Examining the northern spatial extent of estuarine bottlenose dolphins sighted in Roanoke Sound, North Carolina

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October 2020

Introduction

Common bottlenose dolphins (*Tursiops truncatus*) are a highly mobile species found worldwide in a variety of different habitats (Oudejans et al. 2015) in temperate and tropical waters (Rosel et al. 2009). As this cetacean species has adapted to a wide range of environments, bottlenose dolphins vary geographically in numerous biological traits (Fruet et al. 2017, Lusseau et al. 2006). For example, Pacific coastal bottlenose dolphins greatly contrast with bottlenose dolphins in Sarasota, FL, as they have high mobility and range characteristics while those in Sarasota have high geographic fidelity (Hanson and Defran 1993). Although there is no physical barrier to gene flow for bottlenose dolphins, various populations can differ significantly from one another, on both small and large spatial scales (Louis et al. 2014, Rosel et al. 2009). An ecotype is defined as, "groups of populations, which differ across the landscape by genetics and ecological and/or physiological traits" (Louis et al. 2014, Lowry 2012). The classification of different ecotypes has thereby resulted from observing genetically different groups of individuals of the same species (Louis et al. 2014). For example, three genetically distinct groups of bottlenose dolphins in Ireland have been identified in estuarine, coastal, and continental shelf and oceanic waters (Oudejans et al. 2015). In the coastal waters of the Northwest Atlantic, bottlenose dolphins have a continuous distribution from New York to Florida (Rosel et al. 2009). Although there are no physical barriers to genetic exchange (Rosel et al. 2009), two distinct ecotypes of bottlenose dolphin exist in the Northwest Atlantic (Louis et al. 2014, Torres et al. 2003); coastal and pelagic. The coastal and pelagic bottlenose dolphins of the Northwest Atlantic were identified based on differences in genetics, distribution, skull morphology, and diet (Louis et al. 2014, Mead and Potter 1995, Torres et al. 2003).

Dolphins found in Roanoke Sound, NC are coastal Atlantic bottlenose dolphins (*Tursiops truncatus*); the majority of these dolphins belong to the Northern North Carolina Estuarine System Stock (NNCESS) (Hayes et al. 2017). The NNCESS is comprised of approximately 823 individuals (Gorgone et al. 2014). The Roanoke Sound is an important habitat for many dolphins of the NNCESS, as many individuals reside there seasonally from April to November (Hayes et al. 2017, Taylor et al. 2014). Seasonal residency can be attributed to factors such as temperature, predation, habitat suitability, and resource availability (Barco et al. 1999). The southern range of the NNCESS's movement is well documented, as it has been established that they reside in the coastal waters near Pamlico Sound, NC and Beaufort, NC during the winter (Hayes et al. 2017). While the southern end of the stock's range is clear, the northern end of the stock's range is not well established. It was originally believed that this stock's northern range only reached as far as the NC/VA border, but the 2013 stock assessment suggests that some dolphins may move beyond this location (Waring et al. 2015). Recent studies have determined that some individuals

in the NNCESS travel farther north, as dolphins from this stock have been seen in Virginia and Maryland (Grider and Taylor 2019, Jacobs and Taylor 2018, Young and Taylor 2017).

The Outer Banks Center for Dolphin Research (OBXCDR) had studied the NNCESS dolphins in Roanoke Sound since 2008. Through the use of photo identification, OBXCDR has been able to identify and track seasonal residents and transient individuals in this area (Taylor et al. 2014, Taylor et al. 2017). The Mid-Atlantic Bottlenose Dolphin Catalog (MABDC) is the master catalog of dolphins that have been photo identified along the U.S. Atlantic Coast and it is comprised of multiple photo-ID catalogs to assist with the examination of stock structure, including the OBXCDR catalog for Roanoke Sound (Urian et al. 1999). Previously, NNCESS dolphins have been matched between the OBXCDR Catalog and the Maryland (MD-PCDP) Catalog (Grider and Taylor 2019, Jacobs and Taylor 2018), thus indicating that these dolphins may travel farther northward than originally thought.

The goal of this project was to further explore the northern range of NNCESS dolphins by comparing new dolphins from the OBXCDR Catalog to the MP-PCDP catalog. The objectives of this study were to: (1) provide an updated examination of exchange between Roanoke Sound and the MD-PCDP study site and (2) determine if individuals in the population may be traveling farther north than originally thought. Gaining a further understanding of this stock is important for both conservation and management purposes, as bottlenose dolphins can be indicators of the health of the surrounding marine ecosystem.

Methodology

Study Area

This study was conducted within Roanoke Sound in North Carolina (Figure 1). North Carolina's estuaries and sounds are considered some of their most valuable resources; they have been great routes for inexpensive transportation, the waters are not too salty for municipal use, they are the sources of fisheries, nurseries for marine life, and great areas for recreational activities (Giese et al. 1985). The Roanoke Sound is a valuable estuary that ranges from the northern tip of Roanoke Island south towards the Oregon Inlet; Oregon Inlet is an entrance into the Atlantic Ocean. This shallow sound separates Roanoke Island from Nags Head and its average depth is only 3 to 5 feet. Due to the high volume of commercial traffic in Roanoke Sound, there is also a man-made channel which has been dredged through the Sound and has an average depth of 8 to 12 feet. The coastal Atlantic bottlenose dolphins that reside in Roanoke Sound seasonally use the area as a nursery ground (Reibel 2020) as young calves are safe from shark predation and food sources are plentiful due to the amount of seagrass beds. Seagrass beds are nursery grounds for many fish species, including the soniferious species that are a part of the coastal Atlantic bottlenose diet (Gannon and Waples 2004).

Field Data Collection

The data used for this study were collected by the OBXCDR from 2008-2016 using two different methods: dedicated photo-id surveys and opportunistic photo-id surveys. Dedicated

surveys were conducted along a standardized route in Roanoke Sound while aboard a 17-foot outboard vessel. When a group of dolphins was sighted on route, the OBXCDR team slowly approached and began to collect data, which included GPS coordinates, observed behaviors, the animals heading, and other environmental conditions: visibility, sightability, cloud coverage, air and water temperature, salinity, and wind speed. Estimates of the group size and the presence or absence of calves were also recorded while taking photographs of each dolphins' dorsal fin. All of the OBXCDR dedicated photo-id surveys were conducted under NMFS General Authorization Permits LOC-13416 and LOC-17988. These surveys typically occur from April through November each year.

Opportunistic photo-id surveys were conducted while on board the Nags Head Dolphin Watch. The Nags Head Dolphin watch had two pontoon vessels that were approximately 30 and 36 feet in length. When dolphins were sighted during a dolphin tour in Roanoke Sound, the mate/naturalist worked to collect the same data that were collected during dedicated surveys. A predetermined, consistent route was not followed, and dolphin watch vessels adhered to the NMFS Recommended Viewing Guidelines for Bottlenose Dolphins in the Southeast Region.

Data Processing

All photographs and sighting data collected on these surveys were processed through FinBase. FinBase was created to facilitate data entry and analyses, expedite the matching and cataloging process of fin photos, and reduce errors that can occur with manual image file management (Adams et al. 2006). All photos were first cropped to create a closeup image of each dorsal, sorted to determine how many dolphins were present in each sighting, and graded based on the photo quality. The dorsal fin images were then matched to an individual already present in the OBXCDR photo-id catalog or entered as a new fin in the database. Each match was verified by another individual to minimize matching errors. Once these photos were processed and matched/added as a new fin, the updated OBXCDR catalog was submitted to the MABDC.

Data Analysis

I used the MABDC to match new updates from the OBXCDR catalog to the MD-PCDP. Grider and Taylor (2019) matched good quality and distinctive individuals from the OBXCDR catalog through 7/10/2016. I matched the individuals that were added to the OBXCDR catalog since that time through 8/21/2016 (n=31). When comparing the 31 new individuals to the MD-PCDP, the MD-PCDP was filtered by photo quality (Q1 and Q2) and fin distinctiveness (D1 and D2).

Results and Discussion

No confirmed matches were found between the OBXCDR and MD-PCDP catalogs (Table 1). This suggests that the 31 individual dolphins observed in this study are not moving between the NNCESS stock and the Northern Migratory Coastal Stock. These results indicate

that the northern range of the NNCESS is potentially at the NC/VA border, as originally hypothesized, and that the dolphins are not traveling farther northward. However, there are other data and explanations that must be considered.

Previous studies by Grider and Taylor (2019) and Jacobs and Taylor (2018) each identified individuals present in both the OBXCDR and MD-PCDP catalogs. Grider and Taylor (2019) matched 3 individuals and Jacobs and Taylor (2018) matched 1 individual. These studies clearly demonstrate that some exchange does occur between the two study areas, meaning that the 31 individuals in this study may not range as far as MD. It must also be noted that the MD-PCDP catalog has only been collecting data for six years and three of these seasons are available through the MABDC. The OBXCDR catalog has been active since 2008 and the MABDC has been updated through? 2016. As the MD-PCDP continues to grow and collect more data on individual dolphins there is a possibility that more matches will be confirmed. Currently, there are 1,105 individuals in the OBXCDR catalog and only 193 in the MD-PCDP (Table 1).

The previous studies that have identified overlap between these two stock systems are clearly indications that the northern range of the NNCESS may be expanding northward. We must also recognize, however, that these results could potentially indicate that individuals within the Northern Migratory Coastal Stock are traveling farther south and west into estuarine areas. To understand the direction of exchange, it is imperative to continue to examine these questions and compare the OBXCDR and MD-PCDP catalogs when they are updated with new data.

Other factors such a global climate change may also contribute to a shift in stock ranges. A study conducted by Lambert et al. (2011) created a bioclimatic envelop modeling approach to provide quantitative predictions of how the ranges of cetacean species may respond to changing water temperatures. Their approach was prompted as it is widely expected that climate change will result in shifting geographic ranges for many cetacean species. To demonstrate their model Lambert et al. (2011) used common dolphin (*Delphinus delphis*) data from the Northeast Atlantic. Their results demonstrated an aggressive shift in range northward over time as ocean temperatures warm. It is likely that these results can be applied to the coastal Atlantic bottlenose dolphins of the NNCESS as well, meaning that we may begin to see more individuals shift northward towards the Northern Migratory Coastal Stock and northern study areas such as Maryland, Delaware, and New Jersey.

In order to truly understand the current ranges of these bottlenose dolphin stocks and how climate change may impact these shifts in the future, we must continue to collect data and frequently update photo-ID catalog comparisons. These comparisons are imperative to creating a dataset that can be used to determine long-term trends and changes and promote conservation.

Figures and Tables

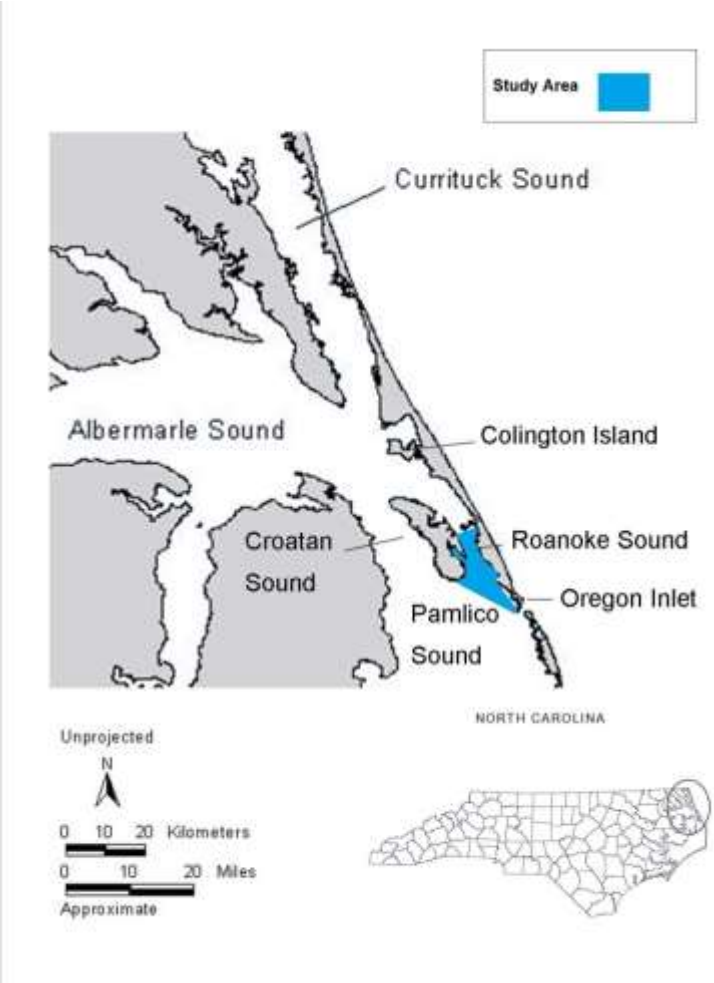

Figure 1: Map of the Outer Banks Center for Dolphin Research study area.

Table 1: Comparison of the two MABDC used in this study

Catalog	Catalog Contact	Study Area	Study Period	Catalog Size (number of individuals)	Number of Fins matched/compared	Number of Matches
NC-OBXCDR	Jessica Taylor	Roanoke Sound, NC	2007-2016	1105	31	N/A
MD-PCDP	Anni Jacoby	Potomac/Chesapeake, MD	2014-2015	193	193	0

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