**Seasonality of *Xenobalanus Globicipitis* presence on Coastal Bottlenose Dolphins (*Tursiops truncatus*) in the Northern Outer Banks of North Carolina**

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## Introduction

Bottlenose dolphins (*Tursiops trucatus*) are found throughout the world in temperate, tropical, and subtropical waters. Dolphins inhabiting water off the east coast of the United States are managed as stocks, or populations of dolphins within an area that interbreed and are functioning elements of their ecosystems (Wade and Angliss 1997). Seven management units of dolphins along the east coast have been identified with revisions resulting in five coastal stocks (Toth 2012). Dolphins found in Roanoke Sound, located in the northern Outer Banks of North Carolina, belong to the Northern North Carolina Estuarine System Stock (Waring et al. 2015)

Bottlenose dolphins utilize Roanoke Sound seasonally, coming in to the sound mainly from May through October (Taylor et. al 2014). The Outer Banks Center for Dolphin Research conducts a long-term monitoring study of these dolphins using photo-identification, a non-invasive technique that involves taking photographs of the dorsal fins of dolphins spotted during survey transects and opportunistic sightings. Dolphins are identified by unique markings, notches, scoops, and cuts in their dorsal fins. These photo identification studies provide information on the dolphin's behavior, ranging patterns, and social structures. Additionally, photos allow for identification of some skin diseases and parasites such as *Xenobalanus Globicipitis* (Toth-Brown and Hohn 2007).

*Xenobalanus* is a dark stalked barnacle that attaches to the dorsal and pectoral fins and tail flukes of a variety of cetaceans (Toth-Brown and Hohn 2007). Although widely considered a parasite, the barnacle does not actually seem to harm or change the behavior of the dolphins. The barnacle only attaches for transportation purposes and feeds via suspension techniques (Toth 2007). *Xenobalanus* has been reported on dolphins as early as 1884 (True 1890). Factors influencing *Xenobalanus* presence are relatively unknown but could include water temperature, nutrient levels, dolphin age and size (Orams and Shuetze 1998). Four different factors potentially affect barnacle presence including host swimming speed, low immunity, upwelling events, and water temperature (VanWaerebeek et al. 1993, Orams and Shuetze 1998, Aznar et al. 2001, Fertl 2002, Kane et al. 2008).

Previous studies on the relationship between bottlenose dolphins and *Xenobalanus* have had varying results. Orams and Schuetze (1998) compared *Xenobalanus* presence on bottlenose dolphins from August 1993 through January 1994 and found that the barnacle was more present on younger/smaller dolphins, but other studies (True 1890) have disputed this. This study also found a correlation between water temperature and *Xenobalanus* presence with higher abundance in lower water temperatures, though with only two months of data compared, this finding has minimal reliability. Toth (2007; 2012) found Xenobalanus loads to be stable within and among years during summer months though minimal data was available for months outside of May to September (Toth-Brown and Hohn 2007; Toth et al. 2012).

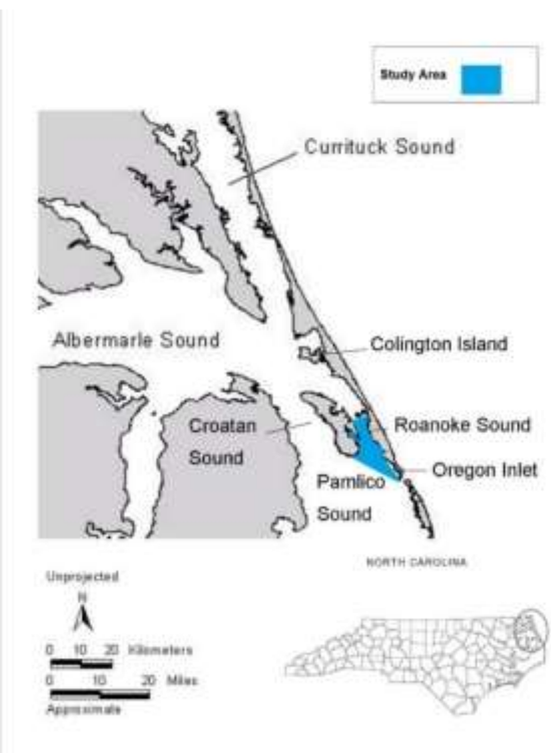
This purpose of this study is to examine the seasonality of *Xenobalanus* presence on bottlenose dolphins in Roanoke sound. This data will assist in the understanding of the exchange of dolphins between Roanoke Sound and the Atlantic Ocean as differing environmental characteristics may lead to different barnacle loads. As *Xenobalanus* are believed to drop off dorsal fins and tails in the warmer, fresher sound water, a large presence of *Xenobalanus* would indicate more time spent in the ocean and less time spent in the sound. Dolphins in the area access Roanoke Sound from the ocean through Oregon Inlet. Degree of exchange through Oregon Inlet throughout the year could have implications for management decisions of bottlenose dolphins in Roanoke Sound.

## Methods

### Data Collection

The study area, denoted in blue in Figure 1, is located in the Roanoke Sound east of Roanoke Island in the Outer Banks of North Carolina. The study utilized the 41-mile stretch between Oregon inlet and the northern tip of Roanoke Island. Roanoke Sound provides habitat for many estuarine species as well as recreation and fishing opportunities for residents and tourists alike. The Sound averages about three and a half feet in depth. The salt water in the Sound comes from the Atlantic Ocean through Oregon Inlet in the south, and the fresher water moves in from the Albemarle and Currituck Sounds in the north. This creates a salinity gradient that makes Roanoke Sound saltier in the south and fresher in the north. The salinity of the Albemarle sound is low (<1 psu) but increases sharply through the Croatan and Roanoke Sounds with salinities in the southern Roanoke Sound reaching 17-19 psu (Jia and Li 2012).

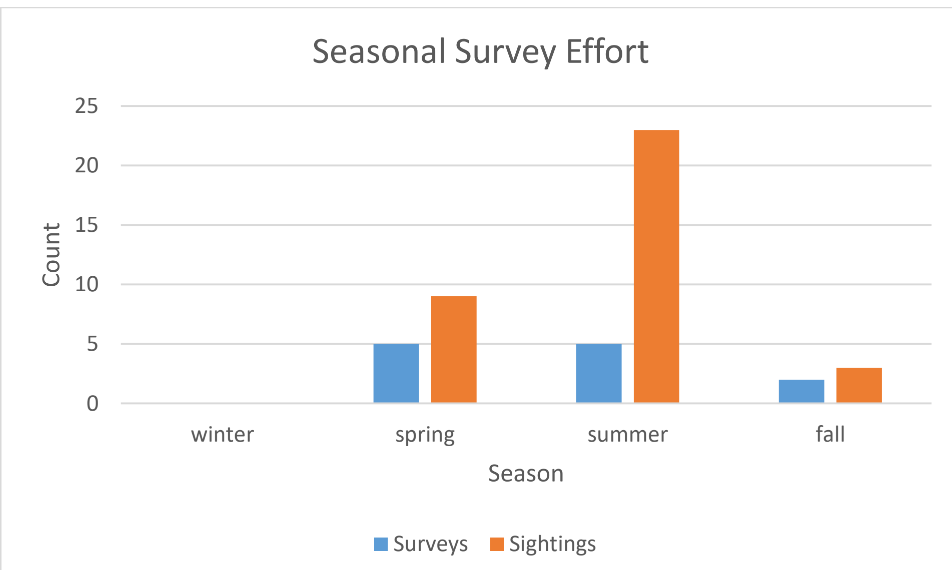
**Figure 1.** Study Area Map



The Outer Banks Center for Dolphin research conducts dedicated transect surveys to monitor bottlenose dolphins in the sound. Dedicated surveys were conducted from a 16' or 17' outboard vessel and followed a standardized transect route uploaded to a handheld GPS unit. The standardized transect was created in November 2011. When dolphins were sighted, they were slowly approached from an angle as to not disturb their behavior. During of each sighting, GPS locations and environmental data including air and water temperature, salinity, and wind speed were recorded along with dolphin activity state, group sizes, and direction of travel. The dolphins were then followed from a distance until either: 1) the dolphins exhibited avoidance behaviors or were lost, 2) the maximum allotment of one hour for the sighting was reached according to the General Authorization permit under which the surveys were conducted, or 3) every dorsal fin had been photographed in the group. At the end of a sighting, the transect route was resumed until completed or another sighting occurs. All dedicated surveys were conducted under a General Authorization Permit (LOC-13416, LOC-17988).

This study utilizes survey data from April through October 2012 and June 2013. Survey effort varied by season as depicted in Figure 2. The seasons are defined as: Spring, March 20$^{th}$ to June 21$^{st}$; Summer, June 21$^{st}$ to September 22$^{nd}$; Fall, September 22$^{nd}$ to December 21$^{st}$; and Winter, December 21$^{st}$ to March 20$^{th}$. Seasons were defined based upon water temperature. The water temperature in Roanoke Sound is impacted greatly by air temperature throughout the seasons as the shallow water reacts quickly to changes in air temperature.

**Figure 2.** OBXCDR Survey Effort




The program FinBase (Adams et al. 2006) was used in the processing of the sighting data and photo-identification images. Images were sorted, graded for photo quality, and linked to the sighting data by matching to the OBXCDR photo-identification catalog. Each fin identification was verified by two researchers.

Original images from April – October 2012 and June 2013 were examined for presence of *Xenobalanus*. Sightings were evaluated for number of individuals with *Xenobalanus* and

*Xenobalanus* load. For each dolphin with *Xenobalanus*, barnacle load was categorized as light (0-5), medium (5-10), or heavy (10+). Examples of *Xenobalanus* loads can be seen in Figure 3.

**Figure 3a-c.** *Xenobalanus* Load Examples

*3a. Heavy Load* *3b. Medium Load* *3c. Light Load*

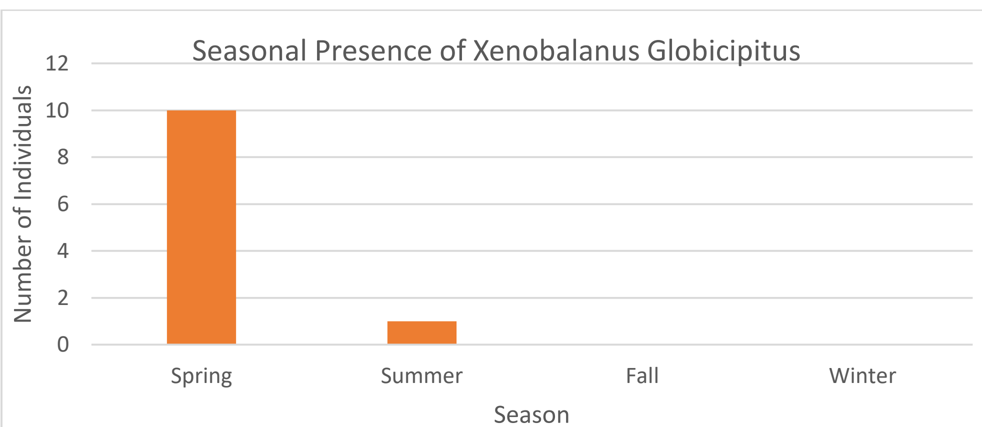
Data Analysis

Prevalence of *Xenobalanus* was calculated by season and overall using the following equation: Number of individuals with *Xenobalanus* in a season ($n_{xeno}$) divided by total number of individuals sighted during that season ($n_{total}$), $P_{xeno}=n_{xeno}/n_{total}$. Individuals sighted with *Xenobalanus* were identified using the OBXCDR catalog to avoid double counting of individual dolphins across sightings. *Xenobalanus* presence was also quantified by load, either light, medium, or heavy. Load was quantified by calculating the proportion of each load type by season and overall using the following equation: $P_{load}=n_{load\ type}/n_{xeno}$.

**Results**

A total of 1606 photos and 207 individual dolphins were screened for *Xenobalanus* presence. between April 17, 2012 and June 9, 2013. Prevalence of *Xenobalanus* by season is displayed in Figure 4.

**Figure 4.** Seasonal Presence of Xenobalanus Globicipitus




The greatest number of individuals were identified with Xenobalanus in the spring. Fewer individuals were identified with the barnacle in the summer, followed by none in the fall. There was no dedicated survey effort in the winter (Figure 2). Seasonal prevalence calculations are displayed in Table 1.

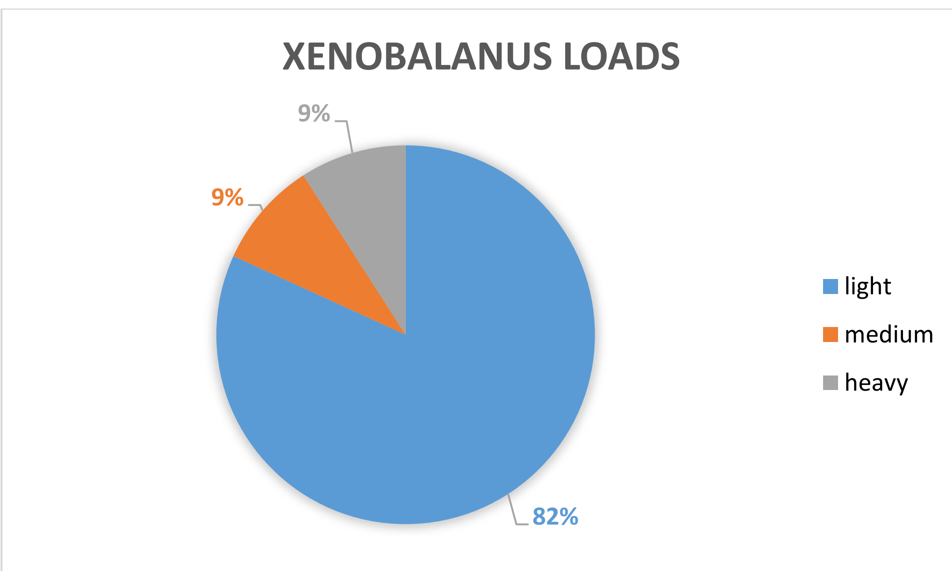
Table 1. Seasonal Prevalence of *Xenobalanus*

| Season | Number of individuals sighted | Number of Individuals with Xenobalanus | Prevalence of Xenobalanus |
|---|---|---|---|
| Spring | 65 | 10 | 0.153846 |
| Summer | 111 | 1 | 0.009009 |
| Fall | 31 | 0 | 0 |
| Winter | 0 | 0 | 0 |

The greatest number of individuals were sighted in the summer (between June 21st and September 22nd), but the greatest proportion of individuals with *Xenobalanus* occurred during the spring (from March 20th to June 21st). No dolphins were sighted with *Xenobalanus* in the fall (Table 1).

In total, out of the 207 individual dolphins sighted, 11 individuals were identified with *Xenobalanus* present (5.3%). This gives an overall *Xenobalanus* prevalence of 0.053 for Roanoke Sound. *Xenobalanus* presence was higher than average total prevalence in the spring of 2012, and lower in all remaining seasons. The distribution of *Xenobalanus* loads is shown in Figure 5.

**Figure 5.** Presence of Different *Xenobalanus* Loads




The majority of the dolphins with *Xenobalanus* had a light load, (Figure 5). Light loads comprise 82% of load prevalence. Medium and heavy loads make up 9.1% each.

## Discussion

Based upon photo-identification data, the highest prevalence of *Xenobalanus* in Roanoke Sound was found in the spring, suggesting that dolphins are exchanging between the ocean and sound most during this season as *Xenobalanus* presence indicates recent time spent in the ocean.

As the dolphins spend more time in the sound throughout the summer, the barnacles detach, contributing to the low prevalence of *Xenobalanus* found in the summer months. Zero dolphins were sighted with *Xenobalanus* in the fall. This supports the hypothesis that bottlenose dolphins move in to Roanoke Sound in the spring and utilize mainly the sound for the summer. Throughout the summer, as the dolphins stay in the sound, the barnacles detach, contributing to the absence of Xenobalanus on dolphins sighted in the fall.

Another important implication of *Xenobalanus* prevalence could be the presence of different stocks of bottlenose dolphins using the sound. Toth et al. (2012) suggested that the presence of *Xenobalanus* could potentially be used as a determinant of stock identify in NJ. Increased *Xenobalanus* prevalence in the spring could indicate coastal stocks using Roanoke Sound during the time and the importance of estuarine environments to coastal dolphins during this season. Future examination of *Xenobalanus* prevalence in the sound could provide insight into movement patterns of both estuarine and coastal stocks which would aid in conservation efforts.

Xenobalanus loads are indicative of ocean-sound exchange as well. The high proportion of light loads could indicate shorter amounts of time spent in the ocean and more exchange through Oregon Inlet. Dolphins that travel between ocean and sound often would be more likely to pick up small *Xenobalanus* loads during their time in the ocean, and lose some barnacles when they drop off in the sound before returning to the ocean to repeat the cycle. The one heavy *Xenobalanus* load was found during a September survey towards the end of the summer. This is unexpected as it is believed that dolphins utilize the sound and then migrate towards the ocean in the fall, and a heavy *Xenobalanus* load indicates recent prolonged ocean exposure. This individual was not sighted during the rest of the year in any season, and was sighted with multiple other dolphins that had not been seen throughout 2012. The individual may be a coastal dolphin migrating from another region with more coastal and less estuarine habitat, such as the New Jersey stock studied by Toth-Brown and Hoth (2007), which would explain the prolonged time in the ocean leading to a heavy *Xenobalanus* load.

Toth-Brown and Hoth (2007) examined *Xenobalanus* presence on coastal bottlenose dolphins off the New Jersey coast. They encountered a greater number of dolphins with *Xenobalanus* (58% as compared to our 5.9%) and a greater proportion of dolphins with medium and heavy loads. This is likely due to the fact that dolphins in New Jersey utilize primarily coastal habitats instead of estuarine. It was also noted that *Xenobalanus* presence was higher in groups encountered further from the shore. They also found that for certain individuals, barnacle presence and load changed over the years studied. This suggests that multiple years' worth of data is necessary to analyze *Xenobalanus* presence. Toth-Brown and Hoth's study was also limited in its seasonal applicability as dolphins migrate away from New Jersey in October, meaning that fall and winter data was limited.

The data in this study only represents one full year of surveys, which limits management implications. Future studies should focus on expanding the current dataset to make findings useful for creating conservation plans for the Outer Banks dolphins. If dolphins truly are exchanging through Oregon Inlet mainly in the spring, it would be important to avoid harmful and potentially disturbing activities in the inlet during this season. Dredging and construction would be most impactful during the spring, and allowing dolphins safe passage during their highest volume season could be an important conservation and management decision.

Future studies should focus on analyzing data from multiple years to strengthen conclusions about seasonality. Toth-Brown and Hoth (2007) noted changes in seasonality and barnacle presence across multiple years, limiting the pertinence of data from just one year. Additionally, standardizing survey effort across seasons would contribute to the applicability of findings. Surveys utilized in this study were focused in the spring and summer, with zero surveys during the winter.

**Conclusions**

*Xenobalanus* presence on bottlenose dolphins in the Roanoke Sound is greatest during the spring months from March to June. Most dolphins with *Xenobalanus* carry only a light load. This indicates an increased level of exchange between ocean and sound throughout the springtime and less exchange during the summer and fall months. Though the data is limited to one year, future studies could expand upon these findings to help provide evidence for conservation plans to ensure the future protection and survival of the dolphins of the northern Outer Banks.

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