Executive summary

The bumphead parrotfish (*Bolbometopon muricatum*) is likely to have been widespread and locally abundant throughout the Indian Ocean, Red Sea and the western Pacific Ocean regions. Now this species is absent or undetectable throughout a large proportion of its former geographical range, due to its low or very low productivity and widespread and intensive coral reef fisheries. This species is abundant only in one third of its former geographical range; this belies the true scale of its disappearance. The remaining *Bolbometopon* strongholds occur in the large reefs of Australia, New Caledonia and parts of Papua New Guinea; outside of these areas the other strongholds constitute less than 3% of the remaining historical geographic range. The report includes a comprehensive compilation of the technical literature, but in critical parts defensible conclusions have not been drawn from this evidence as to the dietary preference of *Bolbometopon*, nor have the available distribution and abundance data been treated in an appropriate and unbiased manner due. This is due to the lack of understanding and application of theory and methods appropriate to the "declining population paradigm". This problem has the potential to result in a substantial bias toward the underestimation of true extinction risk faced by this species in the next one to three generation spans. This potential for underestimation of true extinction risk is compounded by the final evaluation of extinction risk that relies heavily upon vote tallies which ignore the uncertainty embodied by their weightings.

The adequacy, appropriateness and application of data used in the Status Review document are unsatisfactory and not fit for purpose without substantial revision of the data selection, presentation and interpretation. Specifically, there are three critical areas that need to be addressed before this report can be considered to be a scientifically-defensible and transparent overview of the status of the bumphead parrotfish (*Bolbometopon muricatum*).

1. The report appears to discount the scientific evidence that adult abundance may be limited by the cover, composition and quality of live corals, "where over 50% of the diet is composed of live corals", and instead conclude that adult food is not a plausible limiting factor [**Finding 3**]. Consequently, a substantial driver of extinction risk and adult limiting factor, the worldwide decline in the live coral cover, is not evaluated [**Finding 1, 7**].

Key Recommendation 1: The report needs to reconsider the dietary preference of adult Bolbometopon for live coral as a limiting factor and incorporate future live coral projections in any extinction risk assessment.

2. There are several interrelated problems which result in, at best, an overinflated confidence in the health of or underestimation of extinction risk of this species, or at worst, an extinction risk assessment that could be interpreted as non-transparent or biased. First, the understanding of extinction risk is restricted to the "small population" paradigm and the report overlooks the "declining population" paradigm that prevails for assessing extinction risk in the marine environment [**Finding 2**]. This outdated understanding of the extinction risk is compounded by a flawed understanding and / or inconsistent treatment of evidence pertaining to population substructuring, determinants of geographic range size and metapopulation connectivity [**Finding 8**]. Second, there is a bias toward presenting available survey data [**Findings 4 & 5**] of which there are inevitably few. While this in-of-itself is not problematic there is little evidence that the report considers any form of gap analysis to account for and summarize "evidence of absence" [**Finding 10**]. Third, this oversight is compounded by the tendency to conflate the historically documented biogeographic distribution of this species with its current distribution [**Finding 5**], and this, to a lesser or greater degree, stems from the incorrect use of the *present* grammatical tense to describe the abundance and distribution of this species despite an absence of recent evidence for the continued presence of this species [**Finding 9**]. Indeed, in the

report the opportunity is not taken to use methods of inference that are increasingly used to infer absence; for example, an evaluation of locations where fishing pressures greater than that which is consistent with the contemporary existence of *Bolbometopon* [**Finding 1**] or mapping of historical and contemporary presence and abundance [**Findings 5 & 9**]. The simplistic bootstrap analysis of the contemporary abundance of the bumphead parrotfish is misleading *unless* it is used to compare the likely historical abundance against the contemporary hypotheses of abundance. While simplifications are necessary to generate such global abundance estimates there are clear biases in the approach and such simplifications are only defensible if the bootstrapping is undertaken to make *comparisons* in relative abundance between inferred historical and contemporary distribution and abundance [**Finding 6**]. Finally, these inherent biases extend to the final assessment of risk; the report leads with and draws strongest conclusions from tallies of votes that ignore weightings that encapsulate uncertainty [**Finding 11**].

Key Recommendation 2: The understanding of marine extinction risk, population substructuring and metapopulations dynamics needs to reflect current theoretical understanding and empirical evidence. There are a range of data selection, data description, gap analysis, mapping and other methods of inference appropriate for evaluating extinction risk under the "declining population" paradigm. These should be adopted. Key uncertainties should be recognized and incorporated where possible, especially in the final Risk Assessment section and the reporting of these findings in the Executive Summary.

3. The report lacks appropriate levels of citations to published scientific sources and a complete absence of citations to verbal evidence solicited by the Biological Review Team [**Finding 3**].

Key Recommendation 3: The report should be updated to include citations to published scientific sources and citations to any verbal evidence solicited by and used by the Biological Report Team.

As a consequence of these three problems, in particular the conclusions drawn from vote tallies that do not explicitly incorporate the uncertainty weightings, it is highly likely that the risk of extinction faced by the bumphead parrotfish has been considerably underestimated.

Background

The bumphead parrotfish (*Bolbometopon muricatum*) is the world's largest parrotfish, reaching almost 1.5 meters long, it is found only on shallow coral reefs, it shoals and these shoals 'sleep' in shallow back reef coral caves. These behaviors mean this species is very easy to catch at night even with rudimentary hand spears. Its long lifespan (up to 40 years) and associated life history traits mean this species has low or very low productivity with which to withstand and recover from even the lightest fishing pressures. Historically, this species is likely to have been widespread and locally abundant throughout the Indian Ocean, Red Sea and the western Pacific Ocean regions. Now this species is absent or undetectable throughout a very large proportion of its former geographical range.

On January 4th 2010, National Marine Fisheries Service (NMFS) received a petition from WildEarth Guardians requesting that bumphead parrotfish (*Bolbometopon muricatum*) be listed as endangered or threatened under the U. S. Endangered Species Act (ESA). NMFS judged that ESA listing may be warranted and formed a Biological Review Team (BRT) comprised of scientists to conduct the status review. This document is an impartial and independent peer review of the status review of the "Bumphead parrotfish *Bolbometopon muricatum* Status Review, August 30, 2010.

Individual Reviewer's Role in the Review Activities

I was provided with the appropriate documentation, including Demaster et al., and conducted necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review by 1st September 2010. I also conducted an independent peer review in accordance with the ToRs by 15th September 2010.

Evaluate the adequacy, appropriateness and application of data used in the Status Review document

1. In general, does the Status Review include and cite the best scientific and commercial information available on the species, its biology, stock structure, habitats, threats, and risks of extinction?

In one narrower technical sense, yes, but overall, no. This is a very comprehensive compilation of data and literature on the bumphead parrotfish *Bolbometopon muricatum*. However, the considerable focus on the technical details of this species has resulted in three weaknesses: (1) in describing and understanding threats to the bumphead parrotfish, (2) in describing and understanding the theory of extinction risk in the marine environment, (3) there is insufficient referencing of the scientific literature and the complete absence of citations documenting personal communications to the Biological Review Team.

[Finding 1] Overall there is little evidence of any cognizance of the extent and scale of key drivers of extinction risk for coral reef organisms, particularly of habitat loss and fishing pressure. The report emanates from a location typified by relatively pristine and well-managed coral reefs compared with the rest of the world. Notwithstanding the geographic origin of the report and the unique perspectives that might be associated with studying reefs in and around this region, it is difficult to defend an extinction risk assessment made over a 40 and 100 year time frame without an *explicit* description and understanding of global distribution and intensity of fisheries and climate change-induced coral reef degradation and habitat loss.

The scale and distribution of current and future fishing pressure on the coral reefs of island nations is well understood and described here and other references (Newton et al. 2007. Current and future sustainability of island coral reef fisheries. Current Biology 17:655-658). This reference clearly shows the widespread unsustainability of island coral reef fisheries: 55% of 49 coral reef island nations (that represent almost half of the world's coral reef area) are unsustainably exploited according to their fisheries footprints or their exploitation status. One third (17/49) of these island nations have coral reef fisheries footprints greater than or equal to 1 and almost a half of island nations (23/49) have overexploited or collapsed fisheries. The total ecological footprint of coral island nation fisheries is 1.64 which means that each year 64% more fishes, mollusks and crustaceans are caught that can be sustainably produced under a defensible multispecies fisheries production assumption. Coral reef fisheries sustainability is related to human population density expressed as the number of people per areal kilometer of coral reef. Though not reported in the paper, this pattern still holds for coral reef fisheries of continental nations. This has two profound implications for understanding the historical and current status of *Bolbometopon*: nations with human population densities greater than around 1000 people • coral reef km^{-2} are almost certainly overexploited with respect to a multispecies Maximum Sustainable Yield of 5 tonnes km^{-2} of coral reef habitat. Hence future sustainability of coral reef fisheries can only worsen due to the growth in size, affluence and technology, and hence the demand of future human population sizes. The projected increase in the unsustainability of coral reef fisheries is striking: a 160% increase in the unsustainability for coral reef fisheries is predicted by 2050, based on an increase in ecological fisheries footprint from 1.64 to 2.7 from 2000 to 2050. As far as I can tell from the data in this report there are no island nations with coral reef fisheries footprints greater than 0.5 where *Bolbometopon* are currently present, irrespective of coral reef area (based on the data in Table 3, page 26, assuming Palau has zero people per km in accordance with the ban on fishing this species). In 2000, there were 12 island nations with coral reef fisheries footprints greater than 0.5 (American Samoa, Comoros, Guam, Madagascar, Mauritius, Mayotte, Nauru, N. Mariana Islands Philippines, Reunion, Samoa, Sri Lanka) by 2050 two additional countries will have coral reef fisheries footprints > 0.5 (Kiribati and Tokelau). This is a substantial portion of the original range of *Bolbometopon* that is likely to have fishing pressure high enough to eliminate this species. This estimate excludes continental reef nations which, with some notable exceptions (Australia), have substantial coastal poverty and human population densities in excess of that consistent with the survival threshold of *Bolbometopon*,
e.g. Tanzania, Kenya and Indonesia.

The rate of habitat loss, particularly of live coral cover, is one of the highest rates of loss of any habitat in the world, bar that of mangroves (Valiela et al. 2001. Mangrove Forests: One of the Worlds Threatened Major Tropical Environments. Bioscience 51:807-815.). The rate of loss of coral cover in the Caribbean is certainly worse than the rate of deforestation of the Amazon rainforest (Balmford et al. 2002. Economic reasons for conserving wild nature. Science 297:950-953.). The trajectory of decline on Indo-Pacific reefs is lower, and considerably more heterogeneous, than that of the Caribbean (Bruno and Selig. 2007. Regional decline of coral cover in the Indo-Pacific: timing, extent, and subregional comparisons. PLoS Biology **2**:e711.), but the predictions of future coral loss, initially due to bleaching and eventually ocean acidification beyond 2070, are nothing less than stark (for example, Hoegh-Guldberg, et al. 2008. Coral reefs under rapid climate change and ocean acidification. Science 318:1737-1742). In addition the report is inappropriately overly cautious on the difficulty of predicting the development of threats into the future (end of page 9 and start of page 10). This text inappropriately overstates the uncertainty of predicting the development of threats into the future. Such overstatement is not scientifically defensible as there are robust published estimates of relative fishing pressure and coral habitat loss at least out to 2050 that could be used (see above).

[Finding 2] The text and cited literature indicates that the understanding of marine extinction risk embodied in this report is outdated, resulting in an underestimation of extinction risk (see page 9). The theory of extinction risk can be classified into one or other of two paradigms: the ‘declining’ and the ‘small’ population paradigms, *sensu* Caughley. 1994. Directions in conservation biology. Journal of Animal Ecology 63:215-244. Almost all of the literature pertaining to extinction risk in this report and the resultant report text is relevant to the likelihood of extinction of small ‘closed’ terrestrial populations, yet the status of most marine species are of concern due to drivers of decline and hence are evaluated within the ‘declining’ population paradigm.

The small population paradigm is clearly relevant to species susceptible to Allee effects (depensation). Shoaling species such as this parrotfish may be particularly prone to Allee effects (depensation) which would occur once shoal sizes declined beyond a critical threshold, dooming a population to local extinction. Notwithstanding this final nail in the coffin, the most appropriate paradigm within which to consider extinction risk of *Bolbometopon* is the declining population one. A key feature of the declining population paradigm is that an external stressor does not have to kill all individuals to cause extinction. External mortality only has to be sufficient to kill just a bit more than half of all individuals to breach the unstable equilibrium around Maximum Sustainable Yield that would lead to decline to the next stable equilibrium. The next small population equilibrium is either stable, i.e. extinction, or it is the unstable equilibrium that tips the remaining individuals into depensation. The location of the MSY unstable equilibrium depends on life history; but tends to be closer to the carrying capacity for low productivity species. Henceforth killing only one third of individuals may be enough to tip local *Bolbometopon* population over this unstable equilibrium leading to local extinction. Rapid declines resulting in local and regional scale extinctions of marine populations have been widely documented for species with low productivities, similar to this parrotfish. Specifically, the report needs to be aware of and account for the distribution and degree to which levels of exploitation are sufficient to cause declines to the point of depensation for this species.

[Finding 3] Third, some critical aspects of the text do not have any supporting citations. This is particularly notable in the limiting factors table (pages 35-37). This is particularly problematic when evaluating the dietary preferences of *Bolbometopon*. The only published evidence on the diet of *Bolbometopon* indicates that "over 50% of the diet is composed of live corals" yet this table finds that the species is a facultative corallivore and goes on to rule out the need to consider adult food as a plausible limiting factor. This may seem minor but it has profound consequences for the scope of the report and the extinction risk assessment. It would seem precautionary, and a more appropriate treatment of uncertainty, to agree with the peer-reviewed scientific literature and concede that live coral is a plausible limiting factor of adult abundance and proceed accordingly.

A key strength is that the team did an excellent job of interviewing a wide range of knowledgeable scientists – but this is not apparent in the text. There are clearly insights, data and informal knowledge gained from these conversations in the text, but they are not supported with citations. This is a critical weakness; henceforth it is unclear of the source of important information that underpins critical arguments. This is not transparent or scientifically-verifiable.

2. Are methods used valid and appropriate? No, I have serious concerns about the methods used to present, analyze and interpret the data; there are three specific and systemic problems. First, the portrayal and presentation of the supporting information in Figures and Tables is unsatisfactory [Finding 4]. Second, there is a fundamental flaw in the presentation of distributional data and henceforth the conclusions drawn from them is biased toward presenting a healthier-than-likely extinction risk status [Finding 5]. Third, the bootstrapping approach as currently implemented is misleading, but I have a suggestion as to how this analysis could be improved by using it to compare likely historical and contemporary abundances [Finding 6].

[Finding 4] There are some profound problems with the choice of data presented including the graphical presentation of data and description and sources of the data. This has the effect of positively biasing the abundance and distribution of the *Bolbometopon* toward being healthier than likely:

a. Figure 10 (and figures 2, 3, 4, 6, 7). There should be a linear relationship between the data value and the mode of presentation – anything else is visually misleading. Presenting values as pictures, pie slices or histogram bars overinflates the representation and perception of higher values (Tufte, E. R. 1990. Envisioning information. Graphics Press). For the same reasons, the use of the parrotfish picture as a datum is cute but misleading, because the volume of the symbol increases at a greater than linear rate compared to the data values.

b. Figure 7. The figure legend is not clear. What does "Areal breakdown of bumphead parrotfish" mean? Is this the "Percent contribution of scaled forereef by nation?"

[Finding 5]

c. Figure 8 is highly misleading and is poorly described. It is not clear if this is the historical biogeographic range or the current range map. Is this an Extent of Occurrence map or an Area of Occupancy map? Even if it is an Area of Occupancy map it is highly misleading as *Bolbometopon* do NOT occur throughout this area – they only occur on the reefs and not in the open ocean! The inclusion of depth shading is inappropriate and uninformative, particularly since there is no shading actually within the putative range of this parrotfish! This map visualization is valid only if comparing historical biogeographic range with the most likely contemporary presence.

d. Figure 9 is not clearly labeled or contextualized. Are these inhabited or uninhabited islands? Are they fished or not? Are they representative of Indian Ocean islands generally? It would be more scientifically defensible to state that these are small, largely uninhabited and largely unfished islands. Cocos Atoll has been used as a relatively pristine and unfished reference site in scientific studies and is described in the peer-reviewed literature as: "This isolated Australasian atoll may be one of the last pristine reefs in the world, with no recorded history of commercial shark fishing and negligible recreational shark fishing." (Robbins et al. 2006. Ongoing collapse of coral reef shark populations. Current Biology 16:2314-2318). Rowley Shoals are similarly regarded as relatively pristine, and even more so than Cocos Atoll in the published literature (Bellwood et al. 2003. Limited functional redundancy in high diversity systems: resilience and ecosystem function on coral reefs. Ecology Letters 6:281-285).

e. Figure 12. Change the legend to accurately describe these data. There is no demography in this graph; this is a length-at-age graph. State what the lines are, the parameter estimation method and the parameters for each line and sex.

f. Figure 13 is currently impossible to interpret because the axis labels overlap. Additional labeling by ocean basin and subregion are required to help the reader interpret the matrices and evaluate the conclusions drawn from them.

g. Figure 14. What does the absence of a histogram bar mean? Does this mean that all locations without a bar are sink populations supported by Indian Ocean source populations?

h. Why are some data plotted and some tabulated? Table 2 looks ripe for plotting yet this is not done. This raises questions as to its value relative to the other plotted data.

i. Table 3. When are these data from? What is the survey method? What are the "strata"? The Palau conclusion drawn from this table needs to be carefully contextualized as this country has banned fishing for this species.

Throughout the text the report confuses and conflates the historical documented biogeographic distribution of this species with its current distribution. This is not scientifically defensible -in the same way it is not possible to safely state that, “Sea otters are present from Mexico to Alaska”. In the same way that an extinction probability only makes sense within a specified time frame, geographic distributions only make sense with respect to the date when the species were documented in that location.

It is not scientifically defensible to state that this species is found in, or present in a location etc., unless there has been a recent survey there. Instead the scientifically defensible language would be to make clear when you are talking about its historical biogeographic distribution and the present day distribution. This could be made explicit by using the following form of language, “this species has been recorded from x, y and z on this expedition”, or “this species is included in Smith’s taxonomy of fishes (1966) for country x”, or “the FAO species catalogue reports species x as present in the 1992 edition. A useful way to summarize this information would be to update and reconstruct Table 2 of Dulvy and Polunin 2004 and derive extent of occurrence maps from this tabulation.

[Finding 6] The bootstrap analysis and the conclusions drawn from it (Section C iii) should be removed UNLESS it is used to generate a historical versus contemporary comparison. A comparative bootstrap between historical and contemporary periods would be insensitive to the critical assumptions used in this model. There are two problems with the bootstrap analysis and its interpretation: (1) the input data are not transparently tabulated and labeled making it impossible to evaluate the input data and replicate the analysis; (ii) the bootstrap sampling process appears to take random draws from the observed densities from a range of abundance estimates. Below I summarize why this are currently presented and suggest how a valid comparison can be made that is insensitive to some of the problematic bootstrap assumptions.

Unless used in a comparative manner, this approach is too simplistic. If appropriate sampling distributions were used it is likely that one might discover that the outcome is highly dependent on the number of zero estimates included. As currently presented, the approach is likely to overinflate *Bolbometopon* abundance estimates. The input data are mean density estimates, but these cannot be normally distributed, because the estimation of the density of a highly aggregated shoaling parrotfish is a two-stage probabilistic process. The density estimation is a combination of the (massively zero-inflated) Poisson probability of encountering one or more shoals in a given survey time combined with the probability distribution of the shoal sizes. This distribution is bounded by one and therefore must be right-skewed. Simply taking random draws from such data, as has been done here, can only result in inflated sightings and abundance estimates.

The bootstrap analysis can be rescued *only* if used in a comparative analysis to reconstruct historical abundance and compare it to a near contemporary estimate of abundance. Historical abundance could be reconstructed by bootstrapping the best unexploited estimates across the entire distribution. A good argument has been made that the low abundances and absences around the *Bolbometopon* distribution are fishing-induced (Dulvy and Polunin 2004 and papers by Hamilton, R. and Aswani, S.). These documents and the new evidence presented in this report provides compelling estimates of likely baseline encounter rates and shoal sizes from uninhabited and sparsely populated islands. These data could then be used to provide the necessary time series to reconstruct historical abundance and estimate extent of decline. I have already suggested that a revision of the report focuses on gather such data together, see [Finding 5].

3. Are the scientific conclusions factually supported, sound, and logical?

No, I have fundamental concerns that critical portions of the conclusions are not factually supported and hence are unsound [Finding 7]. The intellectual basis for parts of the work are outdated [Finding 8] or inappropriately described in the present grammatical tense [Finding 9] and henceforth the scientific conclusions are not logical.

[Finding 7] In this report there is little recognition of the global trajectory of decline in coral cover and coral reef composition, and this is more likely than not to influence the adult carrying capacity of *Bolbometopon*. This oversight is due to inappropriate classification of the dietary preferences of this species. In the report (Page 35, section H and page 63) this species is described as a facultative corallivore. Instead it would seem more plausible, and indeed more defensible, that its carrying capacity is determined by the food quality of live coral cover, which is predicted to change substantially worldwide. This section omits the critical scientific observation that "over 50% of the diet is composed of live corals (primarily *Acropora* species" [Bellwood and Choat 1990]). This quote from a peer-reviewed paper suggests this species is *more* dependent upon live corals as a food source than is suggested by the interpretation provided in this report. A weaker dietary classification is used elsewhere in the report, "Bumphead parrotfish show little evidence of feeding selectivity; however, a significant portion (up to 50%) of their diet consists of live coral" (Page 35). Note that this oxymoronic sentence includes a critical misquote that appears to be written to suggest that <50% live coral is eaten. Compare this to the actual quote from the peer-reviewed paper which states unambiguously that "over 50%" is eaten. The dividing line between dietary specialists and generalists is arguably arbitrary; but it would be less likely, and hence hard to argue, that a species eating "over 50%" of a particular food item could be defensibly be categorized as "nonselective" (pages 36 and 63) or as "show[ing] little evidence of feeding selectivity". I do not accept the interpretation presented in this report that there is, "little evidence of feeding selectivity". Indeed this is not a scientifically defensible interpretation

Further down the following statement is made: "Bumphead parrotfish appear to be opportunistic foragers and would likely cope with any likely ecosystem shifts in the coral reef community (P. 63)". For example, shifts in benthic species composition (changes in the breakdown of hard corals, soft corals, coralline algae, fleshy algae, sponges, bryozoans, tunicates, etc.) would not adversely impact bumphead parrotfish given their nonselective diet". This is a very strong statement that is not supported by any published evidence I am aware of – given that live corals are arguably overrepresented in their diet it would not be possible to conclude that they are 'nonselective". Since these unsupported narratives exclude the global decline in coral cover as a potential driver of carrying capacity I would, at a minimum, expect to see some citations supporting the statements regarding diet, because the narrative appears at odds with the peer-reviewed literature. Since it is not scientifically defensible to state that this species has a nonselective diet the alternate possibility must be supported that this species has a selective diet, favoring a diet of live coral. I can understand a desire to circumscribe the remit and scope of this report; however this decision to discount the importance of live coral in the diet of *Bolbometopon* is not factually supported. Therefore, to be scientifically-defensible and consistent with the peer-reviewed literature, the revised report should accept that it is more likely than not that this parrotfish has some dietary reliance on live coral and should consider the degree to which live coral cover is a limiting factor on adult abundance.

[Finding 8] I find the treatment of evidence to be, on occasion, unbalanced or contradictory. There are some particular problems pertaining to the classification or otherwise of this species among Distinct Population Segments, which I detail below.

Example 1. On page 63, the following statement is made to dismiss the possibility that climate change is likely to influence this species: “The species also appears to be adapted to a variety of biotic and abiotic conditions given its wide geographic range”.

This directly contradicts the following statement made on page 65 regarding the determination of DPS: “the ecological setting is qualitatively similar throughout the species range”.

So which statement is correct; both conclusions are mutually exclusive? Is this species narrowly adapted to a single ecological setting or is it widely adapted to “a variety of biotic and abiotic conditions”? The answer to this question has a profound implication for this report: either there are significant Distinct Population Segments or there is likely to be a significant effect of climate change on this species. The latter conclusion may be more defensible.

Example 2. The following statement “The loss of any one nominal DPS is unlikely to result in a significant gap in the range of the taxon” is not defensible (Page ii, line 8 and Page 46). It is not scientific to draw inference about metapopulation connectivity and strength of rescue effect based on the biogeographic colonization process that has taken place over more than tens of thousands of years. Also the connectivity and asymmetry in *demographic* connectivity is unknown, hence we have no idea of the relative importance of each component of the geographic range or DPS. The flow of genes or larvae does not constitute *demographic* connectivity. One larva does not connect a population and larval connectivity does not constitute demographic connectivity. This species is likely to have a lifetime reproductive output in excess of 200,000 larvae; yet for a population to remain in equilibrium, neither declining nor increasing, each individual only has to produce one viable offspring. Henceforth, on average, each individual egg or larvae has an incredibly marginal contribution to population growth rate. The individual larval contribution to population growth rate must be less than 1 in 200,000 – which is the lifetime reproductive output multiplied by the likelihood of surviving to maturity (Myers. 1999. The maximum reproductive rate of fish at low population sizes. Canadian Journal of Fisheries and Aquatic Sciences 56, 2404–2419). Using the same demographic logic it is easy to show that settlement/recruitment processes and juvenile habitat are likely to contribute little to the population growth rate that anything that influences adult survival (Heppell, Crowder & Menzel. 1999. Life table analysis of long-lived marine species with implications for conservation and management. Pages 137-147 in Musick, Life in the slow lane: ecology and conservation of long-lived marine animals. American Fisheries Society, Bethesda, Maryland; Kinney & Simpfendorfer. 2009. Reassessing the value of nursery areas to shark conservation and management. Conservation Letters **2**:53-60)

Example 3. I challenge the defensibility of the following statement, “there is no evidence that any nominal DPS differs markedly in its genetic characteristics from other population sectors of the species” (Page ii, line 13). There may be no evidence for population differentiation, but this conclusion is entirely dependent on the resolution of markers used to search for such patterns this uncertainty and bias against detecting population substructuring is not acknowledged or described. The general history of this field of research has been that finer-scale population differentiation has been unveiled as more sophisticated markers have been discovered. Fine-scale population differentiation has been discovered, virtually without exception, in every marine fish species that has been examined with post-allozyme genetic markers. This literature raises two fundamental issues which have not been adequately dealt with here. Firstly, is it more likely that there is no population differentiation or that no differentiation that has been detected *yet*? Secondly, given our increasing understanding of coral reef fish population differentiation is it more than not that there is population differentiation in *Bolbometopon*?

[Finding 9] The language, and specifically the grammatical tense, used to describe the current status of this species is not scientifically defensible, for example “It is generally uncommon”, “despite its rarity” (Page 16), and “It can be found throughout” (Page 10, 5 lines up from the bottom). It is instead more defensible to state that, “Historically, this species has been documented from …” Similarly, “In the United States it occurs in Guam”, is definitely not a scientifically defensible statement – it is likely to be locally extinct there.

Page 21. It is not defensible to state, “Bumphead parrotfish are recorded from” instead it is more correct to state that, “Bumphead parrotfish have been recorded”. There is no recent synoptic survey to confirm or deny their continued presence, as currently stated this implies that this species is naturally of this status.

This section needs to be worded very carefully and in the appropriate grammatical tense. Given the recent published synoptic analyses it might be more defensible to state that this species is common only in areas where fishing is almost non-existent or banned and to highlight these areas in a revised table 1, as suggested in [Finding 6].

The appropriate description of the evidence for and timing of presence and absence, for example as displayed in McClenachan & Cooper. 2008. Extinction rate, historical population structure and ecological role of the Caribbean monk seal. Proceedings of the Royal Society B: Biological Sciences **275**:1351–1358, is an essential requisite of an informative extinction risk evaluation

1. Where available, are opposing scientific studies or theories acknowledged and discussed?

2. Are uncertainties assessed and clearly stated?

No. These issues have been summarized in Findings 2, and 4 to 10.

No. There are two fundamental problems with the treatment of uncertainty in this report. First, the report needs to account for the well-documented bias against detecting declines and extinction in the marine environment. Second, the Executive Summary explicitly concludes with extinction risk assessments that exclude uncertainty weightings.

[Finding 10] There are virtually no survey data that satisfactorily document the decline toward local extinction in marine organisms. While the mode of analysis used in this report is typical of quantitative ecologists, this is an insufficient epistemology and mode of analysis for evaluating extinction risk in data-poor species. Instead local extinction and disappearances are very often inferred against a plausible null expectation. The absence of a species is usually inferred based on the following conditions: that the species was, (1) formerly found in the area, (2) is/was exposed to a threatening process and (3) is/was intrinsically sensitive to the threatening process. This analytical approach is the foundation of the ecological risk assessments that are increasingly used to prioritize species for remedial management (e.g. Braccini et al. 2006. Hierarchical approach to the assessment of fishing effects on non-target chondrichthyans: case study of *Squalus megalops* in southeastern Australia. Canadian Journal of Fisheries and Aquatic Sciences 63:2456-2466). This well-documented asymmetry in inferential power and data availability results in a strong bias against detecting local extinctions and greater uncertainty in inferring current status (e.g. Dulvy et al. 2003. Extinction vulnerability in marine populations. Fish and Fisheries 4:25-64). The only way to balance the asymmetry and avoid the problems of shifting baselines is to apply historical methods of inference that are becoming widespread in the fisheries and conservation literature, to draw inference on historical distributions and abundances. The value of such methods is increasing due to the enormous asymmetric consequences – an unnoticed extinction -due to the high risk of a Type II error of falsely classifying endangered species as being healthy (Peterman and M'Gonigle. 1992. Statistical power analysis and the precautionary principle. Marine Pollution Bulletin 24:231-234).

There is considerable use of all *available* data and this is plotted and referred to throughout the text, yet there is little consideration of what is not available, i.e. data or inferences of absence. This asymmetry needs to be recognized and dealt with. The report largely overlooks zero abundance data, evidence for absence and plausible null hypotheses of historical abundance. The absence of a framework for considering these zeros, evidences of absence and null models of historical abundance, renders this evaluation biased toward the presences rather than the absences. This uncertainty is not acknowledged or accounted for. Data can be absent for two reasons: it hasn’t been collected or the species is likely to be locally extinct. The absence of sightings data in an area frequented by ecologists, divers and photographers may provide compelling evidence of absence. In evaluating extinction risk the zeros are just as important as the positive sightings and identification of areas of abundance. There are numerous locations for which it is highly likely that *Bolbometopon* are suffering exploitation-induced rarity or absence. These data are summarized conveniently in table 2 of Dulvy and Polunin 2004, one of the only peer-reviewed documents available to summarize *Bolbometopon* status. The inclusion of a similar, updated presentation of the absence / low likelihood of presence data is required to provide more balanced picture of the current status and distribution of this species.

[Finding 11] The portrayal and interpretation of uncertainty in the score-based extinction risk assessment of *Bolbometopon* is flawed because it ignores uncertainty and is entirely inconsistent with the precautionary principle. In the Executive Summary and main text the report finds a 45% chance that this species is “Likely to be in danger of extinction in the foreseeable future (100 years) throughout all or a significant portion of its range” and a 50.4% chance that “Neither ‘currently in danger of extinction’ or ‘likely to be in danger of extinction in the foreseeable future (100 years)’ throughout all or a significant portion of its range”. These probabilities and the conclusions drawn from them are acceptable as they are based on *weighted* scores which explicitly and transparently capture uncertainty. Yet the strongest and least defensible statements in the Executive Summary and main text specifically tally up votes for or against – ignoring the uncertainty embodied in the weightings. Incredibly strong yet indefensible statements are made on the on the basis of the unweighted scores (that do not incorporate uncertainty) for example, “The BRT agreed by 3/5 majority that bumphead parrotfish is neither currently in danger of extinction or likely to be in danger of extinction”. Statements like, “The BRT agreed by 3/5 majority” is oxymoronic and misleading. How can a value of 3/5 ever be interpreted as agreement? The scientifically defensible approach is to draw conclusion only from statistics that incorporate uncertainty, i.e. the weighted scores.

Evaluate the findings made in the Status Review

There is a very real risk that the problems outlined in this report may result in biases that leading to a substantial underestimation of extinction risk in the bumphead parrotfish *Bolbometopon muricatum.*

Conclusions and Recommendations in accordance with the ToRs.

To reduce the likelihood of bias in the assessment, to increase transparency, replicability and defensibility of the results I highlight three key recommendations, which in turn are derived from a series of more-specific recommendations based on my findings, to be implemented in the revision of the report.

Recommendations

Key Recommendation 1: There needs to be revised interpretation of the dietary preference of adult *Bolbometopon* for live coral as a limiting factor [Finding 7]. It is recommended that the authors reconsider their current classification of *Bolbometopon* as being a dietary generalist and instead accept the more likely conclusion to be drawn from the available peer-reviewed evidence that *Bolbometopon* have a high live coral content in their diet. The logical conclusion to be drawn from this evidence is that live coral cover may be a factor limiting adult abundance. This then requires a full description and understanding of the historical recent and future coral cover and health trajectories and the degree to which this will contribute to *Bolbometopon* extinction risk within the next 1-3 generation spans.

Key Recommendation 2: The understanding of marine extinction risk, population substructuring and metapopulations dynamics needs to reflect current theoretical understanding and empirical evidence [Finding 2]. Data selection, data description, gap analysis, mapping and other methods of inference appropriate for evaluating "absence of evidence versus evidence of absence" as is more typical of the "declining population" paradigm should be adopted [Findings 4, 5, 6, 9, 10]. Key uncertainties should be recognized and incorporated where possible, especially in the final Risk Assessment section and the reporting of these findings in the Executive Summary [Finding 8, 11].

a. Following **Finding 2**, it is recommended that the text reflects an awareness of the declining population paradigm, and specifically that extinction risk is the outcome where fishing mortality is greater than the population growth rate throughout the bulk of the species range. The report needs to answer the question for each GSU, “where is the fishing mortality likely to exceed the population growth rate”. In answering this question the report needs to note also that if the economic discount rate is higher than the population growth rate then this sets the economic conditions to make it likely that a greater financial return can be achieved by driving the species to local extinction rather than aiming for sustainable exploitation (Clark. 1972. Profit maximization and the extinction of animal species. Journal of Political Economy 81:950-961). The low likely population growth rate of this species and the very high economic discount rates typical of the many developing nations that constitute the geographic range of this species make it unlikely that a sustainable outcome is possible. One approach to answering this question is by accounting for the degree to which levels of exploitation are sufficient to cause declines to the point of depensation for this species. While the authors acknowledge that fishing is a likely driver of decline, this key mechanistic driver is not used in any quantitative way to frame their understanding and generate plausible hypotheses of historical and current status of this species.
b. Following **Finding 4 and 10**, it is recommended that a gap analysis be conducted, to account for the asymmetry in data availability and the increasing uncertainty as abundance declines and become locally extinction. The report needs to extend the table of GSUs (Table 1) to include information on biogeographic occurrence (including dates of sources), current or known occurrence (including dates of sources), any qualitative of quantitative measures of relative abundance, and entries also need to be made to reflect absence of knowledge and or a date of last reported sighting. Appropriate citations and personal communications should also be presented in the table. The report also needs to include a comprehensive summary of the spatial extent, intensity and direction of key pressures. The reported degree of certainty in pressures and drivers should be accurately reflected in this report.
c. Following **Finding 4**, it is recommended all data presentations and associated methods, legends and annotations should be revised to ensure full transparency and the scientific standards of data presentation.
d. Following **Finding 5**, it is recommended that all distributional data and maps are revised to also report, account for and portray the following four elements that are essential for a full and transparent portrayal of distributional information, including; the nature of the evidence (e.g. ship’s log, taxonomy, field guide, personal communication, ecological census), the relevant date (either publication date or date of collection or sighting), the locational information and the source of the information.
e. Following **Finding 9**, it is recommended that the appropriate grammatical tense be used to describe the current and historical status of this species.
f. Following **Findings 5 and 9** and the associated **Recommendations 2c & d**, it is recommended that at least three GIS distribution maps are drawn up to show the extent of

occurrence of *Bolbometopon* where it is: (i) currently in abundance (e.g. Rowley shoals, GBR, sits in the Seychelles, Wake, Palmyra, US Pacific Atolls, Isolated parts of PNG and Solomon Is., Red Sea, Palau), (ii) it is currently in less than abundance (rare, v. rare and uncommon, *sensu* Table 2 of Dulvy and Polunin 2004); and (iii) where the current status is unknown or uncertain but the species has previously been taxonomically or biogeographically described from the area.

g. Following **Finding 6**, it is recommended that the bootstrap analysis is removed. The bootstrap analysis can only be scientifically-defensible if used in a comparative manner to compare the relative abundance between two time periods, such as generated by recommendation 2e above.

h. Following **Finding 7 example 1**, it is recommended that the report explicitly states which of the following statements is correct: “The species also appears to be adapted to a variety of biotic and abiotic conditions given its wide geographic range” OR “the ecological setting is qualitatively similar throughout the species range”. Accordingly the report should revise its conclusions concerning the existence of DPS or the influence of global climate change and the overall extinction risk assessment.

i. Following **Finding 7, examples 2 and 3**, it is recommended that the report is changed to reflect the modern theory and empirical understanding of metapopulation connectivity, rescue effects and the detection of population substructuring.

j. Following **Finding 11**, it is recommended that, if this report and the underlying ESA process is committed to assessing and stating uncertainty then all language pertaining to the number of votes be removed from the Executive Summary. It is recommended that only the weighted scores should be presented and used for inference. The scientifically defensible approach is to draw conclusion only from statistics that incorporate uncertainty, i.e. the weighted scores NOT the tally of votes.

Key Recommendation 3: The report should be updated to include citations to published scientific sources and citations to any verbal evidence solicited by and used by the Biological Report Team. The standards of referencing source material are below what would be acceptable in the peer-reviewed scientific literature. Specifically, it is recommended that; (1) the limiting factors table is supported by citations, (2) evidence derived from conversations and verbal presentations need to be referenced according to the name and location of the provider of the information.

Appendix 1: Bibliography of materials provided for review

Bumphead Parrotfish (*Bolbometopon muricatum)* Status Review, August 30, 2010

Appendix 2: A copy of the CIE Statement of Work

External Independent Peer Review by the Center for Independent Experts

Status Review of Bumphead Parrotfish

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: A Status Review of the bumphead parrotfish (*Bolbometopon muricatum*) is being conducted by a team at the Pacific Islands Fisheries Science Center pursuant to a petition for NMFS to list the species as threatened or endangered and designate critical habitat under the Endangered Species Act. The draft Report of the review team is the subject of the peer review. The draft report will include a comprehensive presentation and evaluation of information on distribution, biology, abundance trends, threats and risks, information on population structure and genetics, and danger of extinction throughout all or a significant portion of its range. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. The combination of required expertise of the CIE reviewers shall include working knowledge and recent experience in coral reef fish biology and ecology, fish population dynamics, and quantitative risk assessment of endangered species. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review as a desk review, therefore no travel is required.

Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, and other pertinent information. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables -Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Conduct an independent peer review in accordance with the ToRs (**Annex 2**).
3) No later than 15 September 2010, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and Dr. David Die, CIE Regional Coordinator, via email to ddie@rsmas.miami.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in

	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
20 August 2010	NMFS Project Contact sends the CIE Reviewers background documents
30 August 2010	NMFS Project Contact sends the Status Report to the peer reviewers
1-14 September 2010	Each reviewer conducts an independent peer review as a desk review
15 September 2010	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
29 September 2010	CIE submits the CIE independent peer review reports to the COTR
4 October 2010	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

this SoW in accordance with the following schedule.

Modifications to the Statement of Work: Requests to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) each CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) each CIE report shall address each ToR as specified in **Annex 2**,

(3) the CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

William Michaels, Contracting Officer's Technical Representative (COTR) NMFS Office of Science and Technology 1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910 William.Michaels@noaa.gov Phone: 301-713-2363 ext 136

Manoj Shivlani, CIE Lead Coordinator Northern Taiga Ventures, Inc. 10600 SW 131st Court, Miami, FL 33186 shivlanim@bellsouth.net Phone: 305-383-4229

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Key Personnel:

NMFS Project Contact:

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Megan Moews Pacific Islands Fisheries Science Center 1601 Kapiolani Blvd., Suite 1110, Honolulu, HI 96814 megan.moews@noaa.gov Phone: 808-944-2120

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

3. The reviewer report shall include the following appendices:

Appendix 1: Bibliography of materials provided for review Appendix 2: A copy of the CIE Statement of Work

Annex 2: Terms of Reference for the Peer Review Status Review of Bumphead Parrotfish

Evaluate the adequacy, appropriateness and application of data used in the Status Review document.

1 In general, does the Status Review include and cite the best scientific and commercial information available on the species, its biology, stock structure, habitats, threats, and risks of extinction?

2 Are methods used valid and appropriate?

3 Are the scientific conclusions factually supported, sound, and logical?

4 Where available, are opposing scientific studies or theories acknowledged and discussed?

10. Are uncertainties assessed and clearly stated? Evaluate

the findings made in the Status Review.

1. Are the results of the Extinction Risk Analysis supported by the information presented?

All information associated with the Status Review document is to remain strictly confidential until the Status Review is posted to the PIFSC website and/or the Federal Register by NMFS.