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Short Note

Sperm Whale (*Physeter macrocephalus*) Behavioral Events Observed During Aerial Surveys in the New York Bight, 2017-2020

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Sperm whales (*Physeter macrocephalus*) in the U.S. Atlantic Exclusive Economic Zone (EEZ) are associated primarily with deeper offshore waters over the continental shelf edge, continental slope, and mid-ocean regions (Cetacean and Turtle Assessment Program [CETAP], 1982; Kenney & Winn, 1987; Wong & Whitehead, 2014; Estabrook et al., 2021). They have been observed in shallower shelf waters off the northeast U.S., including in waters off Montauk Point in the New York Bight (NYB) (Scott & Sadove, 1997). The NYB, an ecologically rich region off the Atlantic coast between New Jersey and Montauk Point (Long Island), New York, includes waters extending from shore to the continental shelf, slope, and abyssal plain. The NYB contains unique features such as the Atlantic coast's largest submarine canyon, the Hudson Canyon. Sperm whales are known to occur in the NYB from older studies (CETAP, 1982; Scott & Sadove, 1997); and, more recently, sperm whale occurrence or detection data have been obtained from shipboard, acoustic, or aerial studies in New York. These include Atlantic Marine Assessment Program for Protected Species (AMAPPS) acoustic and visual aerial surveys (Palka et al., 2021), the New York State Research and Development Authority (NYSERDA) digital aerial surveys (NYSERDA, 2021), and the New York State Department of Environmental Conservation (NYSDEC) visual aerial (Zoidis et al., 2021) and acoustic (Estabrook et al., 2021) surveys.

Overall, as compared to baleen whales, few previous NYB studies have focused on sperm whale behaviors. As a result, sperm whale sociality, conspecific or intraspecific interactions, and behaviors in the NYB have been only minimally described (CETAP, 1982; Scott & Sadove, 1997), which has resulted in a deficient understanding of this species' use of the region for management and conservation planning at state and federal levels. This short note builds on the recent distribution, density, and abundance data presented for large whales in Zoidis et al. (2021) but focuses on a subset of sperm whale behavioral observations in the NYB derived from the 3 y of systematic line-transect monthly aerial surveys, contributing new and useful information on regional sperm whale behaviors.

The NYB Large Whale Aerial Monitoring Program, conducted from March 2017 through February 2020 (see Zoidis et al., 2021, for survey methods, study area maps, and detailed findings), consisted of monthly aerial surveys covering 15 transect lines. Surveys were flown using a small high-wing, twin-engine, six-seat aircraft (Partenavia P68-C) with bubble windows. Flights were conducted at a target altitude of 305 m and groundspeed of 100 to 110 kts when the Beaufort Sea State (BSS) was 5 or lower. For all marine mammal sightings, detailed descriptions of group numbers, age classes, behaviors, position relative to the aircraft, and reaction/no reaction to the aircraft as well as other parameters were noted using *Mysticetus™*, a data collection software. Additional data were collected from a running video camera (Sony Digital 4K recorder; Sony Corporation, Minato City, Tokyo, Japan). A Canon EOS 40D still camera with a Canon EF 100-400 mm f/4.55.6L IS II USM lens (Canon Inc., Tokyo, Japan) was used to take photo-identification photographs; to confirm large whale species identities; to determine factors such as group size, behaviors, or calf presence; and to document unique behaviors.

Behavioral categories were recorded initially at first sighting as an overall behavioral state (i.e., the first observed group behavioral state). Subsequently, additional other behavioral identifiers or more specific modifiers were added for individuals with more detailed activity descriptors such as forage/feed, social, and mating, and with details on discrete behavioral events (e.g., breach, tail slap, movement specifics). The minimum and maximum spacing between nearest individuals within a group in estimated body lengths (BLs) was also noted. All data were keyed into the data collection software. For every sighting, verbal accounts were additionally recorded in real time throughout the observation period using a digital voice recorder with time-stamp capability, with all voices recorded on the aircraft audio system by means of a mini microphone in one earpiece of the headphones worn by each observer. Once species were identified and group counts were obtained, protocols included circling to record detailed descriptions of any unusual aggregate of species or an unusual behavioral display on a case-by-case basis. Circling over sightings to collect behavioral data ended after enough behavioral data were collected and deemed sufficient for describing the unique event or it was deemed necessary to return to line-transect aerial survey protocols based on timing or fuel drivers.

In total, 32 groups (72 animals) of sperm whales were recorded, ranging from a single animal to seven individuals (Zoidis et al., 2021). There were sightings of 18 individual sperm whales, five pairs (including mother–calf pairs), and nine groups of three or more individuals (including mother–calf pairs within the group). The furthest sighting from shore occurred at 222 km, at the offshore edge of Hudson Canyon.

Sperm whale behavioral observations reported herein that are newly described for the NYB include a rosette formation, a phalanx (shoulder-to-shoulder) formation, nursing behavior, and an entangled individual. Sociosexual behavior also was observed and is reported separately (Rickard et al., 2022). All the animals from the sightings reported herein were coded as not reacting to the aircraft; in all cases, no reactions were observed or considered to occur by a group or any individuals as a result of the plane based on protocols for such assessments and decades of behavioral observer experience. Studies have shown that sperm whales behave differently geographically. It is known, for example, that female sperm whales from different ocean basins present different social structures (likely due to differences in predation pressure; Whitehead et al., 2012). This survey effort provided an opportunity to investigate sperm whale activities in mid-Atlantic waters.

Rosette Formation

On 8 August 2018, a group of seven sperm whales (6 adults and 1 juvenile) considered to be a female social grouping unit (Gero et al., 2013) was recorded at 2,000 m depth and 160 km from shore in a BSS of 3. The individuals in the group were within one or two BLs of each other in variable orientations both horizontally and vertically upon initial sighting. The aircraft circled this group and observed the animals for 21 min from 1145 to 1226 h (EST), taking photographs and recording behaviors. Behaviors and orientations changed constantly throughout the observation; highlights of these movements are described below. The sperm whale group formed a dynamic rosette pattern with a tail-out/head-in formation, touching or in close proximity to each other (within 1 BL). Variations included periods of all seven individuals in a circle at the surface horizontally; two animals outside the others circling the rest of the group with the other five still in a circle; a juvenile in the center with all adults surrounding it (Figure 1b); a mix of some animals horizontal at the surface and some vertical with only heads up while still in a circle; a majority of animals with heads up, alternating closer and then further apart; some animals with mouth open; a semi-circle pattern with some animals underwater; and constantly shifting adjacent individuals attempting to reform the circle. During the sighting and upon post-video and photographic review, it was deemed that the rosette formation was not a reaction to the aircraft at 305 m, but, rather, it was due to the bottlenose dolphins seen shortly (~3 min) after the initial large whale observation.

At 3 min and 24 s into the sighting, a group of 15 adult common bottlenose dolphins (*Tursiops truncatus*) were visible at the surface. As soon as the dolphins were sighted, harassment behavior was recorded with the dolphins charging from varying distances, coming within 1 m of the sperm whales and much closer than one sperm whale BL. They appeared with the sperm whale group for most of the observation period, though alternatingly grouped to one side of the rosette (Figure 1a), moving at times around the circle in a flank formation (Figure 1c), then separating, with individuals changing swim speed, accelerating pace, and approaching again. They moved both between individual sperm whales and throughout or outside the whale group (Figure 2a & b) for the remainder of the 21-min observation period, changing positions and coming at the rosette from various sides. The outcome of this was that the dolphins seemingly prompted the continually shifting rosette pattern.

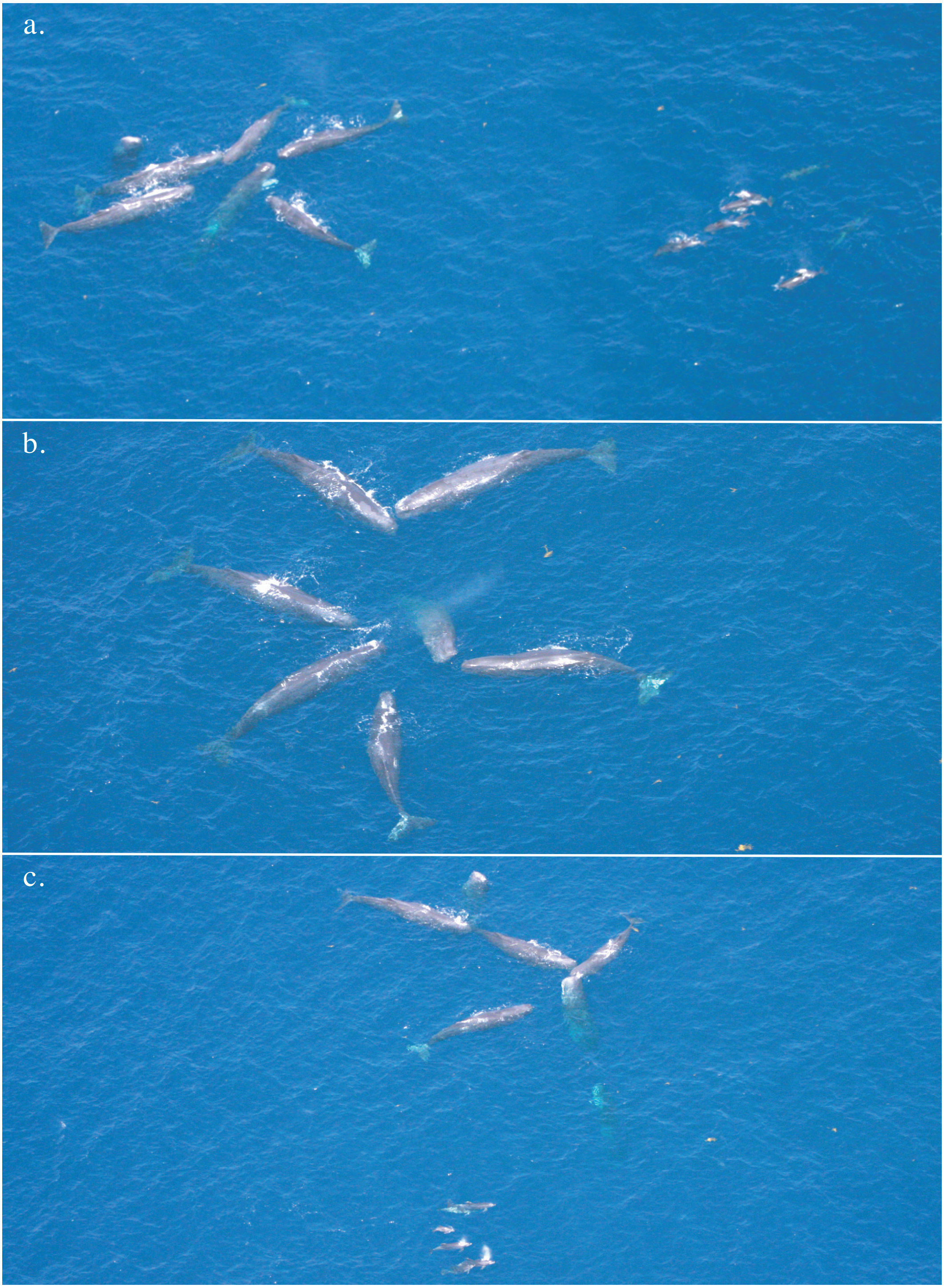

Figure 1. Sperm whales (*Physeter macrocephalus*) observed 8 August 2018 exhibiting the rosette formation: (a) sperm whales (left side) and bottlenose dolphin (*Tursiops truncatus*) group clustered (right side); (b) sperm whale positioning with juvenile in the middle following an interaction with bottlenose dolphins; and (c) dolphin group swimming in flank formation at bottom of photo, circling the sperm whale group. (Photos taken by M. Smultea)

Figure 2. Sperm whales observed 8 August 2018 exhibiting the rosette formation: (a) rosette with dolphins visible to the left of the sperm whales during a close approach interaction; and (b) another close approach interaction with three bottlenose dolphins (including a calf) visible to the right. In both photos, sperm whales were in dynamic movements trying to maintain the rosette. (Photos taken by M. Smultea)

Throughout the entire observation period, all seven whales continually changed positions and orientations such that individual whales altered positions, circle size changed, and BL distances apart were fluid. Dynamic movements throughout the observation period included individual sperm whales observed with their mouths agape (lower jaw extended adjacent to a conspecific), movements of some individuals such that they were observed oriented vertically in the water with one or more proximate animals positioned horizontally adjacent to the vertical animal, or one or two individuals located subsurface yet visible. One pattern observed included breaking the circle with some of the whales turning on their sides forming a semicircle or almost linear pattern briefly then returning to a circle formation (Figure 2a & b). They eventually returned to the rosette formation with heads in and tails outward but with a smaller individual considered to be a juvenile based on its notable size difference at the center of the group (Figure 1b). At 8 min into the observation, two adults from within the group of seven moved out of the rosette for up to 3 min, moving in a circular pattern in an outer circle of the rosette, initially swimming head to tail (head of one animal at the tail of the lead animal), closer than one adult BL with brief (less than 1 min) bouts of touching head to tail or almost touching each other while moving. It was during this interlude that the juvenile was briefly in the center of the rosette (Figure 1b). This latter activity took place during the dolphin harassment and dolphin closest approach, which was within one dolphin BL to one of the sperm whales. During the observation period when the seven sperm whales were at their closest distance from each other with heads pointed in and individuals within less than one sperm whale BL, debris was also observed floating in the water. This was theorized to be regurgitated squid based on appearance and proximity to the mouth of the whales and timeliness during the dolphins' harassment behavior (Whitehead et al., 1990; Smultea et al., 2014). The sperm whales stayed in proximity (< 2 BL) to one another throughout the duration of the observation period. This record reveals the fluidity of sperm whale rosettes.

The rosette formation was first described by Nishiwaki (1962) after observing a sperm whale group circle a harpooned affiliate in a heads-in and flukes-out arrangement resembling the petals of a marguerite flower—a response that seems to occur in the presence of predators, danger, or harassment. Since then, rosette formation as a form of defensive sperm whale behavior has been observed and described in other parts of the world, though not in the NYB. Incidences of smaller odontocetes harassing sperm whales include documentation of false killer whales (*Pseudorca crassidens*), killer whales (*Orcinus orca*), short-finned pilot whales (*Globicephala macrorhynchus*), Risso's dolphins (*Grampus griseus*), and northern right whale dolphins (*Lissodelphis borealis*) harassing or interacting with sperm whales, resulting in a change to behaviors and positions as well as in movements to protect calves. This NYB event shows that bottlenose dolphins also engage in harassment. A short list of geographic examples of odontocete–sperm whale harassment include the following: from the Pacific Ocean (Palacios & Mate, 1996; Smultea et al., 2014; Díaz-Gamboa et al., 2022), Gulf of Mexico (Weller et al., 1996; Fernández et al., 2022), the Caribbean (Dunn & Claridge, 2014), the Falkland Islands (Yates & Brickle, 2007), and Brazil (Sucunza et al., 2022).

The defensive rosette formation behavior has not been previously described from the mid-Atlantic waters of the NYB. Harassment by bottlenose dolphins appears absent in the literature on odontocete–sperm whale interactions, although sperm whales have been documented in association with bottlenose dolphins (Pitman et al., 2001; Wilson & Krause, 2013). CETAP (1982) noted a small percentage of sperm whale sightings (10%) in association with smaller odontocetes, including with bottlenose dolphins, and online video footage of bottlenose dolphin–sperm whale associations exists.

Phalanx (Shoulder-to-Shoulder) Formation

The phalanx or cluster group formation consists of a formation of animals positioned shoulder to shoulder swimming at the same speed in the same direction, moving in unison in a coordinated manner within 100 m of each other (Whitehead & Arnbom, 1987; Whitehead, 1993). During our survey, the phalanx formation was observed on three occasions; dates and specifics are provided in Table 1. Two of these sightings are shown in Figure 3a & b. On all three occasions, the initial behavior state recorded was rest/slow travel, and animals were already in phalanx formation when sighted (vs being a reaction to the aircraft). In the three such events observed during our survey, this formation appeared to be used as a generalized travel formation and not for predator avoidance, which is consistent with other descriptions (e.g., Whitehead, 1985; Pitman et al., 2001; Gemmell et al., 2015). No other notable behaviors were observed concomitant to the phalanx.

Mother–Calf Pair – Nursing

On 26 July 2019, a group of four sperm whales (two mother–calf pairs) separated by greater than three adult BLs were recorded. They were observed 180 km from shore in a BSS of 3 in 2,100-m water depth for 23 min. Initial behavior state for both pairs

Table 1. Phalanx formations and associated survey sighting details; A = adult.

Date	Number of individuals	Observation duration (min)	Beaufort Sea State	Water depth (m)	Distance from shore (km)
11 April 2018	5A	12	1	260	160
27 July 2019	6A	17	5	2,100	180
11 August 2019	7A	14	4	2,000	170

Figure 3. Phalanx group formation observed on (a) 11 April 2018 (*Photo credit:* K. Lomac-MacNair) and (b) 11 August 2019 (*Photo credit:* M. Poster)

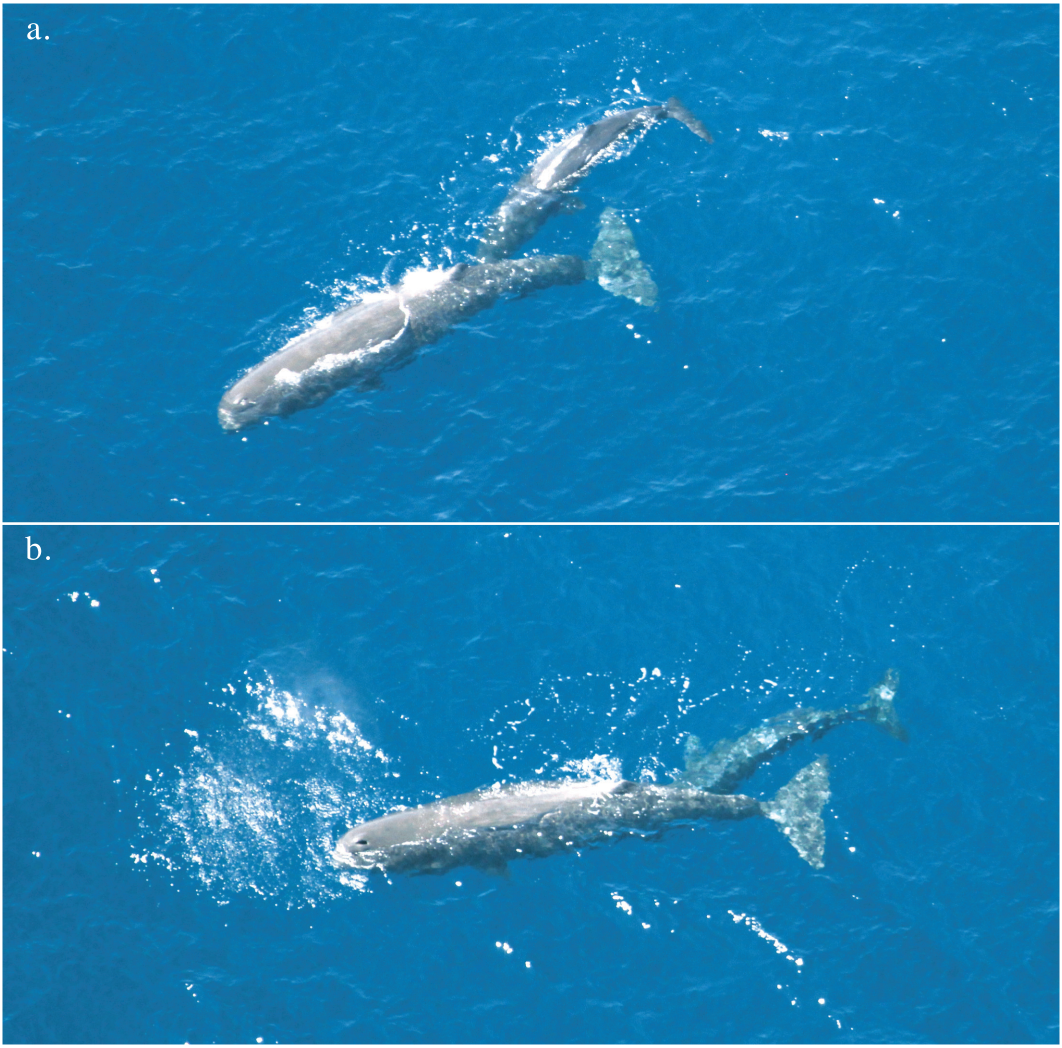

Figure 4. (a & b) Nursing behavior observed on 26 July 2019 (Photos taken by D. Ireland)

was rest/slow travel. Shortly after sighting, nursing behavior was observed and photographed for one of these pairs—the first photo-documentation of such behavior in the NYB. The aircraft circled the nursing pair, and they were focal followed for the entire observation period. The calf was ~1/3 of the size of the mother (Figure 4a & b), positioned in a suckling position throughout the surfacings, with eight separate observed surface respiration bouts by the mother and calf during the 23-min circling of the aircraft.

Upon each surfacing, if the calf was not nursing initially, it promptly returned to the nursing position, always suckling on the same side of the mother. The calf maintained a variable 30 to 45º angle to the mother each nursing bout, underneath her with its head toward the base of the mother's genital area and tail (Figure 4a & b), maintaining right side positioning. This one-sided nursing behavior is known as laterality and has been recorded in other cetaceans, including orcas (Karenina et al., 2013a) and belugas (*Delphinapterus leucas*; Karenina et al., 2013b) or large whale species (e.g., southern right whales [*Eubalaena australis*]; Karenina et al., 2017) and humpback whales (*Megaptera novaeangliae*; Zoidis & Lomac-MacNair, 2017). Very brief (< 1 min) breaks occurred a few times during surfacings for the calf to breath in one or two respirations while the mother was also at the surface in a horizontal position logging during the nursing bouts. Nursing bouts ranged from ~30 s to 2 min. The calf was able to continue nursing during various movements by the mother as she surfaced or stayed subsurface and was still visible to the survey team throughout the observation.

As with Liu et al. (2022), these observations are taken as evidence of the likelihood that these NYB waters are a probable calf rearing location and/or nursing ground for sperm whales. Similar very short large whale calf nursing bout durations have been documented elsewhere (Thomas & Taber, 1984; Würsig et al., 1984; Smultea et al., 2017). Sperm whale calves were noted in the CETAP (1982) study in mid-Atlantic waters in the Gulf of Maine and off Maryland and Virginia with four instances of apparent nursing—three in the spring and one in the summer, similar to our July sighting.

Entanglement

On 16 June 2018, an entangled large, solitary sperm whale, likely an adult male based on head size and body size at an overall length estimated to be ~16 m, was observed in a BSS of 2 offshore. The sighting was at Hudson Canyon at 39° 46' 12.48" and -70° 51' 32.98", roughly 100 nmi from shore at 1,700 m depth (Figure 5). No other sperm whales or other cetaceans were visible throughout the 20-min observation period. Upon first observation, the animal appeared to be deceased due to no observable surface movement coupled with the lack of visible blows for an extended period, unusual surfacing position with only its partial body at surface as if weighed down, and potentially underweight body shape.

We continued to circle the animal after the first sighting. Shallow, short blows were observed roughly 12 min after this sighting. The animal's body then started changing position, either remaining horizontally at the surface (Figure 5a), vertically with the head up and tail down in the water (Figure 5b), or in a partial horizontal position (head and back at surface with tail stock underwater; Figure 5c), with positions alternating back and forth during the aircraft circling period.

Throughout the observation, a large dark black mass, which appeared to be a large fish tote with portions of the object assumed to be net underwater (Figure 5a-c), roughly the size of the animal's head, was visible next to the head near the jaw. This was later identified to be a large plastic tote and fishing net that was entangled in the lower jaw of the animal. When the sperm whale was head up with only the head visible and the body and tail down, which occurred several times during our observations such that the lower jaw and entanglement were clearly visible to the observers, the animal was seen rotating around clockwise. At times, this rotation movement moved the human-made object just under the surface, but it was still visible (Figure 5c). We conjectured this type of movement may have either resulted from the animal being weighed down by the object or that it was a result of the wrapping motion known from other cetacean entanglements (Benjamins et al., 2012; Howle et al., 2019).

During the entire period, the animal remained solitary, and no behaviors were noted other than the change from horizontal/partial horizontal at the water surface to only the head visible at the surface with rotational vertical movement. The event was reported to the National Oceanic and Atmospheric Administration's Northeast Fisheries Science Center Stranding Hotline. Upon review, it was considered unlikely that the animal would be reached by a disentanglement response team due to its recorded distance offshore.

Entanglement and ingestion of marine debris is a recognized cause of marine mammal mortality (Laist et al., 1997; Simmonds, 2017) and has been correlated with sperm whale deaths in other areas (Haase & Félix, 1994; Pace et al., 2008; Jacobsen et al., 2010). Incidences of entanglement in fishing gear in the NYB have been reported for fin (*Balaenoptera physalus*), humpback, and minke (*Balaenoptera acutorostrata*) whales (Stepanuk et al., 2021).

Conclusions

To date, there has been a paucity of sperm whale behavioral observations from the NYB; few publications report detailed sperm whale behaviors in the region. This is likely due in part to their ecology and behavior; they frequently, though not exclusively, occur further offshore in deeper waters (CETAP, 1982; Whitehead et al., 1992) and have long foraging dives (Watwood et al., 2006), keeping them out of view under the surface for extended periods. A lack of behavioral sighting opportunities also arises from the challenges of surveying in offshore areas throughout the year. Offshore pelagic waters are generally difficult to access by vessels—especially in winter; and focal animal aerial survey efforts are expensive (Stanistreet et al., 2018). Obtaining detailed behavioral observations of large whales requires flexible survey designs that allow for circling (from aircraft), going off effort, and pausing line-transect observations (vessel or aircraft), plus there is a time cost in waiting for animals to resurface. Frequently, there is insufficient survey opportunity to catalogue behaviors or expend effort documenting unusual events. Aerial surveys provide a unique advantage with the ability to survey a large area in a short period of time with the potential to pause for focal observations. Furthermore, aerial surveys can document species and their behavior from an overhead "bird's eye" vantage point.

Figure 5. A sperm whale entangled in fishing gear on 17 June 2018: (a) with gear shown on the left side of the head while animal was horizontal at surface; (b) gear shown near the lower jaw as the whale was vertically rotating with chin up; and (c) movement of gear down the back as animal continued to rotate in partial vertical position. (Photos taken by K. Lomac-MacNair)

Descriptions of sperm whale behavioral events from this aerial platform, not previously described in the NYB, provide a glimpse into how these large whales use these waters. This subset of behavioral observations obtained during a 3-y survey contributes to our general understanding of sperm whale behavior, and specifically to behaviors as part of their ecology in the NYB. The photo-documentation of nursing is a first record for the NYB. The entangled sperm whale provides a stark example of the anthropogenic risks to large whales in the U.S. mid-Atlantic waters. The observational data presented herein provide a foundation for future focal sperm whale behavioral studies that may be conducted from vessel or aerial platforms in these waters, and these descriptive events provide valuable data for a fuller understanding of sperm whale activities in this area and a richer view of sperm whales found in these mid-Atlantic waters.

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