Endangered Species Act Status Review Report Queen Conch (*Aliger gigas*): ID425 Peer Review Report

We solicited review of the Draft *Queen Conch Status Review Report* from three potential reviewers. All three agreed to the review and provided comments. Reviewer comments are compiled below and are not in the order of the reviewer identification list below.

Peer Reviewers

- Dr. Dalila Aldana Aranda
  Cinvestav IPN, Unidad Mérida
  Mérida Yucatán México

- Dr. Martha Cecilia Prada
  University of Puerto Rico at Mayagüez
  Boqueron, Puerto Rico

- Dr. Allen Stoner
  Chief Scientist, Community Conch (non-profit organization)
  Washington, USA

Peer Review Directive

- Provide comments on the scientific information and data contained within the status review report.
- If you believe that justification is lacking or specific information was applied incorrectly in reaching specific conclusions, please specify.
- If there is any information missing from the report, please provide the data and the associated citation.

Summary of Peer Review Comments

Major comments are addressed in the bullets below. All non-substantive edits were incorporated within the document when and where appropriate and are not repeated here.

General Comments

A. **Comment:** Added, "Showed the correlation between the lip thicknesses of S. gigas versus the reproductive cycle. They studied 700 organisms sorted in three groups: a) 10-17 mm shell total length, without lip; b) Shell total length ≥ 170mm and lip thickness <5mm and c) Shell total length ≥ 170 mm and lip thickness > 5 mm. Only undifferentiated stages were observed for organisms of 100-170 mm of shell length, without lip. The group of shell length ≥ 170 mm and lip thickness >5 mm exhibits a gametogenesis activity" (by Aldana Aranda, D. and Frenkiel, L. 2007. Lip thickness of Strombus gigas (Mollusca: Gastropoda) versus maturity: A Management Measure. 58th Gulf and Caribbean Fisheries Institute: 407-418p).

   Response: References incorporated and text revised as appropriate.

B. **Comment:** My largest criticism is related to how total abundance estimates are generated and concerns for how errors in those numbers would multiply through the evaluations of connectivity patterns and exploitation rates so critical to threat assessment. Estimation of

abundance obviously depends upon the available density estimates and quantification of "presumed habitat." Again, that was a difficult task, but some of the many assumptions on habitat quantification are questionable.

Response: Both the estimation of total conch abundances and the connectivity simulation required that we have an approximate and spatially explicit map of estimated conch habitat across the entire domain. We carried out an extensive search of available habitat sources, consulting with parties who have been involved in seagrass mapping and similar efforts. We settled on the Millennium Coral Mapping Project as the best available because it is comprehensive across the entire region and has previously been used in peer reviewed simulation work. We acknowledge it has some limitations, but feel it is a defensible estimate based on comparisons with other data sources and estimates of fishing bank areas. We have included a new figure and supporting text in the report to address this concern. In addition, this approach has subsequently been published in Vaz et al. (2022).

C. **Comment:** One does need to go to Appendix III to understand how habitat is quantified. I missed this at first and initially understood "habitat" to be all shelf from 0-20 m deep. SRT POC straightened me out on that and provided the pdf "Polygons 1359". That was a big help, but the text (either in the main body of the report or Appendix III) needs more explicit discussion of how habitat area was determined and how density values were applied to the habitat cells identified.

Response: We agree that the original wording was confusing and suggested that we considered “habitat” to be the entire shelf area from 0-20m, which was not the case. The text was revised to provide clarification on this issue.

D. **Comment:** When I look at “Polygons 1359”, in The Bahamas, I see 3 or 4 times the area (nationwide) that I would consider suitable habitat for queen conch. For example, I have very serious doubts about the two linear clusters of points extending west from the Jumentos and Ragged Islands. This represents a vast area, about 100 cells too many by my count, where I would expect almost no conch. Also, I wonder if those cells were assigned the relatively high values for density that were observed in a narrow region in the lee of that island chain. This area alone would seem to contribute significantly to overestimation of the total number of conch in The Bahamas. Another area with many cells (20) was on the west shelf of Cat Island (eastern Exuma Sound). My team and I surveyed that area extensively in the 1990s and there were very few conch even then. Densities for that area were reported in Stoner et al. (1998) (J Shellfish Res. 17:955- 969; not cited). In sum, I conclude that the criteria used to map "presumed habitat" for conch in The Bahamas were weak.

Response: We acknowledge, based on the status review team’s personal experience in the region, that the habitat map has some deficiencies; it is likely overestimating conch habitat in some areas while underestimating conch habitat in other areas. For example, as the reviewer points out there are some inconsistencies in the Bahamas; conch habitat is likely overestimated in the area to the east of Jumentos Cays, whereas there are no habitat

cells east of Andros Islands where well known conch fishing areas occur. However, for the purposes of the status review, where abundance and connectivity patterns are being summarized at the countrywide scale, the results are robust to some misspecification of habitat, so long as the total area per country is not being grossly overestimated. We understand the reviewer's main concern here to be that the derived abundance estimates are biased based on an overestimate of habitat areas. In response, the reviewers comment we compared the habitat map with alternative sources, compiling estimates of seagrass habitat cover and areal estimates of conch fishing areas from the literature (Figure 5; Horn et al. 2022). Our habitat area estimates generally range from ~30% - 100% of the area of the fishing bank estimates and thus appear to be a conservative estimate of conch habitat across the board.

The reviewer noted that overestimation of habitat in the Bahamas was a particular concern. Targeted surveys of conch fishing areas in seven locations (Jumentos, Little Bahama Bank, Andros, South Abaco, Exuma, and Berry and Cay Sal; communityconch.org, Souza and Kough 2020) estimated number of adult conch at 17.23MT. This estimate is for the surveyed areas alone, and does not include other areas of known conch abundance; for example, Stoner et al. (2013) noted high conch abundances likely extended well outside the Jumentos Cays surveyed areas. The Souza and Kough survey used stratified sampling across representative habitat types on Cay Sal, in areas where fishing was seen to be occurring, and their 1.1M estimate applies to only 66.4 km2 out of a total area of 6000 km2 (i.e., 1% of Cay Sal Bank); the authors noted that similarly high abundances probably existed across the Bank. We note that the estimates from these intensively surveyed areas alone are approximately at the lower bound of our confidence interval; therefore, we feel confident that we are not grossly overestimating abundance in this country.

E. **Comment:** Inquired with colleagues in the Florida Keys about their surveys, and they extrapolated a total abundance at present (Biscayne Bay to the Tortugas) to be somewhere between 490,000 and well below 1 million conch versus 2 million indicated in the report. My colleague in Puerto Rico was concerned by the continuous designation of habitat around all but the north shore of the island and the apparent lack of assigned habitat in St Thomas and St John. He also noted that new surveys by Cruz et al. (2020) may not have been incorporated for the west coast of PR. For Jamaica, fully two-thirds of Pedro Bank is fished routinely, so the cell count there (just 9) seems odd in comparison with 35 along the shoreline of Jamaica where there are very few conch. I wonder how total abundance was estimated for Jamaica. Were the bank and the shore treated with different density values? Much of the exploited area on the Pedro Bank is deeper than 20 m. Maybe that helps to explain the low habitat area.

Response: As mentioned above, the habitat map may be slightly misrepresented at the fine scale, but overall the areas appear to be well in line with or conservative estimates of conch areas. We understand the reviewer is underlying concern here to be that the derived abundances are too optimistic. We searched the same body of literature and pulled out any independent abundance estimates that were reported/available. Our estimates are in line with those independent estimates. Where we have direct

comparisons (e.g., Belize, Colombia, Jamaica) the independent estimates are higher than our estimates, but fall well within our confidence intervals. Where the independent estimates cover only parts of the jurisdiction (e.g., Florida, Dominican Republic, and Bahamas) we cannot make a direct comparison, yet, our estimates would appear to be approximately correct. Certainly, in all cases where direct comparisons were feasible, the independent abundance estimates fall well within our 90% confidence intervals.

F. **Comment:** The SRT notes the limitations of their findings several times in the Review, and it is possible that I missed critical points in the description of methods. That said, my general conclusion based upon the observations note above (and detailed further in the embedded comments) is that conch experts were not consulted adequately and habitat may have been poorly defined for at least some of the major conch-producing locations.

Response: Several conch experts, in addition to those on the SRT, were consulted extensively throughout the process. We put in substantial effort to uncover any available information. We agree that it would be helpful to have areal estimates of fishing banks, and maps of fishing areas or assumed conch habitat from each country; however, these were not currently available.

G. **Comment:** Also, it is not clear how density values were applied to different locations or sub-locations, and the resulting total numbers reported are subject to very large errors. The more highly derived connectivity patterns and exploitation rates would seem to be vulnerable to even greater inaccuracies.

Response: Agreed, this was not detailed sufficiently in the draft status review report. Additional text has been included. Indeed the estimates of abundance have large confidence intervals, but this uncertainty is carried through to both the estimation of exploitation rates and the estimation of connectivity patterns. The density estimates, habitat categorizations, and associated connectivity patterns have subsequently published (Vaz et al. 2022).

H. **Comment:** Socio-economic information is completely absent in this analysis, I recommend introducing at least some preliminary information of the fishery socioeconomic benefits through the value chain and threats on the human health associated with autonomous diving. Perhaps highlight the need for more work on these topics. Potential benefits from the COVID-19 reduced fishing efforts.

Response: The Endangered Species Act listing determinations are based solely on the best scientific and commercial information, without consideration of economic impact. We are not aware of information related to any potential benefits related to COVID-19 reducing fishing efforts. No additional information as provided by the reviewer.

I. Comment: The fact that information from deeper environments (20-40/50m?) is absent, and the fishing is currently taking place in these areas perhaps indicates that it is vital to

collect additional population information from these environments to better understand the real situation across the region.

Response: All documented deep-water populations were included and additional text was added to reinforce this point. We agree that is important to collect information on the status of putative deep-water populations especially when fisheries managers are surveying conch populations to develop TACs and quotas.

Comments made in draft document:

- The structure of the seagrass beds decreases the risk of predation (Ray and Stoner 1995), which is very high for juveniles (Appeldoorn 1988c).
    - **Comment:** This is a good citation, but the best and more recent review articles covering juvenile mortality are Stoner and Glazer 1998. Bull Mar Sci 62:427 Stoner 2019. Rev Fish Sci Aquacul. 27:490
    - **Response:** Additional citations incorporated.
- Juvenile aggregations are found in depths of less than 4 m year round (with peaks in March) and have been observed to be "well defined" or well-formed for at least 5 months, but are usually formed and active for 2 to more than 3 months (Stoner and Lally 1994).
    - **Comment:** This paper is an overview of mass migrations observed in The Bahamas. Not really about the aggregations that we associate with juvenile conch. The Stoner and Ray paper is appropriate, and the review article by Stoner (2003) is probably offers the most comprehensive discussion of aggregation dynamics.
    - **Response**: Incorporated citation and edited language on mass migration and aggregation dynamics. Removed in response to Comment as this citation is related to "mass migrations" that only occurred in The Bahama's in the 1980s-1990s, but are no longer recorded.
- When densities are low and adequate food is available, female conch can lay an average of 13.6 egg masses containing about 750,000 eggs each, resulting in about ten million eggs produced per individual per spawning season (Appeldoorn 1993).
    - **Comment:** Appeldoorn 2020 expanded on this early paper with new very useful analysis and discussion on fecundity, mating frequencies, etc. Gulf Carib Res. 31:10-19.
    - **Response:** Incorporated citation and updated text.
- There is no direct evidence of senescence in aging female conch; however, Stoner et al. (2012a) and Foley and Takahashi (2017) suggest the possibility given that increased lip thickness associated with older individuals limits the internal space available for ovary development.

- **Comment:** No evidence for senescence in the histological or behavioral observations. The possibility is for decreased fecundity because of declining shell volume, not decreased ability to produce eggs or mate-just fewer eggs at a time.
- **Response:** Revised text.

- For this reason, although observed minimum reproductive thresholds are highly variable, the United Nations Environment Programme (UNEP) has recommended a minimum reference point of 100 adults ha^{-1} to avoid significant impacts to recruitment (UNEP 2012).
    - **Comment:** The minimum reproductive thresholds are indeed highly variable, and those minima tend to be the areas of concern. However, it should be noted that the mating frequencies observed at densities above the thresholds are wildly variable even within surveys (i.e., within location with uniform methods). The variation usually increases with density estimates. This is evident in plots of reproductive frequencies vs density provided in the papers cited, and especially in Delgado & Glazer 2020. Again, while emphasis is ordinarily placed on determining the minima, the shapes of the curves are important, and the Farmer & Doerr models does not seem to explain the upper levels of the scatter very well. These upper level density relationships will have important implications with regard to stock-recruitment models. [Maybe not so relevant in the ESA context]
    - **Response:** Agreed, this is not as relevant in the context of this analysis, because we were forced to assume that fecundity was equal on a per-capita basis across the regions. The more important issue was to try to differentiate where densities are so low that the populations are not effectively contributing to the wider population.

- Population structure, genetics, and population connectivity for queen conch.
    - **Comment:** Three other genetic studies to be aware of: Beltrán DM. 2019. Phenotypic and genomic variation of the queen conch (*Lobatus gigas*) in Puerto Rico. Tech. Rept. San Juan, Puerto Rico: Puerto Rico Department of Natural and Environmental Resources, 30 p. [I can supply a copy if needed]; Blythe-Mallett A, Aiken KA, Segura-Garcia I, Truelove NK, Webber MK, Roye ME, Box SJ. 2021. Genetic composition of queen conch (Lobatus gigas) population on Pedro Bank, Jamaica and its use in fisheries management. PLoS One **16(4):** e0245703; Douglas MR, Chafin TK, Claussen JE, Philipp DP, Douglas ME. 2021. Are populations of economically important bonefish and queen conch 'open' or 'closed' in the northern Caribbean basin?. Mar Ecol. 2021;00:e12639.
    - **Response:** Additional citations incorporated into the report and text updated where appropriate.

- Realistic reproductive output levels were simulated by scaling the number of eggs released (on a per-area basis, by country or region) by the observed conch densities that

were compiled (see *Density Estimates* Section below), and also accounting for Allee effects at very low densities.

- **Comment:** I will study the Appendix and Density Estimate section but this seems like an oversimplification of "density", given the heterogeneity of distribution, gregarious behavior, and scale-depend. Further, the density/reproduction functions are wildly different as evaluated in different locations (e.g., comparing Stoner & Ray-Culp 2000; Stoner et al. 2012; Delgado & Glazer 2020, etc.)
- **Response:** Indeed, in the of detailed size composition information by region, we had to assume that per capita fecundity was equal across the region. We modified the text to acknowledge this. This is acknowledged below and we explain how we account for this uncertainty. Additional language was added to reinforce this point.

- For countries where no data were available, we used a nearest-neighbor approach to borrow density estimates; where there was information on the general status (e.g., severely depleted, moderately fished, lightly exploited) we used such information to ensure that the nearest neighbor approach was reasonable.
    - **Comment:** I realize that there might be no good alternative to this approach but the assumptions are large. Different island nations, for example, have very different approaches to fishery regulation, and while Nation A might be severely depleted, better management in Nation B could be lightly exploited. Habitats and recruitment processes might also be quite different. I am not very comfortable extrapolating density estimates. I make additional comments on Table 2.
    - **Response:** Yes, unfortunately, there is no good alternative to this approach; the assumption is large but necessary. The only other option would have been to remove these countries from the analysis that would have essentially meant we consider conch to be extirpated from these locations, which we know to be incorrect. However this assumption was limited to countries with small shelf areas (maximum 377 square km) and thus likely has a limited impact on the analysis overall.

- Many studies reported adult densities separately, note however that the definition of "adult conch" was variable; sometimes it was defined as a function of shell length and other times as lip thickness.
    - **Comment:** Yes, the definition of adult is problematic. Older surveys called flared-lip conch adults, while we know today that lip thickness is the only routinely available method to predict maturity. And the LT/maturity relationships vary geographically (as acknowledged earlier in this Review).
    - **Response:** Agreed, it is challenging; however, we could only make use of the best available information and survey data as the investigators chose to classify "adults" and "juveniles." This limitation is noted in the report.

- In a few cases where only overall densities are reported and no adult densities were reported, we used the global average percentage of adult/overall conch densities across all countries where both metrics were reported (this value was 46.0%).
    - **Comment:** This is a very risky generalization. A survey in a nearshore nursery area might be 0% mature, a deep-water refuge survey might yield 100% mature conch, and a heavily over-exploited fishing ground could be 0% mature. I have observed all of those conditions within the space of a few kilometers in The Bahamas, Florida, Venezuela, and Belize. Overall, I am shocked by an average value as high as 46% over an entire shelf, with the majority of stock over-fished, and the known high mortality rates of juveniles through year-class three.
    - **Response:** The risk associated with this assumption was minimal when considering the way in which it was applied. Firstly, it was applied only in 4 cases: Cayman Island, Saint Lucia, British Virgin Islands, and Honduras. The Cayman Islands and Saint Lucia densities are based on very limited information; it was not clear whether the reported densities were all age classes or adults only; we applied the ratio out of caution. For these two countries the shelves are relatively small and the assumption has very little influence on derived results. In the British Virgin Islands, it was noted that the average length of conch was 14.4 cm, indicating that just under half are adults. In Honduras, the fishery operates over large offshore banks; one study using fishery-dependent data reported that the majority of conch (83%) were adults (Ortiz Lobo 2019). Therefore, the 0.46 ratio used appears reasonable for these applications.
- Spawning Density.
    - **Comment:** Appeldoorn (2020) is relevant to this section.
    - **Response:** Perhaps, but this study involves non-natural enclosures and stocking densities that "were not designed to mimic natural conditions." The lowest stocking density was 143 conch / ha and 100% of females were observed to spawn, which seems well outside the rates observed in natural conditions.
- To quantify recent adult conch density for each country, we subset the data for all years including and after the year 2000
    - **Comment:** Again, realizing the severe limitations of data, I am concerned with this breakpoint. The fishing grounds that I have observed in The Bahamas for more than 30 years indicate that densities and abundances of conch are changing very rapidly. Even in well-protected waters of ECLSP, populations have declined upwards of 90% since the mid-1990s. Spawning stocks off Lee Stocking Island declined from well-above threshold for reproduction in the 1990s to near zero in 2011. Similar recent reports are emerging from fishing grounds (Such as Banco Chinchorro in Mexico.
    - **Response:** Indeed, there are severe limitations with the data; for many jurisdictions, the most recent studies were done in the early 2000s. Note however in Figure 7 that not all jurisdictions are experiencing declines in densities over time, and in fact, many jurisdictions are showing increasing densities. Therefore, while the selection of this breakpoint may paint an overly optimistic picture of the

situation in some countries, it creates a conservative estimate for other jurisdictions.

- Table 2: Median adult conch density per hectare for each country or bank, with descriptions of the data sources used to support the estimates.
    - **Comment:** It is very difficult for me to reconcile a single number for a nation or large area on the basis of a single median value for adult density. Ignoring for a moment the problem of "adult" definition, how surveys were conducted is highly variable. Further, QC are highly aggregated in preferred habitats. I speak from survey experience in The Bahamas, Florida, Belize, and Venezuela primarily, from which I can make some observations. I offer a case in point regarding scale of survey: In 1983-84, Smith and Nierop (1984) consultants for the FAO conducted stratified random surveys for fishery resources on the Little Bahama Bank and the northern half of the Gt Bahama Bank (67 and 160 stations, respectively). Conch were relatively abundant in The Bahamas in the early 1980s. The median densities of conch (all age classes) were estimated at just 28/ha and 21/ha on the LBB and GBB, respectively. Only 9 stations and 5 stations on the two banks yielded more than 50 conch. All of these sites were around the peripheries of the Banks…which we know today are critical habitat. (see Stoner 2003). The point is that random surveys yield very low densities, completely irrelevant to the question of reproductive biology, sustainability, and maybe the threat to extinction. Most of my surveys have been focused on known fishing or nursery grounds and have yielded much higher densities, at least until recently. And, extrapolating densities over totally unsuitable habitat such as the interiors of the large banks or broad shelves is probably meaningless. That will take me to Figures 10 and 11. I understand the methods used to determine habitat area a bit better after receiving the pdf "Polygons 1359", but I believe habitat area is severely overestimated for at least the Bahamas. I discuss the general topic in the cover letter.
    - **Response:** The densities here are provided as a reference, but, as noted in the text, densities were represented by distributions, which were multiplied by estimated habitat areas. Secondly, the surveys used to develop these density estimates were nearly always conducted in areas of conch fishing grounds, and the densities were extrapolated not across entire banks, but rather fractions of the areas of these banks (see General Comment D and Response D for more information). In response to the reviewers comment, we conducted additional comparisons of our estimates with independent estimates. The results strongly suggest that our methods did not lead to overestimates of abundance (see Figure 5 in status review report)

- Table 2 – Bahamas Cay Sal
    - **Comment:** The Souza and Kough study represents an example of a survey targeted on specific fishing grounds. All of the 118 dives were made in areas observed near fishers, and around the periphery of the Bank. Much of the Bank is >20m deep.
    - **Response:** Yes, the areas surveyed are targeted by fishing, so the estimates should

be on the conservative side. In contrast, the reviewer's comment, Souza and Kough note depths of Cay Sal are "mostly ranging from 9 to 16m."

- Table 2: Belize: Distribution derived from fished and unfished sampling points across country reported 2003 - 2018; weighted average of unfished vs. fished densities based on ~15% total area protected (Dahlgren 2014)
    - **Comment:** Here is additional data from Fisheries Department & Tewfik et al 2019.
    - **Response:** We used all available data provided to us by the Fisheries Department and published reports and Tewfik et al. (2019) (See S5 file: Belize).

- Table 2: Costa Rica. No density information available - no commercial fishery and uncommon in local diet; unlikely to be heavily exploited so borrowed from Nicaragua which has relatively high densities
    - **Comment:** The assumptions in determining this density value are large. First, if conch are so abundant in Costa Rica it is hard to imagine that there is little exploitation. Second, the coastal shelves of Nicaragua and CR are entirely different. The former, like Honduras, has vast shallow banks while CR has a narrow shelf suggesting that the oceanography, sedimentology, and ecology and are different. That said, I do not have direct experience with conch in CR.
    - **Response:** Yes, the assumption is large, but the extrapolation was done over a tiny relative area (54 km sq). The narrow shelf of Costa Rica is reflected in this very small estimated area of conch habitat. It is necessary to fill in some value for the purposes of the analysis, other than a "zero" which would imply that conch are extirpated in this area, which we know not to be true.

- Table 2: Cuba
    - **Comment:** Cuba, a very large country, is represented by just one high adult density, based upon 3 sites surveyed 12 years ago. Further, a 20% depletion rate in fished zones seems optimistic. Intuitively, I sense that this density, habitat area, and the derived total number of adults (>400 million) are all over-estimated substantially.
    - **Response:** This was the best information available; it is difficult to see how this estimate could be improved upon given the information available. Several marine scientists working in Cuba were consulted and confirmed that they routinely see high densities of conch and that the resource is underexploited. Furthermore, information provided to us indicates that the average weight of a shell is between 1610 and 2200g, which suggests the populations, are in a generally not overexploited.

- Table 2: Dominica. No density information available - borrow from nearest neighbor (Martinique)
    - **Comment:** The shorelines of Martinique and Dominica are entirely different, and I wonder about comparable nursery ground suitability.
    - **Response:** We acknowledge it has some limitations, but feel it is a defensible estimate based on comparisons with other data sources and estimates of fishing

bank areas. We have included a new figure and supporting text in the report to address this concern. See response to Comment B for more detail.

- Table 2: Grenada: No density information available - borrow from nearest neighbor (Saint Vincent)
    - **Comment:** St Vincent has the vast banks around the Grenadines, Union Island, etc. known for historically important fishing grounds. Not sure how comparable any of that is to the sheer shorelines and narrow shelf of Grenada. Further, despite these large banks St Vincent and the Grenadines is shown as having just 14% the habitat of Grenada. Is there a mistake here?
      Response: No, this is not a mistake. We compared the habitat map with alternative sources, compiling estimates of seagrass habitat cover and areal estimates of conch fishing areas from the literature (Figure 5; Horn et al. 2022). Our habitat area estimates generally range from ~30% - 100% of the area of the fishing bank estimates and thus appear to be a conservative estimate of conch habitat across the board.

- Table 2: Honduras. Distribution derived from 3 banks sampled from 2009-2011; average densities by region weighted by survey area; only overall abundances reported; used global conversion ratio of 0.46.
    - **Comment:** I wonder if Nelson Ehrhardt or Stephen Box might be able to improve on this.
    - **Response:** The available information from Ehrhardt shows that the majority of conch in the Honduran fishery are adults. However, recognizing that the age composition in the fishery does not exactly reflect the age composition of conch present, we applied this more conservative ratio.

- Table 2: Martinique
    - **Comment:** The table shows Martinique and Dominica with identical densities and habitat areas. This is inconceivable to me given the differences in the coastlines and likely habitat for juvenile conch. Most recent surveys from the 1980s to provide the density of 20/ha seems risky at best.
    - **Response:** We have no further information with which to inform these estimates. Even in the case that these densities were substantially overestimated, it would not affect the outcome of the status review; these densities are low and the populations were assumed to not be contributing to overall abundance or connectivity in any significant way.

- Table 2 Panama. Point estimate from one CITES reference from 2000.
    - **Comment:** Conch are relatively abundant in the San Blas Islands based on my own casual observations in 2019. Harvested relatively hard by the Guna people.
    - **Response:** We recognize that this data point is based on extremely limited information - a single point estimate from one a dated CITES reference as noted here. Unfortunately, in the absence of other information this is the best estimate we have at this time.

- Table 2: Saba. Single 2015 study reporting island-wide average with mean and standard deviation.
    - **Comment:** I expect that this density is based upon towed camera surveys including relatively deep water, maybe beyond fishing depths.
    - **Response:** That is correct. We assume the reviewer is concerned that higher densities in deep-water surveys are being extrapolated over shallow water areas. Subsequent analysis, in response to reviewer comments, revealed the abundance estimates were highly conservative in comparison to other estimates (see response to Comment B for more details). We have included a new figure and additional language in the status review report to address this concern more broadly.

- Table 2: United States Florida. Average from studies of non-aggregation sites from 2012 - 2019; cross-shelf densities from Glazer 2020 were derived by dividing total abundance estimates by statistical sampling domain
    - **Comment:** Bob Glazer and Gabe Delgado are the experts on this, but it seems clear to me that the majority of conch are on the reef tract, and spawning never occurs in the Keys nearshore. They have made population estimates recently
    - **Response:** Yes and their population estimates were used in this assessment as noted here. The population estimates from Glazer 2020 cover only a portion of the estimated conch habitat in Florida.

- Figure 8: Adult queen conch median density per hectare by country or territory. Green symbols indicate adult densities sufficient for reproductively active (100 conch/ha) populations, gold symbols indicate adult densities that have significantly reduced reproduction (50-99.9 conch/ha), and red symbols indicate adult densities too low to support reproduction in the population (0-49.9 conch/ha). Areas without adult specific density data are indicated with an X and densities was than borrowed from nearest neighboring country. Those densities were used for connectivity modeling
    - **Comment:** Perhaps the location of the circles can be positioned closer to the actual bank. As it is now, some of them are on land and other on water; it is possible to increase consistency
    - **Response:** Where sub regional estimates are used, the circles appear on banks. Where countrywide estimates are used, the circles appear on land. Language was incorporated into the status review report to reinforce point.

- This extrapolation makes the over-simplistic but necessary assumption that all geographical areas across the jurisdiction support similar densities of conch.
    - **Comment:** While I realize that you needed to make some rough estimates for population abundance, for me, this statement about "over-simplification" is wildly understated. Going back up to page 34, as explained that most of the Bahamian banks are completely unsuitable as habitat for QC. My group worked on what constitutes habitat for years (e.g., Stoner 2003 review article), and I can speculate that less than 10% (maybe less than 5%) of the Great Bahamas Bank, for example, supports queen conch. Even the old Smith and Nierop surveys show that. The density data reported in our surveys are almost entirely focused on fishing grounds, not entire shelf/bank regions; consequently, I have very little

faith in the abundance estimates for The Bahamas. With limited time in other locations, I realize that I cannot speak authoritatively about a wide range of places, but I know that most conch surveys have focused on known conching areas….which are not randomly distributed and represent a complex union of specific habitat features and processes. Random survey design may be more common in at least some of the small island nations, and I am aware that Nicole Baker's surveys in Puerto Rico represent a stratified random design. We all know that highly aggregated distribution creates a very high impact on median values. However, extrapolating non-random, targeted surveys over broad areas (thousands to millions of hectares) seems beyond the pale, even with 100,000 random draws.

- **Response:** We understand the concern here; the existing text was slightly ambiguous; it suggested that we extrapolated densities across the entire jurisdiction. In fact, the densities were only extrapolated across areas that were thought to approximate presumed/estimated conch habitat. These areas were often much smaller than areas of fishing banks, so we feel confident that they are not leading to overestimates. We have made clarifications to the text. Also please note that we are largely relying on surveys, which are routinely used to derive average densities and then extrapolated across larger regions to produce total estimates of abundance for a given region; our methods do not differ from these routine practices. Our habitat areas and densities may differ slightly because we developed a standard method that could be applied to all jurisdictions. These population estimates should be considered as a lower bound estimate because the habitat grid is conservative in that it covers only depths 0-20m, with the exception of published deeper banks where conch are known to occur.

- **Comment:** Despite the depth-related consideration, I disagree with this statement entirely given the explanation above.
- **Response:** Our comparisons suggest that our estimates are indeed conservative. Regardless, we have edited the language here to simply note that these may represent conservative estimates in some regions; this is likely to be the case particularly where very high densities of conch have been documented in deeper unfished waters.

- Seven countries, Cuba, The Bahamas, Nicaragua, Jamaica, the Turks and Caicos Islands, Honduras, and Mexico, accounted for 95 percent of the population of adult queen conch, based upon median population abundance estimates (Figure 10).
  - **Comment:** Maybe important to recognize these estimates are preliminary because are based on data collected from only few countries that are monitoring changes in queen conch densities, and deeper areas have not been accounted for.
  - **Response:** Additional, language added to clarify uncertainty. In addition, upon further review an additional 13 shallow water polygons and 13 additional deep water spawning sites were added for Venezuela, Cuba, The Bahamas, USVI, Turks and Caicos, Saba, Colombia, Belize, Honduras, and Jamaica based on published/available information. However, additional text has been included to indicate that any *unpublished* deep-water locations are unaccounted for in the

estimates.

- Figure 10: Estimated conch abundance by country. Vertical dashed line indicates 95 percent of the total estimated population of adult queen conch across all countries.
    - **Comment:** This is a crucial summary of abundance used in all of the subsequent derived values such as connectivity and exploitation rates. How was within-nation variation in density, particularly in The Bahamas, accommodated over the presumed habitat? Two density values also appear to be shown for Cuba (North and South coasts). Given the stated importance of Cuba, it is important to get this right. There are persons working on conch in Cuba.
    - **Response:** We have included additional text to clarify the methods of extrapolation. There is only one available density value for Cuba; this was applied to the countries estimated habitat.

- Juvenile conch, on the other hand, appear to have more specific habitat requirements (Stoner et al. 1994), and in large parts of their distribution range (e.g. The Bahamas) juvenile conch are associated primarily with native seagrass such as turtle grass, *Thalassia testudinum* (Stoner 2003), which provides both nutrition and protection from predators (Ray and Stoner 1995; Stoner 2003; Stoner and Davis 2010).
    - **Comment:** A key point in this paper (seemingly missed here) is that functional conch habitat is formed by the union of physical and biological features of the benthos, coupled with ecological processes including larval delivery systems, growth, and survival – all of which are variable in space. Consequently, nominal habitat classifications based upon aerial or satellite imagery are not good predictors of suitable habitat. Richard Jones' GIS-related thesis work, numerous transplant experiments, and my review showed that vast expanses of medium-density turtle grass habitat (an example of a nominal habitat classification) in The Bahamas were not suitable for juvenile queen conch, despite this being one of the most preferred habitats. Adult conch have different but equally complicated requirements for reproductive habitat. This is all salient to my criticisms above about extrapolating conch densities over shelf area (0-20 m depth) to yield total numbers of conch. Most shelf environment is not suitable for conch, juvenile or adult, even though it might look appropriate.
    - **Response:** Agreed, revised text as appropriate.

- Recent studies have demonstrated queen conch have the ability to utilize a variety of habitats during its life history and this flexibility may give the species an advantage as seagrass meadows and coarse sand patches come and go over the short-term (Dujon et al. 2019; Stieglitz et al. 2020).
    - **Comment:** disagree somewhat with these authors' interpretation. While conch may have certain apparent flexibilities regarding nominal habitat utilization, the process-oriented factors such as larval delivery, growth, and predation processes that determine settlement, survival, and recruitment to mature adult stages are unforgiving.
    - **Response:** Acknowledged and additional text included.

- Other threats, especially those associated with long-term climate change such as sea level rise and increased erosion, turbidity, siltation, and severity of tropical storms, have the potential to produce more widespread impacts, but how these factors will affect queen conch dynamics and long-term viability is uncertain and not well understood.
    - **Comment:** Change in ocean circulation patterns? Ocean acidification?
    - **Response:** Additional text added to clarify here, but note that this topic ocean acidification and changes in circulation are discussed in more detail in Factor E – Climate Change.

- The severity of threats that directly or indirectly alter the water quality, contaminants, and vegetation or substrate of queen conch habitats depends on the spatial scope and temporal persistence of the specific activities that pose the threats and the local demographics of queen conch populations. A case by case examination of specific activities, an understanding of the cumulative impacts of activities in a given area, and the relative ecological value of populations that are vulnerable to threats (e.g., source or sink populations, juveniles or senescent adult populations) will help to ascertain the certainty with which particular activities will have short- and/or long-term impacts to species persistence.
    - **Comment:** I agree generally with this summary regarding habitat-related issues. The concern is primarily for local impact (except climate change and maybe hurricanes), scale dependent, and site-specific.
    - **Response:** Agreed, and this observation is consistent with the discussion.

- The main product of the queen conch fishery is the white conch meat, with recent regional annual production estimated at about 7,800 mt.
    - **Comment:** The most common product in trade?
    - **Response:** Agreed, and text edited to clarify.

- There is a limited exploitation data on of both queen conch, pearls, shell, and operculum as souvenirs in the tourism industry (Prada et al. 2017)
    - **Comment:** In 2020, around 1.1. ton of queen conch operculum were confiscated in the US due to violations of the CITES & Lacey act.
    - **Response:** Text revised and additional information included.

- Since we know from the information cited in Appendix I that some countries are landing significant amounts of juvenile or sub-adult conch, the converted figures should also be considered an underestimation.
    - **Comment:** Absolutely true where surveillance and enforcement is low. Recent studies of shell middens in The Bahamas show that in some locations 92% of landings are immature conch, and more than half do not have the required "well-formed shell lip".
    - **Response:** Acknowledged and juvenile harvest is discussed on country-by-country bases within Appendix I and also evaluated under Factor D.

- The Turks and Caicos and The Bahamas have large amounts of unreported landings. Cumulatively, the data increases and are very close to the highest levels in the time series

(mid-1990s). Those estimated landings are most likely to be underestimated. The best estimates of unreported landings still account for a significant portion (>15%) of the total catch.

- **Comment:** Very likely true in The Bahamas. I recall Lester Gittens guessing that export values represent about one-half of actual landings.
- **Comment:** IUU fishing maybe around 21% and artisanal production may represent a lot more in some countries, which could be as high as 50%
- **Response:** Additional information was incorporated in analysis as appropriate.

- These evolutionary connections maintain some genetic similarity between distant queen conch stocks but may not be ecologically significant in the shorter term. Recent genetic analyses with newer techniques suggest that even within The Bahamas there is genetic differentiation at distances of only a few hundred kilometers (Truelove et al. 2017)
  - **Comment:** Recent work (Beltran et al 2019), using SNIPS, found genetic variation in conch morphotypes within PR.
  - **Response:** Additional information and citation added.

- An alternative metric using a combination of landings and density surveys has been recommended by working groups and fisheries manager.
  - **Comment:** Not only that, but there is also the issue of not having proper stocks assessments models that deals with unique conch growth characteristics (two-phase growth pattern, shell length, lip thickness and is modification associated with several conch morphotypes)
  - **Response:** Agreed, information regulations and recommendations related to morphology and growth are discussed within the existing regulatory measures section of the report.

- It also can depend on quantifying and/or mapping depths and habitats on which to base extrapolations.
  - **Comment:** Itis also limited by the lack of country capabilities to conduct conch surveys
  - **Response:** Agreed, limited resources for management and capacity for enforcement are discussed in the existing regulatory measures section of the report.

- The leader, by far, is the Turks and Caicos Islands, followed by The Bahamas, Honduras, and Jamaica.
  - **Comment:** Countries mentioned in the text do not correspond with the ones presented in table 3. What about Mexico and DR?
  - **Response:** Thank you for catching this error. The text and tables removed or revised as appropriate.

- Because the size of conch landed is highly variable and most of the weight is from the shell, we treated shell weight as variable from 0.7 - 1.5 kg, whereas the dirty meat weight was assumed to be fixed at 0.183 kg
  - **Comment:** There are recent recommendations from the QC advisory group on

conversion factors, it is recommended to use it.
    - **Response:** Because of the great variation in reporting (especially degree of cleaning) through the years, we felt that the regional estimates used for this analysis of exploitation rate were suitable for the comparisons being made. In Table 4, where landings from individual countries/jurisdictions were reported for interdecadal comparisons, we used the available conversion factors from that locale.

- Because queen conch require a minimum density for effective reproductive activity, measured densities can provide an indication of overfishing or overutilization of the resource.
    - **Comment:** Density is an elusive metric because of scale, and not necessarily a good general index of overfishing. For extreme example, a once huge adult population could be reduced from hundreds of thousands to several hundred or a thousand individuals and, yet, because of gregarious behavior the population could exist with a small remnant aggregation above some reproductive threshold density.
    - **Response:** We note, however, that these density estimates represent country-wide medians and that conch are not distributed evenly across space; even in countries with very low densities there likely exist some areas above the critical threshold where some nominal reproduction continues to take place.
    - **Comment:** There is a lot more information for this country associated to the Ehrhardt work that covered majority of Honduras banks
    - **Response**: In addition to the SRT's literature review, we solicited information during the public comment period and requested information via CFMC and WECFCA. We also attended and requested information from the QCEWG meeting held in Puerto Rico in 2019. Nelson Ehrhardt was also contacted specifically. All information that was provided or found is included within this report and its associated appendix. No additional information was provided or made available by the reviewer.

- They primarily have focused on commercial fishing, either industrial or artisanal
    - **Comment:** Landing data from artisanal captures is also weak due to the complexity in monitoring all landing sites, the lack of enough fishing inspectors or the low self-reporting from fishers. Perhaps industrial data could be the more complete set of information.
    - **Response:** Agreed. Additional text added to capture this point.

- Since we know from the information cited in Appendix I that some countries are landing significant amounts of juvenile or sub-adult conch, the converted figures should also be considered an underestimation.
    - **Comment:** Absolutely true where surveillance and enforcement is low. Recent studies of shell middens in The Bahamas show that in some locations, 92% of landings are immature conch, and more than half do not have the required “well-formed shell lip”.
    - **Response:** Acknowledged and juvenile harvest is discussed on a country-by-

country base within Appendix I and evaluated under Factor D.

- Surveys in 2009-2011 at three other banks demonstrated densities of 73-248 conch/ha with some stability at each site across the three-year time span.
    - **Comment:** All age groups or adults
    - **Response:** The Government of Honduras / Ministry of Aquaculture did not indicate age classes of the conch documented in their surveys in the information provided to NMFS. Additional text added to clarify.

- Management of the Pedro Bank fishery is conducted using abundance surveys and an 8% control rule.
    - **Comment:** Morant Bank and other remote banks are also fished for conch, in lesser extend
    - **Response:** The best available information indicates that the vast majority of fishing for conch occurs on Pedro Bank. We have no specific information related to Morant Bank or others and none was provided by the reviewer to incorporate.

- As long as densities remain above 100 conch/ha, harvest is capped at 8% of the exploitable biomass.
    - **Comment:** Also not clear from the Appendix whether this means adult conch (and by what criterion classified).
    - **Response:** The age class is not specified, but it is noted within the Jamaica summary (see S1: Jamaica), "no information was provided on age structure of the population."

- Management of queen conch on Pedro Bank is further complicated by IUU fishing by other countries.
    - **Comment:** They also monitor CPUE to complement the fishery management of the species, and have in place a functional traceability system.
    - **Response:** Agreed, and topic is discussed in the Regulatory section and in SI - Jamaica.

- In addition, reporting of poaching by other countries (see S1: Nicaragua) adds additional pressure on this population.
    - **Comment:** Their population is comprised mostly by adults, a lack of recruitment patterns or dependence from nearby remote banks remains to be determined.
    - **Response:** Noted, additional text incorporated as appropriate.

- In recent analyses, Tewfik et al. (2019) found that “Despite the existence of mature conchs and observations of reproductive behavior on the atoll, mean adult densities in all habitats fall below what has been commonly considered a minimum threshold to avoid the Allee effect and maintain reproductive behaviors.
    - **Comment:** I believe that this is for Glover’s Reef, in particular, not Belize overall
    - **Response:** Revised text, but also note, Glover's Atoll represents a mature system of fisheries extraction and marine conservation, in place for more than 25 years, where many local fishers comply with existing regulations (Tewfik et al.,

2017). Thus, this observation is conservative.

- Size distribution is tending towards smaller size at maturity, leading to decline in individual fecundity
    - **Comment:** Maybe more importantly, repeat surveys in a few locations show declining lip thickness (i.e., age) of conch with flared shell lips. This shift in age-structure is a clear sign of increasing harvest effects. Conversely, Stoner et al. 2018 report increasing shell lip thickness in the large MPA Exuma Cays Land and Sea Park where the population is senescing for lack of recruitment from outside the Park.
    - **Response:** Revised text to incorporate as appropriate.

- In most range states, conch fishing continues although population densities are quite low; likely well below levels needed for full reproductive output.
    - **Comment:** In shallow waters, densities at deep waters are yet to be determined. Fishing is taken place mostly on these deep waters environments
    - **Response:** The best available information on queen conch densities was used for shallow water locations and published deep-water locations. Additional text was added to clarify that we considered published deep-water locations and note that there are likely deep-water populations that are not accounted for in our estimates.

- In many locations the densities are below the minimum cross-shelf density (~50 conch/ha) at which Allee effects can prevent reproduction.
    - **Comment:** This warrants clarification. 50 adults/ha really refers to a minimum density within reproductive populations, not necessarily cross-shelf density. The QC working groups have recommended 100 adults/ha, and meanwhile Delgado and Glazer 2020 reported the minimum threshold was around 207 adults/ha. So, this often-cited number from Stoner and Ray-Culp will vary over both spatial scale and location. They reported the apparent Allee effect as a demonstration of concept.
    - **Response:** Additional text added to clarify.

- Nicaragua, Honduras, Jamaica, Bahamas, fish very near the target and Columbia and Cuba fish below the 8% target (Figure 17).
    - **Comment:** Probably just some of the Colombian banks, not all, according to R Appeldoorn.
    - **Response:** Clarified that our estimate incorporates both nearshore areas and offshore - we could not differentiate exploitation rates by sub region.

- This section includes an in-depth analysis by country or region that examines the adequacy of current regulations in controlling threats to queen conch populations based on the available information.
    - **Comment:** in some areas this is true, but not across its entire range of distribution… lack of proper data may limit our understanding of these complex dynamics
    - **Response:** Added clarifying text.

- They have developed a recovery plan for queen conch with the primary goal to promote and enhance self-sustainability of the queen conch in Bermuda waters, by increasing population levels though habitat protection, active breeding, and optimal self-recruitment
    - **Comment:** Needs re-wording for clarity. I understand "increasing population levels through habitat protection" But what is "active breeding"?
    - **Response:** This is text directly taken from the recovery plan. Prefer to leave it as-is and not put in our own interpretation. I believe this sentence means they are going to increase population levels by promoting breeding and self-recruitment, likely through habitat protection, etc.

- The queen conch population in Bermuda relies entirely on self-recruitment and, thus, without management or regulatory measures that will protect but also help grow the adult breeding population, queen conch densities will likely decline in the future.
    - **Comment:** It's not clear to me what else can be done if there's no fishing and habitats are protected. Maybe the population is below "critical mass" for survival in Bermuda. Local extinction seems inevitable,
    - **Response:** One of Bermuda's recovery plan actions involve identifying important habitat for the species. They have not yet resolved what habitat needs to be protected at this time. Thus, there are still management options available to address the species decline.

- The queen conch in Nicaraguan are reliant on high self-recruitment, and with the trends of decreasing queen conch densities and increasing export quotas over the past few years, there is an increasing likelihood of stock collapse in the future.
    - **Comment:** Sure? Their surveys do not report the presence of juvenile conch
    - **Response:** This is an assumption based on our modeling efforts. Added text to clarify.

- Although density estimates for all life stages and depth strata from 1994-2018 have remained above the threshold for successful reproduction (142-405 conch/ha; NEPA 2018), the 2018 surveys saw low enough densities in some areas such that the National Fisheries Authority of Jamaica implemented a closure of the queen conch fishery from 2019 to 2020, which was extended to February 2021 (Jamaica Gleaner, Ban on Conch Fishing Extended to February 2012; April 6, 2020).
    - **Comment:** Because they still need to conduct a new survey, accordingly with the regulatory framework, not necessarily is because respond to low conch densities. They have not been lo secure funding for this survey
    - **Response:** Added clarifying text

- In summary, management actions to date have helped to keep queen conch populations on Pedro Bank, on average, at levels above the threshold for reproductive viability; however, there are some alarming signs that suggest current regulations are not adequate to control poaching, prevent habitat degradation, and reverse localized depletion in shallower areas.
    - **Comment:** This is a regional problem, not only a Jamaica one. This statement

looks to me too alarming. Jamaica in many ways could be considered as a model for good QC fishery management
    - **Response:** Revised language. Agree that IUU is a regional problem -- however, we are focusing on each country and we are identifying the threats in each specific country. Our summary section mentions IUU as a regional problem.

- The queen conch commercial fishery in Colombia shifted to the continental shelf Archipelago of San Andrés, Providencia, and Santa Catalina (ASPC), including its associated banks (Quitasueño, Serrana, Serranilla, and Roncador) in the 1970s when populations in San Bernardo and Rosario became severely depleted due to inadequate regulatory mechanisms (Mora 1994).
    - **Comment:** 10 oceanic atolls, but at present only the commercial fishery is allowed at Serrana Bank
    - **Response:** This sentence discusses the historical fishery -- back in the 1970s. The 2nd paragraph discusses the closure of the other banks.

- The queen conch fishery in Panama is not subject to specific regulations apart from the fact that no marine resources may be harvested using SCUBA (Georges et al. 2010).
    - **Comment** QC fishery has been banned for more than 10 years, and counting.
    - **Response:** Unfortunately, the only information we have on Panama is included here. There have not been any updates in recent FAO or CITES documents. However, the FAO has not recorded any landings from 2004-2018 which suggests no export is occurring but we have no other information related to a closure. The reviewer provided no additional information.

- Overall, given the ongoing demand for queen conch, the issues with compliance, appropriateness of certain morphometric regulations, enforcement, and poaching, and the observed low densities and declining trends in many of the queen conch populations, the available information suggests that existing regulatory mechanisms are inadequate to control the harvest and overutilization of queen conch throughout most of its range, significantly contributing to the species' risk of extinction.
    - **Comment:** Agree.
    - **Comment:** Complex dynamics, with countries with higher risk than others, and true understating of actual condition being limited due to lack of data availability including from deep-water environments. Potential recovery from Covid-19 reduced fishing pressure. In fact, there are examples of species recovery after only 2-3 of closure.
    - **Response:** Reviewer provided no additional information related to recovery of stocks. We agree that it is complex with many uncertainties, including the impact of COVID-19. However, we based this evaluation on the best available information we have at this time.

- The longevity estimate for the queen conch is approximately 30 years.
    - **Comment:** I agree with this as the guess for potential maximum longevity, but we need to realize that very few populations today have conch living to that age. We see very old conch only in unfished waters, most often in water deeper than 20 m.

- **Response:** This is the best estimate we have for maximum longevity for conch (Davis 2005; McCarthy 2007). We are not aware and no additional information was provided on other estimates. We agree that there are few populations where very old conch exist. However, we consider longevity here as a consideration in determining the foreseeable future.

- The SRT also considered how long it would take queen conch populations to show recovery after overexploitation
  - **Comment:** Recoveries have been directly (even intuitively) related to the point at which closures were implemented. For example, the Bermuda population was probably down to a few hundred individuals when fishing was banned, and no recovery is likely. Florida and Aruba might be next worst with slow recoveries exhibited. Other recovery efforts such as those in Cuba and on Serrana Bank were started earlier and recoveries have been faster. So, recovery rates depend….
  - **Response:** Agreed and have added text to clarify. It is intuitive that if you halt the decline too late, you are less likely to see recovery due to allee effects. The reverse is also true.

- Populations in Cuba, Jamaica (Pedro Bank), Nicaragua, Turks and Caicos, and the northern Bahamas appear to contain conch populations that achieve some level of reproductive activity, but they appear to be largely self-recruiting, offering limited connectivity via larval exports/dispersal to neighboring countries and, subsequently, providing limited genetic exchange.
  - **Comment:** Not many places with information from mesophotic environments … the use of new genetic with higher discrimination power techniques may update existing Truelove information that utilized microsatellites
  - **Response:** Populations in Cuba, Jamaica (Pedro Bank), Nicaragua, Turks and Caicos, and the northern Bahamas appear to contain conch populations that achieve some level of reproductive activity, but they appear to be largely self-recruiting, offering limited connectivity via larval exports/dispersal to neighboring countries and, subsequently, providing limited genetic exchange.

- Our total population abundance estimate is high, ranging from 464,000,000 to 1,481,000,000 individuals, based on the 10th and 90th percentile abundance estimates across countries. This estimate required numerous assumptions. Those estimates, however, required numerous assumptions, in particular the assumed extent of conch habitat.
  - **Comment:** I am very uncomfortable with these numbers, which are so critical to all of the more derived variables that follow from abundance. I believe that ~100 million conch in The Bahamas, for example is at least double the actual number, and the massive number for Cuba is really a guess based on the available information. Over-inflated abundances would have a large impact on the calculated exploitation rates. Errors in other locations might go the other way (e.g., Pedro Bank).
  - **Response:** We understand the reviewer is underlying concern here to be that the derived abundances are too optimistic. We searched the same body of literature

and pulled out any independent abundance estimates that were reported. Where direct comparisons were feasible, the independent abundance estimates fall well within our 90% confidence intervals (see above response General Comments).

- The SRT also noted that climate change may change the composition of conch shells in the future, potentially making them weaker, which could increase the queen conch's susceptibility to predation; however, at this time, these impacts are highly uncertain.
    - **Comment:** It is also possible that climate change could change relationships with disease or parasitic vectors.
    - **Response:** While we acknowledge that climate change could alter the relationship between conch and disease/parasites we are not aware of any studies that have reviewed this subject and no additional information was provided.

- Queen conch populations have declined throughout a large portion of the species' range, and the best available information indicates that they continue to decline, particularly in the eastern and central/southern Caribbean;
    - **Comment:** Progressive declines in landings in many cases also respond to fishery regulations, thus it is not a simple process that indicate a total failure of the regulations, but to the opposite a complex process that varies across the region
    - **Response:** This does not refer to landings; this is referring to declines in population/numbers/density which does reflect inadequate management.

- For example, surveys conducted in 2009 observed approximately 176-267 conch/ha, while surveys conducted in October 2016, March 2018, and October 2019, reported 70-109 conch/ha suggesting a reduction in densities (FAO Western Central Atlantic Fishery Commission 2020). No additional information was provided on the survey methodology for the more recent surveys (i.e., no location, season, area, or ages class were provided)
    - **Comment:** In my experience, when densities are reported as conch/ha this means all age groups, not adults.
    - **Response:** While this may be true, there is no information on the surveys data obtained for Nicaragua conch to determine whether it includes all age classes. The texts does not include any reference to “adult conch/ ha, but uses the more general term “conch/ha.” We understand that minimum densities specific to adult conch – not juveniles, however this is the best information available at this time and unfortunately it does not include information on age classes. Nonetheless, additional text has been added to clarify this point.