

Response to Comment on Health of Common Bottlenose Dolphins (*Tursiops truncatus*) in Barataria Bay, Louisiana Following the Deepwater Horizon Oil Spill

A comment on our recent publication¹ questions a cause-effect relationship between observed health issues in dolphins and the *Deepwater Horizon* (DWH) oil spill because a dose-response relationship was not demonstrated. Ethical and logistical constraints prohibit experimental manipulations to investigate relationships between oil exposure, internal dose, and adverse health effects in dolphins. Therefore, we designed a correlational study of two Gulf of Mexico (GOM) sites representing extremes of DWH oil exposure: Barataria Bay (BB), which received heavy and prolonged oiling, and Sarasota Bay (SB) where no oil was observed. A correlational study, though not as definitive as an experimental study in which more conditions can be controlled, nevertheless can provide strong evidence for a causal relationship, particularly when findings are consistent with prior experimental studies and when plausible alternative hypotheses for observed effects are considered and ruled out.

Many of the comment's criticisms focus on potential differences between BB and SB. However, our paper not only compares results of BB and SB populations, but also previously reported dolphin health data from other areas. For example, our paper compares cortisol concentrations in the BB and SB populations with values from prior studies of wild dolphins in St. Joseph Bay, FL, and Beaufort, NC, and notes that cortisol values for nearly half of BB dolphins are below any of the values previously measured from the two other populations. Similarly, our study demonstrates hematological and serum biochemical abnormalities in BB dolphins using reference intervals that were derived from dolphins in four different sites along the southeast U.S. coast.

The author of the comment is correct that the lower reference threshold used for comparison of mass:length relationship was derived solely from SB dolphins.² However, although the data were not included in the paper, we did compare these SB reference thresholds with data from dolphins sampled in St. Joseph Bay, FL, prior to the DWH spill, and from dolphins sampled in Mississippi Sound in June–August 1982 as part of a wild dolphin collection and biological sampling effort.³ Mass:length ratio for dolphins from both of these northern GOM sites fit well with the reference intervals computed from SB data (Figure 1); none of the St. Joseph Bay dolphins ($N = 21$) and only 3 of 37 Mississippi Sound dolphins fell below the lower threshold (the expectation based on a 95% confidence interval would be zero to three dolphins below the lower threshold). Furthermore, the median difference from the lower threshold for the three underweight Mississippi Sound dolphins was only 8.6 kg, in contrast with a median difference of 23.5 kg for underweight BB dolphins.

Our study did evaluate other potential stressors to investigate if there was something unique about BB, as compared to all the other areas where dolphin health assessments have been conducted but where similar health issues have not been

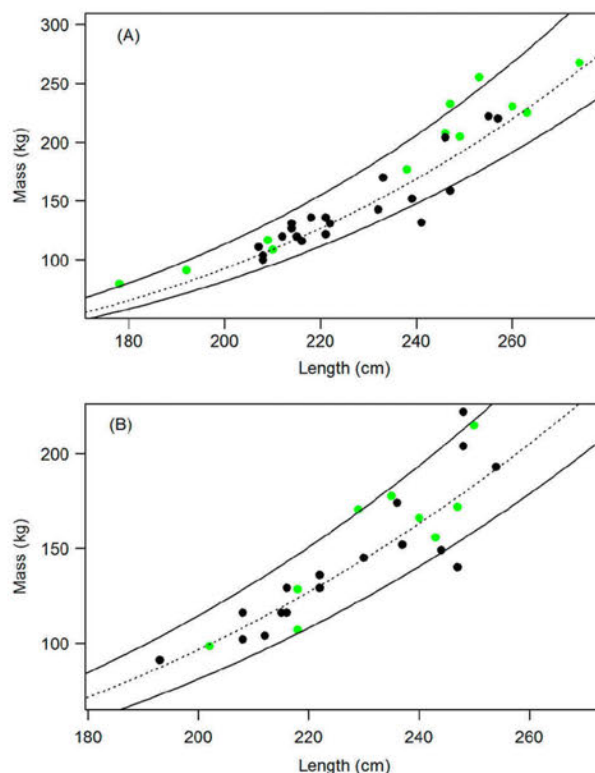


Figure 1. Total mass versus total length for (A) male and (B) female dolphins sampled in Mississippi Sound, 1982 (black circles) and St. Joseph Bay, 2005–2006 (green circles) compared to reference intervals (solid black lines) derived from dolphins in Sarasota Bay.²

observed. In particular, our study focused on factors that have been associated with adverse health effects similar to those observed in BB (e.g., DDT and hypoadrenocorticism), or for which there was a reasonable likelihood of exposure and a plausible mechanism for one or more of the observed effects. We examined a broad suite of other organochlorine pesticides ($n = 22$) as well as 45 polychlorinated biphenyls and 11 polybrominated compounds in blubber. As reported in our paper, BB dolphins ranked very low for concentrations of all of the chemical contaminants evaluated relative to reported values from dolphins in 14 other coastal sites.

In response to the comment on the unusual mortality event (UME), the cause of the UME continues to be investigated, including the potential role of the DWH oil spill in exacerbating the duration and magnitude of this event. After the spill, areas with the greatest increases in dead, stranded dolphins have

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overlapped with inland areas most exposed to DWH oil.^{4,5} Further, since the spill, dolphin stranding rates have been highest in and around BB compared to other northern Gulf of Mexico areas, and high stranding numbers in BB did not occur until after the spill (June 2010). Dolphin stranding data including locations and dates are summarized and mapped on the NOAA Fisheries Web site.⁶

In the paper, we acknowledge that we do not have health measures from before the spill to document whether or not there were pre-existing disease conditions in BB dolphins. However, our paper presents strong correlative evidence implicating DWH oil as an adverse contributor to the poor health of BB dolphins, and it is highly unlikely that disease of the prevalence and severity found in BB dolphins postspill would have gone unnoticed had it existed prior to the spill. We wholeheartedly agree with the author's comment that continued monitoring of the health of this population over time will help improve the understanding of the influence of pre-existing and continuing stressors.

To address other specific points raised by the comment:

The tugboat collision on July 27, 2010, resulted in an estimated release of 7000 gallons of oil.⁷ Allan et al.⁸ report that bioavailable PAHs near Grand Isle (close to the locations of our dolphin sampling) increased 45-fold immediately following the DWH spill, but before the tugboat spill (between May and June), and that PAHs measures taken in August, 2010 (shortly after the tugboat spill) had decreased from the earlier peak. Regardless, the enormous volume and extended persistence of oil in BB from the DWH spill dwarfs exposure to other oil sources for BB dolphins. Cleanup activities from the DWH spill in BB have persisted into 2014.

As referenced in the comment, the prevalence of moderate-severe alveolar-interstitial syndrome (AIS) was greater in BB than the reference site. The authors recognize that although AIS has been associated with pneumonia, pulmonary edema, and pulmonary fibrosis in dolphins,⁹ it is relatively nonspecific with regard to stage of disease, particularly when considered on its own. This is why we considered AIS severity along with the presence of additional lung lesions to characterize lung disease.

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The authors declare no competing financial interest.

The views and opinions expressed herein are those of the authors and do not necessarily reflect the views of NOAA.

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