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Body Condition Scoring System for Delphinids Based on Short-beaked Common Dolphins (Delphinus delphis)

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Abstract

Assessment of body condition is critical for examination of live and dead dolphins. Using live and dead stranded and dead bycaught short-beaked common dolphins (*Delphinus delphis*) from New England waters, a simple, practical body condition scoring (BCS) system was developed that has utility for all delphinid species. Using photographs, a non-invasive, 4-point visual scale was created based on anatomical landmarks which are indicative of body condition and emaciation. The consistency of using this BCS system was tested via a blind study with five trained and experienced stranding responders independently scoring a subset of *D. delphis* cases (n=30) using photo documentation only, and results showed a significant level of agreement among observers. Specific morphometric data relating to body condition were analyzed to determine parameters which, in association with the clinical evaluation of the animal, may be indicative of potential success after release during a live stranding event. Results showed a significant difference in length-to-girth ratios in both the axilla and anterior dorsal fin regions between animals which were released (mean for axilla: single stranded 1.75, mass stranded 1.76; mean for dorsal fin: single stranded 1.79, mass stranded 1.76) and those that died or were deemed unreleasable and euthanized (mean for axilla: single stranded 2.03, mass stranded 1.99; mean for dorsal fin: single stranded 1.99, mass stranded 1.87). Future studies are needed to validate the BCS system and its ability to predict such morphometric parameters and relative health. Use of this BCS system will allow for consistency in determining body condition in delphinid species, thus enabling stranding response agencies to better compare data relating to health and nutritional status in these animals. [JMATE 2014;7(2): 5-13]

Keywords: Body Condition, Stranding, Triage, Nutrition

Introduction

Cape Cod, Massachusetts consistently experiences one of the highest rates of common dolphin strandings worldwide, and it is essential for responders to be able to rapidly and efficiently make informed decisions regarding an animal's nutritional status to maximize triage efficiency (11). Currently, no standardized system has been implemented to assist in determining individual nutritional status and there is a lack of consistency of how delphinid body condition is determined in the field. For example, at the International Fund for Animal Welfare (IFAW) alone, delphinid stranding datasheets have changed throughout the years with body condition classified simply as either emaciated versus not emaciated versus robust, with no specific descriptors on how to classify an animal into one of these groups.

Body condition scoring (BCS) is an important subjective and semi-quantitative tool used to assess and make recommendations relating to nutritional status and overall health in a wide range of species (3, 12). Typically, a scale of 1-to-5 or 1-to-9 is used to assess body fat and muscle, with a lower score indicating emaciation and a higher score indicating obesity. The score of an individual animal is determined based on visual assessment of specific anatomical landmarks and analyses of morphometric parameters which indicate nutritional adequacy (3). BCS systems have been successfully developed to determine nutritional status and survivability in both right and grey whales using photographs providing evidence that a similar system may be useful in evaluating nutritive status and predicted releasability of stranded delphinids during field triage (2, 10).

Studies have shown a significant relationship between body condition and survivability in marine mammals, with failed animals showing a poorer body condition than those that survived (10, 11). A lower

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body condition score may indicate poor nutrition and underlying chronic illness, which may be correlated with decreased delphinid survival rates post-release (11). Currently, body condition of cetaceans can be assessed by analyzing morphometric data such as the relationship between girth, length and weight, as well as by using Body Mass Index (BMI) or ultrasound measurements of blubber thickness as a determinant of body fat condition (5-8, 11). Although useful in determining body condition, these assessments require specialized tools, equipment, and calculations that are not always feasible for use in the field.

The objective of this study is to create a simple, reliable tool to assess body condition of dephinids in the field without the need for specialized equipment such as ultrasound and weight scales. This BCS system will serve as a supplemental tool that will create a standardized method of assessing body condition and allow responders worldwide to compare data relating to nutritional status of stranded delphinids. This standardized BCS system may also be helpful in predicting post-release success in the context of the overall clinical evaluation of the animal.

Materials and Methods

Overview: For this study, data from 802 common dolphins, *Delphinus delphis,* stranded on Cape Cod between November 1999 and June 2014 was provided by the IFAW Marine Mammal Rescue and Research Division database. Twenty bycaught common dolphins from February 2006 to November 2012 provided by the National Oceanic and Atmospheric Administration (NOAA) Northeast Fisheries Observer Program were also examined. These records were screened to include only animals which live-stranded or were bycaught and contained photographs and morphometric parameters of interest: Standard straight lengths were measured in centimeters from the tip of the rostrum to the tail fluke. Girths were measured in centimeters at the level of the axilla and at the anterior dorsal fin from dorsal midline to ventral midline and then doubled (half girth), or as a circumferential measurement (full girth). In some cases blubber thickness from the dorsal and lateral axilla region was measured to the nearest millimeter via ultrasound. Overall weight was obtained by placing the animal onto IFAW's custom designed dolphin cart (Edson International, New Bedford, MA,USA) and then rolling the cart onto four industrial grade postal scales (Rubbermaid, Huntersville, NC). The weight from each scale was summed and the weight of the cart, padding and stretcher was subtracted. For animals that died or were euthanized on site, weight was measured during necropsy using a hanging dynamometer scale (TCI Scales Inc., Snohomish, WA, USA) or digital veterinary platform scale (A and A Scales LLC, Prospect Park, NJ, USA).

Creation of the BCS Chart: Photographs were analyzed in conjunction with the morphometric data and stranding reports to determine specific anatomical landmarks which serve as indicators of body condition or emaciation. The animals in the photographs were in ventral recumbency and were out of the water on either a firm surface, such as a trailer floor or a necropsy table, or on a sandy beach. Areas that were analyzed and were concluded to serve as markers of nutritive condition included: the epaxial section, determined by the degree of concavity or convexity ventrolateral to the dorsal fin; the nuchal crest or degree of depression posterior to the blowhole; the thoracic wall, determined by the visibility of the ribs; and the overall shape and symmetry of the trunk. These areas were categorized according to the degree of loss of body mass, both blubber and muscle, and similar to BCS systems in other species, a visual chart consisting of a 4-point scale was created . (7). During this analysis, a protocol describing the most useful angles to assess delphinid body condition via photographs was also developed.

Test for Consistency: A blind study was then conducted to determine the consistency of scoring animals using the BCS system between different observers. A set of 30 cases consisting of various photographs of stranded live and dead common dolphins were sent out to each of the five trained IFAW stranding responders who independently used the BCS system to score each animal. The non-parametric Kendall's W test was used to analyze the inter-rater consistency of scoring common dolphins via photographs.

Analysis of Morphometric Parameters: In an attempt to further quantify the scale and decrease subjectivity, we analyzed morphometric parameters to look for correlations between these values and the score given to an animal. Animals were grouped according to the type of stranding event; either mass stranded, single stranded, or bycaught. Mass stranded animals were part of an event involving two or more cetaceans stranding at the same time and place, excluding cow and calf pairs (4). The assumption is that this group includes both animals that are healthy and others that are diseased (4). Single stranded animals are likely to have some sort of pathology and a poorer body condition (1). Bycaught animals are those that died due to entanglement in fishing gear and were used as presumptive positive controls. Mass or single stranded animals were further grouped according to final disposition; either released or failed. Released animals were those that passed a field health assessment, were successfully released after stranding, and were not documented to have re-stranded (11). Failed animals are those that stranded alive and either died during the response effort, were initially released and later re-stranded, or were euthanized by IFAW responders due to poor health status. These animals are assumed to have a poorer body condition.

Differences in girth, length to girth ratio (L:G), weight, length to weight ratio, and blubber thickness between the groups were calculated in an attempt to correlate these parameters to the BCS scale and to develop morphometric "predictors of releasability". All statistical analyses were performed using SPSS software. The Kruskal Wallis H test, a non-parametric ANOVA, was used to look for statistically significant differences in morphometric data between groups. Confounding factors such as sex, age, and season were corrected for.

Results

A Body Condition Scoring chart illustrating the parameters for classification in each of the four conditions is shown in Figure 1. Representative photographs of common dolphins in each BCS category are shown in a lateral view of the head in Figure 2, cranio-caudal view in Figure 3, caudo-cranial view in Figure 4, and dorso-ventral view in Figure 5. A significant level of agreement among the raters was observed for the blind study via the inter-rater reliability test, Kendall's W= .664 (χ^2 (28) = 93.0, p<.001). This is considered a moderate-strong agreement considering the small sample size and lends evidence that the BCS chart may be useful in consistent scoring of live-stranded animals in the field.

Data for 121 live stranded common dolphins with length and axilla girth measurements, 94 of which had weight measurements, was available. Two animals, IFAW12-119Dd and IFAW12-340Dd, were excluded due to classification as calf. A calf was defined as having a length of less than 150 cm (4). Three animals, IFAW11-023Dd, IFAW12-118Dd, and IFAW13-124Dd, were excluded due to confirmed pregnancy status either via ultrasound exam or during necropsy. Data from 20 bycaught *D. delphis* were available, two of which, DO-6187 and HO-0009, were excluded due to classification as calf in the necropsy reports. In the mass stranded group, 63 were released (20 females and 43 males) and 33 failed (10 females and 23 males). Of the single stranded group, 7 were released (2 females and 5 males) and 14 failed (6 females and 8 males).

Post-hoc analysis (Figure 6) indicates a significantly higher L:G ratio for both the axilla region ($\chi^2(4) = 53.73$, $p < 0.001$) and anterior dorsal fin (ADF) region ($\chi^2(4) = 36.19$, $p < 0.001$) for the single stranded failed group (Axilla: mean= 2.03, n=14; ADF: mean=1.99, n=14) and the mass stranded failed groups (Axilla: mean=1.99, n=33; ADF: mean=1.87, n=33) compared to the bycatch (Axilla: mean=1.86, n=18; ADF: mean=1.76, n=18), single stranded released (Axilla: mean=1.75, n=7; ADF: mean=1.79, n=7) and mass stranded released (Axilla: mean=1.76, n=63; ADF: mean=1.76, n=57) groups. Other dependent variables were significant, but not at a level that would be appropriate to report given that multiple, independent tests (e.g. too high of a risk of an inflated family-wise type I error rate) were run.

Discussion

To increase consistency and decrease subjectivity, stranding responders should receive proper training prior to using this BCS system in the field. Although some animals may appear to fall into two categories and half points may be useful, (e.g. have a depression posterior to the blowhole but no concavity ventro-lateral to the dorsal fin) a strict 4-point scale was chosen due to the ability to visually discern 4 levels of condition at both the nuchal crest and epaxial area in certain angles of photographs and to help decrease subjectivity and increase the usefulness of future data-sets (2). We follow recommendations of Bradford *et al* to round-up to the higher score if an animal appears to fall within two scores (2). During assessment in the field, animals should be assigned into 1 of the 4

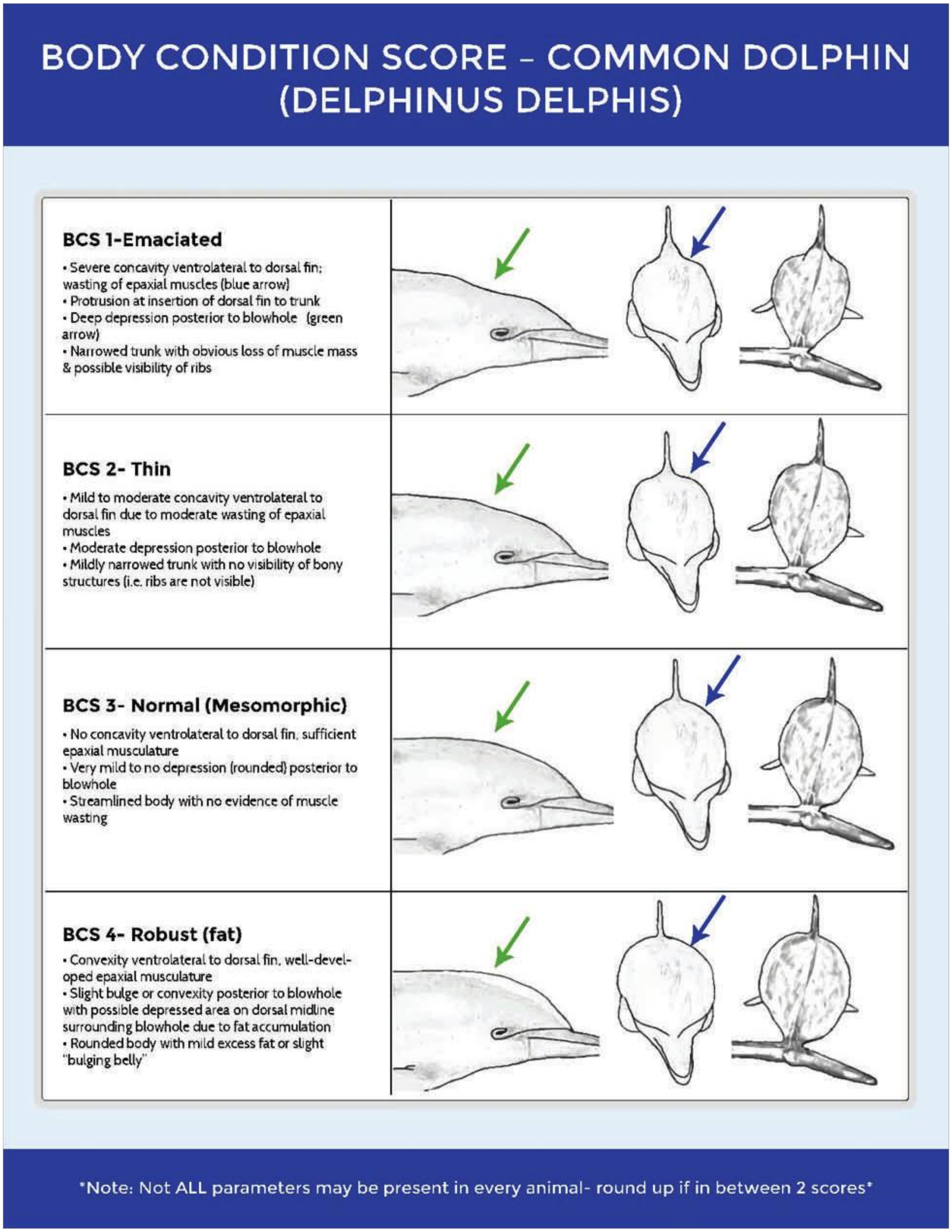

Figure 1: Delphinid Body Condition Scoring (BCS) chart using common dolphins (Delphinus delphis) as an example. Sketches highlight the primary areas of interest. This chart is meant to serve as a field guide for determining body condition during a stranding triage.

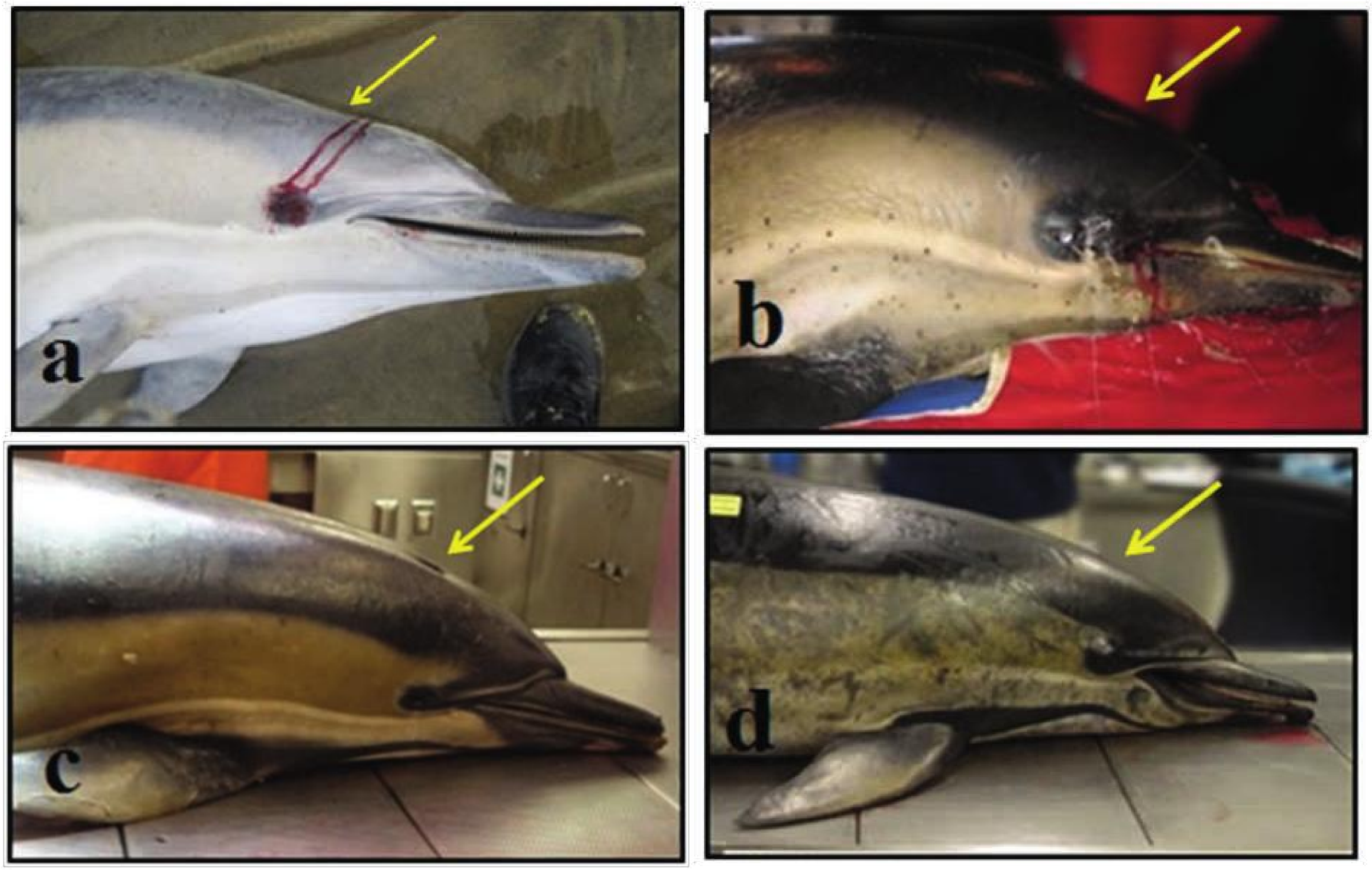

Figure 2: Representative lateral photographs of Common Dolphins (Delphinus delphis) to illustrate anatomical areas indicative of body condition: (a) Note the severity of the cranial dip or "peanut head" in the animal with a BCS of 1; (b) BCS of 2 has less of a cranial dip; (c) BCS of 3 has no cranial dip; (d) Fat accumulation creating a slight bulge in this area can be noted on the animal with a BCS of 4. All photographs are copyright of IFAW and reproduced with permission.

condition categories based on the severity of these characteristics: 1 - Emaciated, 2- Thin (Ectomorphic), 3- Normal (Mesomorphic), 4 - Robust (Endomorphic).

The most consistently observed marker of emaciation in common dolphins is the degree of concavity or depression in the area posterior to the blowhole, best visualized in photos with an eye level lateral view of the head. This area, which has been described as a post-cranial dip or "peanut-head", is currently the standard visual measure of cetacean body score and considered to be the most indicative of emaciation (2, 10). Mesomorphic common dolphins were shown to have a smooth rounded profile caudal to the nuchal crest, while robust animals present with fat accumulation or convexity in this region, a feature that has also been noted in right whales (10). The next most consistently seen marker of emaciation is the wasting or development of the epaxial musculature. This is determined by the degree of concavity or convexity ventrolateral to the dorsal fin. In emaciated animals the muscle atrophy in this region may be so severe that a protrusion at the lateral insertion of the dorsal fin and the trunk may be visible. This parameter is best visualized using photographs with cranio-caudal and caudo-cranial views just above eye level.

The overall shape of the trunk, either narrowed or rounded, was also determined to be indicative of nutritive status and body condition in common dolphins. This parameter can best be determined in aerial photographic views, but differences tend to be more subtle and more difficult to discern in animals with a higher BCS. The wasting of muscles of the thoracic

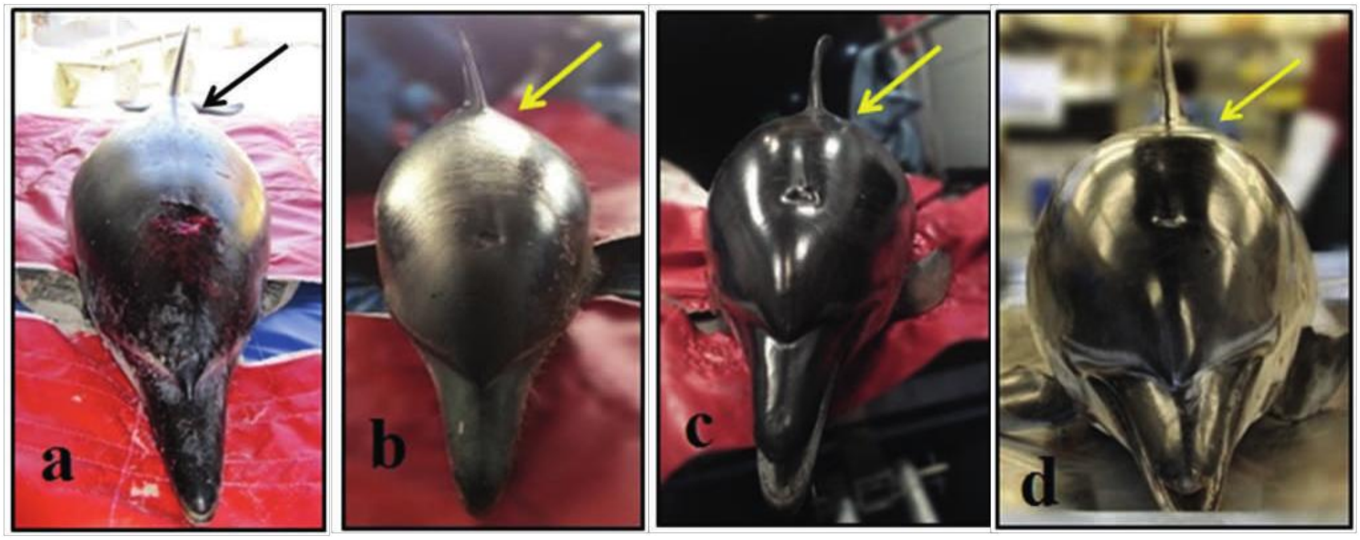

Figure 3: Representative cranio-caudal photographic view of Common Dolphins (Delphinus delphis) to illustrate anatomical areas indicative of body condition: (a) Note the severity of the wasting of the epaxial musculature in the animal with a BCS of 1; (b) BCS of 2 wasting not as severe; (c) BCS of 3 neutral appearance of epaxial muscles; (d) Visible development of the epaxial musculature can be noted on the animal with a BCS of 4. All photographs are copyright of IFAW and reproduced with permission.

Figure 4: Representative caudo-cranial photographic view of Common Dolphins (Delphinus delphis) to illustrate anatomical areas indicative of body condition: (a) Note the severe concavity ventrolateral to the dorsal fin and the protrusion at the insertion of the dorsal fin to the trunk (arrow) in the animal with a BCS of 1; (b) BCS of 2 concavity not as severe; (c) BCS of 3 neutral appearance of epaxial muscles; (d) Visible development of the epaxial musculature can be noted on the animal with a BCS of 4. All photographs are copyright of IFAW and reproduced with permission.

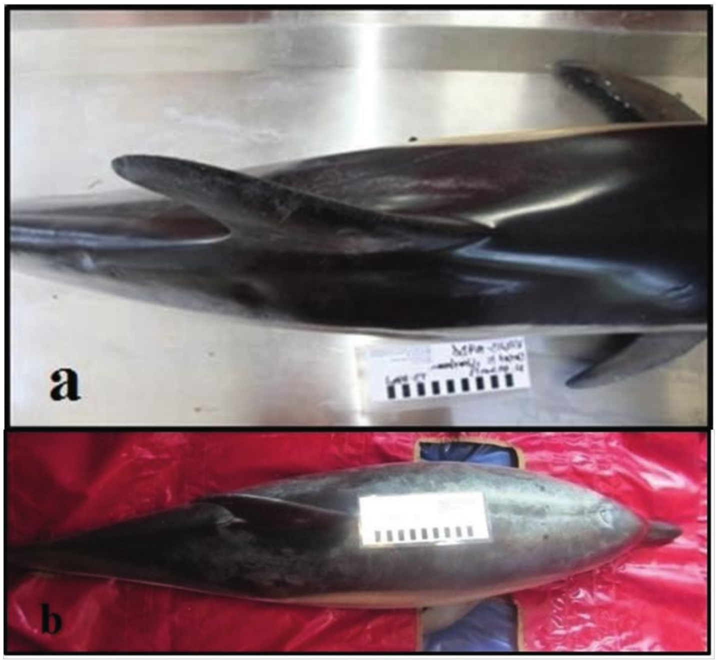

Figure 5: Representative dorso-ventral photographic view of Common Dolphins (Delphinus delphis) to illustrate the overall shape of the truck indicative of body condition: (a) Note the narrowing of the trunk and visibility of the ribs in the animal with a BCS of 1; (b) Rounded shape of the trunk in the animal with a BCS of 4. All photographs are copyright of IFAW and reproduced with permission.

wall, determined by the visibility of the ribs, was our final parameter in our description of the 4-point scale. Although rarely seen in the photographs of our animals, this parameter is indicative of a more advanced level of emaciation and helps to further define those animals with a BCS of 1.

A distinct correlation between the morphometric values and BCS that was assigned via photographs could not be determined. Also, lack of consistent, standardized categorization of body condition in the past made it impossible to realistically compare morphometric data to any sort of vague previous classifications that were given in the field and provided by the retrospective data. Although the L:G ratios correlated well with releasability, some animals with higher L:G ratios did not necessarily appear thin or emaciated in pictures as would be expected, while some animals with lower L:G ratios (assumed more robust) appear thin in pictures, presenting a major caveat for this study. This is likely due to lack of consistent, appropriate photographs to determine BCS and hence

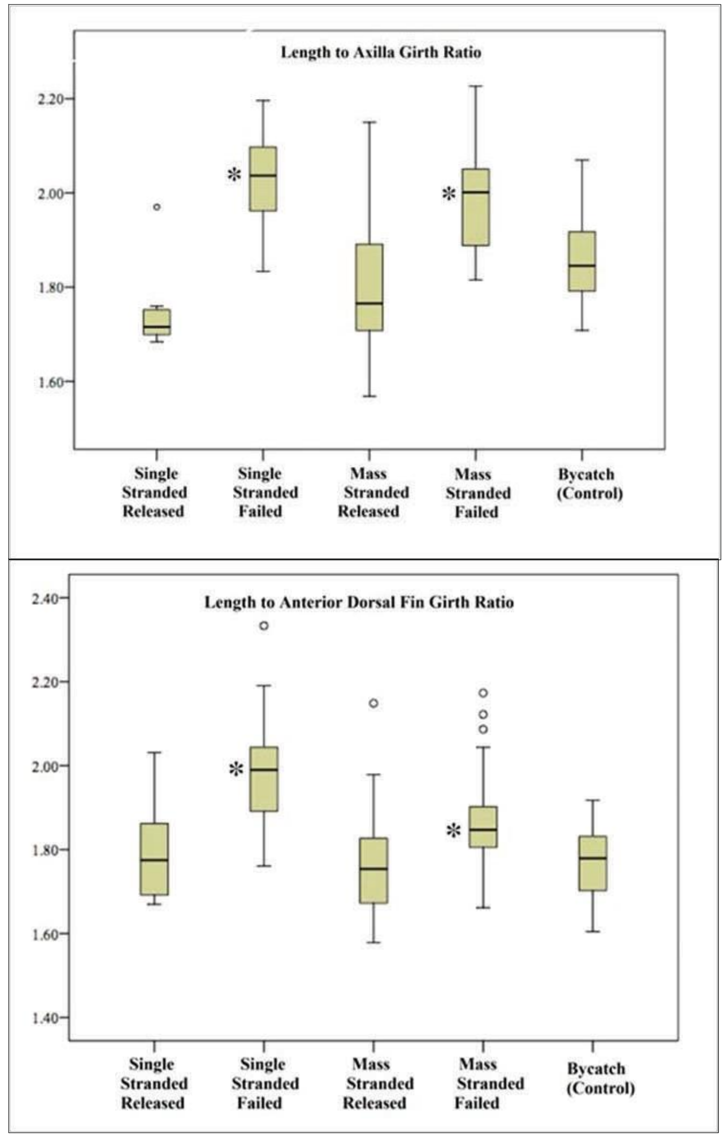

Figure 6 : Box and whisker plots summarizing the results from the Kruskal-Wallis H Test. (a) The mean Length to Axilla Girth Ratio between stranding groups; (b) The mean Length to Anterior Dorsal Fin (ADF) Girth ratio between stranding groups. Asterisk represents statistically significant differences between the stranding groups. Circles represent potential outliers.

led us to develop a photographic protocol. This could also be due to human error and difficulties of field data collection. Due to difficulties in manipulating live dolphins and to limit potential stress due to extended handling, half girths were measured on many of the released animals, rather than full girths as can be done at necropsy, thus calculated L:G ratio of the released animals may be skewed. In the future, full girth measurements should always be taken in the field whenever possible. Similar results were presented by Sharp *et al*. and according to Bradford *et al.,* girth measurements may be able to reflect nutritional status and is considered a better indicator of body condition than blubber thickness in cetaceans (2,11). This provides evidence that decreased girth or a "narrowed trunk" may be indicative of decreased nutritive status and decreased success of release from a stranding triage.

Due to the limited time frame and lack of strandings during this project, we were unable to validate the use of the BCS system and determine the consistency among responders scoring live animals in the field as we did with photographs. BCS systems in other species have been validated by techniques such as ultrasound measurement of blubber thickness in the anatomical areas of interest (9), comparing BCS scores to body condition index (BCI) formulas and dual X-Ray Absorptiometry (12, 13). In the future, responders should assign a body condition score to all animals in the field and collect relevant morphometric data including length, girth, and if possible, weight and blubber thickness measurements, as well as appropriate photographs. Future studies should be aimed at determining if the BCS score can actually serve as a proxy for morphometrics if equipment is unavailable, or as a potential predictor for success upon release.

The development of a metric in order to determine the degree of concavity or convexity, both ventrolateral to the dorsal fin (epaxial muscles) and for the area posterior to the blowhole 'peanut head', would be extremely useful to further define each point on the scale. This could be done using photogrammetric methods with a grid-board behind the animal or perhaps by using a set of 3D rulers to measure the height, which would be a determinant of concavity, between the body of the animal and a second ruler. By allowing observers to discover differences in body curvature and measure a proportion of the body above and below a reference line, such techniques could create a quantitative metric that would be helpful in decreasing the subjectivity of the BCS system. Such techniques, however, would not be feasible for use in the field and are more relevant to an academic study.

Conclusion

This BCS system was created to serve as a simple, non-invasive supplementary tool that can be used to assess nutritional status of stranded delphinids. The goal is that this system will be useful for stranding responders who do not have access to specialized equipment such as weight scales and ultrasound in the field. Although this BCS chart was developed based on characteristics of *Delphinus delphis,* we believe that this system will have utility for use in all delphinid species. Standardization in determining body condition of delphinids will provide consistency in stranding data and allow responders worldwide to be able to compare information regarding nutritional status in these animals.

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