Seasonal Exchange of Bottlenose Dolphins Resident to the Outer Banks of North Carolina

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Background

Bottlenose dolphins (*Tursiops truncatus*) can be found worldwide, in warm temperate waters (Leatherwood and Reeves 1983). In the Western North Atlantic, these populations are separated into two different distinct ecotypes, coastal and offshore. Within those two distinct ecotypes, individuals can display seasonal residency (Toth-Brown and Hohn 2007), year round residency (Pryor and Norris 1991) and transience (Defran and Weller 1999), and the type of residency can depend on protection from predators, food availability, and nursery usage, as well as many other biotic and abiotic factors (Miller *et al.* 2013). To better manage these populations under the Marine Mammal Protection Act (MMPA), a better understanding of the differences between stocks should be established. Determining a better understanding of population structure and stock size will allow for better management plans and long term protection.

In 1997, the Mid-Atlantic Bottlenose Dolphin Photo-identification Catalog (MABDC) was developed in order to better understand bottlenose dolphin stock structure on the Western North Atlantic coast (Urian 2014). The MABDC is a collection of photo-identification research from different locations along the Atlantic coast. Contributors submit data to the MABDC, allowing the data to be shared among individuals and available online. The MABDC is one centralized, comprehensive location for sightings of bottlenose dolphins, which allows for more streamlined, efficient, and widespread research to be completed.

The Northern North Carolina Estuarine System (NNCES) stock of bottlenose dolphins, as defined by the NOAA-NMFS (Waring et al. 2014), occurs from southern Virginia to southern North Carolina. The NNCES includes individuals that use the estuarine waters of the Pamlico Sound from Beaufort, NC to southern Virginia and the lower Chesapeake Bay and coastal waters up to 1 km from shore from early May until late October. In the cooler months (November-April), animals within the NNCES stock migrate south to the coastal waters (within 3 km of shore) between the New River and Cape Hatteras, NC (Waring et al. 2014).

The bottlenose dolphin population in Roanoke Sound, NC, which is included in NNCES, has been monitored since 1997 (Taylor et al. 2014). By using photo identification methods, distinguishable individuals are tracked over time to collect information on population trends that can contribute to the stock assessment. Photo identification is a type of mark and recapture study used to monitor bottlenose dolphins (Weir et al. 2008). The identification process is dependent on clear images of natural markings on the dorsal fins of the cetaceans. This study was initially started by the Nags Head Dolphin Watch, and eventually taken over by the Outer Banks Center for Dolphin Research (OBXCDR) in 2008.

The purpose of this study was to examine the movement patterns of individuals with high site fidelity to Roanoke Sound, NC, specifically, whether these frequently seen individuals travel to Beaufort, NC. This assessment can be utilized to better define the NNCES stock and to better guide management recommendations and practices.

Methods

Data Collection

The study area (Figure 1) is located in the Roanoke Sound of the Outer Banks, approximately 41 square miles. The study area spans from the northern tip of Roanoke Island south to Oregon Inlet. Roanoke Sound is the body of water that separates Nags Head from Roanoke Island. This body of water has many recreational uses as well as important value as a commercial fishing area.

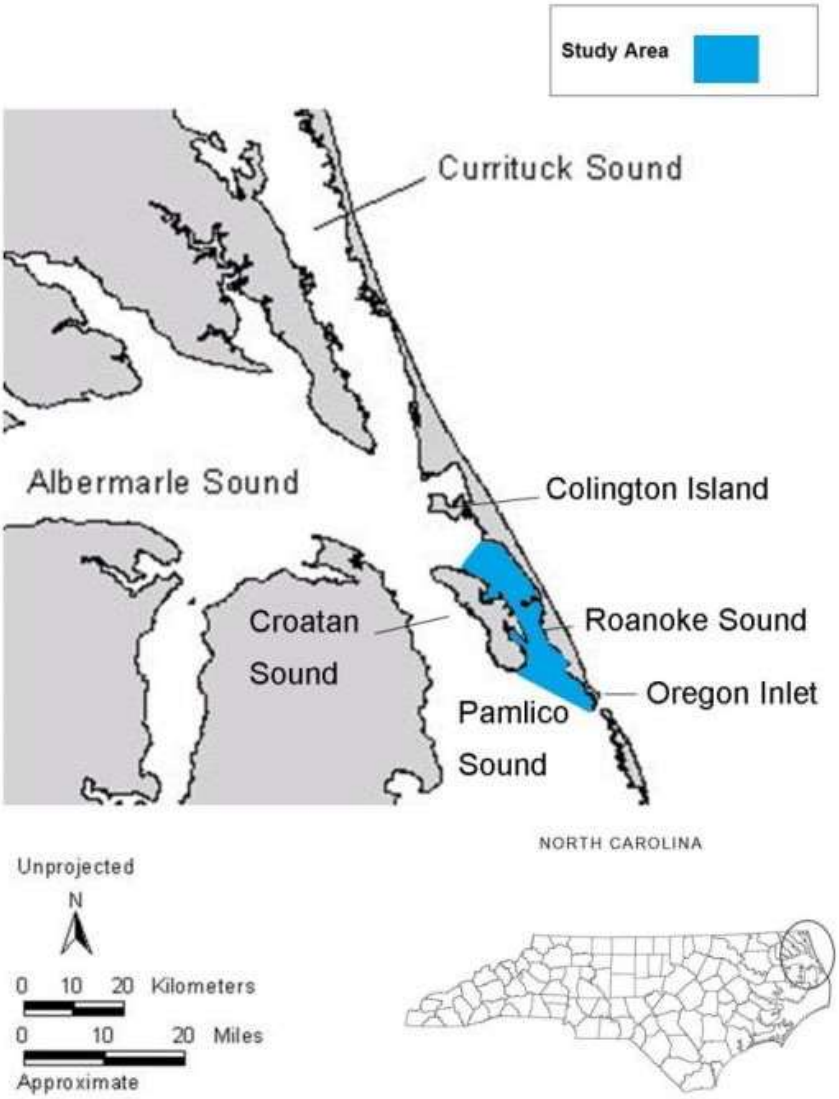

Figure 1: Roanoke Sound Study Area

The OBXCDR regularly conducts both dedicated and opportunistic photo-identification surveys of bottlenose dolphins within the study area. Dedicated exploratory surveys were conducted in the southernmost area of the study site during October 2007. Dedicated photo-id surveys were conducted from June 2008 - August 2008, February 2009, May 2009-October

2009, May 2010-October 2010, and May 2011-October 2011. In November 2011, a standardized transect route was designed to cover the entire study area. Dedicated transect surveys were conducted at least once a month in the study area during November 2011, April 2012-November 2012, and April 2013-November 2013.

All dedicated surveys were conducted from a 16' or 17' outboard vessel in the study area, with the exception of May and July 2013, due to bad weather and boat problems. The standardized transect route was made in the program MapSource and uploaded to a hand held GPS unit that is taken on each survey. During the dedicated survey, when dolphins are sighted, the location was marked on the GPS unit and the dolphins were slowly approached in order to not affect their natural behavior. Additional information including the estimated number of dolphins per group, date, time, activity state, observed behaviors, and environmental conditions such as salinity, water temperature, and visibility, sightability, and cloud cover, was collected for each sighting. Photographs of the dorsal fins of each dolphin were obtained using standard photo-identification techniques (Wursig and Wursig 1977). Sightings were concluded when one of four things happened: If the dolphins exhibited avoidance behavior, the dolphins were lost, the sighting lasted the limit of one hour according to the General Authorization permit under which the surveys were conducted, or all of the dorsal fins within the group were photographed. At the end of each sighting, the vessel would return to the transect where the sighting had started and would continue along the transect until another group was seen or until the transect route was completed.

The opportunistic data was collected from May 2008-October 2013 aboard the Nags Head Dolphin Watch. The collection of data and survey methods were similar to the dedicated survey methods. However, the route differed in locating dolphins, in that a specific transect was not utilized, dolphin approaches were further away, and sightings were conducted under the National Marine Fisheries Service (NMFS) Recommended Viewing Guidelines for bottlenose dolphins for the southeast region. In order to observe how effort has varied over the years, the number of surveys and the number of sightings has been recorded (Figure 2).

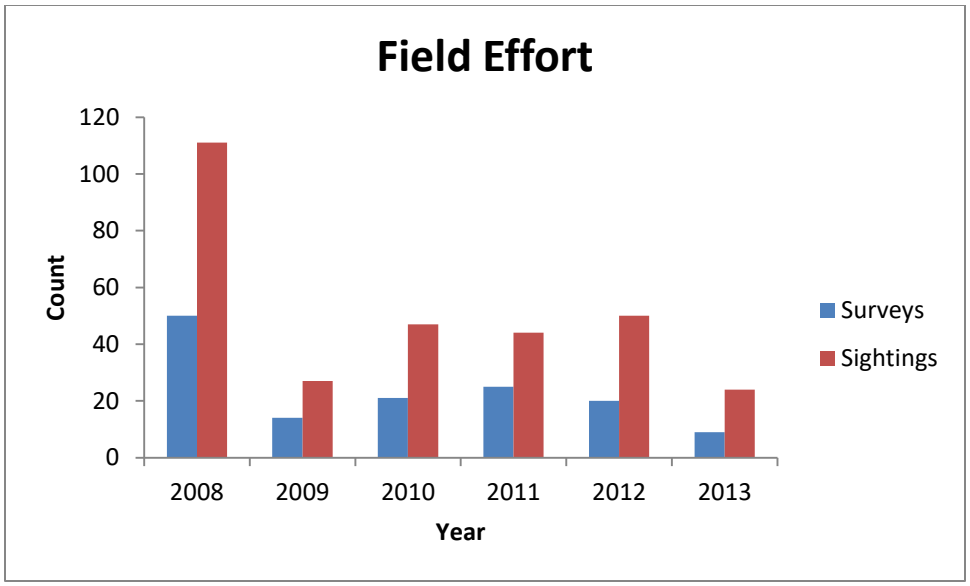

Figure 2: OBXCDR Dedicated and Opportunistic Survey effort

The program FinBase (Adams et al. 2006) was used in the processing of the sighting data and photo-identification images. Images collected from dedicated surveys and opportunistic surveys were sorted, graded for photo quality, and linked to the sighting data by matching to the OBXCDR photo-identification catalog. For every fin matched to the catalog another individual verified the match, to ensure that every match had two researchers validating the match. The data were then sent to Kim Urian, Duke University Marine Lab, in order for it to be added to the MABDC. The OBXCDR catalog includes dorsal fins from October 2007 – July 2014.

In order to examine population estimates and trends, a Bayesian mark-recapture approach was (Durban et al. 2010) applied to 413 dolphins that were identified from high quality images with high and average distinctiveness (Taylor et al. 2016). This methodology was utilized to identify clusters with different levels and patterns of capture probability over time (Gardner et al. 2010; Fearnbach et al. 2012). Three different clusters were established with Clusters 2 and 3 having relatively high site fidelity to Roanoke Sound (Taylor et al. 2016). These 59 individuals were matched to the North Carolina Maritime Museum Catalog (Table 1) using the MABDC. Every match was verified by Keith Rittmaster or Nan Bowles (the contributors for the NCMM), Jessica Taylor of the OBXCDR, and Kim Urian.

Table 1: MABDC catalogs used in comparisons.

Field Site	Catalog Size (approx)	Period	Primary Contact	Organization
Roanoke Sound, NC	330	2007-2013	Jessica Taylor	OBX Center for Dolphin Research
Beaufort, NC	2456	1985-2015	Keith Rittmaster	NC Maritime Museum

The NCMM catalog was selected because it is close to the southern most location of the NNCES. Understanding the exchange between these two locations could give better definition of the stock.

Results

Table 2 shows the matched dolphins from cluster 2 of the OBXCDR catalog to the NCMM catalog. Once matched, the demographics from the OBXCDR catalog were collected to allow for more in depth analysis. Females were determined by a minimum of 3 sightings with a dependent calf. Males were determined by a minimum of 3 sightings with the same adult.

Table 2: Cluster 2 matched dolphin demographics from OBXCDR catalog

ALIAS	NUMBER OBX SIGHTINGS	OBXCDR ID	NCMM ID	GENDER	YEARS SINCE FIRST OBX SIGHTING	MOST RECENT SIGHTING
Artemis	17	6	1489a	female	9	5/29/2012
Knobby Top	17	15	0938a	probably female	9	6/27/2014
FB717	15	33	1342a	female	9	5/23/2014
	5	81	3350a	unknown	8	6/23/2010
Four	10	83	1915p	unknown	8	6/25/2014
Jess squared	11	242	2320a	female	8	9/15/2011
FB459	9	247	1882a	female	8	7/13/2014
	10	283	1596p	unknown	8	8/11/2013
	6	287	1828p	unknown	8	9/12/2012
	12	386	4048a	unknown	8	6/28/2012
	7	728	0149a	unknown	6	10/30/2011

Eleven out of twenty-eight were matched to the NCMM catalog. The remaining seventeen individuals were not found in the NCMM catalog (Figure 3).

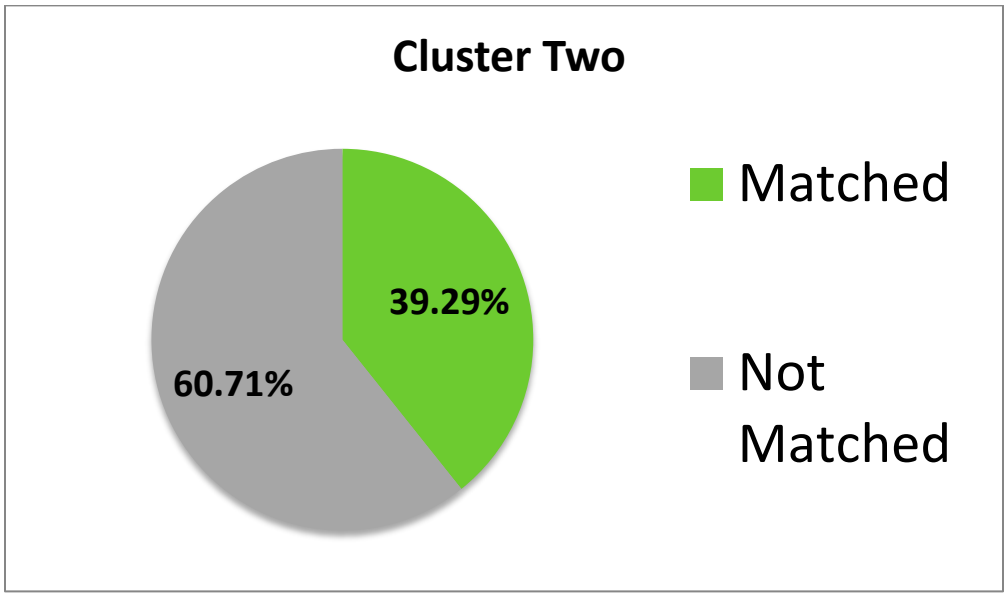

Figure 3: Matching results of dolphins in cluster 2 to the NCMM catalog

Table 3: Cluster 3 matched dolphin demographics from OBXCDR catalog

ALIAS	NUMBER SIGHTINGS	OBXCDR ID	NCMM ID	GENDER	YEARS SINCE FIRST SIGHTING	MOST RECENT SIGHTING
Mohammed	29	1	0618a	male	9	6/27/14
Onion	33	7	0026a	male	9	6/27/14
Pinchers**	28	8	0271a	male	9	6/22/12
Buddha**	27	9	1142a	male	9	8/11/13
Madi	16	12	0465a	female	9	6/27/14
Sprite	34	13	0344a	probably male	9	7/13/14
Skylar	40	18	1019q	male	9	6/27/14
	13	78	2399a	unknown	8	6/25/14
Lilo	38	90	2013a	probably male	8	6/25/14
Vidalia	19	109	3541p	probably female	8	10/3/09
Rake	37	112	2087a	Probably male	8	6/27/14
Rainbow	29	126	2573a	male	8	6/27/14
Moose	28	128	0242q	unknown	8	8/20/13
Fatlip	20	315	0173a	female	8	6/28/12
FB708	27	317	1356a	male	8	6/25/14
Sequoia	30	318	1188a	male	8	6/27/14
	3	503	3944a	unknown	7	9/26/09
Flounder	11	531	3338a	probably female	6	6/27/14
Curly**	18	553	4027a	probably male	7	10/16/13
Sinatra	19	570	3906a	female	8	8/20/13

**deceased

Twenty out of thirty-one were successfully matched to the NCMM catalog. The remaining eleven were not found in the NCMM catalog (Figure 4).

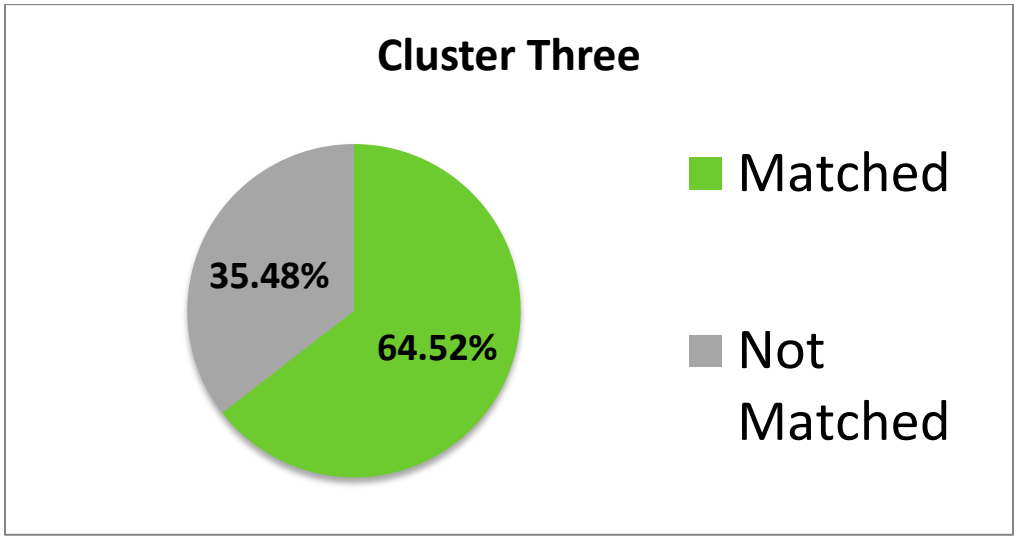

Figure 4: Matching results of dolphins in cluster 3 to the NCMM catalog

Tables 2 and 3 show the matched dolphins from cluster 2 and 3 (respectively) of the OBXCDR catalog to the NCMM catalog. Once matched, the demographics from the OBXCDR catalog were collected to allow for more in depth analysis, From those demographics we were able to assess the gender of the matched dolphins and establish if there was a difference between the genders of the matched dolphins (Figure 5). Gender did not seem to influence whether individuals were sighted in both study areas.

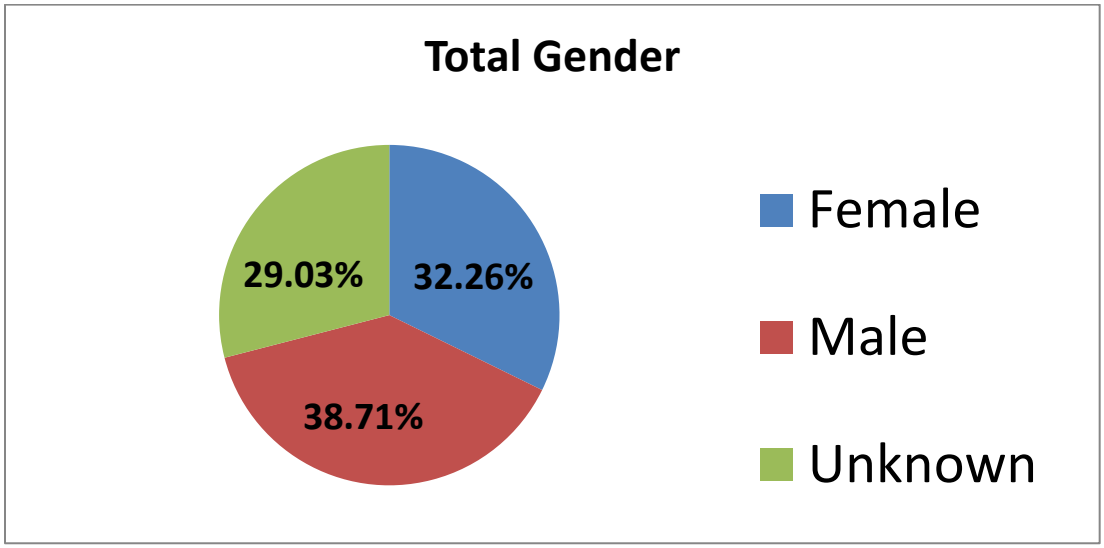

Figure 5: Gender for all matched dolphins from the OBXCDR catalog information.
**Probably male and probably female included in male and female, respectively.

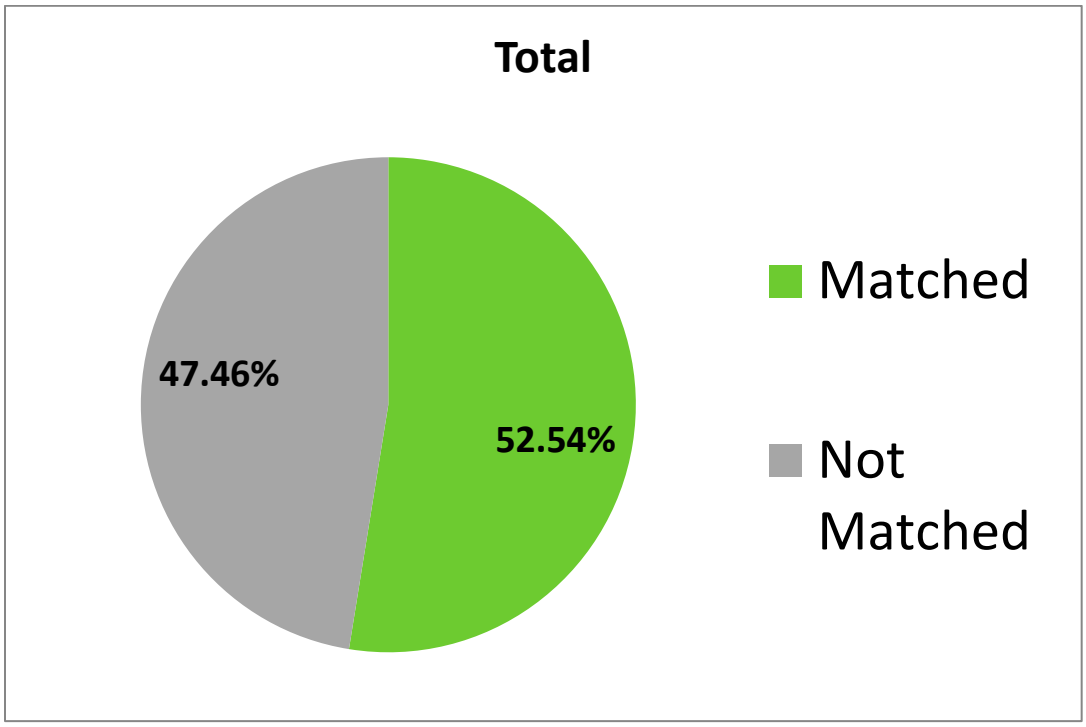

Figure 6: Cumulative matching results of cluster 2 and 3. In total, thirty-one out of a potential fifty-nine were matched.

In order to establish if non-matched dolphins from Clusters 2 and 3 were present in the Beaufort area, we checked the MABDC for previously made matches to other Beaufort area catalogs. Tables 4 and 5 show the results from this analysis. "Maybe" is used for matches pending in the MABDC, showing that a potential match has been suggested.

CatalogID	Alias	Cluster	NCMM	Matched to other Beaufort, NC Catalog?
63	Lisa Caroline	2	NO MATCH	maybe
77		2	NO MATCH	no
103		2	NO MATCH	no
104	Easy	2	NO MATCH	maybe
127		2	NO MATCH	no
131		2	NO MATCH	no
168		2	NO MATCH	no
221		2	NO MATCH	no
237	Emma	2	NO MATCH	no
285		2	NO MATCH	no
289		2	NO MATCH	no
393		2	NO MATCH	no

498		2	NO MATCH	no
541		2	NO MATCH	no
702		2	NO MATCH	no
737		2	NO MATCH	no
818		2	NO MATCH	no

Table 4: Unmatched NCMM cluster 2 dolphins

MABDC cluster two unmatched dolphins were checked to see if they matched to other Beaufort area catalogs. Two of the seventeen were potential matches, still waiting for verification from researchers.

CatalogID	Alias	Cluster	NCMM	Matched to other Beaufort, NC Catalog?
52	Lorna	3	NO MATCH	maybe
54		3	NO MATCH	no
116		3	NO MATCH	no
130	Double Scoop	3	NO MATCH	no
135		3	NO MATCH	no
240	Kerner	3	NO MATCH	no
246	Rocky	3	NO MATCH	yes
281	Winnie	3	NO MATCH	no
364	FB457	3	NO MATCH	yes
561	Cola	3	NO MATCH	no
648	Nick	3	NO MATCH	no

Table 5: Unmatched NCMM cluster 3 dolphins

MABDC cluster three unmatched dolphins were checked to see if they matched to other Beaufort area catalogs. Two of the eleven were matched and one was a potential match still waiting for verification from researchers.

Using demographic data from Tables 2 and 3 we looked to see if there was a significant difference in the number of years since first sighted. This was to check and see if there was a correlation between being seen earlier and being seen more frequently (eg placement in cluster). These results show that there is no difference between years since first sighting (Figure 7). This suggests that there is not a relationship between years since first seen and probability of being seen.

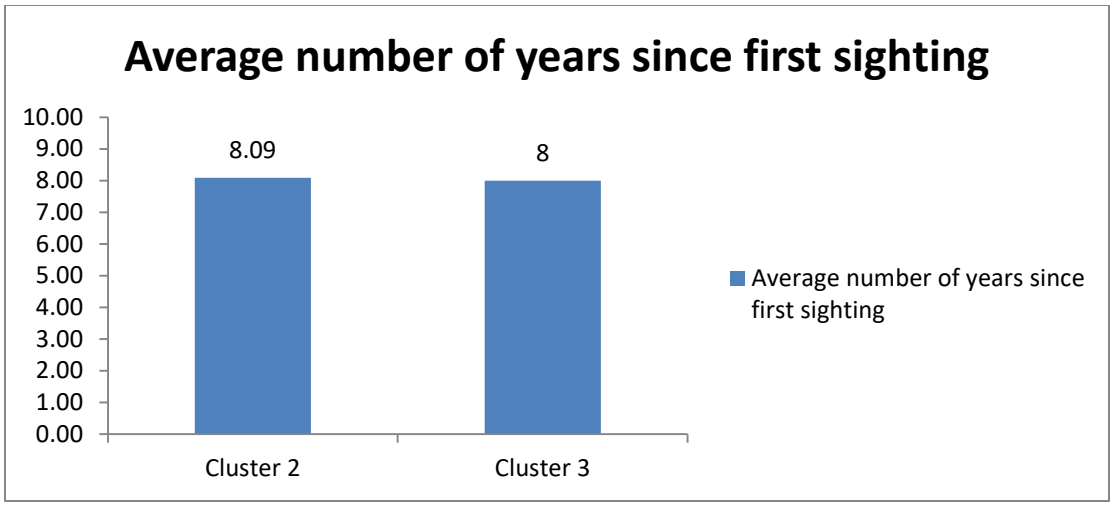

Figure 7: The average number of years since first sighting.

Discussion

Over half of the cluster two dolphins were not matched to the NCMM catalog, (Figure 3). However, nearly 65% of the cluster three dolphins were matched (Figure 4). Cluster two dolphins are less likely to be sighted in both Roanoke Sound as well as near Beaufort NC, than the cluster three dolphins. When the cluster two and cluster three were combined, the matched were slightly greater than the unmatched (Figure 6). Dolphins in cluster three likely occur in the Beaufort area, as well as within the Roanoke Sound, while cluster two dolphins are may be more transient within the Beaufort area.

To further examine this, we also used the MABDC to check whether any of the unmatched dolphins from cluster two or three were previously matched to any other Beaufort area catalogs (Tables 4 and 5). These results show that cluster three was slightly more likely to be matched to other Beaufort catalogs. Cluster 3 had 27.27% potentially matched to other catalogs and cluster 2 had only 11.76% potentially matched. This comparison supports our hypothesis that cluster 3 dolphins are more likely to be sighted within the Beaufort area, than cluster 2 dolphins.

As demonstrated by Figure 5 there was no significant difference in gender, which suggest that there is very little influence of gender on occurrence patterns. Slightly more males were matched; however overall there were an equal proportion of male, female, and unknown dolphins matched between the catalogs. These results could suggest that both males and females use the study area with similar frequency. This finding is corroborated by Rossbach and Herzing (1999) where they identified two communities with high sight fidelity, each with no significant difference in gender, suggesting that these results might be typical behavior for estuarine bottlenose dolphins of both genders.

The average number of years since first sighting was compiled to determine if dolphins seen within Roanoke Sound for a longer period of time were more likely to be matched to NCMM catalog (Figure 7). There was very little difference between the clusters, suggesting that the number of years since they were first sighted has no effect on determining occurrence

patterns. As this study continues and the clusters change it will be important to observe whether or not the years since first sighting has an impact on the sight fidelity or occurrence patterns.

Future studies can potentially look at the relationships between individuals with high sighting probability in Roanoke Sound. Dinis et al. (2016) suggests that there are certain individuals within populations that facilitate relationships between resident and transient dolphins. While the loss of these individuals would probably not have an immediate effect on the social structure, it is thought that they facilitate genetic flow (Quérouil et al. 2007). Understanding social structure is necessary in ensuring a healthy population of dolphins.

Comparisons between Virginia and New Jersey catalogs to the OBXCDR catalog within the MABDC can be examined to help understand whether cluster two and three individuals occur in other locations. This research can help understand if the "resident" dolphins in the Roanoke Sound are considered transient in other locations. This information can help researchers understand and possibly better definite the NNCES, as well as understanding where and when dolphins may be found in certain areas. This research will only be possible through collaboration with other researchers as sighting records or histories for other catalogs would be necessary through contribution to the MABDC. Understanding, more definitively, where dolphins spend their time could help establish the range and a seasonal habitat and therefore also better help establish the range of the NNCES. Furthermore, by better establishing how many individuals are in an area at a given time measures can be taken to protect their populations or to make recommendations for events that might potentially impact their conservation.

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