

Photo-Identification Analyses in the Cape Hatteras Study Area: 2021 Annual Progress Report

Submitted to:

Naval Facilities Engineering Systems Command Atlantic
under Contract No. N62470-20-D-0016, Task Order
21F4035 issued to HDR, Inc.



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May 2022

Suggested Citation:

Waples, D.M. and A.J. Read. 2022. *Photo-Identification Analyses in the Cape Hatteras Study Area: 2021 Annual Progress Report*. Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Systems Command Atlantic, Norfolk, Virginia, under Contract No. N62470-20-D-0016, Task Order 21F4035 issued to HDR, Inc., Virginia Beach, Virginia. May 2022.

Cover Photo Credit:

Group of Cuvier's beaked whales (*Ziphius cavirostris*). Photographed by Andrew Read, Duke University, taken under General Authorization Letter of Confirmation 19903 held by Duke University.

This project is funded by U.S. Fleet Forces Command and managed by Naval Facilities Engineering Systems Command Atlantic as part of the U.S. Navy's marine species monitoring program.

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Acronyms and Abbreviations

BRS	Behavioral Response Study
CEE	Controlled Exposure Experiment
photo-ID	photo-identification

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1. Cape Hatteras Photo-identification

In fieldwork supporting the Atlantic Behavioral Response Study (BRS) in 2021 ([Southall et al. 2022](#)), more than 18,000 digital images were collected in the Cape Hatteras study area. These images were used to confirm species, identify individual animals and conduct follow-up monitoring of satellite-tagged animals. Digital photographs were taken with Canon or Nikon digital SLR cameras (equipped with 100- to 400-millimeter zoom lenses) in 24-bit color at a resolution of 6016 × 4016 pixels and saved in .jpg format. Photographs were obtained from five species, with most taken of Cuvier's beaked whales (*Ziphius cavirostris*), the primary focal species of BRS field efforts (**Table 1**).

Each digital image was graded for photographic quality and animal distinctiveness. All images of sufficient quality and distinctiveness were then sorted by individual within a sighting and assigned temporary identifications. The best image for each individual in that sighting was then selected and these images were compiled into a folder for each sighting for later photo-identification (photo-ID); all of these images were cropped. Sighting data and photo-ID information were stored in an Access database managed by Kim Urian (Duke University Marine Lab).

Table 1. Cetacean sightings with the number of photo-ID images collected for each species in the Cape Hatteras study area in 2021.

Species	Common Name	Number of Sightings	Number of Photo-ID Images
<i>Globicephala macrorhynchus</i>	Short-finned pilot whale	21	676
<i>Physeter macrocephalus</i>	Sperm whale	6	391
<i>Stenella frontalis</i>	Atlantic spotted dolphin	1	61
<i>Tursiops truncatus</i>	Bottlenose dolphin	23	90
Unidentified dolphin	Unidentified dolphin	3	0
<i>Ziphius cavirostris</i>	Cuvier's beaked whale	127	17,241
Total		181	18,459

Images of 86 newly identified animals were added to photo-ID catalogs of short-finned pilot whales (*Globicephala macrorhynchus*), sperm whales (*Physeter macrocephalus*), Atlantic spotted dolphins (*Stenella frontalis*), bottlenose dolphins (*Tursiops truncatus*) and Cuvier's beaked whales. In addition, 21 new photo-ID matches were made within the short-finned pilot whale and Cuvier's beaked whale catalogs. To date, photo-ID catalogs for 11 species have been assembled in the Cape Hatteras study area, across multiple Atlantic Fleet Training and Testing monitoring projects, that include over 2,000 distinct individuals, with 582 individuals re-sighted across all species (**Table 2**).

Table 2. Summary of images collected during fieldwork in the Cape Hatteras study area in 2021, with number of new identifications (IDs), photo-ID catalog sizes, number of new re-sights, and total re-sights to date.

Species	New Images Collected	New IDs	Catalog Size	New Re-sights	Re-sights To Date
<i>Balaenoptera physalus</i>	0	0	1	0	0
<i>Delphinus delphis</i>	0	0	46	0	1
<i>Globicephala macrorhynchus</i>	676	28	1,339	6	469
<i>Grampus griseus</i>	0	0	46	0	6
<i>Kogia</i> sp.	0	0	1	0	0
<i>Megaptera novaeangliae</i>	0	0	2	0	0
<i>Physeter macrocephalus</i>	391	8	28	0	1
<i>Stenella clymene</i>	0	0	3	0	0
<i>Stenella frontalis</i>	61	1	25	0	0
<i>Tursiops truncatus</i>	90	11	360	0	19
<i>Ziphius cavirostris</i>	17,241	38	234	18	86
Total	18,459	86	2,085	24	582

1.1 Cuvier's Beaked Whales

Thirty-eight new identifications were added to the Cuvier's beaked whale photo-ID catalog during 2021. An additional 18 whales were re-sighted, with re-sightings occurring both within and between years. The current re-sighting rate for Cuvier's beaked whales in the Hatteras area is 36 percent, similar to the rate in 2020. To date, 56 of the 86 (65 percent) re-sighted Cuvier's beaked whales have been documented in multiple years, and 28 whales have been re-sighted more than three years after their initial sighting (**Tables 3 and 4**). This is a dramatic increase over last year's photo-ID results, when only nine whales had been sighted over more than three years.

Zca_003 was first seen in May of 2014; it was re-sighted four years later in August 2018 and re-sighted three years after that in July 2021 when it was satellite-tagged (ZcTag124; **Figure 1**). Based on photographs of its erupted teeth, we classify this animal as an adult male. With over seven years between its first and most recent sightings, this whale has the longest photo-ID history in the Hatteras area. Zca_006 was first observed in May 2014 when it was equipped with a DTag. It was re-sighted in June 2015 when it was satellite-tagged (ZcTag040) and photographed again in 2017, 2018, and most recently in August 2020 (**Figure 2**). This adult male has been sighted in more years than any other whale, with five sightings over a six-year period.

We tagged 16 Cuvier's beaked whales in 2021; four tagged individuals were matched to the photo-ID catalog. As mentioned above, ZcTag124 was photographed in 2014 and 2018 before being satellite-tagged in July 2021. ZcTag114 was first observed in May of 2018 and tagged in June 2021. ZcTag118 was photographed in 2017 and 2018 and satellite-tagged in July 2021. And ZcTag112 was first observed in August 2019 when it was satellite-tagged (ZcTag096); it was re-sighted without its original tag and satellite-tagged again in June 2021. To date four Cuvier's beaked whales in our study area have received multiple satellite tags (**Table 5**). In all cases the initial satellite tag and its hardware had been completely shed.

We have observed individual Cuvier's beaked whales associating in the same groups over days to weeks, but long-term social associations are rare. Previously, we had documented only one instance of a long-term association: Zca_024 and Zc_008r were satellite-tagged in the same group in May 2016 (ZcTag046 and ZcTag047, respectively) and were seen together again in June 2017. Zca_008r is an adult female and Zca_024 is an adult male. During this reporting period we identified a second long-term association. Two adult males, Zca_055 and Zca_056, were both tagged in the same group of 3 whales in August 2018 (ZcTag071 and ZcTag072 respectively). Neither was sighted again until they were photographed together in a group of six whales in August 2020. Both whales were encountered again later in August 2020, but in different groups.

We also compared all new Cuvier's beaked whale photo-ID images to a catalog created from images contributed by Kate Sutherland and Brian Patteson from their pelagic birding trips south of Cape Hatteras. We made two additional matches between our catalogs. M-002 was originally photographed by Kate Sutherland in May 2018 and we tagged this whale in September 2021 (ZcTag127; **Figure 3**). M-003 was photographed by Kate Sutherland in May 2004 and we tagged it 15 years later in July 2019 (ZcTag090). We believe that this is the longest term re-sighting record of a Cuvier's beaked

whale in the Northwest Atlantic. We will continue to compare our two catalogs to determine how frequently the Cuvier's beaked whales we observe move south around Cape Hatteras.

We are continuing to use our photographic histories of individual whales to learn more about the demographics of Cuvier's beaked whales in the Hatteras study area. Zca_065, an adult female, was first seen in August 2018 without a calf. She was re-sighted in August 2019 with a calf. The calf is distinctive (**Figure 4**) so we are hoping to follow this calf to gain insight into the age at which calves separate from their mothers and calving intervals of adult females. We are also planning to use our images of re-sighted individuals to look at scar acquisition rates in Cuvier's beaked whales. Some whales, such as Zca_096r, show very few changes in the number of scars over time (**Figure 5**). This whale is either an adult female or a sub-adult, because it has no erupted teeth. Other whales, such as Zca_035, an adult male, accumulate many new scars between re-sightings (**Figure 6**). Zca_035 was first sighted in June of 2017 and it was satellite-tagged in August 2018 (ZcTag076). It was re-sighted in August 2021 with many new scars; based on photographs of erupted teeth this whale was already an adult male at the time of tagging in 2018. We plan to document the rate of scar acquisition in re-sighted Cuvier's beaked whales to determine whether there are differences in how the two sexes acquire scars.

We are continuing to collect biopsy samples from Cuvier's beaked whales off Cape Hatteras to assign sex to animals who lack erupted teeth or extensive scarring—the two distinctive characteristics of adult males. Analysis of these samples will also provide important information on genetic relationships amongst individuals, effective population size, and biochemical markers of diet and stress. In 2021, we collected 21 samples from Cuvier's beaked whales in the BRS study area, including two tagged animals. This brings the total number of biopsy samples of this species off Cape Hatteras to 38. Sub-samples of skin from four Cuvier's beaked whales were also provided to Dr. Jason Somarelli of the Duke Cancer Institute to grow cell lines of this species for future research projects.

Our sighting histories of individual whales will also be contributed to a meta-analysis of Cuvier's beaked whale demography funded by the Office of Naval Research and coordinated by Erin Falcone and Greg Schorr. The goal of this collaborative project is to compare vital rates of Cuvier's beaked whales across populations which experience varying exposure to military sonar. Pigmentation and scarring-density metrics will be applied uniformly to images from each population in a uniform manner, allowing us to classify individual whales to age classes (calf, adult or juvenile) and, in some cases, sex. Estimation of vital rates for each population will require age- and sex-linked life-history data from a large sample of individual animals. It is important to have adequate samples of photo-ID data from each region; the Hatteras photo-ID catalog is one of the largest in this dataset and will be an important contribution to this comparative analysis.

Table 3. Photo-ID matches by year of Cuvier's beaked whales re-sighted over multiple years in the Cape Hatteras study area, 2004–2021.

ID ¹	Year									
	2004	2013	2014	2015	2016	2017	2018	2019	2020	2021
Zca_001r		X		X						
Zca_002 (ZcTag074)		X					X ^m	X ^m		
Zc_003 (ZcTag124)			X				X			X ^y
Zca_003r (ZcTag029)			X ^m				X			
Zca_005			X	X		X				
Zca_006 (ZcTag040)			X	X		X	X		X	
Zca_008r (ZcTag047)			X ^y		X ^m	X ^y	X ^y			
Zca_015 (ZcTag039, ZcTag077)				X			X			
Zca_016			X	X				X		
Zca_019 (ZcTag043)			X	X						
Zca_020				X				X		
Zca_023r				X				X ^y		
Zca_024 (ZcTag046, ZcTag103)					X	X			X ^m	
Zca_027r				X			X			
Zca_028 (ZcTag051)					X					X ^m
Zca_029 (ZcTag054)						X ^y				X
Zca_030 (ZcTag055)						X ^y		X ^m	X	
Zca_031 (ZcTag056)						X		X	X ^y	X ^y
Zca_032						X	X ^m			
Zca_035 (ZcTag076)						X	X ^y			X
Zca_035r (ZcTag048)					X		X			
Zca_038						X	X			X
Zca_040						X ^y		X		
Zca_044r					X		X ^m			
Zca_048						X		X ^m		
Zca_049 (ZcTag114)							X			X ^y
Zca_050 (ZcTag078)							X ^y			X
Zca_050r (ZcTag057)						X	X			
Zca_051r (ZcTag058)						X ^y	X ^m			
Zca_052 (ZcTag084)							X	X ^m	X ^m	
Zca_054r						X ^y		X	X ^y	
Zca_055 (ZcTag071)							X		X	
Zca_056 (ZcTag072)							X		X	X
Zca_058							X	X		
Zca_059r						X	X ^y			

ID ¹	Year									
	2004	2013	2014	2015	2016	2017	2018	2019	2020	2021
Zca_061							X	X		
Zca_063							X ^m		X ^y	
Zca_065							X	X		
Zca_067r (ZcTag060)						X				X
Zca_068r						X				X
Zca_071r (ZcTag081)						X	X ^m			
Zca_074r						X	X			X ^y
Zca_077r (ZcTag085)							X	X ^y		
Zca_078 (ZcTag089, ZcTag109)								X	X	
Zca_082r							X	X		
Zca_083								X	X	
Zca_091								X ^m	X	
Zca_092								X ^m		X
Zca_096r							X ^m			X
Zca_099r (ZcTag083)							X ^m	X		
Zca_108r (ZcTag106)							X		X ^y	X
UNCW M-002			X	X						
UNCW M-004		X				X				
S/P M-001 (ZcTag102)							X		X	
S/P M-002 (ZcTag127)							X			X
S/P M-003 (ZcTag090)	X							X		

¹ Zca=*Ziphius cavirostris* (Cuvier's beaked whale); UNCW M=aerial-vessel match to University of North Carolina at Wilmington catalog; Sutherland M= matches made to the Sutherland/Patteson catalog from seabirding trips south of Cape Point

r – Cuvier's beaked whales that are identified by scarring patterns (rake marks)

m – re-sighted within same month

y – re-sighted within same year

Table 4. Frequency distribution of the number of years between first and last sightings of photo-identified Cuvier's beaked whales in the Cape Hatteras study area.

Number of Years Between First and Last Sighting	Number of Individuals
Less than 1	30
1 to 2	19
2 to 3	9
3 to 4	12
4 to 5	11
5 to 6	2
6 to 7	1
7 to 8	1
More than 8	1
Total	86

Table 5. Satellite tag IDs and tagging dates for Cuvier's beaked whales that have been satellite-tagged multiple times in the Cape Hatteras study area.

Photo-ID Code	Initial Tag ID	Initial Tagging Date	Subsequent Tag ID	Subsequent Tagging Date
Zca_015	ZcTag039	June 2015	ZcTag077	August 2018
Zca_024	ZcTag046	May 2016	ZcTag103	August 2020
Zca_078	ZcTag089	June 2019	ZcTag109	August 2020
Zca_092	ZcTag096	August 2019	ZcTag112	June 2021



Figure 1. Photographs of Zc_003 initially sighted in May 2014 (top) and re-sighted and satellite-tagged in August 2021 (ZcTag124; bottom).



Figure 2. Photographs of Zca_006 during DTagging in 2014 (top), during satellite-tagging in 2015 (middle) and during re-sight in 2020 (bottom).



Figure 3. Photographs of M-002 seen south of Cape Point in May 2018 (top) and north of Cape Point where it was satellite-tagged in September 2021 (bottom).



Figure 4. Photograph of Zca_148r, the calf of Zca_065 (top) and a close-up view to show its distinctive markings (bottom).



Figure 5. Photograph of Zca_096r initially seen in August 2018 (top) and re-sighted in September 2021 (bottom) with little to no change in its scarring patterns between the years.



Figure 6. Photograph of Zca_035 in August 2018 (top) and re-sighted in August 2021 (bottom) with multiple changes in its scarring patterns between the years.

1.2 Short-finned Pilot Whales

Totals of 28 new identifications and 6 new re-sightings were added to the short-finned pilot whale catalog in 2021. The current re-sighting rate of this species is 35 percent, comparable to the rate documented in 2020. More than 200 short-finned pilot whales have been seen on three or more occasions, and 14 animals have been re-sighted more than six times (**Table 6**). More than 100 short-finned pilot whales have been biopsied in our study area between 2006 and 2021 and 95 of those have been genetically sexed, with 69 males and 26 females biopsied to date.

Short-finned pilot whales continue to return to the Cape Hatteras study area over extended periods. More than 110 pilot whales have spans of at least five years between their first and last sightings, and 20 pilot whales have records that span a decade or more (**Table 7**). Three of those 20 short-finned pilot whales were satellite-tagged and three were biopsied (one male, two females). These long-term photo-ID records demonstrate that both male and female short-finned pilot whales exhibit strong, but intermittent, site fidelity to the Cape Hatteras area.

We have photographed many individual short-finned pilot whales in association over long periods. Gma_8-075 and Gma_9-094 were first photographed in the same group in May 2007 and were later seen together in December 2015. Four pilot whales (Gma_1-023, Gma_1-030, Gma_7-016, and Gma_7-112) were observed together in May of 2008 and again in May of 2015. Another two pilot whales (Gma_9-010 and Gma_9-118) were photographed in the same group four times between 2007 and 2014. Gma_242du and Gma_6-116 (GmTag134 and GmTag135) were photographed in May 2015 with five other distinct pilot whales, and all seven were seen in the same group in August of 2018. We will continue to explore short-finned pilot whale social structure in the coming year.

The 28 newly identified short-finned pilot whales added to the Hatteras photo-id catalog were systematically compared to catalogs for this species from Onslow Bay, North Carolina and Jacksonville, Florida, but no new matches were made between the study areas. We have previously matched four pilot whales between the Hatteras and Onslow Bay study areas. Gma_8-165 was seen in Onslow Bay, North Carolina, in a group of 40 short-finned pilot whales in August 2007 and re-sighted and satellite-tagged (GmTag209) in the Cape Hatteras area 11 years later in August 2018. Three other short-finned pilot whales were also photographed with Gma_8-165 in both of these sightings. These four photo-ID matches are the only short-finned pilot whale matches documented between the Cape Hatteras and Onslow Bay catalogs. To date we have not made any matches between the Hatteras and Jacksonville catalogs.

Table 6. Frequency distribution of the number of sightings of photo-identified short-finned pilot whales in the Cape Hatteras study area.

Number of Sightings	Number of Individuals
1	870
2	266
3	98
4	59
5	24
6	8
7	8
8	4
9	1
10	0
11	1
Total	1,339

Table 7. Frequency distribution of the number of years between first and last sightings of photo-identified short-finned pilot whales in the Cape Hatteras study area.

Number of Years Between First and Last Sighting	Number of Individuals
Less than 1	134
1 to 2	49
2 to 3	46
3 to 4	57
4 to 5	71
5 to 6	17
6 to 7	21
7 to 8	40
8 to 9	13
9 to 10	1
10 to 11	13
11 to 12	7
Total	469

Jessica Aschettino provided images of short-finned pilot whales collected by HDR researchers during their offshore field work in the vicinity of Norfolk Canyon from 2020 and 2021 ([Engelhaupt et al., 2021, 2022](#)) (**Table 8**). We graded approximately 2,000 images for photographic quality and animal distinctiveness and all images of sufficient quality and distinctiveness were then sorted by individual within each sighting. The best image for each individual was then compared to the existing Norfolk photo-ID catalog.

We added a total of 50 new individuals to the Norfolk short-finned pilot whale catalog and three pilot whales were re-sighted during 2020–2021 (**Table 9**). Gma_7-016 and Gma_7-017 were initially sighted in the same group in August of 2015 and were re-sighted in the same group in September 2020. Gma_9-022 was first photographed in October 2016 and it was re-sighted in June 2021. These five-year re-sights are the longest for short-finned pilot whales in the Norfolk Canyon area. Ten short-finned pilot whales have been re-sighted by HDR researchers during their field work from 2015 through 2021 (**Table 10**).

We compared short-finned pilot whales in the Norfolk catalog to the Hatteras short-finned pilot whale catalog, which contains 1,339 individuals. Three new matches were made between the two areas, adding to the 40 previous matches; one animal that had been previously matched between the two areas was re-sighted in Norfolk again in 2021 (**Table 11**). Thus, 15 percent (43 of 280) of pilot whales observed in the Norfolk Canyon region have also been photographed in the Cape Hatteras area. Comparing the two catalogs provides additional long-term re-sighting information; 13 of the pilot whales were seen in Hatteras from 2007 to 2009, but not observed again until they were photographed in the Norfolk Canyon area.

The cross-catalog comparisons also provide interesting information on patterns of social associations. For example, M-015 and M-016 were first seen in Hatteras in June 2015, then were re-sighted together in Norfolk in June 2016 and finally were sighted a third time together in Hatteras in October 2017. M-001, M-002 and M-003 were in the same group in Hatteras in June 2014 and re-sighted together in Norfolk Canyon in October 2015. And M-026 and M-046 (matches made during this reporting period) were seen together in October 2013 off Hatteras and re-sighted in the same group in June 2021 off Norfolk. These long-term associations confirm the strong social bonds in this strongly matrifocal species.

Table 8. Number of sightings of short-finned pilot whales and number of images collected by year in the Norfolk Canyon area.

Year	Number of Sightings	Number of Photo-ID Images
2020	10	882
2021	11	1,127
Total	21	2,009

Table 9. Catalog sizes for short-finned pilot whales in the Norfolk Canyon area, including the original 2015–2019 catalog and individuals added during recent photo-ID efforts.

Species	2015–2019 Catalog	New IDs (2020–2021)	Current Catalog Size	New Re-sights	Total Re-sights
<i>Globicephala macrorhynchus</i>	230	50	280	3	10

Table 10. Photo-ID re-sighting histories of short-finned pilot whales off Norfolk, Virginia.

ID	Year						
	2015	2016	2017	2018	2019	2020	2021
Gma_1-008		X	X				
Gma_6-010	X	X					
Gma_7-013	X	X					
Gma_7-016	X					X	
Gma_7-017	X					X	
Gma_7-020	X				X		
Gma_7-039	X	X					
Gma_7-041		X	X				
Gma_7-054		X	X				
Gma_9-022		X					X

Table 11. Photo-ID matches by year of individual short-finned pilot whales, 2007–2021, between the Cape Hatteras study area (HAT) and the Norfolk Canyon study area (NOR).

ID ¹	Year														
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
M-001 GmTag089								HAT	NOR						
M-002								HAT	NOR						
M-003								HAT	NOR						
M-004		HAT							NOR						
M-005		HAT							NOR						
M-006	HAT	HAT ^m							NOR						
M-007 GmTag091								HAT	NOR						
M-008								HAT	NOR						
M-009	HAT								NOR						
M-010							HAT		NOR						
M-012 GmTag177										NOR	HAT				
M-013									HAT	NOR					
M-014									HAT	NOR					
M-015									HAT	NOR	HAT				
M-016									HAT	NOR	HAT				
M-017						HAT				NOR					
M-018	HAT								NOR						
M-019									HAT	NOR					
M-020								HAT		NOR					
M-021	HAT ^m		HAT							NOR					
M-023									HAT	NOR					
M-024									HAT	NOR					
M-025 GmTag223	HAT ^y		HAT							NOR			HAT ^m		
M-026							HAT			NOR					NOR
M-028									HAT		NOR				
M-029									HAT		NOR				
M-030									HAT		NOR				
M-031							HAT				NOR				
M-032						HAT							NOR		
M-033	HAT												NOR		
M-034 GmTag158										HAT	NOR				
M-035									HAT		NOR				
M-036		HAT			HAT						NOR				
M-037		HAT									NOR				

ID ¹	Year														
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
M-038	HAT	HAT									NOR				
M-039	HAT	HAT									NOR				
M-040		HAT						HAT	HAT ^m		NOR				
M-041 GmTag096		HAT		HAT		HAT ^y		HAT			NOR	HAT ^y			
M-042	HAT ^m												NOR		
M-043				HAT		HAT ^m	HAT				NOR				
M-044												HAT		NOR	
M-045												HAT		NOR	
M-046							HAT								NOR

m – re-sighted within same month

y – re-sighted within same year

Dr. Jeremy Kiszka of Florida International University contributed two catalogs of short-finned pilot whale photos collected from researchers and volunteers working around Martinique and Guadeloupe Islands in the Caribbean between 2010 and 2020 (**Figure 7**). We compared both Caribbean catalogs to our short-finned pilot whale catalog from Jacksonville, Florida, which contains 52 individuals (**Table 12**). We identified one potential match between the two sites but we cannot confirm the match due to poor photographic quality of the image from Guadeloupe. We compared both Caribbean catalogs to our short-finned pilot whale catalog from Onslow Bay, North Carolina, which contains 24 whales (**Table 12**) but found no matches.

We are in the process of comparing both of the Caribbean catalogs to a catalog of short-finned pilot whales that we created from images taken during research cruises conducted by National Oceanic and Atmospheric Administration scientists in the Gulf of Mexico and contributed by Keith Mullin of the Southeast Fisheries Science Center. One potential match has been made so far and images were circulated to Jeremy Kiszka, Andrew Read and Kim Urian but all agreed that the Caribbean image was not of sufficient photographic quality to confirm the match. In the coming year we plan to finish comparisons between the Caribbean and Gulf of Mexico photo-ID catalogs and then compare the Caribbean catalogs to the catalogs of short-finned pilot whales off Hatteras, North Carolina and off Norfolk, Virginia.

Linkages between pilot whales in the Caribbean and those inside the U.S. Exclusive Economic Zone are potentially important, because short-finned pilot whales are still harvested in St. Vincent and elsewhere in the Caribbean.

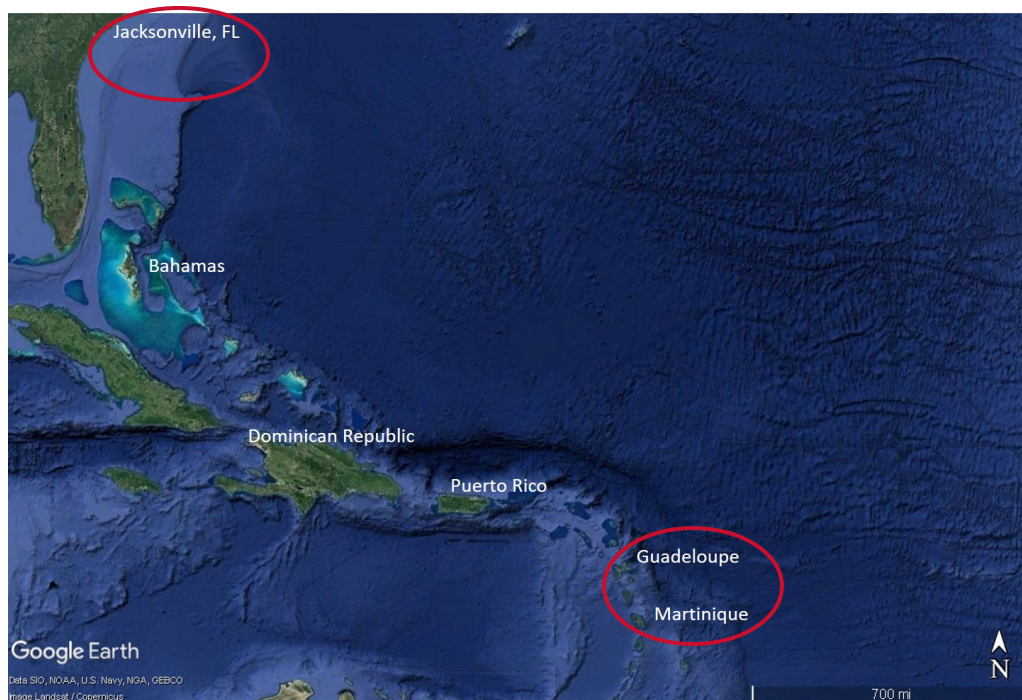


Figure 7. Locations of Guadeloupe and Martinique relative to the Jacksonville, Florida field site.

Table 12. Number of images in each short-finned pilot catalog and years when the images were collected.

Catalog Location	Years Images Collected	Number of Individuals
Guadeloupe, Caribbean	2010–2020	210
Martinique, Caribbean	2013–2016	130
Jacksonville, Florida	2009–2018	52
Onslow Bay, North Carolina	2007–2013	24
Gulf of Mexico	2003–2007	180
Hatteras, North Carolina	2006–2021	1,339
Norfolk, Virginia	2015–2021	280

1.3 Satellite Tag Post-deployment Monitoring

Follow-up monitoring of the health of satellite-tagged animals continues to be an important focus of our photo-ID efforts. We have deployed 88 satellite tags on 84 Cuvier's beaked whales between 2014 and 2021 and resighted 56 of these animals (66 percent). Many re-sightings occurred within the same field season, but 26 of the tagged whales (46 percent) were re-sighted at least a year after tagging (**Table 13**).

ZcTag054 was satellite-tagged in May 2017. It was re-sighted once during that field season but was not seen again until August 2021. Photographs show that the tag has been shed, leaving well-healed scars (**Figure 8**). ZcTag096 was satellite-tagged in August 2019 and re-sighted several times that month. It was re-sighted in June 2021, without its initial tag and with well-healed scars, and satellite-tagged for a second time (**Figure 9**).

Similar to our findings with pilot whales ([Waples and Read 2021](#)), some Cuvier's beaked whales show more noticeable effects of satellite-tagging. ZcTag110 was satellite-tagged in August 2020 and re-sighted a year later in August 2021. At that time the satellite tag had been shed but there was hardware remaining in the dorsal fin (**Figure 10**). ZcTag111 was tagged in July 2020 and re-sighted in August 2021; it had some swelling around the tag location but all hardware had been shed and the dorsal fin appeared to be well healed (**Figure 11**).

To date, we have deployed 80 satellite tags on 79 short-finned pilot whales off Cape Hatteras and resighted 31 of these animals (39 percent). Most of these re-sightings occurred within the same field season, but 11 (35 percent) have been re-sighted across multiple years. A single short-finned pilot whale has been satellite-tagged multiple times. GmTag198 was first seen in the Hatteras area in 2011 and it was observed and satellite-tagged in 2018 and seen twice more that field season. It was seen in July 2019 and was satellite-tagged again (GmTag227).

We also made another resighting of a satellite-tagged short-finned pilot whale. GmTag176 was tagged in May 2017 and re-sighted in October 2020. The tag and all hardware had been shed leaving only two well-healed scars at the tag location (**Figure 12**). Images were provided to Joe Day, a student from Savannah State University, who completed a research project documenting the long-term fate of satellite tags deployed on short-finned pilot whales ([Waples and Read 2021](#)). Joe presented his findings at the annual meeting of the Association for the Sciences of Limnology and Oceanography in 2021.

Table 13. Photo-ID re-sighting histories of cetaceans satellite-tagged in the Cape Hatteras study area. A red X denotes the year when satellite tagging occurred for that individual.

ID	Year							
	2014	2015	2016	2017	2018	2019	2020	2021
GgTag017			X ^m					
GmTag087	X ^y							
GmTag089	X	X						
GmTag091	X	X						
GmTag096	X			X	X			
GmTag097	X	X						
GmTag122		X ^m						
GmTag127		X ^m						
GmTag134 [^]		X			X			
GmTag135 [^]		X ^y			X	X		
GmTag136		X ^y			X			
GmTag140		X		X				
GmTag157			X	X				
GmTag172				X ^m				
GmTag175				X ^m				
GmTag176		X					X	
GmTag179				X	X			
GmTag182				X ^m				
GmTag197					X ^y			
GmTag198 (GmTag227)					X ^y	X		
GmTag199					X ^m			
GmTag201					X ^y			
GmTag203					X ^y			
GmTag204					X ^y			
GmTag205					X ^y			
GmTag206					X ^y			
GmTag207					X ^m			
GmTag208					X ^m			
GmTag216					X ^m			
GmTag218					X ^m			
GmTag223						X ^m		
GmTag226						X ^y		
TtTag015	X ^m							

ID	Year							
	2014	2015	2016	2017	2018	2019	2020	2021
ZcTag029	X ^m				X			
ZcTag039 (ZcTag077)		X			X			
ZcTag040		X		X	X		X	
ZcTag046 (ZcTag103)			X	X			X ^m	
ZcTag047			X ^y	X ^y	X ^y			
ZcTag048			X		X			
ZcTag051			X					X ^m
ZcTag054				X ^y				X
ZcTag055				X ^y		X ^m	X	
ZcTag056				X		X	X	X ^y
ZcTag057				X	X			
ZcTag058				X ^y	X ^m			
ZcTag062				X ^m				
ZcTag069					X ^y			
ZcTag071					X		X ^m	
ZcTag072					X		X ^m	
ZcTag073					X ^y			
ZcTag074					X ^m	X		
ZcTag075					X ^m			
ZcTag076					X ^m			X
ZcTag078					X ^m			X
ZcTag080					X ^m			
ZcTag081					X ^m			
ZcTag082						X ^y		
ZcTag084						X ^m	X ^m	
ZcTag085						X ^y		
ZcTag086						X ^y		
ZcTag088						X ^m		
ZcTag089 (ZcTag109)						X ^m	X	
ZcTag090						X ^y		
ZcTag091						X ^m		
ZcTag092						X ^y		
ZcTag093						X ^y		

ID	Year							
	2014	2015	2016	2017	2018	2019	2020	2021
ZcTag095						X ^m	X	
ZcTag096 (ZcTag112)						X ^m		X ^y
ZcTag097						X ^m		
ZcTag098							X ^y	
ZcTag099							X	
ZcTag101							X ^m	X
ZcTag102							X ^m	X ^m
ZcTag104							X ^m	X
ZcTag105							X ^m	
ZcTag106							X ^m	X
ZcTag107							X ^m	
ZcTag108							X ^m	
ZcTag110							X ^m	X
ZcTag111							X	X
ZcTag114								X ^y
ZcTag116								X
ZcTag117								X
ZcTag120								X ^y
ZcTag121								X ^y
ZcTag123								X ^y
ZcTag124								X ^y
ZcTag125								X
ZcTag126								X

¹ Ggr= *Grampus griseus* (Risso's dolphin); Gma= *Globicephala macrorhynchus* (short-finned pilot whale);
Ttr= *Tursiops truncatus* (bottlenose dolphin); Zca= *Ziphius cavirostris* (Cuvier's beaked whale)

m – re-sighted within same month

y – re-sighted within same year



Figure 8. Photographs of ZcTag054 during satellite-tagging in May 2017 (top) and re-sight in August 2021 (bottom).



Figure 9. Photographs of ZcTag096 during satellite-tagging in August 2019 (top), at re-sight in June 2021 (middle) and during a second satellite-tagging in June 2021 (bottom).



Figure 10. Photographs of ZcTag110 during satellite-tagging in August 2020 (top) and re-sight in August 2021 (bottom).



Figure 11. Photographs of ZcTag111 during satellite-tagging in August 2020 (top) and re-sight in July 2021 (bottom).



Figure 12. Photographs of GmTag176 during satellite-tagging in May 2017 (top) and re-sight in October 2020 (bottom).

2. Acknowledgments

We thank U.S. Fleet Forces Command and Joel Bell (Naval Facilities Engineering Systems Command Atlantic) for their continued support and guidance. We are indebted to Heather Foley and Zach Swaim and also thank Will Cioffi, Anne Harshbarger, Doug Nowacek, Nicola Quick and Brandon Southall for assistance in the field. Thanks to Kim Urian for database management and for providing summary data for this report and to Ziya Zhou for assistance with short-finned pilot whale photo-ID. Thanks to Jeremy Kiszka and colleagues at Observatoire des Mammifères Marins de l'Archipel de Guadeloupe (OMMAG) for contributing images of short-finned pilot whales in the Caribbean and to Keith Mullin for providing images of short-finned pilot whales collected during National Oceanic and Atmospheric Administration cruises in the Gulf of Mexico. Thanks also to Jessica Aschettino for contributing pilot whale images collected by HDR researchers off Norfolk Canyon, and to Brian Patteson and Kate Sutherland for providing Cuvier's beaked whale images collected during their seabirding trips off North Carolina. Photographs were collected under National Oceanic and Atmospheric Administration General Authorizations 19903 and 25471 held by Duke University.

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