**Marine-life Data and Analysis Team (MDAT) Mammal Product Updates**
**Summary of Changes for November 2023 Update, version 3.2**

Overview

Marine mammal individual species or species guild density surface models (DSMs) were originally produced by the Marine Geospatial Ecology Lab at Duke University (MGEL) in 2016 (Roberts et al., 2016) with funding by the U.S. Navy and NASA in support of the Navy's Atlantic Fleet Training and Testing (AFTT) study area Phase III Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS). As part of the Marine-life Data and Analysis Team (MDAT), MGEL developed a suite of "summary products" representing total abundance, species richness, core abundance richness, and species diversity for various groups of species based on ecological similarity, protection status, or vulnerability characteristics. MDAT also provides web-based map services for the individual species and summary products, primarily for regional ocean council's to use in their spatial portals, and also for general access to the data. See the MDAT repository at https://seamap.env.duke.edu/models/mdat/ for a full description.

Interim updates to several species were released in 2017 (Roberts et al., 2017) and 2018 (Roberts et al., 2018), resulting in updates to the MDAT individual species and summary products. The North Atlantic right whale (NARW) model was also updated, with those updates incorporated into MDAT Summary Products in 2022. See the MDAT repository for a full description of updates.

In 2022 a full suite of 31 updated density models for 26 species and 5 species guilds was produced using updated methodology and survey data conducted through 2020, in support of the U.S. Navy's Phase IV EIS/OEIS (Roberts et al., 2023). This document contains a brief summary of the changes to the base-layer models and the MDAT group summary products that occurred in the 2022 update. Additional details on the base-layer models and summary products can be found in the MDAT Technical Report (Curtice et al., 2019), and additional details on the models can be found on the model repository page here:
https://seamap.env.duke.edu/models/Duke/EC/

**November 2023 Release, v3.2**

Marine mammal summary product layers

1. The de-guilding methods for mesoplodont beaked whales in the summary products were updated based on PAM research and sightings data. In this release, the Atlantic coasts are split into three latitudinal areas: south of Cape Hatteras, Cape Hatteras to Georges Bank, and north of Georges Bank. The north of Georges Bank was split into Sowerby's and True's equally and the south of Cape Hatteras was split into Blainville's and Gervais' equally. In the area between Cape Hatteras and Georges Bank, 5% was apportioned to Gervais' and the rest was split equally into Sowerby's and True's (47.5% each). See Figure 1 for current apportioning methods.


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2. This release resolves a bug in which the incorrect layer was used in apportioning the Cuvier's beaked whale density. This updates the summary products that include the Cuvier's density layer as apportioned from the unidentified guild.
3. This release adds stratified density layers to the species richness summary products. This adds the following species to the products:
    a. Killer whale
    b. Northern bottlenose whale
    c. False killer whale
    d. Fraser's dolphin
    e. Melon-headed whale
    f. Pygmy killer whale
    g. Spinner dolphin
    h. White beaked dolphin
4. The symbology of species richness products has been updated to show the full range of the data - previously the highest values were not symbolized and appeared blank.
5. This release changes the threshold used to convert the non-stratified species model layers to presence/absence for inclusion in the species richness summary products from 95% to 99%. The process filters out very low density values where a given species is effectively absent. Species that were modeled as habitat-based density models are considered present in a cell if that cell is included in the area holding 99% of the total predicted abundance for the species.
6. Four climate change vulnerability layers were added based on species identified by Lettrich et al. 2023. The first group is the species that have high or very high vulnerability to climate change, and the remaining three groups are species that are highly or very highly sensitive to climate driven changes in distribution, abundance, or phenology.

Apportioning of Guilds – Updated in August 2023

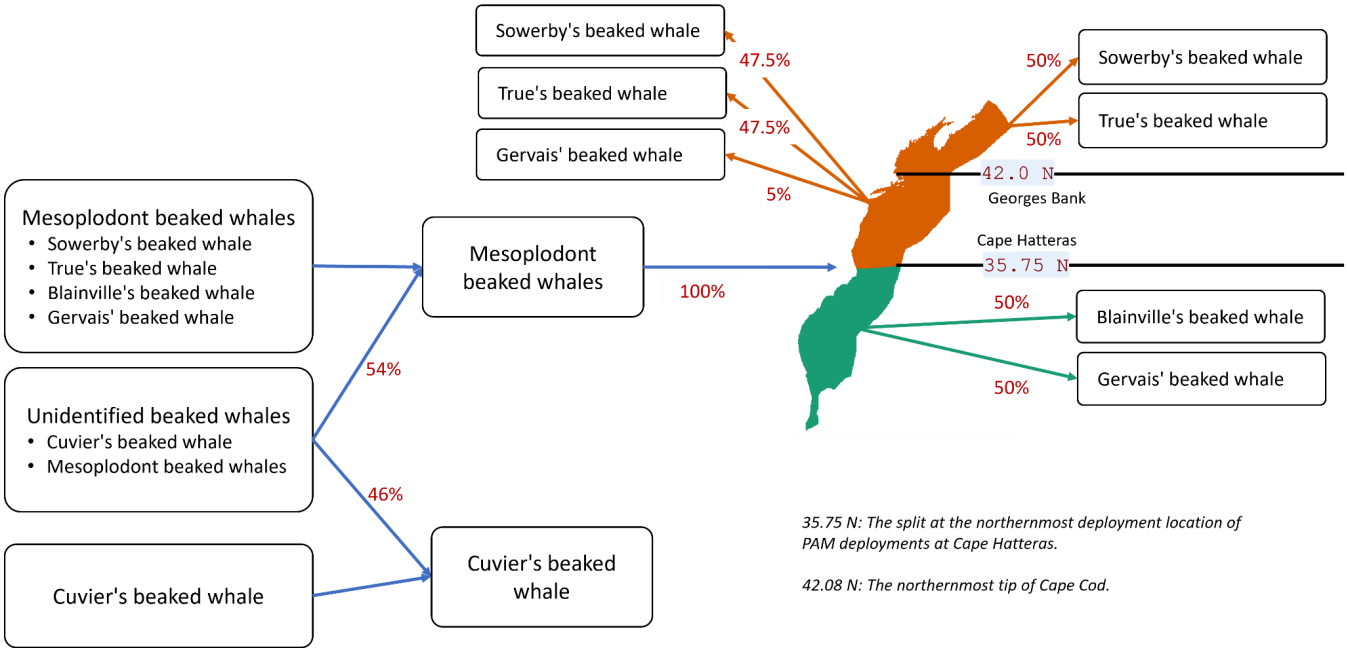


*Figure 1.* The apportioning methods used to assign Mesoplodont beaked whales and unidentified beaked whales to individual species models, last updated in August 2023.

**June 2023 Release, v3.1**

Marine mammal layers

1. A bug in the 5 and 95% rasters, whereby areas where a species is assumed absent are represented with values of NoData rather than Zero, has been fixed.

**March 2023 Release, v3.0**

Marine mammal layers

1. The updated marine mammal density surface models incorporate survey data through 2020. We incorporated a very large amount of additional survey data contributed by both continuing and new collaborators, with total aerial effort increasing by 2,139,000 linear km, or 255%, and shipboard effort by 54,000 km, or 93%. The biggest increase resulted from the incorporation of the southeast U.S. North Atlantic right whale early warning system surveys (SEUS NARW EWS), which together totaled 1,579,800 km of the added aerial effort. The program that provided the broadest overall impact was NOAA AMAPPS (Atlantic Marine Assessment Program for Protected Species). While AMAPPS only contributed about 207,300 km of the additional aerial effort and 33,400 km of the shipboard effort, it was the only program to estimate perception bias, which provided crucial corrections needed to estimate absolute abundance. AMAPPS was also the only program to cover the entire U.S. Exclusive Economic Zone (EEZ) and provided coverage in all four seasons. New contributions from New England Aquarium, the

partnership of New York State Department of Environmental Conservation and TetraTech, HDR, UNCW, and the Virginia Aquarium & Marine Science Center provided critical boosts to seasonal coverage of the Mid-Atlantic Bight and Navy OPAREAs.

2. Spatial resolution was increased to 5km X 5km grid cells for all individual species and summary product layers, while the prediction units remain the number of animals/100km$^2$. Individual species values are density.
3. The color ramp for both individual species and summary products was changed from Viridis to Turbo. A summary of the differences and improvements with Turbo can be found here.
4. For the first time, we incorporated a towed passive acoustic monitoring survey (MCR SOTW Acoustical). This survey was used in models for sperm whales and beaked whales.
5. Changed the resolution of contemporaneous covariates from daily to monthly for selection in all models.
6. Minke whale has been renamed as “Common minke whale,” following the name change by the Society for Marine Mammalogy.
7. We’ve added a new species prediction, with an annual abundance layer, Pygmy killer whale, given a new individual sighting by AMAPPS. The species was previously not modeled individually or as part of a guild.
8. Lacking any evidence of Bryde's whales in the East Coast study area, and given the expert opinions of Rosel et al. (2021), we now believe Bryde's whale is effectively absent from this study area and have not prepared a model for this region. We consider the previous Bryde’s whale model retired, and no longer recommend its use.
9. The number of stratified models was reduced from 13 to 8, increasing the number of taxa modeled with full DSM’s from 16 to 19 and adding 4 limited DSM’s.
10. The seal model is now included in the MDAT release.
11. The start date of most of the models is 1998. Exceptions include 2010 for Cuvier’s beaked whales, Mesoplodont beaked whales, and Unidentified beaked whales; 2003 for the NARW and 2002 for humpback whale; 1995 for False killer whale.
12. The study area was reduced in the north, where we eliminated the Laurentian Channel from the study area and extended in the mid-Atlantic to include the Balanus Seamount and offshore of Blake Spur in the southeast. Additionally, the study area was extended further inshore in certain bays and estuaries, per NOAA’s request.
13. Modeling methodologies were updated.
14. The uncertainty surface estimates were updated, with new methodology used to generate them, and now account for interannual variability. (Previous versions only accounted for the estimated statistical error in model parameter estimates.)

Marine Mammal Summary Product Changes

1. Humpback whale model has been removed from the ESA group, per NOAA declassification
2. It should be noted that the blue whale was previously a stratified model (only one density value in the entire extent) and was excluded from the summary product calculations except the

abundance. In the new release, the blue whale is a non-stratified model (a density surface model) and is now included in the summary product calculations for all products, for the groups in which they occur (cetaceans, baleen, sound sensitivity - low frequency).

3. Pygmy killer whale, a new modeled species, has been added to the All cetaceans, Large delphinoids, and Sound sensitivity high frequency summary product groups. As it's a stratified model, it's only included in the total abundance calculation.
4. The abundance layer of the summary products represents abundance (count of individual animals). To calculate abundance per cell, accumulated density values were divided by four.
5. The de-guilding method for the mesoplodont beaked whales in the summary products was improved in the new release thanks to passive acoustic monitoring (PAM) research and data. In the previous release, the mesoplodont beaked whales was apportioned into four species (Blainville's, Gervais', Sowerby's and True's), equally throughout the entire extent. In this release, based on the PAM research, we estimated Sowerby's and True's occur to the north of Cape Hatteras and Blainville's and Gervais' occur to the south of Cape Hatteras. Thus, the northern part of the layer was split into Sowerby's and True's equally and the southern part of the layer was split into Blainville's and Gervais' equally.
6. The unidentified beaked whales guild was apportioned into the Cuvier's beaked whale and the Mesoplodont beaked whales for the summary products, and the proportion of each has changed in this release from 48% Cuvier's / 52% Mesoplodont to 46% Cuvier's / 54% Mesoplodont, based on additional data.
7. This release fixes a bug in the summary products where the density of the dwarf sperm whale and the pygmy sperm whale apportioned from the Kogia guild was calculated based on the unidentified beaked whale guild not on the Kogia guild.

**February 2022 Release, v2.2**

North Atlantic right whale layers

1. The new density surface release summarizes the era 2010-2018, reflecting the apparent major shift in right whale distributions around 2010. For comparison, results were also summarized for two additional eras, 2003-2009 and 2003-2018. The 2010-2018 era is the recommended density surface for management decisions, and is presented in the regional ocean data portals, while the other results are available for download from the SEAMAP model page linked above.
2. Resolution was increased to 5km X 5km grid cells, while the prediction units remain the number of animals/100km$^2$. Summary products for groups that include North Atlantic right whales remain at standard 10km X 10km grid cell resolution.
3. Updated density predictions for Cape Cod Bay for January-May with estimates from Ganley et al. (2019), and for the month of December using all surveys conducted by the Center for Coastal Studies during the month of December from 2003-2020.
4. Additional survey data were added, and the aggregate database of surveys was to extend up through spring of 2019.
5. The start date of the model was shifted forward to 2003 (from 1998).

6. The study area was extended farther inshore in certain bays and estuaries, per NOAAs request.
7. Modeling methodologies were updated.
8. The uncertainty surface estimates were updated, with new methodology used to generate them, and now account for interannual variability. (Previous versions only accounted for the estimated statistical error in model parameter estimates.)

Mammal Sensitivity layer

1. The name of the Medium Frequency Sound Sensitivity Abundance layer has been changed to High Frequency Sound Sensitivity following guidance from Southall et al., 2019. In accordance with the data in the paper the composition of species in these groups remained unchanged, and the Low Frequency Sound Sensitivity Abundance layer was unaffected.

**June 2019 Release, v2.1**

Individual species or species guild base-layer updates in fall 2018

1. Improved modelling methodology.
    a. Detection functions for shipboard surveys were improved to account for species known to be attracted to ships. This attraction resulted in a problematic “spike” in sightings close to the trackline, mainly in shipboard surveys conducted on two ships by the Southeast Fisheries Science Center (SEFSC). These species are: Atlantic spotted, Clymene, common bottlenose, pantropical spotted, rough-toothed, and short-beaked common dolphins.
    b. Improvements were made to the availability and perception bias corrections.
    c. Improvements were made to the classification of ambiguous sightings for:
        i. Short-beaked common vs Atlantic white-sided dolphin
        ii. Atlantic spotted vs common bottlenose dolphin
    d. The fin and sei whale models were re-fit to include the ambiguous “fin or sei whale” sightings that had been classified into one species or the other. These ambiguous sightings were mistakenly left out of fin and sei whale models produced in 2017.

2. One additional spatial covariate was introduced: a salinity covariate from the Hybrid Coordinate Ocean Model (HYCOM) at 0.08° resolution helped distinguish the more saline waters within and south of the Gulf Stream with the fresher waters north of Cape Hatteras along the continental shelf. This covariate provides a better distinction than other covariates between habits of off-shelf and on-shelf waters north of Cape Hatteras throughout all seasons. It's helpful in modeling species that occur in one of those habitats but not the other (i.e. striped dolphin).
3. Updated model products were produced for:
    - Atlantic spotted dolphin (now 12 monthly predictions for the on-shelf subregion)
    - Atlantic white-sided dolphin
    - Clymene dolphin (previously stratified model, now habitat-based density surface model)
    - Common bottlenose dolphin; renamed from bottlenose dolphin
    - Dwarf and pygmy sperm whales guild (previously stratified model, now habitat-based density surface model); renamed from Kogia guild
    - Fin whale
    - Pantropical spotted dolphin (previously stratified model, now habitat-based density surface model)
    - Risso's dolphin
    - Rough-toothed dolphin (previously stratified model, now habitat-based density surface model)
    - Short-beaked common dolphin
    - Sei whale
    - Striped dolphin

<u>Species group summary product updates</u>

1. Taxa that switched from stratified models to habitat-based density surface models are now included in group summary products as follows (including the "all cetaceans" group). Previously, when these taxa were stratified models, they were not included in group summary products.
    1. Clymene dolphin now included in: Small delphinoids, mid-frequency sound sensitivity
    2. Dwarf sperm whale (Kogia whales) now included in: Sperm and beaked whales, high-frequency sound sensitivity
    3. Pantropical spotted dolphin now included in: Small delphinoids, mid-frequency sound sensitivity
    4. Pygmy sperm whale (Kogia whales) now included in: Sperm and beaked whales, high-frequency sound sensitivity
    5. Rough-toothed dolphin now included: Small delphinoids, mid-frequency sound sensitivity

**June 2018 Release, v2.0**

<u>Individual species or species guild base-layer updates</u>

1. Additional survey data. An additional 1,591,000 km of aerial and 27,000 km of shipboard survey effort was added, increasing the total effort to 2,435,000 km and 85,000 km, respectively. (Of

the additional aerial effort, 1,327,000 km was from the Southeast North Atlantic Right Whale surveys, which only collected sightings of large whales. Therefore, the additional aerial effort that was applicable to other species was 264,000 km.) Reflecting the additional survey data, the new models slightly expand the model study area, adding Long Island Sound and several offshore areas. This update allows for complete seasonal and spatial coverage of the continental shelf (waters from 0 - 200m deep) for most of the study area, and much of the continental slope (waters from 200 - 2000m deep) from Cape Hatteras to Georges Bank.

2. Improved modelling methodology. This update reprocessed the survey data from the North Atlantic Right Whale Sighting Surveys with a methodology that allowed the updated models to incorporate sightings of all species included in multi-species aggregations, rather than just the first species that was sighted, as was done in the first generation models. Detection functions were improved to allow categorical covariates, and many surveys were reprocessed to extract and utilize more covariates in detection functions. The detection hierarchy was updated to reflect the additional surveys. Certain changes to the spatial modeling statistical approached improved model performance.
3. Updated model products were produced for:
    - Fin whale
    - Humpback whale
    - Minke whale
    - North Atlantic right whale
    - Sei whale
    - Pilot whales (a guild)
    - Sperm whale
    - Harbor porpoise
4. In the first generation models, beaked whales were modeled as one guild, owing to the large number of sightings reported as “unidentified beaked whale”. Model collaborators undertook a concerted effort to better identify beaked whales, both in new data and in older surveys for which good photographs existed. These improvements allowed the beaked whales guild to be split into three more taxonomically-precise models:
    - Cuvier’s beaked whale
    - Mesoplodont beaked whales (a guild)
    - Unidentified beaked whales (a guild)
5. Updated environmental predictor data. Some habitat covariates for the spatial models were updated to cover the expanded temporal range, some were replaced by improved covariate products, and two new covariates were added.

<u>Species group summary product updates</u>

1. Treatment of stratified models. Cetacean group richness, diversity, and core area abundance richness summary products now exclude all models which were created as stratified models. Species with too few sightings available to model density from environmental predictors were

instead fitted with a so-called stratified density model. Based on scientific literature reviews, some of these models were split into two or more areas, and stratified models were fit to each of those areas, or the species was considered absent from one or more of the areas. Stratified models have uniform density in each individual stratum. Because these species are rarely sighted, their distribution and habitat are less well understood than the cetacean species or species guilds modeled with habitat-based density models. MDAT diversity products are used to show variation across different habitats, and we lack the information to show these species at that level of variation. Sightings data of these rare species do show differences, but we lack enough data to say anything more detailed. This change results in the exclusion of the following species or species guilds from specific group products, including the "all cetaceans" group:

1. Blue whale: Baleen whales, ESA-listed species, low-frequency sound sensitivity
2. Bryde's whale: Baleen whales, low-frequency sound sensitivity
3. Clymene dolphin: Small delphinoids, mid-frequency sound sensitivity
4. Dwarf sperm whale (Kogia whales): Sperm and beaked whales, high-frequency sound sensitivity
5. False killer whale: Large delphinoids, mid-frequency sound sensitivity
6. Fraser's dolphin: Small delphinoids, mid-frequency sound sensitivity
7. Killer whale: Mid-frequency sound sensitivity, large delphinoids
8. Melon-headed whale: Large delphinoids, mid-frequency sound sensitivity
9. Northern bottlenose whale: Sperm and beaked whales, mid-frequency sound sensitivity
10. Pantropical spotted dolphin: Small delphinoids, mid-frequency sound sensitivity
11. Pygmy sperm whale (Kogia whales): Sperm and beaked whales, high-frequency sound sensitivity
12. Rough-toothed dolphin: Small delphinoids, mid-frequency sound sensitivity
13. Spinner dolphin: Small delphinoids, mid-frequency sound sensitivity
14. White-beaked dolphin: Medium-frequency sound sensitivity, small delphinoids

2. Cetacean group diversity layers have changed. Previously, there was no filtering on the individual species density layers that went into the diversity algorithm. In v2.0, each individual species layer is pre-filtered to contain only the cells that are included in the area holding 95% of the total predicted abundance for the species. (Note: the same low-density filtering algorithm was implemented for the richness layers in the initial release.)

**September 2016 - Initial Release, v1.0**

Using distance sampling methodology, we built statistical models of cetacean density—the number of individual animals found per square kilometer of area—from environmental variables for 26 species and 3 multi-species guilds, and produced maps showing average density across the modeled region. Depending on the survey data that was available and how well each modeled taxon's movement patterns were described in the scientific literature, we produced either 12 monthly maps or one "year-round" map for each taxon.

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