Photo-Identification Analyses in the Cape Hatteras Study Area: 2023 Annual Progress Report

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Prepared by

Danielle M. Waples[1] and Andrew J. Read[1]

Duke | NICHOLAS SCHOOL of the ENVIRONMENT
Duke University Marine Lab

[1]Duke University Marine Laboratory
135 Duke Marine Lab Road,
Beaufort, NC 28516

Submitted by:

HDR

Virginia Beach, VA

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Cover Photo Credit:

Adult male “Ziphius” beaked whale (*Ziphius cavirostris*) surfacing off Cape Hatteras, North Carolina. Photographed by Annie Harshbarger, Duke University, taken under General Authorization Letter of Confirmation 25471 held by Duke University.

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Acronyms and Abbreviations

BRS	Behavioral Response Study
DUML	Duke University Marine Lab
Gg	*Grampus griseus* (Risso's dolphin)
Gm	*Globicephala macrorhynchus* (short-finned pilot whale)
GOM	Gulf of Mexico
HAT	Cape Hatteras study area
ID	identification/Identifier
JAX	Jacksonville
MarEcoTel	Marine Ecology and Telemetry Research
N/A	Not Applicable
NEAQ	New England Aquarium
NOAA	National Oceanic and Atmospheric Administration
NOR	Norfolk Canyon
OSB	Onslow Bay
photo-ID	photo-identification
SBU	Stony Brook University
SP	Sutherland/Patteson
Tt	*Tursiops truncatus* (bottlenose dolphin)
UNCW	University of North Carolina Wilmington
Zc/Zca	*Ziphius cavirostris* (goose-beaked whale)

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1. Cape Hatteras Photo-Identification

During fieldwork supporting the Atlantic Behavioral Response Study (BRS) in 2023 (Southall et al. 2024) and other related research, more than 17,000 digital images were collected within the Cape Hatteras study area. These images were used to confirm species, identify individual animals, compile sighting histories, and conduct follow-up monitoring of satellite-tagged animals. Digital photographs were taken with Canon or Nikon digital single lens reflex 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 of them being *Ziphius cavirostris*, which will be referred to as '*Ziphius*' or Zc, the primary focal species of BRS field efforts (**Table 1**).

Table 1. Cetacean sightings with the number of photo-ID images collected for each species within the Cape Hatteras study area during 2023.

Species	Common Name	Number of Sightings	Number of Photo-ID Images
Globicephala macrorhynchus	Short-finned pilot whale	20	543
Mesoplodon species	*Mesoplodon* species	7	1,575
Physeter macrocephalus	Sperm whale	2	54
Tursiops truncatus	Bottlenose dolphin	16	181
Unidentified odontocete	Unidentified odontocete	1	3
Unidentified ziphiid	Unidentified ziphiid	5	257
Ziphius cavirostris	Goose-beaked whale	86	14,465
Total	—	**147**	**17,078**

Note: photo-ID = photo-identification; *Mesoplodon* species are known Mesoplodonts; Unidentified ziphiid may be either Mesoplodonts or *Ziphius*.

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).

Images of 50 newly identified animals were added to photo-ID catalogs of short-finned pilot whales (*Globicephala macrorhynchus*), sperm whales (*Physeter macrocephalus)*, bottlenose dolphins (*Tursiops truncatus*) and *Ziphius* (**Table 2**). Twenty-two new photo-ID matches were made within the short-finned pilot whale and *Ziphius* catalogs. Additionally, a bottlenose dolphin, Ttr_2-007, first sighted in September 2013, was re-sighted in October 2022, nine years after its initial sighting; this is the second nine-year re-sight for this species off Cape Hatteras (**Figure 1**).

Table 2. Summary of images collected by species during fieldwork within the Cape Hatteras study area in 2023, with number of new identifications, 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
Balaenoptera physalus	0	0	1	0	0
Delphinus delphis	0	0	46	0	1
Globicephala macrorhynchus	543	13	1,388	4	480
Grampus griseus	0	0	47	0	6
Kogia species	0	0	1	0	0
Megaptera novaeangliae	0	0	2	0	0
Mesoplodon species	1,575	10	10	2	2
Physeter macrocephalus	54	1	30	0	1
Stenella clymene	0	0	3	0	0
Stenella frontalis	0	0	42	0	0
Tursiops truncatus	181	7	369	1	19
Ziphius cavirostris	14,465	29	312	18	135
Total	**16,818**	**60**	**2,251**	**25**	**644**

In addition to the existing 11 photo-ID catalogs previously created for cetacean species within the Cape Hatteras area, a new catalog was created during 2023. Seven sightings of *Mesoplodon* species occurred during 2023 field efforts and more than 1,500 digital images were taken. It is difficult to distinguish among *Mesoplodon* species without photographs of adult males, where the placement of erupted teeth along the mandible is used for species identification (McLellan et al. 2018). At least some of the sightings were of Gervais' beaked whales (*Mesoplodon europaeus*), based on tooth placement of an adult male photographed in July 2023 and coloration patterns of non-adult males similar to those described by McLellan et al. (2018) from aerial surveys conducted off Cape Hatteras (**Figures 2** and **3**). Many of the Mesoplodonts exhibited distinct dorsal fin notches as well as distinctive rake marks, similar to *Ziphius*. Ten distinct individuals were included in the new catalog, including one adult male and one mother/calf pair. Two individuals were re-sighted after their initial sighting; Meso_008 was photographed on 17 July 2023 in a group of three individuals and on the following day 18 July 2023 with another animal. Meso_001 was first photographed on 12 July 2023 and re-sighted almost a week later on 18 July 2023 (**Figure 4**).

To date, therefore, photo-ID catalogs for 12 taxa have been assembled within the Cape Hatteras study area, across multiple U.S. Navy Atlantic Fleet Training and Testing monitoring projects. These catalogs include more than 2,250 distinct individuals, with 644 individuals re-sighted across all species (**Table 2**).

Figure 1. Photographs of Ttr_2-007, initially sighted in September 2013 (top) and re-sighted in October 2022 (bottom).

Figure 2. Photograph of Meso_009 taken in July 2023; note placement of erupted teeth midway along the mandible, a characteristic of Gervais' beaked whales (description from McLellan et al. 2018).

Figure 3. Photograph of a non-distinctive *Mesoplodon* in the same group as Meso_009 in July 2023; note the dark gray stripe along the top of the back with multiple thin gray stripes projecting laterally from the dorsal stripe, a characteristic of Gervais' beaked whales (description from McLellan et al. 2018).

Figure 4. Photographs of Meso_001, initially sighted 12 July 2023 (top) and re-sighted 18 July 2023 (bottom).

1.1 *Ziphius*

Twenty-nine new identifications were added to the *Ziphius* Duke University Marine Lab (DUML) photo-ID catalog during 2023. An additional 18 whales were re-sighted, with re-sightings occurring both within and between years. The current re-sighting rate for *Ziphius* within the Cape Hatteras area is 44 percent, an increase from 2022, when it was 41 percent. To date, 89 of the 135 (66 percent) re-sighted *Ziphius* have been documented in multiple years, and 57 whales have been re-sighted more than three years after their initial sighting (**Tables 3** and **4;** tables and figures are provided at the end of this subsection).

Eleven *Ziphius* were tagged during 2023; two of these tagged individuals had prior photo-ID histories. Zca_098, an adult male (**Figure 5**), was first seen in August 2020, when it was satellite-tagged (ZcTag102). It was re-sighted multiple times in August and September 2021; at that time the satellite tag had been shed, leaving only a well-healed scar. It was seen again in August 2023, when it was satellite-tagged for a second time (ZcTag143). Zca_072 was first seen in May 2019 and re-sighted in August 2021, when it was biopsied and genetically identified as a male; given the lack of erupted teeth it has been classified as a subadult male. It was re-sighted in August 2023 and satellite-tagged (ZcTag146); it still had no erupted teeth at the time of tagging and remains a subadult male (**Figure 6**). To date, six *Ziphius* within the study area have been satellite-tagged multiple times (**Table 5**). In all cases, the initial satellite tag and its hardware had been completely shed, leaving only well-healed scars.

During this study, we have observed individual *Ziphius* associating in the same groups over days to weeks, but long-term social associations continue to be rare. Previously, only three instances of a long-term association had been documented; the first was an adult male/adult female pair satellite-tagged in the same group in May 2016 (ZcTag046 and ZcTag047, respectively) and seen together again in June 2017. A second long-term association involved two adult males tagged in the same group of three in August 2018 (ZcTag071 and ZcTag072, respectively) and photographed together in a group of six in August 2020. A third long-term association also involved a pair of adult males. Zca_056 and Zca_035 were satellite-tagged in separate groups during August 2018 (ZcTag072 and ZcTag076, respectively) and were re-sighted together in August 2020 and in August 2021. An additional long-term association was documented during this reporting period. Zca_049, an adult male, and Zca_080r were photographed in the same group in May 2018 and were re-sighted together in June 2023. Given that Zca_080r has acquired no new rake marks during a five year period, it is probable this animal is an adult female (**Figure 7**). This would be the second time that an adult male and adult female have been observed in a long-term association.

We are continuing to compare images of *Ziphius* between the catalogs created from University of North Carolina Wilmington (UNCW) aerial surveys, seabirding trips conducted by Kate Sutherland and Brian Patteson (SP) off Cape Hatteras, and images collected by HDR researchers near Norfolk Canyon (HDR). We made nine matches between the four catalogs; the three longest-term re-sightings are derived from these inter-catalog comparisons (**Table 6**). UNCW M-003 was first photographed by the aerial survey team off Cape Hatteras in August 2014. It was photographed in 2015, 2019, 2020, and June 2022, when it was seen for the first time with a calf, confirming that this whale is an adult female. SP M-003, an adult male, was photographed by Kate Sutherland in May 2004 south of Cape

Hatteras, and it was satellite-tagged 15 years later in July 2019 (ZcTag090); we believe this is the longest re-sighting record of a Cuvier's beaked whale in the Northwest Atlantic. SP M-004 was originally photographed by Kate Sutherland in July 2010, and was sighted off Cape Hatteras 10 years later in August 2020, when it was satellite-tagged (ZcTag108). A new inter-catalog match was made during this reporting period; SP M-005 was first photographed by Duke researchers in May 2019; it was re-sighted and photographed by Kate Sutherland and Brian Patteson in August 2023 (**Figure 8**). We have also documented occasional movements between Cape Hatteras and Norfolk Canyon from the large sample of the tracks of satellite-tagged whales. These comparisons are increasing the knowledge regarding patterns of residency and movements of this population (**Figure 9**).

In addition to the catalogs described above, we created two additional catalogs during 2023. Orla O'Brien, a research scientist at the New England Aquarium (NEAQ), contributed images and sighting data of *Ziphius* collected during aerial surveys in the Northeast Canyons and Seamounts Marine National Monument. The images were collected between 2017 and 2023 (**Figure 10**). Lesley Thorne and Joshua Meza-Fidalgo contributed images of *Ziphius* collected by Stony Brook University (SBU) researchers in 2019 during boat-based surveys along the shelf break off New York (**Figure 10**). All contributed images were processed for photographic quality and animal distinctiveness, and a new catalog was created for each of these research groups (**Table 7**). Therefore, to date, we have created and will continue to maintain six *Ziphius* catalogs in the western North Atlantic.

We have been very conservative in assigning age class and sex to individuals in the DUML *Ziphius* photo-ID catalog. An animal is only classified as an adult male if there are photographs of erupted teeth and is considered an adult female if it is photographed in close proximity to a calf (less than two-thirds the size of the mother). The only animal classified as a subadult male was genetically classified as a male from a biopsy sample, and photographs show it lacked erupted teeth. No animal in our population has been classified as a subadult female. Many individuals in the catalog remain "unknown," both in terms of age class and sex.

During 2023, we contributed photo-ID images and sighting histories of individual whales sighted between 2006 and 2020 to a meta-analysis of *Ziphius* demography funded by the Office of Naval Research and led by Erin Falcone and Greg Schorr of Marine Ecology and Telemetry Research (MarEcoTel). The goal of this collaborative project is to compare vital rates of *Ziphius* across populations that experience varying exposure to tactical sonars. To understand vital rates, accurate information is needed regarding the age and sex of individuals within that population (Coomber et al. 2022). Frazer Coomber designed and tested methods to use scarring density thresholds and pigmentation patterns to classify *Ziphius* in the Mediterranean Sea to age class and sex (Coomber et al. 2016). These methods were tested on two populations of *Ziphius* off southern California and Guadalupe Island, Mexico (Coomber et al. 2022); the results of this study showed that sex-based scarring density thresholds were not different between the three regions and, therefore, can likely be applied to other populations.

As part of our participation in this meta-analysis project, we assisted in processing our photographs for pigmentation characteristics, as well as a subset for scar tracing and scar density determination. A detailed protocol prepared by Erin Falcone and Erin Keene of MarEcoTel was followed, based on the methods developed by Coomber et al. (2016; **Figure 11**).

Once the image processing was completed, age classes and sexes were assigned to our individual whales. Using the photographs the team provided for documentation of erupted teeth and/or the presence of a calf, along with the scarring density values and pigmentation scores, Erin Falcone was able to classify many *Ziphius* that had been previously considered “unknown” in terms of age class or sex. The number of individuals in our catalog with an age class assignment increased from 156 using our conservative methods to 242 using the methods developed by Coomber et al. (2016; **Table 8**). Likewise, the number of individuals assigned a sex increased from 117 to 229 (**Table 9**). Even using these additional methods, however, many individuals in our catalog cannot be assigned a sex and/or age class. Coomber et al. (2022) noted that differentiating between adult females and subadult males remains challenging.

Several *Ziphius* individuals of particular interest transitioned from one age class to another over the course of field work. Erin Falcone classified Zca_043 as a subadult male when it was first sighted in August 2017; it was re-sighted in July 2020 with newly erupting teeth and was classified as an adult male; it accumulated many additional scars over this three year period. (**Figure 12**). In contrast, Zca_023r was first photographed in October 2015 and was classified as a subadult female by Erin Falcone; the whale was re-sighted in July 2019 and was then classified as an adult female; it had acquired few if any new scars over those four years (**Figure 13**). Males in the population appear to acquire scars much more rapidly than the females, similar to the findings of Rosso et al. (2011), who documented that in a population of *Ziphius* in the Mediterranean Sea, the rate of scar acquisition was six times higher in males than females of the same age. These authors found this to be true for adult as well as subadult males, and they hypothesized that agonistic interactions among males likely start before they reach maturity (Rosso et al. 2011). We plan to use the methods developed by Coomber et al. (2016, 2022), particularly the scarring density threshold, to assign age class and sex to *Ziphius* from photographs acquired in the future.

Table 3. Sighting histories of *Ziphius* re-sighted over multiple years within the Cape Hatteras study area, 2004–2023.

ID[a]	Year													
	2004	2010	2011	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Zca_001r				X		X								
Zca_002 (ZcTag074)				X					X[m]	C				
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_011r (ZcTag070)			X						X[m]					
Zca_015 (ZcTag039, ZcTag077)						X			X					
Zca_016 (UNCW M-003)					X	X				X	X		X	X
Zca_019 (ZcTag043)					X	X								
Zca_020						X				X				
Zca_022						X					X			
Zca_023r						X				X[y]				
Zca_024 (ZcTag046, ZcTag103)							X	X			X[m]			
Zca_026							X					X[y]		
Zca_027r (ZcTag129)						X			X		X	X	X	
Zca_028 (ZcTag051)							X					X[m]		
Zca_029 (ZcTag054)								X[y]				X[y]		X[m]
Zca_030 (ZcTag055)								X[y]		X[m]	X			
Zca_031 (ZcTag056)								X		X	X[y]	X[y]		X[m]
Zca_032								X	X[m]					
Zca_033								X			X			X
Zca_034 (ZcTag126)								X				X[m]		
Zca_035 (ZcTag076)								X	X[y]		X	X		
Zca_035r (ZcTag048)							X		X					
Zca_036								X				X[y]		

ID[a]	Year													
	2004	2010	2011	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Zca_037 (ZcTag068)								X[y]			X			
Zca_038								X	X			X		
Zca_039								X	X					
Zca_040								X[y]		X				
Zca_043								X			X			
Zca_044r							X		X[m]		X			
Zca_046r							X				X			
Zca_048								X		X[m]				
Zca_049 (ZcTag114)									X			X[y]	X	X
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]			X
Zca_054r (ZcTag049, ZcTag099)							X	X[y]		X	X[y]			
Zca_055 (ZcTag071)									X		X[m]			
Zca_056 (ZcTag072)									X		X[m]	X		X
Zca_057 (ZcTag079)									X				X	
Zca_058									X	X				
Zca_059									X[y]			X		X
Zca_059r								X	X[y]					
Zca_061									X	X				
Zca_063 (ZcTag098)									X[m]		X[y]			
Zca_065									X	X		X	X	
Zca_066									X[m]			X[m]		
Zca_067									X				X	
Zca_067r (ZcTag060)								X			X	X		
Zca_068r								X				X[m]		
Zca_071r (ZcTag081)								X	X[m]					X

ID[a]	Year													
	2004	2010	2011	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Zca_072										X		X		X
Zca_074										X		X		
Zca_074r								X	X			X[y]		X
Zca_075										X	X[m]			
Zca_076										X[y]	X[y]			
Zca_077r (ZcTag085)									X	X[y]				
Zca_078 (ZcTag089, ZcTag109)										X	X			
Zca_080									X					X[y]
Zca_082r									X	X				
Zca_083										X	X		X	
Zca_086 (ZcTag091)										X[m]		X		
Zca_091 (ZcTag095)										X[m]	X			
Zca_092 (ZcTag096, ZcTag112)										X[m]		X		X
Zca_096r									X[m]			X		
Zca_098 (ZcTag102, ZcTag 143, SP M-001)									X		X[m]	X[m]		X
Zca_099											X	X[m]		
Zca_104 (ZcTag108)											X[m]		X	X
Zca_106											X			X
Zca_106r (ZcTag111)									X		X[m]	X		
Zca_108r (ZcTag106)									X		X[y]	X	X	
Zca_112r									X		X[y]	X	X	
Zca_117r									X[y]			X		
Zca_145r										X		X		
Zca_146r (ZcTag101)										X	X[m]	X		
Zca_162r (ZcTag104)											X[m]	X		
Zca_166r (ZcTag110)											X[m]	X		
UNCW M-004				X				X						
SP M-002 (ZcTag127)									X			X		

ID[a]	Year													
	2004	**2010**	**2011**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
SP M-003 (ZcTag090)	X									X				
SP M-004 (ZcTag108)		X									X[m]			
SP M-005										X				X
HDR M-001											X		X	

[a] ID = Identification; Zca = *Ziphius cavirostris*; UNCW M = aerial-vessel match to University of North Carolina Wilmington catalog; SP M = matches made to the Sutherland/Patteson catalog from seabirding trips south of Cape Point; HDR M = matches made to the HDR catalog from vessel research trips offshore Norfolk, Virginia; 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 *Ziphius* within the Cape Hatteras study area.

Number of Years Between First and Last Sighting	Number of Individuals
Less than 1	46
1 to 2	22
2 to 3	10
3 to 4	16
4 to 5	19
5 to 6	11
6 to 7	6
7 to 8	2
8 to 9	1
More than 10	2
Total	**135**

Table 5. Satellite tag IDs and tagging dates for *Ziphius* that have been satellite-tagged multiple times within the Cape Hatteras study area.

Initial Tag ID	Initial Tagging Date	Subsequent Tag ID	Subsequent Tagging Date	Years Between Initial and Subsequent Tag
ZcTag039	June 2015	ZcTag077	August 2018	3.1
ZcTag046	May 2016	ZcTag103	August 2020	4.2
ZcTag049	May 2016	ZcTag099	July 2020	4.1
ZcTag089	June 2019	ZcTag109	August 2020	1.2
ZcTag096	August 2019	ZcTag112	June 2021	1.9
ZcTag102	August 2020	ZcTag143	August 2023	3.0

Note: ID = Identifier

Table 6. Summary of photo-ID matches made between the Duke University catalog and other *Ziphius* catalogs.

Match Number	Initial Sighting	Last Sighting	Years Between Initial and Last Sightings
UNCW M-001	August 2014	September 2014	0.1
UNCW M-002	September 2014	May 2015	0.7
UNCW M-003	August 2014	June 2022	7.8
UNCW M-004	May 2013	August 2017	4.2
SP M-001	May 2018	August 2020	2.2
SP M-002	May 2018	September 2021	3.3
SP M-003	May 2004	August 2019	15.2
SP M-004	July 2010	August 2020	10.1
SP M-005	May 2019	August 2023	4.3
HDR M-001	August 2020	August 2022	2.0

[a] UNCW M = aerial-vessel match to University of North Carolina Wilmington catalog; SP M = matches made to the Sutherland/Patteson catalog from seabirding trips south of Cape Point; HDR M = matches made to the HDR catalog from vessel research trips offshore Norfolk, Virginia

Table 7. Location and contributor of *Ziphius* catalogs created; includes number of images in each catalog and years when the images were collected.

Catalog Descriptor[a]	Research Location	Contributor(s)	Years Images Collected	Number of Individuals
SP catalog	South of Cape Point, North Carolina	Kate Sutherland/ Brian Patteson	2003–2023	21
DUML catalog	Cape Hatteras, North Carolina	Andy Read	2007–2023	310
UNCW catalog	Cape Hatteras, North Carolina Aerial Surveys	Bill McLellan	2012–2017	51
NEAQ catalog	Northeast Canyons and Seamounts Marine National Monument Aerial Surveys	Orla O'Brien	2017–2023	7
HDR catalog	Norfolk, Virginia	Jessica Aschettino	2019–2022	3
SBUcatalog	New York Shelf Break, New York	Lesley Thorne/ Josh Meza-Fidalgo	2019	4

[a] SP catalog= Sutherland/Patteson catalog from seabirding trips south of Cape Point; DUML catalog= Duke University Marine Lab catalog from research trips off Cape Hatteras; UNCW catalog= University of North Carolina Wilmington catalog made from aerial surveys; NEAQ catalog=New England Aquarium Northeast Canyons and Seamounts Marine National Monument catalog from aerial surveys; HDR catalog= HDR catalog from research trips offshore Norfolk, Virginia; SBU catalog= Stony Brook University catalog from research trips off the New York shelf break

Table 8. Age class assignments of individual *Ziphius* from DUML (based on photographs of males with erupted teeth and females with calves) versus assignments from MarEcoTel (based on photographs, scarring densities, and pigmentation characteristics).

Descriptor[a]	Adult	Subadult	Calf	Unknown	Total
DUML	110	1	5	156	272
MarEcoTel	182	55	5	30	272

[a] DUML= Duke University Marine Lab; MarEcoTel= Marine Ecology and Telemetry Research

Table 9. Sex assignments of individual *Ziphius* from DUML (based on photographs of males with erupted teeth, females with calves, and genetically identified animals from biopsies) versus assignments from MarEcoTel (based on photographs, biopsies, scarring densities, and pigmentation characteristics).

Descriptor[a]	Male	Female	Unknown	Total
DUML	98	19	155	272
MarEcoTel	133	96	43	272

[a] DUML= Duke University Marine Lab; MarEcoTel= Marine Ecology and Telemetry Research

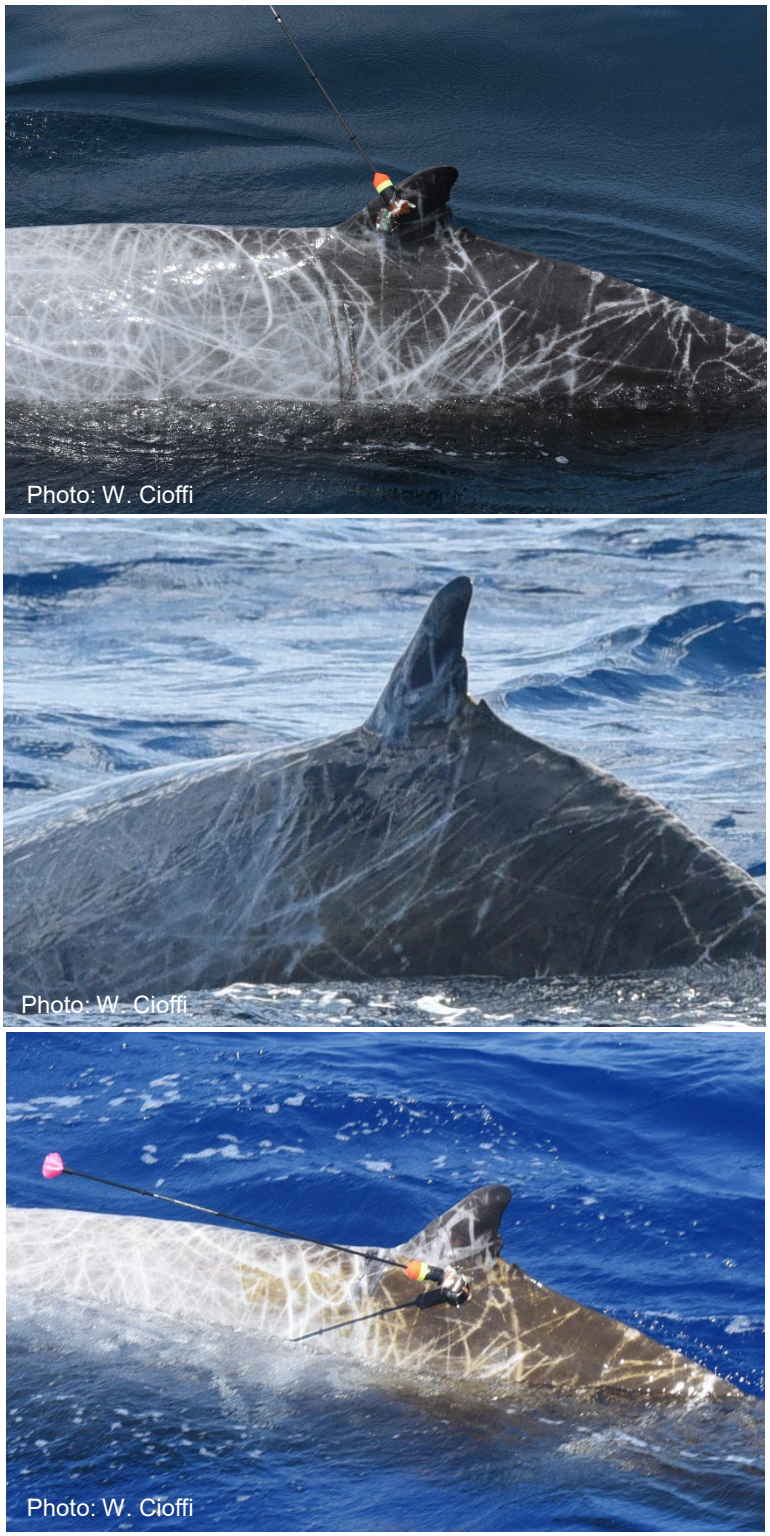

Figure 5. Photographs of Zca_098, initially satellite-tagged in August 2020 (ZcTag102; top), re-sighted multiple times during 2021 (middle), and satellite-tagged a second time in August 2023 (ZcTag143; bottom).

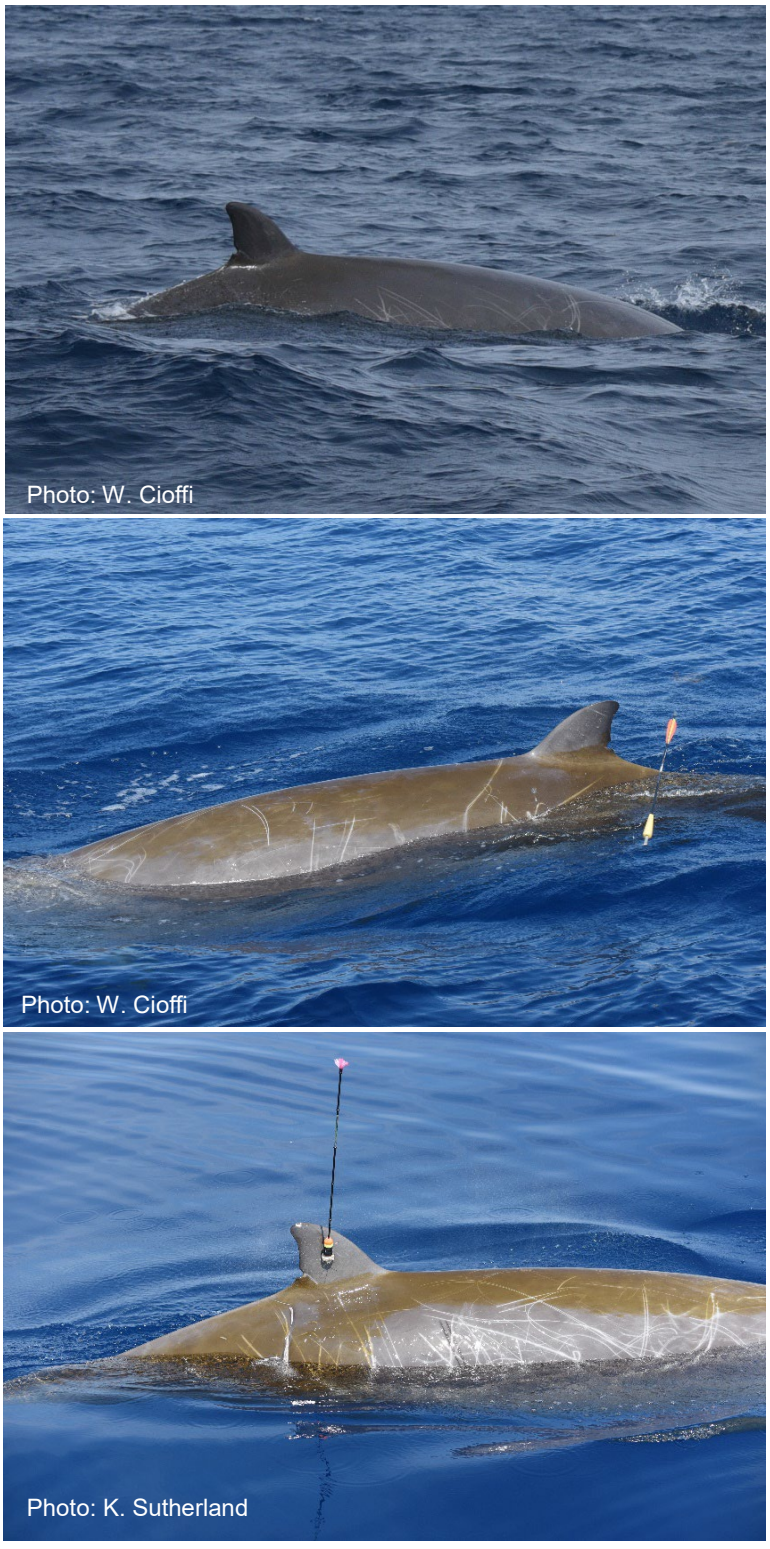

Figure 6. Photographs of Zca_072, initially sighted in May 2019 (top), re-sighted and biopsied in August 2021 (middle), and satellite-tagged in August 2023 (ZcTag146; bottom).

Figure 7. Photographs of Zca_080r, initially sighted in May 2018 (top) and re-sighted in June 2023 (bottom). Note that few, if any, new scars have been accumulated over that period.

Figure 8. Photographs of SP M-005, initially sighted in 2019 (top), and re-sighted in 2023.

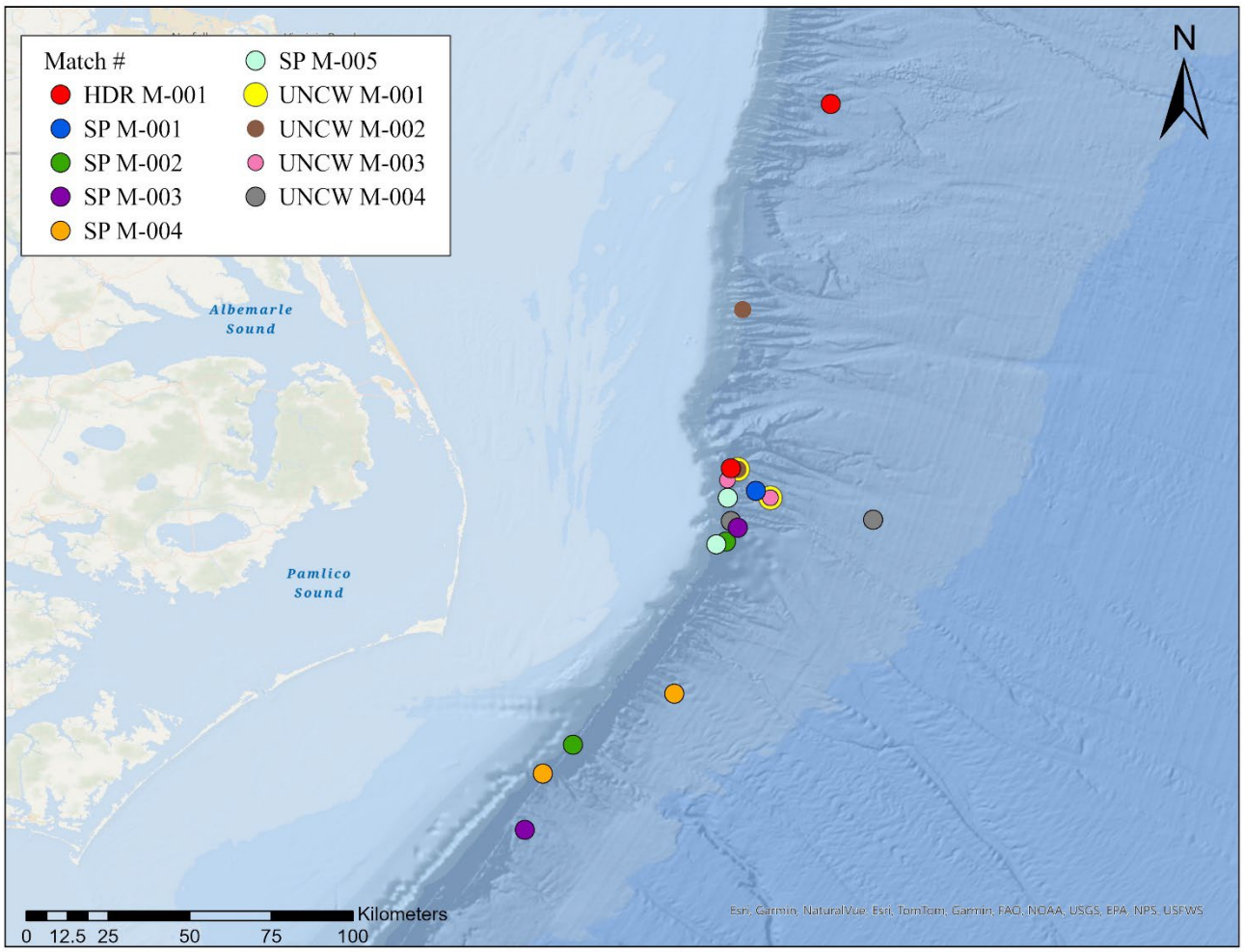

Figure 9. Map of sighting locations of *Ziphius* matched between the Duke University catalog and three external catalogs (HDR M = matches made to the HDR catalog from Norfolk, Virginia; SP M = matches made to the Sutherland/Patteson catalog from south of Cape Point; UNCW M = matches made to the University of North Carolina Wilmington catalog from aerial surveys).

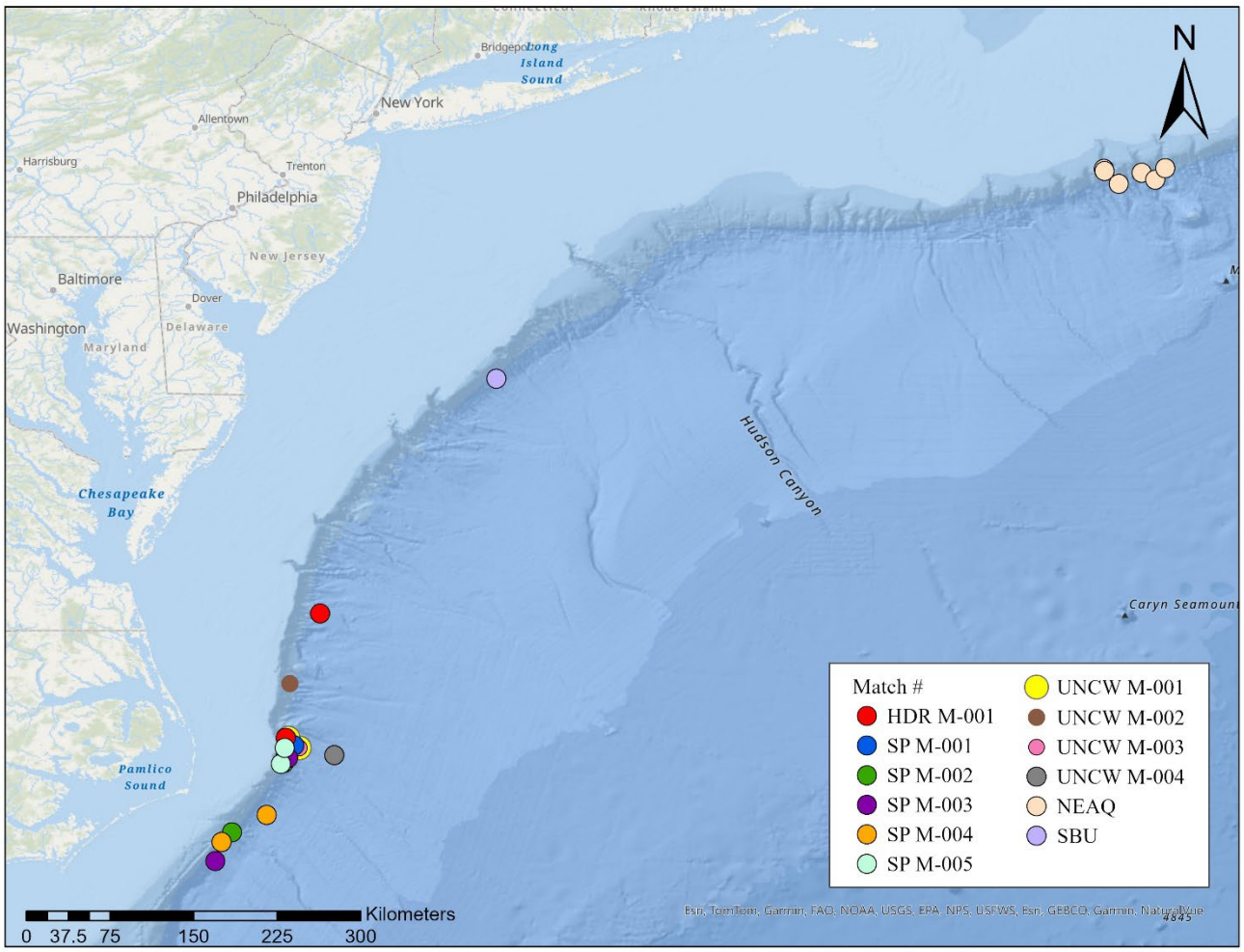

Figure 10. Map of sighting locations of *Ziphius* matched between the Duke University catalog and three external catalogs together with sighting locations of newly created catalogs (NEAQ = New England Aquarium Northeast Canyons and Seamounts Marine National Monument aerial survey sightings; SBU= Stony Brook University sightings from research trips off the New York shelf break).

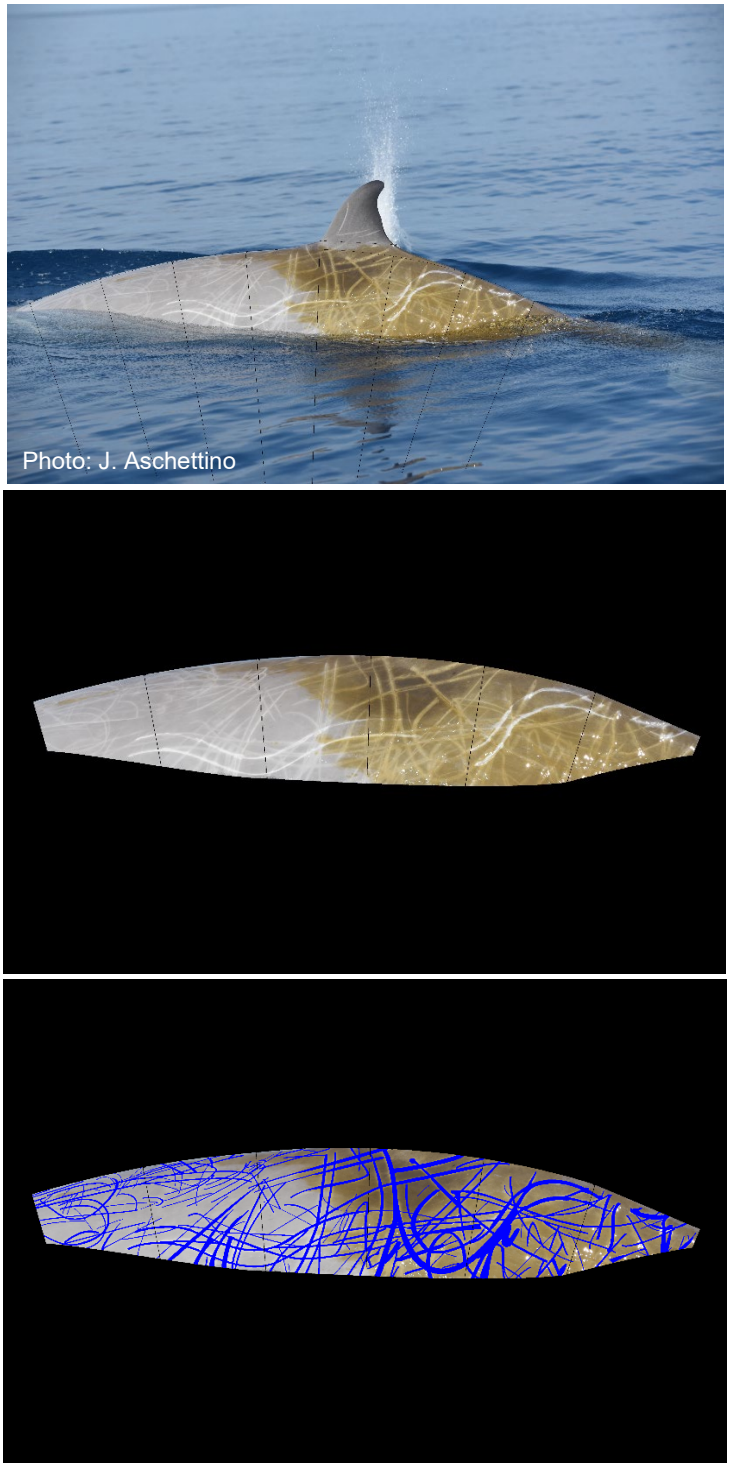

Figure 11. Photographs of Zca_063 with delineated Regions of Interest (top), with the background cleared around the Regions of Interest (middle), and with scars traced within each Region of Interest (bottom). All image processing was done using ImageJ software following the protocols written by Erin Falcone and Erin Keene (MarEcoTel), based on the methods developed by Coomber et al. (2016).

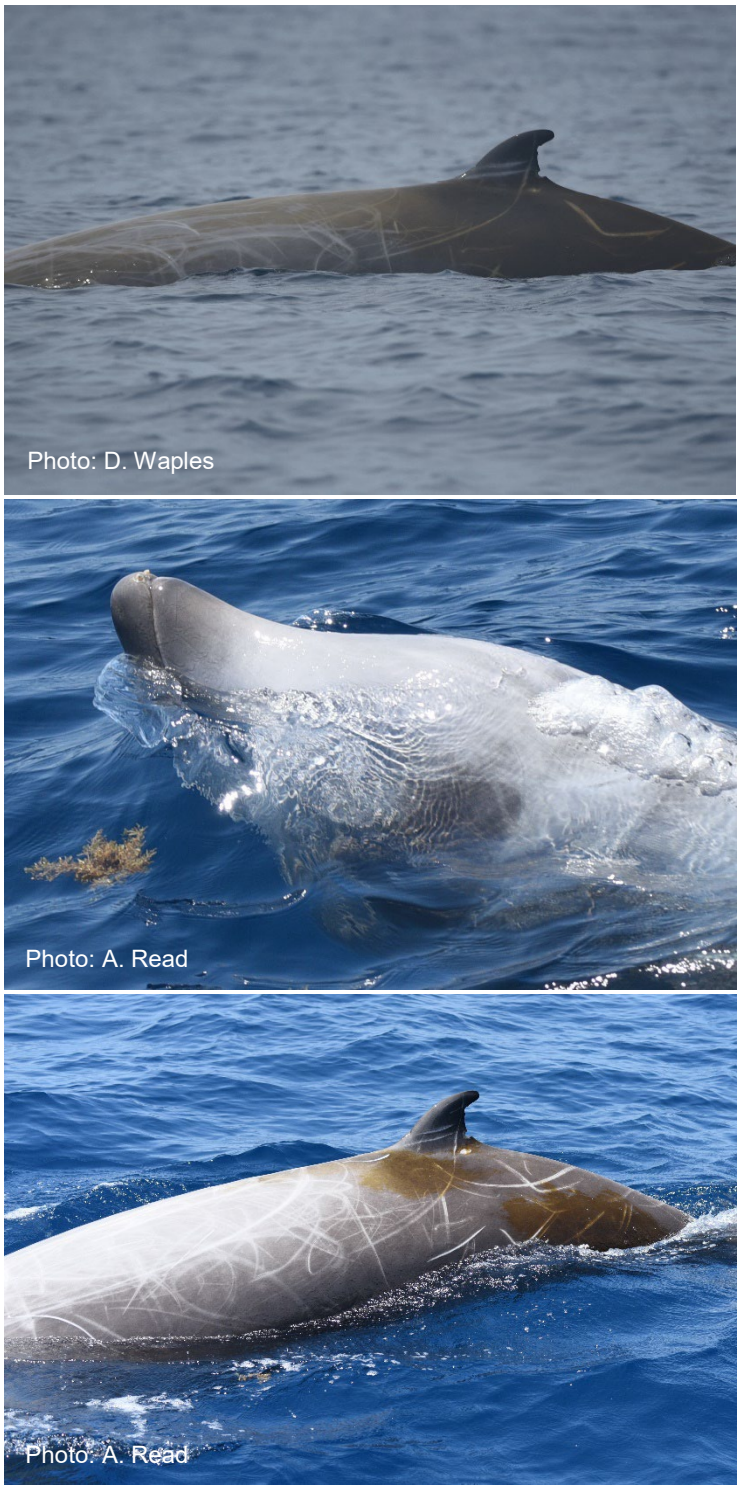

Figure 12. Photographs of Zca_043, initially sighted in 2017 and classified as a subadult male (top), and re-sighted in 2020 with newly erupting teeth, at which time it was classified as an adult male (middle; bottom). Note the accumulation of new scars over that period.

Figure 13. Photographs of Zca_023r, initially sighted in October 2015 and classified as a subadult female (top) and re-sighted in July 2019 and classified as an adult female (bottom). Note that few, if any, new scars were acquired during that period.

1.2 Short-Finned Pilot Whales

Despite little field effort directed at this species, we added 13 new identifications and four new re-sightings to the short-finned pilot whale catalog during 2023. The current re-sighting rate of this species is 35 percent, unchanged from 2022. More than 200 short-finned pilot whales have been photographed on three or more occasions, and 14 animals have been re-sighted more than six times (**Table 10;** tables and figures are provided at the end of this subsection). More than 100 short-finned pilot whales have been biopsied within the study area between 2006 and 2022, and the sex of 95 whales has been determined from molecular analysis, with 69 males and 26 females sampled to date.

Short-finned pilot whales return to or are resident within the Cape Hatteras study area over extended periods. More than 120 pilot whales have spans of at least five years between their first and last sightings, and 24 pilot whales have records that span a decade or more (**Table 11**). Three of these 24 whales were satellite-tagged, and three others 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. Additionally, a new long-term re-sighting was found during this period: Gma_7-225 was first seen in May 2008; it was re-sighted multiple times during 2015, again in 2018, and finally in October 2022 (**Figure 14**). This is only the second time a 14-year re-sight has been found with the Hatteras short-finned pilot whale catalog. It is also interesting that while this individual has relatively subtle markings, it has been identifiable across the many years and has not accumulated additional markings over that period.

We have documented many associations of short-finned pilot whales over long periods. For example, 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 2008 and May 2015. Another two pilot whales (Gma_9-010 and Gma_9-118) were photographed in the same group four times between 2007 and 2014. Finally, five pilot whales (Gma_1-099, Gma_6-331, Gma_7-430, Gma_8-191, and Gma_9-168) were seen in the same group in August 2017 and re-sighted together four years later in August 2021. These long-term associations confirm lasting social bonds in this strongly matrifocal species.

We are in the process of systematically comparing the 13 newly identified short-finned pilot whales added to the Cape Hatteras photo-ID catalog to catalogs for this species from Onslow Bay, North Carolina, and Jacksonville, Florida. We have previously matched four pilot whales between the Cape Hatteras and Onslow Bay study areas. These four photo-ID matches are the only short-finned pilot whale matches documented between the Cape Hatteras and Onslow Bay catalogs. To date, no matches have been made between the Cape Hatteras and Jacksonville catalogs.

Jessica Aschettino provided images of short-finned pilot whales collected by HDR researchers during their field work within the Norfolk Canyon area from May through October 2023. Approximately 1,700 images were graded 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. A total of 25 new individuals were added to the Norfolk short-finned pilot whale catalog; this catalog currently contains 320 individuals (**Table 12**). There was one new re-sighting of a pilot whale from the Norfolk catalog; M-045 was initially sighted off Hatteras, North Carolina, in May 2018 and re-sighted off Norfolk Canyon

in November 2020 before being re-sighted again off Norfolk Canyon in June 2023 (**Table 13; Figure 15**).

We compared the 25 new individuals in the Norfolk short-finned pilot whale catalog to the Hatteras short-finned pilot whale catalog, which contains 1,388 individuals. Three new matches were made, adding to the 44 previous matches between the two areas. M-048 was first seen off Cape Hatteras in May 2011 and re-sighted in the Norfolk Canyon area more than 12 years later in October 2023 (**Figure 16**). This photo-ID match represents the longest re-sight between these two research areas. M-049 was first photographed off Hatteras in May 2015 and re-sighted off Norfolk Canyon in August 2023. And M-050 was seen off Hatteras in May 2015 and August 2017, and re-sighted for a third time off Norfolk Canyon in May 2023. To date, 47 short-finned pilot whales have been matched between the Norfolk and Hatteras catalogs (**Table 14**).

Comparing the two catalogs provides additional long-term re-sighting information; 13 of the pilot whales were seen within Cape Hatteras from 2007 to 2009, but not observed again until they were photographed within the Norfolk Canyon area from 2015 onwards. We also compared the new Norfolk pilot whale IDs to the short-finned pilot whale catalogs from Onslow Bay, North Carolina, and Jacksonville, Florida, but did not make any matches.

We have completed comparisons of two catalogs of short-finned pilot whale photographs collected from researchers and volunteers working around Martinique and Guadeloupe Islands in the Caribbean and contributed by Dr. Jeremy Kiszka of Florida International University. We compared both Caribbean catalogs to our short-finned pilot whale catalogs from Jacksonville, Florida, and Onslow Bay and Cape Hatteras, North Carolina. There were several potential matches between the sites, but they could not be confirmed due to poor photographic quality (**Table 15**).

We also compared both Caribbean catalogs to a catalog of short-finned pilot whales that were created from images taken during research cruises conducted by National Oceanic and Atmospheric Administration (NOAA) scientists in the Gulf of Mexico (provided by Keith Mullin, Southeast Fisheries Science Center). Again, several potential matches were made, and images were circulated to Dr. Jeremy Kiszka, Dr. Andrew Read (Duke University), and Kim Urian; however, all these analysts agreed that the matches could not be confirmed, either due to poor photographic quality or a lack of distinctive markings.

During this reporting period, we finished comparisons between the Caribbean catalogs and the catalog of short-finned pilot whales off Norfolk, Virginia but did not make any confirmed matches. We hope to receive further image contributions from Dr. Kiszka from the Caribbean. Linkages between pilot whales from the Caribbean and those inside the United States Exclusive Economic Zone are important, because short-finned pilot whales are still harvested in St. Vincent and elsewhere within the Caribbean.

Lesley Thorne and Joshua Meza-Fidalgo contributed images of short-finned pilot whales collected by SBU researchers in 2018 and 2019 during surveys along the shelf break off New York. Approximately 350 images of short-finned pilot whales were graded for photographic quality and animal distinctiveness. All images of sufficient quality and distinctiveness were sorted by individual within a sighting, the best image for each individual in that sighting was selected, and these images

were compiled into a folder. A new photo-ID catalog was created for the SBU short-finned pilot whales and 14 identifications were added (**Figure 17**). This catalog is an important addition as previous satellite tagging of short-finned pilot whales off Cape Hatteras shows that they frequently use this area (Foley 2018; **Figure 17**) and we have had no previous photo-ID coverage this far north prior to the creation of this catalog. All of the new identifications were compared to the Norfolk-HDR catalog (320 animals) and the Hatteras-DUML catalog (1,388 animals) but no matches were made.

Currently we have created short-finned pilot whale catalogs for six research locations (**Table 16**). We will continue to maintain and update these catalogs and make inter-catalog comparisons for short-finned pilot whales. To date, 57 photo-ID matches have been made between four of the catalogs (**Table 17**). These inter-catalog comparisons have yielded some interesting insights into the social behavior and long-distance movements of these animals. Four pilot whales were first photographed in the same group in Onslow Bay in August 2007; they were sighted together again 11 years later off Cape Hatteras in August 2018, demonstrating a long-term stable social group. A new match made during this reporting period (M-048) was first seen off Cape Hatteras in May 2011 and re-sighted within the Norfolk Canyon area more than 12 years later in October 2023. The longest-term photo-ID match made to date, and the longest geographic distance between any photo-ID match made, also comes from an inter-catalog comparison. M-042 was first photographed in Hatteras in May 2007. We matched it to the catalog of short-finned pilot whales from the Gulf of Mexico in 2004. This pilot whale was re-sighted within the Norfolk Canyon area in January 2019, almost 15 years after its initial sighting (**Figure 18)**. We look forward to receiving additional photographs from the contributors to increase understanding of the movements of short-finned pilot whales along the United States east coast, Gulf of Mexico, and Caribbean.

Table 10. Frequency distribution of the number of sightings of photo-identified short-finned pilot whales within the Cape Hatteras study area.

Number of Sightings	Number of Individuals
1	912
2	272
3	96
4	59
5	26
6	9
7	8
8	4
9	1
10	0
11	1
Total	**1,388**

Table 11. Frequency distribution of the number of years between first and last sightings of photo-identified short-finned pilot whales within the Cape Hatteras study area.

Number of Years Between First and Last Sighting	Number of Individuals
Less than 1	132
1 to 2	49
2 to 3	45
3 to 4	63
4 to 5	69
5 to 6	17
6 to 7	20
7 to 8	46
8 to 9	14
9 to 10	1
10 to 11	13
11 to 12	7
More than 12	4
Total	**480**

Table 12. Number of new identifications, re-sights within the Norfolk Canyon catalog, and matches to the Cape Hatteras catalog of short-finned pilot whales made during each field season by HDR researchers.

Field Season	New IDs	Catalog size	Resights within NOR catalog	Matches between NOR and HAT catalogs
2015	84	84	0	11
2016	47	131	3	13
2017	48	179	3	13
2018	19	198	0	0
2019	32	230	1	3
2020	26	256	2	2
2021	26	282	1	1
2022	13	295	0	1
2023	25	320	1	3
Total	**320**	**320**	**11**	**47**

Notes: HAT = Cape Hatteras study area; ID = Identifications; NOR = Norfolk Canyon study area

Table 13. Photo-ID re-sighting histories of short-finned pilot whales off Norfolk Canyon, Virginia.

ID	Year								
	2015	2016	2017	2018	2019	2020	2021	2022	2023
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_8-030							X		X
Gma_9-022		X					X		

Note: ID = identifier

Table 14. Photo-ID matches by year of individual short-finned pilot whales, 2007–2023, between the Cape Hatteras and Norfolk Canyon study areas.

ID	Year																
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
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						
M-038	HAT	HAT									NOR						
M-039	HAT	HAT									NOR						

ID	Year																
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
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			NOR
M-045												HAT		NOR			
M-046							HAT								NOR		
M-047									HAT							NOR	
M-048					HAT												NOR
M-049									HAT								NOR
M-050									HAT		HAT						NOR

Notes: HAT = Cape Hatteras study area; ID = Identifier; NOR = Norfolk Canyon study area

[m] Re-sighted within same month

[y] Re-sighted within same year

Table 15. Number of images in each short-finned pilot whale catalog, years when the images were collected, and whether the catalogs have been compared to the Caribbean catalogs.

Catalog Location	Years Images Collected	Number of Individuals	Comparisons to the Caribbean Catalogs Completed
Guadeloupe, Caribbean	2010–2020	210	N/A
Martinique, Caribbean	2013–2016	130	N/A
Jacksonville, Florida	2009–2018	52	Yes
Onslow Bay, North Carolina	2007–2013	24	Yes
Gulf of Mexico	2003–2007	180	Yes
Hatteras, North Carolina	2006–2022	1,375	Yes
Norfolk, Virginia	2015–2023	320	Yes

Note: N/A = Not Applicable

Table 16. Location and contributor of short-finned pilot whale catalogs created for other research groups; includes number of images in each catalog and years when the images were collected.

Descriptor[a]	Research Location	Contributor(s)	Years Images Collected	Number of Individuals
GOM catalog	Gulf of Mexico	Keith Mullin	2003–2007	180
HAT catalog	Cape Hatteras, North Carolina	Andy Read	2006–2023	1,375
OSB catalog	Onslow Bay, North Carolina	Andy Read	2007–2013	24
JAX catalog	Jacksonville, Florida	Andy Read	2009–2018	52
HDR catalog	Norfolk Canyon, Virginia	Jessica Aschettino	2015–2023	320
SBU catalog	New York Shelf Break, New York	Lesley Thorne/ Josh Meza-Fidalgo	2018–2019	14

[a] GOM catalog= Catalog from NOAA research cruises in the Gulf of Mexico; HAT catalog= Duke University Marine Lab catalog from research trips off Cape Hatteras; OSB catalog= Duke University Marine Lab catalog from research trips off Onslow Bay; JAX catalog = Duke University Marine Lab catalog from research trips off Jacksonville; HDR catalog= HDR catalog from research trips offshore Norfolk; SBU catalog= Stony Brook University catalog from research trips off the New York shelf break

Table 17. Details on short-finned pilot whale inter-catalog comparisons including the two catalogs that were compared to each other, the number of photo-ID matches made between the two catalogs and the time between the shortest and longest photo-ID match made between the two catalogs.

Descriptor[a]	Descriptor[a]	Number of Matches	Range between Shortest and Longest Matches (years)
HAT catalog	GOM catalog	5	2.9–9.9
OSB catalog	HAT catalog	4	11.0[b]
HAT catalog	NOR catalog	47	1.4–12.4
NOR[c] catalog	GOM catalog	1	14.6

[a] GOM catalog= Catalog from NOAA research cruises in the Gulf of Mexico; HAT catalog= Duke University Marine Lab catalog from research trips off Cape Hatteras; OSB= Duke University Marine Lab catalog from research trips off Onslow Bay; HDR catalog= HDR catalog from research trips offshore Norfolk

[b] All four short-finned pilot whales were seen in the same sighting in OSB and HAT.

[c] This match is also one of the HAT-GOM matches

Figure 14. Photographs of short-finned pilot whale Gma_7-225 photographed off Cape Hatteras in May 2008 (top), October 2015 (middle), and October 2022 (bottom).

Figure 15. Photographs of short-finned pilot whale M-045 photographed off Cape Hatteras in May 2018 (top), off Norfolk Canyon in November 2020 (middle) and June 2023 (bottom).

Figure 16. Photographs of M-048 in May 2011 off Cape Hatteras (top), and in October 2023 within the Norfolk Canyon area (bottom).

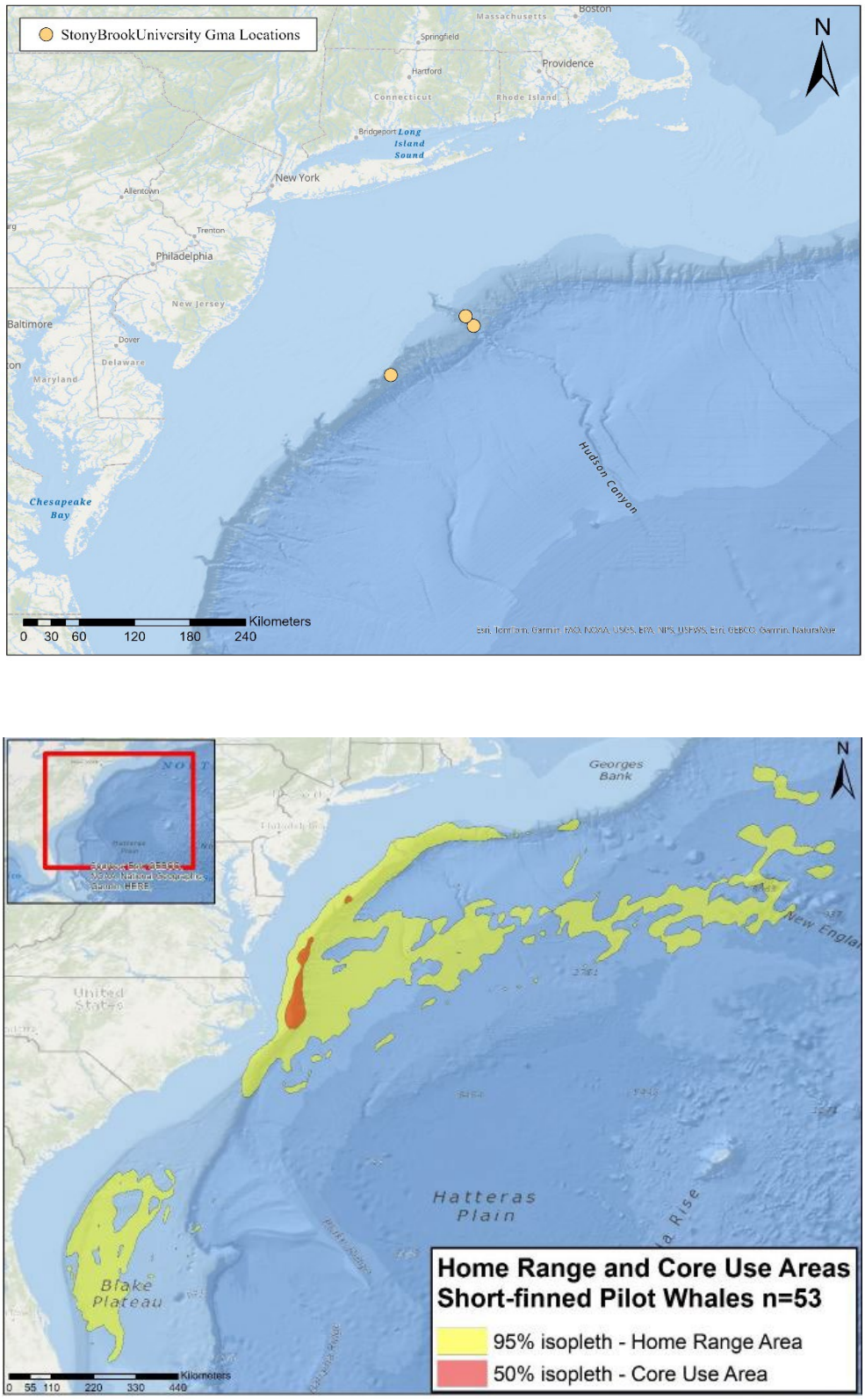

Figure 17. Map of Stony Brook University short-finned pilot whale sighting locations (top), and satellite-tagged short-finned pilot whale home range and core use areas (bottom; from Foley [2018]).

Figure 18. Photographs of short-finned pilot whale M-042 photographed in the Gulf of Mexico in 2004 (top), off Cape Hatteras in 2007 (middle), and within the Norfolk Canyon area in 2019 (bottom).

1.3 Satellite Tag Post-Deployment Monitoring

Follow-up monitoring of the health of satellite-tagged animals continues to be an important focus for this study's photo-ID efforts. We deployed 107 satellite tags on 101 individual *Ziphius* between 2014 and 2023 and have re-sighted 68 of these animals (67%). Many re-sightings occurred within the same field season, but 38 of the whales (56%) were photographed at least one year after tagging (**Table 18**).

ZcTag108, an adult male, was satellite-tagged in August 2020. It was re-sighted several times during that field season and observed again in October 2022 from the Research Vessel *Shearwater*; however, the quality of the photographs was insufficient to evaluate the presence of the tag. The whale was photographed again in July 2023, and the images show that the tag has been completely shed, leaving well-healed scars on both sides of the dorsal fin (**Figure 19**). ZcTag054 and ZcTag056, both adult males, were satellite tagged in the same group in May 2017. Both were seen multiple times over the following years; both were seen again, on the same day but in different groups, in 2023 (**Figures 20** and **21**).

During 2023, three *Ziphius* were re-sighted for the first time since they were satellite-tagged (**Table 18**). ZcTag081 was satellite-tagged in August 2018 and not re-sighted until July 2023. The photographs were of marginal quality but sufficient to determine that the tag and associated hardware had been shed, leaving a white scar at the tagging location (**Figure 22**). ZcTag132 was satellite-tagged in August 2022 and re-sighted in July 2023, when the tag and all hardware had been shed, leaving several small scars (**Figure 23**). Finally, ZcTag096 was tagged in August 2019, and re-sighted and satellite tagged a second time in June 2021 (ZcTag112); there were no remains of the previous tag, only two small scars. It was re-sighted again in August 2023; the second tag and hardware had also been shed, leaving only a second set of small scars at the tagging site (**Figure 24**).

To date, the research team has 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 12 of the re-sightings (39 percent) occurred across multiple years (**Table 18**). Given the very limited effort with short-finned pilot whales during the 2023 field season, with only 20 sightings and 543 photographs, we did not re-sight any of the satellite-tagged short-finned pilot whales.

Table 18. Photo-ID sighting histories of cetaceans satellite-tagged and re-sighted within the Cape Hatteras study area; note a red X denotes the year when satellite tagging occurred for that individual.

ID[a]	Year										
	2006–2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
GgTag017				X[m]							
GmTag087		X[y]									
GmTag089		X	X								
GmTag091	X	X	X								
GmTag096	X[y]	X			X	X[y]					
GmTag097	X[y]	X	X								
GmTag122	X		X[m]								
GmTag127			X[m]								
GmTag134			X			X				X	
GmTag135			X[y]			X	X			X	
GmTag136	X		X[y]			X[m]					
GmTag140			X		X						
GmTag157				X	X						
GmTag172					X[m]						
GmTag175	X				X[m]						
GmTag176	X				X			X			
GmTag179					X	X					
GmTag182					X[m]						
GmTag197	X	X	X		X	X[y]					
GmTag198 (GmTag227)	X					X[y]	X[y]				
GmTag199						X[m]					
GmTag201						X[y]				X	
GmTag203						X[y]					
GmTag204			X[y]			X[y]					
GmTag205						X[y]					
GmTag206						X[y]					
GmTag207	X[y]		X			X[m]					
GmTag208						X[m]					
GmTag216						X[m]					
GmTag218	X[y]		X[m]			X[m]					
GmTag223	X[y]			X			X[m]				
GmTag226							X[y]				
TtTag015		X[m]									

ID[a]	Year										
	2006–2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
ZcTag029		X[m]				X					
ZcTag039 (ZcTag077)			X			X					
ZcTag040		X	X		X	X		X			
ZcTag046 (ZcTag103)				X	X			X[m]			
ZcTag047		X[y]		X[y]	X[y]	X[y]					
ZcTag048				X		X					
ZcTag049 (ZcTag099)				X	X[y]		X	X[y]			
ZcTag051				X					X[m]		
ZcTag054					X[y]				X[y]		X[m]
ZcTag055					X[y]		X[m]	X			
ZcTag056					X		X	X[y]	X[y]		X[m]
ZcTag057					X	X					
ZcTag058					X[y]	X[m]					
ZcTag060					X			X	X		
ZcTag062					X[m]						
ZcTag069						X[y]					
ZcTag071						X		X[m]			
ZcTag072						X		X[m]	X		X
ZcTag073						X[y]					
ZcTag074	X					X[m]	X[m]				
ZcTag075						X[m]					
ZcTag076					X	X[m]		X	X		
ZcTag078						X[m]			X		
ZcTag079						X				X	
ZcTag080						X[m]					
ZcTag081					X	X[m]					X
ZcTag082							X[y]				
ZcTag084						X	X[m]	X[m]			X
ZcTag085						X	X[y]				
ZcTag086							X[y]	X[y]			
ZcTag088							X[m]				
ZcTag089 (ZcTag109)							X	X			
ZcTag090							X[y]				
ZcTag091							X[m]		X		

ID[a]	Year										
	2006–2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
ZcTag092							X[y]				
ZcTag093							X[y]				
ZcTag095							X[m]	X			
ZcTag096 (ZcTag112)							X[m]		X[y]		X
ZcTag097							X[m]				
ZcTag098						X[m]		X[y]			
ZcTag101							X	X[m]	X		
ZcTag102 (ZcTag143)								X[m]	X[y]		X
ZcTag104								X[m]	X		
ZcTag105								X[m]			
ZcTag106						X		X[y]	X	X	
ZcTag107								X[y]			
ZcTag108								X[m]		X	X
ZcTag110								X[m]	X		
ZcTag111						X		X[m]	X		
ZcTag114						X			X[y]	X	X
ZcTag115									X[y]		
ZcTag116									X[y]		
ZcTag117									X[y]		
ZcTag120									X[y]		
ZcTag121									X[y]	X	
ZcTag122									X[y]	X	
ZcTag123									X[y]		
ZcTag124		X				X			X[y]		
ZcTag125									X[m]		
ZcTag126					X				X[m]		
ZcTag129			X			X		X		X[y]	
ZcTag130						X	X		X	X[y]	
ZcTag131										X[m]	
ZcTag132										X	X
ZcTag135										X[m]	
ZcTag136											X[m]
ZcTag137											X[y]

ID[a]	Year										
	2006–2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
ZcTag144											X[m]

[a] ID = identification; Gg= *Grampus griseus* (Risso's dolphin); Gm= *Globicephala macrorhynchus* (short-finned pilot whale); Tt=*Tursiops truncatus* (bottlenose dolphin); Zc=*Ziphius cavirostris*

[m] – Re-sighted within same month

[y] – Re-sighted within same year

Figure 19. Photographs of ZcTag108 during satellite-tagging in August 2020 (top), and at re-sight in July 2023 (middle and bottom).

Figure 20. Photographs of ZcTag054 during satellite-tagging in May 2017 (top) and re-sight in July 2023 (bottom).

Figure 21. Photographs of ZcTag056 during satellite-tagging in May 2017 (top) and re-sight in July 2023 (bottom).

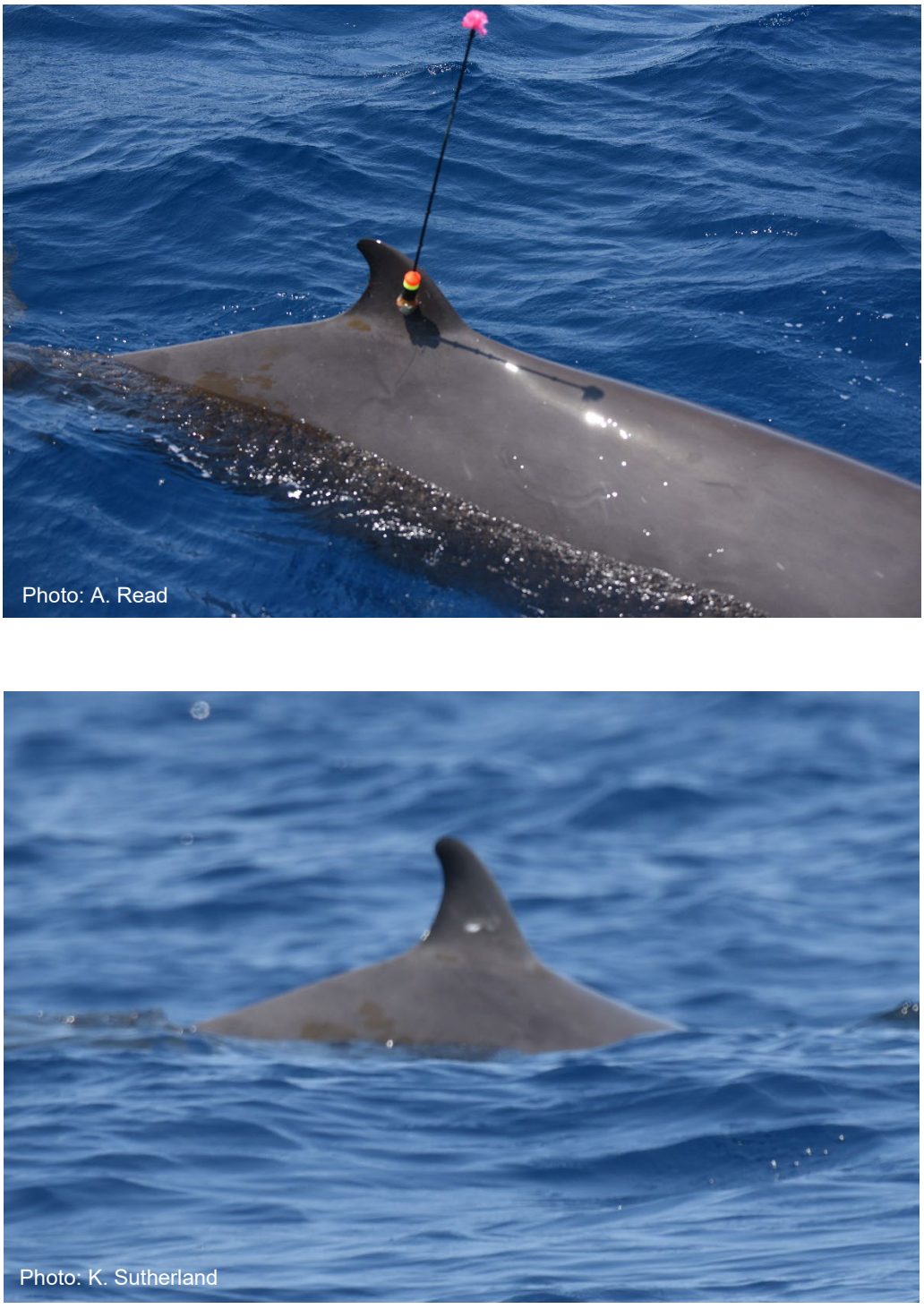

Figure 22. Photographs of ZcTag081 during satellite-tagging in August 2018 (top) and re-sight in July 2023 (bottom).

Figure 23. Photographs of ZcTag132 during satellite-tagging in August 2022 (top) and at re-sight in July 2023 (middle; bottom).

Figure 24. Photographs of ZcTag096 during satellite-tagging in August 2019 (top) and at re-sight and re-tagging (ZcTag112; middle) and at second re-sight in August 2023 (bottom). Note the presence of two sets of healed scars in the bottom image.

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3. References

Coomber, F., A. Moulins, P. Tepsich, and M. Rosso. 2016. Sexing free-ranging adult Cuvier's beaked whales (*Ziphius cavirostris*) using natural marking thresholds and pigmentation patterns. *Journal of Mammalogy* 97(3):879–890.

Coomber, F.G., E.A. Falcone, E.L. Keene, G. Cárdenas-Hinojosa, R. Huerta-Patiño, and M. Rosso. 2022. Multi-regional comparisons of scarring and pigmentation patterns in Cuvier's beaked whales. *Mammalian Biology* 102:733–750.

Foley, H.J. 2018. Spatial ecology and movement patterns of deep-diving odontocetes in the western North Atlantic ocean. Master of Science thesis, North Carolina State University, Raleigh, NC.

McLellan, W.A., R.J. McAlarney, E.W. Cummings, A.J. Read, C.G. Paxton, J.T. Bell and D.A. Pabst. 2018. Distribution and abundance of beaked whales (Family Ziphiidae) off Cape Hatteras, North Carolina, U.S.A. *Marine Mammal Science* 34(4):997-1017.

Rosso, M., M. Ballardini, A. Moulins, and M. Wurtz. 2011. Natural markings of Cuvier's beaked whale *Ziphius cavirostris* in the Mediterranean Sea. *African Journal of Marine Science* 33(1):45–57.

Southall, B.L, W. Cioffi, H. Foley, C. Harris, J. Joseph, N. Quick, T. Margolina, M. McKenna, D. Nowacek, A.J. Read, R. Schick, Z.T. Swaim, D.M. Waples, and D.L. Webster. 2024. *Atlantic Behavioral Response Study (BRS): 2023 Annual Progress Report*. Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Systems Command Atlantic, Norfolk, Virginia, under Contract No. N62470-15-D-8006, Task Order 20F4029, issued to HDR Inc., Virginia Beach, Virginia. April 2024.

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