Charlotte Pfamatter

Research Proposal - ERII

# Climate Change and Alterations of Behavioral Patterns of *Tursiops truncatus* in the Chesapeake Bay

## Introduction

As humans are contributing unfathomable quantities of carbon into the atmosphere through the production of excess air pollution, the planet's oceans and bodies of water are paying the price for anthropogenic climate change. In the past fifty years, the planet has experienced general increase in temperature, which has had repercussions in oceans and other major bodies of water (Simmonds, 2007). The consequences for global climate change are reflected by the health of the world's bodies of water, especially in the major oceans. It has been recognized that climate change has induced effects such as increased temperatures, extreme weather patterns, ocean acidification, alterations in oceanic circulation, rising sea levels, and changes in nutrient quantities (Briery, 2009).

Ultimately all of these changes in water conditions are contributing to shifts in all elements of hydrospheric systems. On a more focused level, marine ecosystems are negatively impacted, which can be observed in their behavior from alterations in the conditions of the water due to exponential climate change (Simmonds, 2007). Scientists have observed that marine animal behavior has been modified on all scales and on all significance levels because of how abrupt changes in natural systems have forced adaptation. For example, it has been concluded that vaquitas, dolphin-related mammals who are sensitive to habitat ranges, have altered typical migratory behavior due to climate change (Simmonds, 2007). Evidence from this study confirms that many marine animal populations are highly vulnerable to temperature fluctuations due to climate change. This study leaves the need for additional research to be built upon it in order to completely comprehend how animal behavior is being altered by climate change.

The damaging repercussions of climate change in water systems is particularly present in the greater Chesapeake Bay in the east coast of the United States. The Bay is not excluded from current trends that similar bodies of water are experiencing as global temperatures are increasing. With the background provided, it is rational to conclude that animal behavior is deviating from normal standards in the Chesapeake Bay due to climate change. An example of evidence may be present amongst migratory animals due to their deeply biological programming to react to temperature differences. Specifically, the bottlenose dolphin in the Chesapeake Bay can reflect greater comprehension of how animal behavior may manipulate under the influence of rising temperatures.

An example of concern regarding the alterations in behavioral patterns caused by climate change may be found in the migration patterns of the *Tursiops truncatus*, or the common bottlenose dolphin. One study showed that although bottlenose dolphins are highly advanced in their social skills, climate change altered their social organization because prey availability changed (Lusseau, 2004). However, research has yet to reach to the Chesapeake Bay regarding the effects climate change has on bottlenose dolphin migratory behavior. This prompts the need for more research to be conducted to dissect the link between climate change and migration and how it affects the greater health and biodiversity of the Chesapeake Bay.

These occurrences in the Chesapeake Bay matter. One major reason is because valuable fisheries up and down the east coast depend on the health of the Chesapeake Bay in particular. These fisheries depend on the Chesapeake Bay to be a healthy breeding and feeding ground for species who are all intertwined in the reliance of the migration patterns of each other and predators. Being one of the most productive estuaries in the world, alterations in general migratory behavior are indirectly becoming an economic issue for Virginia and the greater east coast as well as an environmental issue (Wood, 2002). If the Chesapeake Bay is warmer, bottlenose dolphins will be less likely to migrate back to their original habitats on time because they prefer warmer temperatures. If they linger in the Chesapeake Bay for an extended period of time, the populations of fish and shrimp that they prey on will decrease, which will decrease overall biodiversity. These assumptions add an additional layer of complication to these issues, therefore making it necessary to draw a hypothesis and conduct research relevant for deeper understanding of how marine animal behavior in the Chesapeake Bay is influenced by climate change.

The research hypothesis is as follows: as climate change causes water temperature to increase, bottlenose dolphin migratory behavior will become delayed, causing a decrease in quantities of their prey. Researching this hypothesis will reveal greater truths on how climate change the Chesapeake Bay by means of animal behavior that is modified due to increased water temperatures.

**Significance**

Experimentation with climate change and the Chesapeake Bay in this proposal carries great importance. As a whole for our society, understanding the possible outcomes of this proposal is critical in a time where climate change is the center of worldwide political and environmental commotion. This research can help the government predict the risk of climate change, which can in turn increase governmental funding for further climate research (National Centre for Atmospheric Science, 2017). This is paramount for agencies such as the Chesapeake Bay Foundation and others that are dedicated to the salvation of the Chesapeake Bay. This estuary is one of the nation's most precious natural treasures.

However, its ecosystems are under great stress as the proportion of climate change is increasing (Chesapeake Bay Foundation, 2018). At this time, the Chesapeake Bay as a whole is struggling to balance all of the repercussions of the increased water temperatures due to climate change, therefore the specific aims proposed will assist in finding deeper answers to current understandings of climate change while raising complex questions related to the discoveries of this proposal.

**A1)** The proposal investigates the correlation between the increase in water temperatures due to global climate change in the Chesapeake Bay and the alteration of animal behavior, which can be analyzed by means of monitoring migrational timing in Bottlenose dolphins (Briery, 2009). The testing of Aim I has the potential to open the doors to future experiments such as finding a correlation between the time that the Bottlenose dolphins spend in the Chesapeake Bay and other ecosystemic issues as a result, such as possible overconsumption of prey. If this were studied, measuring the correlation between predator and prey populations during prime migration season under the variable of temperature will reveal how climate change is affecting animal behavior while displaying how ecosystemic diversity is challenged. As a result, this can close the gap between the current understanding of climate change on the Chesapeake Bay and the effects that Bottlenose dolphin migration timing has on biodiversity, which has yet to be studied. This is an example of an exemplary follow up study that could develop after this initial research.

**A2)** The proposal examines the correlation between the increase in water temperatures due to global climate change in the Chesapeake Bay and the alteration of animal behavior, which can be revealed by Bottlenose dolphin pod density. Currently, there is a gap in the knowledge concerning the Chesapeake Bay's rising temperatures and Bottlenose dolphin pod behavior, specifically density. The testing of Aim II can result in improved comprehension of the mysterious phenomenon of travelling in pods as a distinct animal behavior belonging to porpoises. Other hypotheses can arise from this experiment concerning how climate change is resulting in alterations of other pod patterns, such as the direction of travel. These subtle changes in pod patterns can become proof of how climate change alters animal behavior. Aim II is a dynamic experiment that will encourage the continuation of research to further the awareness of how climate change is affecting the Chesapeake Bay as a whole and how it is affecting animals that inhabit its waters.

**Specific Aims**

As anthropogenic climate change is negatively modifying the normal state and qualities of water systems, it has resulted in alterations in animal behavioral patterns (Briery, 2009). At this time, this issue is a pressing concern in the Chesapeake Bay estuary, located in the east coast of the United States. Deviations from traditional constants in animal behavioral patterns can easily be monitored in migratory animals due to their deeply biologically programmed life processes (Simmonds, 2007). In the Chesapeake Bay, a species well known for migrating in and out of its waters is the *tursiops truncatus*, or the common bottlenose dolphin. Research must be done regarding the hypothesis that as climate change causes water temperature to increase, bottlenose dolphin migratory behavior will become delayed. Researching this hypothesis will reveal greater truths on how climate change the Chesapeake Bay by means of animal behavior that is modified due to increased water temperatures.

**Aim I. To determine if Bottlenose Dolphins are lingering significantly longer than normal in the Chesapeake Bay Waters due to climate change.** It is known that common bottlenose dolphins typically inhabit warmer waters such as around the Florida peninsula and in the Gulf of Mexico. However, there is a gap in current understanding if increasing water will delay migration or cause migration to occur earlier in prime migration season. From this observation, we hypothesize that as water temperatures rise in the

Chesapeake Bay, the dolphins will be more reluctant to leave the Bay and return to their original habitats on time because the water temperatures in the Chesapeake Bay will mimic their original habitat. Measuring the potential correspondence between warmer water temperature and the postponing or postponing of migration season can confirm and validate that climate change is indeed altering animal behavior in the Chesapeake Bay, which can apply to other estuaries around the globe.

**Aim II. To determine if increased warmer temperatures will increase population density of the common bottlenose dolphins in the Chesapeake Bay.** It is well known that dolphins are social animals that spend most of their time travelling in pods. Studies have yet to determine if increased water temperatures due to climate change coincide with the number of common bottlenose dolphin pod collections present in the Bay. We hypothesize that if water temperatures are increased due to climate change, then the number of Bottlenose dolphin pods will increase in the Chesapeake Bay after prime migration season compared to the beginning of migration season. Measuring how increased water temperature may affect the number of the collections of pods can reveal how climate change is stimulating natural animal behaviors.

**Proposal Project Design**

**Aim I. To determine if Bottlenose Dolphins are lingering significantly longer than normal in Chesapeake Bay waters due to climate change.** The study would be located in the mouth of the Chesapeake Bay nearshore lines, similar to the protocol found in Blaylock (1981) and Wilcox (1998). This location was selected because it was found to have a larger abundance of the Bottlenose Dolphin population in the Bay according to Blaylock (1981). The independent variable of the experiment will be time, while the dependent variable will be the number of weeks lingering after seasonal migration. As stated in Wilcox (1998), the presence of *tursiops truncatus* in the Chesapeake Bay is between May and November. To begin the methodology, two hundred specimen will be selected at random and tagged with a tracking device in May. After November passes, the number of *tursiops truncatus* individuals that remain on location will be recorded. The number of remaining *tursiops truncatus* specimen will be recorded every two weeks until the last week of December. Water temperature will be recorded at the two week interval as well. Data will be collected over the period of five years. The analysis of the data can be compared in two different ways. In one scenario, the data collected in this study could be generally compared to the migration season declared in Blaylock (1981). Another way of analyzing this data would be to alter our study slightly by only tracking the lingering of dolphin calves, which then can be compared to Figure 5 in Blaylock (1981).

A potential problem that could arise in this experiment could be that subjects all leave before the December cut off. If this were to occur, then data collection will cease until the next year. Another problem of concern may be the death of the subjects. However, the large sample size will ideally cushion for death.

**Aim II. To determine if increased water temperatures will increase population density of the common bottlenose dolphins in the Chesapeake Bay.** The study would be located in the mouth of the Chesapeake Bay nearshore lines, similar to the protocol found in Blaylock (1981) and Wilcox (1998) due to the abundance of *tursiops truncatus* samples. The independent variable would be time, while the dependent variable would be the presence of dolphin pods and how many individuals are in each pod. The methodology would begin with volunteers riding out to the location on a boat. For 8 hours a day during one week in April (pre-migration time), one week in July (mid-migration time), and one week in November (post-migration time), they will record the number of *tursiops truncatus* pods, the number of specimen in the pods, and the water temperature in the study location, similar to the procedure in Wilcox

(1998). The duration of the study will be over the course of 5 years. Figure 2 found in Blaylock (1981) would serve as a comparison and a control. This figure is a bar graph showing the number of *tursiops truncatus* herds and herd size in the Chesapeake Bay in the years 1980 through 1981. This chart and other data from Blaylock (1981) will be compared to graphical results from this study in order to determine a pattern between climate change and *tursiops truncatus* pod density.

A potential problem that could arise in this experiment could be that weather patterns may alter the typical pod behavior or make it difficult for the volunteers to record every possible pod sighting. In order to best adjust for weather factors, the facilitators of the experiment must be prepared to make the best judgements with regard to the weather. If it is unsafe to go out into the Bay or if the weather will lead to bad data collection, then flexibility will need to be demanded and rescheduling will take place. In addition, depending on volunteers to help collect data adds a risk element. It is possible that the volunteers will not meeting expectations or will misinterpret data. To eliminate this issue, volunteers will need to be given an incentive to put forward their best work and to actually participate.

**Expected Outcomes**

**Aim I. To determine if Bottlenose Dolphins are lingering significantly longer than normal in Chesapeake Bay waters due to climate change.** The proposed experiment is a 5 year study located in the mouth of the Chesapeake Bay that is comparing post-migration lingering of 200 tagged *tursiops truncatus* individuals to previous data collected in Blaylock (1981) and Wilcox (1998). From May to December, the number of dolphins lingering in the Bay past the end of their migration season will be measured, along with water temperature.

If our hypothesis is correct, then we predict that if water temperatures in the Chesapeake Bay are rising due to global climate change, then dolphins will linger past their migration season in the Chesapeake Bay. We expect that the tagged dolphins will linger in the mouth of the Chesapeake Bay longer over each year of the study due to the rising water temperature trends found due to global climate change. Our expectation can be justified by Figure 2 from (Lynn, 2002). This data comes from *tursiops truncatus* migration patterns in a Texas Bay similar to the Chesapeake Bay. There are a greater number of sightings in the prime migration season of the *tursiops truncatus* in both males and females, which is around May to November. However, this data is showing that dolphins are still present past the typical inhabitation time, therefore it justifies the expectation that we have for the outcome of this experiment.

28 GULF OF MEXICO SCIENCE, 2002, VOL. 20(1)

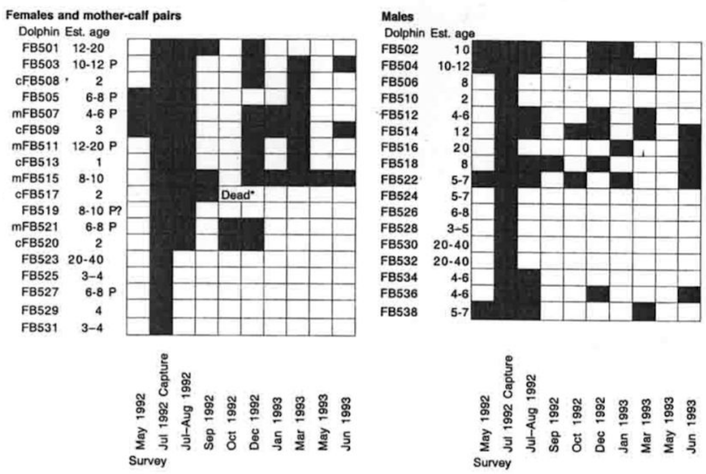


Fig. 2. Sightings of freeze-branded dolphins across surveys. "m" and "c" denote mother–calf pairs, "P" denotes a pregnant dolphin. Sex and length-based age estimates from Sweeney (1992). *FB517, calf of FB515, was found dead on 13 Sep. 1992. Necropsy showed that it died from an intestinal infarction unrelated to the study (TMMSN, 1992).

**Aim II. To determine if increased warmer temperatures will increase population density of the common bottlenose dolphins in the Chesapeake Bay.** The proposed experiment is a 5 year observational study in the mouth of the Chesapeake Bay that requires a group of volunteers riding a boat to the location and recording sightings of *tursiops truncatus* pods, the number of *tursiops truncatus* individuals in each pod, and water temperature. This will occur 8 hours a day for a week during pre-migration season, migration season, and post-migration season.

If our hypothesis is correct, then we predict that if water temperatures in the Chesapeake Bay are rising due to global climate change, then dolphin pod sightings will increase in the migration and post-migration months over time. We expect a positive correlation between rising water temperatures and the presence of *tursiops truncatus* pods with high densities in the Chesapeake Bay. Therefore, we expect that the quantity of pods and pod densities overall will increase due to the rising water temperature trends found due to global climate change. Our expectations can be justified by Figure 2 in Blaylock (1981), which is showing the relation between number of *tursiops truncatus* herds (interchangeable with the term "pod") and herd size. Figure 3 in the same study shows how herd density of the herds that were sighted in relation to the sight of the study. These figures play a role in understanding the typical statistics for *tursiops truncatus* pod behavior and can serve as a basic understanding of their normal distributions and grouping preferences. Figure 2 from (Lusseau, 2004) shows statistics from their more recent study on how climate change affects *tursiops truncatus* group behavior in the (a) graph. The main takeaway from this figure is that the observed group size data seems to be generally higher than the data collected in Figure 3 in Blaylock (1981), which justifies our expectations of our aims and experiments.

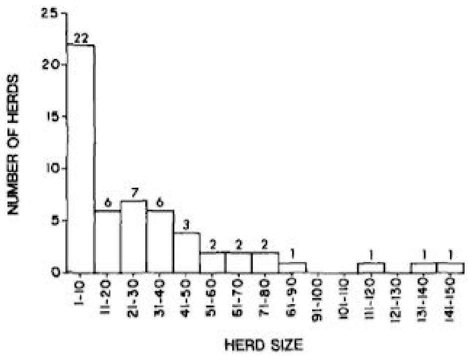


FIGURE 2.—Distribution of bottlenose dolphin herd sizes. Numbers above bars denote the number of herds in that size class.

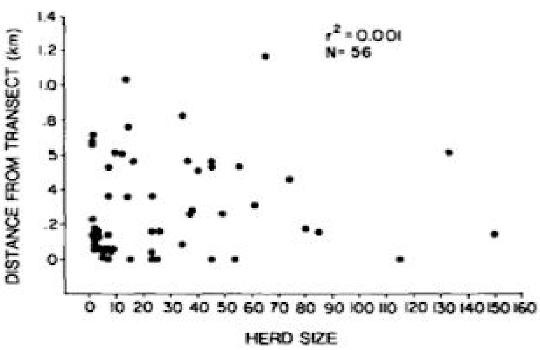


FIGURE 3.—Scatterplot of sighting distance (in kilometers) versus herd size of bottlenose dolphins. (Note that some of the points in the 1–10 size class and the interval 0–0.2 km represent more than one herd.)

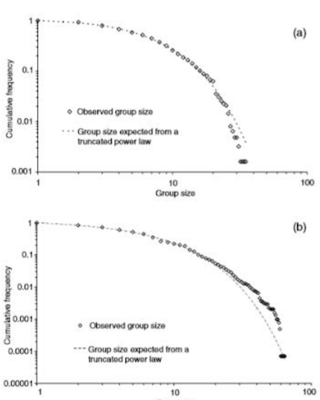


**Figure 2.** Group-size cumulative frequency distribution of all groups of (a) bottlenose dolphins and (b) killer whales. The truncated power law model, $p(n) = an^{-b}e^{-n/n_c}$, provided a significant fit to both distributions (bottlenose dolphins: $R^2 = 0.999$, $P < 0.0001$, $a = 1.20 \pm 0.008$, $b = -0.11 \pm 0.012$, $n_c = 5.7 \pm 0.10$. Killer whales: $R^2 = 0.998$, $P < 0.0001$, $a = 1.17 \pm 0.01$, $b = 0.05 \pm 0.016$, $n_c = 6.6 \pm 0.17$). The same model was fitted for each year separately and regression analyses results are presented in Table 1 (bottlenose dolphins) and Table 2 (killer whales).

Sources

Blaylock, R., 1981, Distribution and abundance of the bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821), in Virginia., *Fishery Bulletin.*

Briery, A., Kingsford, M., 2009, Impacts of Climate Change on Marine Organisms and Ecosystems, *Current Biology*.

Brusa, J., Young, R., et al., 2016, Abundance, Ranging Patterns, and Social Behavior of Bottlenose Dolphins (*Tursiops truncatus*) in an Estuarine Terminus, *Aquatic Mammals*.

Chesapeake Bay Foundation. 2018. "*Climate Change*". http://www.cbf.org/issues/climate-change/

Lusseau, D., Williams, R., et al., 2004, Parallel influence of climate on the behaviour of Pacific killer whales and Atlantic bottlenose dolphins, *Ecology Letters*.

Lynn, S., Wursig, B., 2002, Summer Movement Patterns of Bottlenose Dolphins in a Texas Bay, *Gulf of Mexico Science*.

National Centre for Atmospheric Science, 2017. "Who Uses NCAS-Climate Research?". https://www.ncas.ac.uk/en/who-uses-our-research

Simmonds, M., Isaac, S., 2007, The impacts of climate change on marine mammals: early signs of significant problems, *Oryx*.

Temple, A., Tregenza, N., et al., 2016, Spatial and Temporal Variations in the Occurrence and Foraging Activity of Coastal Dolphins in Menai Bay, Zanzibar, Tanzania, *PLOS One*.

Wood, R., Boesch, D., et al., 2002, Future Consequences of Climate Change for the Chesapeake Bay Ecosystem and Its Fisheries, *American Fisheries Society Symposium*.

Kenney, R., Winn, H., 1983, Cetacean High-Use Habitats of the Northeast United States Continental Shelf, *Fishery Bulletin/US Dept. of Commerce National Oceanic and Atmospheric Administration.*

Wilcox, T., Barco, S., Swingle, M., 1998, Distribution of the Atlantic Bottlenose Dolphin (*Tursiops truncatus*) in the Chesapeake Bay Drainage in Virginia, *Banisteria*.