University of Miami Independent System for Peer Review:

Review of Garrison et al (2003) Abundance of Mid-Atlantic Coastal Morphotype Bottlenose Dolphin During Winter and Summer 2002.

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1. Executive Summary

The objective of the Garrison *et al.* report was to estimate the abundance of the summer and winter management units of coastal bottlenose dolphins between New Jersey and Florida with a precision of 20 – 30 % CV. In order to achieve this it was necessary to estimate the spatial distribution of the dolphin populations, by unit, to determine if there were obvious stock boundaries or relationships between group size and density and environmental variables such as sea surface temperature and depth. A biopsy program was undertaken to determine the relative spatial proportions of each morphotype. Aerial surveys were conducted in summer and winter with stratification of effort by stratum (0-20 m and 20 – 40 m depth strata). Independent teams of observers were used to enable estimation and correction of perception bias relating to perpendicular sighting distance. The sightings of groups from these surveys were apportioned to each morphotype using the genetic and spatial data in order to generate the estimate of coastal dolphin abundance by season for each unit. Garrison *et al.* achieved the targeted level of precision for the winter abundance estimates but had poor precision for the summer abundance estimates. The variability of the results were affected by the failure of the biopsy surveys to consistently allocate effort to the intermediate strata where mixing between the morphotypes occurs.

Some potential biases and problems with the data analysis were detected. Several of these problems may be resolved by re-analyzing the existing data. These problems need to be addressed and are listed below.

1. An aspect of perception bias that was not investigated was bias in detection of groups related to the size of the group. This bias has been detected in other bottlenose dolphin aerial surveys. This bias is further compounded by an apparent correlation between group size and depth (or distance from shore), and the use of the mean group size to generate the final abundance estimates.

2. Availability bias was not assessed. This bias is routinely controlled in aerial surveys and would be likely to occur in the several units that have low mean group size.

3. Some of the logisitic regression and general additive models clearly did not accurately model the observed data. The effect of this inaccuracy upon the abundance estimates was not quantified. In part, this inaccuracy appears to have resulted from low survey effort in the deep stratum and a resulting outlier effect.

4. There is insufficient information given regarding the genetic analysis of the biopsy samples. In particular, the following have not been addressed: the potential for hybrids, duplicate sampling, sampling of highly related individuals and contamination of samples. In addition, there is a potential bias resulting from interannual variability in the spatial distribution of the dolphin populations and the use of biopsy samples dating back to 1998.

In summary, at present these abundance estimates represent the best available information on which to proceed with protected species management for the western North Atlantic coastal bottlenose dolphins. It may be possible to reduce or remove several of the highlighted problems with this report by some reanalysis of the existing data. Due to the relatively low precision of some of the abundance estimates the resulting Potential Biological Removal (PBR) calculations will likely be very low. Considering the nature of the potential biases in this abundance estimation, it is doubtful that any of these biases would result in such a significant overestimate of abundance that the resulting PBR would fail to protect the population from depletion.

2. Background

Considerable genetic structure has been uncovered in the population of western North Atlantic bottlenose dolphins between New Jersey and Central Florida. This population is comprised of two genetically distinct morphotypes (Hoelzel *et al.* 1998) that may be reproductively isolated. These morphotypes have been termed “coastal” and “offshore” types due to their respective nearshore and deep-water habitats. Further evidence of morphological variation and parasite loads (Mead and Potter 1995), diet (Walker *et al.* 1999) and hematology (Duffield *et al.* 1983) supports the distinctiveness of these two ecotypes. To date, it has not been possible to differentiate between the morphotypes from aerial surveys leading to the need for biopsy sampling to characterize their spatial distribution and potential overlap.

The biopsy program undertaken by the National Marine Fisheries Service (NMFS 2001) was intended to identify the spatial overlap between the coastal and offshore morphotypes as well as to detect latitudinal stock structure in the coastal morphotype. Genetic samples were collected mainly from three large-vessel cruises during the summers of 1997, 1998 and 1999. Of the 237 biopsies collected, only nine were identified as the coastal morphotype. Some limited coastal biopsy collections were undertaken to supplement these data and a classification and regression analysis indicated that the morphotypes fell into three strata. This analysis suggested that between 0 - 6 km distance from shore all dolphins would be expected to be coastal morphotype, from 6 – 39 km from shore there was a mixed, or intermediate, zone containing both coastal and offshore morphotypes and finally beyond 34 km from shore all dolphins could be expected to be of the offshore type. The 2001 NMFS report indicated that the sampling effort in the 6 - 39 km strata was poor, resulting in few samples (15 sampled locations). Due to the presence of a region of overlap between the two morphotypes, NMFS (2001) concluded that future biopsy effort should be focused in the intermediate strata in order to be able to accurately determine the proportions of coastal and offshore morphotypes for apportionment of aerial survey data. This conclusion was echoed by Garrison (2001) who added that due to the observation of differing spatial distribution in summer and winter it would be necessary to focus future biopsy collection about the spatial boundaries in both seasons.

The coastal morphotype has received the greater research attention of the two morphotypes due to its depleted status (under the MMPA). Effort has been undertaken to determine if the population between New Jersey and Central Florida is structured. Originally, this population was thought to be a single migratory stock based on the progressive southward trend of the 1987 - 1988 mortality event (Scott *et al.* 1988). Subsequently, a complex stock structure of the coastal morphotype has been uncovered. Based on genetic and photo-ID data, NMFS (2001) determined that the coastal morphotype was comprised of seven summer management units. These units are the northern migratory unit, the northern North Carolina unit, the southern North Carolina unit, the South Carolina unit, the Georgia unit, the northern Florida unit and the central Florida unit. There was a marked seasonal component to the stock structure, with the northern migratory unit moving south in winter resulting in overlap between this unit and both the northern and southern North Carolina units.

Spatial distribution of the bottlenose dolphin populations has been considered as a method to identify potential habitat boundaries of the coastal morphotype and provide information about group size and density in relation to habitat variables. Garrison (2001) evaluated summer spatial distribution based on three replicate aerial surveys conducted in 1995 between Cape Hatteras, NC and Sandy Hook, NJ. He was able to define a 12 km spatial boundary containing 80% of overall sightings for this area. Garrison also evaluated spatial distribution from a winter aerial survey conducted in 1995 from Cape Hatteras south to Ft. Pierce, FL. This survey indicated a broader distribution with a boundary of 27 km from shore. Since the summer and winter surveys did not overlap it is hard to draw any inferences about changes in seasonal distribution from this data.

The initial aerial surveys of the inshore western North Atlantic bottlenose dolphins did not attempt to partition between the coastal and offshore morphotypes. The preliminary abundance estimates for bottlenose dolphins in the area between Cape Hatteras and mid-Florida was 12,345 with a coefficient of variation (CV) of 0.18% (Blaylock and Hoggard 1994). More recent abundance estimates have been focused upon estimating the abundance of the coastal morphotype in these waters. The aerial survey methodology followed the guidelines in Buckland *et al.* (1993) with line-transects conducted orthogonal to the shore, randomization of transects, and replication. In 1995, summer aerial surveys were conducted north of Cape Hatteras and in winter of the same year an additional survey was conducted south of Cape Hatteras. These surveys were used to calculate the abundance of the coastal morphotype in these two areas (Garrison and Yeung 2001). The abundance estimates were partitioned into the NMFS (2001) management units, and the overall estimate for winter was 20,020 coastal dolphins. However, this abundance calculation was problematic due to an assumption of a single migratory stock of coastal dolphins in the original aerial survey design and a failure to account for potential visibility bias along the transects.

2. Review activities

This review consisted of examining the background material supplied by the CIE (listed in Appendix I) and obtaining and reading supplementary material (Appendix I, Part II). In addition, the NOAA online archive was investigated for additional material that might help with this review (such as the NMFS-SEFC-492 report).

After an initial review of the report by Garrison *et al.* [Abundance of Mid-Atlantic Coastal Morphotype Bottlenose Dolphin During Winter and Summer 2002. Garrison et al. (2003) Southeast Fisheries Science Center. NOAA Fisheries. 117pp], additional material was sought. Only the literature cited in this review is included in Appendix I.

Finally a detailed review of the Garrison *et al.* report was conducted with cross-referencing with the reading material. The list of notes that were complied from this review formed that basis of the report below. Since the greatest source of variability in the abundance estimates appeared to have resulted from the estimation of the distribution of the coastal and offshore morphotypes, I decided to focus much of my review effort upon this aspect of the report.

3. Comments on the quality of the report

I consider that the Garrison *et al.* report is very cumbersome with a poor layout. Therefore I feel that it is necessary to make some comments regarding the format and arrangement of this report since I believe that it is unacceptable in its current state.

For ease of readership, it is important to ensure that the structure is consistent throughout the report. In the text and first section of the tables, the management units are always referred in order from northernmost to southernmost. The order of tables in the last section (abundance) is inverted. The figures do not appear to be in the same sequence as in the text. The need to constantly flip pages to compare between figures is annoying. This is made worse by a lack of standardization of axis (e.g., Figure 22 both the x and y axis). I strongly recommend that the layout of the figures be reconsidered, especially for section IV. For this section I would like to see all the figures pertaining to a management unit (by season) on a single page. I envisage a four panel figure with one panel indicating transect lines and group sightings on a map, a second panel showing SPUE by distance from shore and third panel showing group size by distance from shore with a final panel free to show anything of particular interest (group size by depth). Much of the material in the methodology and results sections would benefit from clarification and elaboration. In particular, interpretation of some of the methodology is difficult. Finally, I have noted errors in the report including many typos, and, in Figure 29, there are only three data points for the offshore morphotype, but in the text and Table 13, five sample locations are mentioned.

4. Aerial survey methodology

An aerial survey program was designed to estimate the summer and winter abundances and spatial structure of coastal morphotype bottlenose dolphins between New Jersey and Florida. The objective of the surveys was to obtain abundance estimates for each management unit with a CV between 20 - 30%. A secondary objective was to investigate spatial distribution to determine if there were obvious stock boundaries and to investigate the relationship between group size and density and environmental variables such as sea surface temperature (SST), depth and season.

The survey design and aircraft were similar to those used in most good aerial surveys. Observers were divided into two independent teams in order to quantify perception bias (using the mark-recapture line transect (MRLT) approach). Bubble windows were used on the plane including a belly window to allow observation of the trackline itself. An infra-red thermometer was deployed in the belly window and was calibrated against data from satellite data. Curiously, night-time satellite data were most similar to the thermometer readings, and this was never fully explained. The aircraft traveled at a standard survey speed of 100 knots recording time, GPS location and heading. Surveys were only flown in favorable conditions. Tracklines were perpendicular to the shore.

The summer survey was planned for 15 July – 31 August 2002, and 6,734 km of the intended 7,610 km were completed. The summer survey was stratified with transects every 10 km in the 0 - 20 m depth zone and every 30 km in the 20 – 40 m depth zone. The winter survey was planned for 15 January – 28 February 2002, and 6,411 km of the intended 7,500 km of transect was completed. The winter survey was conducted in two sets of replicate lines. The first set of transects were every 10 km in the 0 - 20 m depth zone and the second set of replicates were offset by 2 – 5 km from the first set. The second set was also spaced every 10 km apart but extended from 0 to the 40 m depth zone. The summer survey extended over a greater latitudinal range than did the winter survey. Most effort in the winter survey was focused around North and South Carolina. In both seasons, 185 groups of dolphins were sighted, with a count of 2,544 individuals in summer and 2,114 individuals in winter.

A key issue with aerial survey design is control of visibility bias. Failure to do so was one of the primary criticisms of the previous (Garrison and Yeung 2001) abundance estimates. Including two independent teams of observers on the aircraft allowed the control of one form of visibility bias – perception bias. Here, a mark-recapture line transect (MRLT) approach was used where the initial sighting of a group was treated as a mark, and sighting of the same group by the other team was considered the capture. This method may be biased if dolphins respond the aircraft or if the act of observation of the group influences the second team's chance of observation. I note that the teams were composed of two sets of observers separated by a curtain and one scientist to record data. To further isolate the observer teams, communication with the pilot and recorder was conducted upon separate intercom systems. A second facet of perception bias is the change in sighting efficiency with group size and with distance (perpendicular sighting distance) from the plane. With respect to the distance from the plane, a nonparametric smoothing spline was fitted to the graphs of sighting probability by distance. This seems to be a sensible approach, but it would have been nice to include a separate spline for each team in the figures, as this may have indicated if there was an effect of the team using the belly window.

A component of perception bias that was not corrected or examined was the relationship between perception of dolphin groups and group size. Garrison *et al.* even cite a report by Forney *et al.* (1995) that both identified and quantified the effect of group size related bias in perception of bottlenose dolphin off California. The authors claim that because group sizes were relatively large for most management units, they expect the potential group size perception bias to be small. Examination of mean group size from the abundance estimates indicates that in many management units, mean group size was small. Thus, I believe that this should have been investigated in more detail, and may still be able to be investigated with the current dataset. Upon sighting of a dolphin group, the observer waits for a while to give the other team a chance to sight the dolphin before instruction is given to the pilot to break off transect and circle the group. Group size is estimated during the circling. Thus it would be a simple matter to estimate the effect of group size bias by examination of the sizes of groups that were only observed by one team. Given the spatial data that indicates that in some areas group size decreases with distance from shore (DFS), I disagree with the claim that the effect of group size related perception bias would be small but note that the researchers have recognized the possibility of this bias (pg 29).

A second aspect of visibility bias that was not corrected was availability bias. Availability bias results when dolphin groups are not visible during the fly-over by the survey plane. This can occur when dolphins are underwater, when water turbidity is high and so forth. The standard way to estimate availability bias is to determine the proportion of time a dolphin spends at the surface (e.g., Barlow *et al.* 1998). Carretta *et al.* (1998) use a method of tandem aerial surveys to quantify availability bias in the estimation of abundance of southern California coastal bottlenose dolphins. Due to the variability uncovered in this current survey, a series of tandem surveys could be considered in order to further examine issues of availability bias.

The winter (January – February 2002) aerial surveys were composed of two sets of replicate flights. No information is given regarding when these replicates were flown. In later analyses the data appear to have been combined rather than averaged (except for the bootstrap analyses p.44). Since the replicate inshore transects were only between 2-5 km apart, there was a considerable risk of double counting groups. This would have increased the number of groups and abundance estimate of dolphins within the 0-20 m depth strata. Aside from the section describing the replicates, I have been unable to determine how these replicates were analyzed in later sections of the report. If a replicate transect line was surveyed shortly (i.e. minutes – hours) after the first transect line, then the probability of sighting of the same group would be relative to dolphin travel speed. Cockcroft *et al.* (1992) estimated that South African coastal bottlenose dolphins travel with an average speed of 3.5 km h^{-1} with an upper limit of 6 km h^{-1}. If the replicate transect line was flown much later (days – weeks), then there would also be a proportion of groups surveys that would be double counted if the data were combined. If the transects were treated as individual surveys and analyzed separately, then double counts would not be problematic; but it is not clear from the text that this is the case (e.g. Tables 25-28 do not indicate replicate surveys). Garrison *et al.* need to clarify how they treated these replicate transect lines and risk of double counting.

5. Analysis of spatial distribution

For the analysis of spatial pattern, Garrison *et al.* used generalized additive models (GAM). This approach seemed reasonable since the models do not assume a linear structure in the data. Considering such latitudinal complexity, and with the presence of two potentially spatially segregated morphotypes, linear approaches would not be valid for the analysis of these data. The spatial distribution was analyzed based on the 2002 aerial survey data. The authors should outline reasons for not including data from previous aerial surveys, especially since they combine these data with biopsy data collected across many seasons. I like the concept of using the spatial distribution of group size in combination with biopsy data to correct the abundance estimates. However, I have some concerns relating to the effect of outliers and poorly fitting models on the resulting abundance corrections.

Since the probability that a particular bottlenose dolphin group was of the coastal morphotype was defined by the combination of genetic and spatial data, the spatial models used need to be evaluated. For some of the management units, the analytical and bootstrapped GAM models appear to fit the data very well. In other units, the models did not fit (e.g. Figure 14 summer South Carolina). The spatial data did not take into account whether the group sighted was coastal or offshore. This meant that occasional sightings at the extreme end of the survey range might have skewed the data resulting in interpretations that were not valid for the coastal types. For example, in the results for the summer northern migratory unit and the northern North Carolina unit, there were sizable gaps in sightings (coinciding with the coastal and offshore dolphin distribution). I would like to see how the regression and models changed if only the inshore component of these areas were used in the analysis. Of course, it would be somewhat circular to use morphotype to correct these models, but perhaps thought should be given to the effect of low survey effort in the 20 – 40 m depth strata on the overall model performance.

6. Distribution of coastal and offshore morphotypes

Garrison *et al.* recognized that in order to calculate an abundance of coastal dolphins from New Jersey to Florida, it would be necessary to determine the relative proportion of coastal and offshore morphotypes occurring at each depth interval in each management unit to generate a probabilistic model to apportion the aerial survey data. Therefore, the objective of their biopsy program was to representatively sample across a broad spatial scale, to determine the patterns of distribution of each morphotype.

Historic biopsy data were incorporated into the analysis, including systematic sampling from 1998 – 2002. The previous summer samples (1998, 1999, 2000) were predominantly collected from a large-vessel line transect abundance survey and the majority of the samples collected were from waters > 20 m depth. In July - August 2001, an extensive sampling program was undertaken for the purpose of description of the distribution of the two morphotypes. Unfortunately, the majority of effort in this survey was directed at finding dolphin groups to sample, thus resulting in a relatively low yield of 55 samples. The samples were unevenly distributed throughout the spatial range of sampling effort and, in effect, a representative sample was only collected at region 1. To overcome this problem, Garrison *et al.* elected to focus sampling effort on the northern and southern North Carolina units. They used a small coastal vessel and an offshore 41 m vessel with a small boat. Spotter planes were used to improve the sampling efficiency, and effort was concentrated in the intermediate zone. A total of 49 samples were collected. In the winters of 2001 – 2002, mainly inshore surveys were conducted due to weather conditions. While 125 samples were collected, these were clustered in distribution.

Due to a lack of samples, morphotype distribution could not be assessed on a per management unit basis. To overcome this, Garrison *et al.* pooled the samples to make two regional units based on location north or south of Cape Lookout. The choice of Cape Lookout was based upon differences in distribution of dolphin groups and sample distribution. In my opinion, this was a valid method to overcome the lack of samples while trying to account for at least some of the regional differences observed in dolphin distribution. In the northern region, there were no biopsy samples collected from the intermediate region. The offshore morphotypes ranged from 0 - 12.6 km from shore, and the closest offshore morphotype was found at 36.9 km from shore, indicating a significant spatial division between these populations. Garrision *et al.* (pg 31) state that "no inferences can be made about overlap between morphotypes at intermediate depths in absence of samples" but since there were no sightings of dolphins during the aerial survey, this would simplify the abundance calculation from this region. In the southern area, there was overlap in distribution with coastal morphotypes detected at 74.6 km and 82.5 km from shore and offshore morphotype samples collected as close as 15.4 km from the shore. The distribution of coastal and offshore morphotypes profoundly influences the later analyses, and hence it is important to assess the quality of this information.

The analysis of the morphotypes included both mtDNA and nuclear microsatellite markers (see NMFS 2001). The Garrison *et al.* report includes insufficient information to assess the quality of the genetic analysis of the biopsy samples, e.g., Tables 11 and 12 report sample locations but not sample size. The collection of biopsy samples and resulting spatial information can be biased by a variety of factors. It is possible that biopsy sample collection is biased due to avoidance of one morphotype over the other (as noted by the authors) or by one gender. A gender bias is more likely to influence latitudinal stock structure patterns, especially if one gender (say males) has a greater dispersal range than the other gender. Since much of the sampling is localized in nature, some estimate needs to be made of the risk of sampling highly related individuals or even duplicate samplings of the same individual. If there were resident coastal sub-populations that were readily found due to small dispersal distance (possibility indicated by preliminary telemetry data, NMFS 2001), then repeated sampling from this population over time might bias the morphotype proportion estimates. Outlier samples must also be critically evaluated due to their large influence upon the resulting logistic regression models and subsequent apportionment of abundance (for example, the deep (~40 m depth) coastal sample collected in winter in the Georgia unit). The potential for contamination must be addressed. A comparison of mtDNA and microsatellite information should indicate if such samples are hybrids. Given the possible influence of such samples, it is unacceptable to fail to investigate them further.

Considering that Garrison *et al.* (pg 38) state that "the relative distribution of coastal vs offshore morphotypes remains the most significant source of uncertainty" in the data, then the success of the sampling surveys of 2001 - 2002 must be criticized. As previously noted (NMFS 2001, Garrison 2001), the biopsy surveys should have focused effort upon the intermediate strata of morphotype mixing in both summer and winter. However, winter sampling in the North Carolina area was "primarily to improve definition of latitudinal stocks, and therefore they did not attempt to include broader coverage further offshore" (pg 37). Further, in relation to sample collection at the Georgia management unit "there are no samples from intermediate wares between 10 – 40 km from shore, since little survey effort has been expended in this region". The only conclusion that can be drawn is that the sampling strategy was poorly planned, and that the surveys had competing objectives that directly resulted in the poor precision of the current abundance estimates.

Logistic regression was used to calculate the probability of the morphotype of a given group being the coastal morphotype. Since the northern migratory and northern North Carolina units were spatially segregated with respect to morphotype, the groups sighted could be easily partitioned without the need for logistic regression. In the southern units, the range of the coastal and offshore morphotypes overlapped, requiring a probabilistic measure for apportionment of the groups. The logistic regression curve generated for the summer biopsies south of Cape Lookout suggests that this method may be valid but is also imprecise. The curve suggests that a proportion of bottlenose dolphins in the 0 – 10m depth zone might be offshore types, and that a proportion in the 35 – 80 m depth zone might be coastal. Since this curve is used to calibrate the abundance estimates, this might lead to a significant underestimate of coastal dolphin abundance by apportioning a significant proportion of dolphin groups within the shallowest strata to offshore morphotypes. To estimate the potential magnitude of this bias, I would like to see an analysis that applies a logistic regression only within the zone of overlap and assumes that all groups sighted in less than ~10 m are coastal and all groups sighted at greater than ~34 m are offshore morphotypes. The logistic regression model for the winter Georgia unit (Figure 30) should also be treated in this fashion. At present, the confidence intervals suggest that as much as 30% of dolphins in the 1 m depth interval could be offshore morphotypes. The outlier effect discussed above is also evident in the size of the confidence intervals about the regression model in the winter Georgia unit. The large confidence intervals about these logistic regression models will have the effect of introducing considerable uncertainty into the abundance estimation and consequently result in a lowering of Potential Biological Removal (PBR). Garrison *et al.* identify a bias resulting from the constraint of the upper limit of the confidence limits to one, thus causing the random predictor to generate more probability values below the predicted curve than above it. While their solution is simply to obtain more samples, in order to reduce the size of the confidence limits, I would suggest that they apply the regression to only the region of overlap in morphotypes. Limitation of the regression might reduce this bias, especially because this bias occurs at the other end of the spectrum as well.

The assumption of apportionment of dolphin groups in the abundance calculations is that the spatial distribution of biopsy samples is the same as the spatial distribution of the population. The authors noted that while the aerial surveys were conducted within a defined period from January – February, the winter biopsy collection extended from October to March. Of course, another consideration not noted by the authors is that since there is evidence of interannual variability, at least in the north, then the use of biopsy samples extending back to 1998 may invalidate the above assumption for both summer and winter abundance estimates. With about 346 samples in their collection, it would have been sensible to at least attempt to examine if such a bias in distribution might exist. On the other hand, if it is considered valid to use biopsy samples dating back to 1998, then perhaps aerial survey data dating back to that period might help in the characterization of spatial distribution patterns.

7. Abundance estimation

Garrison *et al.* initially estimated the abundance of all bottlenose dolphins within the survey area. This was conducted using standard line transect theory with correction for perpendicular sighting distance (PSD). The final equation used to calculate the density of individuals was: $D = (n \,.\, E(S)\,) \,/\, (2L\mu)$. The authors note that a potential source of bias in this equation is the assumption that it is equally easy to perceive small groups at distance as it is to perceive large groups. This bias affects mean group size, $E(S)$, and can be corrected. On page 41, Garrison *et al.* state that there is no evidence of group size bias in the current analysis and hence use mean group size throughout. There is no evidence that Garrison *et al.* attempted to determine the extent or presence of group size bias, even though this may be possible with the MRLT data as mentioned above. During the aerial surveys, the estimated strip width for the individual teams was 10 – 20 m greater than the effective strip width of both teams, regardless of season. In conjunction with other reports of group size bias in bottlenose dolphin aerial surveys and the decline of sighting probability with PSD, this suggests that there may have been a higher probability of single team sightings at distance, and this might imply an effect of group size bias. Group size bias may lead to an overestimate of the abundance of coastal dolphins and should be investigated.

The perception bias relating to PSD was effectively controlled through the application of a non-parametric smoothing spline. This corrected for an overestimate of sighting probability close to the trackline. The non-parametric sighting function was combined with the Direct Duplicate estimator of Palka (1995) to generate abundance estimates that account for the dependence of sighting rates on distance from the trackline. Bootstrapping was used to estimate variance. This approach overcomes the perception bias problem of the abundance estimate generated from the 1995 aerial surveys. These results were presented as a lengthy series of tables (Tables 19 – 28). For the summer surveys the %CV of the abundance estimates after perception bias correction were lower on average than the %CV for individual teams. The perception bias correction also tended to result in a slight increase in the abundance estimates. The effect of reduction in %CV of the winter survey and slight increase in abundance estimate due to perception bias correction was also apparent. While the precision of the summer surveys as reflected in %CV by management unit was poor, the precision of the winter surveys was within the 20 - 30% CV objective, with the exception of the South Carolina deep stratum (20 – 40 m). Whether the increase in precision in the winter surveys was as a result of the effect of conducting two replicate surveys or simply as a result of increased survey effort in a smaller range is unclear.

The abundance of the coastal morphotype was generated by combination of the logistic regression models and spatial analyses with the abundance estimates. The assignment of a particular group to the coastal morphotype was based about a spatially explicit density estimate and the probability that animals at the spatial location are from the coastal morphotype. This probability and density estimate were also conditional upon environmental covariates. Thus, error or bias in the earlier models (i.e. logistic regression models, spatial models, morphotype detection) would be compounded at this stage. Statistical uncertainty in this approach was correctly reflected in the analyses by the incorporation of variability from both the abundance estimates and the regression models. Overall, this combined variability only increased the final %CV estimated by 5 – 10%, but essentially this was due to the effect of averaging variability from the different models. The authors identify several assumptions made in this approach. The first assumption is that the spatial locations and associated SST and depth are representative of the underlying spatial distribution and habitat of the population. Since the design of the line transects was random and perpendicular to the coast, I agree with Garrison *et al.* that this assumption is likely met. I am concerned that the second assumption is not met. If group size decreases with distance from shore (as is indicated in the spatial analysis of some units) and there is an unidentified bias towards sighting larger groups, then the assumption that group sighting probabilities are independent of the spatial location is not met. For the summer abundance of coastal dolphins in the northern migratory and northern North Carolina, the logistic regression model could not be implemented. Thus the observed spatial partitioning between coastal and offshore morphotypes was used. Given the absence of sightings in the intermediate zone for this season, this approach is valid.

8. Conclusions

These abundance estimates are an improvement over previous abundance estimates of western North Atlantic coastal bottlenose dolphins since these estimates utilize the updated (NMFS 2001) management units, explicitly account for bias relating to perpendicular sighting distance and combine well-designed summer and winter aerial surveys with biopsy collection for the identification of spatial patterns in the distribution of the coastal and offshore morphotypes. On the whole I am satisfied with the appropriateness of the design, execution and analysis of the aerial surveys. The abundance estimates for the winter surveys reached their targeted precision level (20 – 30 % CV). Although many of the final summer abundance estimates have poor precision and failed to reach their %CV target range, the abundance estimates are still relevant for the determination of Potential Biological Removal (PBR). I have some reservations about these estimates and these will be discussed below.

The primary source of variability in these estimates was the distribution of the coastal and offshore morphotypes. Previous reports (e.g. NMFS 2001, Garrison 2001) have highlighted the need to focus biopsy sampling effort on the intermediate zones. The first such attempt took place in 2001 but was hampered by poor sampling efficiency. The biopsy sampling undertaken in this study was aided by spotter planes to overcome this problem. Despite the stated attempt to focus sampling effort upon the zone of mixing, Garrison *et al.* report that a proportion of the sampling effort was allocated to definition of the latitudinal stocks. In such areas, this resulted in a lack of effort and paucity of samples in the critical zones of intermixing between the coastal and offshore morphotypes. Considering the sizable expenditure of resources and effort in obtaining these abundance estimates, it is disappointing that the precision of the estimates were negatively influenced by a lack of effort in obtaining biopsy samples in the critical areas. However, the precision of the abundance estimates may be improved by further biopsy sampling with a particular focus on the regions with the highest %CV and least biopsy samples from intermediate zones.

The effect of low precision (or high %CV) on the management of these populations will be to result in a lower Potential Biological Removal (PBR). The use of *Nmin* in the PBR calculations is a form of safety factor that incorporates the uncertainty of poor precision of abundance estimates by resulting in a lower, more conservative PBR (Wade 1998, Taylor *et al.* 2000). The *Nmin* estimates for summer and winter coastal morphotypes of the Garrison *et al*. (2003) report are given in Tables 33 and 38 respectively. For some of the abundance estimates the *Nmin*'s are very low (e.g. Florida management units) and improvement of the precision will likely result in an increase in the PBR.

A perennial problem with abundance estimation of cetaceans is controlling for all the potential sources of variability and bias that may influence the resulting estimate. The survey design and execution was by-and-large very good. There are, however, several forms of variability or potential bias that do not appear to have been adequately addressed, including:

1. Interannual variability and the use of biopsy samples dating back to 1998. The inclusion of these older samples assumes that in the previous years the spatial pattern of the two morphotypes was identical to that of 2002.

2. Perception bias relating to group size, especially since there is evidence of correlation between group size and distance from shore. There may be sufficient data in the MRLT analysis to examine this issue.

3. Availability bias. Contrary to a rather general statement by the authors, in several management units mean group size was quite small (< 5). Thus availability bias may be more serious than claimed by Garrison *et al.*

4. There appears to be a considerable outlier effect in the spatial analysis due to low sighting rates of groups out to 80 km from shore. This is likely a result of low survey effort in the deep stratum. Consideration needs to given to the consequences of this low sample effort upon the overall general additive model (GAM) performance.

5. There is insufficient information given regarding the genetic analysis of the biopsy samples. In particular the following have not been addressed: the potential for hybrids, duplicate sampling, sampling of highly related individuals and contamination of samples.

In summary, at present these abundance estimates represent the best available information on which to proceed with protected species management for the western North Atlantic coastal bottlenose dolphins. It may be possible to reduce or remove several of the highlighted problems with this report by some reanalysis of the existing data. Due to the relatively low precision of some of the abundance estimates, the resulting PBR calculations will likely be very low. Considering the nature of the potential biases in this abundance estimation, it is doubtful that any of these biases would result in such a significant overestimate of abundance that the resulting PBR would fail to protect the population from depletion.

Appendix A.

Bibliography of material provided by the Center for Independent Experts

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Taylor BL, Wade PR, DeMaster DP and Barlow J (2000) Incorporating uncertainty into management models for marine mammals, *Conservation Biology*, 11, 1243-1252.
Wade PR (1998) Calculating limits to the allowable human-caused mortality of cetaceans and pinipeds, *Marine Mammal Science*, **14** 1-37.
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Appendix B. A copy of the statement of work.

Statement of Work

Consulting Agreement between the University of Miami and Dr. Franz Pichler

January 21, 2003

General

NOAA Fisheries', Southeast Fisheries Science Center (SEFSC), Protected Species and Biodiversity Division undertook aerial surveys to estimate abundance of bottlenose dolphin in the Mid-Atlantic during the winter and summer of 2002. In addition, extensive skin biopsy sampling was conducted during 2001 and 2002 to allow genetic identification of coastal vs. offshore morphotype bottlenose dolphins and describe their relative spatial distribution. The intent was to obtain current information on the winter and summer abundance of coastal morphotype bottlenose dolphin management units that are subject to incidental takes (i.e., mortalities) in coastal gillnet fisheries. This information is required by a Marine Mammal Protection Act (MMPA) Take Reduction Team (TRT), which began to deliberate the status of these dolphin populations in a series of meetings in 2002. The TRT will reconvene in early April 2003 to revise previous recommendations for reducing fishery takes of bottlenose dolphins and consider new abundance estimates and other information as appropriate. The SEFSC is requesting that the Center of Independent Experts (CIE) undertake a peer review of the new abundance estimates and the statistical methodology used to develop them from the winter and summer 2002 aerial surveys.

The CIE consultant shall analyze the new mid-Atlantic bottlenose dolphin estimates focusing on the following issues:

1. The appropriateness of the design, execution, and analysis of the aerial surveys used to derive abundance estimates for bottlenose dolphins in the mid-Atlantic.

2. The appropriateness of the statistical methodologies used to distinguish the spatial distribution and habitats of coastal vs. offshore morphotype bottlenose dolphins.

3. The appropriateness of the resulting abundance estimate for coastal morphotype bottlenose dolphins from combined genetic data, spatial distribution information, and aerial survey data.

4. Determine if potential biases have been adequately identified and whether appropriate measures of statistical uncertainty have been included in the resulting abundance estimates.

The consultant shall be provided the report to be reviewed, "Abundance of Mid-Atlantic Coastal Morphotype Bottlenose Dolphin During Winter and Summer 2002." The consultant shall also be provided and may consult extensive background material (listed in Appendix I) to assist in addressing the aforementioned issues.

The consultant shall conclude, in a written report, whether the analyses represent the best available information on which to proceed with protected species management for this population of bottlenose dolphin.

Specific

The consultant's duties shall not exceed a maximum total of two weeks- several days for document review and several days to produce a written report of the findings. The consultant may perform all review, analysis, and writing duties out of the consultant's primary location, as no travel is required. Finally, no consensus report shall be accepted.

The itemized tasks of the consultant include:

1. Reading and considering various supplementary reports (listed in Appendix I) that provide context and background on the bottlenose dolphin abundance surveys;

2. Reading and analyzing the SEFSC report, "Abundance of Mid-Atlantic Coastal Morphotype Bottlenose Dolphin During Winter and Summer 2002";

3. Submitting a written report of findings, analysis, and conclusions. No later than March 1, 2003, submit the written report[1] (see Annex I for formatting structure) addressed to the "University of Miami Independent System for Peer Review," and sent to Dr. David Sampson, via email to David.Sampson@oregonstate.edu, and to Mr. Manoj Shivlani, via email to mshivlani@rsmas.miami.edu.

[1] The written report will undergo an internal CIE review before it is considered final. After completion, the CIE will create a PDF version of the written report that will be submitted to NMFS and the consultant.

ANNEX I: REPORT GENERATION AND PROCEDURAL ITEMS

1. The report shall be prefaced with an executive summary of findings and/or recommendations.

2. The main body of the report shall consist of a background, description of review activities, summary of findings, and conclusions/recommendations.

3. The report shall also include as separate appendices the bibliography of materials provided by the Center for Independent Experts and the Southeast Fisheries Science Center and a copy of the statement of work.

APPENDIX I: BACKGROUND MATERIAL ON BOTTLENOSE DOLPHIN SCIENCE

National Marine Fisheries Service. November 2001. Draft 2002 Stock Assessment Report for the Western North Atlantic Coastal Stock of Bottlenose Dolphin (Tursiops Truncatus).

National Marine Fisheries Service. September 2000. 2000 Stock Assessment Report for the Western North Atlantic Coastal Stock of Bottlenose Dolphin (Tursiops Truncatus).

Atlantic Scientific Review Group review of Bottlenose Dolphin documents. October 2001.

NMFS response to the Atlantic Scientific Review Group. November 2001.

Comments from one member of the Team for the CIE peer review. December 2001.

Letter from Rick Marks to the Honorable James V. Hansen and the Honorable Don Young of the U.S. House of Representatives Resources Committee regarding the bottlenose dolphin take reduction team process. August 2001.

NMFS response to Rick Marks letter to the House Resources Committee. September 2001.

Palka, D., F. Wenzel, D. L. Hartley, and M. Rossman. June 2001. Summary of bottlenose dolphin strandings from New York to Virginia.

Hohn A., P. T. Martone. July 2001. Characterization of bottlenose dolphin strandings in North Carolina, 1997-2000.

Hohn A., B. Mase, J. Litz, W. McFee, and B. Zoodsma. November 2001. Characterization of human-caused strandings of bottlenose dolphins along the Atlantic coast from South Carolina to Florida, 1997-2000.

References on Stock Structure

National Marine Fisheries Service. June 2001. Preliminary stock structure of coastal bottlenose dolphins along the Atlantic coast of the U.S.

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