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Dive Distribution and Group Size Parameters for Marine Species Occurring in the U.S. Navy's Atlantic and Hawaii-California Training and Testing Study Areas

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14. ABSTRACT

An important element of the Navy's comprehensive environmental planning is the acoustic effects analysis executed with the Navy Acoustic Effects Model (NAEMO) software. NAEMO was developed to estimate the possible impacts of anthropogenic sound on marine animals, combining established acoustic propagation modeling with data regarding the distribution and abundance of marine species. This report recommends species-typical static depth distributions and group size information for all marine mammal and sea turtle species that occur in the Atlantic Fleet Training and Testing (AFTT) and Hawaii-California Training and Testing (HCTT) Study Areas that will be modeled using NAEMO.

15. SUBJECT TERMS

Marine mammals, Sea turtles, Dive profile, Group size, Atlantic Fleet Training and Testing (AFTT), Hawaii-California Training and Testing (HCTT), Navy Acoustic Effects Model (NAEMO), Acoustic modeling

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LIST OF ABBREVIATIONS AND ACRONYMS

AFTT	Atlantic Fleet Training and Testing
DTAG	Digital Acoustic Recording Tag
HRC	Hawaii Range Complex
HCTT	Hawaii-California Training and Testing
m	meter(s)
NAEMO	Navy Acoustic Effects Model
NMFS	National Marine Fisheries Service
NOCAL	Northern California
NUWC	Naval Undersea Warfare Center
SD	Standard Deviation
SOCAL	Southern California
TDR	Time-Depth Recorder
U.S.	United States
USFWS	United States Fish and Wildlife Service

1. INTRODUCTION

The United States (U.S.) Navy is required to assess potential impacts of Navy-generated sound in the water on protected marine species in compliance with applicable laws and regulations, including the National Environmental Policy Act, Executive Order 12114, the Marine Mammal Protection Act, and the Endangered Species Act. This report describes the methods and analytical approach to quantifying the depth distributions in the water column and group sizes of marine mammals and sea turtles to be used within the Navy Acoustic Effects Model (NAEMO).

1.1 THE NAVY ACOUSTIC EFFECTS MODEL

NAEMO is the standard model used by the Navy to estimate potential impacts to marine species from impulsive and non-impulsive sound sources used during Navy training and testing activities. NAEMO combines marine species distribution information with environmental parameters, propagation characteristics, sound source parameters, and typical training or testing scenarios in order to assess the level of behavioral disturbance, hearing impacts (including both temporary and permanent threshold shifts), and other injuries predicted for individual marine mammals and sea turtles likely to be in the vicinity of Navy training and testing activities.

1.2 DATA INPUTS

NAEMO first uses location-specific density and group size information (more detailed information regarding species density is available in the Density Technical Report by U.S. Department of the Navy (In Prep.-a, In Prep.-b) to patchily distribute a given marine species into a simulation area. The depth distribution data are then used to place animals in the water column at the depths at which they are typically found. An animal is reassigned a new depth every four minutes (min) throughout the simulation based on the depth distribution for that species. Where available, seasonal or geographically-specific depth and group size information is used.

Density data are not available for all taxa of concern for Navy activities (Section 2.1). In addition to available marine mammal and sea turtle data, specific information about environmental conditions and projected Navy activities within a study area is needed to run NAEMO and quantify potential impacts to marine mammals and sea turtles. These environmental data include information about bathymetry, seafloor composition (e.g., rock, sand), and factors that vary throughout the year such as wind speed and sound velocity profiles. The details of Navy training and testing activities are also collected, including location, frequency, and source characteristics. For more detailed information about the NAEMO model, consult the Quantitative Analysis Technical Report (U.S. Department of the Navy 2024).

2. MARINE MAMMAL AND SEA TURTLE DEPTH DISTRIBUTIONS

The best available science from literature reviews was used to obtain species-specific depth distribution information for the Atlantic Fleet Training and Testing (AFTT) and Hawaii-California Training and Testing (HCTT) Study Areas (Figure 2-1). Journal articles, books, technical reports, cruise reports, funding agency reports, theses, dissertations, and raw data from individual researchers were assessed for this report. Usable depth distribution data were data that presented percentage of time at depth for a species. In some cases, the closest data to this were percentage of dives to a certain depth, which was sometimes used as a proxy for percentage of time in each depth bin. Some studies did not include bins, but displayed continuous dive profiles over the entire duration of a tag. On these profiles, the DataTheif MATLAB program was used to generate dive profiles with depth bins.

As described in Section 1.1, depth distribution data are combined with species density data during the NAEMO modeling process. Densities were obtained from the Navy Marine Species Density Database. In some instances, density data were provided for guilds of species, rather than for individual species (e.g., pilot whales, *Kogia* spp., beaked whales, and AFTT seals are all groups of two or more species). These multi-species guilds were created because observers could not differentiate closely-related species at sea, or because the sample sizes of the species observed individually were too small to incorporate into density modeling. For these cases, a single representative species was chosen or a composite depth distribution was created to correspond to the multi-species groupings contained in the density data. For some species groups, like the beaked whales, multiple guilds may contain the same species (e.g., unidentified beaked whales and Mesoplodont beaked whales). Each density layer needed to be matched with a dive profile, which is why each guild is presented in this document.

The information required for representing a species in NAEMO specifically focuses on the percent of time each animal spends in the water column, defined here as a range of depths extending from the surface to the maximum dive depth of each species. Within the research, percentage values may be slightly above or below 100 percent, due to decimal rounding, especially when animals spend smaller percentages of time close to their maximum dive depth. However, NAEMO requires that the percentages add to 100 percent; therefore, where applicable, if the sum was over 100, the “extra” percentage was removed from the deepest bins and, if the sum was less than 100, the difference was added to the surface bin. In all cases, this difference was less than one percent. Rather than reduce the deepest bin to zero during this adjustment process, the deep bins were sometimes halved in order to show a fraction of a percentage when it has been recorded that a species is capable of reaching that depth bin. For pinniped species, time spent hauled out of the water is not represented (this is accounted for in the density data). Depth distributions contain percent time spent in the water only, either at the surface or in given depth bins. NAEMO requires that depth bins begin at zero and that the bin following the previous bin start and end with the same depth (i.e., the first bin would be 0–5 meters and the following depth bin would be 5–10 meters). If the research contained a small gap, such as where a depth bin ended at five meters and the next started at six meters, the depths were adjusted so that the second bin started at five meters instead.

It should be noted that dive profile research needed to be completed by the Fall of 2022, before modeling began for both AFTT and HCTT Study Areas. As a result, despite the fact that this document is not being published until 2024, research for this technical report stops in 2022. The next-phase document will contain any of the dive studies that have been conducted from 2022 onwards.

2.1 SURROGATE SPECIES AND STUDY AREAS

Depth distribution data within this report are based upon species-specific tagging data obtained during literature review. If tagging data were not available for a particular species or guild, data for the most similar species were used in the form of a surrogate. A species will generally only be considered a surrogate for modeling if the species is closely related (within the same genus or family), feeds on similar prey, or has a distribution in similar water types (e.g., continental shelf waters). The exception to the general surrogate selection is the two species of *Kogia* spp. (dwarf and pygmy sperm whales), for which there are no other species in their family to choose as surrogates. Therefore, a species from another family within their suborder (Odontoceti) was chosen as a surrogate. Surrogate species (if required) for all species are provided in Table 2-1 for both AFTT and HCTT Study Areas. The HCTT Study Area is divided into Northern California (NOCAL), the Point Mugu Sea Range (PMSR), Southern California (SOCAL), and the Hawaii Range Complex (HRC) in Table 2-1.

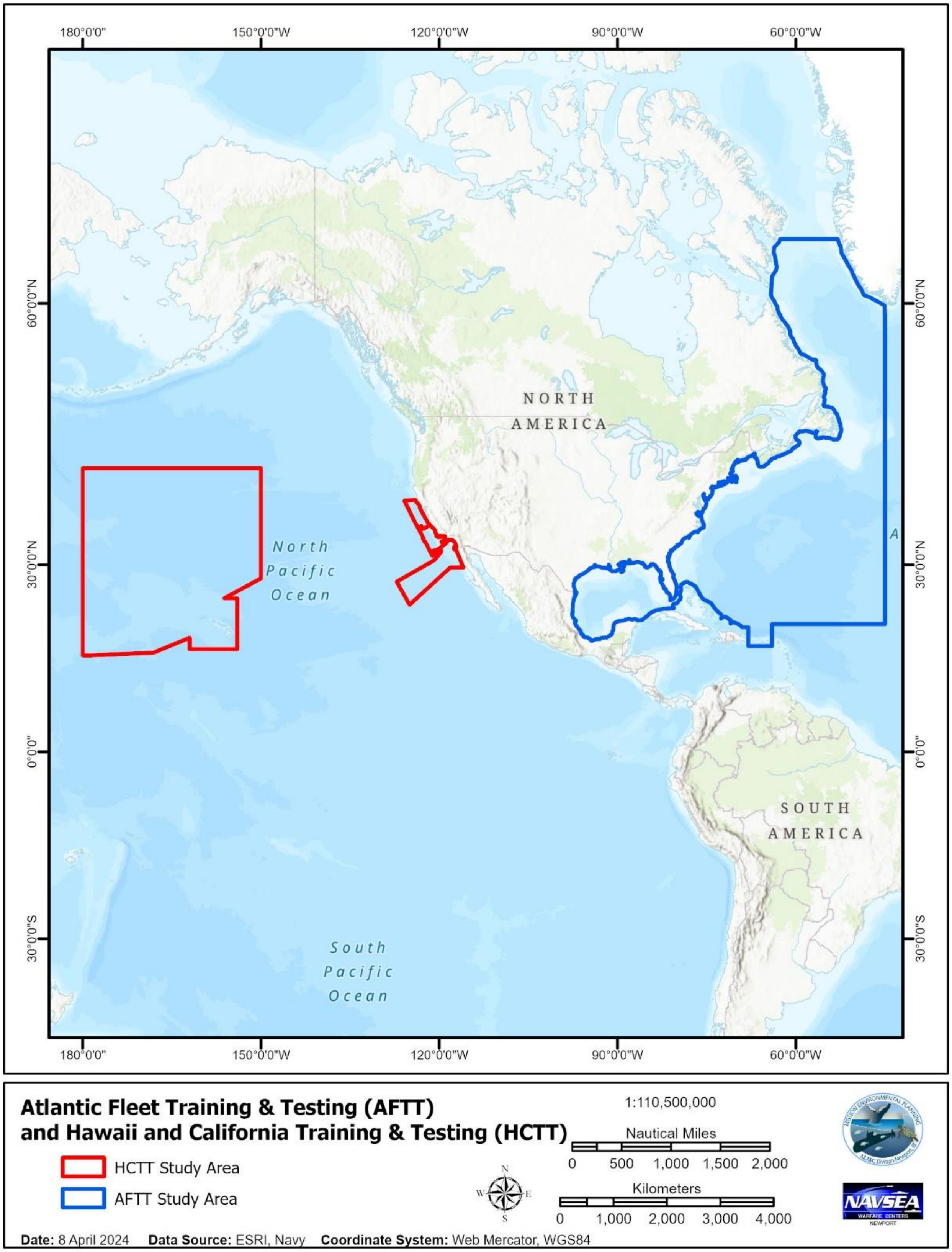

Figure 2-1. Atlantic Fleet and Hawaii-California Training and Testing Study Areas.

Table 2-1. Presence of each species in the AFTT or HCTT Study Areas.

Species Name	Common Name	Surrogate Species	AFTT Study Area	HCTT Study Area			Section
				NOCAL, PMSR	SOCAL	HRC	
Cetaceans							
Family Balaenidae							
Eubalaena glacialis	North Atlantic right whale	N/A	X	-	-	-	2.2.1.1.1
Family Balaenopteridae							
Balaenoptera acutorostrata	Minke whale	N/A	X	X	X	X	2.2.1.2.1
Balaenoptera borealis	Sei whale	Bryde's whale	X	X	X	X	2.2.1.2.2
Balaenoptera edeni	Bryde's whale	N/A	X	X	X	X	2.2.1.2.3
Balaenoptera musculus	Blue whale	N/A	X	X	X	X	2.2.1.2.4
Balaenoptera physalus	Fin whale	N/A	X	X	X	X	2.2.1.2.5
Balaenoptera ricei	Rice's whale	N/A	X	-	-	-	2.2.1.2.6
Megaptera novaeangliae	Humpback whale	N/A	X	X	X	X	2.2.1.2.7
Family Delphinidae							
Delphinus capensis	Long-beaked common dolphin	Pantropical spotted dolphin	X	X	X	-	2.2.1.3.1
Delphinus delphis	Short-beaked common dolphin	Pantropical spotted dolphin	X	X	X	-	2.2.1.3.2
Feresa attenuata	Pygmy killer whale	Risso's dolphin	X	-	-	X	2.2.1.3.3
Globicephala macrorhynchus	Short-finned pilot whale	N/A	Modeled as pilot whale guild	X	X	X	2.2.1.3.4
Globicephala melas	Long-finned pilot whale	N/A	Modeled as pilot whale guild	-	-	-	2.2.1.3.5

Species Name	Common Name	Surrogate Species	AFTT Study Area	HCTT Study Area			Section
				NOCAL, PMSR	SOCAL	HRC	
Globicephala spp. (G. macrorhynchus, G. melas)	Pilot whale guild (long-finned and short- finned pilot whales)	Short-finned pilot whale	X	-	-	-	2.2.1.3.6
Grampus griseus	Risso's dolphin	N/A	X	X	X	X	2.2.1.3.7
Lagenodelphis hosei	Fraser's dolphin	Short-finned pilot whale	X	-	-	X	2.2.1.3.8
Lagenorhynchus acutus	Atlantic white-sided dolphin	Pantropical spotted dolphin	X	-	-	-	2.2.1.3.9
Lagenorhynchus albirostris	White-beaked dolphin	Pantropical spotted dolphin	X	-	-	-	2.2.1.3.10
Lagenorhynchus obliquidens	Pacific white-sided dolphin	Pantropical spotted dolphin	-	X	X	-	2.2.1.3.11
Lissodelphis borealis	Northern right whale dolphin	Pantropical spotted dolphin	-	X	X	-	2.2.1.3.12
Orcinus orca	Killer whale	N/A	X	X	X	X	2.2.1.3.13
Peponocephala electra	Melon-headed whale	Risso's dolphin	X	-	-	X	2.2.1.3.14
Pseudorca crassidens	False killer whale	Risso's dolphin	X	-	-		2.2.1.3.15
Blackfish guild (*F. attenuata*, *P. crassidens*, *O. orca*, *P. electra*)	Pygmy killer whale, false killer whale, killer whale, and melon-headed whale	Risso's dolphin	X	-	-		2.2.1.3.16

Species Name	Common Name	Surrogate Species	AFTT Study Area	HCTT Study Area			Section
				NOCAL, PMSR	SOCAL	HRC	
Stenella frontalis	Atlantic spotted dolphin	N/A	X	-	-		2.2.1.3.17
Stenella attenuata	Pantropical spotted dolphin	N/A	X	-	-		2.2.1.3.18
Stenella coeruleoalba	Striped dolphin	Pantropical spotted dolphin	X	X	X		2.2.1.3.19
Stenella longirostris	Spinner dolphin	Pantropical spotted dolphin	X	-	-		2.2.1.3.20
Stenella clymene	Clymene dolphin	Pantropical spotted dolphin	X	-	-		2.2.1.3.21
Steno bredanensis	Rough-toothed dolphin	N/A	X	-	-		2.2.1.3.22
Tursiops truncatus	Bottlenose dolphin	N/A	X	X	X		2.2.1.3.23
Family Eschrichtiidae							
Eschrichtius robustus	Gray whale	N/A	-	X	X	-	2.2.1.4.1
Family Kogiidae							
Kogia breviceps	Pygmy sperm whale	Short-finned pilot whale	Modeled as Kogiid whales	Modeled as Kogia whales	Modeled as Kogia whales	X	2.2.1.5.1
Kogia sima	Dwarf sperm whale	Short-finned pilot whale	Modeled as Kogiid whales	Modeled as Kogia whales	Modeled as Kogia whales	X	2.2.1.5.2
Kogia spp. (Kogia breviceps and sima)	Kogiid whales or Kogia spp.	Short-finned pilot whale	X	X	X	-	2.2.1.5.3
Family Phocoenidae							
Phocoena phocoena	Harbor porpoise	N/A	X	X	-	-	2.2.1.6.1
Phocoenoides dalli	Dall's porpoise	N/A	-	X	X	-	2.2.1.6.2
Family Physeteridae							
Physeter macrocephalus	Sperm whale	N/A	X	X	X	X	2.2.1.7.1

Species Name	Common Name	Surrogate Species	AFTT Study Area	HCTT Study Area			Section
				NOCAL, PMSR	SOCAL	HRC	
Family Ziphiidae							
Berardius bairdii	Baird's beaked whale	Cuvier's beaked whale	-	X	X	-	2.2.1.8.1
Hyperoodon ampullatus	Northern bottlenose whale	Cuvier's beaked whale	X	-	-	-	2.2.1.8.2
Indopacetus pacificus	Longman's beaked whale	Blainville's beaked whale	-	-	-	X	2.2.1.8.3
Mesoplodon densirostris	Blainville's beaked whale	N/A	X	X	X	X	2.2.1.8.4
Ziphius cavirostris	Cuvier's beaked whale	N/A	X	X	X	X	2.2.1.8.5
AFTT beaked whale guild (*Z. cavirostris, M. mirus, M. europaeus, M. densirostris, M. bidens*)	Cuvier's, True's, Gervais', Blainville's, and Sowerby's beaked whales	Blainville's beaked whale	X	-	-	-	2.2.1.8.6
Mesoplodont whale guild *Mesoplodon spp. (M. densirostris, M. ginkgodens, M. stejnegeri, M. carlhubbsi, M. perrini, M. peruvianis)*	Blainville's, ginkgo-toothed, Stejneger's, Hubb's, Perrin's, and pygmy beaked whales	Blainville's beaked whale	-	-	-	X	2.2.1.8.7
Small beaked whale guild *Mesoplodon spp. (M. densirostris, M. ginkgodens,*	Blainville's, ginkgo-toothed, Stejneger's, Hubb's, Perrin's, and	Blainville's beaked whale	-	X	X	-	2.2.1.8.8

Species Name	Common Name	Surrogate Species	AFTT Study Area	HCTT Study Area			Section
				NOCAL, PMSR	SOCAL	HRC	
M. stejnegeri, M. carlhubbsi, M. perrini, M. peruvianis)	pygmy beaked whales						
Unidentified beaked whale guild (*Ziphius cavirostris, Mesoplodon densirostris, M. bidens, M. europaeus,* M. mirus)	Cuvier's, Blainville's, Sowerby's, Gervais', and True's beaked whales	Blainville's beaked whale	X	-	-	-	2.2.1.8.9
Carnivores							
Family Mustelidae							
Enhydra lutris nereis	Southern sea otter	N/A	-	X	-	-	2.2.2.1.1
Family Otariidae							
Arctocephalus townsendi	Guadalupe fur seal	N/A	-	X	X	-	2.2.2.2.1
Callorhinus ursinus	Northern fur seal	N/A	-	X	X	-	2.2.2.2.2
Eumetopias jubatus	Steller sea lion	N/A	-	X	-	-	2.2.2.2.3
Zalophus californianus	California sea lion	N/A	-	X	X	-	2.2.2.2.4
Family Phociidae							
Cystophora cristata	Hooded seal	N/A	X	-	-	-	2.2.2.3.1
Halichoerus grypus	Gray seal	N/A	Modeled as seal guild	-	-	-	2.2.2.3.2
Erignathus barbatus	Bearded seal	N/A	X	-	-	-	2.2.2.3.3
Mirounga angustirostris	Northern elephant seal	N/A	-	X	X	-	2.2.2.3.4
Monachus schauinslandi	Hawaiian monk seal	N/A	-	-	-	X	2.2.2.3.5
Pagophilus groenlandicus	Harp seal	N/A	X	-	-	-	2.2.2.3.6
Phoca hispida	Ringed seal	N/A	X	-	-	-	2.2.2.3.7
Phoca vitulina	Harbor seal	N/A	Modeled as seal guild	-	X	-	2.2.2.3.8

Species Name	Common Name	Surrogate Species	AFTT Study Area	HCTT Study Area			Section
				NOCAL, PMSR	SOCAL	HRC	
Seal guild (Halichoerus grypus, Phoca vitulina)	Gray seal and harbor seal	Composite of gray seal and harbor seal	X	-	-	-	2.2.2.3.9
Sirenians							
Family Trichechidae							
Trichechus manatus	West Indian manatee	N/A	X	-	-	-	2.2.3.1.1
Sea Turtles							
Family Cheloniidae							
Caretta caretta	Loggerhead sea turtle	N/A	X	X	X	X	2.2.4.1.1
Chelonia mydas	Green sea turtle	N/A	X	X	X	X	2.2.4.1.2
Eretmochelys imbricata	Hawksbill sea turtle	N/A	X	-	-	X	2.2.4.1.3
Lepidochelys kempii	Kemp's ridley sea turtle	N/A	X	-	-	-	2.2.4.1.4
Lepidochelys olivacea	Olive ridley sea turtle	N/A	X	-	-	X	2.2.4.1.5
Family Demochelyidae							
Dermochelys coriacea	Leatherback sea turtle	N/A	X	X	X	X	2.2.4.2.1

2.2 MARINE MAMMAL AND SEA TURTLE DIVE BEHAVIOR SUMMARIES

This section discusses the depth distributions that were constructed for each species, surrogate species, or guild based on the best available science. Ideally, depth distributions would be specific to different locations; however, most of the time diving data were not available for the precise locations within the AFTT and HCTT Study Areas. Marine mammal and sea turtle dive behaviors are not easily stereotyped, but a species' behavior can generally be quantified by using an average percentage of time that an animal will typically spend within a range of depths, or depth bin. For each species, a distribution throughout the water column is presented, along with a list of the references that are the source of the data and an explanation about how these references were used to create the distribution. Depth bins are given in meters (m). Depending on the species, the distribution may cover a larger or smaller range of depths, such as for a shallow diving fur seal or a deep diving sperm whale. Likewise, depth bins may be smaller near the surface or larger at greater depths (e.g., 20-m bins near the surface where the animal spends more time or 100-m bins at the deepest depths the animal can reach). For certain species (e.g., North Atlantic right whale, humpback whale, and sperm whale), more than one depth distribution is given due to documented seasonal or geographic differences in diving behavior. Individual species are listed within each order.

2.2.1 Cetaceans

2.2.1.1 Family Balaenidae

2.2.1.1.1 Eubalaena glacialis, North Atlantic Right Whale

North Atlantic right whales migrate between their feeding grounds in temperate and sub-polar shelf waters and near-shore waters, and their breeding grounds in sub-tropical near-shore waters (Kenney 2002). Their prey consist entirely of zooplankton, particularly large copepods. Right whales are skim feeders that swim open-mouthed, both at the surface and at depth, through patches of congregated prey (Baumgartner et al. 2017; Kenney 2002; Kenney et al. 2001; Mate and Nieukirk 1992).

Due to a separation of behaviors based on location within a foraging ground or within a breeding ground, two separate representative depth distributions were compiled for North Atlantic right whales. Foraging grounds include all waters off the North American seaboard that are north of Cape Hatteras, North Carolina. In order to build a representative depth distribution for the North Atlantic right whale on foraging grounds, depth distributions for 46 whales from the Bay of Fundy were provided by Nowacek and McGregor (2010). The Bay of Fundy data reflect skim feeding both at the surface and at depth (Nowacek and McGregor 2010). Parks et al. (2011) examined dive behavior during the spring feeding season in Cape Cod Bay (Parks et al. 2011). Parks et al. (2011) reported whales spent on average 84 percent of time within 3 meters (m) of the surface, while Nowacek and McGregor (2010) reported whales spent on average 32.89 percent of time in the top 10 m. The average of these percentages amounts to 58.45 percent of the whales' time spent in the surface bin (0–10 m). The remaining depth bins provided by Nowacek and McGregor (2010) were redistributed proportionally to account for the remaining 41.56 percent of time. The resulting depth distribution for right whales on foraging grounds is given in Table 2-2. This distribution is consistent with maximum dive depths reported in the literature of 174 m (Baumgartner and Mate 2003) and 272 m (Mate and Nieukirk 1992).

Table 2-2. Percentage of time at depth for the North Atlantic right whale on feeding grounds[1].

Depth Bin (m)	% of Time at Depth	Depth Bin (m)	% of Time at Depth
0–10	58.45	110–120	5.19
10–20	2.39	120–130	4.79
20–30	1.66	130–140	3.88
30–40	1.22	140–150	3.31
40–50	2.08	150–160	1.94
50–60	1.07	160–170	0.84
60–70	0.97	170–180	0.28
70–80	2.29	180–190	0.02
80–90	2.33	190–200	0.01
90–100	2.62	200–210	0.005
100–110	4.65	210–220	0.005

[1] Based on data from Nowacek and McGregor (2010) and Parks et al. (2011).

This representative depth distribution is consistent with tagging results from Baumgartner et al. (2017), who reported whales spending the majority of time (72 percent) in the upper 10 m. North Atlantic right whales have been assumed to dive to the depth of the seafloor, based on both, data from tagged individuals and photographs of whales with seafloor sediments on their bodies (Baumgartner et al. 2017; Hamilton and Kraus 2019). The depth at which prey are found strongly influences the dive depths of North Atlantic right whales (Baumgartner et al. 2017). Because the depth distribution of prey changes vertically throughout the day as well as seasonally, the foraging depths of the whales change as well (Baumgartner et al. 2017).

To build a representative depth distribution for North Atlantic right whales on breeding grounds, depth distributions for six whales in the South Atlantic Bight were provided by Nowacek and McGregor (2010) (Table 2-3). The South Atlantic Bight encompasses the continental shelf from Cape Hatteras, North Carolina south to Cape Canaveral, Florida. The depth distribution in Table 2-3 will also be used for both migration periods and any other movements to the south of Cape Hatteras.

Table 2-3. Percentage of time at depth for the North Atlantic right whale on breeding grounds[1].

Depth Bin (m)	% of Time at Depth
0–4	46.05
4–8	29.16
8–12	9.73
12–16	14.76
16–24	0.3130

[1] Based on data from Nowacek and McGregor (2010).

This representative dive depth distribution is consistent with other studies that tagged individuals from breeding grounds (Dombroski et al. 2021; Nowacek et al. 2002). Dive depths are shallower in breeding than foraging grounds because breeding grounds are located in shallower habitats. The maximum dive depths at breeding grounds are presumed to be determined by the depth of the habitat rather than maximum dive abilities of whales (Dombroski et al. 2021; Nowacek et al. 2002; van der Hoop et al. 2017). Dombroski et al. (2021) reported that lactating females were found up to 80 percent of time at depths less than or equal to 3.5 m, while non-lactating (i.e., pregnant and juvenile) whales were found at a maximum of 30 percent of time at these depths. The median maximum dive depth recorded for all whales was 5 to 16 m (Dombroski et al. 2021). Nowacek et al. (2015) reported that the mean maximum dive depth for mother-calf pairs was less than 10 m. Mother-calf pairs spend a higher percentage of time near the surface than non-lactating whales because mother-calf pairs mainly spend their time resting (Cusano et al. 2019).

2.2.1.2 Family Balaenopteridae

2.2.1.2.1 Balaenoptera acutorostrata, Minke Whale

Minke whales are widely distributed throughout the world oceans, occurring in coastal and continental shelf waters, the deeper waters along continental slopes, and further seaward (Dorsey et al. 1990; Øien 1990). Fish (e.g., capelin, sandlance, and herring) and planktonic crustaceans (e.g., krill) are the main components of the minke whale diet (Haug et al. 1995). Minke whales feed by side-lunging into schools of prey as well as gulping large amounts of water (Jefferson et al. 2008; Stimpert et al. 2014).

Little data have been collected on the dive behavior of minke whales. In order to build a representative depth distribution for minke whales, data from Figure 2 in Blix and Folkow (1995) were used. Blix and Folkow (1995) presented a time-depth record for a single minke whale tagged off the west coast of Svalbard, a Norwegian archipelago. This animal was predominantly foraging between 25 and 50 m. Two depth bins and the time spent within each depth bin were estimated, with the resulting depth distribution shown. The depth distribution data are derived from a short (75 min) dive profile of a single animal, in which two behaviors are represented, cruising (52 percent of time), and foraging (48 percent of time); however, the amount of time spent in these two behaviors can vary significantly among individuals (Blix and Folkow 1995). The depth distribution for minke whales is given in Table 2-4.

Table 2-4. Percentage of time at depth for the minke whale[1].

Depth Bin (m)	% of Time at Depth
0–25	79.7
25–65	20.3

[1] Based on data from Blix and Folkow (1995).

More recent data suggest that the minke whale can dive to greater depths than depicted by this distribution. For example, minke whales in the Antarctic have been associated with krill patches found at a median depth of 118 m (Friedlaender et al. 2009b), and two tagged whales were recorded to dive to a maximum depth of 105 m (Stimpert et al. 2014). The mean dive depth for the tagged whales in Antarctica was 18 m (Stimpert et al. 2014). Off Scotland, minke whales are found where patches of pre-spawning herring occur at depths between 100 and 150 m (MacLeod et al. 2003b), while off the coast of California, tagged minke whales dove to 130 m (Southall et al. 2014), although in both cases whales spent the majority of their time in the top 25 m of the water column. There is also limited evidence that minke whales may exhibit diurnal variation in diving behavior (Joyce et al. 1990; Stockin et al. 2001). Christiansen et al. (2015) did not tag minke whales, but did observe their surfacing patterns during different activities. Surface foraging, near-surface foraging, deep foraging, traveling, and resting were observed. The depth distribution shown in Table 2-4 is considered representative for minke whales until more information becomes available.

2.2.1.2.2 Balaenoptera borealis, Sei Whale

Sei whales have a cosmopolitan distribution, migrating between high-latitude feeding grounds and low-latitude breeding grounds (Horwood 2002). They have been found on the outer edge of the continental slope in waters 500 to 2,250 m deep (Baines and Reichelt 2014). Sei whales are capable of diving for between 5 and 20 minutes (Reeves et al. 2002) to feed on plankton, predominantly copepods and euphausiids, which occur between the surface and depths around 150 m (Baines and Reichelt 2014; Budylenko 1978; Flinn et al. 2002). They may also feed on small schooling fish and cephalopods by both gulping and skimming.

Little data have been collected on the dive behavior of sei whales. Sei whales are not thought to be deep divers. Baumgartner et al. (2011) found that sei whales were absent during times when copepods were at depth, suggesting that sei whales may only be able to feed effectively on copepod aggregations when they are at or near the surface. In addition, Baumgartner and Fratantoni (2008) observed low calling rates during the night when copepods were at the surface, and higher calling rates during the day when copepods were at depth. This study speculated that sei whales reduced calling rates to accommodate nighttime feeding on the copepod aggregations at the surface, and increased calling rates during the day when copepods migrated to deeper depths where they were unavailable as prey to the sei whales. Ishii et al. (2017) also found that sei whale behavior varied based on the depth copepod aggregations were found. Two sei whales were tagged in this study and one individual showed significantly deeper dives during the daytime when food sources were at greater depths, which refutes that sei whales are not migrating to deeper depths to track food sources. As with other studies, whales were found in shallow water (10 m) with copepods after sunset (Ishii et al. 2017).

Due to a lack of available data on the dive behavior of sei whales, they will be represented by a surrogate species: the Bryde's whale (Section 2.2.1.2.3). The Bryde's whale is the closest relative to the sei whale (Sasaki et al. 2005); these species are of similar body size (Horwood 2002) and feed on similar prey in the Northern Hemisphere (Flinn et al. 2002; Mizroch et al. 1984). While sei whales differ from other Balaenopterids in their prey preference for copepods, this preference means that, like Bryde's whales, sei whales are not thought to be deep divers and spend most of their time near the surface (Alves et al. 2010). Foraging sei whales and Bryde's whales utilize similar water depths (Alves et al. 2010; Baumgartner et al. 2011). In Ishii et al. (2017), where sei whales were hypothesized to follow migrating copepods, two tagged sei whales were recorded diving to average foraging depths of 14.2 and 17.9 m, with the deepest foraging depth recorded at 48 and 57 m, respectively (Ishii et al. 2017). This falls within the range of behavior depicted in the Bryde's whale dive profile in Table 2-5.

2.2.1.2.3 Balaenoptera edeni, Bryde's Whale

Bryde's whales are found in tropical and temperate waters, with separate coastal and offshore forms (Best 2001; Weir 2007). There is ongoing debate about the taxonomic relationship between two morphotypes — the larger -*brydei* form, found within the AFTT and HCTT Study Areas, and the smaller -*edeni* form, found outside of the AFTT and HCTT Study Areas (Sasaki et al. 2006). These two forms are genetically distinct, and are differentiated by geographic distribution, inshore/offshore habitat preferences, and size. However, for both morphotypes, which are not easily distinguished at sea, the scientific name *B. edeni* is commonly used. In

2021, scientists determined that the Rice's whale, which is located only in the Gulf of Mexico, was a unique species, genetically and morphologically distinct from Bryde's whales; therefore Rice's whale is discussed in Section 2.2.1.2.6. The main prey of Bryde's whales include pelagic schooling fish species, such as sardines, mackerel, and herring (Siciliano et al. 2004), as well as cephalopods and small crustaceans (Kato 2002; Omura 1962).

To build a representative depth distribution for Bryde's whales, data from Table 1 in Alves et al. (2010) were used. Alves et al. (2010) reported a distribution of time spent in shallow versus deep dives for two whales tagged with a time-depth recorder near Madeira Island, Spain. Though these data are not strictly an indication of time spent in the two different depth bins (time spent diving down to 40 to 292 m includes time passing through the 0- to 40-m depth bin), the data are the best available approximation of time spent at depth. The depth distribution for Bryde's whales is given in Table 2-5.

Table 2-5. Percentage time at depth for the Bryde's whale[1,2].

Depth Bin (m)	% of Time at Depth
0–40	84.7
40–292	15.3

[1] Based on data from Alves et al. (2010).

[2] This depth distribution is also representative of the sei whale.

Little other data have been collected on the dive behavior of Bryde's whales. Dong et al. (2022) tagged one Bryde's whale off the coast of China, tracking the whale's movements for six hours. The depth of the area in which this whale occurred was 8 to 10 m. In this shallow area, the Bryde's whale spent roughly 11 percent of its time on the water's surface (less than 0.5 m) and 89 percent of its time diving (Dong et al. 2022).

2.2.1.2.4 Balaenoptera musculus, Blue Whale

Blue whales have a cosmopolitan distribution, living in both coastal and offshore waters (Jefferson et al. 2008). Blue whales track the diel vertical migration of their prey and feed almost exclusively on euphausiids, or krill (Sears 2002). Although surface feeding has been observed during the daylight, it is more usual for blue whales to dive to at least 100 m into layers of euphausiid concentrations during daylight hours and feed nearer the surface at night (Sears and Perrin 2008).

To build a representative depth distribution for blue whales, data from Figures 4 and 8 in Oleson et al. (2007), as well as Figure 2 from Acevedo-Gutiérrez et al. (2002) were used. Oleson et al. (2007) provided graphs of the percent time at depth of 38 blue whales off the coast of California in Figure 8. The data for the non-vocal, AB callers, and D callers were averaged together to get a general depth distribution. However, percentage of time at the surface was ignored by this study. By incorporating the average number of surfacing events over time in the sample dive profile from Figure 4 in Oleson et al. (2007) and the average time spent at surfacing events from Figure 2 in the Acevedo-Gutiérrez et al. (2002) study, a percent time spent in the surface bin could be estimated (20.9 percent). The remaining bins from the Oleson et al. (2007) study were redistributed proportionally to account for the remaining 79.1 percent of time. The depth distribution for blue whales is given in Table 2-6.

Table 2-6. Percentage of time at depth for the blue whale[1].

Depth Bin (m)	% of Time at Depth	Depth Bin (m)	% of Time at Depth
0–5	21.2	155–165	2.2
5–15	12.7	165–175	2.3
15–25	9.9	175–185	2.2
25–35	6.4	185–195	2.2
35–45	5.3	195–205	1.4
45–55	4.0	205–215	1.1
55–65	3.5	215–225	1.1
65–75	2.8	225–235	1.0
75–85	2.2	235–245	0.9
85–95	2.4	245–255	0.7
95–105	2.1	255–265	0.7
105–115	2.1	265–275	0.3
115–125	2.0	275–285	0.2
125–135	2.1	285–295	0.2
135–145	2.1	295–305	0.2
145–155	2.3	305–315	0.2

[1] Based on data from Oleson et al. (2007) and Acevedo-Gutiérrez et al. (2002).

While other studies did not include depth distributions for blue whales, they did provide additional information to categorize dive behavior. Mate et al. (2016) noted that blue whale dive profiles often recorded stereotypical upward excursions during the bottom phase of the dive, which are known to indicate feeding lunges (Calambokidis et al. 2008; Croll et al. 2001; Fahlbusch et al. 2022). Blue whales in the Gulf of St. Lawrence conducted foraging dives to 150 m, where feeding lunges were observed (Doniol-Valcroze et al. 2011). Similarly, a study conducted in Monterrey Bay found that blue whales fed on the most concentrated patches of krill at depths of 130 to 150 m (Schoenherr 1991). Blue whales off central California foraged at depths between 130 and 300 m (Calambokidis et al. 2008; Croll et al. 2001; Fahlbusch et al. 2022), while in southern California, dive depths ranged from 50 to 350 m (Acevedo-Gutiérrez et al. 2002; Croll et al. 2001; De Vos et al. 2012; Goldbogen et al. 2012; Goldbogen et al. 2013; Mate et al. 2016; Oleson et al. 2007; Southall et al. 2014). Seven whales tagged off the coast of Southern California dove to a mean depth of 140 m and a maximum depth of 204 m during foraging, while to only a mean depth of 67.6 m during non-foraging dives (Croll et al. 2001). These data are consistent with the depth distribution in Table 2-6.

2.2.1.2.5 Balaenoptera physalus, Fin Whale

The fin whale occurs in greatest concentrations in cold and temperate waters around the globe, and are commonly found seaward of the continental slope (Aguilar 2002). Prey species include euphausiids (Laidre et al. 2010; Ruchonnet et al. 2006; Vikingsson 1997), schooling fish such as herring and capelin (Nøttestad et al. 2002b), and cephalopods (Flinn et al. 2002). A 2001 study has shown that dense prey concentrations are typically found at depths greater than 100 m off the coast of California (Croll et al. 2001).

To build a representative depth distribution for fin whales, data from Figure 4a in Croll et al. (Croll et al. 2001) and the text of Goldbogen et al. (2006) were used. Due to the lack of data on time spent at depth, the data from Croll et al. (2001) will be used as a proxy for percentage of time spent at depth. Croll et al. (2001) found that, amongst the 15 tagged fin whales, there was a maximum dive depth of 316 m. Foraging dives were deeper and longer in duration than non-feeding dives. Goldbogen et al. (2006) reported that tagged whales spent 40 percent of time in the top 50 m. Time spent at depths below 50 m were extracted from dive profiles presented in Croll et al. (2001) to represent the remaining 60 percent of time. The depth distribution for fin whales is given in Table 2-7.

Table 2-7. Percentage of time spent at depth for the fin whale[1].

Depth Bin (m)	% of Time at Depth
0–50	40
50–70	13.9
70–90	9.6
90–110	8.1
110–130	11.4
130–150	8.4
150–170	3.5
170–190	2.0
190–210	1.4
210–230	0.6
230–250	0.6
250–270	0.2
270–290	0.1
290–310	0.2

[1] Based on data from Croll et al. (2001) and Goldbogen et al. (2006).

While other studies did not include depth distributions for fin whales, they did provide additional information to categorize dive behavior. Off southern California, foraging dives of 100 to 300 m (Acevedo-Gutiérrez et al. 2002; Goldbogen et al. 2006; Mate et al. 2016) have been recorded. While dive depths of 350 m were recorded off the coast of southern California (Mate et al. 2016). Southall et al. (2014) reported that dives by fin whales rarely exceeded 250 m. Meanwhile, foraging dives off the coast of Alaska had a grand mean depth of 115 m (Witteveen et al. 2015) and in the Ligurian Sea, a maximum dive to over 470 m was noted (Panigada et al. 1999). Fonseca et al. (2022) measured whale dives off of the Azores and noted the diel pattern of behavior and dive type. These data are mostly consistent with the depth distribution in Table 2-7.

2.2.1.2.6 Balaenoptera ricei, Rice's Whale

The Rice's whale is the only resident baleen whale in the Gulf of Mexico, remaining there year-round, and are closely related to the Bryde's whale. Rice's whales were determined to be a separate species from the Bryde's whale in 2021. There are fewer than 100 individuals remaining. Rice's whales live only in the northeastern Gulf of Mexico, primarily along the continental shelf break in waters between 100 and 400 m deep. Limited data suggest Rice's whales spend the daytime making dives to the bottom and nighttime within 50 ft of the surface, which aligns with the data taken from Soldevilla et al. (2017).

To build a representative depth distribution for Rice's whales, data from Figure 3d in Soldevilla et al. (2017) was used. Because time was expressed in hours at depth and split between day and night, these values were combined and placed over the total tag time recorded to come up with a percentage of time in each depth bin (Soldevilla et al. 2017). The depth distribution for Rice's whales is given in Table 2-8.

Table 2-8. Percentage of time spent at depth for the Rice's whale[1].

Depth Bin (m)	% of Time at Depth
0–5	38.49
5–10	19.0
10–15	5.58
15–20	3.72
20–25	3.07
25–30	2.1
30–35	1.36
35–40	0.97
40–60	2.83
60–80	2.67
80–100	1.7
100–120	1.7
120–140	1.62
140–160	1.86
160–180	2.51
180–200	2.59
200–220	2.91
220–240	2.18
240–260	2.43
260-275	0.71

[1] Based on data from Soldevilla et al. (2017).

2.2.1.2.7 Megaptera novaeangliae, Humpback Whale

Humpback whales have a cosmopolitan distribution in the coastal and continental shelf waters of the globe. They migrate between mid- to high-latitude foraging grounds and low-latitude breeding grounds (Clapham 2002). Humpback whales feed on a variety of organisms, including euphausiids and small schooling fish (Hain et al. 1982; Hazen et al. 2009; Laerm et al. 1997; Witteveen et al. 2015).

Due to a separation of behaviors based on location within a foraging ground or within a breeding ground, two separate representative depth distributions were compiled for humpback whales. To build a representative depth distribution for humpback whales on foraging grounds, data from Figure 3.8 as well as the text of Dietz et al. (2002) were used. Dietz et al. (2002) shows the number of dives per hour to specific depth bins. The data from Dietz et al. (2002) will be used as a proxy for percentage of time spent at depth for the six whales tagged off the foraging grounds of West Greenland. While Figure 3.8 begins at a depth of 8 m, the text states that the average time spent at the surface is 83.3 percent during mid-day and 75 percent at midnight, resulting in an average surface time of 79.2 percent. The data from Dietz et al. (2002) were then redistributed proportionally to account for the remaining 20.8 percent of time. The depth distribution for humpback whales on foraging grounds is given in Table 2-9.

Table 2-9. Percentage of time at depth for humpback whales on foraging grounds[1].

Depth Bin (m)	% of Time at Depth
0–8	79.2
8–20	11.65
20–35	2.70
35–50	1.04
50–100	1.56
100–150	1.56
150–200	1.25
200–300	0.935
300–400	0.105

[1] Based on data from Dietz et al. (2002).

While other studies did not include depth distributions for humpback whales, they did provide additional information to categorize dive behavior on feeding grounds. Dive depths on the Greenland foraging grounds (Dietz et al. 2002) are consistent with the depth of feeding reported by Simon et al. (2012) off Greenland, Stimpert et al. (2012) off Antarctica, Goldbogen et al. (2008) off central California, and Witteveen et al. (2015) and Dolphin (1987a) off Alaska. However, Dolphin (1987b) reported that 75 percent of feeding dives were to less than 60 m, and Friedlaender et al. (2009a) found evidence of bottom feeding in the shallower water (less than 50 m) of the Gulf of Maine. While the depth distribution in Table 2-9 has a maximum depth of 400 m, over 95 percent of the time is in the top 50 m. Therefore, the depth distribution in Table 2-9 is consistent with these studies as well.

Humpback whales have major breeding grounds in several locations, including the West Indies, Hawaii, Mexico, and Japan (Clapham 2002). To build a representative depth distribution for humpback whales on breeding grounds, data from Table 3 in Baird et al. (2000) were used. Baird et al. (2000) reported the time at depth data for 10 whales in Hawaiian waters. While all 10 whales were thought to be males, the whales were engaged in a variety of behaviors, including escorting females and calves. Therefore, the depth distribution in Table 2-10 represents the best estimate of time spent at depth by whales on a breeding ground. Baird et al. (2000) found that, on average, about 40 percent of a whale's time was spent in the top 10 m and about 90 percent of the time was spent in the top 100 m. The depth distribution for humpback whales on breeding grounds is given in Table 2-10.

Table 2-10. Percentage of time at depth for the humpback whale on breeding grounds[1].

Depth Bin (m)	% of Time at Depth	Depth Bin (m)	% of Time at Depth
0–10	39.65	90–100	1.55
10–20	26.51	100–110	1.39
20–30	11.65	110–120	1.31
30–40	4.25	120–130	0.92
40–50	3.04	130–140	0.72
50–60	2.47	140–150	0.30
60–70	2.14	150–160	0.23
70–80	1.66	160–170	0.15
80–90	1.97	170–180	0.09

[1] Based on data from Baird et al. (2000).

While other studies did not include depth distributions for humpback whales, they did provide additional information to categorize dive behavior on breeding grounds. Dive depths on the Hawaiian breeding grounds are mostly consistent with dive depths and percent time at depth reported by Derville et al. (2020) for males and mother-calf pairs off New Caledonia, and reported by Stimpert et al. (2012) for calves under six months of age. Huetz et al. (2022) tagged 29 calves of different age classes and found that calves increased the duration of their dives with age. Mother-calf pairs in this study showed high levels of synchrony (Huetz et al. 2022). Derville et al. (2020) reported that whales left the breeding grounds and traveled into pelagic waters where there were seamounts during the breeding season and during early migration stages.

2.2.1.3 Family Delphinidae

2.2.1.3.1 Delphinus capensis, Long-Beaked Common Dolphin

It was not until the mid-1990s that the long-beaked common dolphin was separated from the short-beaked common dolphin as a distinct species (Heyning and Perrin 1994). Long-beaked common dolphins are thought to be coastal foragers, feeding mostly on pelagic fish, particularly those in the families Scombridae, Scianidae, and Serranidae (Niño-Torres et al. 2006) as well as krill and squid (Reeves et al. 2002).

No data have been collected on the dive behavior of the long-beaked common dolphin. Due to the lack of available data on the diving behavior of the long-beaked common dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2.1.3.18). The closest relative to the long-beaked common dolphin is the short-beaked common dolphin, which is also represented by the pantropical spotted dolphin. While the long-beaked common dolphin is considered a more coastal species than the short-beaked common dolphin, in many areas their distributions overlap. The depth distribution of the long- beaked common dolphin can be found in Table 2-16.

2.2.1.3.2 Delphinus delphis, Short-Beaked Common Dolphin

While species of common dolphins are sympatric in some nearshore continental shelf waters, short-beaked common dolphins are typically found in deeper waters along the continental slope (Cañadas and Hammond 2008; Heyning and Perrin 1994; Jefferson et al. 2009; Rosel et al. 1994; Selzer and Payne 1988). They feed on epipelagic and mesopelagic fish and squid (Selzer and Payne 1988), and also forage at night on vertically-migrating prey associated with the deep scattering layer (Evans 1994; Neumann and Orams 2003; Ohizumi et al. 1998; Pusineri et al. 2007).

Little data have been collected on the dive behavior of the short-beaked common dolphin. Evans (1975; 1994) described the late afternoon and evening diving behavior of an adult female short-beaked common dolphin in the Pacific Ocean. Before 1730, the dolphin mostly remained in the top 10 m, at which time it switched to a pattern of regular dives to 50 m, with a maximum dive depth of just over 200 m (Evans 1974, 1994).

Due to the lack of available data on the diving behavior of the short-beaked common dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2.1.3.18). Pantropical spotted dolphins also make shallower dives during the day than at night, when they forage on vertically-migrating prey associated with the deep scattering layer (Scott and Chivers 2009). During the day, pantropical spotted dolphins spend 94 percent of their time in the top 20 m of the water column, while at night 95 percent of their time is spent in the top 50 m (Baird et al. 2001). Evans (1994) reported the maximum dive depth for three short-beaked common dolphins was 257 m. Similarly, maximum dive depths for pantropical spotted dolphins are 122 m for daytime and 213 m for nighttime (Baird et al. 2001). Pantropical spotted dolphins and common dolphins are members of the same subfamily, Delphinidae (LeDuc et al. 1999) and their behavior shows clear similarities in diving pattern, foraging behavior, and water column usage. The depth distribution of the short-beaked common dolphin is given in Table 2-16.

2.2.1.3.3 Feresa attenuata, Pygmy Killer Whale

Pygmy killer whales inhabit tropical and subtropical waters of the continental slope and waters farther offshore (Donahue and Perryman 2002). Analyses of their stomach contents indicate that their primary prey include cephalopods and fish, although other marine mammals also constitute some portion of their diet (Mignucci-Giannoni et al. 1999; Perryman and Foster 1980). Some shallow-water prey (from less than 200 m deep) have been reported in the stomachs of stranded pygmy killer whales, though these prey species may have been consumed as animals moved closer to shore prior to stranding (Sekiguchi et al. 1992; Zerbini and de Oliveira Santos 1997). Characteristics of their echolocation clicks indicate that pygmy killer whales could detect fish and cephalopod prey at distances of 50 to 200 m (Madsen et al. 2004b).

Pygmy killer whales were found around the Island of Hawaii in coastal waters as shallow as six m and offshore waters as deep as 3,000 to 5,000 m (Baird et al. 2017; McSweeney et al. 2009). In recent years, data have been collected on the dive behavior of pygmy killer whales from a limited number of individuals. Pulis et al. (2018) tagged two adult males in the Gulf of Mexico, and found that 96 percent of the dives occurred at night in waters 200 to 1,200 m deep (Pulis et al. 2018). The average dive depth was 127.5 m, and the deepest dive reached 368 m (Pulis et al. 2018). The dive depths in this study fall within the range of the surrogate species, the Risso's dolphin (Table 2-13). These pygmy killer whales spent 26.8 percent of the recorded time at depths greater than or equal to 30 m (Pulis et al. 2018), which is likely slightly less than their surrogate species, the Risso's dolphin.

Due to a limited sample size (two individuals) and lack of additional data on the dive behavior of pygmy killer whales, they will be represented by a surrogate species: the Risso's dolphin (Section 2.2.1.3.7). The closest relatives to the pygmy killer whale for which diving behavior have been studied are three members of the subfamily Globicephalinae: the short-finned pilot whale, the long-finned pilot whale, and the Risso's dolphin (LeDuc et al. 1999). Risso's dolphins and pygmy killer whales have both been placed in the Globicephalinae family (Vilstrup et al. 2011). The pygmy killer whale (at 2.3 m long) is closer in size to the Risso's dolphin (4 m) than to the pilot whales (6 m). Both pygmy killer whales and Risso's dolphins are found in deep water and feed on squid and other cephalopods. The depth distribution for the pygmy killer whale can be found in Table 2-13.

2.2.1.3.4 Globicephala macrorhynchus, Short-Finned Pilot Whale

Short-finned pilot whales occur in tropical and warm-temperate waters along the continental shelf and slope (Davis et al. 1998). Short-finned pilot whales feed predominantly on squid, but they also feed on octopus and fish occasionally (Mintzer et al. 2008; Reeves et al. 2002). On the U.S. Pacific coast the neritic cephalopod, *Loligo* spp., is the dominant prey (Mintzer et al. 2008). Short-finned pilot whales feed on vertically migrating prey, diving deep during dusk and dawn and staying near surface at night (Baird et al. 2003).

To build a representative depth distribution for short-finned pilot whales, data from Figure 9 in Wells et al. (2013) were used. Wells et al. (2013) tagged two male pilot whales after a mass stranding event in the Florida Keys. However, one of the individual tags stopped transmitting after 16 days, but the other tag transmitted for a total of 67 days; thus, the representative depth distribution contains only the Wells et al. (2013) data from the individual with the longer transmission time. Due to the lack of data on time spent at depth, the proportion of dives made to specific depth ranges from Wells et al. (2013) will be used as a proxy for percentage of time spent at depth. The depth distribution for short-finned pilot whales is given in Table 2-11.

Table 2-11. Percentage of time at depth for the short-finned pilot whale[1,2].

Depth Bin (m)	% of Time at Depth
0–2	32.25
2–50	46.75
50–100	3.00
100–200	5.00
200–300	4.25
300–400	2.75
400–500	1.75

Depth Bin (m)	% of Time at Depth
500–600	1.75
600–700	1.75
700–800	0.5
800–900	0.125
900–1,000	0.125

[1] Based on data from Wells et al. (2013).

[2] This depth distribution is also representative of the following species: the long-finned pilot whale, pilot whale guild, Fraser's dolphin, pygmy sperm whale, dwarf sperm whale, and *Kogia* spp. guild.

While other studies did not include depth distributions for short-finned pilot whales, they did provide additional information to categorize dive behavior. In the Mariana Archipelago, Hill et al. (2019) tagged five short-finned pilot whales that dove more often to intermediate depths (101 to 499 m) at twilight and night, suggesting they were targeting vertically migrating prey. The maximum depths recorded in Jensen et al. (2011) were roughly 700 m and in Joyce et al. (2017) were roughly 880 m—hundreds of meters shallower than the maximum depth in Table 2-11. Other studies tagged whales in the Bahamas (Claridge et al. 2015), the Madeira Islands (Alves et al. 2013), and the Canary Islands (Soto et al. 2008) found similar maximum dive depths as reported above (984 to 1,019 m). Slightly greater dive depths (roughly 1,100 to 1,500 m) were recorded for whales tagged near Cape Hatteras (Adamczak et al. 2021; Quick et al. 2017), the Bahamas (Joyce et al. 2016), and Kaua'i (Baird et al. 2021). Based on the percent of time at depth in Table 2-11, the total time spent in deeper waters constitutes a very small percentage of the whale's total time. Alves et al. (2013) and Adamczak et al. (2021) support this conclusion.

2.2.1.3.5 Globicephala melas, Long-Finned Pilot Whale

Long-finned pilot whales are commonly found in cold and temperate continental shelf and slope waters (Buckland et al. 1993; Payne and Heinemann 1993). Long-finned pilot whales prey on epipelagic, mesopelagic, and demersal squid and fish (Desportes and Mouritsen 1993; Gannon et al. 1997).

To build a representative depth distribution for long-finned pilot whales, data from Table 2 from Heide-Jorgensen et al. (2002) were used. The maximum reported dive depth was 828 m. Data from the individual whales of different sexes and sizes, as well as in a variety of locations, were rounded to sum 100 percent of each individual whale's time, then averaged together to create the depth distribution given in Table 2-12.

Table 2-12. Percentage of time at depth for the long-finned pilot whale[1].

Depth Bin (m)	% of Time at Depth
0–17	74.4
18–35	5.2
36–53	2.2
54–101	3.8
102–149	2.8

Depth Bin (m)	% of Time at Depth
150–197	1.8
198–299	3.4
300–401	2.6
402–599	2.9
600–797	0.9

[1] Based on data from Heide-Jorgensen et al. (2002).

While other studies did not include depth distributions for long-finned pilot whales, they did provide additional information to categorize dive behavior. Maximum reported dive depths for long-finned pilot whales differ by location, including a depth of 617 m off the coast of Norway (Aoki et al. 2017; Isojunno et al. 2018; Visser et al. 2014), and a depth of 648 m in the Mediterranean Sea (Baird et al. 2002). Long-finned pilot whales show some diurnal variation in diving behavior, with the deepest dives occurring shortly after sunset when the whales may target vertically migrating prey (Baird et al. 2002). Mate et al. (2005) reported whales spending between 5.6 and 47.4 percent of their time at the surface, while Hooker et al. (2011) found long-finned pilot whales spent an average of 67 percent of time in the top 10 m of the water column. Aoki et al. (2017) reported the long-finned pilot whale to spend around 16 percent of time in deep dives (to depths greater than 250 m) while Visser et al. (2014) found that long-finned pilot whales spent roughly 72 percent of their time in shallow diving bouts. The representative depth distribution in Table 2-12 is consistent with distribution data reported in Table 1 in Nawojchik et al. (2003), Figures 3a and 8a in Aoki et al. (2013), Figure 3 in Sivle et al. (2012), and plots from post-sonar exposure and silent passes of a ship in Miller et al. (2011).

Despite the presence of depth distribution data for long-finned pilot whales, there is a lack of available separate density data for each species of pilot whale. As a result, the two species must be represented by one depth distribution. After comparing the depth distribution given in Table 2-12 with the depth distribution for the short-finned pilot whale given in Table 2-11, the short-finned pilot whale (Section 2.2.1.3.4) data were selected as the representative depth distribution for use. The short-finned pilot whale data represent a majority of time spent in the top 50 m of the water column rather than at depth. Both pilot whales are members of the same subfamily, Globicephalinae, feed on mesopelagic prey, and are similar in size. The depth distribution for long- finned pilot whales can be found in Table 2-12.

2.2.1.3.6 Pilot Whale Guild

Within the AFTT Study Area, the distributions of short-finned and long-finned pilot whales overlap. As it is difficult to distinguish these two species when viewing them at sea, much of the density data from surveys are reported as generic “pilot whales.” Because the short-finned pilot whale depth distribution found in Table 2-11 was selected as the representative depth distribution for both species of pilot whale (Section 2.2.1.3.5), these data were also selected to represent the depth distribution for the pilot whale guild. Within this guild, the best available population estimate for short-finned pilot whales in the western North Atlantic is 28,924 and the best available population estimate for long-finned pilot whales is 39,215. Thus, the long-finned pilot whale has a slightly larger population size in the AFTT Study Area (Hayes et al. 2022). However, short-finned pilot whales inhabit a larger geographic range, spanning from the western

North Atlantic to the Gulf of Mexico, while long-finned pilot whales are only found in the western North Atlantic. The representative depth distribution for the pilot whale guild is given in Table 2-11.

2.2.1.3.7 Grampus griseus, Risso's Dolphin

Risso's dolphins are commonly found in temperate and tropical waters along continental slopes and deep oceanic waters (Azzellino et al. 2008; Baumgartner 1997; Green et al. 1992). Vertically migrating cephalopods are the primary food source for Risso's dolphins (Bearzi and Saylan 2011; Clarke and Pascoe 1985; Soldevilla et al. 2010). Dolphins begin to forage around dusk (Soldevilla et al. 2010; Visser et al. 2021).

To build a representative depth distribution, data from Figure 5 in Wells et al. (2009) were used. Wells et al. (2009) reported on the movement and diving behavior of a rehabilitated adult male Risso's dolphin that stranded on the Gulf Coast of Florida. Due to the method of tag attachment, this animal remained tagged for 23 days, which is the largest dive profile dataset available for a Risso's dolphin. Based on Figure 5, the depth distribution for Risso's dolphins was estimated for four 6-hour blocks of time. The tagged animal in this study travelled through waters with a mean depth of 548 m (range 3 to 22,300 m), and was therefore likely not diving close to the seafloor. The deepest dive recorded on the tag was in the 400 to 500 m depth range, and less than 0.1 percent of dives were deeper than 200 m (Wells et al. 2009). The average time spent in these depth bins was calculated for the representative depth distribution. The depth distribution for the Risso's dolphin is given in Table 2-13.

Table 2-13. Percentage of time at depth for the Risso's dolphin[1,2].

Depth Bin (m)	% of Time at Depth
0–1	24.75
1–2	13.5
2–10	16.5
10–50	43.5
50–100	1.1875
100–150	0.1375
150–600	0.425

[1] Based on data from Wells et al. (2009).

[2] This depth distribution is also representative of the following species: the blackfish guild, pygmy killer whale, melon-headed whale, and false killer whale.

While other studies did not include usable depth distributions for Risso's dolphin, they did provide additional information to categorize forage dive behavior. Much of the dive information about Risso's dolphins is focused on prey or foraging dolphins (Arranz et al. 2018; Benoit-Bird et al. 2019; Sweeney et al. 2019; Visser et al. 2021). Forage dive depths for Risso's dolphins may not completely align with the dive profile depth distributions because the percentage of time spent travelling and surfacing were not included. Studies differed in the depths at which foraging centered around. These depths may be dependent on the ecology of the foraging location and dive strategy of dolphins (Visser et al. 2021). Risso's dolphins perform deeper dives when spin diving, which occurs when dolphins actively accelerate and rotate while beginning the diving process (Visser et al. 2021). Sweeney et al. (2019) found that 95.6 percent of prey capture events occurred at depths greater than 10 m, and dive depths were clustered between 58 and 78 m (Sweeney et al. 2019). Table 2-13 indicates that only minimal time is spent between 50 to 600 m, and these depths are where studies indicate foraging mainly occurs (Benoit-Bird et al. 2019; Sweeney et al. 2019; Visser et al. 2021).

2.2.1.3.8 Lagenodelphis hosei, Fraser's Dolphin

Fraser's dolphins are commonly found in the tropics worldwide in waters deeper than 1,000 m. While they do have occasional strandings in temperate waters, those are thought to be extralimital occurrences (Louella and Dolar 2002; Reeves et al. 2002).
Little data have been collected on the dive behavior of Fraser's dolphins. Robison and Craddock (1983) reported that the mesopelagic fish, shrimp, and squid species that were found in the stomachs of three dolphins typically inhabit depths between 250 and 500 m. Fraser's dolphins in the Sulu Sea, off the coast of the Philippines, were found to feed on vertically migrating species in the upper 200 m of the water column, as well as on non-migrating species found at depths below 600 m (Dolar et al. 2003). Fraser's dolphins have also been seen herding fish near the water's surface (Watkins et al. 1994).

Due to the lack of available data on the diving behavior of the Fraser's dolphin, it is represented by a surrogate species: the short-finned pilot whale (Section 2.2.1.3.4). Dolar et al. (1999) found that Fraser's dolphins have myoglobin concentrations consistent with those of other deep-diving marine mammals, and relative muscle masses much greater than those of other dolphins their size, both of which indicate an enhanced diving ability. Therefore, despite their smaller size, the Fraser's dolphin will be modeled using the depth distribution of the short- finned pilot whale, another species in the family Delphinidae that feeds on mesopelagic and bathypelagic prey at similar deep depths (Desportes and Mouritsen 1993; Gannon et al. 1997). The depth distribution for the Fraser's dolphin is given in Table 2-11.

2.2.1.3.9 Lagenorhynchus acutus, Atlantic White-Sided Dolphin

Atlantic white-sided dolphins are found in cold temperate and sub-polar waters, ranging from the continental shelf to further offshore of the continental slope (Palka et al. 1997). They feed on both epipelagic and mesopelagic fish and squid (Couperus 1997; Craddock et al. 2009; Doksaeter et al. 2008; Weinrich et al. 2001).

Little data have been collected on the dive behavior of Atlantic white-sided dolphins. One stranded and rehabilitated dolphin with a satellite tag provided basic dive behavior information (Mate et al. 1994). Over a six-day period, no dives were longer than four minutes, and no surface durations lasted longer than one minute; the Atlantic white-sided dolphin spent 89 percent of its time beneath the surface at unknown depths. White-sided dolphins caught in bottom trawl and sink gillnet fisheries as bycatch were recovered in nets fished at a mean depth of 189.8 m (range 55 to 503 m), although the exact depths at which the animals were entangled are unknown (Craddock et al. 2009).

Due to the lack of available data on the diving behavior of the Atlantic white-sided dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2.1.3.18). Both species are members of the same family, Delphinidae, and forage on similar vertically migrating prey species that come to the surface layer (above 200 m) at night (Scott and Chivers 2009; Wang et al. 2003). The depth distribution for the Atlantic white-sided dolphin is given in Table 2-16.

2.2.1.3.10 Lagenorhynchus albirostris, White-Beaked Dolphin

White-beaked dolphins occur only in the temperate and subarctic North Atlantic Ocean, generally in coastal and continental shelf waters (Kinze 2002). Fish species constitute the primary prey of white-beaked dolphins (e.g., Atlantic cod, haddock, herring, and hake); however, cephalopods and benthic crustaceans are also part of their diet (Ostrom et al. 1993; Reeves et al. 1999). They have also been observed cooperatively herding schooling fish species at the surface (Reeves et al. 1999).

Little data have been collected on the dive behavior of the white-beaked dolphin. White-beaked dolphins generally prefer shallow waters less than 200 m deep (Jefferson et al. 2008). In the 1970s and 1980s, white- beaked dolphins off the northeastern U.S. Atlantic coast may have shifted habitats with Atlantic white-sided dolphins. During this time, white-beaked dolphins, which were normally found in inshore waters, moved offshore due to an increase in sand lance on the continental shelf and a decline in herring. A study recorded the diving depth of a single female in Icelandic waters for almost 14 hours (Rasmussen et al. 2013). It was found that the female spent 18 percent of time from 0 to 2 m, and 82 percent of time at depths greater than 2 m. The dolphin’s deepest dive was to 45 m, which reached the bottom depth of the bay (Rasmussen et al. 2013). The percent of time spent at the surface (0 to 2 m) in this study is similar to that recorded for the surrogate species (20.4 percent), the pantropical spotted dolphin (Table 2-16).

Due to the lack of available data (i.e., sample size of one for less than 14 hours) on the diving behavior of the white-beaked dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2.1.3.18). The closest relative to the white-beaked dolphin is the Atlantic white-sided dolphin, which is also represented by the pantropical spotted dolphin. The depth distribution for the white-beaked dolphin can be found in Table 2-16.

2.2.1.3.11 Lagenorhynchus obliquidens, Pacific White-Sided Dolphin

Pacific white-sided dolphins inhabit cold temperate waters of the North Pacific, in both offshore and coastal waters (Becker et al. 2014; Brownell et al. 1999; Waerebeek and Würsig 2002). Their primary prey species include mesopelagic fish and cephalopods, as well as epipelagic fish in shallower waters (Brownell et al. 1999; Kajimura and Loughlin 1988; Miyazaki et al. 1991; Morton 2000; Walker and Jones 1994).

Little data have been collected on the dive behavior of the Pacific white-sided dolphin. Hall (1970) trained a captive Pacific white-sided dolphin to dive to a depth of 214 m. However, Black (1994) reported that in coastal waters, 70 percent of dives were shorter than 20 seconds in duration, and dives longer than 90 seconds were rare, indicating that most dives are shallow. Heise (1997) similarly reported that 70 percent of foraging dives were less than 15 seconds in duration. Therefore, Pacific white-sided dolphins are not considered deep divers. This species is thought to feed mostly at night or in the morning (Stroud et al. 1981) when their mesopelagic prey rise to surface waters. In areas where Pacific white-sided dolphins were observed, potential prey was abundant in a shallower layer, at approximately 80 to 90 m depth. Water depth affected the potential prey abundance at all depth layers (0 to 300 m), as potential prey were more abundant in areas with a shallower water depth (Iwahara et al. 2020).

Due to the lack of available data on the diving behavior of the Pacific white-sided dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2.1.3.18). Pantropical spotted dolphins spend the majority of their time in the top 50 m, and their maximum diving depths are within the range of the dive depth of the trained Pacific white-sided dolphin (Baird et al. 2001; Hall 1970; Scott and Chivers 2009). Pantropical spotted dolphins and Pacific white-sided dolphins also feed on similarly migrating prey species. The depth distribution for the Pacific white-sided dolphin can be found in Table 2-16.

2.2.1.3.12 Lissodelphis borealis, Northern Right Whale Dolphin

The northern right whale dolphin is abundant in cold, deep, temperate waters across the North Pacific Ocean (Becker et al. 2014; Forney and Barlow 1998; Jefferson and Newcomer 1993b; Leatherwood and Walker 1979; Rankin et al. 2007). They are known to commonly associate with Pacific white-sided dolphins and Risso’s dolphins (Forney and Barlow 1998; Jefferson and Newcomer 1993b), with which they show dietary overlap (Walker and Jones 1994). Northern right whale dolphins near the southern California coast feed principally on cephalopods and a diverse variety of myctophid fish (Jefferson and Newcomer 1993a; Jefferson et al. 1994; Leatherwood and Walker 1979).

Little data have been collected on the dive behavior of the northern right whale dolphin. Some evidence based on stomach contents suggests that northern right whale dolphins may dive as deep as 200 m (Fitch and Brownell 1968; Jefferson et al. 1994). Individual northern right whale dolphins have been observed to dive for brief periods (10 to 75 seconds), but can also remain submerged for up to 6.5 minutes (Cruickshank and Brown 1981; Leatherwood and Walker 1979). Northern right whale dolphins have comparatively low muscle myoglobin content among odontocetes, suggesting they are not deep divers (Noren and Williams 2000).

Due to the lack of available data on the diving behavior of the northern right whale dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2.1.3.18). Of the two dolphins with which the northern right whale dolphin associates the most, the Risso’s dolphin is considered a much deeper diver than the Pacific white-sided dolphin. Because northern right whale dolphins have low muscle myoglobin content and are thought to feed on prey only as deep as 200 m, they are thought to be shallower divers. Therefore, due to dietary similarity and frequent association with the Pacific white-sided dolphin, the northern right whale dolphin will be represented by the same surrogate species, the pantropical spotted dolphin. The depth distribution for the northern right whale dolphin can be found in Table 2-16.

2.2.1.3.13 Orcinus orca, Killer Whale

Killer whales have a cosmopolitan distribution, but are most commonly observed in temperate, coastal waters (Ford 2002). Killer whales feed on a variety of prey, although most populations exhibit some degree of dietary specialization. In the northeastern Pacific and Antarctic, sympatric populations in each location are socially (and, in some cases, reproductively) isolated by foraging specializations for fish or marine mammal species (Ford et al. 1998; Pitman and Ensor 2003; Saulitis et al. 2000).

While there is a separation of diving behaviors based on preferred prey of the killer whale, the killer whale density data required that killer whales not be differentiated in this manner. So, while there could be two separate representative depth distributions compiled for killer whales, based on whether they are fish-eating killer whales or mammal-eating killer whales, only the profile for fish-eating killer whales was used. Fish-eating killer whales have been studied more extensively than mammal-eating ecotypes, although there is still limited published information on diving behavior of either. Fish-eating killer whales will either chase individual prey at the surface, or collectively herd schooling fish towards the surface (Dietz et al. 2020; Domenici et al. 2000; Nøttestad et al. 2002a). Mammal-eating killer whales have different foraging strategies than fish-eating killer whales (Barrett-Lennard et al. 1996; Pitman and Ensor 2003). Mammal-eating killer whales often attempt to capture prey from below, where a prey’s silhouette against brighter surface waters may improve detection. Miller et al. (2010) found deeper dives for mammal-eating killer whales occurred during the day. Because fish-eating killer whales spend longer percentages of time in surface waters, this profile is considered more conservative for use in the model.

To build a representative depth distribution for fish-eating killer whales, data from Figure 2 in Sivle et al. (2012), Figure 1e in Kvadsheim et al. (2012), as well as plots from post sonar exposure and/or silent pass of the ship from Miller et al. (2011) were used. Since all three studies analyzed the potential effects of sonar on the dive behavior of killer whales, only dive profiles from periods of time when no sonar was active were used. Depth distributions were extracted from the presented dive profiles. Individual depth distributions for each animal were averaged to create the representative depth distribution in Table 2-14.

Table 2-14. Percentage of time at depth for fish-eating killer whales[1].

Depth Bin (m)	% of Time at Depth
0–20	81.5
20–40	8.6
40–60	4.5
60–80	2.4
80–100	2.1
100–120	0.5
120–140	0.3
140–150	0.1

[1] Based on data from Kvadsheim et al. (2012), Miller et al. (2011), and Sivle et al. (2012).

While other studies did not include usable depth distributions for killer whales, they did provide additional information to categorize dive behavior. This representative depth distribution is consistent with Baird (1994) and Shapiro (2008), who reported that fish-eating resident killer whales spent the vast majority of their time in the top 20 m. Wright et al. (2017) similarly states that fish-eating killer whales spend little time below 30 m. Wright et al. (2017) examined the dive behavior for foraging versus non-foraging dives and attempted to align confirmed prey capture with a specific depth. Killer whales in this study were found to typically be after Coho salmon in depths deeper than 100 m; however, foraging dives comprised only 6.7 percent of dives recorded (by number). Non-foraging dives recorded were 64.7 percent, and none of these exceeded 21 m depth (Wright et al. 2017). This is consistent with the distribution in Table 2-14. Baird et al. (2005a) tagged a total of 34 Southern Resident killer whales and the average of all the tagged killer whale deepest dives was 141 m, which is consistent with the depth distribution in Table 2-14 (Baird et al. 2005a). Studies in different locations found a wide variety of maximum dive depths, likely based on depth of preferred prey (Baird et al. 2005a; Richard et al. 2020; Schorr et al. 2022; Towers et al. 2019). Schorr et al. (2022) found that offshore killer whales use the water column broadly and forage on the seafloor in certain locations. Towers et al. (2019) and Richard et al. (2020) were both studying depredation by whales, which occurs when whales remove fish caught on longlines. This practice may lead to deeper foraging dives by whales than normal, as compared to when whales naturally chase or herd fish (Towers et al. 2019).

2.2.1.3.14 Peponocephala electra, Melon-Headed Whale

Melon-headed whales occur in oceanic tropical and subtropical waters (Baird et al. 2021; Claridge et al. 2015; Joyce et al. 2017; Joyce et al. 2016; Perryman et al. 1994; West et al. 2018). Melon-headed whales feed on a variety of mesopelagic fish (e.g., myctophids) and cephalopod (Brownell Jr. et al. 2009; Gross et al. 2009; Jefferson and Barros 1997; West et al. 2018). Inferences can be made on the dive behavior of the melon-headed whale from the primary prey species, myctophids, which are vertical migrators that descend to depths of 700 to 3,000 m during the day and rise to 200 m or less at night (Clarke 1973). Cephalopods are also vertical migrators, descending to depths of 400 to 700 m during the day and rising to 100 to 150 m at night (Young 1978).

Melon-headed whales are assumed to only feed at night (Brownell Jr. et al. 2009; Claridge et al. 2015). Multiple tagging studies have found that these whales mainly only dive below the surface at night, foraging at depths of 50 to 525 m (Claridge and Durban 2008; Joyce et al. 2017; Joyce et al. 2016; West et al. 2018). Tagged whales from one study were found to frequently dive to depths of 300 to 350 m at night, while never diving deeper than 25 m during daylight hours (Joyce et al. 2017). This corresponds to data from Claridge et al. (2015), which recorded a median nighttime forage dive of 336 m and a maximum dive of roughly 500 m. In West et al. (2018), median dive depths were between 219 and 247 m. Noren and West (2020) found high levels of myoglobin in adult melon-headed whales. Rather than for prolonged diving, high myoglobin levels likely aid melon-headed whales in endurance swimming, as they are acknowledged to not be deep or long-duration divers (Noren and West 2020).

Due to the lack of available data on the percent of time at depth for the melon-headed whale, it will be represented by a surrogate species: the Risso's dolphin (Section 2.2.1.3.7). Both species are members of the same subfamily, Globicephalinae, feed on mesopelagic prey, and are similar in size. The closest relative to the melon-headed whale is actually the pilot whale; however, pilot whales are more than twice the size of melon-headed whales (LeDuc et al. 1999). The small size of melon-headed whales may indicate that they do not dive as deeply as their larger relatives, which is supported by the maximum dive depth data from Joyce et al. (2017; 2016), Claridge et al. (2015), and West et al. (2018) where the maximum depth ranged from 450 to 504 m. Therefore, the Risso's dolphin is a more suitable surrogate species for dive behavior than the pilot whale. The depth distribution for the melon-headed whale is given in Table 2-13.

2.2.1.3.15 Pseudorca crassidens, False Killer Whale

False killer whales inhabit tropical and temperate waters along and offshore of the continental slope (Baird et al. 2021; Odell and McClune 1999). Stomach content analyses have revealed that false killer whales feed on oceanic cephalopods (Alonso et al. 1999; Andrade et al. 2001), while observations indicate that they consume a variety of prey (including fish and other marine mammals) both at depth and at the surface (Acevedo-Gutiérrez et al. 1997; Perryman and Foster 1980; Stacey et al. 1994).

Little data have been collected on the dive behavior of the false killer whale. Cummings and Fish (1971) estimated that false killer whales would be capable of diving to depths up to 500 m. Based on measurements of their echolocation clicks, whales may detect large fish at up to 200-m distance and cephalopods at about half that distance (Madsen et al. 2004a), which may suggest false killer whales are capable of diving to at least 200 m. Unpublished time-depth recorder data of a single whale showed that all dives to deeper than 100 m occurred during the day, with a maximum depth exceeding 234 m (Baird 2009). Dives during the nighttime remained within the top 100 m of the water column. Ligon and Baird (2001) reported that three instrumented whales showed a maximum diving depth of 53 m, with an average dive depth range of 8 to 12 m; however, the time of day that the dives occurred was not reported.

Due to the lack of available data on the diving behavior of the false killer whale, it will be represented by a surrogate species: the Risso's dolphin (Section 2.2.1.3.7). The closest relatives to the false killer whale for which diving behavior have been studied are three members of the subfamily Globicephalinae: the short- finned pilot whale, the long-finned pilot whale, and the Risso's dolphin (LeDuc et al. 1999). False killer whales are in between these species in size, but the limited data suggest that false killer whales do not dive as deep as pilot whales. Risso's dolphins and false killer whales also both feed on pelagic cephalopods (Clarke and Pascoe 1985). The depth distribution for the false killer whale is given in Table 2-13.

2.2.1.3.16 Blackfish Guild

In the Gulf of Mexico portion of the AFTT Study Area, the blackfish guild is comprised of the pygmy killer whale, false killer whale, melon-headed whale, and killer whale. The pygmy killer whale, false killer whale, and melon-headed whale all use the Risso's dolphin (Section 2.2.1.3.7) as a surrogate species for their dive distributions. Based on the population abundances of these whales in the Gulf of Mexico, the majority of the blackfish whales in the Gulf of Mexico would be melon-headed whales; therefore, Risso's dolphin will be used as a surrogate species for the depth distribution of this guild. Risso's dolphins and melon-headed whales have both been placed in the Globicephalinae family and are closely related (Vilstrup et al. 2011). The depth distribution of blackfish whales in the Gulf of Mexico portion of the AFTT Study Area can be found in Table 2-13.

2.2.1.3.17 Stenella frontalis, Atlantic Spotted Dolphin

The Atlantic spotted dolphin is usually found in shallow, continental shelf waters. Atlantic spotted dolphins feed on both mesopelagic fish and squid, as well as benthic invertebrates (Perrin et al. 1994a). In the Bahamas, the Atlantic spotted dolphin diet consists of, in order of highest consumption: flying fish, squid, needlefish, and ballyhoo/half beaks (Herzing and Elliser 2013).

To build a representative depth distribution for Atlantic spotted dolphins, data from Table 1 in Davis et al. (1996) were used. Davis et al. (1996) tracked a tagged dolphin in water with a mean depth of 32.6 m (range 12 to 63 m) and indicated that it was consistently diving deep enough to reach the seafloor. Davis et al. (1996) reported no diel pattern in the depth of dives. The depth distribution for Atlantic spotted dolphins is given in Table 2-15.

Table 2-15. Percentage of time at depth for the Atlantic spotted dolphin[1].

Depth Bin (m)	% of Time at Depth
0–10	76.2
10–20	11.4
20–30	8.3
30–40	2.9
40–60	1.2

[1] Based on data from Davis et al. (1996).

While other studies did not include usable depth distributions for Atlantic spotted dolphins, they did provide additional information to categorize dive behavior. This representative depth distribution is consistent with tagging results from Griffin (2005), who reported dolphins diving to the seafloor at 30 m, with animals spending most of their time in the top 10 m. While Atlantic spotted dolphins are often observed in deeper water than 60 m (Davis et al. 1998; Herzing and Elliser 2013), Herzing and Elliser (2013) observed Atlantic spotted dolphins near Little Bahama Bank spending most of the day in shallow water and moving into deeper water when the deep scattering layer rises after dark to forage.

2.2.1.3.18 Stenella attenuata, Pantropical Spotted Dolphin

Pantropical spotted dolphins are found in warm temperate and tropical waters over the continental slope and offshore in deeper waters (Perrin and Hohn 1994). Pantropical spotted dolphins feed on both epipelagic and mesopelagic fish and squid (Wang et al. 2003). In general, pantropical spotted dolphins dive deeper at night, foraging on prey associated with vertical migrations of the deep scattering layer (Robertson and Chivers 1997; Scott and Chivers 2009; Silva et al. 2016).

To build a representative depth distribution for pantropical spotted dolphins, data from Figure 4 and Table 2 in Baird et al. (2001) and Figure 9 and Table 2 in Scott and Chivers (2009) were used. While Baird et al. (2001) looked at pantropical spotted dolphin diving behavior around the Hawaiian Islands, Scott and Chivers (2009) recorded data on these dolphins in pelagic waters. Baird et al. (2001) reported pantropical spotted dolphins spend on average 88.5 percent of their time within 10 m of the surface during the day.

Baird et al. (2001) reported the daytime average percentage of time in two-meter intervals for the top 10 meters. For the Baird et al. (2001) nighttime and Scott and Chivers (2009) data, the percentage of time determined for the top 10 m was uniformly distributed across these 2-m intervals. Daytime and nighttime averages were calculated for the Baird et al. (2001) data, and these were then averaged with the Scott and Chivers (2009) data. The resulting mean daytime and nighttime depth distribution data are presented in Table 18. Baird reported maximum daytime and nighttime dive depths at 122 m and 213 m, respectively (Baird et al. 2001); however, Scott and Chivers (2009) calculated that dives to more than 120 m accounted for less than 0.1 percent of all dives. They also noted that daytime dives were primarily shallow and above the thermocline (Scott and Chivers 2009). The depth distribution for pantropical spotted dolphins is given in Table 2-16.

Table 2-16. Percentage of time at depth for the pantropical spotted dolphin[1,2].

Depth Bin (m)	% of Time at Depth
0–2	20.4
2–4	10.7
4–6	8.6
6–8	9.0
8–10	9.5
10–20	21.3
20–30	8.8
30–40	3.8
40–50	2.5
50–60	1.9
60–70	1.1

Depth Bin (m)	% of Time at Depth
70–80	0.6
80–90	0.6
90–100	0.4
100–110	0.4
110–120	0.15
120–130	0.05
130–140	0.05
140–150	0.05
150–160	0.05
160–170	0.05

[1] Based on data from Baird et al. (2001) and Scott and Chivers (2009).

[2] This depth distribution is also representative of the following species: the long-beaked common dolphin, short-beaked common dolphin, Atlantic white-sided dolphin, white-beaked dolphin, Pacific white-sided dolphin, northern right whale dolphin, Clymene dolphin, striped dolphin, and spinner dolphin.

While other studies did not include usable depth distributions for pantropical spotted dolphins, they did provide additional information to categorize dive behavior. Silva et al. (2016) provided additional information that categorized the daytime dive behaviors of five pantropical spotted dolphins in Hawaiian waters. This study found that dolphins spent 76.9 percent of time in the top 10 m and were mainly found in shallow waters during daytime hours (Silva et al. 2016). Baird et al. (2001), which was used to create the representative dive profile from both daytime and nighttime data, reported higher percentages of time (i.e., 88.5 percent) than Silva et al. (2016) within 10 m of the surface during the day.

2.2.1.3.19 Stenella coeruleoalba, Striped Dolphin

Striped dolphins prefer tropical and warm temperate waters and have an oceanic distribution, with most observations occurring beyond the continental shelf (Archer II 2002; Cañadas et al. 2002; Chavez-Rosales et al. 2019; Davis and Fargion 1996; Davis et al. 1998; Perrin et al. 1994b). Striped dolphins primarily feed on small, pelagic, vertically migrating prey (Blanco et al. 1995). Stomach contents analyses suggest that foraging occurs mostly in the dusk and early evening hours (Ringelstein et al. 2006). Their distribution in the North Atlantic Ocean is associated with a mesopelagic prey community comprised of fish and cephalopod species (Doksaeter et al. 2008).

Little data has been collected on the dive behavior of the striped dolphin. A single striped dolphin carrying a time-depth recorder dove to a mean depth of 22.6 m (SD = 17.5)) during the day and 126.7 m (SD = 120.9) at night, with a maximum dive depth of 705 m (Minamikawa et al. 2003).

Due to the lack of available data on the diving behavior of the striped dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2.1.3.18). The observed pattern of shallow daytime diving and deeper nighttime diving reported in Minamikawa et al. (2003) is consistent with similar diving behavior seen in short-beaked common dolphins (Section 2.2.1.3.2) and their surrogate species, the pantropical spotted dolphin (Section 2.2.1.3.18), which is also in the genus *Stenella*. Additionally, all three species occur in similar water depths (Davis et al. 1998). However, it is acknowledged that the striped dolphin may dive to deeper depths on average, due to the deep maximum dive depth recorded by Minamikawa et al. (2003). The depth distribution for striped dolphins is given in Table 2-16.

2.2.1.3.20 Stenella longirostris, Spinner Dolphin

Spinner dolphins typically reside in tropical pelagic waters, although they have a coastal distribution around the Hawaii and French Polynesia island chains (Benoit-Bird and Au 2003). The prey of spinner dolphins consists of vertically-migrating mesopelagic fish, cephalopods, and crustaceans, as well as pelagic organisms concentrated in near-surface waters with a shallow thermocline (Lammers 2004; Reilly 1990).

No data have been collected on the dive behavior of the spinner dolphin. Many of the vertically-migrating prey of the spinner dolphin spend daytime hours at depths from 700 to 3,000 m, but ascend to depths between the surface and 200 m at night. Spinner dolphins in Hawaiian waters mostly forage in deep water at dusk and early evening, but dive to shallow depths due to the vertical migration of their prey at night (Benoit-Bird and Au 2003; Lammers 2004). Letessier et al. (2022) found, through visual sighting and passive acoustic monitoring, that spinner dolphins in their study participated in a regular diurnal behavior where dolphins would enter a lagoon in the morning and leave in the afternoon for nighttime foraging offshore.

Due to the lack of available data on the diving behavior of the spinner dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2.1.3.18). Pantropical spotted dolphins also forage mostly at night on vertically-migrating fish and cephalopod prey and their foraging dives are primarily limited to the upper 200 m of the water column (Baird et al. 2001). Gross et al. (2009) found no niche differentiation between the two species. The depth distribution for striped dolphins can be found in Table 2-16.

2.2.1.3.21 Stenella clymene, Clymene Dolphin

Clymene dolphins are found in deep tropical and warm temperate waters beyond the continental shelf (Jefferson 2002a). The limited information available regarding their prey suggests they primarily feed on squid and vertically migrating myctophid fish, which are associated with the deep scattering layer (Perrin et al. 1981).

No data has been collected on the dive behavior of the Clymene dolphin. Some authors have speculated that their size limits them to the upper 250 m of the water column (Davis et al. 1998), although preliminary evidence suggests similarly-sized striped dolphins are capable of diving much deeper (Minamikawa et al. 2003).

Due to the lack of available data on the diving behavior of the Clymene dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2.1.3.18). Also in the genus *Stenella* and a shallower diver amongst the dolphin species, striped and spinner dolphins are the Clymene dolphin's closest relatives. Thus, the Clymene dolphin will be represented by the same surrogate species, the pantropical spotted dolphin. The depth distribution for the Clymene dolphin is given in Table 2-16.

2.2.1.3.22 Steno bredanensis, Rough-Toothed Dolphin

Rough-toothed dolphins are commonly found in waters along the continental shelf in tropical and warmer temperate waters (Baird et al. 2021; Davis et al. 1998; Shaff and Baird 2021). Rough-toothed dolphins have been reported feeding on squids and fishes near the surface, which may indicate that they primarily make shallow dives (Lodi and Hetzel 1999; Pitman and Stinchcomb 2002).

To build a representative depth distribution for rough-toothed dolphins, data from Table 9 in Wells et al. (2008) were used. Wells et al. (2008) reported time-at-depth data from four rehabilitated and released adult rough-toothed dolphins in the Atlantic Ocean and presented the percentage of dives to greater than 2 m for each animal. While these data underestimate surface time (since an animal had to dive below 2 m depth for the tag to save the data), they indicate that rough-toothed dolphins spend the majority of their time in the upper 25 m of the water column. Only two of the four dolphins (three dives total) reached the 200- to 300-m depth bin, and dives were generally shallowest during the daytime. The data from Wells et al. (2008) were averaged across all four animals. The depth distribution for rough-toothed dolphins is given in Table 2-17.

Table 2-17. Percentage of time at depth for the rough-toothed dolphin[1].

Depth Bin (m)	% of Time at Depth
0–10	78.6
10–25	16.24
25–50	3.81
50–75	0.93
75–100	0.29
100–150	0.11
150–200	0.01
200–300	0.01

[1] Based on data from Wells et al. (2008).

Other than the Wells et al. (2008) study, little data have been collected on the dive behavior of the rough-toothed dolphin. An early study by Watkins et al. (1987) reported rough-toothed dolphins rubbing against a deployed hydrophone at a depth of 70 m. A 2021 study of nine individuals by Shaff and Baird (2021) found tagged rough-toothed dolphins to have grand mean maximum dive depths of 76.9 m and 399.5 m, respectively. All tagged dolphins dove to depths greater than 203 m (Shaff and Baird 2021). The dolphins in the study were found to spend between 83.6 and 93.7 percent of time at depths less than 30 m (Shaff and Baird 2021). The Shaff and Baird (2021) study generally aligns with the data from Wells and colleagues, showing 84 to 94 percent of time between 0 and 30 m. Wells et al. recorded 94 percent of time at this depth with dives below 130 m occurring rarely. The deepest recorded dive by Shaff and Baird was slightly deeper than observed by Wells colleagues, measuring at 399 m (Shaff and Baird 2021).

2.2.1.3.23 Tursiops truncatus, Bottlenose Dolphin

Bottlenose dolphins have a cosmopolitan distribution in the tropical and temperate waters of the world (Wells and Scott 2002). They reside in estuarine, coastal, and offshore continental shelf and slope waters. Populations vary in their migratory and foraging behavior (Wells and Scott 2002). Bottlenose dolphins feed primarily on fish species, with squid and other invertebrates contributing to their diet as well (National Marine Fisheries Service 2015). Due to the range of habitats in which bottlenose dolphins are found, prey species may be epipelagic, pelagic, mesopelagic, or benthic in origin, depending on the region and habitat (Mead and Potter 1990; Rossbach and Herzing 1997; Shane 1990; Wells and Scott 1999). The presence of deep-sea fish in the stomachs of some offshore animals suggests that they can dive to depths greater than 500 m (Reeves et al. 2002).

Little data have been collected on the dive behavior of bottlenose dolphins. To build a representative depth distribution for bottlenose dolphins, data from Table 4 in Klatsky (2004) were used. Dolphins 39999 and 40000 were tagged for 30 and 48 hours, respectively, whereas Dolphin 40001 was tracked for 45 days, providing 792 hours of dive data. So, while Klatsky (2004) presents the percentage of time at depth for three individuals, only the data from Tag 40001 were considered for the depth distribution in to provide the most comprehensive view of bottlenose dolphin diving behavior. Klatsky (2004) reported that the maximum recorded depth of a dolphin was 492 m; therefore, that was used as the maximum depth associated with this depth distribution. The depth distribution for bottlenose dolphins is given in Table 2-18.

Table 2-18. Percentage of time at depth for the bottlenose dolphin[1].

Depth Bin (m)	% of Time at Depth
0–6	64.6
6–10	3.9
10–26	5.7
26–50	2.5
50–76	2.0
76–100	1.7
100–150	3.6
150–200	2.5
200–250	2.1
250–300	2.2
300–350	1.9
350–400	1.7
400–450	1.6
400–492	4.0

[1] Based on data from Klatsky et al. (2004).

These data are consistent with animals foraging up to 500 m off Hawaii, and spending the majority of their time between the surface and 50 m (Baird et al. 2021; Baird et al. 2014). A separate study by the same author, also off the coast of Hawaii, recorded maximum dive depths greater than that reported in Table 2-18, up to 623.5 m (Baird et al. 2021). However, the median depth of foraging dives (for dives deeper than 50 m) was 311.5 m (Baird et al. 2021). Because depths were not reported on for dives to less than 50 m, it is unclear whether or not this dive data is consistent with that in Table 2-18.

2.2.1.4 Family Eschrichtiidae

2.2.1.4.1 Eschrichtius robustus, Gray Whale

Gray whales are distributed coastally throughout the Pacific Ocean, migrating annually between Arctic and subtropical waters (Jones and Swartz 2002; Swartz 1986). Gray whales forage within the water column with modified skimming techniques to capture neritic fish, and will scrape along the benthos to acquire benthic fish, squid, annelids, crustaceans, and mollusks (Darling et al. 1998; Dunham and Duffus 2002; Jones and Swartz 2002; Nerini 1984). Gray whales have been reported foraging in water up to 120 m deep (Cacchione et al. 1987; Dunham and Duffus 2002; Würsig et al. 1986), although in many areas whales forage in waters less than 20 m deep (Guerrero 1989; Ljungblad et al. 1987; Malcolm and Duffus 2000; Malcolm et al. 1995; Stewart et al. 2001; Woodward and Winn 2006).

To build a representative depth distribution for gray whales, data from Figure 3 in (Malcolm et al. 1995) were used. Malcolm et al. (1995) reported the percentage of time at depth for a single foraging whale carrying a tag for over eight hours in waters off British Columbia in an area with a mean bottom depth of 18 m. The majority of dives (76 percent) were ventilation dives (to a mean depth of 2.3 m), while 13 percent were feeding dives (to a mean depth of 16.7 m). The whale appeared to spend little time at intermediate depths within the water column, spending most of its time either at the surface breathing or at the bottom feeding. Due to the large size of gray whales, the data from Malcolm et al. (1995) was summed into four-meter bins for the representative depth distribution. The depth distribution for gray whales is given in Table 2-19.

Table 2-19. Percentage of time at depth for the gray whale[1].

Depth Bin (m)	% of Time at Depth
0–4	39.0
4–8	8.5
8–12	7.0
12–16	16.0
16–20	28.0
20–22	1.5

[1] Based on data from Malcolm et al. (1995).

While other studies did not include depth distributions for gray whales, they did provide additional information to categorize dive behavior. The representative depth distribution data compare to a later study with a larger sample size of whales, where 79 percent of dives by whales off Vancouver Island were to a mean depth of 2.2 m, and 15 percent of dives were to a mean depth of 12 to 19 m (Malcolm and Duffus 2000). Woodward and Winn (2006) and Woodward (2006) similarly reported that six whales feeding along the central British Columbia coast had a mean dive depth of 11 m (range 2.4–28.9 m). The percentage of time near the surface (19.5 percent from 0 to 2 m) is also consistent with other studies in the same region (14.2 percent and 17.5 percent) (Stelle et al. 2008) and in the Bering Sea (22 percent) (Würsig et al. 1986).

Furthermore, the dive depth is similar to the reported foraging depths in British Columbia and other regions (Guerrero 1989; Ljungblad et al. 1987; Malcolm and Duffus 2000; Malcolm et al. 1995; Stewart et al. 2001; Woodward and Winn 2006). Stewart et al. (2001) described the diving behavior post-release for a rehabilitated calf in southern California. All dives were less than 20 m deep, and 85 percent of dives were less than 10 m deep. An earlier release of a post-rehabilitated calf in the same area documented a much deeper maximum diving depth (170 m) and an average diving depth of approximately 50 m (Evans 1974), which is deeper than the that in the representative depth distribution.

2.2.1.5 Family Kogiidae

2.2.1.5.1 Kogia breviceps, Pygmy Sperm Whale

Pygmy sperm whales have a cosmopolitan distribution in all temperate and tropical waters (Bloodworth and Odell 2008). Mid- and deep-water cephalopods predominantly contribute to the diet of the pygmy sperm whale (Beatson 2007; Bloodworth and Odell 2008; Fernandez et al. 2009; McAlpine et al. 1997; Ross 1979; Santos et al. 2006).

Little data have been collected on the dive behavior of pygmy sperm whales. These whales are difficult to observe, due to long dive times and shallow blows, and their skittish nature makes tagging exceptionally difficult (Hildebrand et al. 2019). Sightings of pygmy sperm whales in the North Atlantic are most common in waters ranging from 400 to 1,000 m in depth (Clarke 2003; McCullough et al. 2021; Scott et al. 2001; Waring et al. 2006). Based on the analysis of the stomach contents of whales stranded in New Zealand, Beatson (2007) concluded that pygmy sperm whales feed at shallower depths within the water column than sperm whales, although some prey species are found at depths greater than 600 m. Plon (2004) found that prey species from the stomachs of stranded pygmy sperm whales in South Africa are found at depths below 300 m. More recent studies suggest that they may feed as deep as 600 to 1,000 m (Hildebrand et al. 2019; McCullough et al. 2021).

Due to the lack of available data on the diving behavior of the pygmy sperm whale, it will be represented by the surrogate species: the short-finned pilot whale (Section 2.2.1.3.4). The short-finned pilot whale is another primarily squid-eating species (Mintzer et al. 2008; Reeves et al. 2002), which forages deep in the water column (Jensen et al. 2011). The broad similarity in prey types and oceanic habitat suggests similarity in diving behavior to the short-finned pilot whale. The depth distribution for the pygmy sperm whale can be found in Table 2-11.

2.2.1.5.2 Kogia sima, Dwarf Sperm Whale

Dwarf sperm whales have a cosmopolitan distribution in all temperate and tropical waters (Willis and Baird 1998). Little data have been collected on the dive behavior of dwarf sperm whales, due in large part to the difficulties associated in tagging this species (Hildebrand et al. 2019). There is some indication that dwarf sperm whales have a more coastal distribution than pygmy sperm whales, and prey often include more continental shelf and slope species than those of the pygmy sperm whale (Ross 1979; Wang et al. 2002). The preferred prey species of dwarf sperm whales are found deep in the water column, with some species found below 400 m (Wang et al. 2002). Recent research suggests that the feeding depths for *K. sima* may be similar to *K. breviceps*, in that it frequents deeper shelf and slope waters from 600 to 1,000 m, and thus, use of the same surrogate is appropriate (Hildebrand et al. 2019).

Due to the lack of available data on the diving behavior of the dwarf sperm whale, it will be represented by the surrogate species: the short-finned pilot whale (Section 2.2.1.3.4). The broad similarity in depth at which preferred prey can be found and oceanic habitat suggests similarity in diving behavior to the short-finned pilot whale. In addition, the dwarf sperm whale's closest relative, the pygmy sperm whale, is also represented by the short-finned pilot whale. The depth distribution for the dwarf sperm whale can be found in Table 2-11.

2.2.1.5.3 Kogiid Whales Guild and Kogia spp. Guild

Within the AFTT Study Area, dwarf and pygmy sperm whales are in the Kogiid whales guild. Within the HCTT Study Area, dwarf and pygmy sperm whales are in the Kogia whales guild. The two *Kogia* species are difficult to distinguish when viewed at sea and are found in overlapping areas within these study areas. Therefore, much of the density data from surveys is combined for both species into a generic guild. Because the depth distributions for both *Kogia* species are represented by the short-finned pilot whale, these data also represent the depth distribution for the guild. Therefore, the depth distribution for *Kogia* spp. whales can be found in Table 2-11.

2.2.1.6 Family Phocoenidae

2.2.1.6.1 Phocoena phocoena, Harbor Porpoise

Harbor porpoises inhabit temperate and subarctic continental shelf waters in the northern hemisphere. Their diet consists primarily of fish, including both pelagic schooling and benthic species (Bjorge and Tolley 2002; Recchia and Read 1989). Cephalopods, crustaceans, euphausids, and polychaetes also contribute to their overall diet (Recchia and Read 1989; Smith and Read 1992; Walker et al. 1998).

To build a representative depth distribution for harbor porpoises, data from Figure 3 in Otani et al. (1998), Figures 2 and 3 in Westgate et al. (1995), Figure 1 in Otani et al. (2000), Figures 2, 3, and 4 in Cooper et al. (1993), and Figure 7 in Westgate and Read (1998) were used. Cooper (1993) reported that porpoises in the Bay of Fundy were capable of diving to 150 m, but spent most of their time in the top 50 m of the water column. Westgate et al. (1995) reported porpoises diving to a maximum of 226 m, but that average dive depth for individual porpoises ranged from 14 to 41 m, and the depth range with the greatest proportion of dives was 2 to 10 m. Otani et al. (1998) found that harbor porpoises off the coast of Japan spent 74 to 86 percent of their time in the top 20 m of the water column, with an average dive depth of 12–19 m. The time at depth was visually inspected and averaged from all of the above figures to create the depth distribution for the harbor porpoise. This was done to include a total of 14 different harbor porpoises into the dive distribution. While data from Cooper (1993), Otani et al. (1998), and Westgate et al. (1995) show the number or frequency of dives to specific depth bins, this data will be used as a proxy for percentage of time spent at depth. The depth distribution for harbor porpoises is given in Table 2-20.

Table 2-20. Percentage of time at depth for the harbor porpoise[1].

Depth Bin (m)	% of Time at Depth	Depth Bin (m)	% of Time at Depth
0–10	39.0	110–120	0.4
10–20	17.8	120–130	0.4
20–30	12.7	130–140	0.3
30–40	10.1	140–150	0.2
40–50	6.9	150–160	0.2
50–60	4.6	160–170	0.1
60–70	2.5	170–180	0.1
70–80	1.5	180–190	0.1
80–90	1.4	190–200	0.1
90–100	1.0	200–210	0.1
100–110	0.4	210–226	0.1

[1] Based on data from Cooper (1993), Otani et al. (2000), Otani et al. (1998), Westgate and Read (1998), and Westgate et al. (Westgate et al. 1995).

While other studies did not include depth distributions for harbor porpoises, they did provide additional information to categorize dive behavior. Nielsen et al. (2018) found that the median maximum dive depth of 17 tagged harbor porpoises over the continental shelf off of Greenland was roughly 200 m. Offshore, this median maximum dive depth actually decreased 150 to 200 m (Nielsen et al. 2018). In a study by Linnenschmidt et al. (2013), three harbor porpoises were tagged. Two of the harbor porpoises showed consistent diving activity throughout the day while one harbor porpoise showed a diel diving pattern with few dives during the day. Teilmann et al. (2013) found harbor porpoises spent more time between 0 and 2 m at night than during the day; this may be due to the movement of their prey throughout the water column (e.g., herring and sprat) (Cardinale et al. 2003). Van Beest et al. (2018) found that bathymetry and sea surface salinity were the most important environmental drivers of porpoise fine-scale movements. Salinity is likely an environmental indicator of potentially important feeding areas, based on the associated tracked movements (van Beest et al. 2018).

2.2.1.6.2 Phocoenoides dalli, Dall's Porpoise

Dall's porpoises can be found in the subarctic and cool temperate North Pacific Ocean, including the Bering Sea, Okhotsk Sea, and Sea of Japan (Jefferson 2002b). Primary prey species include epipelagic and mesopelagic schooling fish and cephalopod species (Jefferson 1988; Ohizumi et al. 2000; Stroud et al. 1981; Walker 1996).

To build a representative depth distribution for the Dall's porpoise, data from Figures 3 and 4 in Baird and Hanson (1998) were used. Baird and Hanson (1998) tagged three Dall's porpoises with time-depth recorders in the waters between Washington State and British Columbia. Each animal had a median dive depth of less than 40 m, and maximum dive depths ranged from 197 to 278 m. Data from the tagged Dall's porpoises were averaged together to create the representative depth distribution below. The depth distribution for Dall porpoises is given in Table 2-21.

Table 2-21. Percentage of time at depth for the Dall's porpoise[1].

Depth Bin (m)	% of Time at Depth	Depth Bin (m)	% of Time at Depth
0–1	5.3	50–60	4.8
1–2	15.7	60–70	4.7
2–3	8.8	70–80	3.8
3–4	3.2	80–90	2.3
4–5	3.8	90–100	2.0
5–6	1.7	100–110	1.1
6–7	1.0	110–120	0.7
7–8	1.3	120–130	0.4
8–9	1.3	130–140	0.40
9–10	1.7	140–150	0.4
10–11	1.3	150–160	0.3
11–20	11.7	160–170	0.3
20–30	8.3	170–180	0.3
30–40	6.8	180–190	0.3
40–50	6.2	190–200	0.1

[1] Based on data from Baird and Hanson (1998).

The representative depth distribution is consistent with stomach contents analyses, which suggest that Dall's porpoises feed high in the water column on vertically-migrating mesopelagic species, but occasionally forage on deeper benthic prey (Jefferson 1988; Ohizumi et al. 1998). Recent modeling work suggests that although these profiles are limited in scope, they are an accurate representation of the generally shallow coastal dive behavior for this species (Becker et al. 2014).

2.2.1.7 Family Physeteridae

2.2.1.7.1 Physeter macrocephalus, Sperm Whale

The sperm whale has a cosmopolitan distribution, preferring deeper waters seaward of the continental shelf edge (Whitehead 2002). Females and immature males tend to inhabit tropical and temperate waters below 40° latitude, while maturing and adult males move to higher latitudes, occurring in polar waters as adults (Whitehead 2002). Sperm whales feed on cephalopod species, primarily squid, as well as mesopelagic and demersal fish and occasionally crustaceans (Fiscus et al. 1989; Flinn et al. 2002; Kawakami 1980; Martin and Clarke 1986).

To account for published differences in the foraging dive behavior of whales in different regions, separate depth distributions were generated for the Atlantic Ocean, Gulf of Mexico, and the Pacific Ocean. In general, time spent at depth for the regions is consistent with foraging dives to 800 to 1,200 m in the western North Atlantic Ocean (Sivle et al. 2012; Teloni et al. 2008; Watwood et al. 2006), and 400 to 1,300 m in the western North Pacific Ocean (Amano and Yoshioka 2003; Aoki et al. 2012; Aoki et al. 2007). Overall, sperm whales typically spend 70 to 80 percent of their time between 20 and 400 m (Sivle et al. 2012; Teloni et al. 2008). At mid and low latitudes, females and immature animals undertake stereotypic dives lasting about 45 minutes and to depths between 400 and 1,200 m (Teloni et al. 2008; Watwood et al. 2006). Off of Japan, females and immature sperm whales performed similarly stereotyped dive patterns to 1,400 m, lasting 30 to 50 minutes (Aoki et al. 2012). Radically different dive behavior has been observed at high latitudes, where mature males undertake dives lasting up to 60 minutes and to depths of nearly 1,900 m (Sivle et al. 2012; Teloni et al. 2008).

To build a representative depth distribution for sperm whales in the Atlantic Ocean, data from Figure 4 in Sivle et al. (2012), Figure 2 in Teloni et al. (2008), and Figure 2 and raw data from Watwood et al. (2006) were used. Sivle et al. (2012) found that the four tagged sperm whales in their study made regular deep dives to depths of 200 to 1,500 m, averaging a duration of 25 min, followed by a period of 5 to 15 min of shallow diving close to the surface. Sivle et al. (2012) found that sperm whales spend 80 percent of their time deeper than 20 m. Teloni et al. (2008) recorded the dives of four male sperm whales. Dive duration was between 6 and 60 minutes and dives ranged in depth between 14 and 1,860 m, with a median depth of 175 m. Most surfacing events (92 percent) lasted less than 15 minutes (Teloni et al. 2008). Watwood et al. (2006) reported that for whales in the Atlantic Ocean, Gulf of Mexico, and Ligurian Sea, typical foraging dives lasted 45 minutes, regardless of location. Data was extracted from the depth profiles given by Sivle et al. (2012) and Teloni et al. (2008). The resulting data were then averaged across the four whales recorded in the Teloni et al. (2008) study. The data from Sivle et al. (2012), Teloni et al. (2008), and Watwood et al. (2006) were then averaged together for the resulting representative depth distribution for sperm whales in the Atlantic Ocean that is shown in Table 2-22.

Table 2-22. Percentage of time at depth for the sperm whale in the Atlantic Ocean[1].

Depth Bin (m)	% of Time at Depth	Depth Bin (m)	% of Time at Depth
0–50	29.35	700–800	3.30
50–100	19.14	800–900	2.93
100–150	13.48	900–1,000	1.83
150–200	3.33	1,000–1,100	1.44
200–250	2.72	1,100–1,200	1.18
250–300	2.29	1,200–1,300	1.38
300–350	2.35	1,300–1,400	0.57
350–400	1.39	1,400–1,500	0.50
400–450	1.17	1,500–1,600	0.49
450–500	1.03	1,600–1,700	0.59
500–600	2.94	1,700–1,800	1.03
600–700	5.52	1,800–1,900	0.05

[1] Based on data from Sivle et al. (2012), Teloni et al. (2008), and Watwood et al. (2006).

Other studies that took place in the Atlantic Ocean recorded maximum dives that were hundreds of meters less (approximately 1,200 to 1,439 m) than the maximum dive depth in the representative depth distribution (Joyce et al. 2017; Joyce et al. 2016; Rivas 2020; Towers et al. 2019). Whales in the Gulf of Maine typically dove to depths between 70 and 100 m, which were defined by the shallow waters of the region (Tran et al. 2014). Tran et al. (2014) recorded dives lasting 25 minutes without surfacing, whereas Joyce et al. (2017) and Claridge et al. (2015) recorded dives off the Bahamas lasting around 48 minutes at a grand mean depth of 904 m. Twelve sperm whales tagged off of the Azores had few dives greater than 1,000 m (Rivas 2020), similar to the representative depth distribution. Two tagged whales off the coast of South Georgia were found to spend around 76 percent of time at depths greater than 15 m (Towers et al. 2019), which also aligns with the representative dive profile in Table 2-22.

For the representative depth distribution of sperm whales in the Gulf of Mexico, data from Figure 2 in Watwood et al. (2006) were used. In the Gulf of Mexico, 29 tagged whales spent 28 percent of their time within 10 m of the surface (Watwood et al. 2006). The data represented in Figure 2 was obtained as raw data from the author, then binned, resulting in the depth distribution for sperm whales in the Gulf of Mexico provided in Table 2-23.

Table 2-23. Percentage of time at depth for the sperm whale in the Gulf of Mexico[1].

Depth Bin (m)	% of Time at Depth	Depth Bin (m)	% of Time at Depth
0–50	35.36.21	500–550	7.72
50–100	1.89	550–600	7.33
100–150	1.85	600–650	4.74
150–200	1.77	650–700	6.24
200–250	1.78	700–750	3.24
250–300	1.83	750–800	1.08
300–350	2.37	800–850	0.27
350–400	4.41	850–900	0.55
400–450	5.98	900–950	1.38
450–500	8.93	950–1,000	0.43

[1] Based on data from Watwood et al. (2006).

In another study in the Gulf of Mexico, a maximum reported dive depth was recorded at 1,100 m (Azzara 2010). This is slightly deeper than the maximum depth in the representative depth distribution.

To build a representative depth distribution for sperm whales in the Pacific Ocean, data from Aoki et al. (2007) were used. Aoki et al. (2007) tagged four whales off the coast of Japan. The mean dive depth for nighttime was 515 m averaged over the two tag locations; the mean dive depth for the daytime was 749.5 m. While this may suggest a diel diving pattern that follows the availability of prey, the pattern seems to depend largely on location (Aoki et al. 2012). The depth distribution for sperm whales in the Pacific Ocean is given in Table 2-24.

Table 2-24. Percentage of time at depth for the sperm whale in the Pacific Ocean[1].

Depth Bin (m)	% of Time at Depth
1–50	30.2
50–100	4.8
100–150	3.3
150–200	3.3
200–250	3.1
250–300	2.5
300–350	2.5
350–400	3.6
400–450	5.3
450–500	6.5
500–600	9.8
600–700	6.5
700–800	8.6
800–900	8.4
900–1,000	1.3
1,000–1,100	0.3

[1] Based on data from Aoki et al. (2012).

In the representative depth distribution, maximum dive depths are a few hundred meters shallower than sperm whales recorded diving in the Gulf of California (1,500 m to greater than 1,600 m (Irvine et al. 2017; Mate and Nieukirk 1992). In the Gulf of Alaska, whales were recorded diving to depths of 800 m, which was indicative of the depth of the seafloor (Mathias et al. 2012). Sperm whales off the coast of New Zealand spent the majority of their underwater (i.e., non-surface) dive time at depths of 300 to 600 m and dove to maximum depths of 943 m (Miller et al. 2013).

2.2.1.8 Family Ziphiidae

2.2.1.8.1 Berardius bairdii, Baird's Beaked Whale

Baird's beaked whales inhabit temperate waters of the North Pacific Ocean and adjoining seas, primarily in the deep waters offshore of the continental shelf (Balcomb 1989; Kasuya 1986). This species consumes benthic and epibenthic fish and cephalopods, and occasionally feeds on mesopelagic species as well (Balcomb 1989; Kasuya 1986; Walker et al. 2002).

Little data have been collected on the dive behavior of Baird's beaked whales. Stomach contents analysis suggests that whales are feeding at depths of 800 to 1,200 m off of Japan, feeding on prey at or near the seafloor (Reeves et al. 2002; Walker et al. 2002). Minamikawa et al. (2007) reported that one animal carrying a time-depth recorder dove down to a maximum depth of 1,777 m, with dives lasting up to 64.4 minutes, which is similar to the maximum dive duration of 67 minutes observed by Kasuya (Kasuya 1986). The maximum dive depth reported by the first deployment of a multi-sensor tag on this species was given as roughly 1,400 m (Stimpert et al. 2014).

Due to the lack of data on the diving behavior of the Baird's beaked whale, it will be represented by a surrogate species: Cuvier's beaked whale (Section 2.2.1.8.5). The Cuvier's beaked whale is also a member of the subfamily Ziphiidae, and the feeding habits and types of prey for the two species are similar. The diving pattern of Baird's beaked whales appears very similar to other beaked whales, in which a long-duration deep dive is followed by shorter-duration shallow dives (Minamikawa et al. 2007; Tyack et al. 2006). The depth distribution for the Baird's beaked whale can be found in Table 2-26.

2.2.1.8.2 Hyperoodon ampullatus, Northern Bottlenose Whale

Northern bottlenose whales are found in deep, cold temperate and subpolar waters of the North Atlantic Ocean (Gowans 2002). The primary prey of bottlenose whales is squid, principally those species of the genus *Gonatus* (Hooker et al. 2001; Santos et al. 2001b). They also eat herring, various deep-sea fish, shrimp, and sometimes sea cucumbers and starfish (Reeves et al. 2002).

Little data have been collected on the dive behavior of northern bottlenose whales. Hooker and Baird (1999) reported on the diving behavior of two individuals from Canadian waters. Both individuals routinely dove deeper than 800 m, reaching a maximum dive depth of 1,453 m.

Due to the lack of available data on the diving behavior of the northern bottlenose whale, it will be represented by a surrogate species: the Cuvier's beaked whale (Section 2.2.1.8.5). Cuvier's beaked whales are also deep-diving members of the family Ziphiidae and are of similar size to female northern bottlenose whales (Leatherwood and Reeves 1983). Additionally, the primary prey for the northern bottlenose whale is squid, as is the primary prey for Cuvier's beaked whales. The depth distribution for the northern bottlenose whale can be found in Table 2-26.

2.2.1.8.3 Indopacetus pacificus, Longman's Beaked Whale

Longman's beaked whales inhabit generally warm, deep, pelagic waters of tropical and subtropical regions (McCullough et al. 2021). Little is known about the Longman's beaked whale feeding behaviors. Similar to other beaked whales who dive deep to forage for food, their diet most likely consists primarily of cephalopods (Yamada 2002).

Little data have been collected on the dive behavior of the Longman's beaked whale. The existence of Longman's beaked whales had previously only been known from the skeletal remains of stranded animals (Moore 1972; Pitman 2002a); however, some live sightings (Dalebout et al. 2003; Pitman et al. 1999) and acoustic recordings (McCullough et al. 2021) have been recognized as this species. Dive times have been found to last from 11 to 33 min, although one dive may have been over 45 min (Anderson et al. 2006; Gallo-Reynoso and Figueroa-Carranza 1995).

Due to the lack of available data on the diving behavior of the Longman's beaked whale, it will be represented by a surrogate species: the Blainville's beaked whale (Section 2.2.1.8.4). Though originally placed in the *Mesoplodon* genus, differences in features of the skull have led to the reclassification of this species into its own genus, *Indopacetus*; the previous classification in the same genus, and the current classification into the same family, is the primary reason for using Blainville's beaked whale as the surrogate species. The depth distribution for the Longman's beaked whale can be found in Table 2-25.

2.2.1.8.4 Mesoplodon densirostris, Blainville's Beaked Whale

Blainville's beaked whales inhabit deep temperate and tropical waters of the world's oceans (Pitman 2002b). Little is known about its prey species, but the diet of Blainville's beaked whales includes mesopelagic cephalopods, fish, and crustaceans (Herman et al. 1994; Hickmott 2005; MacLeod et al. 2003a; Mead 1989).

To build a representative depth distribution for Blainville's beaked whales, data were acquired from Figures 3a and 3b from Arranz et al. (2011), Figure 6 from Baird et al. (2005b), Figures 3a and 3b from Baird et al. (2006), Figure 1 from Barlow et al. (2013), Digital Acoustic Recording Tag (DTAG) data from Johnson and Aguilar de Soto (2008b) and Johnson and Aguilar de Soto (2008), DTAG data from Tyack (2010) and Figure 1b from Tyack et al. (2006). Arranz et al. (2011) tagged nine whales to collect acoustic and movement data, looking to study buzz and click behaviors during dives; Figures 3a and 3b show the dive profile of a male Blainville's beaked whale over a period of 17 hours. Baird et al. (2005b) tagged four Blainville's beaked whales and presented cumulative percentage of time spent at depth for two individuals: an adult female with a young calf, the daytime data for a large sub-adult or adult female, and the nighttime data for the same sub-adult or adult female. Different data from that same female whale were used to create another set of dive profiles after a 22.6-hour deployment, as published in Baird et al. (2006). Barlow et al. (2013) used DTAGs to collect acoustic information for beaked whales in an attempt to estimate density and abundance; Figure 1 is a typical dive profile for a tagged whale captured over a 15-hour period. Raw DTAG data for two animals in the Canary Islands, provided by Johnson and Aguilar de Soto (2008a, 2008b), were binned, as well as raw DTAG data from one animal in the Bahamas by Tyack (2010). Tyack et al. (2006) used DTAGs to create a representative dive profile for Blainville's beaked whale in an attempt to study how depth impacts foraging tactics. Data from each source were arranged into 100 m bins, and those bins were averaged together to create a representative depth distribution. The depth distribution for Blainville's beaked whales is given in Table 2-25.

Table 2-25. Percentage of time at depth for the Blainville's beaked whale[1,2].

Depth Bin (m)	% of Time at Depth	Depth Bin (m)	% of Time at Depth
1–100	54.3	800–900	4.7
100–200	10.2	900–1,000	3.0
200–300	3.8	1,000–1,100	2.2
300–400	3.2	1,100–1,200	1.8
400–500	3.7	1,200–1,300	1.1
500–600	3.4	1,300–1,400	0.55
600–700	3.8	1,400–1,500	0.05
700–800	4.2		

[1] Based on data from Arranz et al. (2011), Baird et al. (2005b), Baird et al. (2006), Barlow et al. (2013), Johnson and Aguilar de Soto (2008b; 2008), Tyack et al. (2006), and Tyack (2010).

[2] This depth distribution is also representative of the Longman's beaked whale, the HCTT small beaked whale guild, and the AFTT beaked whales guild, Mesoplodont beaked whales guild, and unidentified beaked whales guild.

While the maximum forage dive depth off the Bahamas was found to be 1,900 m (Claridge et al. 2015; Joyce et al. 2017), Joyce et al. (2020; 2016) found maximum dive depths of Blainville's beaked whales to reach 1,400 to 1,500 m, which is consistent with the data presented in Table 2-25. The percent of time at foraging depths (roughly greater than or equal to 650 m) were reported to be between 20 and 30 percent (Claridge et al. 2015; Joyce et al. 2017) these percentages correspond to the percent of time at these depths reported above.

2.2.1.8.5 Ziphius cavirostris, Cuvier's Beaked Whale

Cuvier's beaked whales inhabit slope waters with steep gradients around the world's oceans, with the exception of the high polar seas (Heyning 1989). Stomach contents analyses indicate that prey species include mesopelagic and benthic cephalopods, fish, and crustaceans (Heyning 1989; Hickmott 2005; Santos et al. 2001a). However, it appears that Cuvier's beaked whales eat mostly squid, and the majority of their prey are open-ocean species that occur well below the surface, including on or near the seafloor in deep water (Reeves et al. 2002).

To build a representative depth distribution for the Cuvier's beaked whale (Table 2-26), data from Figure 1 from Aguilar de Soto et al. (Aguilar de Soto et al. 2006), Figures 5 from Baird et al. (2005b), Figure 3c from Baird et al. (2006), Figure 2a from Baird et al. (2008), Figure 1 from Barlow et al. (2013), DTAG data from Johnson and Sturlese (2008), Figure 1a from Kvadsheim et al. (2012), and Figures 2a and 3a from Schorr et al. (2014) were used. Aguilar de Soto et al. (Aguilar de Soto et al. 2006) presented a time-depth profile of a Cuvier's beaked whale off of Italy over a 15.6-hour period. Baird et al. (2005b) presented the cumulative percentage of time spent at depth for an adult female during the day and at night. Similarly, Baird et al. (2008) looked at diel variation in Cuvier's beaked whale diving behavior, presenting the cumulative percentage of time spent at depth for two tagged whales during both the day and night. Barlow et al. (2013) used DTAGs to collect acoustic information for beaked whales in an attempt to estimate density and abundance; Figure 1 is a typical dive profile for a tagged whale captured over a 15-hour period. Raw DTAG data collected on multiple occasions for an animal in Liguria, Italy, provided by Johnson and Sturlese (2008), were binned. Kvadsheim et al. (2012) presented changes in dive behavior in response to sonar; as this report portrays normal Cuvier's beaked whale behavior, the portion of the dive profile provided by Kvadsheim et al. (2012) in which sonar was used has been omitted from the typical depth distribution calculated. Schorr et al. (2014) provided multi-day tag data for Cuvier's beaked whales, allowing for observation of diel patterns in dive behavior. The depth distributions from these studies were averaged together to create the representative depth distribution provided in Table 2-26.

Table 2-26. Percentage of time at depth for Cuvier's beaked whale[1,2].

Depth Bin (m)	% of Time at Depth
0–100	32.3
100–200	10.3
200–300	11.7
300–400	5.5
400–500	4.1
500–600	3.9
600–700	5.1
700–800	4.1
800–900	3.4
900–1,000	4.8
1,000–1,100	4.3
1,100–1,200	3.3
1,200–1,300	2.2
1,300–1,400	1.4
1,400–1,500	1.1
1,500–1,600	0.3
1,600–1,700	0.9
1,700–1,800	0.5
1,800–1,900	0.8

[1] Based on data from Aguilar de Soto et al.(Aguilar de Soto et al. 2006), Baird et al. (2005b), Baird et al. (2006), Baird et al. (2008), Barlow et al. (2013), Johnson and Sturlese (2008), Kvadsheim et al. (2012), and Schorr et al. (2014).

[2] This depth distribution is also representative of the Baird's beaked whale and the northern bottlenose whale.

While other studies did not include depth distributions for Cuvier's beaked whales, they did provide additional information to categorize dive behavior. Shearer et al. (2019) tagged 11 animals off Cape Hatteras and found that most surface intervals were very short in duration, but all animals occasionally performed extended surface intervals. Neither Quick et al. (2020) nor Shearer et al. (2019) found a correlation between deep dives and surface intervals. Dives were bi-modal with shallow dives occurring 50 to 800 m and deep dives occurring upwards of 800 m (Shearer et al. 2019). This representative depth distribution is consistent with foraging dives from 689 to 1,888 m in the Mediterranean Sea (Tyack et al. 2006), to 1,450 m off Hawaii (Baird et al. 2006), and to 1,900 m off the Bahamas (Claridge et al. 2015; Joyce et al. 2017; Joyce et al. 2016). Shearer et al. (2019) stated that the maximum dive depth is location and prey-specific as

Cuvier's beaked whales are thought to feed on the seafloor rather than on a vertically-migrating layer. Barlow et al. (2020) found that near-bottom habitat is likely important for foraging, while Barlow et al. (2018) found that individuals in their study rarely foraged at or near the seafloor. Mean foraging depth is typically shallower than seafloor depth off of California (Barlow et al. 2018; Barlow et al. 2020) but closer to the bottom off Cape Hatteras (Shearer et al. 2019). Based on the representative depth distribution in Table 2-26, Cuvier's beaked whales spent 31.9 percent of their time between 0 and 100 m, 36.1 percent of time deeper than 500 m, and 23 percent of time deeper than 800 m; these values remain consistent with the data reported by Baird et al. (2008), in which Cuvier's beaked whales spend 12.4 to 51.1 percent of their time spent at depths less than 50 m, and from 33.9 to 52.1 percent of time at depths greater than 500 m. Barlow et al. (2020) found that Cuvier's beaked whales spent almost twice as much time at near surface depths at night versus during the day. Table 2-26 is also consistent with Joyce et al. (2017), which indicates 22.6 percent of time is spent at depths greater than 800 m.

2.2.1.8.6 AFTT Beaked Whale Guild

Within the AFTT Study Area, beaked whales are represented as guilds due to the difficulty of identifying beaked whales at sea to the individual species level, and because this information was separated out in the density data used in the model. The AFTT beaked whale guild is comprised of all beaked whale species that would be present in the entire study area, including the Gulf of Mexico, the East Coast, and offshore the Northeast Atlantic Ocean: Cuvier's beaked whale, Blainville's beaked whale, Sowerby's beaked whale (*Mesoplodon bidens*), Gervais' beaked whale (*Mesoplodon europaeus*), and True's beaked whale (*Mesoplodon mirus*). While both Blainville's and Cuvier's beaked whales are located within the AFTT Study Area, the depth distribution for Blainville's beaked whales (Section 2.2.1.8.4) was used as the representative species for this guild. Blainville's beaked whales spend a greater percentage of time in the upper 100 m of water than Cuvier's, making the model a more conservative estimate of affected beaked whales. The depth distribution of beaked whales in the AFTT Study Area can be found in Table 2-25.

2.2.1.8.7 Mesoplodont Beaked Whale Guild

Within the AFTT Study Area, beaked whales are represented as guilds due to the difficulty of identifying beaked whales at sea to the individual species level, and because this information was separated out in the density data used in the model. The AFTT beaked whale guild is comprised of Mesoplodon species that would be present along the East Coast portion of the AFTT Study Area: Blainville's beaked whale, Sowerby's beaked whale, Gervais' beaked whale, and True's beaked whale. The depth distribution for Blainville's beaked whales (Section 2.2.1.8.4) was used as the representative species for this group. Blainville's beaked whales spend a greater percentage of time in the upper 100 m of water than Cuvier's, making the model a more conservative estimate of affected beaked whales. The depth distribution of beaked whales in the AFTT Study Area can be found in Table 2-25.

2.2.1.8.8 Small Beaked Whale Guild, Mesoplodon spp.

Within the California portion of the HCTT Study Area, a small beaked whale guild has been established. This guild was created to account for the difficulties associated with identifying beaked whales to the species level at sea. The beaked whale guild includes: Blainville's beaked whale, Ginkgo-toothed beaked whale (*Mesoplodon ginkgodens*), Stejneger's beaked whale (*Mesoplodon stejnegeri*), Hubb's beaked whale (*Mesoplodon carlshubbi*), Perrin's beaked whale (*Mesoplodon perrini*), and pygmy beaked whale (*Mesoplodon peruvianus*). The depth distribution used for this group is that of the Blainville's beaked whale (Section 2.2.1.8.4). The depth distribution for the small beaked whale guild in the HCTT Study Area can be found in Table 2-25.

2.2.1.8.9 Unidentified Beaked Whale Guild

Within the AFTT Study Area, beaked whales are represented as guilds due to the difficulty of identifying beaked whales at sea to the individual species level, and because this information was separated out in the density data used in the model. The AFTT beaked whale guild is comprised of all species that would be present along the East Coast portion of the AFTT Study Area: Cuvier's beaked whale, Blainville's beaked whale, Sowerby's beaked whale, Gervais' beaked whale, and True's beaked whale. The depth distribution for Blainville's beaked whales (Section 2.2.1.8.4) was used as the representative species for this group. Blainville's beaked whales spend a greater percentage of time in the upper 100 m of water than Cuvier's, making the model a more conservative estimate of affected beaked whales. The depth distribution of beaked whales in the AFTT Study Area can be found in Table 2-25.

2.2.2 Carnivores

2.2.2.1 Family Mustelidae

2.2.2.1.1 Enhydra lutris nereis, Southern Sea Otter

The sea otter is a species that ranges around the North Pacific Ocean rim, from Baja California, Mexico to the east coast of the Russian Kamchatka peninsula and the Kuril Islands towards Japan. According to the spring 2019 sea otter census results, the northernmost sea otters detected in the mainland survey were near Point Año Nuevo in 2019. At the southern end of the mainland range, 102 sea otters were counted southeast of Point Conception, 67 more than were counted in 2018 (Hatfield et al. 2019). Sea otters inhabit nearshore waters. Typically, due to water depths, foraging would occur closer to shore and resting may occur nearshore or further offshore (Lafferty and Tinker 2014; Laidre et al. 2009). Off the coast of California, kelp forest habitat and depth were the primary determinants of sea otter distribution. Within kelp forest habitat, otter observations peaked in areas of water that were roughly 13 m deep. Outside of the kelp forest habitat, otters were found in slightly deeper water depths, 15.5 m on average. However, the otters never strayed far from the edge of the kelp forest habitat. The depths used by otters for feeding were twice as deep as where otters rested (Lafferty and Tinker 2014). Sea otter prey includes benthic invertebrates (abalone, sea urchins, mussels, clams, snails, crabs, and worms) and occasionally bottom fish (Kenyon 1981; Laidre and Jameson 2006; Riedman and Estes 1990).

Early studies of sea otter dive behavior assumed average dives to be within 10 to 30 m of the surface (Kenyon 1981), but one record reported recovery of a sea otter carcass from a crab pot set at 97 m (Newby 1975), and assumed the otter dove to that depth, but perished after getting stuck in the crab pot. Thometz et al. (2016) examined the foraging dive behavior of southern sea otters off the coast of California and found that the deepest foraging dives were performed by males (the maximum depth was 88 m), while the maximum dive by a female was 69 m. Bodkin et al. (2004) examined dive distributions of 14 foraging northern sea otters in Port Althorp, southeast Alaska, from May through July. This study also found that dive behavior was related to sex and size, with females averaging a maximum dive depth of 49 m compared to 82 m for larger males (Bodkin et al. 2004). Wolt (2014) also examined the dive behavior of sea otters in Alaska, but focused primarily on those with dependent pups. There are differences in distribution with age/sex classes, with juvenile males tending to rest and forage farther offshore than juvenile and adult females. Juvenile males also forage in deeper water than either female class (Ralls et al. 1995).

Thometz et al. (2016) found that the mean foraging dive depth for all otters was 8.3 m and the range of mean dives was 2.3 to 28.6 m. Bodkin et al. (2004) calculated that sea otters in their southeast Alaska study completed a mean of 174 foraging dives per day and that these dives averaged a depth of 18.9 m (standard deviation (SD) = 4.6 m)) (Bodkin et al. 2004). Foraging dives had a mean depth of 2.7 m (SD = 0.2 m) when compared to traveling dives by the same animals (Bodkin et al. 2004). An observational study of sea otters off northern Washington state (Laidre and Jameson 2006) reported an average foraging dive time of 0.9 minutes (54 seconds), consistent with both Bodkin et al. (2004) and Thometz et al. (2016). Finally, Wolt et al. (Wolt et al. 2012) looked at sea otter dive behavior in Simpson Bay, Alaska where dives mirrored the bathymetry of the bay, which was roughly 30 m deep. Mean dive duration, depending on bathymetry, ranged from 62 to 114 seconds for individual foraging dives (Bodkin et al. 2004; Thometz et al. 2016; Wolt et al. 2012).

While dive data is available for foraging sea otters in southeast Alaska and coastal California, these foraging dives have been found to mirror the bathymetry of the local area. According to all existing dive data, sea otters may be found in up to 100 m of water (Bodkin et al. 2004; Thometz et al. 2016), depending on bathymetry in the areas where dive data was logged. In the HCTT Study Area, off the coast of California, sea otters would occupy similar depths. While most sea otters would forage in waters less than 40 m deep (Bodkin et al. 2004; Thometz et al. 2016; Wolt et al. 2012), it is assumed any sea otter found in more than 40 m of water would be diving to or near the bottom in order to forage, unless they are traveling, grooming, or participating in social interactions.

While several studies have created activity budgets for sea otters (Bodkin et al. 2007; Esslinger et al. 2014; Wolt 2014; Yeates et al. 2007), the data from Laidre et al. (2006) is the most robust, utilizing the behavior of 25 sea otters. According to Laidre et al. (2006), within a 24-hour time budget where all age and sex classes of sea otters were combined, sea otters spent roughly 45 percent of their time resting, 41 percent of their time foraging, and 14 percent in “other” behavior. Laidre et al. (2006) classified “other” behavior (similar to (Gelatt et al. 2002)), as grooming, swimming, or any active non-feeding behavior. As discussed above, Bodkin et al. (2004) describe this type of behavior as “traveling dives” and measured these as averaging around 2.7 m.

Sea otters are expected to forage at or near the seafloor; therefore, their dive depth is dictated by the bathymetry of the location (Wolt et al. 2012) in their typical coastal habitats. To build a representative depth distribution for the northern sea otter, the activity budget in Laidre et al.

(2006) was used and adjusted for time spent underwater. The 0- to 5-m bin includes time spent underwater while traveling, participating in "other" behavior, and foraging between 0 and 5 m. The total percentage of time spent in the 0- to 5-m depth bin was calculated to be 29.2 percent of underwater time. The remaining 70.8 percent of underwater time would be expected to be at depths between 6 and 100 m (accounting for depths greater than the deepest recorded otter dive), and dependent on the water depth of the foraging area. The depth distribution of southern sea otters is given in Table 2-27.

Table 2-27. Percentage of time at depth for the sea otter[1].

Depth Bin (m)	% of Time in Other (Traveling) Behavior at Depth	% of Time Foraging at Depth	% of Time at Depth
0-5	25.5	3.7	29.2
6-100	0	70.8	70.8

[1] Based on data from Laidre et al. (2006).

2.2.2.2 Family Otariidae

2.2.2.2.1 Arctocephalus townsendi, Guadalupe Fur Seal

Guadalupe fur seals live in the waters off southern California and the Pacific coast of Mexico. The entire Guadalupe fur seal population breeds at only two rookery locations: the east side of Isla Guadalupe and the southeast side of Isla Bonito del Este (Maravilla-Chavez and Lowry 1999). Single animals have occasionally been seen at islands along the coast of Baja California and California (Stewart et al. 1987). Squid, teleost fish, and crustaceans comprise the diet of the Guadalupe fur seal (Aurioles-Gamboa and Camacho-Ríos 2007; Belcher and Lee 2002; Riedman 1990).

Little data have been collected on the dive behavior of Guadalupe fur seals. To build a representative depth distribution for Guadalupe fur seals, data from Figure 2 in Lander et al. (2000) were used. Lander et al. (2000) obtained information on the diving behavior of Guadalupe fur seals by satellite tagging a single female following its rehabilitation and release off of southern California. Most dives were performed at night and lasted 2 to 4 minutes (mean dive time of 1.7 min, SD = 1.0 minutes), with a maximum dive duration of 18 minutes (Lander et al. 2000). The mean dive depth was 15.7 m (SD = 11.8 m). The maximum recorded dive depth was 130 m, although most dives were less than 20 m deep. While Lander et al. (2000) reported only the number of dives to various depth bins, this is used as a proxy for the time spent at depth. The bins over 40 m were presented together as they represented a small percentage of time at depth. The depth distribution for Guadalupe fur seals is given in Table 2-28.

Table 2-28. Percentage of time at depth for the Guadalupe fur seal[1].

Depth Bin (m)	% of Time at Depth
0–20	92.0
20–40	7.0
40–160	1.0

[1] Based on data from Lander et al. (2000).

Data from Gallo-Reynoso et al. (2008) also studied the diving behavior of one adult female, finding a mean dive depth of 17 m (SD = 10 m) with an average dive duration of 2.6 min (SD = 1.4 minutes). Kirkman et al. (2019) studied the dive behavior and foraging effort of female Cape fur seals (*Arctocephalus pusillis pusillis)* at the Kleinsee colony in South Africa. Most dives were in the depth range of epipelagic prey (less than 50 m depth), and at night, showing their dependence on small, vertically-migrating, schooling prey. Although the Cape fur seal is a different species of fur seal, the similar prey consumption allows a comparison to the Guadalupe fur seal. This data aligns with the representative depth distribution in Table 2-28.

2.2.2.2.2 Callorhinus ursinus, Northern Fur Seal

Northern fur seals occupy the pelagic waters of the North Pacific Ocean, Bering Sea, and Sea of Japan, ranging coastally as far south as Baja California, Mexico and Japan, and with an at-sea southern limit around 35° N (Gelatt and Lowry 2008). Northern fur seals are known to feed in the deep waters along the continental shelf break, as well as shallower waters of the shelf itself (Gentry 2002; Ponganis et al. 1992). The diet of northern fur seals varies regionally and seasonally, but is comprised principally of finfish (e.g., Pacific herring, sand lance, capelin, myctophids) and squid; they will occasionally feed upon other prey such as birds and crustaceans (Ream et al. 2005; Riedman 1990).

To build a representative depth distribution for the northern fur seal, data from Table 1 in Kooyman et al. (1976) were used. The dive behavior and physiology of the northern fur seal was among the earliest pinniped species to be tagged and tracked (Kooyman et al. 1976). Table 1 indicates the number of dives to specific depth bins; thus, this data from Kooyman et al. (1976) will be used as a proxy for percentage of time spent at depth. Kooyman et al. (1976) found that shallow dives (0–20 m) lasted less than 1 minute in duration. Deeper dives, from 20 to 140 m, lasted from 2 to 5 minutes. The maximum dive depth in this study was 190 m. The average interval between dives was 17 minutes. The depth distribution for northern fur seals is given in Table 2-29.

Table 2-29. Percentage of time at depth for the northern fur seal[1].

Depth Bin (m)	% of Time at Depth
0–20	48.36
20–50	42.32
50–80	5.94
80–110	0.96
110–140	1.99
140–170	0.39
170–200	0.04

[1] Based on data from Kooyman et al. (1976).

While other studies did not include depth distributions for northern fur seals, they did provide additional information to categorize dive behavior. Because northern fur seals spend the vast majority of their lives at sea (87 to 90 percent of the year), only coming ashore to breed for 35 to

45 days from June to August, most of the tagging studies examine the dive behavior of females on excursions from breeding colonies in the Bering Sea (Baker 2007; Baker and Donohue 2000; Goebel et al. 1991; Jeanniard-du-Dot et al. 2017; Kooyman et al. 1976; Kuhn et al. 2009; Ream et al. 2005). In general, adult females on foraging excursions generally follow one of three dive profiles: shallow, deep, or mixed depth. Shallow-diving seals show a crepuscular pattern with dive depths varying according to movement of the deep scattering layer. Deep-diving seals show no temporal pattern, apparently ignoring the diel movements of vertically migrating prey, and have no consistent change in depth within bouts. Mixed-depth divers alternate between dive profiles, perhaps shifting prey types (Gentry 2002). Female northern fur seals dive mostly at night (68 percent) (Gentry 2002). Individuals may be consistent in their diving behavior, presumably choosing prey sources at different depths, as evidenced by unique fatty acid profiles specific to a differentiated prey type (deep versus vertically migrating species, for example); however, other evidence points towards a seasonal shift in dive behavior (Gentry 2002; Gentry et al. 1986; Hobson and Sease 1998; Hobson et al. 1997). Radio-tracking studies suggest that deep-diving patterns are used while foraging on the continental shelf, while shallow-diving patterns occur over deeper waters off the shelf break or in the Aleutian Basin (Gentry et al. 1986; Goebel et al. 1991). Female northern fur seals have been recorded diving to a maximum depth of 256 m (Ponganis et al. 1992), although they most frequently dive between 50 and 60 m (Gentry et al. 1986). Female pups have shallower dives with a grand mean dive depth of 7.8 m (Lee et al. 2014). The activity budgets for adult females on foraging trips range from 9 to 17 percent of time spent resting, 26 to 29 percent of time spent diving, and 29 to 57 percent of time spent at the surface (Gentry et al. 1986; Jeanniard-du-Dot et al. 2017).

Male northern fur seal diving behavior has also been examined (Sterling and Ream 2004) and has revealed that (like parturient females), juvenile males exhibit shallow- versus deep-dive patterns based upon foraging location (deep dives in water less than 200 m deep, shallow nighttime dives in waters up to 3,000 m deep). In a study of 19 juvenile male northern fur seals on foraging excursions during the breeding season in the Bering Sea, the maximum recorded dive depth was 175 m, with a mean dive depth of 17.5 m (SD = 1.5 m) (Sterling and Ream 2004). A different study found male juveniles to have a grand mean dive depth of 6.8 m in the Bering Sea (Lee et al. 2014).

2.2.2.2.3 Eumetopias jubatus, Steller Sea Lion

Steller sea lions inhabit the Pacific Ocean north of approximately 30° N latitude (Loughlin 2002; Schusterman 1981). They feed on an assortment of shallow water fish, cephalopods, bivalves, and crustaceans (Schusterman 1981; Tollit et al. 2004). One study found that Steller sea lions feed on mackerel resting on the seafloor at night (Olivier et al. 2022).

To build a representative depth distribution for the Steller sea lion, data from Figure 2 and the text of Rehberg et al. (2009) was used. Rehberg et al. (2009) reported on the summer diving behavior of five adult sea lions belonging to the Eastern Alaska stock. They also summarized similar data on four Western Alaska stock females from Merrick (1995) and Merrick and Loughlin (1997). A dive was counted as any movement of the animal below 4 m depth. Due to the lack of data on time spent at depth, the data will be used as a proxy for depth distribution data. Skinner et al. (2012) and Rehberg et al. (2009) reported that on average females spent 15.1 percent and 22.1 percent of their time at sea submerged, respectively. Therefore, the distribution from Rehberg et al. (2009) will be adjusted to represent 22.1 percent of an animal's time, with 77.9 percent of time spent between depths of 0 to 4 m. The maximum dive depth reported in this study was 236 m. The resulting depth distribution is given in Table 2-30.

Table 2-30. Percentage of time at depth for the Steller sea lion[1].

Depth Bin (m)	% of Time at Depth
0–4	77.9
4–10	8.8
10–20	6.6
20–50	4.3
50–100	1.9
100–236	0.5

[1] Based on data from Rehberg et al. (2009) and Skinner et al. (2012).

While other studies did not include usable depth distributions for Steller sea lions, they did provide additional information to categorize dive behavior. Olivier et al. (2022) found that 33 percent of foraging time was spent diving, with the rest of the time spent swimming near the surface. The depth distribution in Table 2-30 is consistent with research suggesting most dives are within the top 50 m (Fadely et al. 2005; Loughlin et al. 1998; Loughlin et al. 2003; Merrick and Loughlin 1997; Merrick et al. 1994; Olivier et al. 2022; Skinner et al. 2012). The maximum dive depth in Table 2-29 is shallower than in some studies (Loughlin et al. 2003; Olivier et al. 2022). However, there is evidence that adult females dive deeper during the winter than the summer (Merrick and Loughlin 1997; Merrick et al. 1994), although in both seasons the majority of dives are shallow (<50 m). The depths to which Steller sea lions dive aligns with the presence of prey. Though prey abundance is seasonally and geographically variable, the general assertion that Steller sea lions spend the majority of their time in the top 50 m of the water column is consistent (Sigler et al. 2009). Many studies use trained Steller sea lions to examine dive behavior (Fahlman et al. 2008; Hindle et al. 2010; Rosen et al. 2017; Volpov et al. 2016; Young et al. 2011) or use Steller sea lions that were in or recently released from captivity (Goundie et al. 2015; Thomton et al. 2008).

2.2.2.2.4 Zalophus californianus, California Sea Lion

California sea lions primarily breed on island beaches off of southern California, along Baja California, Mexico, and in the Gulf of California (Heath 2002). They eat a variety of prey, including schooling fish, crustaceans, and cephalopods (García-Rodríguez and Aurioles-Gamboa 2004; Melin et al. 2008; Porras-Peters et al. 2008). California sea lions often make shallow dives in some coastal areas for epipelagic prey, and deeper dives in others, such as the Gulf of California, for mesopelagic prey (Costa et al. 2004; Lowry and Carretta 1999; Melin and DeLong 1999).

To build a representative depth distribution for California sea lions, data from Figure 4 in Feldkamp et al. (1989) and Figure 1a in Weise (2006) were used. Both figures show the number of dives to specific depth bins; thus, the data from Feldkamp et al. (1989) and Weise (2006) will be used as a proxy for percentage of time spent at depth. Because data indicate differences in diving behavior of males (Weise 2006) and females (Feldkamp et al. 1989; Kuhn 2006; Melin et al. 2008), data from Weise (2006) and Feldkamp et al. (1989) were averaged to create a composite distribution. Weise (2006) reported an average dive depth of 32 m, but that most dives occurred within the depth range of 10 to 20 m. Feldkamp et al. (1989) found that the maximum dive depth for females was roughly 274 m. The mean depths ranged from 31 to 98 m, but the majority of dives went to between 20 and 50 m. In order to account for the time spent at the surface, an activity budget from Table 3 in Thomas et al. (2010) was used, incorporating both male and female sea lions. Based on these numbers, a percent time swimming at the surface (63.62 percent) was added into the average taken from the Feldkamp et al. (1989) and Weise (2006) data. The remaining averages from both studies were redistributed proportionally to account for the remaining 36.38 percent of time. The resulting depth distribution profile includes data from all three studies. The depth distribution for California sea lions is given in Table 2-31.

Table 2-31. Percentage of time at depth for the California sea lion[1].

Depth Bin (m)	% of Time at Depth	Depth Bin (m)	% of Time at Depth
0–10	68.3	120–130	0.5
10–20	5.9	130–140	0.40
20–30	6.0	140–150	0.5
30–40	4.8	150–160	0.5
40–50	4.0	160–170	0.5
50–60	2.3	170–180	0.3
60–70	1.5	180–190	0.1
70–80	1.0	190–200	0.1
80–90	0.7	200–210	0.2
90–100	0.7	210–220	0.1
100–110	0.7	220–230	0.1
110–120	0.6	230–500	0.2

[1] Based on data from Feldkamp et al. (1989), Weise (2006), and Thomas (2010).

While other studies did not include usable depth distributions for California sea lions, they did provide additional information to categorize dive behavior. Mean dive depths reported for female California sea lions range from 45 to 70 m with maximum dive depths ranging from 104 to 279 m (Kuhn 2004; Kuhn 2006; Melin et al. 2008). While this dataset does not necessarily capture the maximum dive depths reported in several locations (greater than 200 m) (Costa et al. 2004; Feldkamp et al. 1989; Kuhn 2004; Kuhn 2006; Melin et al. 2008), the depth distribution is consistent with studies by Kuhn (2004) and Melin (2008), both of whom demonstrated that the majority of dives (ranging from 55 to 85 percent) were less than 50 m deep. Similarly, Melin and DeLong (1999) reported that most dives were shallower than 100 m. McHuron et al. (2018) recorded a maximum dive depth of 363.5 m in a juvenile female sea lion, which is not as deep as the adults dive. Therefore, although the depth distribution in Table 2-31 may be shallower than seen in some locations, it does capture published diving behavior for the species, and is representative for California sea lions.

2.2.2.3 Family Phocidae

2.2.2.3.1 Cystophora cristata, Hooded Seal

Hooded seals typically inhabit continental shelf and slope waters of the North Atlantic Ocean. Adults feed on commercial-size fish such as capelin, cod, and redfish, as well as squid and amphipods (Bjørke 2001; Haug et al. 2004; Hauksson and Bogason 1997).

To build a representative depth distribution for hooded seals, both the text and data from Figures 2A-L in Folkow and Blix (1999) were used. Folkow and Blix (1999) reported tag data from 16 seals from the Greenland Sea. The seals had an average submersion time of 77 percent. While not an estimate of time spent at depth, it is the closest approximation to a depth distribution in the published literature. Due to the lack of data on time spent at depth, the data from Folkow and Blix (1999) will be used as a proxy for percentage of time spent at depth. Assuming a submersion time of 77 percent gives us a remaining surface time of 23 percent, which has been included as the 0- to 1-m bin below. The remaining distribution bins were taken from the data in the text of Folkow and Blix (1999), which is also displayed in Figures 2A through 2L. The remaining bins from the Folkow and Blix (1999) depth distribution were redistributed proportionally to account for the remaining 77.0 percent of time. The depth distribution for hooded seals is given in Table 2-32.

Table 2-32. Percentage of time at depth for the hooded seal[1].

Depth Bin (m)	% of Time at Depth
0–1	23
1–52	13.09
52–100	6.16
100–600	54.67
600–968	1.925
968–1,016	1.155

[1] Based on data from Folkow and Blix (1999).

While other studies did not include usable depth distributions for hooded seals, they did provide additional information to categorize dive behavior. Andersen et al. (2013) tagged northwest Atlantic males and females after their annual molt. These data showed that 50 percent of total dives occurred in waters less than 500 m deep, 90 percent did not exceed 500 m, and 35 percent were between 150 and 300 m. For both sexes, it appeared that maximum dive depths varied seasonally (Andersen et al. 2013). Vacquie-Garcia et al. (2017) acknowledge that differences in migration patterns and diving behavior have been documented between the northwest and northeast Atlantic hooded seals. Vacquie-Garcia et al. (2017) tagged males, females, and pups, with both adult males and adult females reaching similar depths to those in Table 2-32 and pups diving shallower. Bajzak et al. (2009) reported dive depths for post-breeding seals consistent with those from Folkow and Blix (1999), although the seals dove to shallower depths during the molting period. Seals from the Gulf of St. Lawrence spent a similar percentage of their time diving, but considerably less during the molting period (Bajzak et al. 2009). However, the depth distribution in from Folkow and Blix (1999) represents dive depths from seals in waters of different depths; therefore, this depth distribution represents the best representative depth distribution.

2.2.2.3.2 Halichoerus grypus, Gray Seal

Gray seals are found in temperate, coastal waters of the North Atlantic Ocean. Gray seals feed on both pelagic (e.g., herring and sand lance) and benthic (e.g., flatfish) prey (Bowen et al. 1993; Iverson et al. 2004).

To build a representative depth distribution for gray seals, data from the text of Harvey et al. (2008), a maximum dive depth from Beck et al. (2003), as well as an activity budget from Thomson et al. (1991), were used. Harvey et al. (2008) presented a distribution of maximum dive depths for a range of age, sex, and seasonal classes, which (while not an exact representation of time spent in each depth range) is a good approximation as gray seals are primarily shallow divers. Due to the lack of data on time spent at depth, the data from Harvey et al. (2008) will be used as a proxy for percentage of time spent at depth. However, the data from Harvey et al. (2008) only consider when the animal is beneath the surface. Thompson et al. (1991) tracked three swimming juvenile gray seals and reported that across three behavioral states (traveling, short trips, and resting), animals spent on average 84.1 percent of their time submerged. Therefore, the average time spent at the surface from Thompson et al. (1991) was combined with the dive distribution data from Harvey et al. (2008) to generate an estimate of the depth distribution for the gray seal. The maximum dive depth of 412 m reported by Beck et al. (2003) is used as the maximum depth. The depth distribution for gray seals is given in Table 2-33.

Table 2-33. Percentage of time at depth for the gray seal[1].

Depth Bin (m)	% of Time at Depth
0–40	81.7
40–100	14.2
100–200	3.3
200–412	0.8

[1] Based on data from Harvey et al. (2008), Beck et al. (2003), and Thompson et al. (1991).

While other studies did not include usable depth distributions for gray seals, they did provide additional information to categorize dive behavior. Beck et al. (2003) reported that 73.9 percent and 59.4 percent of dives were in the top 60 m during the day and night, respectively, and that 95.9 percent of dives were in the top 120 m. Lidgard et al. (2003) found that 41 percent of dives were within 10 m of the surface.

2.2.2.3.3 Erignathus barbatus, Bearded Seal

Bearded seals are limited to circumpolar Arctic and sub-Arctic waters that are relatively shallow (primarily less than about 490 m deep) and seasonally ice-covered because they are closely associated with sea ice. Bearded seals follow the advancement and retreat of the polar ice cap during seasonal migrations (Antonelis et al. 1994). To remain associated with their preferred ice habitat, bearded seals generally move north in late spring and summer as the ice melts and retreats and then south in the fall as sea ice forms. In U.S. waters, they are found off the coast of Alaska over the continental shelf in the Bering, Chukchi, and Beaufort Seas. Bearded seals are often found further offshore than the sympatric ringed seal (Bengston et al. 2005). They are generalist feeders, consuming both pelagic and demersal fish, as well as epifaunal and infaunal invertebrates. Their main prey includes fish such as polar cod and capelin, crabs, shrimp, and mollusks (Antonelis et al. 1994; Hjelset et al. 1999; Lowry et al. 1980). Bearded seals primarily feed on or near the seafloor on invertebrates (e.g., shrimps, crabs, clams, and whelks) and some fish (e.g., cod and sculpin). Bearded seals are considered shallow divers, with most dives to less than 100 m (Kingsley et al. 1985). They do not like deep water and prefer to forage in waters less than 200 m deep where they can reach the ocean floor.

To build a representative depth distribution for bearded seals, data from Figure 4 in Gjertz et al. (2000b) was used. Gjertz et al. (2000b) reported diving behavior of adult females and their pups in shallow, coastal regions around Svalbard, Norway. This study provided an estimate of percentage of dives to varying depths, which will be used as a proxy for percentage of time at depth. The tags did not record data until deeper than two meters, so for a surface bin amount, an activity budget from Krafft et al. (2000) was used. Figure 1 showed that female seals in this study spent 48.37 percent of their time at the surface. Therefore, the average time spent at the surface from Krafft et al. (2000) was combined with the dive distribution data from Gjertz et al. (2000b) to generate an estimate of the depth distribution for the bearded seal. The depth distribution for bearded seals is given in Table 2-34.

Table 2-34. Percentage of time at depth for the bearded seal[1].

Depth Bin (m)	% of Time at Depth
0–2	48.37
2–10	19.43
10–20	5.24
20–30	1.86
30–40	3.39
40–50	5.21
50–60	6.35
60–70	5.0
70–80	1.98
80–90	1.35
90–100	0.58
100–150	1.17
150–200	0.07

[1] Based on data from Gjertz et al. (2000b) and Krafft et al. (2000).

While other studies did not include usable depth distributions for bearded seals, they did provide additional information to categorize dive behavior. Watanabe et al. (2009) looked the diving and swimming style of pups that were still nursing. The pups in this study spent roughly half of their time hauled out of the water. Olnes et al. (2020) provide a description of juvenile bearded seal movement, diving, and haul-out behaviors in the Pacific Arctic, obtained from 24 seals tagged with satellite-linked data recorders along Alaska's coast from 2014 to 2018. Olnes et al. (2020) found that seals spent half their time near the sea floor. Hauling out occurred less in the winter and increased during spring and summer, coinciding with the annual molting period. When ice was at its minimum extent, seven seals frequently hauled out on land. Hamilton et al. (2018) tagged five adult bearded seals with GPS-Argos-CTD-SRDLs in Svalbard, Norway from 2011 through 2012 to document their diving, activity, and movement patterns. The seals spent little time hauled out (≤ 5 percent), while diving occupied 74 percent of their time. Dives were generally shallow (mean: 24 ± 7 m, max: 391 m) and of short duration (6.6 ± 1.5 minutes, max: 24 minutes) with deeper, longer dives in winter/spring compared to summer.

2.2.2.3.4 Mirounga angustirostris, Northern Elephant Seal

Northern elephant seals are limited to the North Pacific Ocean, with breeding haul-outs located along the western coast of North America from northern California to Baja California, Mexico. Seals utilize deep waters for foraging, traveling north and west from breeding beaches, and traveling as far north as the Gulf of Alaska and Aleutian Islands (Hindell 2002). Elephant seals feed primarily on vertically migrating epipelagic and mesopelagic squid, but eat a variety of prey species, including elasmobranchs, crustaceans, other cephalopods, and fish (Adachi et al. 2021; DeLong and Stewart 1991; Sinclair 1994; Stewart and Huber 1993).

To build a representative depth distribution for northern elephant seals, data from DeLong and Stewart (1991), Hakoyama et al. (1994), Le Boeuf et al. (1986), and Naito et al. (1989) were used. In addition, a surface time from DeLong and Stewart (1991) was incorporated into the data. The text of DeLong and Stewart (1991) states that northern elephant seals are submerged 86 percent of the time, leaving an above- surface time percentage of 14 percent (DeLong and Stewart 1991). Due to the lack of data on time spent at depth, the data from these sources, citing percentage of dives to specific depth bins will be used as a proxy for percentage of time spent at depth. As the data show sex differences in foraging and diving behavior (DeLong and Stewart 1991; Hakoyama et al. 1994; Le Boeuf et al. 1986; Le Boeuf et al. 1993; Naito et al. 1989), males and females were averaged together to create a representative depth distribution. In males, the data averaged from Figure 1 in Delong and Stewart (1991) and Figure 4 in Hakoyama et al. (1994) showed that 83 percent of dives took place between the surface and 500 m, most frequently occurring from 300 to 500 m. In females, the data averaged from Figure 1 in Le Boeuf et al. (1986), Figure 2 in Naito et al. (1989), and Figure 4 in Hakoyama et al. (1994), showed that 85 percent of dives were to depths of 300 to 700 m, most frequently from 400 to 600 m. For males, dives deeper than 500 m were unusual, whereas dives over 700 m were rare for females (DeLong and Stewart 1991; Hakoyama et al. 1994; Le Boeuf et al. 1988; Le Boeuf et al. 1986; Naito et al. 1989). Data from each Figure were summed into 100-m bins and averaged together. The remaining bins of each study were averaged and redistributed proportionally to account for the remaining 86 percent of non-surface time. The resulting depth distribution profile includes data from all studies. The depth distribution for northern elephant seals is given in Table 2-35.

Table 2-35. Percentage of time at depth for the northern elephant seal[1].

Depth Bin (m)	% of Time at Depth
0–100	21.4
100–200	7.6
200–300	8.9
300–400	13.4
400–500	18.0
500–600	16.3
600–700	10.0
700–800	2.2
800–900	0.8
900–1000	0.5
1,000–1,100	0.5
1,100–1,200	0.4

[1] Based on data from DeLong and Stewart (1991), Hakoyama et al. (1994), Le Boeuf et al. (1986), and Naito et al. (1989).

While other studies did not include usable depth distributions for northern elephant seals, they did provide additional information to categorize dive behavior. Le Boeuf and Naito (2022) reported four major dive types for northern elephant seals: pelagic foraging, benthic foraging, transit, and drift dives. The same study revealed that females forage pelagically over deep water in the open ocean in the deep scattering layer, while males tend to forage benthically near continental slopes. Transit dives occur when elephant seals travel to and from foraging sites and passive drift dives are thought to serve the purpose of digestion, rest, and sleep (Le Boeuf and Naito 2022). Robinson et al. (2012), Martinez et al. (2018), and Adachi et al. (2021) found that the dive depths of most seals showed a clear diel pattern, consistent with targeting vertically-migrating prey species. Robinson et al. (2012) found the mean dive depth to be 516 m and a mean dive duration of 23.1 min. Naito et al. (2013) found the mean dive depths of foraging seals to range from 507 to 562 m, and Adachi et al. (2021) found seals foraging at depths around 400 to 600 m. Active bottom dives made up the greatest percentage of dives (54.0 percent) in (Robinson et al. 2012), but were rare in Adachi et al. (2021). Maximum dive depths for elephant seals covered a wide range of depths, from less than 1,000 m (Crocker et al. 2006; Davis et al. 2001; Davis and Weihs 2007; Kienle et al. 2022; Le Boeuf et al. 1988) to greater than 1,000 m (Adachi et al. 2021; Martinez et al. 2018), upward to the deepest dive ever recorded by an elephant seal at 1,747 m (Robinson et al. 2012).

2.2.2.3.5 Monachus schauinslandi, Hawaiian Monk Seal

The range of the Hawaiian monk seal is limited to the central Pacific Ocean, with breeding colonies principally in the northwestern Hawaiian Islands (Gilmartin and Forcada 2002; Johanos and Baker 2002). Hawaiian monk seals primarily consume benthic prey; stomach contents and scat analyses indicate that prey constitute both diurnal and nocturnal species. Reef-associated fish and octopus compose a large portion of the diet (DeLong et al. 1984; Goodman-Lowe 1998; Kenyon and Rice 1959). Most seals focus foraging efforts in the top 100 m of the water column, although some seals dive to greater than 500 m deep (Parrish et al. 2002; Parrish et al. 2000; Parrish et al. 2005; Stewart et al. 2006; Wilson and D'Amico 2012).

To build a representative depth distribution for Hawaiian monk seals, data from two Stewart and Yochem (2004a, 2004b) studies were used. Figure 25 from Stewart and Yochem (2004a) and Figure 40 from Stewart and Yochem (2004b) provided time at depth for weaned pups, juveniles, and adults that could be averaged for a representative depth distribution. Stewart and Yochem (2004a, 2004b) presented depth distributions for 18 animals from Kure Atoll and Laysan Island, respectively. The maximum dive depth reported was greater than the recording limit of the tag at 490 m; therefore, 500 m is used as a conservative maximum dive depth. Most dives of all seals were shallower than 40 m and lasted less than 6 to 8 min (Stewart and Yochem 2004a, 2004b). The depth distribution for Hawaiian monk seals is given in Table 2-36.

Table 2-36. Percentage of time at depth for the Hawaiian monk seal[1].

Depth Bin (m)	% of Time at Depth
0–4	33.0
4–20	34.68
20–40	13.2
40–60	5.45
60–80	3.58
80–100	2.08
100–120	2.53
120–140	2.0
140–160	0.75
160–180	0.69
180–200	0.25
200–250	0.38
250–350	0.88
350–500	0.56
200–250	0.38
250–350	0.88
350–500	0.56

[1] Based on data from Stewart and Yochem (2004a, 2004b).

While other studies did not include usable depth distributions for Hawaiian monk seals, they did provide additional information to categorize dive behavior. In the representative depth distribution above, 92 percent of the monk seals' time is spent within the top 100 m. This is consistent with other studies that have demonstrated Hawaiian monk seal foraging occurring at shallow reef sites (DeLong et al. 1984; Littnan et al. 2004; Parrish et al. 2000; Schlexer 1984; Wilson and D'Amico 2012; Wilson et al. 2017a; Wilson et al. 2017b).

2.2.2.3.6 Pagophilus groenlandicus, Harp Seal

Harp seals are found in ice-associated waters of the Arctic (Grecian et al. 2022; Lavigne 2002; Malde 2019). Harp seals forage on a variety of prey, including Arctic cod and capelin, amphipods, and krill (Haug et al. 2004; Lawson et al. 1998; Nilssen et al. 2001).

Given the characteristic shallow diving pattern in the post-breeding to post-molting period (spring), two depth distributions are given in Table 2-37 for the harp seal. Folkow et al. (2004) characterized diving behavior of 16 adult harp seals throughout the year in two different years. To build a representative depth distribution for harp seals during the breeding and molting season, data from Figure 5A in Folkow et al. (2004) were used. To build a representative depth distribution for harp seals during the remainder of the year, data from Figure 7C of Folkow et al. (2004) were used. This study reported that after the period of time close to the ice edge, the seals then moved into deeper water in the open ocean, diving up to 492 m and 568 m in the different years. While close to the ice edge during the breeding and molting season in summer, seals spent most of their time in shallow depths, with 70 to 90 percent of their diving time spent in the top 50 m of the water column (Folkow et al. 2004). A large proportion of the seals (9 out of a total of 14; both years) at some time dove deeper than 450 m, and dives deeper than 300 m represented greater than 12 percent of all dives. There were significant seasonal variations in diving depths, with dives being significantly shallower in spring/summer than in autumn and winter (Folkow et al. 2004). The depth distribution for harp seals is given in Table 2-37.

Table 2-37. Percentage of time at depth for the harp seal[1].

Depth Bin (m)	% of Time at Depth	
	Post-breeding to Post-molting (Spring)	Remainder of Year (Summer, Winter, Fall)
0–20	52	32
20–50	29	17
50–100	12	16
100–200	5	18
200–300	2	11
300–400	0	5
400–492	0	1

[1] Based on data from Folkow et al. (2004).

While most other studies did not include usable depth distributions for harp seals, they did provide additional information to categorize dive behavior. Lydersen and Kovacs (1993) found that lactating females had maximum dive depths of 90 m, which is consistent with the majority of seals in the data above. The maximum dive depths for post-weaned molted juveniles from the Northwest Atlantic and Greenland Seas were 125 m and 75 m, respectively (Grecian et al. 2022). A separate study by Malde (2019) found post-weaned juveniles from the Greenland Seas to largely dive between 0 and 200 m; however, a few dives were reported as being a few hundred meters deeper (600 m) than that reported by Folkow et al. (2004). Nordøy et al. (2008) reported dive depths for both sexes during the molting-breeding season to mainly be in the 20 to 300 m range. Based on the published diving depths for the harp seal, Table 2-37 largely encompasses the diving behavior of the species.

2.2.2.3.7 *Phoca hispida, Ringed Seal*

Ringed seals have a circumpolar distribution within Arctic waters. Ringed seals are associated with continental shelf waters, and occasionally associated with deep Artic Basin waters (Von Duyke et al. 2020). Ringed seals mainly inhabit waters with sea ice in winter months, and mainly inhabit open-water without sea ice in the fall (Crawford et al. 2019; Von Duyke et al. 2020). Primary prey species include arctic cod, amphipods, and crustaceans (Labansen et al. 2007; Wathne et al. 2000).

To build a representative depth distribution for ringed seals, data from Figure 3 in Gjertz et al. (2000a) were used, along with a surface bin taken from Lydersen (1991). Gjertz et al. (2000a) reported the percentage of dives to different depths for seven ringed seals. This data from Gjertz et al. (2000a) will be used as a proxy for percentage of time spent at depth. Gjertz et al. (2000a) found that 48 percent of all dives were shallower than 20 m and 90 percent of dives were shallower than 100 m. Because percentage of time spent at the surface was not calculated in Gjertz et al. (2000a), the Lydersen (1991) data were used to estimate this time. The Lydersen (1991) data are from a single female ringed seal over a six day period. If the percentage of time at the surface (30.3 percent) from Lydersen (1991) is used as an estimate, and the percentage of dives taken as a proxy for the percentage of time, then the following representative depth distribution results. The remaining bins of the Gjertz study were redistributed proportionally to account for the remaining 69.7 percent of non-surface time. The resulting depth distribution profile includes data from both studies. The depth distribution for ringed seals is given in Table 2-38.

Table 2-38. Percentage of time at depth for the ringed seal[1].

Depth Bin (m)	% of Time at Depth
0–1	30.3
1–4	9.76
4–8	13.24
8–12	5.23
12–16	3.49
16–20	1.39
20–30	5.58
30–40	4.88
40–50	4.18
50–100	14.64
100–150	5.58
150–200	1.39
200–300	0.35

[1] Based on data from Gjertz et al. (2000a) and Lydersen (1991).

While other studies largely did not include usable depth distributions for ringed seals, they did provide additional information to categorize dive behavior. These dive depths are consistent with Wathne et al. (2000), who found that ringed seals feed on shallower prey than harp seals, which make 35 percent of their dives to deeper than 100 m. Adult ringed seals in the Arctic region were recorded as diving to depths of almost 300 m (Von Duyke et al. 2020), between 100 and 150 m (Crawford et al. 2019), and between 80 and 100 m (Everett et al. 2018). Crawford et al. (2019) found more than 57 percent of dives by adults and juveniles were between 2 and 10 m, and juveniles on rare occasions reached depths between 300 and 350 m. Results from other studies are mostly consistent with the representative dive profile.

2.2.2.3.8 Phoca vitulina, Harbor Seal

Harbor seals are found in shallow inshore and coastal waters of the Northern Hemisphere (Burns 2002). Prey species include epibenthic and benthic fish (e.g., sand lance, flounder, and herring) and squid (Brown and Mate 1983; Olesiuk 1993; Payne and Selzer 1989).

To build a representative depth distribution for harbor seals, data from Table 3 in Womble et al. (2014) and an activity budget from Bowen et al. (1999) were used. Womble et al. (2014) studied the dive behavior of 12 female harbor seals in Alaska. Table 3 shows the percentage of dives to specific depth bins; thus, these data from Womble et al. (2014) will be used as a proxy for percentage of time spent at depth. Seals in this study were found to dive most frequently (81.6 percent) to depths shallower than 50 m. It should be noted that this study cites the percentage of dives to certain depths, as opposed to the percentage of time spent in each depth bin, including time spent in that bin on the way to a deeper bin. However, the Womble et al. (2014) data are the best available estimate of time spent at depth. The activity budget from Bowen et al. (1999) provided a surface time of 85.01 percent. The remaining bins from Womble et al. (2014) were redistributed proportionally to account for the remaining 14.99 percent of non-surface time. The resulting depth distribution profile includes data from both studies. The depth distribution for harbor seals is given in Table 2-39.

Table 2-39. Percentage of time at depth for the harbor seal in the HCTT Study Area[1].

Depth Bin (m)	% of Time at Depth
0-4	85.01
4–50	12.22
50–100	2.32
100–150	0.37
150–200	0.05
200–250	0.02
250–300	0.01

[1] Based on data from Womble et al. (2014) and Bowen et al. (1999).

While other studies did not include usable depth distributions for harbor seals, they did provide additional information to categorize dive behavior. Gjertz et al. (2001) reported the maximum depth reached by harbor seals to be within the 200 to 350 m range; however, additional studies have reported shallower maximum dive depths, reaching less than 100 m off Nova Scotia (Bowen et al. 1999), Svalbard (Heide-Jorgensen et al. 2001), and in Prince William sound (Frost et al. 2001). Hastings et al. (2004) observed that less than six percent of harbor seals dive to depths greater than 100 m, although one seal dove to 508 m (Hastings et al. 2004). Harbor seals near Svalbard, Norway, dove to a maximum depth of 452 m, although 50 percent of dives were shallower than 40 m, and 95 percent were to less than 250 m (Gjertz et al. 2001). Eguchi and Harvey (2005) observed that males dive deeper than females, with males diving to depths shallower than 154 m and females diving to depths shallower than 76 m for 95 percent of the time.

2.2.2.3.9 Seal Guild in the AFTT Study Area

Within the AFTT Study Area, seals are often difficult to distinguish when viewing at sea. Many surveyed species are listed as “unidentified.” Therefore, the density data from these surveys have been combined for the two most abundant species of seals in the AFTT Study Area, gray seals (Section 2.2.2.3.1) and harbor seals (Section 2.2.2.3.8). As a result, the depth distributions for the two species from Table 2-33 and Table 2-39 were averaged together using the source data from Womble et al. (2014), Harvey et al. (2008), Beck et al. (2003), Bowen et al. (1999), and Thompson et al. (1991) to create a representative depth distribution for seals in the AFTT Study Area. While the surface bin for harbor seals (0 to 50 m) was slightly larger than the surface bin for gray seals (0 to 40 m), they were averaged together to create a composite depth distribution for these two species. The resulting representative depth distribution for seals in the AFTT Study Area is given in Table 2-40.

Table 2-40. Percentage of time at depth for seals in the AFTT Study Area[1].

Depth Bin (m)	% of Time at Depth
0–50	89.47
50–100	8.26
100–200	1.86
200–412	0.41

[1] Based on Womble et al. (2014), Harvey et al. (2008), Beck et al. (2003), Bowen et al. (1999), and Thompson et al. (1991).

2.2.3 Sirenians

2.2.3.1 Family Trichechidae

2.2.3.1.1 Trichechus manatus, West Indian Manatee

The West Indian manatee is found in coastal and estuarine waters of the mid-Atlantic United States south through the waters of central Brazil (Aven et al. 2016; Gonzalez-Socoloske et al. 2009; Reynolds III and Powell 2002). Manatees are primarily herbivores, feeding on plants in all parts of the water column (Alves-Stanley et al. 2010; Baugh et al. 1989; Keith-Diagne et al. 2022; Lefebvre et al. 2000). There are occasional reports of manatees feeding on fish and invertebrate prey (Courbis and Worthy 2003; Etheridge et al. 1985; Keith-Diagne et al. 2022; O'Shea et al. 1991). Manatees are limited to shallow water (less than 20 m), due to the light requirements of the vegetation on which they feed (Slone et al. 2022; Wells et al. 1999). Keith-Diagne et al. (2022) reported a maximum dive duration of 24 minutes with most dives being less than five meters in depth. Tagged manatees in the Gulf of Mexico were almost always found in shallow waters within 1,000 m of the shore (Slone et al. 2022).

To build a representative depth distribution for manatees, data from Figure 8 in Nowacek et al. (2002) and Figure 3 in Edwards et al. (2016) were used. Nowacek at al. (2002) reported the percent time at depth for two manatees in a central Belize lagoon. The manatees were located in water that ranged from 1.5 to 10.5 m deep. The average time spent in portions of the water column was 80 percent in less than 3 m and 57 percent in less than 1.5 m of water. The Edwards et al. (2016) study was conducted during winters in Tampa Bay, FL, from 2002 to 2005, using tag data from nine manatees. In the area of the study, the water depth averages 4 m, but reaches a maximum of 27 m. Mean dive depth of these manatees was 1.09 m (SD = 0.17) with a maximum dive depth ranging from 6.0 to 16.2 m. Manatee diving behavior showed a diel pattern, diving deeper during the day and shallower at night (Edwards et al. 2016). The data from Nowacek et al. (2002) and Edwards et al. (2016) were averaged together to create the representative depth distribution for West Indian manatees. The depth distribution for West Indian manatees is given in Table 2-41.

Table 2-41. Percentage of time at depth for the West Indian manatee[1].

Depth Bin (m)	% of Time at Depth
0–1.0	46.46
1.1–2.0	31.38
2.1–3.0	10.83
3.1–4.0	10.83
4.1–16.2	0.50

[1] Based on data from Nowacek et al. (2002) and Edwards et al. (2016).

2.2.4 Sea Turtles

2.2.4.1 Family Cheloniidae

2.2.4.1.1 Caretta caretta, Loggerhead Sea Turtle

Loggerhead turtles are widely distributed in subtropical and temperate waters (Dodd Jr. 1988). The loggerhead turtle occurs worldwide in habitats ranging from coastal estuaries to waters far beyond the continental shelf (Dodd Jr. 1988). The species may be found hundreds of miles out to sea, as well as in inshore areas such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers. Results from tagging data of juvenile loggerheads in both the eastern and western North Atlantic suggest that the location of currents and associated frontal eddies are important to the foraging ecology of the pelagic stage of this species (McClellan et al. 2007). Tagging data revealed that migratory routes may be coastal or may involve crossing deep ocean waters; an oceanic route may be taken even when a coastal route is an option (Schroeder et al. 2003). Their large heads support powerful jaws and enable them to feed on hard-shelled prey, such as whelks and conch (Erhart et al. 2003).

To build a representative depth distribution for loggerhead turtles in the HCTT Study Area, data from Figure 2c in Howell et al. (2010) and the text of Sakamoto et al. (1990) were used. The data recorded in Howell et al. (2010) are an average of data from fourteen adult loggerheads captured incidentally by long- line vessels in the central North Pacific Ocean during 2002 to 2004. The turtles were tracked for a period ranging from 51 to 578 days. Technical limitations of the tags used in the Howell et al. (2010) study did not allow for the precise dive depth to be recorded at depths greater than 150 m. The maximum dive depth in other literature for the loggerhead turtle is 233 m, recorded from a female turtle tagged off the coast of Japan (Sakamoto et al. 1990). This value was used to represent the maximum depth for the representative depth distribution below for loggerhead sea turtles in the HCTT Study Area is shown in Table 2-42.

Table 2-42. Percent of time at depth for the loggerhead turtle in the HCTT Study Area[1].

Depth (m)	% of Time at Depth	Depth (m)	% of Time at Depth
0–1	19.25	30–40	0.25
1 –5	43.75	40–50	0.25
5–10	13.00	50–60	0.25
10–15	9.00	60–80	0.25
15–20	9.00	80–100	0.25
20–25	3.00	100–150	0.25
25–30	1.25	150 – 233	0.25

[1] Based on Howell et al. (2010) and Sakamoto et al. (1990).

To build a representative depth distribution for loggerhead sea turtles in the AFTT Study Area, data from the Gulf of Mexico Marine Assessment Program for Protected Species (GoMMAPPS 2022) was used, as well as a maximum depth from Sakamoto et al. (1990). As part of the GoMMAPPS project, collaborators from the United States Fish and Wildlife Service tagged 133 hardshell turtles at nesting sites in or off the coasts of Alabama, Florida, Mississippi, and Louisiana. All tagged turtles were adults and most tagged animals were female. Fifty-nine of the tagged animals were loggerhead turtles that were tracked migrating and foraging within the AFTT Study Area, particularly in the Gulf of Mexico. Data from Arendt et al. (2009) and Iverson et al. (2019) correlates to the GoMMAPPS (2022) data. The depth distribution for loggerhead sea turtles in the AFTT Study Area is shown in Table 2-43.

Table 2-43. Percentage of time at depth for the loggerhead turtle in the AFTT Study Area[1].

Depth Bin (m)	% of Time at Depth
0–3	19.0
3–5	13.0
5–10	17.0
10–20	20.0
20–30	21.0
30–40	9.0
40–50	0.25
50–100	0.25
100–150	0.25
150–233	0.25

[1] Based on data from GoMMAPPS (2022) and Sakamoto et al. (1990).

While other studies did not include usable depth distributions for loggerhead turtles, they did provide additional information to categorize dive behavior. Most studies found that, on average, loggerhead turtles spend over 90 percent of their time underwater (Byles 1988; Narazaki et al. 2006; Renaud and Carpenter 1994) and remain at depths shallower than 100 m (Hawkes et al. 2006; Houghton et al. 2002; McClellan et al. 2007; Narazaki et al. 2006; Polovina et al. 2003). Routine dive depths are typically shallower than 30 m (Houghton et al. 2003; Iverson et al. 2019; Iverson et al. 2004), although dives of up to 233 m were recorded for a post- nesting female loggerhead off Japan (Sakamoto et al. 1990), and time-depth recorder (TDR)-tagged turtles near Brazil recorded occasional dives in the 200 to 300 m depth bin (Barcelo et al. 2013). Dives can last anywhere from 4 to 120 minutes (Bentivegna et al. 2003; Byles 1989; Dodd and Byles 2003; Renaud and Carpenter 1994; Sakamoto et al. 1990), though approximately 80 percent have a duration of about 2 minutes (Howell et al. 2010). Iverson et al. (2019) tagged 25 adult female nesting loggerhead sea turtles in the Gulf of Mexico. Turtles spent the highest proportion of time between five and 20 m during inter-nesting and migration, and between 20 and 40 m while foraging (Iverson et al. 2019). Higher sea surface temperature was associated with more dives per day, longer dives, and more dives to the seafloor. Higher net primary productivity was also associated with more long dives and dives to the bottom, while lower net primary productivity led to an increased frequency of overall diving (Iverson et al. 2019). Dive data for loggerhead turtles taken during tropical storms within the AFTT Study Area are available from Wilson et al. (2017c) and Crowe et al. (2020), but these studies do not likely represent normal sea turtle dive behavior and were not utilized.

2.2.4.1.2 Chelonia mydas, Green Sea Turtle

The green turtle has a global distribution, occurring throughout tropical and, to a lesser extent, subtropical waters (Marine Turtle Specialist Group 2004) and is generally distributed between 30° N and 30° S. Green turtles are highly migratory and undertake complex movements and migrations through geographically disparate habitats, with the longest migrations occurring between foraging habitats and nesting beaches. Hatchlings swim to offshore areas where they float passively in major current systems. Juveniles leave the pelagic habitat and recruit to protected lagoons and open coastal areas that are rich in seagrass or marine algae (Bresette et al. 2006), the main prey items of green turtles. Green sea turtles will spend the majority of their lives in these coastal areas (Bjorndal and Bolten 1988; National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) 1991). A small number of green sea turtles appear to remain in open ocean habitats for extended periods, perhaps never recruiting to coastal foraging sites (National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) 2007a; Pelletier et al. 2003). The optimal developmental habitats for late juveniles and foraging habitats for adults are warm, shallow waters (3 to 5 m in bottom depth) with abundant submerged aquatic vegetation and in close proximity to nearshore reefs or rocky areas (Ernst et al. 1994).

To build a representative depth distribution for green sea turtles in the HCTT Study Area, data from Figure 13a in Gaos et al. (2020) and a maximum dive depth from Rice and Balazs (2008) were used. Technical limitations of the tag used in the Godley et al. (2002) study did not allow for the precise dive depth to be recorded at depths greater than 45 m. The maximum dive depth in the literature for the green sea turtle is 138 m, recorded from an adult female turtle migrating between nesting grounds on French Frigate Shoals in the Northwest Hawaiian Islands and foraging grounds off Laniakea, Oahu, Hawaii (Rice and Balazs 2008). This value was used to represent the maximum depth for the dive distribution profile. Gaos et al. (2020) tagged 84 adult and juvenile turtles in Guam, Tinian, and Saipan in the Marianas Islands. The turtles' activity was predominantly foraging, but some inter-island movement was captured. The dive data presented do not discriminate between behavioral states. The depth distribution for green sea turtles in the HCTT Study Area is given in Table 2-44.

Table 2-44. Percentage of time at depth for the green sea turtle in the HCTT Study Area[1].

Depth Bin (m)	% of Time at Depth
0–5	59.23
6–10	16.98
11–15	11.68
16–20	6.78
21–25	2.61
26–30	1.39
31–35	0.73
36–40	0.26
41–45	0.06
45–138	0.28

[1] Based on data from Gaos et al. (2020) and Rice and Balazs (2008).

To build a representative depth distribution for green turtles in the AFTT Study Area, unpublished data from GoMMAPPS (2022) and a maximum dive depth from Rice and Balazs (2008) was used. As a part of the GoMMAPPS project, collaborators at the United States Fish and Wildlife Service tagged 133 hardshell turtles at nesting sites in or off the coasts of Alabama, Florida, Mississippi, and Louisiana. All turtles were adults. Most tagged animals were females. Eleven of the tagged animals were green turtles and were tracked both migrating and foraging within the AFTT Study Area, particularly the Gulf of Mexico. Though the number of green turtles tagged were lower than in some available studies, these data were used given their direct applicability to the AFTT Study Area. Green turtles from this study spent more time at shallow depths compared to those reported in Gaos et al. (2020) which may be because the green turtles in the Gulf of Mexico do not need to cross any deep-water areas as part of their migratory routes. The depth distribution for green sea turtles for AFTT is given in Table 2-45.

Table 2-45. Percentage of time at depth for the green sea turtle in the AFTT Study Area[1].

Depth Bin (m)	% of Time at Depth
0–5	59
5–10	23
10–20	16
20–30	1
30–40	0.375
40–50	0.125

Depth Bin (m)	% of Time at Depth
50–60	0.125
60–70	0.125
70–100	0.125
100–138	0.125

[1] Based on data from GoMMAPPS (2022) and Rice and Balazs (2008).

While other studies did not include usable depth distributions for green turtles, they did provide additional information to categorize dive behavior. Blanco et al. (2012) reported that four turtles near Costa Rica spent 46 percent of their time at the surface, and while the majority of their time was in the top 10 m, the deepest dive was to 110 m. Seventy percent of the dives of migrating and foraging turtles near Brazil were to less than 30 m depth (Chambault et al. 2015). Hatase et al. (2006) observed that green turtles dive to a maximum of 80 m in areas of the open ocean (where depths are greater than 200 m), while green turtles migrating between the northwestern and main Hawaiian Islands reached a maximum depth greater than 138 m at night (the deepest dives ever recorded for a green turtle), but only 4 m during the day (Rice and Balazs 2008). In their coastal habitat, green turtles typically make dives shallower than 30 m (Cheng et al. 2013; Godley et al. 2002; Hatase et al. 2006; Hays et al. 2000; Hochscheid et al. 1999) and often not exceeding 17.5 m (Ballorain et al. 2013; Hays et al. 2004; Rice and Balazs 2008). Green turtles are known to both forage and rest at depths of 20 to 50 m (Balazs 1980; Brill et al. 1995). A recent study in Equatorial Guinea (Mettler et al. 2020) found that 81 percent of all dives only reached depths of 15 to 25 m across multiple behavioral types, which aligns with studies from other regions.

2.2.4.1.3 Eretmochelys imbricata, Hawksbill Sea Turtle

The hawksbill is the most tropical of the world’s sea turtles, occurring in all oceans but rarely above or below 30° N and 30° S (Witzell 1983). Hawksbill nesting occurs in at least 70 countries, although much of it is now at only low densities. Juveniles and adults share the same foraging areas, including tropical, nearshore waters associated with coral reefs, hard bottoms, or estuaries with mangroves (Musick and Limpus 1997). Coral reefs are optimal hawksbill habitat for juveniles, subadults, and adults (National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) 1998). Hawksbill sea turtles are also found around rocky outcrops and high-energy shoals—optimum sites for sponge growth, their preferred prey item—as well as mangrove-fringed bays and estuaries where coral reefs are absent (National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) 2007b). While hawksbill sea turtles are known to occasionally migrate large distances, possibly in the open ocean, this is the most coastal of the marine turtles in these study areas. There is very little available information on hawksbills in the pelagic environments of the Atlantic and Pacific Oceans.

To build a representative depth distribution for hawksbill sea turtles, data from Figure 13 in Gaos et al. (2020) were used. Data from nine juvenile and subadult hawksbills captured and tagged off the Marianas Islands were used to generate a time at depth profile. Hawksbill turtles tagged in the study spent most of their time in depths shallower than 25 m, with an average depth of 15.3 m, diving up to a depth of 100 m, which is the deepest recorded depth for this species. The dataset used to derive the depth distribution for hawksbill turtles was from juvenile and subadult turtles. Ideally, data from adult specimens are preferred since dive capacity and habitat use are influenced by body size (Schreer and Kovacs 1997). However, individuals of the same species in the same habitat can vary in body length by a factor of four (Diez and van Dam 2002; McGowan et al. 2008) and in body weight by a factor of 20 (Storch et al. 2005). To date, there have been no studies where a large number of time depth recorders have been deployed on turtles across a wide range of body sizes, enabling investigation of scaling in dive capacity and habitat use (Blumenthal et al. 2009). As a result, the data obtained from studies with juvenile turtles represents the best available data and should be interpreted as generally representative across the entire hawksbill population. The depth distribution for hawksbill sea turtles is given in Table 2-46.

Table 2-46. Percentage of time at depth for the hawksbill sea turtle[1].

Depth Bin (m)	% of Time at Depth
0–2	11.31
3–10	66.25
11–20	11.49
21–30	4.68
31–40	3.59
41–50	2.04
51–91	0.65

[1] Based on data from Gaos et al. (2020).

While other studies did not include usable depth distributions for hawksbill turtles, they did provide additional information to categorize dive behavior. In general, studies have found that hawksbills may have one of the longest routine dive times of all sea turtles. Starbird et al. (1999) reported that inter-nesting females at Buck Island, U.S. Virgin Islands, averaged 56.1-minute dives, longer than those reported in Puerto Rico by Van Dam and Diez (1996). Turtles in Eastern Tropical Pacific spent 89% of their time in waters less than 10 m deep, with the majority of time in the 5- to 10-m depth bin, and dove to a maximum depth of 40 m (Gaos et al. 2012). Resident juvenile hawksbill turtles in Brewers Bay, U.S. Virgin Islands showed diel differences in space-use with long periods of relative inactivity (e.g., resting) during the night and activity (e.g., foraging) during the day (Matley et al. 2020). Changes in water temperature has an effect on the behavioral ecology of hawksbill turtles, with an increase in nocturnal dive duration with decreasing water temperatures during the winter (Storch et al. 2005). Warmer temperatures lead to shorter dive durations and higher rates of movement (Matley et al. 2020).

2.2.4.1.4 Lepidochelys kempii, Kemp's Ridley Sea Turtle

The Kemp's ridley has one of the smallest ranges of all marine turtle species. The distribution of the Kemp's ridley population is most concentrated in the Gulf of Mexico, with year-round occurrence throughout the Gulf and southern Atlantic coasts of Florida, and seasonal occurrence along the Atlantic coast as far north as Nova Scotia, Canada (Lazell Jr. 1980; Morreale et al. 1992), though sightings north of Cape Cod are exceedingly rare. Habitats frequently utilized by

Kemp's ridley turtles in U.S. waters include warm-temperate to subtropical sounds, bays, estuaries, tidal passes, shipping channels, and beachfront waters where their preferred food, the blue crab, is known to exist (Landry and Costa 1999; Lutcavage and Musick 1985; Seney and Musick 2005).

Kemp's ridley sea turtles are small relative to other species of marine turtles and only recently have time-depth recording tags become small enough to successfully tag this species. Older studies have described Kemp's ridley diving behavior generally due to the limited capabilities of the very high-frequency (VHF) radio, sonic, and satellite telemetry equipment used in these studies. General migration and movement data indicate that Kemp's ridley turtles generally utilize waters less than 50 m deep as adults, and even shallower waters as juveniles. Byles and Plotkin (1994) noted that 18 adult females stayed in waters less than 50 m in depth during post-nesting movements in the Gulf of Mexico after nesting in Tamulipas, Mexico. This was supported by Renaud (1995) which reported that juvenile Kemp's ridleys occupy coastal waters of less than 20 m in depth and adults remain in offshore areas with depths shallower than 50 m. Data compiled in Shaver et al. (2005) for 11 adult male in the Gulf of Mexico (Tamulipas, Mexico) showed that the majority of locations were recorded in waters of 37 m or less. Shaver and Rubio (2007) studied 28 adult female Kemp's ridley turtles and noted similar results after nesting in North Padre and Mustang Island, Texas. Lastly, Seney and Landry (2008) found that six adult females spent 80 percent of their time in locations with waters less than 10 m deep after nesting in Galveston, Texas. The submergence time of Kemp's ridley turtles varies seasonally; dives are longest during the winter (greater than 30 minutes), and average around 15 minutes the remainder of the year (Renaud and Williams 2005). Over a 12-hour period, Kemp's ridley turtles spend as long as 96 percent of their time submerged (Byles 1989; Gitschlag 1996; Renaud and Williams 2005; Sasso and Witzell 2006).

A few recent datasets have become available that report time at depth for Kemp's ridleys turtles. Wildermann et al. (2019) tagged four small juvenile turtles captured at sea in the Gulf of Mexico. These animals rarely dove deeper than 3 m, which may reflect their small size rather than their available habitat. As a part of the GoMMAPPS project, collaborators at the USFWS tagged 133 hardshell turtles at nesting sites in or off the coasts of Alabama, Florida, Mississippi, and Louisiana. All turtles were adults. Most tagged animals were females. Sixty-three of the tagged animals were Kemp's ridley turtles and were tracked both migrating and foraging within the AFTT Study Area, particularly in the Gulf of Mexico. This is by far the most comprehensive dataset on Kemp's ridley dive data to date. The depth distribution for Kemp's ridley sea turtles for the AFTT Study Area is shown in Table 2-47 and is based on the GoMMAPPS (2022) data.

Table 2-47. Percentage of time at depth for the Kemp's ridley sea turtle in the AFTT Study Area[1].

Depth Bin (m)	% of Time at Depth
0–5	34
5–10	19
10–20	33
20–30	10
30–40	4

[1] Based on data from GoMMAPPS (2022).

2.2.4.1.5 Lepidochelys olivacea, Olive Ridley Sea Turtle

Olive ridley sea turtles are globally distributed and have a large range in tropical and subtropical regions of the Pacific, Indian, and South Atlantic oceans; they are generally found between 40° N and 40° S. Most olive ridley turtles lead a primarily pelagic existence. The Pacific population migrates throughout the Pacific, from their nesting grounds in Mexico and Central America to the North Pacific (National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) 2007c). The olive ridley is the most abundant sea turtle in the open ocean waters of the eastern tropical Pacific Ocean (Pitman 1990). While olive ridleys are primarily a pelagic species and are known to migrate great distances in the Pacific, there are few pelagic records of this species in the Northwest Atlantic, and little is known about their migration patterns (National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) 2007c). A few reports of olive ridley turtles in the North Atlantic, as far north as the Grand Banks, indicate that the species does traverse the entire Atlantic Ocean, although their occurrence north of the equator is believed to be rare (National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) 2007c). In the AFTT Study Area, potential impacts to olive ridley turtles are assessed qualitatively and no dive table will be used.

To build a representative depth distribution for olive ridley sea turtles, data from the text and Figure 3 in Chambault et al. (2017a), as well as a maximum dive depth from Swimmer et al. (2006) were used. The depth distribution data given in the Chambault study is based on data recorded from 14 satellite tracked adult female olive ridley turtles, which were tagged after nesting in French Guiana. The data found that the tagged olive ridley sea turtles performed 80 to 90 percent of their dives in the upper 10 m of the water column. The maximum dive depth in Chambault et al. (2017a) was 50 m and may be the result of only tagging nesting females. In other literature, a maximum dive depth of 340 m was recorded by an adult female after nesting in Indonesia, away from the nesting beach (Fukuoka et al. 2022). This value was used to represent the maximum depth for the dive distribution profile. The depth distribution for olive ridley sea turtles is given in Table 2-48.

Table 2-48. Percentage of time at depth for the olive ridley sea turtle in the HCTT Study Area[1].

Depth (m)	% of Time at Depth	Depth (m)	% of Time at Depth
0–5	55.0	70–80	1.0
5–10	25.0	80–90	1.0
10–20	7.0	90–100	1.0
20–30	3.0	100–150	0.50
30–40	2.0	150–200	0.50
40–50	1.0	200–250	0.40
50–60	1.0	250–300	0.30
60–70	1.0	300–340	0.30

[1] Based on data from Chambault et al. (2017a) and Fukuoka et al. (2022).

While other studies did not include usable depth distributions for olive ridley sea turtles, they did provide additional information to categorize dive behavior. Olive ridley turtles can dive and feed at considerable depths (80 to 300 m) (Eckert 1995), although only about 5 to 10 percent of their time is spent at depths greater than 100 m (Eckert et al. 1986; Polovina et al. 2003). In the eastern tropical Pacific Ocean, at least 25 percent of their total dive time is spent in the permanent thermocline, located between 20 and 100 m (Parker et al. 2003). Olive ridleys spend considerable time at the surface basking, presumably to speed their metabolism and digestion after a deep dive (Spotila 2004). In the open ocean of the eastern Pacific, olive ridley sea turtles are often seen near flotsam, possibly feeding on associated fish and invertebrates (Pitman 1992). Olive ridleys in the shallow (less than 40 m depth) coastal waters near Oman routinely made use of the entire water column during dives (Rees et al. 2012). The average dive durations for adult females and males are reported to be 54.3 and 28.5 min (Plotkin, as cited in Lutcavage and Lutz (1997). In a separate study by McMahon et al. (2007), olive ridleys exhibited exceptionally long dive durations (greater than two hours), allowing this species to exploit deeper benthic prey.

2.2.4.2 Family Dermochelyidae

2.2.4.2.1 Dermochelys coriacea, Leatherback Sea Turtle

The leatherback sea turtle is globally distributed in tropical, subtropical, and warm-temperate waters throughout the year, and throughout cooler temperate waters during warmer months (James et al. 2005a; National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) 1992). Adult leatherback turtles forage in temperate and subpolar regions in all oceans and migrate to tropical nesting beaches between 30° N and 20° S (Bleakney 1965; Brongersma 1972; Goff and Lien 1988; Threlfall 1978). The leatherback is typically associated with continental shelf habitats and pelagic environments. To a large extent, the oceanic distribution of leatherbacks may reflect the distribution and abundance of their favored prey, macro-planktonic soft-bodied animals such as jellyfish, salps, and pyrosomes (Wallace et al. 2013). It is suggested that leatherbacks make scouting dives while transiting as an efficient means for sampling prey density and perhaps also to feed opportunistically at these times (James et al. 2006b; Jonsen et al. 2007).

To build a representative depth distribution for leatherback turtles, data from Figure 2 as well as the text of Houghton et al. (2008), Figure 7 from Chambault et al. (2017b), and Figure 2.9 from Asada (2020) were used. Houghton et al. (2008) tagged 13 adult leatherback sea turtles—12 from Grenada and one captured off the coast of Ireland over the course of four years. Chambault et al. (2017b) tagged 10 nesting females in French Guiana in 2015. Asada (2020) tagged 10 nesting females in the U.S. Virgin Islands from 2015 to 2018, nine of which transmitted. The data in Houghton et al. (2008), though older, was retained as it documented deeper dives than the two more recent studies. The studies account only for the percentage of dives made to each depth bin, rather than the percent of time spent in each bin. Houghton et al. (2008) found that 99.6 percent of dives were to depths shallower than 300 m with only 0.4 percent extending to greater depths. Houghton et al. (2008) supports the hypothesis that deep dives are periodically employed to survey the water column for diurnally descending gelatinous prey. The depth distribution for leatherback turtles in the AFTT and HCTT Study Areas is provided in Table 2-48. No recent studies from the Pacific Ocean had the required data to generate a dive profile specific to the HCTT Study Area. However, summary data from Okuyama et al. (2021) documented similar depths to the studies from the Atlantic, indicating that using the same depth distribution for both regions is reasonable. Bins less than 300 m in Table 2-49 were generated by a visual examination and combination of bins from Chambault et al. (2017b) and Asada (2020).

Table 2-49. Percentage of time at depth for the leatherback sea turtle[1].

Depth Bin (m)	% of Time at Depth
0–10	13.0086
10–50	8.0
50–100	60.0
100–150	9.0
150–200	7.0
200–250	2.0
250–300	0.5
300–400	0.2
400–500	0.1
500–600	0.07
600–700	0.04
700–800	0.03
800–900	0.03
900–1,000	0.001
1,000–1,100	0.0014
1,100–1,200	0.005
1,200–1,280	0.005

[1] Based on data from Houghton et al. (2008), Chambault et al. (2017b), and Asada (2020).

While other studies did not include usable depth distributions for leatherback sea turtles, they did provide additional information to categorize dive behavior. The leatherback is the deepest diving sea turtle, with a recorded maximum depth of 1,280 m (Doyle et al. 2008), though most dives are much shallower, usually less than 250 m (Hays et al. 2004; Sale et al. 2006). Fossette et al. (2007) reported that 80 percent of the leatherback's time at sea is spent diving, which is in agreement with the roughly 20 percent of time in the surface bin of the representative depth distribution. Dodge et al. (2014) found that over 90 percent of the time was spent in the top 100 m of the water column, and 25 percent of time was spent at the surface. Similarly in the Atlantic, Hays et al. (2004) determined that leatherbacks spent 71 to 94 percent of their diving time at depths from 70 to 110 m. Daytime foraging dives off of the Canadian Atlantic coast during summer ranged between 5.5 and 97 m with a median depth of 21.5 m (Heaslip et al. 2012). Leatherbacks dive deeper and longer in the lower latitudes versus the higher (Dodge et al. 2014; James et al. 2005a; James et al. 2005b), where they are known to dive to waters with temperatures just above freezing (James et al. 2006a; Jonsen et al. 2007). James et al. (2006b) noted that dives in higher latitudes are punctuated by longer surface intervals and much more time at the surface; individuals spend up to 50 percent of their time at or near the surface in northern foraging areas, perhaps in part to thermoregulate (i.e., bask). Increased dive depth with temperature, which is correlated with latitude, was also noted in the Pacific Ocean (Okuyama et al. 2021). While transiting, leatherbacks make longer and deeper dives (Jonsen et al. 2007).

During inter-nesting periods, tag data has revealed that dives are likely constrained by bathymetry adjacent to nesting sites (Hays et al. 2006; Myers and Hays 2006).

2.3 CONCLUSIONS

The recommended static depth distributions are provided for 59 marine animal species occurring within the AFTT and HCTT Study Areas. These distributions, especially those that rely on surrogates, should be updated periodically as new data becomes available. Also, for most species, only a single depth distribution is presented; ideally, each species should have multiple distributions available, depending on the behavior and age/sex class of the animals being modeled, as well as the geographic location and season in which the simulation occurs. More detailed depth distribution data will permit improved realism for the scenarios being modeled.

3. MARINE MAMMAL GROUP SIZE INFORMATION

3.1 INTRODUCTION

Many marine mammals are known to travel and feed in groups. The NAEMO accounts for this behavior by incorporating species-specific group sizes into the modeled animal distributions, and accounting for statistical uncertainty around the group size estimate. The vast majority of group size data were derived from the same survey and observation data that was used to develop the Navy Marine Species Density Database models and was delivered to the Naval Undersea Warfare Center (NUWC) Division Newport in the appropriate format by the density providers. Exceptions to this exist in AFTT for West Indian manatees, ringed seals, harp seals, hooded seals, and bearded seals. Alternative density estimates were used for these species.

Group size data for AFTT and HCTT include mean group size, SD, and a range (the minimum and maximum number of animals reported). If a range of means was given in any particular study, the maximum value was used to represent the mean as a conservative estimate of animals present. Minimum and maximum group sizes were also determined for each species. The standard deviations are incorporated in NAEMO by randomly and repetitively selecting a value from the Poisson or lognormal distribution defined by the mean group size and standard deviation provided. For HCTT survey data, the Southwest Fisheries Science Center specified which species' group size followed a Poisson distribution and which followed a log-normal.

3.2 ATLANTIC FLEET TRAINING AND TESTING STUDY AREA GROUP SIZES

Group size data for the AFTT Study Area are presented in Table 3-1. This may be provided by species or guild, depending on the density data available. For those species for which only alternative density estimates were available, a constant distribution of "1" was used.

Table 3-1. Mean group size, standard deviation, and ranges for marine mammals in the AFTT Study Area.

Species	*Mean Group Size*	*Standard Deviation*	*Range*	*Distribution Used*
Atlantic spotted dolphin	23.34	29.64	1–329.5	Log-normal
Atlantic white-sided dolphin	15.72	27.27	1–500	Log-normal
Beaked whales	2.43	1.65	1–22	Log-normal
Bearded seal	1	0.05	1–1	Constant
Blackfish guild	43.73	73.26	1–400	Log-normal
Blainville's beaked whale	2.43	1.65	1–22	Log-normal
Blue whale	1.03	0.18	1–2	Log-normal
Bottlenose dolphin	10.54	16.89	1–374	Log-normal
Bryde's whale	1.77	1.45	1–7.25	Log-normal
Clymene dolphin	92.45	119.39	2–1,000	Log-normal
Cuvier's beaked whale	2.42	1.58	1–10	Log-normal
Dwarf and pygmy sperm whales	1.79	1.26	1–11.5	Log-normal
Dwarf sperm whale	1.79	1.26	1–11.5	Log-normal
False killer whale	16.5	17.88	1–70	Log-normal
Fin whale	1.46	1.14	1–18	Log-normal
Fraser's dolphin	53.79	64.82	3–250	Log-normal
Gervais' beaked whale	2.43	1.65	1–22	Log-normal
Gray seal	2.05	8.46	1–150	Log-normal
Green sea turtle	1.08	0.683	1–16	Log-normal
Harbor porpoise	2.39	4.65	1–200	Log-normal
Harbor seal	2.05	8.46	1–150	Log-normal
Harp seal	1	0.05	1–1	Constant
Hooded seal	1	0.05	1–1	Constant
Humpback whale	1.92	2.73	1–63	Log-normal
Kemps ridley sea turtle	1.21	0.832	1–11	Log-normal
Killer whale	3.75	2.67	1–10	Log-normal
Leatherback sea turtle	1.06	0.439	1–14	Log-normal
Loggerhead sea turtle	1.31	1.17	1–34	Log-normal
Long-finned pilot whale	12.33	19.21	1–500	Log-normal
Melon-headed whale	122.92	97.97	16–400	Log-normal
Mesoplodont beaked whales	2.69	1.65	1–14	Log-normal
Minke whale	1.13	0.59	1–12	Log-normal
North Atlantic right whale	3.06	3.79	1–80	Log-normal
Northern bottlenose whale	3.17	2.65	1–10	Log-normal
Pantropical spotted dolphin	60.06	58.66	1–650	Log–normal
Pilot whales	12.33	19.21	1–500	Log-normal
Pygmy killer whale	9.75	6.67	1–30	Log-normal
Pygmy sperm whale	1.79	1.26	1–11.5	Log-normal
Rice's whale	2.45	2.09	1–11	Log-normal
Ringed seal	1	0.05	1–1	Constant
Risso's dolphin	9.46	11.94	1–150	Log-normal

Species	Mean Group Size	Standard Deviation	Range	Distribution Used
Rough-toothed dolphin	19.23	15.88	2–99	Log-normal
Seals	2.05	8.46	1–150	Log-normal
Sei whale	2.46	4.13	1–79	Log–normal
Short-finned pilot whale	12.33	19.21	1–500	Log-normal
Short-beaked common dolphin	30.52	109.62	1–3,500	Log-normal
Sowerby's beaked whale	2.43	1.65	1–22	Log-normal
Sperm whale	1.91	1.9	1–37	Log-normal
Spinner dolphin	135.84	158.46	6–800	Log-normal
Striped dolphin	53.6	55.98	1–500	Log-normal
True's beaked whale	2.43	1.65	1–22	Log-normal
Unidentified beaked whales	2.13	2.19	1–22	Log-normal
West Indian manatee	1	0.05	1–1	Constant
White-beaked dolphin	3.98	3.82	1–25	Log-normal

3.3 HAWAII AND CALIFORNIA TRAINING AND TESTING STUDY AREA GROUP SIZES

Group size data for the HCTT Study Area are presented in Table 3-2 for the California portion of the Study Area and in Table 3-3 for the Hawaii Range Complex. This data may be provided by species or guild, depending on the density data available.

Table 3-2. Mean group size, standard deviation, and range for marine mammals in the California portion of the HCTT Study Area.

Species	Mean Group Size	Standard Deviation	Range	Distribution Used
Baird's beaked whale	7.36	0.9568	1–27	Log-normal
Blue whale	1.66	0.0498	1–8.6	Poisson
Bottlenose dolphin (CA OR WA Offshore)	14.67	1.7604	1.4–76.5	Log-normal
Bottlenose dolphin (California Coastal)	13	0.91	1–99	Log-normal
Bryde's whale	1.66	0.0498	1–8.6	Poisson
California sea lion	2.141	5.647958	1–88	Log-normal
Cuvier's beaked whale	1.99	0.1194	1–5	Poisson
Dall's porpoise	3.74	0.1122	1–32	Poisson
False killer whale	5.576	0.792	1–26.07	Log-normal
Fin whale	2.01	0.0804	1–29.5	Poisson
Gray whale	1.75	0.00525	1–9	Poisson
Green sea turtle	1	0	1–1	Constant
Guadalupe fur seal	1.167	0.372273	1–2	Poisson
Harbor porpoise	2.16	0.1512	1–11	Poisson
Harbor seal	1	0	1–1	Poisson

Species	*Mean Group Size*	*Standard Deviation*	*Range*	*Distribution Used*
Humpback whale	1.7	0.034	1–14	Poisson
Killer whale	7.06	0.9884	1–47.7	Log-normal
Kogia spp.	1.38	0.2346	1–2	Poisson
Leatherback sea turtle	1	0	1–1	Constant
Loggerhead sea turtle	1	0	1–1	Constant
Long-beaked common dolphin	282.98	28.298	1–2,150	Log-normal
Minke whale	1.13	0.0565	1–3	Poisson
Northern elephant seal	1.011	0.104133	1–2	Poisson
Northern fur seal	1.352	1.120808	1–12	Poisson
Northern right whale dolphin	45.31	8.6089	1.4–855.5	Log-normal
Pacific white-sided dolphin	54.18	8.6688	1–1,870	Log-normal
Pantropical spotted dolphin	71.904	9.851	4.3–312.4	Log-normal
Pygmy killer whale	14.6	5.84	10.8–18.4	Log-normal
Risso's dolphin	18.49	1.4792	1–150	Log-normal
Sea otter	1.167	0.372273	1–2	Poisson
Sei whale	1.7	0.255	1–5	Poisson
Short-beaked common dolphin	154.68	7.734	1–1,910	Log-normal
Short-finned pilot whale	26.38	5.8036	10–61.7	Log-normal
Small beaked whale guild	2.05	0.1025	1–5	Poisson
Sperm whale	7.68	1.2288	1–109.2	Log-normal
Steller sea lion	1.442	0.870968	1–4	Poisson
Striped dolphin	37.7	4.147	1–271.7	Log-normal

Table 3-3. Mean group size, standard deviation, and range for marine mammals in the Hawaii Range complex.

Species	*Mean Group Size*	*Standard Deviation*	*Range*	*Distribution Used*
Blainville's beaked whale	1.7	1.02	1–2.3	Poisson
Blue whale	2.8	0.14	2.8–2.8	Poisson
Bottlenose dolphin	22.297	4.192	1–111.5	Log-normal
Bryde's whale	1.512	0.094	1–2.7	Poisson
Cuvier's beaked whale	2.2	1.76	1–5.1	Poisson
Dwarf sperm whale	2.7	0.81	2.3–3.5	Poisson
False killer whale	5.576	0.792	1–26.07	Log-normal
False killer whale (Hawaii Pelagic)	5.576	0.792	1–26.07	Log-normal
False killer whale (MHI Insular)	19	8.778	1.7–52	Log-normal
False killer whale (NWHI)	19	8.778	1.7–52	Log-normal
Fin whale	2.3	0.115	2.3–2.3	Poisson

Species	***Mean Group Size***	***Standard Deviation***	***Range***	***Distribution Used***
Fraser’s dolphin	359.6	107.88	291.9–427.3	Log–normal
Green sea turtle	1	0.05	1–1	Constant
Hawaiian monk seal	1	0	1–1	Constant
Hawksbill sea turtle	1	0.05	1–1	Constant
Humpback whale	2.597	0.371	1–65.8	Poisson
Killer whale	4.9	0.245	4.9–4.9	Log-normal
Leatherback sea turtle	1	0.05	1–1	Constant
Loggerhead sea turtle	1	0.05	1–1	Constant
Longman’s beaked whale	15	6	6.8–22.6	Log-normal
Melon-headed whale	187.9	93.95	86.4–246.2	Log-normal
Minke whale	1	0.05	1–1	Poisson
Olive ridley sea turtle	1	0.05	1–1	Constant
Pantropical spotted dolphin	54.625	19.72	4.7–97.8	Log-normal
Pantropical spotted dolphin (4 Islands)	54.625	19.72	4.7–97.8	Log-normal
Pantropical spotted dolphin (Hawaii Island)	75.429	14.86	2.3–426.3	Log-normal
Pantropical spotted dolphin (Hawaii Pelagic)	71.904	9.851	4.3–312.4	Log-normal
Pantropical spotted dolphin (Oahu)	87.267	7.156	79.4–101.4	Log-normal
Pygmy killer whale	14.6	5.84	10.8–18.4	Log-normal
Pygmy sperm whale	1.4	0.7	1–2.3	Poisson
Risso’s dolphin	21.357	2.563	2.2–60.4	Log-normal
Rough-toothed dolphin	23.622	2.362	3–80.8	Log-normal
Sei whale	3.1	3.1	1–5.1	Poisson
Short-finned pilot whale	27.962	2.234	2.3–178.3	Log-normal
Sperm whale	9.504	0.913	1–41	Log-normal
Spinner dolphin	47.7	47.7	9.3–125.8	Log-normal
Striped dolphin	44.176	4.285	1–219.9	Log-normal

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