Mid-Atlantic Humpback Whale Photo-Identification Efforts: 2022/23 Annual Progress Report

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Dorsal fin and fluke images of humpback whale (*Megaptera novaeangliae*) HDRVAMn003. Cover photographs collected by Amy Engelhaupt and Jessica Aschettino, taken under National Marine Fisheries Service Scientific Research Permit No. 21482, issued to Dan Engelhaupt, HDR Inc.

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Acronyms and Abbreviations

API	application programming interface
ID	identifications or identification number
km	kilometer(s)
LiDAR	Light Detection and Ranging
m	meter(s)
MAHWC	Mid-Atlantic Humpback Whale Catalog
MGEL	Marine Geospatial Ecology Lab
MINEX	Mine Neutralization Exercise
NAHWC	North Atlantic Humpback Whale Catalog
NAVFAC LANT	Naval Facilities Engineering Systems Command Atlantic
OBIS-SEAMAP	Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations
OPAREA	Operating Area
photo-ID	photo-identification
UME	Unusual Mortality Event
U.S.	United States
VACAPES	Virginia Capes Operating Area
VAQF	Virginia Aquarium & Marine Science Center Foundation

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1. Introduction and Background

Photo-identification (photo-ID) efforts on humpback whales (*Megaptera novaeangliae*) off Virginia began during the early 1990s, with shore-based counts in 1991 and vessel-based efforts in 1992 led by researchers from what is now the Virginia Aquarium & Marine Science Center Foundation (VAQF) (Swingle et al. 1993). Using fluke and dorsal fin images (Katona and Whitehead 1981), individual whales were recognized and cataloged. Photographs collected from whalewatch vessels and stranded animals comprised the majority of photo-IDs available for this area (Wiley et al. 1995, Barco et al. 2002). Images of humpback whales were compared with catalogs from other regions, and individuals were shown to match known whales from the Gulf of Maine, Gulf of St. Lawrence, and Newfoundland (Barco et al. 2002).

Beginning in January 2015, HDR Inc. has been monitoring humpback whales to assess their occurrence, habitat use, and behavior within and near United States (U.S.) Navy training and testing areas off Virginia, first via the Mid-Atlantic Humpback Whale Monitoring Project, and now via the Mid-Atlantic Nearshore and Mid-shelf Baleen Whale Monitoring Project, which is an evolution of the initial efforts with a greater focus on mid-shelf waters and all baleen whale species. The humpback whale field season off Virginia Beach runs from approximately the end of October through March, typically concentrated between December and February, with smaller numbers of sightings occurring outside this timeframe. Since the inception of the Mid-Atlantic Humpback Whale Monitoring Project, nine field seasons have occurred, with a focus on photo-ID, biopsy sampling, and tagging using medium-resolution satellite tags and high-resolution suction-cup tags, as well as on drone-based photography for length and body-condition assessments. This report will focus on the results from the photo-ID and drone efforts, and details about tagging and biopsy sampling are provided in Aschettino et al. (2024).

With the influx of photo-ID data accumulating from the Mid-Atlantic Humpback Whale Monitoring Project, multiple local whale watches operating within the area, and historical sightings and strandings data being housed in non-digital format, a need was identified to integrate and manage photo-ID data from these various sources more effectively. In 2017, the Mid-Atlantic Humpback Whale Catalog (MAHWC) was established by researchers from the VAQF with funding support from U.S. Fleet Forces Command, managed by Naval Facilities Engineering Systems Command Atlantic (NAVFAC LANT) as part of the U.S. Navy's Marine Species Monitoring Program (Mallette and Barco 2017). VAQF maintained the role as catalog curator for over 4 years, working closely with the Marine Geospatial Ecology Lab (MGEL) at Duke University to develop and model the catalog after the Mid-Atlantic Bottlenose Dolphin Catalog (Urian at al. 1999), which is hosted on the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP; http://seamap.env.duke.edu; Halpin et al. 2006, 2009; Fujioka et al. 2014) platform. Beginning in 2023, HDR Inc. and NAVFAC LANT took on the curator role for the catalog, and additional funding was provided to Duke University to convert the older 32-bit Microsoft Access database to a newer 64-bit database. Additional funding was also provided to Happywhale (Cheeseman et al. 2022) to allow for the integration of their animal identification algorithm into the database.

During HDR Inc.'s 2022/23 field season, baleen whale sightings included humpback whales, North Atlantic right whales (*Eubalaena glacialis*), and fin whales (*Balaenoptera physalus*). This report will focus on results from the humpback whale sightings only. See Aschettino et al. 2024 for further information and details from the North Atlantic right whale and fin whale photo-ID efforts.

2. Methods

The study area for this project includes waters within and around the mouth of Chesapeake Bay; the W-50 Mine Neutralization Exercise (MINEX) region off Virginia Beach; and, beginning with the 2020/21 field season, the mid-shelf region of the Virginia Capes Operating Area (VACAPES OPAREA) (**Figure 1**). Details of overall survey methods are outlined in Aschettino et al. 2024.

2.1 Photo-ID

Photographs were collected in the field using a digital single-lens reflex camera (Canon 7D, 7D Mark II, or 1DX Mark II) or a mirrorless camera (Canon R5) with a zoom lens (Canon 100- to 400-millimeter or Canon 100- to 500-millmeter). Photographs were post-processed using ACDSee (Versions 7–9) by cropping the best image of each individual whale's dorsal fin (left and right) and tail flukes (when obtained).

Photographs were assembled into a project catalog managed by HDR Inc., in which each new whale was assigned a unique identifier using the naming convention "HDRVA," followed by the two-letter abbreviation for the scientific name of the species, followed by a numerical sequence of three numbers (e.g., HDRVAMn001). Each whale was then compared with the others. At the end of the 2014/15 field season and at the end of the 2022/23 season, images of humpback whale flukes were submitted to Allied Whale for comparison to the North Atlantic Humpback Whale Catalog (NAHWC). Images of humpback whale dorsal fins and flukes were submitted to the VAQF for comparison with the Gulf of Maine Humpback Whale Catalog (curated by the Center for Coastal Studies) and integration into the MAHWC (Mallette and Barco 2019), prior to the 2021/22 season. Subsequent seasons were integrated into the MAHWC by HDR Inc. and NAVFAC LANT curators. Images of humpback whales from all seasons were annually compared with images from local whale-watch operation Rudee Tours, and images through the 2021/2022 season were compared with Gotham Whale (Brown et al. 2022).

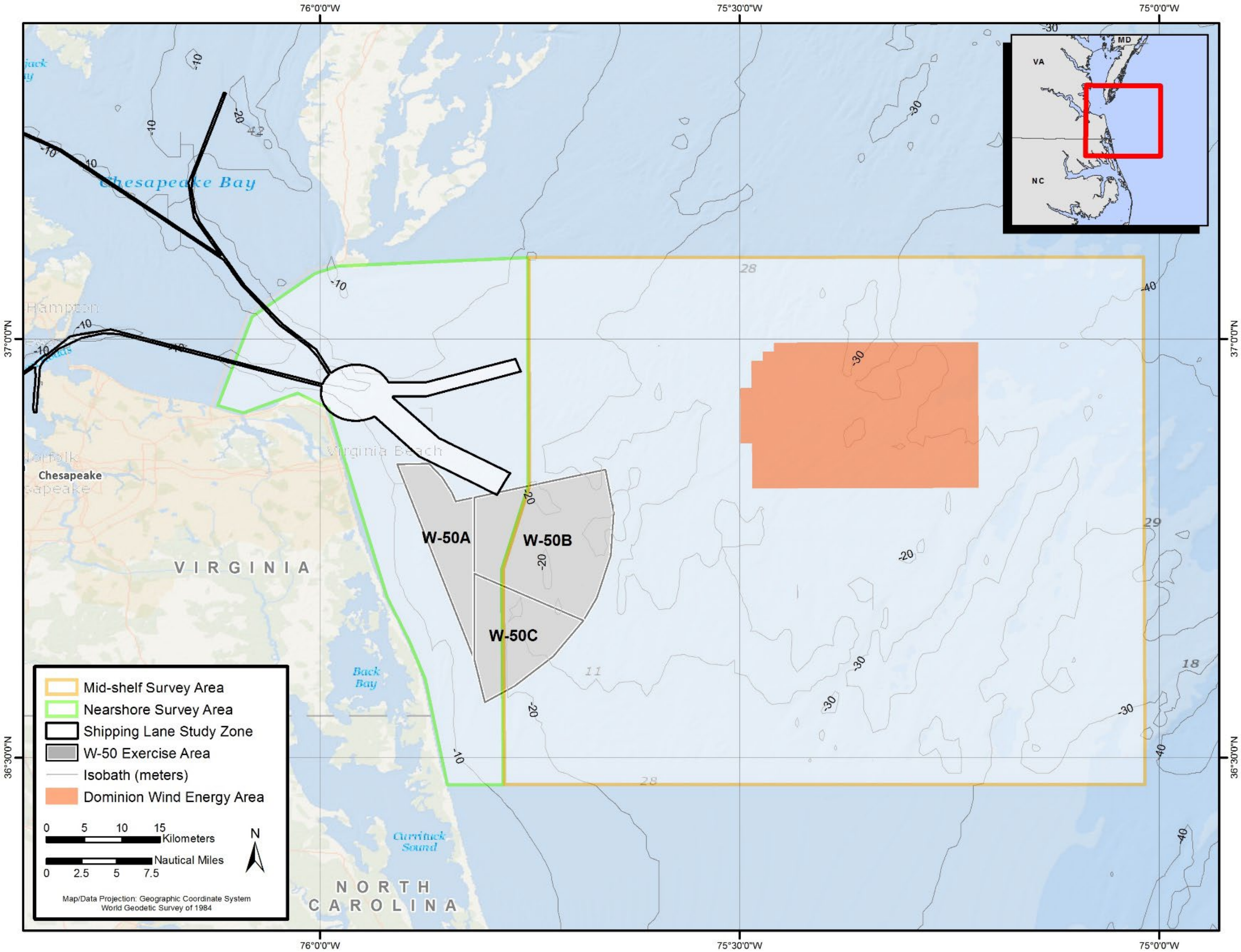

Figure 1. Map of the nearshore and mid-shelf study area, which includes waters within and around the mouth of Chesapeake Bay shipping lanes, the W-50 MINEX region off Virginia Beach, and the Dominion Wind Energy Area.

2.1 Mid-Atlantic Humpback Whale Catalog and Happywhale

Beginning in 2023, HDR Inc. and NAVFAC LANT took on the curator role for the MAHWC. Curator training protocols had been preliminarily developed by personnel from VAQF (Mallette and Barco 2017); however, extensive revisions were required to update the document based on recent updates to the structure and functionality of the catalog. With input from Ei Fujioka and Kim Urian of Duke University, the document was amended in 2023 and will act as a resource for future catalog curators.

To aid researchers in managing their data and images, OBIS-SEAMAP hosts an online framework for viewing fin and fluke images, mapping sighting locations, and matching individuals across projects or locations (Halpin et al. 2009). The framework is tied to a Microsoft Access database, so that updates made to the database can then be pushed to the online platform where users can view the MAHWC, with authorized users (i.e. those who have been assigned as contributors or collaborators) having login credentials. The curator handbook provides detailed information regarding how to enter photographs and associated metadata into the database, as well as how to work within the OBIS-SEAMAP platform. When the MAHWC was first established, it was built on a 32-bit platform. However, in order to perform on most computers, it was necessary to upgrade the system to a 64-bit platform.

Happywhale.com is a citizen science platform that allows any user to upload image(s) of whales to gain information on where that whale had been previously seen. An artificial intelligence-based automated image recognition algorithm was developed for humpback whale flukes, which constitutes the majority of the image types available on Happywhale. Currently, 95,917 individuals are in the humpback whale database, of which 9,333 are from the North Atlantic and Atlantic Arctic.

OBIS-SEAMAP and Happywhale have established a data exchange mechanism where Happywhale's encounter records and associated images are imported into the OBIS-SEAMAP database at a scheduled interval (currently monthly). In order to integrate the Happywhale machine-learning, animal-identification algorithm into the MAHWC, Happywhale developed a web component containing essential features of the animal identification algorithm, and MGEL incorporated the web component into the MAHWC. Any humpback whale fluke photographs entered into the MAHWC can therefore be matched using fast, accurate, automated image recognition (Cheeseman et al. 2022) against a known set of individuals. So the known set of individuals is as useful and relevant to the MAHWC as possible, Happywhale hosts and maintains a humpback whale fluke photo-ID catalog containing representative fluke photographs of all available, known, MAHWC individuals as well as fluke images of all available North Atlantic individuals from research collaborators and citizen science sources.

2.2 Drone and Photogrammetry

The use of a drone was incorporated into the field effort beginning in the 2018/19 field season. A DJI Phantom 4 Pro V2.0 was used to collect morphometric data and assess overall body condition. In the field, live video was also used to assist the research team during tagging attempts to maximize successful deployments. Data were typically collected at flight heights between 15 and 30 meters (m), depending on the behavior of the focal animal during the time of the encounter. The drone collected 4K ultra-high-definition video at 30 frames per second. Initial measurements were made from data using altitude values from the drone's stock barometer, although some error is expected with this method. HDR Inc. used open-source software developed by researchers at Duke University (Torres and Bierlich 2020) to calculate lengths.

Following the methodology described in Dawson et al. (2017), the DJI Phantom 4 Pro V2.0 was retrofitted with a custom Light Detection and Ranging (LiDAR) (Lightware SF11) altimeter in 2020. This upgrade increases precision (to within 5 centimeters) and consistency of the drone altimetry measurements to minimize possible error in estimated animal lengths. Attribute-grading criteria for images, based on Christiansen et al. (2018), were used to assess drone still images for data collected during the 2021/22 and 2022/23 season. Images were assessed for six of the seven attributes, including camera focus, body straightness, body roll, body arch, body pitch, and body length measurability. Each attribute was scored as either a 1 (good), 2 (medium), or 3 (poor). Any image receiving a score of 3 for any of the six attributes or a 2 for both roll/arch, roll/pitch, or arch/pitch, would be removed from analysis based on Christiansen et al. (2018). However, due to limited screen grabs from some flights/individuals, the best photograph of each whale was selected for measuring, despite the potential for exclusion from analysis based on the criteria scores.

Age class of humpback whales were assigned based on subjective size assessments from the research vessel. The length of the HDR Inc. research vessel was often used for reference in making these subjective assessments. For example, individuals that were estimated to be approximately the length of the vessel (8.8 m) or smaller were typically classified as juveniles, whereas individuals that appeared longer than the research vessel were typically classified as sub-adults or adults. Although not precise, these estimates roughly fall in line with the estimated length at weaning of 8.0 m (Rice 1963) and length at sexual maturity starting at 11.0 m for humpback whales (Nishiwaki 1959). Furthermore, Stevick (1999) reported lengths of stranded humpback whales of known age and 16 individuals under 5 years of age measured 8.5-12.5 m in length (mean=10.2 m) and 7 individuals aged 7-17 years of age measured 12.8-14.2 m in length (mean=13.2 m).

3. Results

3.1 Photo-ID

The first survey for the 2022/23 field season occurred on 21 November 2022, and the last survey occurred on 06 March 2023. In total, 24 vessel surveys were conducted, covering 3,379 kilometers (km) of trackline with more than 185 hours of effort (Aschettino et al. 2024). In total, 49 baleen whale sightings, including 33 humpback whale sightings composed of 48 individuals, 9 North Atlantic right whale sightings composed of 36 individuals, and 7 fin whale sightings composed of 13 individuals, occurred during the 2022/23 field season. Details from the North Atlantic right whale and fin whale photo-ID efforts are included in Aschettino et al. (2024).

The 33 sightings of humpback whales during the 2022/23 season included 48 total individuals and resulted in 36 unique humpback whales identified using dorsal fin and fluke images. An additional humpback was also seen during the Outer Continental Shelf Cetacean Study surveys in March 2023 (Engelhaupt et al. 2024) bringing the total identified for the 2022/23 season to 37 (**Figure 2**; **Appendix A**, **Table A-1**).

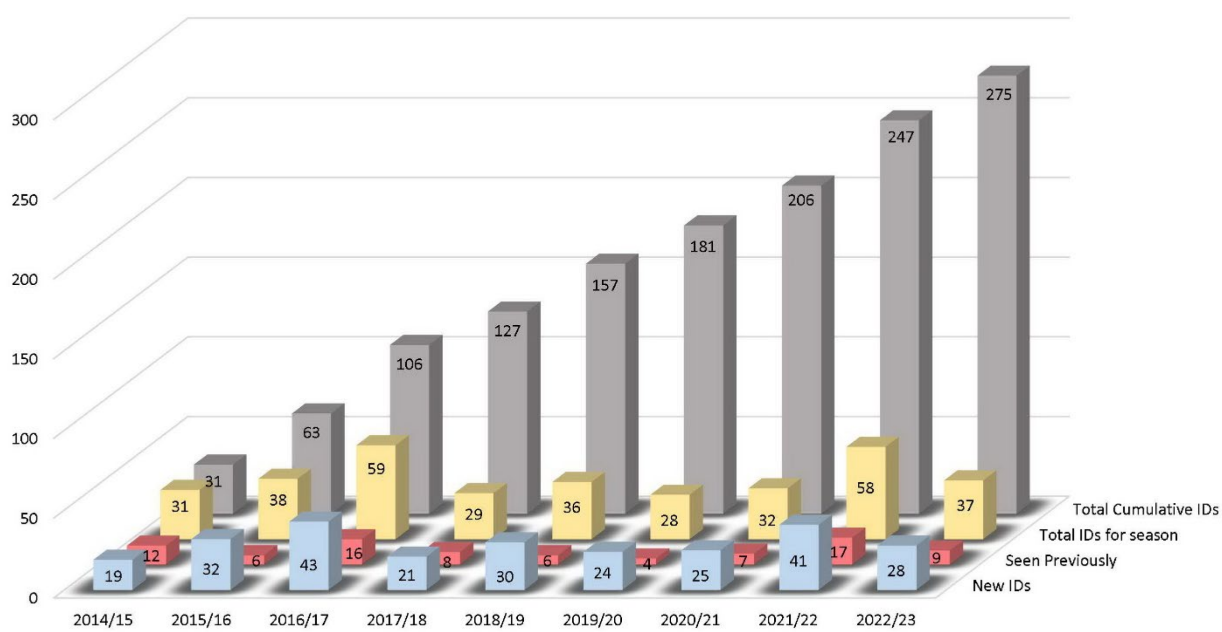

Figure 2. Humpback whale identifications (ID) over nine field seasons within the Virginia study area (yellow bars = total number of IDs each season; red bars = number of those IDs seen in previous seasons; blue bars = number of new IDs added to catalog; gray bars = total number of cumulative unique IDs).

Of the 37 unique humpback whales seen during the 2022/23 season, 10 (27.0 percent) were categorized as juveniles based on their estimated size in the field, 1 (2.7 percent) was classified as a juvenile/sub-adult, 5 (13.5 percent) were classified as sub-adults, 9 (24.3 percent) were classified as sub-adults/adults, and 8 (21.6 percent) were classified as adults. Nine (24.3 percent) of the 37 individuals were re-sights to HDR Inc.'s catalog; 1 individual had not been seen since the initial 2014/15 season (HDRVAMn004), and the remaining re-sights included individuals from four of the eight previous field seasons. The additional 28 whales were new individuals added to the growing project catalog, which, to date, has 275 unique humpback whales, inclusive of identifications added from previous bottlenose dolphin density surveys (2012-2015) (Engelhaupt et al. 2016) and the Outer Continental Shelf Break/VACAPES Offshore Cetacean Study ongoing since 2016 (**Figure 2**; **Appendix A**, **Table A-1**).

Only 5 of the 37 humpback whales (13.5 percent) were seen on more than 1 occasion during the 2022/23 season, and only 1 of those was seen on 3 or more occasions. Within-season re-sightings spanned 0.8 to 45.2 days apart (mean = 15.0 days; median = 6.0 days). This is down from most previous seasons—38.6 percent during 2021/22; 42.9 percent during 2019/20; 44.7 percent during 2018/19; 21.9 during 2017/18; and 69.5 percent during 2016/17—but comparable to the 2020/21 season (12.9 percent). For all humpback whales sighted since the beginning of this project, 136 individuals (49.5 percent) have only been seen on 1 occasion, whereas the remaining 139 individuals (50.5 percent) have been observed on 2 or more occasions (**Table 1; Appendix A**, **Table A-1**). The majority of humpback whales (229, 83.3 percent) were only seen during one field season (**Table 2; Appendix A**, **Table A-1**). However, 46 individuals (16.7 percent) were seen for two or more field seasons (**Table 2; Appendix A**, **Table A-1**). Including all years of data, individuals that were re-sighted within the same season (excluding same-day re-sightings) were seen 0.8 to 98.9 days from the initial sighting (mean = 24.7 days; median = 20.1 days).

Table 1. Frequency distribution of the number of sightings of photo-identified humpback whales since 2015.

Number of sightings	Number of individuals
1	136
2	60
3	21
4	25
5	9
6	6
7	3
8	4
9	3
11	4
14	1
17	1
18	1
21	1
Total	**275**

Table 2. Frequency distribution of the number of seasons photo-identified humpback whales were seen since 2015.

Number of seasons seen	Number of individuals
1	229
2	28
3	10
4	4
5	4
Total	**275**

Evidence of human interaction, either presumed line-entanglement scars (**Figure 3**) or propeller scars (**Figure 4**), was apparent on at least 28 of the 275 (10.2 percent) cataloged humpback whales and 6 individuals are known to be deceased (**Appendix A**, **Table A-1**).

Figure 3. Cataloged humpback whale HDRVAMn179 with an apparent line entanglement scar in front of the leading dorsal hump.

Figure 4. Cataloged humpback whale HDRVAMn222 with apparent propeller scarring along the body's right side.

3.2 Mid-Atlantic Humpback Whale Catalog Development and Happywhale Integration

Developers at MGEL converted the older 32-bit MAHWC Microsoft Access database to a newer 64-bit database in order to make the catalog compatible with newer Windows operating systems. The online catalog, hosted on OBIS-SEAMAP, was also modified so that contributors and curators of the MAWHC can interact with Happywhale using an identification application programming interface (API).

The workflow between the online MAHWC and Happywhale is as follows:

1. Contributors or curators submit a fluke image using the Happywhale web component within the OBIS-SEAMAP MAHWC online platform.
2. Happywhale accepts the images and puts them through its animal identification algorithm.
3. The results of the identification task are returned to and visualized on the web component. Up to five proposed matches are shown, with an associated score for each image ranked from 0 to 1, higher score indicating a more likely match. In the event that an image is uploaded that already exists in Happywhale, the API returns with a score of “1”: an exact match.
4. Contributors or curators review the proposed matches and pick the correct match or reject it. When a match is chosen, the Happywhale’s Animal identifier is assigned to the MAHWC animal and saved in the MAHWC database only.

Happywhale’s identification API is now available on the OBIS-SEAMAP MAHWC platform (**Figure 5**).

During the study year, HDR Inc. worked on updating the curator-training protocols and learning the Microsoft Access database and OBIS-SEAMAP portion of the MAHWC. The database was updated with all of HDR Inc.’s sighting records and humpback whale images through the end of the 2022/23 season. Images included the best dorsal fin and fluke image, comprehensive of every sighting of a given whale. Details of biopsy status, tag status, and gender (if known) are included within the MAHWC and are viewable to all authorized users with a login.

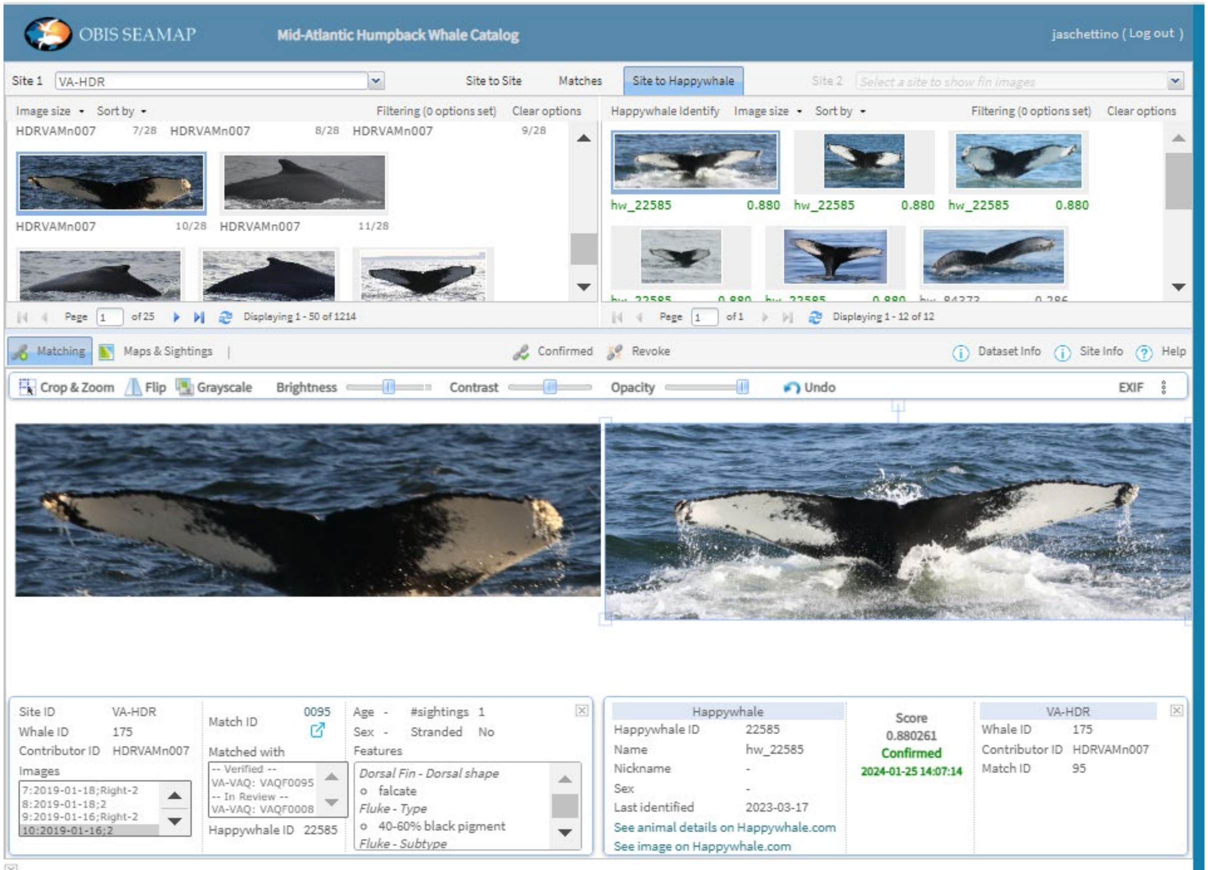

Figure 5. The API within the OBIS-SEAMAP MAHWC returns match suggestions. In this example, HDRVAMn007 was matched with the Happywhale animal 22585 with a score of 0.880261.

The best fluke image available for each of HDR Inc.'s cataloged whales and associated metadata were also uploaded separately to Happywhale in order to make publicly available all of the whales sighted during survey efforts. Starting with images collected during the 2021/22 season, dorsal fins were added as well (Happywhale will begin using another algorithm for dorsal fin matching in the future). In total, 243 individual whales were added to Happywhale, and 199 of those individuals yielded match records (**Appendix A**, **Table A-1**). Whales were matched to feeding grounds in waters off the northeastern U.S., Canada, and Iceland, and were also matched to breeding grounds off the Dominican Republic and the Turks and Caicos Islands (**Figure 6)**. Matches within the Mid-Atlantic, including Virginia, New York, and New Jersey, were also made; in fact, some whales were only matched within Virginia and not to outside areas.

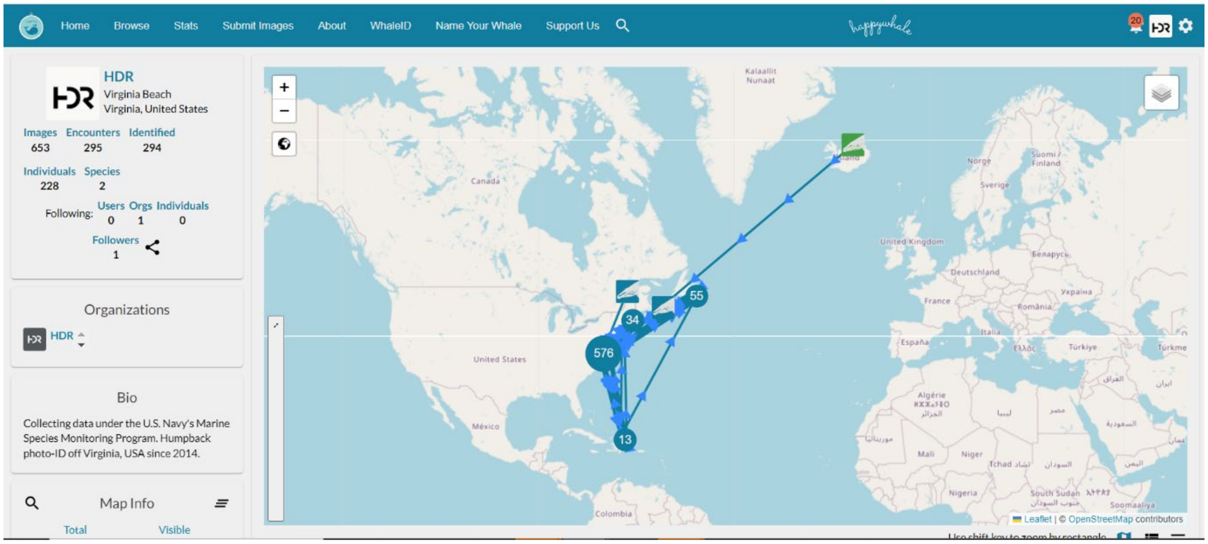

Figure 6. Connections from humpback whales observed during HDR Inc.'s surveys. Note sightings to feeding grounds, breeding grounds, and as far east as Iceland.

Within Happywhale, all users maintain rights to their data; however, the data are openly accessible to view and explore. Within the HDR homepage on Happywhale, all individual humpback whales observed during HDR Inc. surveys are viewable. The user can click on any given whale to see whether that individual has been seen within other areas. As an example, HDRVAMn272 was first seen in August 2012 within the Newfoundland and Labrador, Canada region (Captain Wayne's Excursions, Deb Young). The most recent sighting was in February 2024 in the Dominican Republic (Moto Marina Tours, David Martin Buglass) (**Figure 7**). The number 4 (on **Figure 7**) shown off Canada's east coast indicates that four different sightings have occurred within that region (three sightings by Captain Wayne's Excursions and one sighting by Molly Bawn Whale and Puffin Tours, Jeannine Winkel). Users can make additional comments or notations. For example, under this individual whale's "bio" section, it is noted she is a known female due to observations with a calf (Captain Wayne's Excursions, Deb Young).

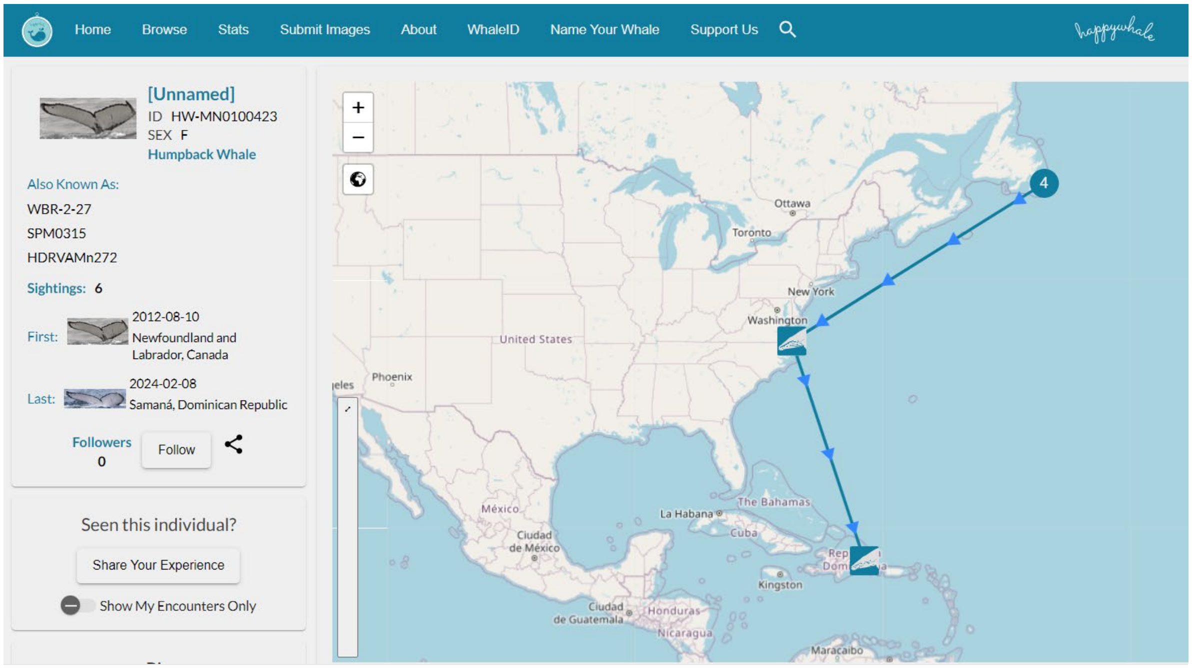

Figure 7. Sighting history of individual humpback whale HDRVAMn272, seen off Newfoundland and Labrador, Canada, Virginia, U.S., and Samaná, Dominican Republic.

3.3 Drone Photogrammetry Results

Drone video was collected on numerous humpback whales and was used to observe behaviors, look for potential entanglements or injuries that would not be apparent from the vessel, assist with tagging approaches, and record video that could then be used to measure body length. The lengths of 70 individuals have been calculated to date (data from December 2018 through December 2022) (see Aschettino et al. 2023: Table 3**; Table 3; Figure 8**). Each of these whales has a unique identifier in the catalog. Body length measurements of whales seen before the 2021/22 season can be found in Aschettino et al. 2023. Between November 2021 and December 2022, 33 individuals were measured for the first time, and the body lengths for 10 individuals that were measured previously were measured again (**Table 3**); however, grading criteria methodology has since been updated, so caution should be taken when making comparisons to measurements from previous years. **Table 3** reports the measurements from the best images for all 43 individuals with drone video since November 2021. Individuals whose best image does not meet all grading criteria from Christiansen et al. (2018) have been included in **Table 3** for reference to individual, age-class field estimates; however, they have been excluded from the descriptive statistics calculations below. The 25 measured humpback whales that met the grading criteria ranged in size from 9.35 to 13.93 m in total length, with a mean length of 11.92 m and a median length of 11.91 m. There were 7 whales (28 percent) that measured under 11.0 m, and the remaining 18 whales (72 percent) measured greater than 11.0 m. Since water clarity improves farther from shore, whales measured farther from shore were more likely to meet the grading criteria whereas whales closer to shore were more likely not to meet the criteria.

Table 3. Overall lengths of all humpback whales measured between November 2021 and December 2022 using drone photogrammetry, sorted from smallest to largest.

Humpback whale ID	Length based on photogrammetry (m)	Total unique measurement days	Age-class assigned based on initial visual assessment
HDRVAMn216	6.21[a]	1	Juvenile
HDRVAMn259	8.72[a]	1	Sub-adult/adult
HDRVAMn181	8.74[a,d]	2	Sub-adult/adult[b]
HDRVAMn246	8.94[a]	1	Juvenile
HDRVAMn248	9.23[a]	1	Juvenile
HDRVAMn247	9.25[a]	1	Juvenile
HDRVAMn206	9.35	1	Sub-adult/adult[b]
HDRVAMn241	9.53[a]	1	Juvenile
HDRVAMn227	9.95	1	Second-year calf
HDRVAMn236	10.03[a]	1	Juvenile
HDRVAMn250	10.32	1	Sub-adult/adult
HDRVAMn186	10.43[c]	5	Sub-adult/adult[b]
HDRVAMn163	10.44[a,c]	2	Juvenile
HDRVAMn172	10.47[d]	6	Adult[b]
HDRVAMn244	10.56	1	Juvenile[e]
HDRVAMn215	10.62[c]	2	Sub-adult/adult
HDRVAMn223	10.98[a]	2	Sub-adult/adult
HDRVAMn228	11.01	1	Adult
HDRVAMn232	11.13	1	Sub-adult/adult
HDRVAMn123	11.16[a]	1	Juvenile
HDRVAMn230	11.21[a]	1	Sub-adult/adult
HDRVAMn058	11.3	1	Sub-adult/adult[e]
HDRVAMn260	11.46	1	Sub-adult/adult
HDRVAMn097	11.55[a,c]	2	Sub-adult/adult[b]
HDRVAMn220	11.59	1	Sub-adult/adult
HDRVAMn132	11.82[a,c]	5	Sub-adult/adult[b]
HDRVAMn073	11.91	1	Adult
HDRVAMn261	12.25[a]	1	Adult
HDRVAMn004	12.43	1	Adult
HDRVAMn012	12.77[c]	3	Sub-adult[b]
HDRVAMn233	12.84	1	Sub-adult/adult
HDRVAMn218	12.85	1	Sub-adult/adult
HDRVAMn008	12.92	1	Sub-adult/adult
HDRVAMn240	13.07	1	Adult
HDRVAMn201	13.29	1	Sub-adult/adult
HDRVAMn231	13.35	1	Sub-adult/adult
HDRVAMn198	13.37	1	Sub-adult/adult[e]
HDRVAMn226	13.49	1	Adult
HDRVAMn256	13.58	1	Sub-adult/adult
HDRVAMn219	13.67[a]	1	Sub-adult/adult

Humpback whale ID	Length based on photogrammetry (m)	Total unique measurement days	Age-class assigned based on initial visual assessment
HDRVAMn263	13.85[a]	1	Adult
HDRVAMn235	13.93	1	Adult
HDRVAMn003	14.36[a,c]	3	Adult

Key: ID = identification number
[a] Measurement excluded from descriptive statistics calculations based on image grading criteria
[b] Most recent assessment; assigned a different age class in previous years
[c] Measurement longer than previous years
[d] Measurement shorter than previous years
[e] Assessed as two different age classes within same season

Figure 8. Total length measurement being taken in MorphoMetriX using a still video grab from drone-collected data for humpback whale HDRVAMn208.

Each whale had been assigned an age-class in the field based on subjective size assessments from the research vessel (**Table 3**). The smallest field-assigned age class was a whale that appeared to be juvenile-sized but was positioned alongside an adult whale in a way that resulted in the research team concluding the whale may be a second-year calf (HDRVAMn227). This was the second smallest whale, measuring 9.95 m (meeting the grading criteria). Interestingly, the smallest measured whale (HDRVAMn206) that met the grading criteria measured 9.35 m and was assigned a sub-adult/adult age-class in the field. Whales that measured greater than 10.0 m but less than 11.0 m were assigned age-classes of juvenile or sub-adult/adult. All whales that measured over 11.0 m were assigned age-classes of sub-adult, sub-adult/adult, or adult. Therefore, whales that measured larger were more likely to be assigned an age class corresponding to larger size, but smaller whales, or those of intermediate length, were more difficult to assign an age-class to that corresponded to a smaller size.

4. Discussion

Photo-ID studies take years, even decades, to produce meaningful results. While data analyses from this multi-year project are ongoing, each field season builds a more comprehensive picture of humpback whale presence and use of the waters within and around the mouth of Chesapeake Bay and the surrounding area. Shipping channels, W-50 MINEX, U.S. Navy OPAREAS, and wind energy development areas all overlap with the habitat that baleen whales use seasonally.

The number of humpback whale identifications has grown over the course of this study. When assessing all nine seasons, two “peaks” of individual identifications are evident—the 2016/17 season and the 2021/22 season, with 59 and 58 individuals seen per season, respectively (**Figure 2**). All other seasons have had somewhere between 28 and 38 individuals identified. Because these surveys are not designed to support density or abundance estimates, trends in sightings across study years cannot be evaluated statistically; however, some subjective inferences may be made. Future effort should look at whether there were any meteorological or oceanographic trends for the years with peak whale occurrence in the region. Further analysis of water-temperature data collected from CTD measurements, buoy data, and tag data collected during this study may provide a better understanding of thresholds that result in humpback whales (and presumably their prey) remaining in or moving outside the nearshore area.

Of the 275 whales identified since the project’s inception, the majority (229, 83.3 percent) were only seen during one field season; the remaining 46 individuals (16.7 percent) were seen for two or more field seasons (**Table 2; Appendix A**, **Table A-1**). Approximately half of all cataloged whales were seen on two or more occasions. When re-sighted within the same season, individuals were seen between 0.8 and 98.9 days from the initial sighting (mean = 24.7 days; median = 20.1 days). These data help shed light on the numbers of humpback whales using the waters at the mouth of the Chesapeake Bay and provide insight into how long they remain within the area. Based on these results, there are likely a small number of whales that are at an increased risk for anthropogenic activities during the time they remain in the study region.

Part of the increase in the number of identifications over the first three seasons is likely due to effort—the 2016/17 and 2017/18 field seasons began 2 months earlier than the 2014/15 season and 1 month earlier than the 2015/16 field season. Also, during the 2014/15 season, effort was focused on collecting focal follows of individual whales, so priority was given to staying with one whale over a longer period of time rather than collecting as many photo-IDs of animals within the surrounding areas as possible. Overall effort on the water, both in terms of survey days and hours, also increased during the first three field seasons, partially accounting for the increase in sighting information during the 2016/17 field season. In more recent years, effort has also expanded to the mid-shelf area, so less coverage is focused on nearshore waters, but additional opportunities are available for sightings of whales farther from shore.

Interactions with vessels, both large and small, are a significant cause for concern for both humpback and other baleen whales within the study area. In April 2017, the National Marine Fisheries Service declared an Unusual Mortality Event (UME) for humpback whales within the Atlantic Ocean, from Maine to North Carolina, based on elevated mortalities of this species since January 2016 (NOAA 2024). At the time of this report, 214 humpback whales are included in this UME, and 57 (27.6 percent) of those have occurred along the shore or in waters off the coast of Virginia or North Carolina (NOAA 2024). Given this designation, a group of subject matter experts, the UME working group, will further investigate what is causing or contributing to the increased number of humpback whale deaths within this area. Some of the whales examined thus far have exhibited evidence of peri-mortem vessel strike, but the UME investigation process remains ongoing. Evidence of human interaction, either presumed line-entanglement scars (**Figure 3**) or propeller scars (**Figure 4**), was apparent on approximately 10 percent of all cataloged humpback whales throughout this study, which is an alarmingly high rate of occurrence. In addition, 6 cataloged whales are known to be deceased (**Appendix A**, **Table A-1**), 4 deaths which occurred in the primary study area, and a 5th which occurred south of the primary study area, off North Carolina (the 6th was off Massachusetts). Results from necropsies concluded that 3 out of the 4 whales killed within the study area showed injuries consistent with peri-mortem vessel interactions (Marine Mammal Health and Stranding Response Program; Virgina Aquarium & Marine Science Center). Vessel strikes pose a significant risk to humpback whales, and previous analysis of tagging data from this study show a high level of occurrence by humpback whales within shipping lanes at the mouth of the Chesapeake Bay (Aschettino et al 2020b). From November through April, a ship-speed reduction rule is in effect at the mouth of Chesapeake Bay as part of the Seasonal Management Area (SMA) set up to protect Endangered Species Act -listed North Atlantic right whales. These speed restrictions require all vessels 65 feet (19.8 m) or longer to travel at 10 knots (18.5 km/hour) or less, and a proposed rule to extend these restrictions to smaller vessels within a wider area is under review. One problem with the current SMA is that the areas that humpback whales (and other species) frequently occur are not within these boundaries. For instance, only 14 of 33 humpback whale sightings (42.4 percent) during the 2022/23 season occurred within the SMA boundaries (Aschettino et al. 2024: Figure 6).

While the UME working group will look at humpback whales of all age classes, approximately two-thirds of the humpback whales identified during the 9 years of survey effort on this project appear to be juveniles that are spending more time within the nearshore study area than larger animals, presumed to be adults, and may be at greater risk for injury. Sightings of sub-adult-sized humpback whales are highest early in the field season or farther from shore within the mid-shelf region, and those individuals are often re-sighted less frequently, suggesting that sightings early in the season may be whales passing through the area rather than whales remaining within the nearshore study area for longer durations. The large percentage of juveniles observed in this study matches both historic stranding (e.g., Wiley et al. 1995) and observational (e.g., Swingle et al. 1993) data for the area.

Matching of HDR Inc.'s cataloged humpback whales to other regions is ongoing. Currently, all humpback whales with fluke images observed during these survey efforts are available on Happywhale, and matches have been found to feeding grounds in waters off the northeastern U.S., Canada, and Iceland, as well as breeding grounds off the Dominican Republic and the Turks and Caicos Islands (**Figure 6)**. Matches within the Mid-Atlantic, including Virginia, New York, and New Jersey, were also made; in fact, some whales were only matched within Virginia and not to outside areas. Humpback whales of the West Indies distinct population segment (Bettridge et al. 2015) are known to migrate from six northern feeding grounds in the Gulf of Maine, the Gulf of St. Lawrence, Newfoundland/Labrador, western Greenland, Iceland, and

Norway to Caribbean Sea waters during winter months (Katona and Beard 1990, Christensen et al. 1992, Palsbøll et al 1997). Matches to these areas are therefore to be expected, but the sighting histories and timelines that can be gained from incorporating these details into a platform such as Happywhale is invaluable.

Integration of the drone component to the study, beginning in 2018, has allowed for additional opportunities to examine body condition and estimate length. The drone also proved valuable in assisting with tag deployments, observing unique behavior (such as bubble-net feeding), and collecting follow-up images from tagged whales. The study team recently retrofitted the drone and installed a custom LiDAR altimeter, which increases the precision and consistency of the drone altimetry measurements to minimize possible error in measured animal lengths. HDR Inc. is in the process of acquiring a new American-made drone to be National Defense Authorization Act-compliant with improved capabilities such as LiDAR sensors, longer flight times, a higher-resolution camera, and the capacity to also deploy suction cup tags.

Efforts for the 2023/24 field season continue to focus on pushing farther into the mid-shelf waters, as well as continuing photo-ID efforts within nearshore waters. A stakeholders' meeting will take place for those in the Mid-Atlantic who are interested in continuing collaboration efforts on the MAHWC. Happywhale will be updated with dorsal fin images of humpback whales (for those not already loaded) to help improve future animal identification algorithms. At the end of the 2023/24 season, all humpback whale identifications will be added and incorporated into the MAHWC and Happywhale.

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Appendix A
Sighting History Table

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Table A-1. Sighting history (number of days seen per season) and additional information for all photo-identified humpback whales off Virginia Beach, Virginia: December 2014–March 2023

HDR Catalog ID	Season 1 Dec 2014–Apr 2015	Season 2 Oct 2015–May 2016	Season 3 Nov 2016–Mar 2017	Season 4 Oct 2017–Mar 2018	Season 5 July 2018–May 2019	Season 6 Dec 2019–Mar 2020	Season 7 Nov 2020–Apr 2021	Season 8 Nov 2021–Mar 2022	Season 9 Nov 2022–Mar 2023	Total No. Days Seen	Total No. Seasons Seen	Biopsied? (Y/N)/ Gender (M/F/U)	Satellite Tagged? (Y/N) (No.)	D-/CATS Tagged? (Y/N)	Estimated Age Class (A/SA/J/Ye/C)	Propeller Scars or Injuries? (Y/N/P)	Total No. Focal Follows	Happywhale match? (Y/N)	Total No. Focal Follow Minutes
HDRVAMn003	1						1	2		4	3	N/U	N	N	A	N	0	Y	—
HDRVAMn004	1								2	3	2	N/U	N	N	A	N	0	Y	—
HDRVAMn005	2		5							7	2	Y/F	Y	N	A	N	1	Y	64
HDRVAMn006	2									2	1	N/U	N	N	J	N	1	Y	69
HDRVAMn007	4	1	7		8	1				21	5	Y/F	Y	N	J	N	1	Y	60
HDRVAMn008	5							2		7	2	N/U	N	N	J; SA/A	N	3	Y	215
HDRVAMn009	4									4	1	Y/F	N	N	J	N	2	Y	112
HDRVAMn010	1	2		1						4	3	Y/M	Y (2)	N	J	N	1	Y	76
HDRVAMn011	4		1							5	2	Y/F	N	N	J	N	1	Y	60
HDRVAMn012	3	2	6	2	3		2			18	6	Y/F	Y (3)	Y	J; SA/A	N	3	Y	47
HDRVAMn013	10									10	1	Y/F	N	N	J	N	4	Y	357
HDRVAMn014	5	1	1	1						8	4	Y/F	N	N	J	N	1	Y	60
HDRVAMn015	2		1							3	2	Y/F	N	N	J	N	1	Y	58
HDRVAMn016	1									1	1	N/U	N	N	U	N	0	Y	—
HDRVAMn017	1									1	1	N/U	N	N	U	N	0	Y	—
HDRVAMn018	1									1	1	N/U	N	N	U	Y	0	Y	—
HDRVAMn019	1									1	1	N/U	N	N	U	N	0	Y	—
HDRVAMn020	1									1	1	N/U	N	N	U	N	0	Y	—
HDRVAMn021	2		3	2	6	1				14	5	N/U	N	N	SA	N	1	Y	78
HDRVAMn022	2									2	1	N/U	N	N	J	N	1	Y	85
HDRVAMn023	1		3[a]	—	—	—	—	—	—	4	2	Y/M	Y	N	J	N	1	Y	80
HDRVAMn024	2									2	1	Y/M	N	N	A	P	1	Y	60

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[b] Sighting occurred on offshore survey

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HDRVAMn025	1						1			2	2	Y/M	N	N	SA/A	N	1	Y	62
HDRVAMn027	2	3	1	1[b]						7	4	Y/F	N	N	J	N	1	Y	61
HDRVAMn028	1									1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn029	1									1	1	Y/M	N	N	J	P	1	Y	63
HDRVAMn030	1	1								2	2	N/U	N	N	A	N	1	Y	62
HDRVAMn031	1		1	1						3	3	Y/M	Y	N	J	N	0	Y	—
HDRVAMn032	1									1	1	N/U	N	N	SA	N	1	Y	—
HDRVAMn033	1									1	1	N/U	N	N	J	N	0	Y	63
HDRVAMn034	1									1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn035		2								2	1	N/U	N	N	J	N	0	Y	—
HDRVAMn036		2								2	1	N/U	N	N	J	N	0	Y	—
HDRVAMn037		3								3	1	N/U	N	N	J	N	0	Y	—
HDRVAMn039		1								1	1	Y/M	Y	N	J	N	0	Y	—
HDRVAMn041		1								1	1	Y/M	Y	N	J	N	0	Y	—
HDRVAMn042		6								6	1	N/U	N	N	J	N	0	Y	—
HDRVAMn043		1								1	1	N/U	N	N	J	N	0	N	—
HDRVAMn044		1								1	1	Y/F	Y	N	J	Y	0	Y	—
HDRVAMn045		6								6	1	Y/M	Y	N	J	Y	0	Y	—
HDRVAMn046		4								4	1	N/U	N	N	J	N	0	Y	—
HDRVAMn047		1								1	1	N/U	N	N	J	N/A	0	N	—
HDRVAMn048		2	1							3	2	Y/M	Y	N	SA/A	N	0	Y	—
HDRVAMn049		2	6	1, 1[b]				1		11	4	Y/F	Y (2)	N	SA/A	N	0	Y	—
HDRVAMn050		4								4	1	Y/M	N	N	J	N	0	Y	—
HDRVAMn051		9								9	1	Y/M	N	N	J	Y	0	Y	—

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HDRVAMn052		3								3	1	Y/F	N	N	J	N	0	Y	—
HDRVAMn053		2								2	1	N/U	N	N	J	Y	0	Y	—
HDRVAMn054		7								7	1	Y/M	Y	N	J	N	0	Y	—
HDRVAMn055		2								2	1	N/U	N	N	J	N	0	Y	—
HDRVAMn056		2								2	1	N/U	N	N	J	N	0	Y	—
HDRVAMn057		1								1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn058		1						3		2	4	N/U	N	N	J/SA; SA/A	Y	0	Y	—
HDRVAMn059		1	2							3	2	Y/M	Y	N	SA	N	0	N	—
HDRVAMn060		1								1	1	N/U	N	N	J	N/A	0	N	—
HDRVAMn061		3								3	1	Y/M	Y	N	J	N	0	Y	—
HDRVAMn062		3								3	1	N/U	N	N	J	N	0	Y	—
HDRVAMn063		4								4	1	Y/M	Y	N	J	N	1	Y	120
HDRVAMn064		2	12	2	3	2				21	5	Y/F	Y (2)	N	J	N	0	Y	—
HDRVAMn065		1	3							4	2	N/U	N	N	J	N	0	Y	—
HDRVAMn066		2	2							4	2	Y/M	Y	N	J	N	0	Y	—
HDRVAMn067		1[b]								1	1	N/U	N	N	J	N	0	N	—
HDRVAMn068		1								1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn069			1							1	1	Y/F	Y	N	SA	N	0	Y	—
HDRVAMn071			2							2	1	Y/M	Y	N	SA	N	0	Y	—
HDRVAMn072			1							1	1	N/U	N	N	J	N	0	N	—
HDRVAMn073			1					1,1[b]	1	4	3	N/U	N	N	SA; A	N	0	Y	—
HDRVAMn074			1							1	1	N/U	N	N	J	N/A	0	N	—

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HDRVAMn075			1							1	1	N/U	N	N	SA	N/A	0	N	—
HDRVAMn076			1							1	1	N/U	N	N	SA	N	0	Y	—
HDRVAMn077			1							1	1	N/U	N	N	SA	N	0	Y	—
HDRVAMn078			1[a]	—	—	—				1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn079			3							3	1	N/U	N	N	J	N	0	Y	—
HDRVAMn080			1							1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn081			9							9	1	Y/F	Y	N	J	N	0	Y	—
HDRVAMn082			4	—[a]	—	—	—	—	—	3	1	Y/F	Y	N	J	N	0	Y	—
HDRVAMn083			2							2	1	N/U	Y	N	J	N	0	Y	—
HDRVAMn084			11							11	1	Y/F	Y	N	J	N	0	Y	—
HDRVAMn085			8							8	1	N/U	N	N	J	Y	0	Y	—
HDRVAMn086			1					1		2	2	N/U	N	N	J; SA	N/A	0	N	—
HDRVAMn087			3							3	1	N/U	N	N	J	N/A	0	N	—
HDRVAMn088			6							6	1	Y/M	Y	N	J	N	0	Y	—
HDRVAMn089			1							1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn090			4[a]	—	—	—	—	—	—	4	1	Y/M	Y	N	J	Y	0	Y	—
HDRVAMn091			5[a]	—	—	—	—	—	—	5	1	Y/M	N	N	SA	Y	0	Y	—
HDRVAMn092			6							6	1	Y/F	Y	N	J	N	0	Y	—
HDRVAMn093			6		4	1				11	3	Y/F	Y (3)	N	J	N	0	Y	—
HDRVAMn094			1							1	1	N/U	N	N	J	N	0	N	—
HDRVAMn095			2							2	1	Y/M	Y	N	J	N	0	Y	—
HDRVAMn096			5							5	1	Y/M	N	N	J	N	0	Y	—
HDRVAMn097			1					2		3	2	N/U	Y	N	J; SA	N	0	Y	—
HDRVAMn098			8							8	1	Y/F	N	N	J	N	0	Y	—
HDRVAMn099			6							6	1	Y/F	Y	N	J	N	0	Y	—

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HDRVAMn100			1[a]	—	—	—	—	—	—	1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn101			1							1	1	Y/M	Y	N	J	N/A	0	N	—
HDRVAMn102			7							7	1	Y/M	Y	N	J	N	0	Y	—
HDRVAMn103			4							4	1	N/U	N	N	J	N	0	Y	—
HDRVAMn104			4							4	1	Y/F	Y	N	J	N	0	Y	—
HDRVAMn105			3							3	1	Y/F	Y	N	J	N	0	Y	—
HDRVAMn106			3							3	1	N/U	N	N	J	P	0	Y	—
HDRVAMn107			2							2	1	N/U	N	N	J	N	0	Y	—
HDRVAMn108			2							2	1	N/U	N	N	J	N	0	Y	—
HDRVAMn109			3							3	1	Y/M	N	N	J	N	0	Y	—
HDRVAMn110			2							2	1	N/U	N	N	J	N	0	Y	—
HDRVAMn111			1							1	1	Y/F	N	N	SA/A	N	0	Y	—
HDRVAMn112			1							1	1	Y/M	N	N	J	P	0	N	—
HDRVAMn113				1						1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn114				2						2	1	N/U	N	N	J	N/A	0	N	—
HDRVAMn115				2						2	1	N/U	N	N	J	N	0	Y	—
HDRVAMn116				1						1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn117				1						1	1	N/U	N	N	J	N	0	N	—
HDRVAMn118				1						1	1	N/U	N	N	J	N/A	0	N	—
HDRVAMn119				2						2	1	N/U	N	N	J	N	0	Y	—
HDRVAMn120				1						1	1	Y/M	Y	N	J	N	0	Y	—
HDRVAMn121				1						1	1	N/U	N	N	J	N/A	0	N	—
HDRVAMn122				3						3	1	Y/M	N	N	J	N	0	N	—
HDRVAMn123				1						1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn124				1						1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn125				2						2	1	N/U	N	N	J	Y	0	N	—

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HDRVAMn126				1[b]						1	1	Y/M	Y	N	SA/A	N	0	Y	—
HDRVAMn127				1[b]						1	1	N/U	N	N	J	N	0	N	—
HDRVAMn128				1[b]						1	1	N/U	N	N	A	N	0	N	—
HDRVAMn129				1[b]						1	1	N/U	N	N	A	N/A	0	N	—
HDRVAMn130				1[b]						1	1	N/U	N	N	J/SA	N	0	N	—
HDRVAMn131				1[b]						1	1	N/U	N	N	U	N	0	Y	—
HDRVAMn132					1		1	2		4	3	Y/F	Y	N	J; SA/A	N	0	Y	—
HDRVAMn133					1[b]					1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn134					1[b]			2		3	2	N/U	N	N	J; SA/A	N	0	Y	—
HDRVAMn135					2					2	1	N/U	N	N	J	N	0	N	—
HDRVAMn136					1					1	1	N/U	Y	N	J	N	0	Y	—
HDRVAMn137					2					2	1	N/U	N	N	J	N	0	Y	—
HDRVAMn138					1					1	1	N/U	N	N	J	N/A	0	N	—
HDRVAMn139					1					1	1	N/U	N	N	J	N/A	0	N	—
HDRVAMn140					1					1	1	N/U	N	N	U	N	0	Y	—
HDRVAMn142					4					4	1	N/U	N	N	J	N/A	0	N	—
HDRVAMn143					2					2	1	N/U	N	N	J/SA	N	0	Y	—
HDRVAMn144					1					1	1	N/U	N	N	J	N	0	N	—
HDRVAMn145					2					2	1	N/U	N	N	J	N	0	Y	—
HDRVAMn146					1[b]					1	1	Y/M	Y	N	J	N	0	Y	—
HDRVAMn147					1					1	1	N/U	N	N	J	Y	0	Y	—
HDRVAMn148					3					3	1	N/U	N	N	J	N	0	N	—
HDRVAMn149					4					4	1	N/U	N	N	SA/A	N	0	Y	—
HDRVAMn150					1					1	1	N/U	N	N	SA/A	N	0	N/A	—
HDRVAMn151					2[a]	—	—	—	—	2	1	Y/F	Y	N	J	N	0	Y	—
HDRVAMn152					3					3	1	Y/M	Y	N	J	N	0	N	—

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HDRVAMn153					2					2	1	Y/F	Y	N	J	N	0	N/A	—
HDRVAMn154					1					1	1	Y/F	Y	N	J	N	0	N/A	—
HDRVAMn155				1[b]						1	1	N/U	N	N	J	N	0	N/A	—
HDRVAMn156					2					2	1	Y/F	N	N	SA/A	N	0	Y	—
HDRVAMn157					1					1	1	N/U	N	N	SA/A	N	0	Y	—
HDRVAMn158					1					1	1	N/U	N	N	J	N/A	0	N	—
HDRVAMn159					1					1	1	N/U	N	N	J	N/A	0	Y	—
HDRVAMn160					1					1	1	N/U	N	N	A	N	0	Y	—
HDRVAMn161					1					1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn162					1					1	1	N/U	Y	N	J	N/A	0	Y	—
HDRVAMn163					2			2		4	2	Y/F	Y (2)	N	J	N	0	N	—
HDRVAMn164					1					1	1	N/U	N	N	J	N	0	N	—
HDRVAMn165					1					1	1	N/U	N	N	J	N/A	0	Y	—
HDRVAMn166						3				3	1	Y/U	Y	N	J	N	0	Y	—
HDRVAMn167						1				1	1	N/U	N	N	J	Y	0	N	—
HDRVAMn168						1				1	1	N/U	N	N	SA/A	N	0	Y	—
HDRVAMn169						1				1	1	N/U	N	N	J	N/A	0	N	—
HDRVAMn170						2				2	1	N/U	N	N	SA/A	N	0	N/A	—
HDRVAMn171						1		1		2	2	N/U	N	N	J	N	0	Y	—
HDRVAMn172						3	1	1		5	3	Y/U	Y (2)	N	SA/A; A	N	0	Y	—
HDRVAMn173						4				4	1	Y/U	Y	N	J	N	0	Y	—
HDRVAMn174						3	3			6	2	N/U	Y	N	J	Y	0	Y	—
HDRVAMn175						1		1	1	3	3	Y/U	Y	N	J; J/SA	N	0	Y	—
HDRVAMn176						1				1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn177						4				4	1	N/U	Y	N	J	N	0	Y	—
HDRVAMn178						1				1	1	N/U	N	N	J	N	0	Y	—

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HDRVAMn179						1	1			2	2	N/U	N	N	J	Y	0	Y	—
HDRVAMn180						1				1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn181						1		1		2	2	N/U	N	N	J; SA/A	N	0	Y	—
HDRVAMn182						2				2	1	Y/U	N	N	SA	N	0	Y	—
HDRVAMn183						1				1	1	N/U	N	N	SA	N/A	0	N	—
HDRVAMn184						4				4	1	Y/U	Y	N	J	N	0	Y	—
HDRVAMn185						1				1	1	N/U	N	N	SA	N	0	Y	—
HDRVAMn186						2		1		3	2	Y/U	Y	N	SA	N	0	Y	—
HDRVAMn187						2				2	1	N/U	Y	N	SA	N	0	Y	—
HDRVAMn188						1				1	1	N/U	N	N	SA	N	0	Y	—
HDRVAMn189						1				1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn190							1			1	1	Y/U	N	Y	J	N	1	Y	313
HDRVAMn191							1		1	2	2	N/U	N	N	J; SA	N	0	Y	—
HDRVAMn192							1			1	1	N/U	N	N	SA/A	N	0	N	—
HDRVAMn193							2			2	1	Y/U	Y	N	J	N	0	Y	—
HDRVAMn194							1			1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn195							1			1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn196							1			1	1	Y/U	Y	N	SA/A	N	0	Y	—
HDRVAMn197							2			2	1	N/U	N	N	SA/A	N	0	N	—
HDRVAMn198							1	3		4	4	N/U	N	N	A	N	0	Y	—
HDRVAMn199							1			1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn200							2			2	1	N/U	N	N	SA/A	N	0	Y	—
HDRVAMn201							1		1	2	2	N/U	N	N	SA/A	N	0	Y	—
HDRVAMn202							1			1	1	Y/U	Y	N	SA/A	N	0	Y	—
HDRVAMn203							1	1		2	2	N/U	N	N	SA/A	N	0	N	—

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[a] Deceased

[b] Sighting occurred on offshore survey

HDR Catalog ID	Season 1 Dec 2014–Apr 2015	Season 2 Oct 2015–May 2016	Season 3 Nov 2016–Mar 2017	Season 4 Oct 2017–Mar 2018	Season 5 July 2018–May 2019	Season 6 Dec 2019–Mar 2020	Season 7 Nov 2020–Apr 2021	Season 8 Nov 2021–Mar 2022	Season 9 Nov 2022–Mar 2023	Total No. Days Seen	Total No. Seasons Seen	Biopsied? (Y/N)/ Gender (M/F/U)	Satellite Tagged? (Y/N) (No.)	D-/CATS Tagged? (Y/N)	Estimated Age Class (A/SA/J/Ye/C)	Propeller Scars or Injuries? (Y/N/P)	Total No. Focal Follows	Happywhale match? (Y/N)	Total No. Focal Follow Minutes
HDRVAMn204							2			2	1	Y/U	Y	N	J	N	0	Y	—
HDRVAMn205							2			2	1	N/U	N	N	J	N	0	N/A	—
HDRVAMn206							1	1		2	2	N/U	N	N	J	N	0	Y	—
HDRVAMn207							1			1	1	N/U	N	N	J	N	0	N/A	—
HDRVAMn208							1			1	1	N/U	N	Y	J	N	1	N	—
HDRVAMn209							1			1	1	N/U	N	N	A	N	0	N	—
HDRVAMn210							1[b]			1	1	N/U	N	N	A	N	0	N/A	—
HDRVAMn211							1[b]	1		2	2	N/U	N	N	J; A	N	0	Y	—
HDRVAMn212							1[b]			1	1	N/U	N	N	J	N	0	N/A	—
HDRVAMn213							1[b]			1	1	N/F	N	N	A	N	0	N/A	—
HDRVAMn214							1[b]			1	1	N/U	N	N	C	N	0	N/A	—
HDRVAMn215								1		1	1	N/U	N	N	SA/A	N	0	Y	—
HDRVAMn216								1		1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn217								1[b]		1	1	N/U	N	N	SA/A	N	0	Y	—
HDRVAMn218								2		2	1	N/U	N	N	SA/A	N	0	Y	—
HDRVAMn219								1		1	1	Y/U	Y	Y	SA/A	N	1	Y	307
HDRVAMn220								1		1	1	N/U	N	N	SA/A	Y	0	Y	—
HDRVAMn221								1	1	2	2	N/U	N	N	SA/A	Y	0	Y	—
HDRVAMn222								1		1	1	N/U	N	N	SA/A	Y	0	N	—
HDRVAMn223								2		2	1	Y/U	Y	N	SA/A	N	0	N	—
HDRVAMn224								1		1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn225								1		1	1	Y/U	Y	N	SA/A	N	0	Y	—
HDRVAMn226								1		1	1	N/F	N	N	A	N	0	Y	—
HDRVAMn227								1		1	1	N/U	N	N	C	N	0	Y	—
HDRVAMn228								1		1	1	N/U	N	N	A	N	0	Y	—

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HDRVAMn229								1		1	1	N/U	N	N	SA/A	N	0	Y	—
HDRVAMn230								2		2	1	N/U	N	N	SA/A	N	0	N	—
HDRVAMn231								2	1	3	2	N/U	N	N	SA/A	N	0	Y	—
HDRVAMn232								2		2	1	N/U	N	N	SA/A	N	0	N	—
HDRVAMn233								1		1	1	Y/U	Y	N	SA/A	N	0	Y	—
HDRVAMn234								2		2	1	N/U	N	N	J	Y	0	Y	—
HDRVAMn235								1		1	1	N/U	N	N	A	N	0	Y	—
HDRVAMn236								1		1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn237								1		1	1	N/U	N	N	SA/A	N	0	Y	—
HDRVAMn238								1		1	1	N/U	N	N	SA/A	N	0	N	—
HDRVAMn240								1[b]		1	1	N/U	N	N	A	N	0	Y	—
HDRVAMn241								1[b]		1	1	N/U	N	N	J	N	0	N	—
HDRVAMn242								1[b]		1	1	N/U	N	N	J	Y	0	Y	—
HDRVAMn243								1		1	1	N/U	Y	N	SA	N	0	N	—
HDRVAMn244								2		2	1	N/U	N	N	SA/A	N	0	Y	—
HDRVAMn245								2		2	1	N/U	N	N	J	N	0	Y	—
HDRVAMn246								4		4	1	Y/U	Y	N	J	N	0	Y	—
HDRVAMn247								3	1	4	2	N/U	N	N	J	N	0	Y	—
HDRVAMn248								4		4	1	N/U	N	N	J	N	0	Y	—
HDRVAMn249								1		1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn250								1		1	1	N/U	N	N	SA/A	N	0	Y	—
HDRVAMn251								1		1	1	Y/U	Y	N	J	N	0	N	—
HDRVAMn252								1		1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn253								1	1	2	2	N/U	N	N	A; J	N	0	Y	—
HDRVAMn254									1	1	1	N/U	N	N	A	N	0	N	—

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HDRVAMn255									2	2	1	N/U	N	N	A	N	0	N	—
HDRVAMn256									2	2	1	N/U	N	N	SA/A	N	0	Y	—
HDRVAMn257									1	1	1	N/U	N	N	SA/A	N	0	Y	—
HDRVAMn258									1	1	1	N/U	N	N	SA/A	N	0	N	—
HDRVAMn259									1	1	1	N/U	N	N	SA/A	N	0	Y	—
HDRVAMn260									1	1	1	N/U	N	N	A	N	0	Y	—
HDRVAMn261									2	2	1	N/U	N	N	A	N	0	Y	—
HDRVAMn262									1[b]	1	1	N/U	N	N	J	Y	0	N	—
HDRVAMn263									1	1	1	N/U	N	N	SA/A	N	0	N	—
HDRVAMn264									1	1	1	N/U	N	N	A	N	0	Y	—
HDRVAMn265									1	1	1	N/U	N	N	A	N	0	Y	—
HDRVAMn266									1	1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn267									1	1	1	—	N	N	A	Y	0	Y	—
HDRVAMn268									2	2	1	Y/U	Y	Y	SA	N	0	Y	—
HDRVAMn269									2	2	1	N/U	N	N	SA	N	0	N	—
HDRVAMn270									1	1	1	N/U	N	N	SA	N	0	N	—
HDRVAMn271									1	1	1	N/U	N	N	A	N	0	N	—
HDRVAMn272									1	1	1	N/U	N	N	A	N	0	Y	—
HDRVAMn273									3	3	1	N/U	N	N	J	N	0	Y	—
HDRVAMn274									1	1	1	N/U	N	N	J	N	0	N	—
HDRVAMn275									1	1	1	N/U	N	N	J	N	0	Y	—
HDRVAMn276									1	1	1	N/U	N	N	SA	N	0	Y	—
HDRVAMn277									1	1	1	N/U	N	N	SA	N	0	Y	—
HDRVAMn278									1	1	1	N/U	Y	Y	J	N	0	Y	—
HDRVAMn279									1	1	1	N/U	N	N	J	N	0	N	—

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HDRVAMn280									1	1	1	N/U	N	N	J	N	0	N	—
HDRVAMn281									1	1	1	N/U	N	N	SA/A	N	0	N	—
HDRVAMn282									1	1	1	N/U	N	N	J	N	0	N	—
HDRVAMn283									1	1	1	N/U	N	N	A	N	0	N	—
Total	**66**	**91**	**168**	**38**	**69**	**48**	**38**					**69**	**62 / 7**	**4**		**28**	**32**		**2,571**

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