# Queen Conch, *Strombus gigas* (Linnaeus 1758)

# Biological Report – Peer Review Report

## Peer Reviewers:

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## Peer Review Directive:

1. Please provide comments on the scientific information and data contained within the biological assessment for the queen conch (Strombus gigas).

2. If you believe that justification is lacking or specific information was applied incorrectly in reaching specific conclusions, please specify.

## General Remarks:

- Some of the tables and figures are not in chronological order

- Adding a standalone section on Restoration that has subsections related to 1) use of hatchery-reared conch, and 2) translocations. The Aquaculture section has some restoration ionformation interspersed with general aquaculture information. These are really two separate disciplines (i.e. aquaculture and restoration) so they need to be treated differently.

- Adding a standalone section on Disease and Ecotoxicology rather than incorporating this within Mortality. Ecotoxicology was one of the primary supporting justifications in the petition for the ESA listing and the information related to queen conch ecotoxicology is buried in this document. The information that is within this review is minimal. I think a more thorough review of the ecotoxicologiy of conch would be beneficial. Finally, toxicology and disease can be subacute and, therefore, placing them in a section on Mortality implies effects that may not be appropriate.

- Condensing and better organizing the Connectivity section. There is a lot of information in this section. Some is repetitive; I think that it could be tightened up quite a bit. I also suggest that a more focused review of open versus closed populations with respect to connectivity and recovery of populations is appropriate.

- Suggest a standalone section on Conservation Efforts to include CITES, IUCN, and other educational efforts. Some of this is embedded within the Description of Fisheries and Fishery Management section but I suggest it would be better broken out in its own section. Perhaps there would be some benefit to discussing the use of marine reserves for conch conservation and management in a section devoted to this

- This Biological Assessment represents a thorough and concise review of queen conch taxonomy, distribution, life history, mortality, etc. in Sections 1 to 5. These introductory sections are not exhaustive in covering the published record, but the authors provide a solid discussion of the most relevant and important literature including very recent contributions from around the Caribbean region. These sections are accurate and my criticisms are minor (see below).

- The first data in the report on conch density are provided in Table 1. While I realize that this Table was not intended to summarize the stock status for queen conch, I believe that Table 1 has limited usefulness. A smattering of old and recent data are tabulated; however, real comparisons are difficult because some data are stratified by depth

intervals, juvenile and adult data are sometimes separated/sometimes not, and there are many other density data reported in later (Section 6) but not represented here. No doubt a complete comparison would be difficult because of inconsistency in survey approaches and reporting. Given these difficulties, the ESA policy managers should not place much emphasis on this oversimplified tabulation.

- Section 6 provides the most critical content for the Biological Assessment – observations and data related to stock status around the Caribbean region. No doubt this was a difficult challenge because observations needed to be collected for more than 30 large and small nations that occur within the geographic range of queen conch. The authors did an admirable job of gathering up the scattered information from fisheries departments, recent workshops, and personal communications. In some cases, data on stock status are sparse or non-existent, and conclusions are based upon anecdotal information. This occurs for even some of the nations with very large exports of queen conch meat. For example, Nicaragua is one of the seven primary exporting nations, but the entire text for Nicaragua spans just one-half page and one small table. Therein lays one of the significant problems for the ESA policy managers who will make the final determination for queen conch.

- In their summary statement (Section 6.28) the authors point out that seven nations export most of the conch shipped to the US and other importing nations. Of these, they conclude that "only the Bahamas is still struggling with declining stocks." This is a very strong statement, and gives the overall impression that queen conch is not threatened. First, they note that several nations within the queen conch geographic range never had significant fisheries and imply that these stocks need not be considered important. At the same time, however, some of these stocks have been lost almost entirely. Also, the authors seem to give little importance to the substantial losses observed in many or most of the nations with smaller conch populations. While new control rules have been instituted, often to meet CITES requirements; others have adopted few to no regulations or controls as stocks have declined to levels where the fisheries have been abandoned. My quick tabulation reveals that more than half of the nations within the queen conch distribution have either closed their fisheries entirely or they have severely overfished stocks whereby no within-stock reproduction is likely. Again, the authors conclude that among the primary exporting nations, only the Bahamas is struggling with a declining stock. This reviewer feels that this is over-optimistic evaluation for the species overall, and I elaborate under the new sub-heading on page 3.

- The authors of this Biological Assessment made an attempt to summarize the legislation and regulations concerning queen conch fisheries in the long list of nations where conch exist (see comments on Tables 13 and 14, below). Despite this tabulation, this reviewer

believes that the primary failing of the Biological Assessment is that it lacks a substantial synthesis of queen conch vulnerability, and I suggest that the ESA policy managers will want to consider the subject species with a broad view on the ecological concepts affecting species survival. (i.e., the authors of the Assessment do not seem to bring stock status observed in individual nations back around to the general principles, such as Allee effect, in their summation. Given that, the following are some of my observations based upon both this report (especially section 6) and my own knowledge of the literature and experience with the subject species:

- Most nations have not had budgets to conduct good surveys of their queen conch populations except at multi-year intervals (or not at all). Some of the best surveys have been conducted in the Bahamas, and it is not surprising that these are the surveys showing the clearest signs of population decline.

- Many of the fisheries maintaining stable catch-per-unit-effort (CPUE) have done so by fishers ranging farther from port and with increased use of surface-supply-air (hookah) and scuba (see detailed comments below on this subject). Because the depth range of queen conch is relatively shallow (30-40 m), virtually every conch is vulnerable to scuba divers (i.e., there is no depth refuge once divers begin using compressed air).

- CPUE has also been maintained by the increasing capture of juveniles in many nations. New data show that queen conch are not sexually mature until a substantial shell lip thickness (i.e., greater age) is achieved. This means that juvenile conch are being harvested legally, even when a flared shell lip is required.

- The authors point out (section 3.1) that there appears to be an increasing incidence of disease in queen conch. Until recently, the species was believed to have no disease-related mortality. Thus, this may pose a new vulnerability for the species.

- Results published in the last decade show that reproduction in queen conch is highly dependent upon the density of mature adults, and the panel of queen conch experts meeting in Miami in April 2012 recommended that a density of at least 100 adults per hectare is needed for a successful reproductive population. That policy was adopted by a wider group of national representatives at a CITES and CFMC sponsored meeting in Panama in the spring 2013. This density criterion was not mentioned by the authors of the Biological Assessment, though the density effect is very apparent in their Figure 2. There are now relatively few conch populations with adult densities above the threshold required for mating. This is exacerbated by the decreasing age of conch in fished populations.

- When queen conch stocks have fallen below the threshold density for reproduction, there has been little indication of population recovery. Complete moratoria on conch collection in Bermuda and Florida, for example, have resulted in little population growth, and many of the smaller nations, particularly in the eastern Caribbean, have lost their conch populations almost entirely. Other closures in Colombia and Cuba, for example, seem to have resulted in a better outcome.

- The management plans developed for individual nations sound good, but there are numerous problems associated with regulation compliance (as with any threatened species): a) Lack of funding often means that basic surveys are either incomplete or infrequent. b) Poaching is a widespread problem and trans-national marketing of conch meat can result in overfishing or exporting above the established quotas. These topics received little mention in the Biological Assessment. c) Enforcement of regulations is often difficult in Caribbean nations.

- Stock replenishment experiments with hatchery-reared juveniles have been conducted since the 1980s – in Venezuela, Puerto Rico, the Bahamas, and Turks and Caicos Islands. None of these experiments has been successful in increasing conch populations in the wild. Also, conch culture in the Turks and Caicos reported by the authors has been discontinued. Consequently, re-seeding with hatchery-reared individuals cannot, at present, be used as viable option for stock re-building.

- As noted above, the authors observe that seven nations export most of the queen conch meat that is shipped to the US and other nations, and that "only the Bahamas is still struggling with declining stocks." Here, I suggest that this statement is overly optimistic

- Nicaragua – There was no major fishery for queen conch before the 1990s. The fishery is now conducted on an industrial scale with 20 m vessels. Landings, export quotas, and actual exports have all increased by huge margins over the last 15 years. Also, conch catch data are combined with other invertebrate species (as reported by the authors). Adult densities seemed good in 2009, but I question the sustainability of that fishery based upon the sparse data for Nicaragua.

- Honduras – It would have been very useful if the results of stock assessments for 2006 to 2012 had been reported in the Biological Assessment. If export values return to the previous level of more than 1000 metric tons per year, I doubt the likelihood of sustainability. Honduras reported a standing stock of 21,000 metric tons, but this included all age classes and there is no requirement for harvesting mature conch.

- Belize – The deep-water stock is believed to support the intensive inshore fishery, where adults and juveniles are harvested almost entirely. Juveniles currently make up more than 70% of the inshore population, and the deep-water stock remains unsurveyed. The meat weight requirement for harvest is just 85 g; this means that juveniles are harvested routinely.

- Colombia – This is a difficult case because there are several different bank and island systems where conch are harvested. The southern grounds were quickly fished to extinction in the 1970s. On the northern grounds, effort increased and landings were down in the 1990s. CPUE was also down in the 1990s and early 2000s, and fisheries needed to be closed. Furthermore, a long series of openings and population crashes resulted in enforced closures with some signs of recovery, but 2010 surveys on the Serrana Bank showed that queen conch were completely gone after earlier high densities. With the data reported, this reviewer has a hard time reaching the conclusion that the stocks are not declining.

- Turks and Caicos – This nation has a long record of conch capture and export. However, the authors report that CPUE has been maintained by fishers going farther from port, thus increasing the "effective effort". Kathleen Wood at the Department of Environment and Maritime Affairs has reported (personal communication, 2012) that catches have diminished substantially over the last two years, but funds for new surveys are not yet available.

- The age structure of adult populations within the Bahamas has shifted to younger and younger individuals, typical of overfished stocks. Unfortunately, few other surveys include data on age structure.

- Heavily fished areas in the Bahamas, Turks and Caicos, and Cuba are showing high percentages of samba (stunted) conch. Stoner et al. (2012) hypothesized that this is related to selective pressure exerted on the genotype by selective fishing for large conch.

- Based upon these points, I believe that the health of queen conch populations in the primary exporting nations expressed by the authors of this Biological Assessment is overly optimistic.

**Tables 13 and 14**

- These tables are useful to some extent in summarizing regulations related to queen conch fisheries in the long list of nations where conch are present; however, there is incomplete and inconsistent information that will make it difficult for the ESA policy managers to evaluate differences among nations. For example, the requirement for 5 mm lip thickness

is listed in Table 14 for Antigua, but there is no mention of a lip requirement in the Bahamas. There is other confusion about requirements for flared lip vs lip thickness requirements.

- More importantly, Table 13 has a column showing whether or not scuba is permitted for fishing. In fact, scuba is not permitted in the Bahamas, but surface-supply air (hookah) is now widespread there. Puerto Rico does not allow hookah, but fishing is almost entirely conducted with scuba. Honduras uses no scuba, but fishing is conducted almost entirely by hookah (i.e., not shown here). In fact, hookah is nearly as threatening to conch populations as scuba because divers can spend many hours on the bottom gathering conch to depths as great as 25 meters. Both types of gear should be summarized as both are highly threatening when conch live only in relatively shallow water.

- A matrix of stock status for the nations, in addition to a more complete matrix of regulations, would be especially useful to the ESA policy managers. As mentioned above, more than half of the Caribbean nations have either lost their conch populations or have seriously overfished stocks.

## Comments on Biological Report Sections

### Species Description

- Comment "Since the length of S. goliath is mentioned, there probably should be mention of the length of S. giags."
- Comment "what tissue – the foot, the shell?"
- Comment "or by holding the conch out of the water for a short period of time the egg grove or verge can be observed"
- Comment "3.5-4 years"
- Comment "colored body and proboscis is also different"
- Comment "I am not aware that there are differences-What are they?"

### Range and Distribution

- Comment "and small population in Texas at the Flower Gardens NMS"
- Commenter added text "or even shallower (1-10 m in Florida, Glazer and Kidney 2004.)."
- Comment "insert references"

### Diet and Feeding

- Comment regarding larval conch feeding, biology, and ecology.
- Comment on a citation that was referenced "Stoner and Scwarte did not find conch deeper than 25m"

- Comment on a contradiction in text “  This is contradicted on page 4 where is says 4-18m citing Laughlin and Weil”
- Comment “Feeding on LIVE seagrass  is refuted by Stoner et al, 1995 in which he also cites Randall 1964 and Stoner and Waite 1991”
- Comment “Is this identified as the reason in any publication?  If so, needs citation.”
- Comment “Larval conch feeding biology and ecology???”

**Habitat Use and Movement**

- Comment “Suggest at least a sentence or two on preferable settlement habitat.”
- Comment “When reproducing, conch prefer coarse sand substrates (Glazer and Kidney 2004).”
- Comment “Observations of habitat occupancy by adult conch may be influenced substantially by fishing (Glazer and Kidney 2004).”
- Comment “This is contradicted on page 4 where is says 4-18m citing Laughlin and Weil”
- Comment “Stoner and Scwarte did not find conch deeper than 25m”
- Comment “In the pper, this is 27,705 m^2 but a much better reference is inserted”
- Commenter added text “In general, males have larger home ranges than females (Glazer et al. 2003).”
- Commenter added text “Retarded growth rates of juvenile conchs in the presence of predators was subsequently confirmed in a laboratory study (Delgado et al. 2002).”
- Comment “Missing something here”

**Reproduction**

- Comment “there is some redundancy of info in this section”
- Comment “it is more of a placement than attachment”
- Comment “I typically use egg grove”
- Comment “dropped for what to 29.1˚C”
- Comment “female conch lay approx. 9 egg masses per seasons (Davis et al., 1984)”
- Comment “I think they were observed to copulate”
- Comment 3-5 days see page 12, depending, tempt.”
- Commenter added text “In The Bahamas, , when they and start moving into deeper habitats where they feed (Stoner 1989a); whereas, .  in Florida they may remain in shallow waters in close association with nursery areas because resources are adequate to support juvenile and adult populations year round (Glazer and Kidney 2004).”
- Commenter added text …“within discrete aggregations with densities”…

**Life Stages, Growth, Recruitment, and Connectivity**

- Comment "metamorphosis is triggered by trophic cues in their environment (Davis and Stoner)"
- Comment "this is well understood in the hatchery (Davis papers)"
- Comment "this is really per year"
- Comment "same repeat to section 1.7"
- Comment "A chemical cue often associated with red algae or a similarly polar molecule is required to induce metamorphosis (Myanmanus 1988, Davis 1994)."
- Commenter added text "Morales (2004) extended these studies to include an analysis of mtDNA structure of populations in the Caribbean region and similarly concluded that in general the population was pan-mictic with some local anomalies."
- Commenter modified text "However, more recent data suggest that the local spawning population is increasing and locally produced larvae may, in fact, be contributing significantly to larval supply and upstream sources of larvae may be very limited (Delgado et al. 2008, Glazer and Delgado 2012)."
- Comment "I don't think this study examined genetic connectivity, just larval dispersal in a probabilistic model."
- Comment "I don't understand this – if they are isolated, they must originate in Alacranes which is Mexico."
- Commenter added text "Delgado et al (2008) conducted a drift vial study that suggested that most larvae produced along the Yucatan coast and in Alacranes Reef remained in Mexico or were transported to Texas. However, one vial released in Alacranes was recovered in West Palm Beach suggesting that there were transport mechanisms in effect that would facilitate advection towards Florida."
- Comment "I don't think this study examined genetic connectivity, just larval dispersal in a probabilistic model."
- Comment "I don't understand this – if they are isolated, they must originate in Alacranes which is Mexico."
- Comment on a statement that required a reference

**Mortality Associated with Disease**

- Comment "predation on newly settled juveniles. Ray et al"
- Comment "They also have an opercula that can be used as a defense mechanism"
- Comment on the title of the section "This probably needs a new title mortality is not tied to the parasite. Also suggest that a general toxicology and disease section be created and this section rolled into it. More comments are below."
- Comment "In San Andres, the densities of conch were very low (below the reproductive threshold.)"

- Comment “This is very important since the populations that were examined included those that did not reproduce and those that reproduced normally. I think this brings into question the stated effects of the parasite on reproduction. I question the effects of the parasite on reproduction.”
- Comment sentence added “Juvenile conch popuatios are receive high predation from porcupine fish (). In Florida, the most significant predators on adult conch are loggerhead turtles (Caretta caretta) and the horse conch, Fasciolaria.”
- Comment “I suggest a standalone section for ecotoxicilogy since this is one of the primary focus areas in the petition by Wild Earth Guardians. Also, I would suggest adding the Apicomplexa to this section. This section may also be incorporated into the reproduction section since the effects are generally on reproduction.”

**Climate Change**

- Comment “will also be an issue for the larval shells”
- Commenter added text “Furthermore, chronic effects on larval conch from acidification may affect their distribution thus impacting metapopulation structure.
- Other, more subtle effects of a changing climate may also have deleterious effects on conch populations. Currents are expected to be affected under future climates (Liu et al. 2012) thus potentially impacting larval dispersal. Habitats may transition to different composition thus impacting settlement and other processes influenced by habitat quality. Increased sea surface temperatures may result in temperatures approaching or exceeding thermal thresholds or may result in disassociation of contaminants from the substrate. Phenology may be impacted; the timing of reproduction may change as favorable temperatures for reproduction become more attenuated. Frequency and/or intensity of extreme weather may have a direct impact on populations.”

**Aquaculture**

- Comment “add another reference from Davis”
- Comment “other stick enhancement studies - Stoner and Davis in Bahamas- Glazer and Delgado in FL Keys
- Comment “ This was in the Florida Keys and the source of H20 was from the bay side”
- Comment “Laurencia is more reliable and produces a “stronger” metamorphosed conch”
- Comment “This facility is currently not in operation. It has downsized and then was sold and has been inactive for about 2 years”
- Comment “need reference see pg 23”
- Comment “need to reference spring, Ashley Dissertation on conditioning conch for restoration”
- Comment “1 Glazer 2) Stoner Davis research needs to be cited here”
- Comment “Not sure this is accurate anymore as the farm is closed, I believe.”
- Comment “Actually, this is not correct. In Florida, the best size for release was 10 cm”

- Comment “Suggest talking about restoration efforts here both with hatchery-reared conch and with translocation as this is likely valuable related to species conservation.”
- Comment “Suggest discussion of open versus closed populations and need for restoration.”
- Commenter added text and citations “Fish and Wildlife Commission’s Fish and Wildlife Research Institute’s Marine Research Institute marine laboratory on Long Key existed for the purpose of restocking experiments. Releases occurred in 1993, 1994 and 1996. Variables that were examined included density of conch at release, size of conch, season of release, lunar phase and habitat. Additional studies focused on predator avoidance conditioning and cost-benefit analyses. Conclusions from multiple experiments demonstrated that the best season was fall and this was probably due lower predator densities at this time of year (Glazer and Jones 1997). The optimal release size was approximately 10.5cm; mortality was significantly higher at both smaller and larger sizes (Glazer and Delgado 1999). At the smaller sizes, higher mortality was likely due to a lack of burial behavior; whereas the higher morality associated with larger individuals morphological deficiencies associated with culturing artifacts (i.e. spine length) in larger conch. The studies also demonstrated that queen conch that are naïve (i.e., not exposed to predators) have poorer survival because they do not bury and less dense shells. However, after exposure to a predator, survival was significantly greater (Delgado et al. 2002). For conch released at 10.5 cm, the authors estimated that a conch surviving would cost approximately $9.06 to produce in 1999 (Glazer and Delgado 1999).”
- Comment “Got rid of the Florida comments because those are old data – the population is slowly recovering”
- Comment “Suggest talking about restoration efforts here both with hatchery-reared conch and with translocation as this is likely valuable related to species conservation.”
- Comment “Suggest discussion of open versus closed populations and need for restoration.”
- Comment “aggregating adult conch together in areas could also provide a means of stock enhancement and restoration”
- Comment “also important to add egg farms into this section as a source of eggs for hatcheries and also for stock enhancement?
- Comment “ I don’t agree with this statement”

**Description of Fisheries and Fishery Management**

- Comment “also it was possible to ship overseas because of freezers”
- Comment “what does this mean? Not sustainable at the current fishery level?”
- Comment “This, obviously, is suggested only. I think perhaps a section on traditional management and alternatives may be helpful.”
- Additional text added by reviewer “A number of species-specific life-history attributes make conch a particularly difficult species to manage using traditional fisheries modeling

techniques (Ehrhardt and Valle 2008). These include the propensity to form dense aggregations, strong density-dependant reproduction, and habitat and density-dependant plasticity that my result in large junveiles with greater meat weight than smaller adults. For this reason, a number of researchers have suggested that ecosystem-based methods that employ closed fishing areas should be part of a comprehensive management approach (Glazer 2009, Appeldoorrn et al. 2011)."

- Comment "Bonaire? Lac Bay used to support conch fishing."
- Comment "Suggest the new court ruling that limits Colombian jurisdictions and expands Nicaraguan waters be mentioned."
- Comment "I think this section would benefit also from a discussion on reproductive thresholds, ecotoxicology in Florida conch,"
- Comment "This estimate is only for the offshore breeding aggregations and does not include the nearshore or deepwater poplations."
- Comment "A hole in the spire used to remove the conch is taken as prima faci evidene of illegal collection"
- Comment "This is very old information as per the citation. There are much newer exstimates – the offshore breeding population has likely increased from ~6,000 in 1986 to > 60,000 in 2012."
- Additional text added by reviewer "Annual landings, value and price/kg of queen conch landed in Florida from 1953 through 1976, (from Stevely and Warner 1980)."