate that the petitioned species may be at risk of extinction that is cause for concern due to the loss of coral reef habitat or the direct effects of ocean warming and acidification. This is discussed in more detail for *T. noae* specifically above under Factor A and below under Factor E. Therefore, we conclude that the petition does not provide substantial information that inadequate regulatory mechanisms controlling greenhouse gas emissions is an operative threat that acts or has acted on the species to the point that the petitioned action may be warranted.

Factor E: Other Natural or Manmade Factors

Aside from the information previously discussed for giant clams in general in the *Other Natural or Manmade Factors* section, the petition does not provide any species-specific information regarding how climate change related threats, including ocean warming and acidification, are negatively impacting *T. noae* populations throughout its range. We could also not find any additional information in our files regarding these threats to the species. As such, we cannot conclude that the petition presented substantial information that other natural or manmade factors, including climate change related threats, are operative threats that act or have acted on the species to the point that the petitioned action may be warranted.

Conclusion

The petition did not provide substantial information that any identified or unidentified threats may be acting on *T. noae* to the point that it may warrant listing as threatened or endangered under the ESA. We evaluated the extremely limited population status information and threat information presented in the petition and in our files and cannot conclude that substantial information has been presented that indicates the petitioned action may be warranted for this species.

Petition Findings

Based on the above information and the criteria specified in 50 CFR 424.14(b)(2), we find that the petition and information readily available in our files present substantial scientific and commercial information indicating that the petitioned action of listing the following giant clam species as threatened or endangered may be warranted: *H. hippopus, H. porcellanus, T. costata, T. derasa, T. gigas, T. squamosa,* and *T. tevoroa.* Therefore, in accordance with section 4(b)(3)(A) of the ESA and NMFS' implementing regulations (50 CFR 424.14(b)(3)), we will commence status reviews of these species. During the status reviews, we will determine whether these species are in danger of extinction (endangered) or likely to become so within the foreseeable future (threatened) throughout all or a significant portion of their ranges. We now initiate this review, and thus, we consider these giant clam species to be candidate species (69 FR 19975; April 15, 2004). Within 12 months of the receipt of the petition (August 7, 2017), we will make a finding as to whether listing these species as endangered or threatened is warranted as required by section 4(b)(3)(B) of the ESA. If listing these species is found to be warranted, we will publish a proposed rule and solicit public comments before developing and publishing a final rule. We also find that the petition and information readily available in our files do not present substantial scientific and commercial information indicating that the petitioned action of listing *T. crocea, T. maxima,* and *T. noae* is warranted.

Information Solicited

To ensure that the status reviews are based on the best available scientific and commercial data, we are soliciting information relevant to whether the giant clam species for which we have made positive findings are endangered or threatened. Specifically, we are soliciting information in the following areas: (1) Historical and current distribution and abundance of these species throughout their respective ranges; (2) historical and current population trends; (3) life history in marine environments, including growth rates and reproduction; (4) historical and current data on the commercial trade of giant clam products; (5) historical and current data on fisheries targeting giant clam species; (6) any current or planned activities that may adversely impact the species; (7) ongoing or planned efforts to protect and restore the species and its habitats, including information on aquaculture and/or captive breeding and restocking programs for giant clam species; (8) population structure information, such as genetics data; and (9) management, regulatory, and enforcement information. We request that all information be accompanied by: (1) Supporting documentation such as maps, bibliographic references, or reprints of pertinent publications; and (2) the submitter's name, address, and any association, institution, or business that the person represents.

References Cited

A complete list of references is available upon request to the Office of Protected Resources (see **ADDRESSES**).

Authority: The authority for this action is the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

Dated: June 21, 2017.

Samuel D. Rauch III,

Deputy Assistant Administrator for Regulatory Programs, National Marine Fisheries Service.

[FR Doc. 2017–13275 Filed 6–23–17; 8:45 am]

BILLING CODE 3510–22–P