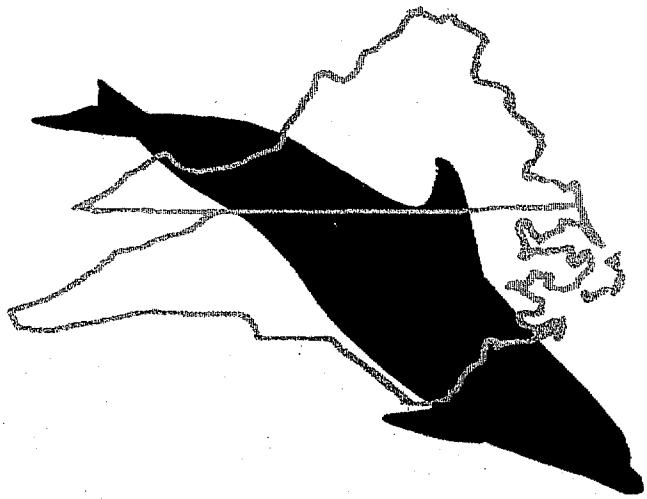
Sighting Patterns of Coastal Migratory Bottlenose Dolphins (*Tursiops truncatus*) in the near shore Waters of Virginia and North Carolina



Final Report

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Submitted by

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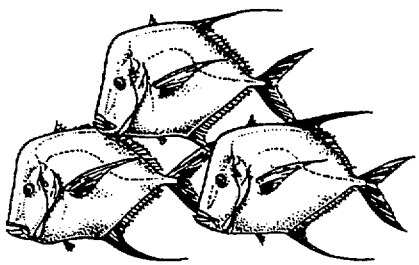

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ABSTRACT

The Virginia/North Carolina bottlenose dolphin photo-identification and migration project has been very successful. The goals of the project were to: (1) promote photo-identification research in Virginia and North Carolina and (2) bring researchers from North Carolina and Virginia together to compare data and learn more about dolphin movement along the mid-Atlantic coast. The Virginia Marine Science Museum (VMSM) conducted 58 research cruises in the primary study area off Virginia Beach. Additional to the primary research cruises, VMSM conducted two cruises off Assateague and Wallops Islands and five cruises inside the outer banks of North Carolina in cooperation with the North Carolina Maritime Museum and the University of North Carolina at Wilmington. Photographs taken on all 1996 research cruises are currently being analyzed. Bottlenose dolphin photographs taken in previous years off Virginia Beach were compared with similar photo-catalogs from Cape Charles, Virginia, Beaufort, North Carolina, Wilmington, North Carolina and to photographs taken in the outer banks near Cape Hatteras. Twenty-four and twelve dolphin matches were made from Virginia Beach to Beaufort and Cape Charles, respectively. Five matches were also made between Cape Charles and Beaufort. No matches were made between Virginia Beach and Wilmington, but several were made between Beaufort and Wilmington. In addition, five of the nine dolphins identified at Cape Hatteras matched dolphins in Beaufort. Matches between the Virginia Beach and Cape Charles research groups occurred primarily in the summer, indicating that the same population of dolphins may occur throughout the lower Chesapeake Bay. Matches between Virginia Beach and Beaufort were seasonally separated with dolphins photographed primarily in summer months (July-August) in Virginia Beach occurring in the winter months (Jan.-March) in Beaufort. These data contribute substantially to our knowledge of dolphin migration between adjacent state waters and, for the first time, allow us to propose migratory ranges for coastal dolphins. A computer programmer was contracted to develop a bottlenose dolphin database for Virginia and North Carolina. Researchers from both states met to design the database and are currently entering data. This project has been a very successful collaborative effort between research groups in Virginia and North Carolina. Studying highly mobile animals such as dolphins requires cooperation among research groups, conservation organizations, and government agencies. Collaboration also makes good use of limited research funds for protected species such as dolphins.

INTRODUCTION

Bottlenose Dolphins in Virginia and North Carolina

Bottlenose dolphins (*Tursiops truncatus*) appear seasonally in the coastal waters of Virginia (Barco, *et al.* 1995; Swingle 1994; Kenney 1990). The Cetacean and Turtle Assessment Program (CETAP), a large scale aerial survey which included continental shelf waters from Cape Hatteras, North Carolina to Canada, demonstrated a bimodal distribution of bottlenose dolphins in the Northwest Atlantic (Kenney 1990). The inshore component of the observed distribution is now recognized as the coastal stock of Atlantic bottlenose dolphins (Wang, *et al.* 1994; Kenney 1990). In the CETAP survey area, the coastal stock displays seasonal changes in abundance and distribution consistent with a migrating population. For example, the CETAP abundance estimate for coastal dolphins ranged from 0 in winter to 400-700 in summer (Kenney 1990).

Coastal dolphins north of Cape Hatteras are migratory, coastal dolphins south of Cape Hatteras, however, are not exclusively migratory, some groups may remain in one area all year. In the estuarine and ocean waters of Beaufort, NC, bottlenose dolphins are present year round but individuals are apparently not resident throughout the year (Rittmaster and Thayer 1995; Rittmaster and Thayer 1994). In the Indian and Banana River systems of eastern Florida, dolphins appear to be resident throughout the year (Odell and Asper 1990). The residents of the Indian and Banana river system have been termed "estuarine" dolphins and have a distinctly different diet from coastal dolphins in Florida (Barros 1995; Barros and Odell 1990). Thus, the coastal stock of Atlantic bottlenose dolphins can be further divided into coastal migratory and coastal resident (and/or estuarine) groups.

Atlantic coastal dolphins gained national attention during a 10 month period in 1987-88, when these dolphins experienced a mass mortality event that is estimated to have decreased the population by over 50% (Scott, *et al.* 1988). The dolphins affected by this event were described as a separate group from other coastal dolphins, because the mortalities started in New Jersey and Virginia in the summer and moved southward in the fall and winter. This group of bottlenose dolphins is currently referred to as the coastal migratory stock (Scott *et al.* 1988; Scott 1994). Coastal migratory dolphins are believed to be the portion of the coastal stock which undergoes a yearly seasonal migration (Wang *et al.* 1994). Currently, all coastal bottlenose dolphins north of Cape Hatteras are described as coastal migratory. The distribution of stranded dolphins from 1987-88 provides

the only description of coastal migratory dolphins south of Cape Hatteras. Because of the mass mortality, the National Marine Fisheries Service (NMFS) assigned a "depleted" status to the coastal migratory stock in 1992. Even though coastal migratory dolphins are now considered a depleted stock, we cannot yet define the southern limit of coastal migratory dolphins or northern limit of coastal resident dolphins (Wang, *et al.* 1994). Without such basic knowledge as the range of the coastal migratory stock, wildlife managers and legislators cannot assess the impact of human and other activities on this depleted stock. One way to learn more about the movement of migratory dolphins is to identify dolphins north of Cape Hatteras in the summer and follow them to their winter range.

CETAP surveys identified Cape Hatteras as an important dividing line between seasonal and year round dolphin presence (Kenney 1990). Two well established dolphin research groups operate on either side of Cape Hatteras. The northern group is headed by Mark Swingle and Susan Barco at the Virginia Marine Science Museum (VMSM). The VMSM primary study area is located approximately 180 kilometers north of Cape Hatteras surrounding Cape Henry (Figure 1). The southern research group is located at Cape Lookout and Beaufort Inlet, 120 kilometers south of Cape Hatteras (Figure 1). The research is conducted by Keith Rittmaster, Vicky Thayer and Nan Bowles of the North Carolina Maritime Museum (NCMM). Both groups use photo-identification as their primary research method.

Bottlenose Dolphin Photo-identification

Photo-identification is a non-invasive method for identifying animals which relies on natural tags possessed by an individual (Lien and Katona 1990). Photo-identification has been applied to many species of cetaceans across diverse geographic areas (Hammond, *et al.* 1990). Photo-identification studies have been conducted on mysticetes, particularly humpback, right, and bowhead whales (Glockyer-Ferrari and Ferrari 1990; Hamilton and Mayo 1990; Rugh 1990). In killer whales (*Orcinus orca*) near Vancouver Island, British Columbia, photo-identification research resulted in the recognition of two discrete groups, resident individuals and transient individuals, whose movement patterns, feeding habits, and vocalizations are distinctly different (Bigg, *et al.* 1990; Morton 1990).

Methods of photo-identification of bottlenose dolphins which were developed in the 1970's (Wursig and Wursig 1979), rely upon distinctive dorsal features (*e.g.* Connor and Smolker 1985; Ballance 1990; Hansen 1990; Shane

1990; Wells and Scott 1990; Wursig and Jefferson 1990; Wilson, *et al.* 1993) (Figure 2). Dolphin photo-identification may be a viable, relatively inexpensive method of determining the range of coastal migratory dolphins along the Atlantic coast of the U.S. This project will provide the first test of determining dolphin movement along the Atlantic coast of the US using photo-identification.

Project Goals

The goals of this project were to: (1) promote photo-identification research in Virginia and North Carolina and (2) bring researchers from Virginia and North Carolina together to compare data and learn more about dolphin movement along the mid-Atlantic coast. To achieve our first goal, we collaborated with North Carolina researchers to design a relational database for photo-identification data. The database will standardize most of the data collection and analyses between VMSM and NCMM. We also used grant funding to document sightings of identifiable bottlenose dolphins that appeared in Virginia waters. By providing travel and consulting funds, we were able to bring researchers from Virginia and North Carolina together to compare identifiable dolphins from different study areas. The matches that we made as a result of comparing data provide new evidence for patterns of dolphin migration between Virginia and North Carolina.

METHODS

VMSM used photo-identification to identify individual bottlenose dolphins in a 24 km study area up to 1 km off the coast of Virginia Beach, Virginia (Figure 3). We conducted additional research cruises in northeastern Virginia off the coast of Assateague and Wallops Islands and along the North Carolina outer banks at Hatteras Inlet, Ocracoke Inlet, and around Roanoke Island.

To collect data on dolphin associations, we photographed each group of dolphins separately. For this study, we defined a dolphin "group" as a collection of individuals observed within a given area. Dolphins separated by greater than 100 m were considered to be in different groups. The 100 m distance was chosen because it represented the accuracy with which our global positioning system unit (GPS) could determine position. The term "encounter" refers to a photographic session with a group of dolphins. Photographs and associated data, such as location, water temperature, group size and composition were collected for each

encounter. We used several different boats, ranging from 5-6 m throughout the study. Optimally, three people were onboard during a cruise, a captain who watched the course and speed (typically 30-40 kph when searching for dolphins), an observer who recorded data, and a photographer who shot fin photographs.

When dolphins were encountered, the boat was slowed. Before moving close enough to photograph individuals, the time of initial observation, behavior, and direction of the group were recorded. The boat then moved parallel to the group, and the location, number of dolphins, and group composition were recorded. Position data were obtained using a Global Positioning System (GPS) unit. The maximum, minimum, and best estimate of total group number were recorded for each group. The "best estimate" was the observers' estimation of how many dolphins were in the group. This number was not simply the average of maximum and minimum number, but rather a point estimate that took observation conditions into account. The final count was recorded after a consensus was reached among observers.

Once location, behavior, number, and group composition data were recorded, attempts were made to photograph each dolphin in the group. When the dolphins were moving predictably in one direction, the captain placed the boat just behind and to one side of the group and set the speed slightly faster than that of the group. Thus, the boat would slowly pass by each dolphin. If the group was not moving predictably in one direction, the captain attempted to keep the boat in neutral and drift into the group or stay in gear and maintain minimal steerage while approaching. Photographing was continued until sufficient photos were taken to adequately document the group unless other vessels moved close to the group and/or the water and weather conditions deteriorated.

All photographs for the study were taken using 35 mm SLR cameras with zoom or telephoto lenses. VMSM used Kodak Ektachrome 100 or 200 ASA slide films. Film and frame numbers were recorded for each encounter. To further insure that each group was accurately recorded, a photograph of the data sheet was taken at the beginning and end of each group encounter and each roll. All slides were stamped with the trip number and the group number.

Slides were then sorted for usable photographs. Poorly focused shots and other shots not useful for identification were discarded or catalogued elsewhere. Slides of fins and other distinguishable characteristics were then sorted by group. A system for categorizing fin markings was developed in order to systematically

examine the fin photographs. The system, developed by VMSM and NCMM, has been adapted to each study area (Barco, *et al.* 1995).

For the purposes of this paper, a "sighting" will refer to a photographic record of an identifiable dolphin. "Resights" of an individual are defined as sightings that occur on different days within a study area. A resight record includes all sightings of an individual plotted over time. A "match" refers to confirmed sightings of a dolphin in two different study areas.

All photographs of identifiable dolphins were first compared within an encounter. We may collect several photographs of each individual during a single encounter. All usable photographs of an individual are compared with individuals identified on all other encounters during that year. We can then determine the total number of individuals sighted in one year and the number of within-season resights for each individual. A year-long population estimate can be calculated from the above data using capture/recapture analyses (where a capture is equivalent to an identifiable photograph of a dolphin) (Begon 1979). Coefficients of association, which determine the likelihood of an individual being seen with another individual, can also be calculated for dolphins with more than five resights.

Following within-season analysis, photographs are integrated into the VMSM master catalog which contains all previously identified individuals since 1989. During the entire process, sightings and resights must be confirmed by three experienced researchers. All must agree before a resight, or a new sighting0 is confirmed (debate is allowed, but the decision must be unanimous).

For this project, dolphin sightings were also compared between research groups. We developed additional fin matching standards to insure that confirmed matches between study areas were acceptable. In order for a match between studies to be confirmed, the following conditions had to be met: (1) there had to be more than one photograph of each individual from each study site (more than one photo in one sighting is acceptable), (2) the fin had to have more than one unique feature, and (3) one researcher from each group plus a third unbiased researcher had to agree that the dolphins were the same. Dolphin photographs were compared between the VMSM primary study site and the following areas (Figure 1): Assateague, Cape Charles (operated by Christopher Newport University - CNU), NCMM (Beaufort), Wilmington. Additionally, NCMM compared photographs with Wilmington and Cape Charles. The seasonality of

matches made between study areas was compared for trends in order to develop hypotheses regarding dolphin migration.

RESULTS

VMSM conducted 58 research cruises in the Virginia Beach study area in 1996. Approximately 100 dolphin groups were encountered and photographed. We counted 1501 dolphins during the 1996 season (April to October) (Table 1). Results of the 1996 photo-identification are still being analyzed and entered into a newly developed database. VMSM also conducted two cruises off Assateague/Wallops Islands in northeastern Virginia and five cruises along the North Carolina outer banks (Table 1A). These cruises resulted in four encounters with dolphin groups.

Comparing photographs with other research groups resulted in matches between VMSM and Cape Charles, VMSM and NCMM, NCMM and Cape Charles, and NCMM and Wilmington (Table 1B). Only one identifiable dolphin was photographed in the Assateague/Wallops Island study area, and it did not match any dolphins in the VMSM catalog. No matches were made between VMSM and Wilmington or the outer banks. Of the nine dolphins identified in the outer banks study area, five matched NCMM photographs.

DISCUSSION

The matches that were made between study areas provide valuable information about the movement of dolphins along the Virginia/North Carolina coasts. Dolphins photographed in both Virginia and North Carolina generally appeared in different seasons (Figure 4). Most of the matches represent dolphins appearing in Virginia Beach in the summer (July-August) and in Beaufort in winter (January-March). With the exception of one individual (VMSM 0242), none of the VMSM/NCMM matches were photographed in the same month in both study areas (Figure 4). The exceptional individual was photographed in Virginia Beach in August and/or September of 1992, 1993, and 1994. It was photographed once in North Carolina in August of 1995 and was not photographed

in Virginia Beach in 1995, but was photographed in Virginia Beach in July and August of 1996 (Table 2).

The matches between VMSM and Cape Charles occurred in the same season and often in the same month of the same year (Figure 5). Seven of the twelve VMSM/Cape Charles matches are actually resights because the photographs taken by Cape Charles were taken within the Virginia Beach study area. These resights provide valuable information about the presence of identified individuals off Virginia Beach, but do not provide information about dolphin movement between areas. There appears to be a seasonal component to the VMSM/Cape Charles matches, with most of the Cape Charles sightings occurring in May and June and most of the VMSM sightings in August.

When examining these photo-identification data, we must take effort into account. The majority of the Cape Charles photo-identification cruises in 1993-1996 occurred in May and June, during a Christopher Newport University Dolphin Field Schools. The apparent seasonal trend actually reflects an effort bias toward May and June. All but one of the July-September matches were collected in 1992 (Table 2). Since 1994, VMSM has consistently conducted photo-identification cruises May through September (weather permitting). Cruises are conducted opportunistically in April, October, and November. No photo-identification cruises are conducted December-March because there are no dolphins present in the study area (Barco 1995). Fewer cruises were conducted from 1989-1993 and most occurred June-August. From 1986-1994, NCMM did not conduct many cruises in winter months. Cruises were conducted consistently April-October and opportunistically in March, November and December. For the past two years, NCMM has conducted cruises year round on a consistent schedule. It is interesting to note that although the majority of the NCMM effort has been in non-winter months, the majority (14/24 = 58%) of the VMSM/NCMM matches occur in winter (Figure 4). Effort data are not available for the Wilmington study area. The photographs that we examined were collected between 1992 and 1994. A new research group is collecting photographs and plans are being made to examine those photographs.

All of the outer banks photographs were collected during a research trip in September 1996. There has been no other effort in the area. We had limited success finding dolphin groups (2 encounters in five trips over three days). The weather forced us to conduct all of the cruises in Pamlico and Roanoke sounds and not in the ocean. We spent several hours on the beach scanning the ocean for

dolphin groups but did not observe any. Local pier operators and commercial fishermen had seen dolphins recently but indicated that later in the year (November-February) was the best time to encounter dolphins in the ocean. Of the nine dolphins we identified, over half (5) were matched to the NCMM dolphin catalog. There does not appear to be a strong seasonal presence for the Beaufort/outer banks matches (Figure 6). None of the dolphins matched to the outer banks were photographed in Beaufort in April, May, June or February. The sample size is so small that lack of sightings in these months cannot be interpreted as a trend. From the matching success rate between Beaufort and "inshore outer banks " sightings, it is apparent that work should continue in this area. Dolphins appearing along the ocean coast of the outer banks should also be studied to see if/when they match individuals in the VMSM and NCMM catalogs.

SUMMARY

Migration is the movement of organisms coordinated in space and time (Quinn and Brodeur 1991). Although the data we collected is limited, sighting dates support the existence of a group of dolphins migrating between Virginia Beach, Virginia and Beaufort, North Carolina. Because of the timing of the matches (*i.e.* summer in Virginia Beach and winter in Beaufort) the northern and southern limits of these individuals may be close or equivalent to Virginia Beach and Beaufort. If this is the case, then dolphins seen north of Virginia Beach in the summer may not occur as far south as Beaufort in winter, and dolphins seen between Virginia Beach and Cape Hatteras in summer may spend the winter south of Beaufort. Atlantic coastal migratory dolphins may exhibit relatively discrete migratory ranges that overlap spatially but not temporally (Figure 7). These ranges may shift from year to year based on environmental conditions and/or prey availability. The data we present support this migration model, but are not inconsistent with other models. Clearly, we need more information about dolphin movement between Virginia Beach and Beaufort before we can test this or any model.

Additional evidence for discrete ranges comes from resights within each study area and from association data. Individuals are often resighted each year at roughly the same time and place. Two examples are: VMSM 0016 which was sighted in Virginia Beach in August of 1989, 1993,1994, 1995 and 1996, and

NCMM 1120 which was sighted in February of 1987, 1994 and 1996. In addition, several individuals maintain associations between study areas. They were photographed in the same group in Virginia Beach and were also photographed together in Beaufort (e.g. VMSM 0072 & VMSM 1996-2, VMSM 0079 & VMSM 0085). Other individuals were photographed within days of each other in each area (Table 2). Matches made between Virginia Beach and Cape Charles suggest that the summer range of migratory dolphins in Virginia encompasses both study areas. Thus, dolphins found in the summer in Virginia Beach may be part of a large, stable group of individuals that migrate together. The entire migratory range of these dolphins include, but are not limited to, the Virginia Beach and Beaufort study areas. Continued photo-comparison and association analyses are needed.

The matches between Beaufort and the outer banks and between Beaufort and Wilmington indicate a more complex situation south of Cape Hatteras. Not only do dolphins appear throughout the year in Beaufort, but they also appear to exhibit a seasonal habitat preference (Rittmaster and Thayer 1995; Rittmaster and Thayer 1994). Dolphins are seen more frequently in the ocean in the winter months and in the estuary in the summer. Individuals matched to Virginia Beach occur in the ocean or in the inlet adjacent to the ocean. Individuals matched in Wilmington and on the outer banks occur at all times of the year and in both the ocean and the estuary. Dolphins observed in the Beaufort, Wilmington and inshore outer banks may belong to one of several possible groups. Dolphins may exhibit stable, overlapping home ranges similar to dolphins in Sarasota, Florida (Wells and Scott 1990). Dolphins in the ocean in summer may be migratory individuals with a range different from the Virginia Beach/Beaufort individuals.

This work is beginning to answer the question of where migratory dolphins in Virginia can be found in the winter. Much more work is needed to develop and test migratory models. Photo-identification appears to be a viable tool for this research. Collaboration between research groups is essential to determine the movements of these highly mobile, marine mammals. We present this project as a model of collaborative effort and hope that work similar to this will be supported in the future.

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Table 1: (A) Results of VMSM photo-identification and
(B) photo-comparison with other research groups

A-Photo-identification effort and results

Study Area	**# Cruises**	**# Encounters**	**# Dolphins**
Virginia Beach	58	100	1501
Assateague/Wallops	2	2	43
Outer Banks	5	2	20
Total	65	104	1564

B-Photo-comparison results (Total IDed = # of dolphins identified in study area)

Study Area	**# Total IDed**	**# Matches**	**Matched with**	**# Total IDed**
Virginia Beach	500+	24	Beaufort	1400+
Virginia Beach	500+	5 (+7)*	Cape Charles	200+
Virginia Beach	500+	0	Wilmington	100+
Virginia Beach	500+	0	Outer Banks	9
Beaufort	1400+	5	Cape Charles	200+
Beaufort	1400+	9	Wilmington	100+
Beaufort	1400+	5	Outer Banks	9

* The Cape Charles research group photographed 7 of the matched dolphins in the VMSM Virginia Beach study area; therefore, they do not represent matches between different study areas.

Table 2: Results of photo-identification comparison between research groups. VMSM sightings are listed in the left column and other research groups in the right column.

	VMSM Photo-ID		Matches		
	Catalog #	Dates	Research Group	Catalog #	Dates
1	VMSM 0014	20-Jul-93	NC Maritime Museum	NCMM 1276	29-Oct-92
		04-Jun-94			05-Apr-94
		15-Jun-94			11-Apr-95
		07-Jul-95			
		28-Jul-96			
2	VMSM 0079	20-Jul-93	NC Maritime Museum	NCMM 86Z	18-Nov-93
		24-Aug-93			19-Nov-93
		28-Jul-95			15-Mar-94
		30-Jul-96			31-Mar-94
		17-Aug-96			25-Nov-94
					16-Mar-95
					07-Feb-96
3	VMSM 0016	??-Aug-89	NC Maritime Museum	NCMM 1021Q	26-Jan-96
		??-Sep-89			
		08-Aug-93			
		20-Aug-94			
		26-Aug-94			
		27-Aug-94			
		31-Aug-94			
		13-Sep-94			
		19-Aug-96			
4	VMSM 0387	24-Aug-95	NC Maritime Museum	NCMM 261Z	17-Jan-95
					13-Mar-95
					22-Feb-96
					25-Feb-96
5	VMSM 0219	19-Aug-94	NC Maritime Museum	NCMM 459Z	18-Nov-93
					22-Oct-94
					30-Nov-94

	VMSM Photo-ID		Matches		
	Catalog #	Dates	Research Group	Catalog #	Dates
6	VMSM 0085	20-Jul-93	NC Maritime Museum	NCMM 257Z	12-Feb-94
		24-Aug-95			13-Mar-94
		06-Sep-95			15-Mar-94
					17-Jan-95
					22-Jan-96
					26-Jan-96
					30-Jan-96
					07-Feb-96
					14-Mar-96
7	VMSM 0268	24-Aug-93	NC Maritime Museum	NCMM 1454	17-Jan-96
		29-May-94			07-Feb-96
8	VMSM 0029	11-Jun-94	NC Maritime Museum	NCMM 1261	24-Oct-95
		13-Jul-94			31-Oct-95
		16-Jun-95			16-Mar-96
		05-Jul-96			17-Apr-96
		04-Aug-96			08-May-96
		21-Aug-96			
		27-Aug-96			
9	VMSM 0036	04-Jun-94	NC Maritime Museum	NCMM 1225	17-Jan-95
		12-Jun-94			11-Apr-95
		08-Aug-94			27-Apr-95
		09-Jun-95			22-Feb-96
		02-Jul-96			
		16-Jul-96			
		28-Jul-96			
10	VMSM 0031	22-Aug-94	NC Maritime Museum	NCMM 1502	22-Feb-96
		16-Sep-94			
		22-Sep-95			
11	VMSM 0002	18-Aug-92	NC Maritime Museum	NCMM 1308	16-Apr-95
		06-Jul-94			07-Feb-96
		13-Jul-94			10-Feb-96
		27-Jul-94			

	VMSM Photo-ID		Matches		
	Catalog #	Dates	Research Group	Catalog #	Dates
12	VMSM 0004	18-Jul-94 19-Jul-94 20-Jul-94	NC Maritime Museum	NCMM 1123	17-Jan-96 10-Feb-96 25-Feb-96
13	VMSM 0073	??-Aug-89 ??-Sep-89 28-Aug-90 17-May-92 15-Jul-92 18-Aug-92 25-Jun-93 20-Jul-93 01-Jul-95 28-Jul-96	NC Maritime Museum	NCMM 1517	25-Jan-96
14	VMSM 0034	08-Jul-92 05-Aug-92 27-Sep-92 24-Aug-93 21-Jun-94 30-Jun-94 12-Aug-94 08-Jun-95 16-Jun-95 25-Jul-95	NC Maritime Museum	NCMM 291Z	24-Nov-94
15	VMSM 0021	03-Aug-94 05-Aug-94 10-Aug-94	NC Maritime Museum	NCMM 155	30-Nov-94
16	VMSM 0192	??-Jun-89 ??-Aug-89 05-Aug-92 08-Aug-93 07-Jun-94	NC Maritime Museum	NCMM 636	24-Nov-92
17	VMSM 0242	09-Sep-92 27-Sep-92 24-Aug-93 03-Aug-94 28-Jul-96 17-Aug-96 19-Aug-96	NC Maritime Museum	NCMM 191	26-Jan-95 01-Aug-95

	VMSM Photo-ID		Matches		
	Catalog #	Dates	Research Group	Catalog #	Dates
18	VMSM 0011	09-Aug-93 14-Aug-94 19-Aug-94 08-Sep-94 24-Sep-94	NC Maritime Museum	NCMM 1111	22-Oct-94
19	VMSM 1996-1	22-Aug-96	NC Maritime Museum	NCMM 1120	14-Feb-87 01-Feb-94 07-Feb-96 22-Feb-96
20	VMSM 1996-2	28-Jul-96	NC Maritime Museum	NCMM 1531	25-Jan-96
21	VMSM 1996-3	16-Jul-96 24-Aug-96	NC Maritime Museum	NCMM 1402	27-Dec-95
22	VMSM 1996-4	21-Aug-96 14-Sep-96	NC Maritime Museum	NCMM 1288	27-Apr-95
23	VMSM 0445	15-Jul-92	NC Maritime Museum	NCMM 116	10-Apr-92
24	VMSM 0177	24-Aug-95	NC Maritime Museum	NCMM 842	25-Dec-95

1	VMSM 0053	6/93	Christpher Newport U.	Z251	6/94
2	VMSM 0018	6/93 5/94 6/94 7/94	Christpher Newport U.	Z218	5/94 6/94
3	VMSM 0025	8/94 9/94	Christpher Newport U.	Z088	5/93 5/94 6/94
4	VMSM 0244	8/94	Christpher Newport U.	Z250	6/94
5	VMSM 0155	8/94	Christpher Newport U.	Z216	5/94
6	VMSM 0056	8/93	Christpher Newport U.	Z049	7/92 9/92 7/93 6/94 8/94
7	VMSM 0072	8/92 5/93 5/95	Christpher Newport U.	Z057	9/92

	VMSM Photo-ID		Matches		
	Catalog #	Dates	Research Group	Catalog #	Dates
8	VMSM 0073	8/89 9/89 8/90 8/92 6/93 7/93 7/95	Christpher Newport U.	Z027	7/92 9/92
9	VMSM 0059	5/94 6/94 8/94 6/95	Christpher Newport U.	Z226	6/94
10	VMSM 0242	9/92 8/93 8/94	Christpher Newport U.	Z047	7/92 6/94
11	VMSM 0020	7/94 8/94 9/94 7/95	Christpher Newport U.	Z151	6/93
12	VMSM 0234	8/94	Christpher Newport U.	Z956	6/95

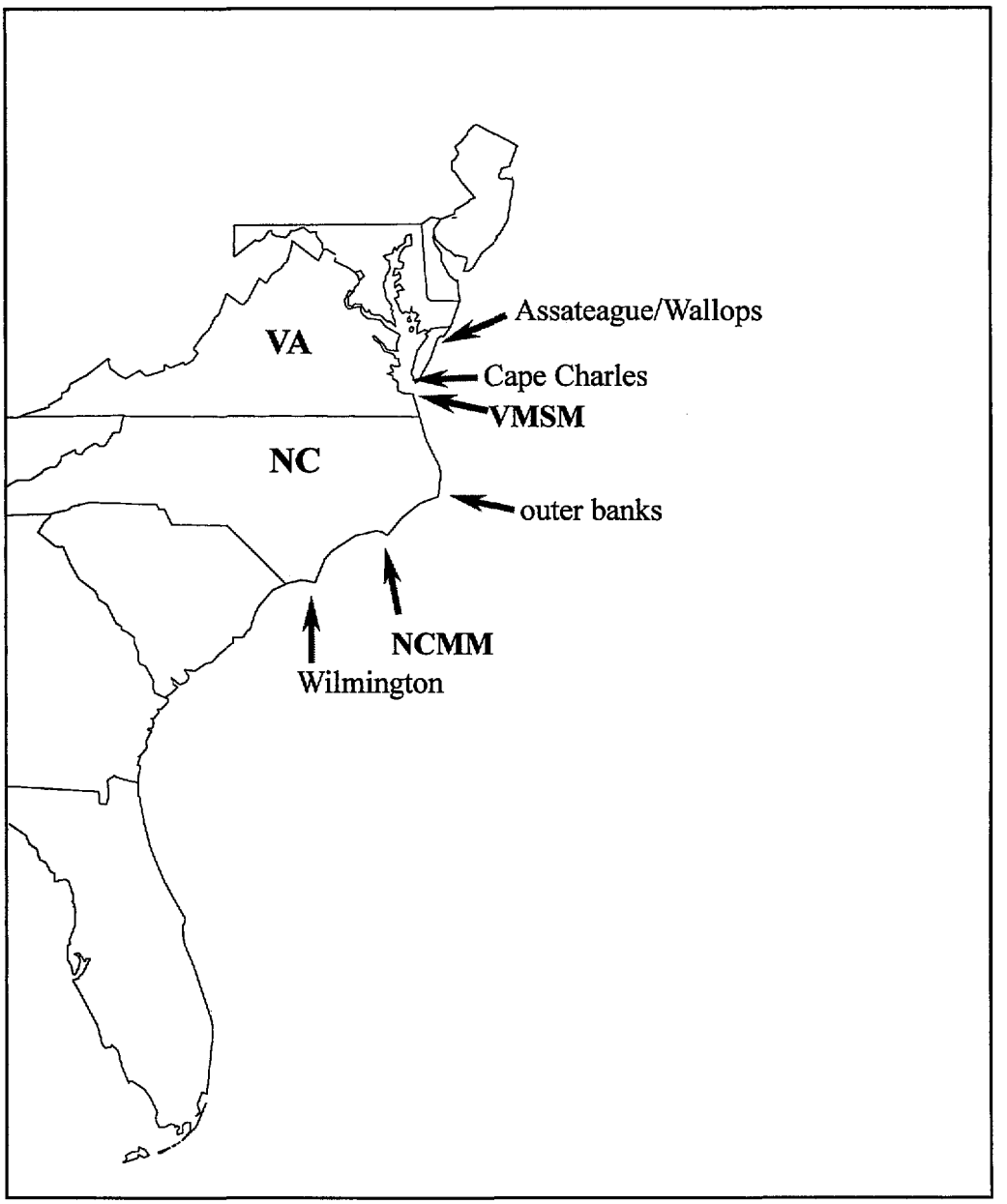


Figure 1: Mid-Atlantic and southeast US coast showing the study areas which were part of the project.

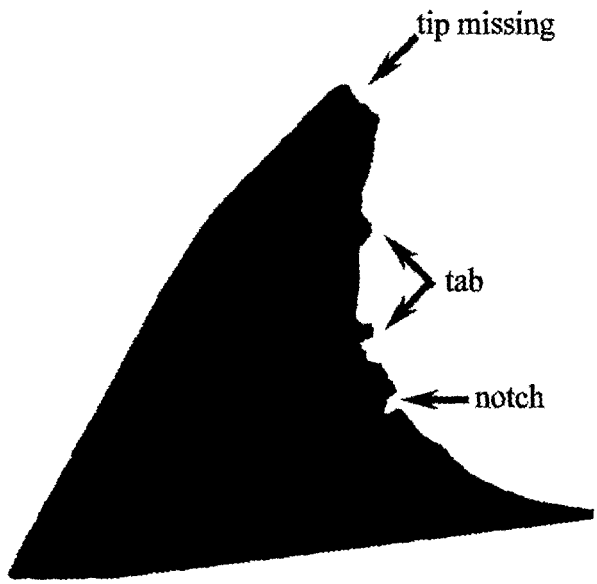


Figure 2: Example of an identifiable bottlenose dolphin dorsal fin. This indiviual has at least four distinctive features that make it identifiable.

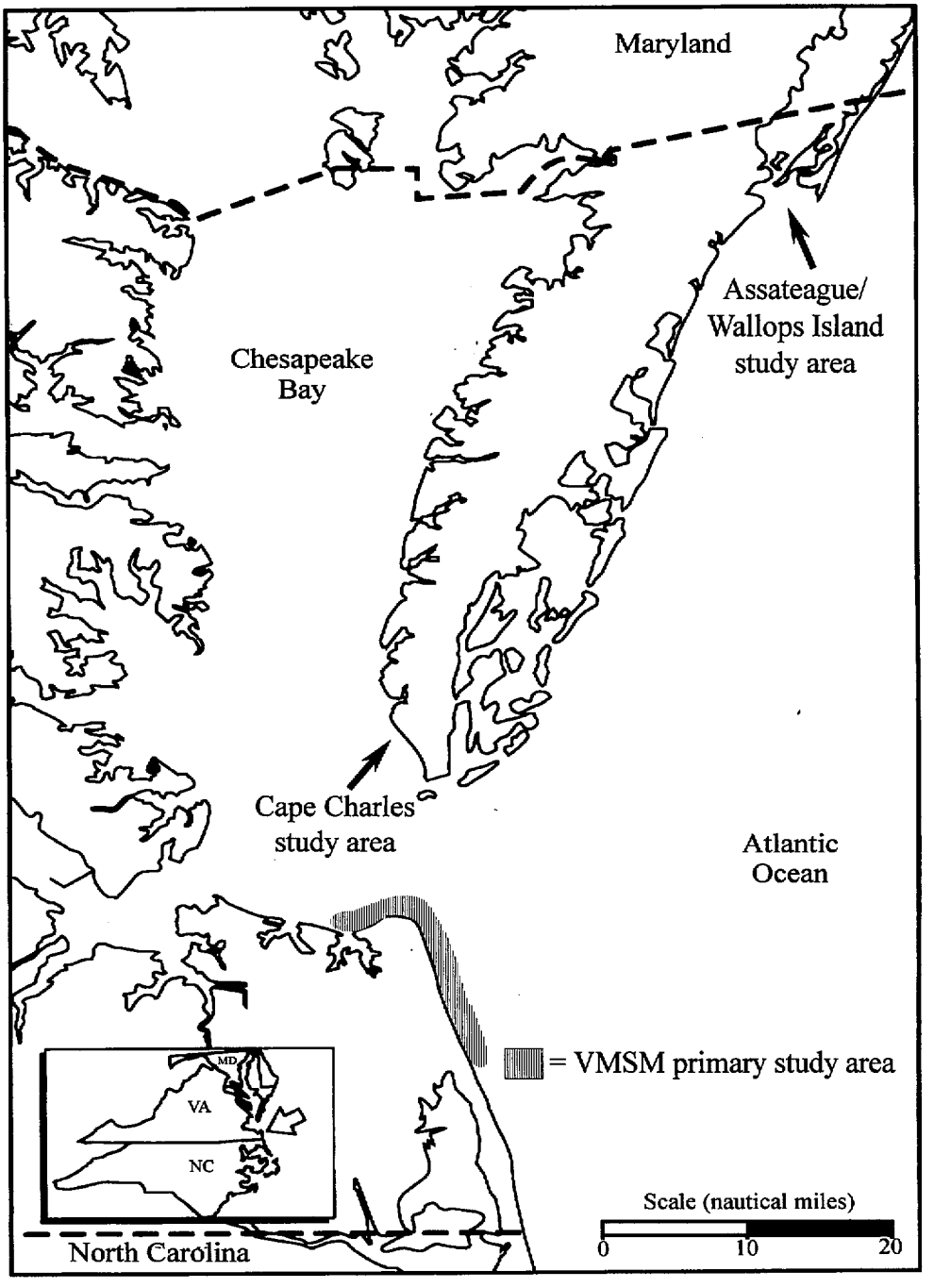


Figure 3: Virginia coastline showing VMSM primary photo-identification study area and location of Assateague/Wallops Island study area and Cape Charles research group study area.

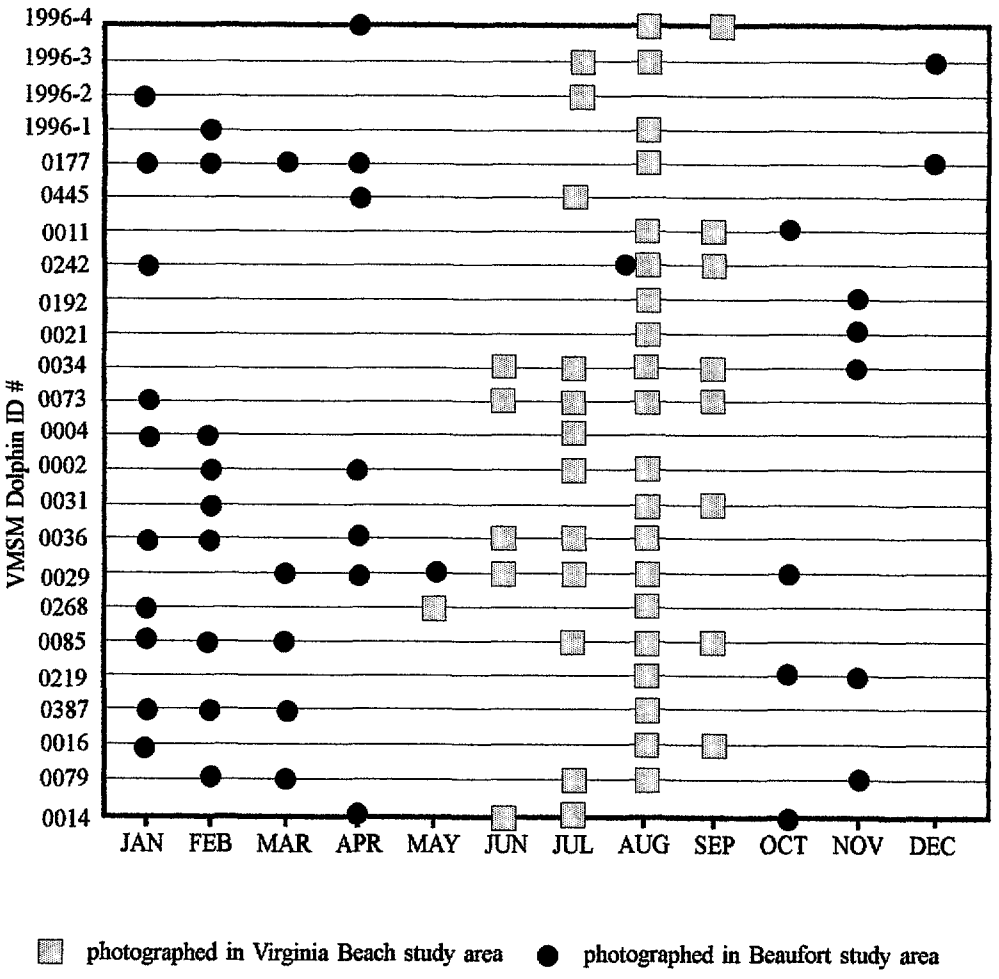


Figure 4: Seasonal representation of dolphin sightings between the Virginia Beach, VA and Beaufort, NC study areas. Each horizontal line represents the resight record of an individual dolphin. Circles represent sightings in Beaufort and squares represent sightings in Virginia Beach.

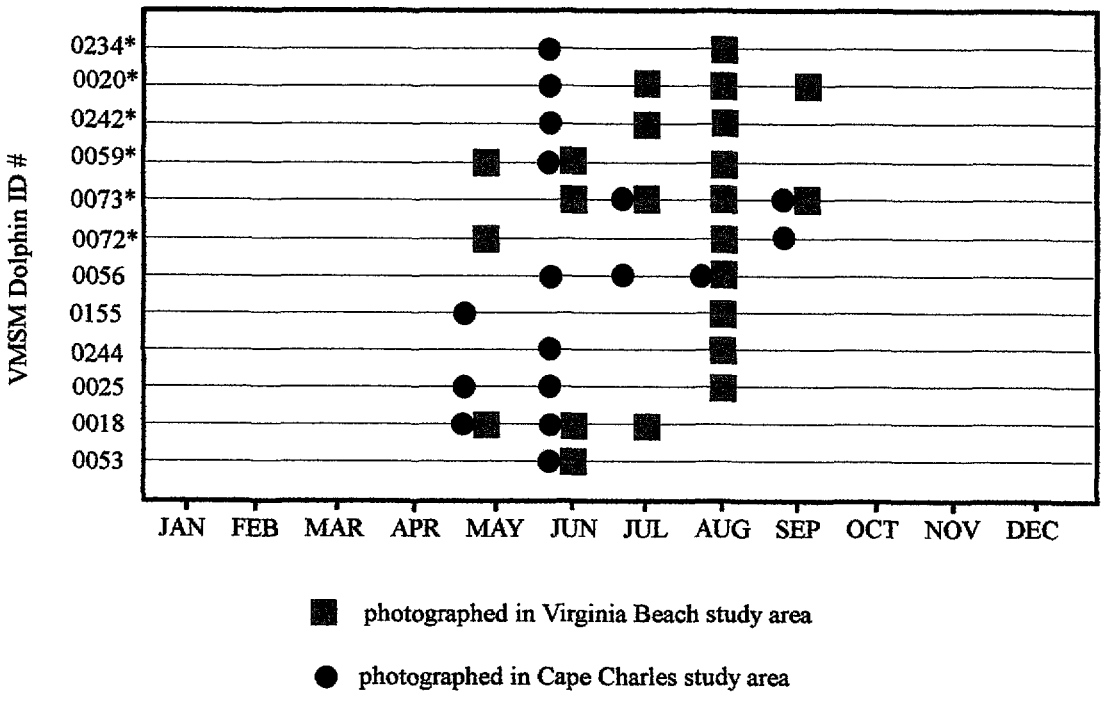


Figure 5: Seasonal representation of dolphin sightings between the Virginia Beach, VA and Cape Charles, VA research groups. Each horizontal line represents the resight record of an individual dolphin. Circles represent sightings collected by the Cape Charles group and squares represent sightings in Virginia Beach. The Cape Charles study area overlaps the Virginia Beach area. * indicates matches made in the overlapping area.

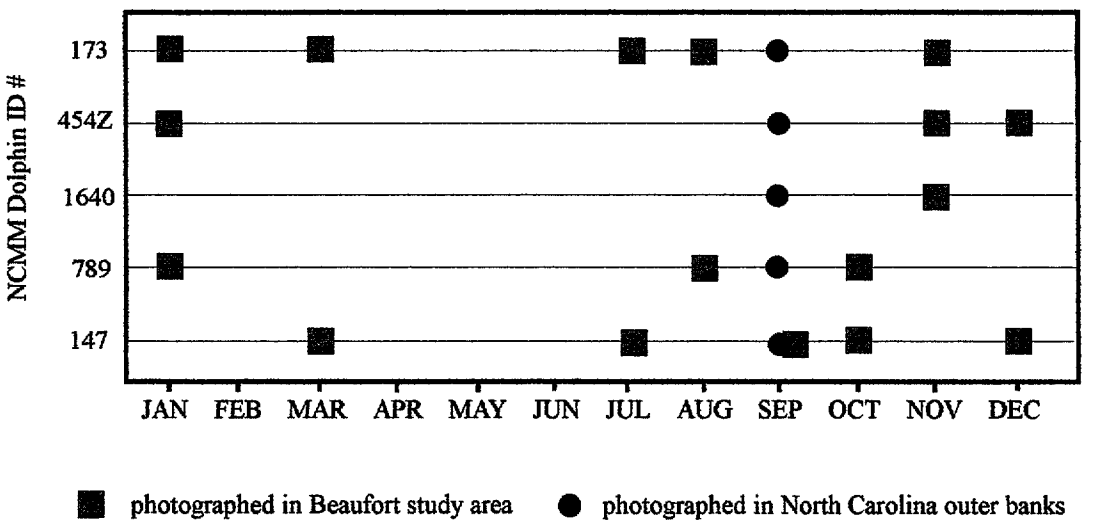


Figure 6: Seasonal representation of NCMM dolphin resight records for individuals identified in the outer banks. Each horizontal line represents the resight record of an individual dolphin. Circles represent sightings collected in the outer banks and squares represent sightings in Beaufort.

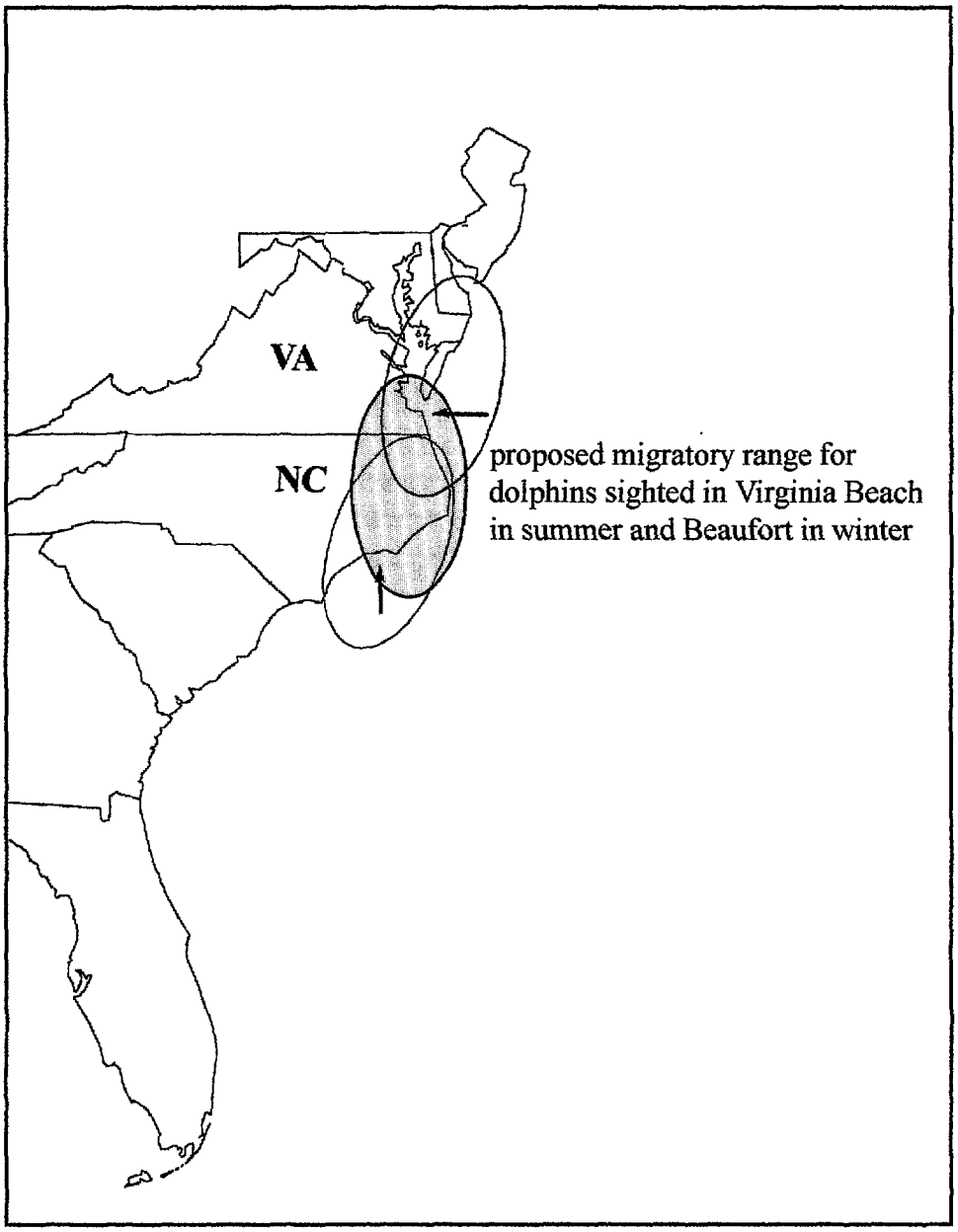
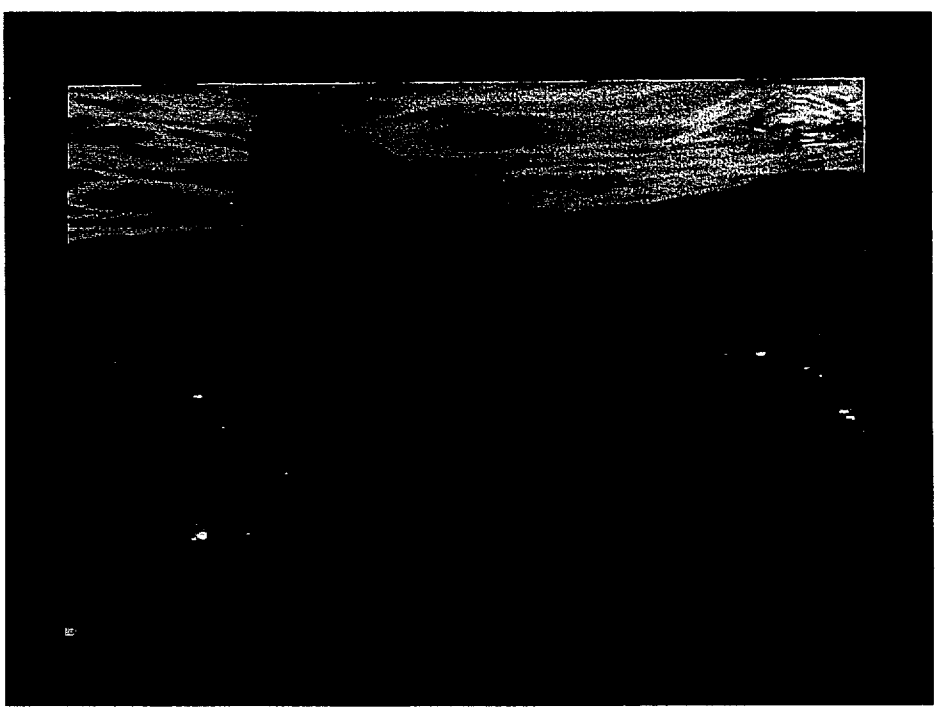


Figure 7: Potential overlapping migratory ranges for coastal migratory bottlenose dolphins. Arrows indicate the Virginia Beach (top) and Beaufort (bottom) study areas. Shaded oval represents the proposed migratory range for dolphins sighted in Virginia Beach in the summer and Beaufort in the winter.

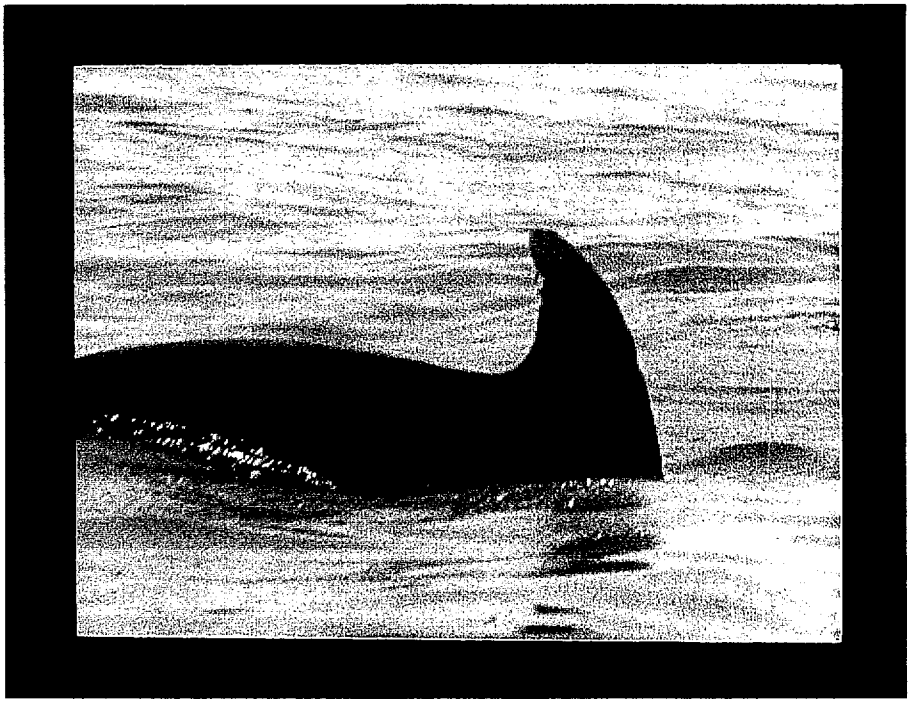
APPENDIX 1: Examples of VMSM/NCMM matches.

VMSM 0242

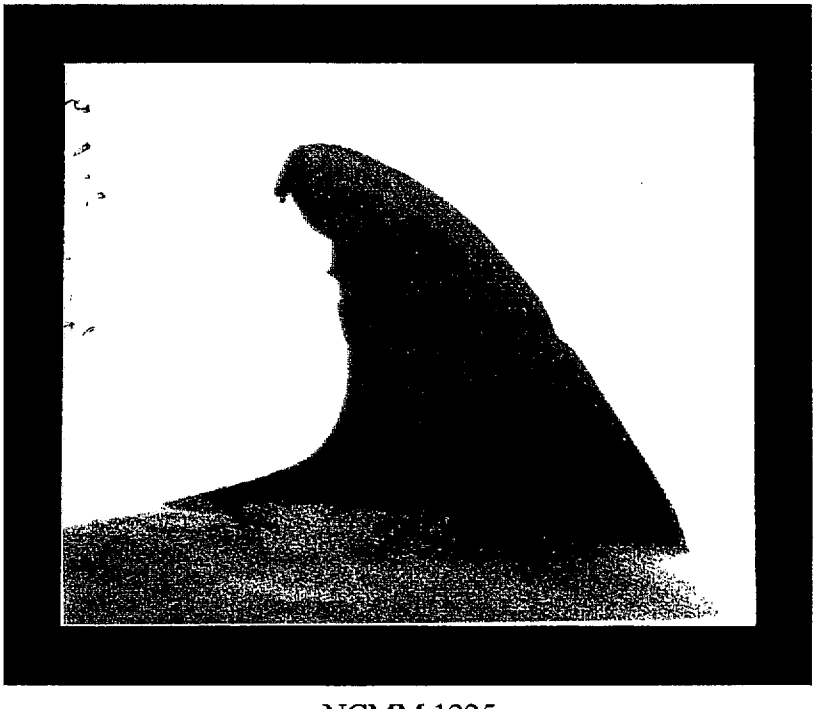


NCMM 191

APPENDIX 1 cont.: Examples of VMSM/NCMM matches.



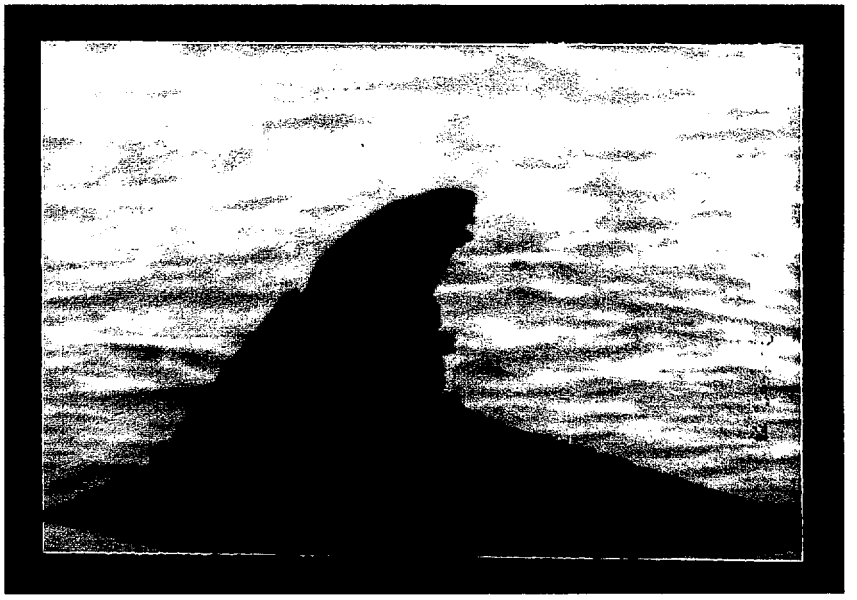
VMSM 0036



NCMM 1225

APPENDIX 1 cont.: Examples of VMSM/NCMM matches.

VMSM 0034



NCMM 291Z

(Note: The string-like material on the fin is a barnacle called *Xenobalanus*. It is not a distinctive fin feature.)

APPENDIX 2

Disk demonstraing the dolphin photo-id relational database developed through this grant. The database was created using Microsoft Visual Foxpro software by Justin Weaver. A customized version of the database and software were provided to the North Carolina Maritime Museum as a provision of the grant. A shareware version of the database is available to other research groups free of charge.