VINEYARD MID-ATLANTIC

CONSTRUCTION AND OPERATIONS PLAN

VOLUME II APPENDIX

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VINEYARD MID-ATLANTIC

VINEYARD OFFSHORE

PUBLIC VERSION

Vineyard Mid-Atlantic COP

Appendix II-N Zooplankton and Ichthyoplankton Entrainment Assessment

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Revision	Date	Description
0	January 2024	Initial submission.
0	January 2025	Resubmitted without revisions.

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List of Acronyms

BOEM	Bureau of Ocean Energy Management
cm	centimeter
C	Celsius
COP	Construction and Operations Plan
CWA	Clean Water Act
CWIS	cooling water intake structure
DIF	design intake flow
EcoMon	Ecosystem Monitoring
EFH	Essential Fish Habitat
EPRI	Electric Power Research Institute
ESP	Electrical Service Platform
F	Fahrenheit
ft	feet
ft/s	feet per second
gal	gallon
gal/day	gallon per day
gal/hr	gallon per hour
HAPC	Habitat Areas of Concern
HVAC	high voltage alternating current
HVDC	high voltage direct current
in	inch
km	kilometer
m	meter
m/s	meter per second
m^3	cubic meter
m^3/hr	cubic meter per hour
m^3/day	cubic meter per day
MAFMC	Mid-Atlantic Fishery Management Council
mi	mile
mm	millimeter
MW	megawatt
NEFMC	New England Fishery Management Council
NEFSC	Northeast Fisheries Science Center
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
OECC	Offshore Export Cable Corridor
spp	species

List of Acronyms (Continued)

SWLP	seawater lift pump
TSV	through screen velocity
WTG	wind turbine generator

1 Introduction

1.1 Vineyard-Mid-Atlantic Overview

Vineyard Mid-Atlantic LLC (the "Proponent") proposes to develop, construct, and operate offshore renewable wind energy facilities in Bureau of Ocean Energy Management (BOEM) Lease Area OCS-A 0544 (the "Lease Area") along with associated offshore and onshore transmission systems. This proposed development is referred to as "Vineyard Mid-Atlantic." Vineyard Mid-Atlantic includes wind turbine generator (WTG) and electrical service platform (ESP) positions within the Lease Area. One or two positions will be occupied by ESPs and the remaining positions will be occupied by WTGs. Offshore export cables installed within an Offshore Export Cable Corridor (OECC) will transmit power from the renewable wind energy facilities to onshore transmission systems on Long Island, New York. At its closest point, the 174 square kilometer (km^2) (43,056 acre) Lease Area is approximately 38 km (24 miles [mi]) south of Fire Island, New York.

1.2 Background and Objectives

Given that several potential buildout scenarios for the Lease Area are under consideration (see Section 3.1 of COP Volume I) and the total power that will be delivered from the Lease Area to shore has not yet been determined, the Proponent is retaining the option to use HVAC and/or HVDC offshore export cables. As discussed in Section 2.6 of COP Volume I, the decision of whether to use HVAC or high voltage direct current (HVDC) transmission technology to deliver power from the offshore renewable wind energy facilities to shore is driven by the rated capacity of the facilities, the distance to the POI, supply chain constraints, and the requirements of New York State's offshore wind solicitations, and the potential for shared offshore transmission facilities, among other considerations.

The electrical equipment in the ESP topside(s) require cooling. High voltage alternating current (HVAC) equipment can be air cooled, whereas high voltage direct current (HVDC) equipment requires water cooling. For HVDC ESP(s), the Proponent anticipates that seawater will be withdrawn through pipes that are attached to the foundation and pumped to heat exchangers located in the topside. Before entering the heat exchangers, the seawater will likely be passed through filters. After leaving the heat exchangers, the warmed seawater will be discharged below the water's surface through pipes that are attached to the foundation. Alternatively, HVDC ESP(s) could potentially use closed loop water cooling (where no water is withdrawn from or discharged to the sea) if such technology becomes technically and commercially feasible.[1]

[1] Although this technology is not currently available in the offshore wind market (BOEM 2022), the Proponent is aware of a number of firms that are working to develop and test closed loop cooling systems for use in offshore wind HVDC ESPs.

If HVDC ESPs are used, the ESPs to be installed for Vineyard Mid-Atlantic will include a cooling water intake structure (CWIS) which takes in seawater to cool the ESP system. The CWIS for Vineyard Mid-Atlantic has a maximum design intake (DIF) of 47,200 cubic meters per day (m^3/day) (12,500,000 gallons per day [gal/day]). This entrainment of water is assumed to result in a 100% mortality rate of zooplankton, including ichthyoplankton (i.e., egg and larval fishes). The CWIS for the Vineyard Mid-Atlantic ESPs are subject to National Pollutant Discharge Elimination System (NPDES) regulations under the Clean Water Act (CWA) because they fit the description of a new facility that is considered a point source, as described in 40 CFR §125.81. Vineyard Mid-Atlantic is therefore subject to Section 316(b) requirements because it will have a DIF greater than 7,571 m^3/day (2,000,000 gal/day) and will use at least 25 percent of the total water withdrawn for cooling purposes.

The objectives of this assessment are to quantify the potential effects to marine organisms as a result of CWIS operation in the Lease Area. This will help determine if the location, design, construction, and capacity of the ESP reflects the best technology available (BTA) to minimize harmful impacts on the environment, as required in Section 316(b) of the CWA defined at §122.21(r)(4). The assessment quantifies the densities of ichthyoplankton and zooplankton taxa present within 25 kilometers [km] (15.5 mi) of the Lease Area (this area is referred to as the "Study Area", see Figure 1.2-1) by examining publicly-available Ecosystem Monitoring (EcoMon) plankton sampling data that are collected by the National Oceanic and Atmospheric Administration (NOAA). These densities and the quantity of water used by the CWIS are used to estimate losses (i.e., total mortality) from entrainment of both non-fish zooplankton and ichthyoplankton. These estimated losses are compared to other similar sources of entrainment as well as early-life stage mortality that is predicted without anthropogenic sources of entrainment.

Figure 1.2-1 Study Area for Vineyard Mid-Atlantic Entrainment Analysis

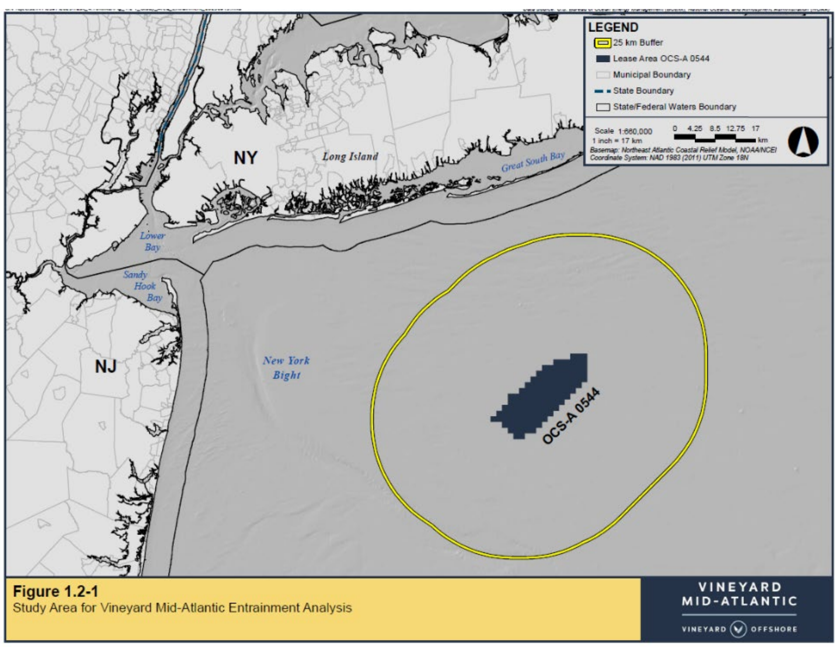


Figure 1.2-1
Study Area for Vineyard Mid-Atlantic Entrainment Analysis

2 CWIS Operation

The CWIS takes in water through three pipes that are located in the mid to upper portion of the water column, with water depths in the Lease Area ranging from approximately 38.6 to 47.1 meters (m) (127 to 155 feet [ft]). Each intake pipe is approximately 2.2 m (7.2 ft) in diameter, and therefore has a surface area of 3.8 square meters (m^2) (40.9 square feet [ft^2]) through which it draws in water. Under normal conditions, only two pipes will be used simultaneously at any given time and the third intake pipe would be used for redundancy and back-up purposes. In order to prevent large objects from entering the intake pipes, steel bars or a mesh screen will be fitted across the opening of each pipe.

Each of the intake pipes have one seawater lift pump (SWLP) that, when running at a maximum operating capacity of 82%, pulls in water at a maximum design capacity of 984 cubic meters per hour (m^3/hr) (259,943 gallons per hour [gal/hr]) or 23,616 m^3/day (6.2 million gal/day). This results in a maximum through screen velocity (TSV) of 0.15 meters per second (m/s) (0.49 feet per second [ft/s]) per pump.

This study conservatively uses the maximum expected flow rate of two pumps operating at 82% capacity for 24 hours per day, 365 days per year. It is important to note that this is very conservative as the amount of cooling water used will vary with the amount of electricity being produced by the wind farm, and with seasonal variations in water temperature. Therefore, standard operating procedure for the SWLPs are expected to be less on a daily average. This analysis may be updated at a later date with a more realistic range of expected flow rates as that technical information becomes available. However, the conservative assumptions used in this analysis result in a total intake for two pumps of 1,968 m^3/hr (519,900 gal/hr) or 47,200 cubic meters per day (m^3/day) (12,500,000 gallons per day [gal/day]). Flow rate is assumed to be the same throughout the year and throughout each season, though in actuality the flow rate will be lower at times.

3 Species of Concern

Essential Fish Habitat (EFH) designations in the Lease Area correspond to the currently accepted designations by the New England Fishery Management Council (NEFMC), Mid-Atlantic Fishery Management Council (MAFMC), and NOAA Highly Migratory Species Division. The species list provided in Table 3.0-1 was retrieved from NOAA's online EFH mapper tool[2] in August 2023.

Table 3.0-1 Species with Designated EFH in the Study Area

Species Common Name (Scientific Name)	Life Stage			
	Egg	Larvae	Juvenile	Adult
Northeast Multispecies Fishery Management Plan (Northeast Fisheries Science Center [NEFSC])				
Atlantic cod (*Gadus morhua*)	X	X		X
Haddock (*Melaongrammus aeglefinus*)		X	X	
Ocean pout (*Zoarces americanus*)	X		X	X
Pollock (*Pollachius virens*)	X	X		
Red hake (*Urophycis chuss*)	X	X	X	X
Silver hake (*Merluccius bilinearis*)	X	X	X	X
Windowpane flounder (*Scophthalmus aquosus*)	X	X	X	X
Winter flounder (*Pseudopleuronectes americanus*)		X	X	X
Witch flounder (*Glyptocephalus cynglossus*)	X	X	X	X
Yellowtail flounder (*Limanda ferruginea*)	X	X	X	X
Monkfish Fishery Management Plan (NEFSC)				
Monkfish (*Lophius americanus*)	X	X	X	X
Skate Fishery Management Plan (NEFSC)				
Little skate (*Leucoraja erinacea*)			X	
Winter skate (*Leucoraja oceallata*)			X	X
Atlantic Herring Fishery Management Plan (NEFSC)				
Atlantic herring (*Clupea harengus*)		X	X	X
Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan (MAFMC)				
Atlantic butterfish (*Peprilus triacanthus*)		X	X	X
Atlantic mackerel (*Scomber scombrus*)	X	X	X	X
Spiny Dogfish Management Plan (MAFMC)				
Spiny dogfish (*Squalus acanthias*)			X	X

2 Source: EFH Mapper (noaa.gov)

Table 3.0-1 Species with Designated EFH in the Study Area (Continued)

Species Common Name (Scientific Name)	Life Stage			
	Egg	Larvae	Juvenile	Adult
Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan (MAFMC)				
Scup (*Stenotomus chrysops*)			X	X
Summer flounder (*Paralichthys dentatus*)	X	X		X
Bluefish Fishery Management Plan (MAFMC)				
Bluefish (*Pomatomus saltatrix*)		X		X
Atlantic Surfclam and Ocean Quahog Fishery Management Plan (MAFMC)				
Ocean quahog (*Arctica islandica*)			X	X
Consolidated Atlantic Highly Migratory Species Fishery Management Plan (NOAA Highly Migratory Species Division)				
Atlantic albacore tuna (*Thunnus alalunga*)			X	
Atlantic bluefin tuna (*Thunnus thynnus*)			X	
Atlantic skipjack tuna (*Katsuwonus pelamis*)			X	X
Atlantic yellowfin tuna (*Thunnus albacares*)			X	
Blue shark (*Prionace glauca*)[1]		X	X	X
Common thresher shark (*Alopias vulpinus*)[1]	X	X	X	X
Dusky shark (*Carcharhinus obscurus*)[1]		X	X	X
Sandbar shark (*Carcharhinus plumbeus*)[1]		X	X	X
Shortfin mako shark (*Isurus oxyrinchus*)[1]	X	X	X	X
Tiger shark (*Galeocerdo cuvier*)			X	X
White shark (*Carcharodon carcharias*)[1]		X	X	X
Habitat Areas of Concern [HAPC] (Summer Flounder and Inshore Juvenile Atlantic Cod)				
Summer flounder HAPC[2]				
Juvenile inshore Atlantic cod HAPC[2]				

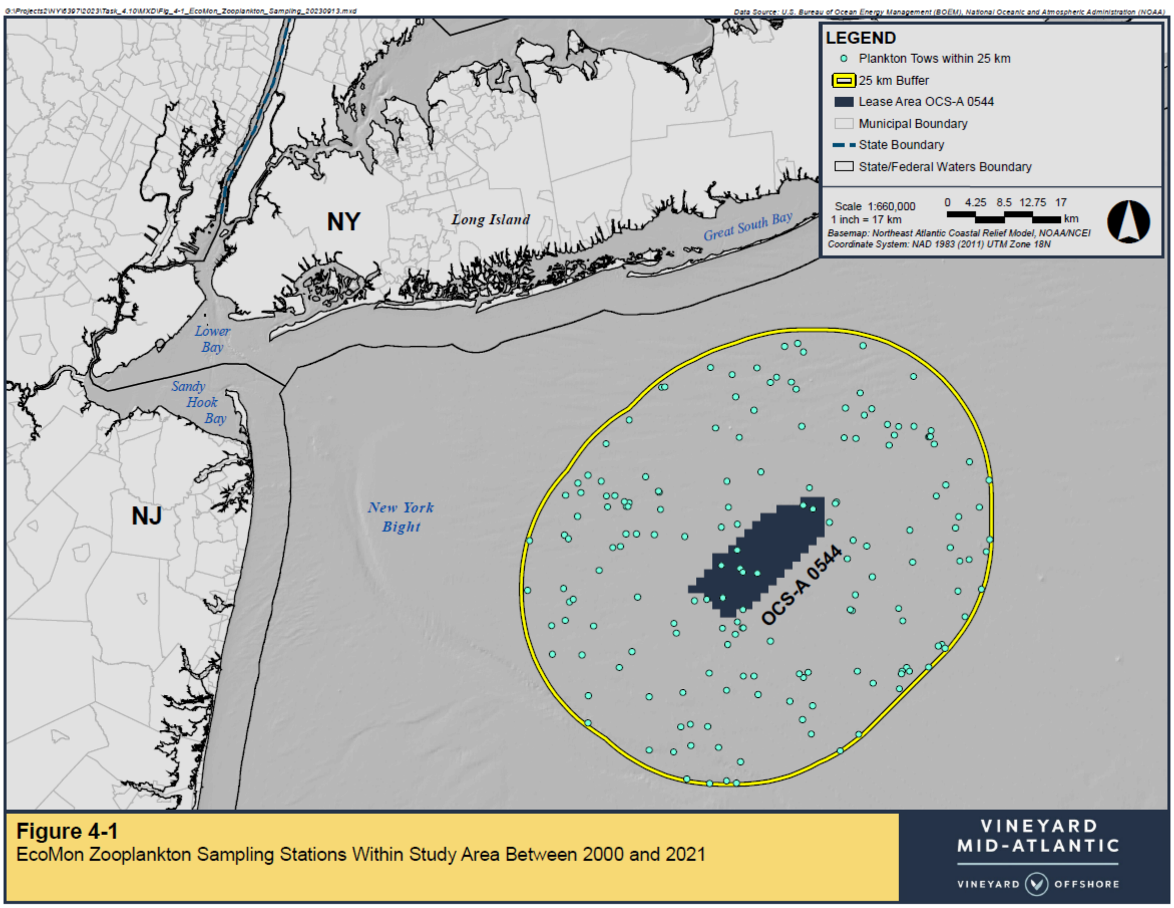
Notes:
1. For these species, the term 'larvae' refers to neonates.
2. For these species, no HAPC were shown overlapping with the Study Area.

The intake pipe will be covered by steel bars or a metal grate, as described in Section 2.1. Therefore, it is expected that juveniles and adults of the species listed in Table 3.0-1 will be excluded from the intake pipe, and that only eggs and larvae (excluding shark neonates) will be susceptible to entrainment by the CWIS system. Table 3.0-1 includes a total of 22 fish species with egg or larval life stages susceptible to entrainment present in the Lease Area.

4 Plankton Data

To evaluate the entrainment of plankton caused by CWIS operation, species abundance data were obtained from the NOAA Ecosystem Monitoring program from January 2000 to September 2021 (NEFSC 2023). The EcoMon data includes plankton tows conducted using a 60 centimeter [cm] (24 inches [in]) bongo plankton net with either 0.333 millimeter [mm] (0.013 in) or 0.505 mm (0.020 in) mesh. For this analysis, only plankton tows that were conducted within the Study Area (25 km [15.5 mi] of the Lease Area) were examined, as indicated in Figure 4.0-1. Applying a buffer to the Lease Area results in a dataset representative of plankton data that could be easily transported to within the Lease Area by oceanographic processes.

Figure 4.0-1 EcoMon Zooplankton Sampling Stations Within Study Area Between 2000 and 2021



Due to variations in abundance of each plankton species throughout the year, the EcoMon data were examined by season, defined as winter: December through February, spring: March through May, summer: June through August, and fall: September through November. This breakdown provides more insight into seasonal trends of plankton throughout the year, rather than simply averaging the whole year, and resulted in 24 winter tows, 61 spring tows, 32 summer tows, and 55 fall tows within the Study Area.

4.1 Ichthyoplankton

The EcoMon dataset contained plankton density data for 14 of the 22 fish species defined in Table 3.0-1 as having egg and larval life stages that are susceptible to entrainment present in the vicinity of the CWIS operations. Additionally, the dataset contained Atlantic herring larvae, even though the EFH analysis did not list this species as having egg or larval life stages present in Lease Area. Since ichthyoplankton eggs are not recorded in the EcoMon database, the data provided in Table 4.1-1 represents ichthyoplankton larvae. Approximations of the number of eggs entrained can be made for species with eggs in the Lease Area by multiplying larvae entrainment by 10. This assumption is based on a 10% survival rate from eggs to the larval stage (Dahlberg 1979; Pepin 1991).

Table 4.1-1 Ichthyoplankton in the Study Area: Estimated Mean Larval Density as Number per 100 cubic meters [m^3] (26,417 gallons [gal]) by Season

Species Common Name (Scientific Name)	Winter	Spring	Summer	Fall	Total by Species
Atlantic cod (*Gadus morhua*)	0	0.04	0	0	0.04
Haddock (*Melaongrammus aeglefinus*)	0	0.07	0.13	0	0.2
Pollock (*Pollachius virens*)	0	0.05	0	0	0.05
Red hake (*Urophycis* species [spp.])	0	0.01	18.97	53.25	72.23
Silver hake (*Merluccius bilinearis*)	0	0.09	2.48	2.50	5.07
Windowpane flounder (*Scophthalmus aquosus*)	0	0.23	0.03	3.92	4.18
Winter flounder (*Pseudopleuronectes americanus*)	0	0.10	0.02	0	0.12
Witch flounder (*Glyptocephalus cynglossus*)	0	0.45	0.67	0	1.12
Yellowtail flounder (*Limanda ferruginea*)	0	7.55	37.29	0	44.84
Monkfish (*Lophius americanus*)	0	0	0.25	0.08	0.33
Atlantic herring (*Clupea harengus*)	0	0	0.03	3.45	3.48
Atlantic butterfish (*Peprilus triacanthus*)	0	0	5.81	1.70	7.51
Atlantic mackerel (*Scomber scombrus*)	0	23.02	0.22	0	23.24
Summer flounder (*Paralichthys dentatus*)	0.04	0	0	30.30	30.34
Bluefish (*Pomatomus saltatrix*)	0	0	3.74	0.12	3.86
Total	**0.04**	**31.61**	**69.64**	**95.32**	**196.61**

4.2 Zooplankton

The EcoMon database also contained plankton tow data for 51 species that were found in the Lease Area (Table 4.2-1). This includes *Calanus finmarchicus,* a planktonic copepod that is an important prey species for many animals, including the North Atlantic right whale (*Eubalaena glacialis*).

Table 4.2-1 Zooplankton in the Study Area: Average Density as Number per 100m³ (26,417 gal) by Season

Scientific Name	Winter	Spring	Summer	Fall	Total by Species
Centropages typicus	78,352	106,577	39,707	22,502	247,138
Calanus finmarchicus	1,947	14,263	22,070	2,736	41,016
Pseudocalanus spp.	2,313	45,249	13,091	170	60,823
Penilia spp.	0	0	72,378	115,651	188,029
Temora longicornis	1,167	51,074	7,042	168	59,451
Centropages hamatus	5,917	1,859	1,245	7	9,028
Echinodermata	18	358	57,554	421,089	479,019
Appendicularians	1,120	5,791	5,574	11,828	24,313
Paracalanus parvus	23,189	8,867	1,984	5,809	39,849
Gastropoda	19,266	56,370	19,058	1,948	96,642
Acartia spp.	88	212	8,952	13,054	22,306
Metridia lucens	2,486	3,158	302	121	6,067
Evadne spp.	23	4,012	4,927	8,564	17,526
Salpa	0	0	23,000	10,504	33,504
Oithona spp.	1,568	4,316	4,963	3,080	13,927
Cirripedia	116	699	136	5	956
Chaetognatha	4,162	3,701	6,251	7,335	21,449
Hyperiidea	2,308	604	6,576	3,301	12,789
Gammaridea	17	53	10	44	124
Calanus minor	245	28	1,182	6,931	8,386
Copepoda	9	0	5	153	167
Clausocalanus arcuicornis	909	1,051	87	396	2,443
Decapoda	53	666	520	953	2,192
Euphausiacea	43	97	241	488	869
Protozoa	51	32	13	178	274
Acartia longiremis	21	450	1,064	49	1,584
Eucalanus spp.	0	0	0	1,950	1,950
Pelecypoda	95	126	545	303	1,069
Polychaeta	55	222	30	472	779

Table 4.2-1 Zooplankton in the Study Area: Average Density as Number per 100m^3 (26,417 gal) by Season (Continued)

Scientific Name	Winter	Spring	Summer	Fall	Total by Species
Podon spp.	0	118	228	1,137	1,483
Pisces	4	59	354	574	991
Bryozoa	32	65	86	299	482
Clausocalanus furcatus	0	4	212	1,546	1,762
Calanus spp.	0	0	0	21	21
Oncaea spp.	402	28	14	4,510	4,954
Corycaeidae	6	20	12	1,407	1,445
Ostracoda	0	2	0	177	179
Temora stylifera	0	0	18	1,323	1,341
Mysidacea	55	7	0	362	424
Temora spp.	9	6	14	110	139
Tortanus discaudatus	0	232	231	-	463
Paracalanus spp.	0	22	138	59	219
Siphonophores	10	65	4,793	1,783	6,651
Coelenterates	0	1,312	350	1,343	3,005
Ctenophores	0	0	398	0	398
Meganyctiphanes norvegica	0	0	57	0	57
Thysanoessa raschii	0	0	94	0	94
Thysanoessa gregaria	0	0	0	5	5
Thecosomata	2,170	34,369	18,783	559	55,881
Spiratella spp.	17,076	21,922	50	43	39,091
Creseis spp.	0	0	0	24	24
Total	**165,302**	**368,066**	**324,339**	**655,071**	**1,512,778**

5 Entrainment Analysis

5.1 Methods

The number of plankton entrained per day and per season was calculated by multiplying the average number of plankton found in the water by the volume of water used per CWIS. Average plankton counts are presented in Tables 4.1-1 and 4.1-2. The daily water withdrawal volume used for these calculations was the conservative maximum expected flow rate of two pumps operating at 82% capacity for 24 hours per day, 365 days per year, which totals 47,200 m^3/day (12,500,000 gal/day), as defined in Section 2.2. The seasonal average density (# per 100 m^3) of each type of plankton presented in Tables 4.1-1 and 4.1-2 were multiplied by 25% of the total yearly intake volume to estimate the total number of entrained organisms in each of the four seasons. Mortality for all entrained plankton was conservatively assumed to be 100%.

$$\text{Number entrained daily} = \frac{X \text{ larvae}}{100\text{m}^3} \times \frac{100\text{m}^3}{26{,}417 \text{ gal}} \times \frac{12{,}500{,}000 \text{ gal}}{\text{day}} = \frac{Y \text{ larvae}}{\text{day}}$$

$$\text{Number entrained seasonally} = \frac{Y \text{ larvae}}{\text{day}} \times \frac{365 \text{ days}}{\text{year}} \times 0.25 = \frac{Z \text{ larvae}}{\text{season}}$$

5.2 Results

5.2.1 Ichthyoplankton Entrainment Losses

Ichthyoplankton were not present in the winter season, with the exception of one tow that contained summer flounder larvae. Many ichthyoplankton species show a distinct seasonal peak in larvae abundance, such as Atlantic mackerel peaking in the spring, yellowtail flounder peaking in the summer, and red hake peaking in the fall. Estimated daily entrainment losses of ichthyoplankton species ranged from 0 to approximately 22,400 individuals per day, with the greatest losses expected for red hake in fall. Seasonal estimated ichthyoplankton losses of EFH species from CWIS entrainment ranged from 0 to about 4.1 million larvae with the greatest losses expected for red hake in fall. Seasonal estimated losses are presented in Table 5.2-1. In total, 8.7 million ichthyoplankton larvae of EFH species are expected to be entrained over the course of one year.

Table 5.2-1 Estimated Number of Larval Fish Entrained by Season

Species Common Name (Scientific Name)	Winter	Spring	Summer	Fall	Total by Species
Atlantic cod (*Gadus morhua*)	-	1,511	-	-	1,511
Haddock (*Melaongrammus aeglefinus*)	-	2,879	5,492	-	8,371
Pollock (*Pollachius virens*)	-	2,216	-	-	2,216
Red hake (*Urophycis* spp.)	-	439	818,878	2,299,000	3,118,317
Silver hake (*Merluccius bilinearis*)	-	3,800	107,094	107,944	218,838
Windowpane flounder (*Scophthalmus aquosus*)	-	10,017	1,282	169,178	180,477
Winter flounder (*Pseudopleuronectes americanus*)	-	4,217	904	-	5,121
Witch flounder (*Glyptocephalus cynglossus*)	-	19,380	28,889	-	48,269
Yellowtail flounder (*Limanda ferruginea*)	-	326,078	1,609,948	-	1,936,026
Monkfish (*Lophius americanus*)	-	-	10,659	3,415	14,074
Atlantic herring (*Clupea harengus*)	-	-	1,376	148,924	150,300
Atlantic butterfish (*Peprilus triacanthus*)	-	-	250,862	73,269	324,131
Atlantic mackerel (*Scomber scombrus*)	-	993,922	9,648	-	1,003,570
Black seabass (*Centropristis striata*)	-	-	210,383	25,679	236,062
Summer flounder (*Paralichthys dentatus*)	1,583	-	-	1,308,331	1,309,914
Bluefish (*Pomatomus saltatrix*)	-	-	161,390	5,252	166,642
Total by Season	**1,583**	**1,364,459**	**3,216,805**	**4,140,992**	**8,723,839**

5.2.2 Zooplankton Entrainment Losses

Similar to ichthyoplankton, zooplankton densities varied seasonally with different species peaking between seasons. Based on seasonal averages, the total number of non-ichthyoplankton zooplankton expected to be entrained per CWIS is 65.3 billion individuals annually. Estimated zooplankton losses from entrainment are summarized in Table 5.2-2.

Table 5.2-2 Estimated Number of Zooplankton Entrained by Season

Scientific Name	Winter	Spring	Summer	Fall	Total by Species
Centropages typicus	3,383,058,726	4,601,764,990	1,714,465,535	971,584,053	10,670,873,304
Calanus finmarchicus	84,061,868	615,848,611	952,928,295	118,155,593	1,770,994,367
Pseudocalanus spp.	99,880,860	1,953,727,335	565,258,471	7,352,561	2,626,219,227
Penilia spp.	-	-	3,125,110,820	4,993,533,526	8,118,644,346
Temora longicornis	50,393,976	2,205,259,002	304,071,302	7,256,250	2,566,980,530
Centropages hamatus	255,462,828	80,256,741	53,747,492	320,195	389,787,256
Echinodermata	786,428	15,479,060	2,485,049,554	18,181,668,573	20,682,983,615
Appendicularians	48,360,486	250,041,705	240,693,027	510,704,517	1,049,799,735
Paracalanus parvus	1,001,236,393	382,846,521	85,657,909	250,838,039	1,720,578,862
Gastropoda	831,862,824	2,433,929,782	822,864,036	84,097,288	4,172,753,930
Acartia spp.	3,811,474	9,162,334	386,547,475	563,643,098	963,164,381
Metridia lucens	107,329,641	136,371,930	13,049,444	5,219,911	261,970,926
Evadne spp.	981,123	173,220,074	212,735,244	369,785,727	756,722,168
Salpa	-	-	993,068,811	453,545,510	1,446,614,321
Oithona spp.	67,690,184	186,367,588	214,298,317	132,994,373	601,350,462
Cirripedia	4,989,632	30,169,660	5,888,735	217,951	41,265,978
Chaetognatha	179,703,633	159,792,408	269,913,217	316,715,934	926,125,192
Hyperiidea	99,655,922	26,066,512	283,922,717	142,544,654	552,189,805
Gammaridea	720,060	2,269,419	446,592	1,892,950	5,329,021
Calanus minor	10,592,674	1,190,869	51,045,082	299,259,538	362,088,163
Copepoda	396,587	-	217,130	6,586,676	7,200,393

Table 5.2-2 Estimated Number of Zooplankton Entrained by Season (Continued)

Scientific Name	Winter	Spring	Summer	Fall	Total by Species
Clausocalanus arcuicornis	39,270,000	45,375,999	3,760,304	17,114,644	105,520,947
Decapoda	2,305,797	28,758,096	22,439,242	41,156,389	94,659,524
Euphausiacea	1,875,711	4,175,530	10,425,239	21,052,881	37,529,361
Protozoa	2,197,528	1,363,056	542,366	7,665,215	11,768,165
Acartia longiremis	895,559	19,442,828	45,921,307	2,128,796	68,388,490
Eucalanus spp.	-	-	-	84,178,814	84,178,814
Pelecypoda	4,103,697	5,434,804	23,537,291	13,098,384	46,174,176
Polychaeta	2,380,080	9,601,975	1,316,731	20,361,558	33,660,344
Podon spp.	-	5,082,056	9,856,238	49,097,726	64,036,020
Pisces	179,745	2,538,678	15,269,547	24,780,547	42,768,517
Bryozoa	1,372,403	2,827,091	3,715,899	12,909,697	20,825,090
Clausocalanus furcatus	-	173,900	9,165,719	66,768,842	76,108,461
Calanus spp.	-	-	-	903,357	903,357
Oncaea spp.	17,368,189	1,204,006	613,137	194,709,923	213,895,255
Corycaeidae	279,288	842,206	503,155	60,732,250	62,356,899
Ostracoda	-	90,227	-	7,632,272	7,722,499
Temora stylifera	-	-	774,338	57,116,806	57,891,144
Mysidacea	2,360,236	292,823	-	15,636,248	18,289,307
Temora spp.	374,333	263,943	620,315	4,769,383	6,027,974
Tortanus discaudatus	-	10,025,994	9,985,164	-	20,011,158
Paracalanus spp.	-	930,798	5,959,358	2,544,373	9,434,529
Siphonophores	447,771	2,810,761	206,942,768	76,989,329	287,190,629
Coelenterates	-	56,648,172	15,100,452	57,984,973	129,733,597

Table 5.2-2 Estimated Number of Zooplankton Entrained by Season (Continued)

Scientific Name	Winter	Spring	Summer	Fall	Total by Species
Ctenophores	-	-	17,185,246	-	17,185,246
Meganyctiphanes norvegica	-	-	2,451,238	-	2,451,238
Thysanoessa raschii	-	-	4,068,769	-	4,068,769
Thysanoessa gregaria	-	-	-	210,107	210,107
Thecosomata	93,709,401	1,483,986,813	810,992,479	24,153,527	2,412,842,220
Spiratella spp.	737,302,786	946,553,811	2,146,214	1,854,722	1,687,857,533
Creseis spp.	-	-	-	1,049,881	1,049,881
Total	**7,137,397,843**	**15,892,188,108**	**14,004,271,721**	**28,284,517,561**	**65,318,375,233**

6 Discussion

The objectives of this study were to characterize the existing plankton community and quantify potential maximum/worst-case impacts of entrainment. The most conservative estimates were used for each CWIS, including 1) a maximum expected flow rate of two CWIS pumps operating at 82% capacity for 24 hours per day, 365 days per year; and 2) a 100% mortality rate of entrained plankton. However, the volume of intake will vary with the amount of electricity being produced by the wind farm, and with seasonal variations in water temperature. Additionally, the CWIS is expected to heat the water by 8.5 °Celsius [C] (15.3 °Fahrenheit [F]) and the water is within the system for only a short time. Water temperatures in this area are highest in July and August with an average temperature of 23.4 °C (74.1°F) between 2019-2022 based on data from the NOAA Buoy #44025 (see Section 3.2 of COP Volume II). Therefore, water exiting the entrainment system will rarely be above 32°C (89.6 °F). While a specific marine entrainment survival rate study of directly comparable equipment was not available, Electric Power Research Institute (EPRI) (2000) found that 33°C (91.4°F) was the upper limit at which many organisms survived entrainment in existing power plants located along the Hudson River in New York. Therefore, while 100% mortality is assumed for this study, it is reasonable to consider that some plankton may survive entrainment of the CWIS.

Vineyard Mid-Atlantic is expected to generate a minimum of 2,000 megawatts (MW) of renewable energy per day regardless of the number of ESPs to be used. To assess the impacts of entrainment from the Vineyard Mid-Atlantic CWIS, a comparison was made to cooling water intakes of several traditional fossil fuel power plants with similar MW capacity and located in the New York Bight region that have been permitted for use. Power plants ranging in MW capacity of 800 MW to 2300 MW with open cooling systems used between 2.6 million m^3/day (700 million gal/day) and 9.5 million m^3/day (2,500 million gal/day) (NYSDEC SEU nd; NYSDEC 2017; NYSDEC 2019). This equates to a volume of water usage rate of 2,426 m^3/MW (641,000 gal/MW) to 4,402 m^3/MW (1,163,000 gal/MW). With Vineyard Mid-Atlantic expected to generate a minimum of 2,000 MW per day, the facility will use a maximum of 24 m^3/MW (6,250 gal/MW) produced, which is significantly lower than open water cooling systems associated with these traditional fossil fuel power plants and more consistent with the ratio demonstrated at a closed cooling system, the Bethlehem facility, which has a capacity of 750 MW per day and uses 45 m^3/MW (12,000 gal/MW) (NYSDEC 2002). As a result of reduced daily water usage, entrainment estimates for the CWIS are considerably lower than those of other open-system power plants. In the unlikely event that two 2000 MW ESPs with CWIS were used, Vineyard Mid-Atlantic will use a maximum of 48 m^3/MW (12,500 gal/MW) and the total intake volume would increase to 94,400 m^3/day (25 million gal/day). This water usage rate and total intake volume are still considerably lower than most similarly-sized traditional fossil fuel power plants.

The ichthyoplankton species that are most susceptible to entrainment mortality correlate with a period of peak primary production that begins in early summer and extends through the fall. The species with the largest number of larvae expected to be impacted by entrainment include Atlantic mackerel in the spring, yellowtail flounder in the summer, red hake in the fall, and summer flounder in the fall.

To put the results into further context, one CWIS is expected to remove 47,200 m^3/day (12,500,000 gal/day) per day, which is roughly 0.0006% of the volume of water within the Lease Area, assuming an average water depth of 42.5 m (138 ft). Additionally, according to EPRI (2004), 99.9% of young spawned by a typical female fish can expected to die prior to adulthood. Similarly for the fish entrained at a CWIS, only a fraction would have survived to reproduce or be harvested by fishermen. Therefore, if the annual number of equivalent adults (age 1) lost to entrainment[3] were calculated using the forward projection approach as described in EPRI (2004), it is expected that tens to thousands of times fewer age-one equivalent fish would be lost to entrainment when compared to larvae lost due to high early-life stage mortality.

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3 Age-one equivalents are the fish at the stage that would be expected to survive to the next life stage until the cohort reached age one (i.e., age of equivalence) (EPRI 2004).

7 References

Dahlberg MD. 1979. A review of survival rates of fish eggs and larvae in relation to impact assessments. Marine Fisheries Review. 12 pp.

Electric Power Research Institute (EPRI). 2000. Review of Entrainment Survival Studies: 1970–2000, EPRI, Palo Alto, CA: 2000. 1000757.

Electric Power Research Institute (EPRI). 2004. Extrapolating impingement and entrainment losses equivalent to adults and production foregone. EPRI Report 1008471. EPRI, Palo Alto CA.

[NEFSC] Northeast Fisheries Science Center. 2023. Zooplankton and ichthyoplankton abundance and distribution in the North Atlantic collected by the ecosystem monitoring (EcoMon) project from 1977-02-13 to 2021-11-15 (NCEI Accession 0187513). [2000-2021]. [accessed 2023 June 28] https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:0187513.

[NYSDEC] New York Department of Environmental Conservation. 2002. Bethlehem Energy Center – Ruling, January 3, 2002. Available online at: Bethlehem Energy Center - Ruling, January 3, 2002 - NYS Dept. of Environmental Conservation.

[NYSDEC] New York Department of Environmental Conservation. 2017. Fact Sheet: New York State Pollutant Discharge Elimination System (SPDES) Draft Permit Renewal with Modification Indian Point Electric Generating Station. Available online at: Indian Point Final Draft Fact Sheet (ny.gov).

[NYSDEC] New York Department of Environmental Conservation. 2019. Initial Water Withdrawal Permit Ravenwood Generating Station. DEC #2-6304-0002400056. Available online at: 2019WWpermit.pdf (treichlerlawoffice.com).

[NYSDEC SEU] New York Department of Environmental Conservation Bureau of Habitat, Steam-Electric Unit. No Date (nd). Biological Fact Sheet – Cooling Water Intake Structure: Arthur Kill Generating Station. Available online at: Biological Fact Sheet - Cooling Water Intake Structure Bureau of Habitat, Steam Electric Unit - PDF Free Download (businessdocbox.com).

Pepin P. 1991. Effect of temperature and size on development, mortality, and survival rates of the pelagic early life history stages of marine fish. Canadian Journal of Fisheries and Aquatic Sciences. 48:503-518.