Appendix B

Supplemental Information and Additional Figures and Tables

Appendix B:Supplemental Information and Additional Figures and Tables

B.1 Climate and Meteorology

The National Climatic Data Center defines distinct climatological divisions to represent geographic areas that are nearly climatically homogeneous. Locations within the same climatic division are considered to share the same overall climatic features and influences. New Jersey's north-south orientation, with the highest elevations in the northern portion and lower coastal plains in the south and along the bays and the ocean, contributes to climatic differences between the northern and southern portions of the state. Temperature differences are greatest in the winter and least in summer (New Jersey State Climatologist 2020). New Jersey has four well-defined physiographic belts that parallel the Atlantic Coast—the Coastal Plain, Piedmont, Highlands, and the Valley and Ridge Province (New Jersey Geological Society 2003). The Proposed Action is within the New Jersey Coastal Plain climatic division (NOAA 2021).

B.1.1 Ambient Temperature

The Onshore Project area is characterized by mild seasons and storms that bring precipitation (rain and snow) to the region; the mild seasons are influenced by sea winds that reduce both the temperature range and mean temperature while providing humidity (NJDEP 2010). Air temperatures in the Project area are generally moderate. Air temperature data collected from the Office of the New Jersey State Climatologist, Rutgers University, which averaged the annual, seasonal, and monthly means in southern and coastal areas of New Jersey for 1985–2009, indicate that the annual mean air temperature was 53.2°F (11.8°C) (NJDEP 2010). The mean seasonal air temperature between 1985 and 2010 during the winter ranged from approximately 32–43°F (0–6°C) and in the spring from 54–64°F (12–18°C). The mean seasonal air temperature during the summer ranges from approximately 68–75°F (20–24°C) and during the fall from 53–65°F (12–18°C). The lowest average air temperatures occur in January and the highest in July (NJDEP 2010; NCDC 2021a). Recent offshore air temperature data were downloaded from NOAA buoys near the Offshore Project area. Data for the years 2014–2018 were downloaded from Atlantic City, New Jersey (Buoy No. ACYN4). Table B.1-1 summarizes average temperatures at the Atlantic City buoy.

Table B.1-1. Representative temperature data for the Project area

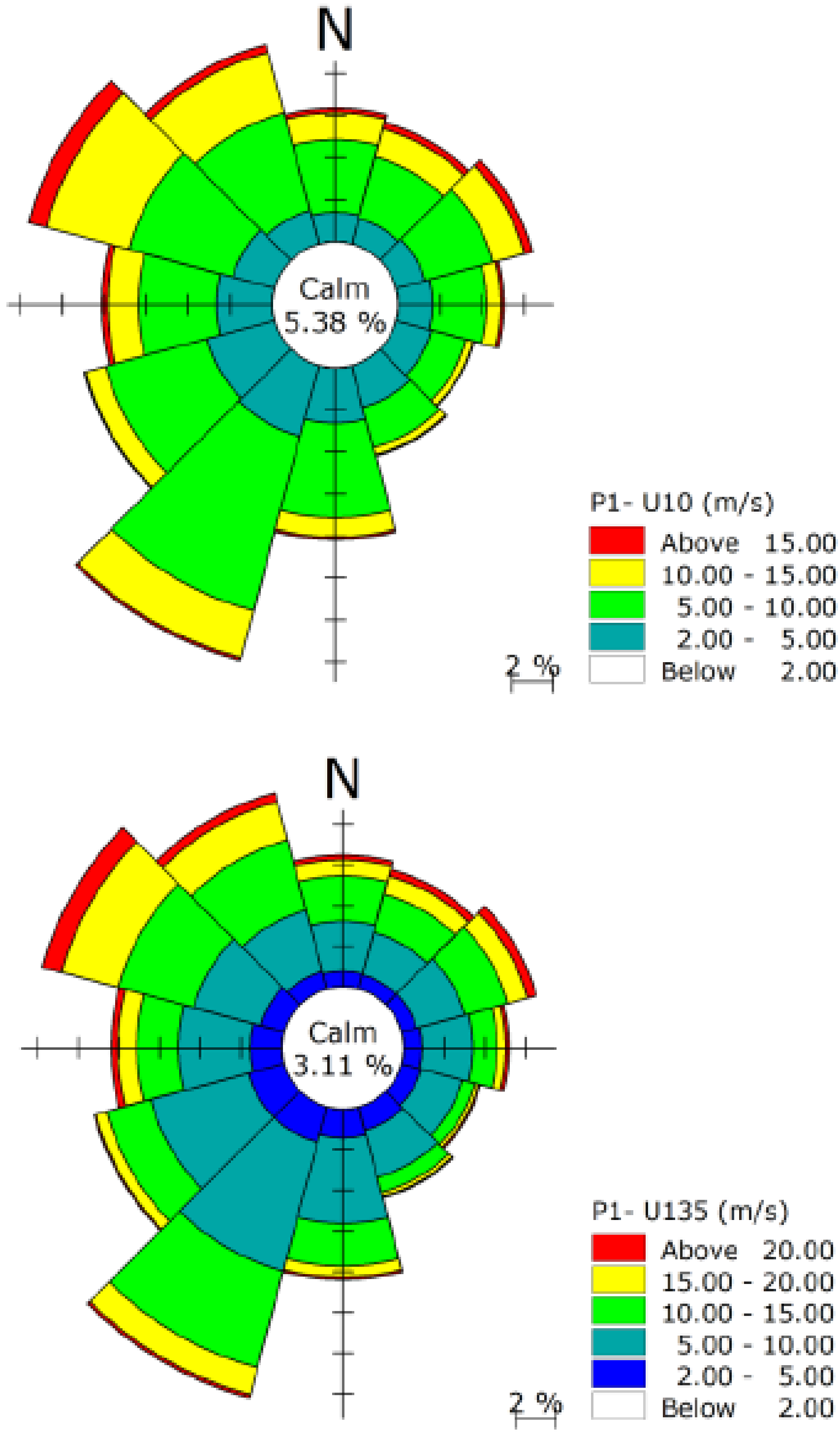
NOAA Station	Year	Annual Average °F/°C	Number of Observations
Atlantic City Buoy (No. ACYN4)	2014	53.8/12.1	86,432
	2015	55.4/13.0	86,357
	2016	55.6/13.1	81,252
	2017	55.9/13.3	85,57
	2018	52.9/11.6	63,856

Source: NDBC 2022

B.1.2 Wind Conditions

Prevailing winds in the middle latitudes over North America flow mostly west to east ("westerlies"). Westerlies within the Lease Area vary in strength, pattern, and directionality. Winds during the summer are typically from the southwest and flow parallel to the shore, and winds in the winter months are typically from the northwest and flow perpendicular to the shore. Spring and fall are more variable, with winds from either the southwest or northeast (Schofield et al. 2008). Data for the Project were generated through numerical models using a location within the Lease Area and are shown on Figure B.1-1. The highest-frequency wind directions generally were from south-southwest to north-northwest.

Extreme wind conditions on the U.S. East Coast are influenced by both winter storms and tropical systems. Several northeasters occur each winter season, while hurricanes are rarer but potentially more extreme. The tropical systems therefore define the wind farm design, based on extreme wind speeds (those with recurrence periods of 50 years and beyond).



Source: COP, Appendix II-B, Figure 2-1; Atlantic Shores 2023.
Elevations are 10 meters AMSL (U10) and 135 meters AMSL (U135).

Figure B.1-1. Wind rose graphs of mean wind speeds for the Lease Area

Table B.1-2 summarizes wind conditions in the region, including the monthly average wind speeds, monthly average peak wind gusts, and hourly peak wind gusts for each individual month. Data from 1984 through 2008 show that monthly mean wind speeds range from a low of 10.9 miles per hour (17.6 kilometers per hour) in July to a high of 17.4 miles per hour (28.0 kilometers per hour) in January. The monthly wind mean peak gusts reach a maximum during January at 24.1 miles per hour (38.7 kilometers per hour). The 1-hour average wind gusts reach a maximum during September at 63.3 miles per hour (101.9 kilometers per hour) (NDBC 2018).

Table B.1-2. Representative wind speed data

	Monthly Average Wind Speed		Monthly Average of Hourly Peak Gust		Monthly Maximum Hourly Peak Gust	
Month	mph	km/hr	mph	km/hr	mph	km/hr
January	17.4	28.0	24.1	38.7	61.6	99.1
February	16.2	26.1	21.9	35.2	56.8	91.5
March	15.5	25.0	20.5	33.0	57.5	92.6
April	14.0	22.6	19.0	30.6	56.8	91.5
May	12.7	20.4	16.2	26.1	60.2	96.9
June	11.5	18.5	15.3	24.6	47.6	76.7
July	10.9	17.6	14.7	23.7	50.1	80.6
August	11.2	18.0	15.2	24.4	48.6	78.2
September	13.0	20.9	18.0	28.9	63.3	101.9
October	14.8	23.9	20.5	33.0	60.6	97.6
November	16.3	26.3	21.8	35.0	57.3	92.2
December	17.1	27.6	23.8	38.3	56.2	90.4
Annual	14.0	22.6	19.1	30.7	63.3	101.9

Source: NDBC 2018.
Note: Data presented are for National Data Buoy Center buoy station #44009 (southeast of Cape May, New Jersey).
km/hr = kilometers per hour; mph = miles per hour.

B.1.3 Precipitation and Fog

Data from a study conducted by NJDEP indicate the Lease Area is characterized by mild seasons and storms throughout the year, with precipitation in the form of rain and snow being most common (NJDEP 2010). Average monthly precipitation data from the National Climatic Data Center are presented in Table B.1-3.

Table B.1-3. Monthly precipitation data[1]

Month	Precipitation (inches/centimeters)	
	Atlantic City Marina, New Jersey	Brant Beach, Beach Haven, New Jersey
January	3.08/7.82	3.25/8.26
February	2.87/7.29	2.86/7.26
March	4.02/10.21	3.97/10.08
April	3.39/8.61	3.26/8.28
May	3.22/8.18	2.78/7.06
June	2.68/6.81	3.05/7.75
July	3.31/8.41	3.92/9.96
August	3.92/9.96	3.71/9.42
September	3.08/7.82	2.78/7.06
October	3.47/8.81	3.65/9.27
November	3.35/8.51	2.91/7.39
December	3.62/9.19	3.36/8.53
Annual Average	3.33/8.47	3.29/8.36

Sources: NCDC 2021a, 2021b.
[1] Precipitation is recorded in melted inches (snow and ice are melted to determine monthly equivalent).

Snowfall amounts can vary quite drastically within small distances. Data from Lewes, Delaware, show that the annual snowfall average is approximately 12 inches (30.5 centimeters), and the month with the highest snowfall is January, averaging around 4 inches (10.2 centimeters) (WRCC 2020).

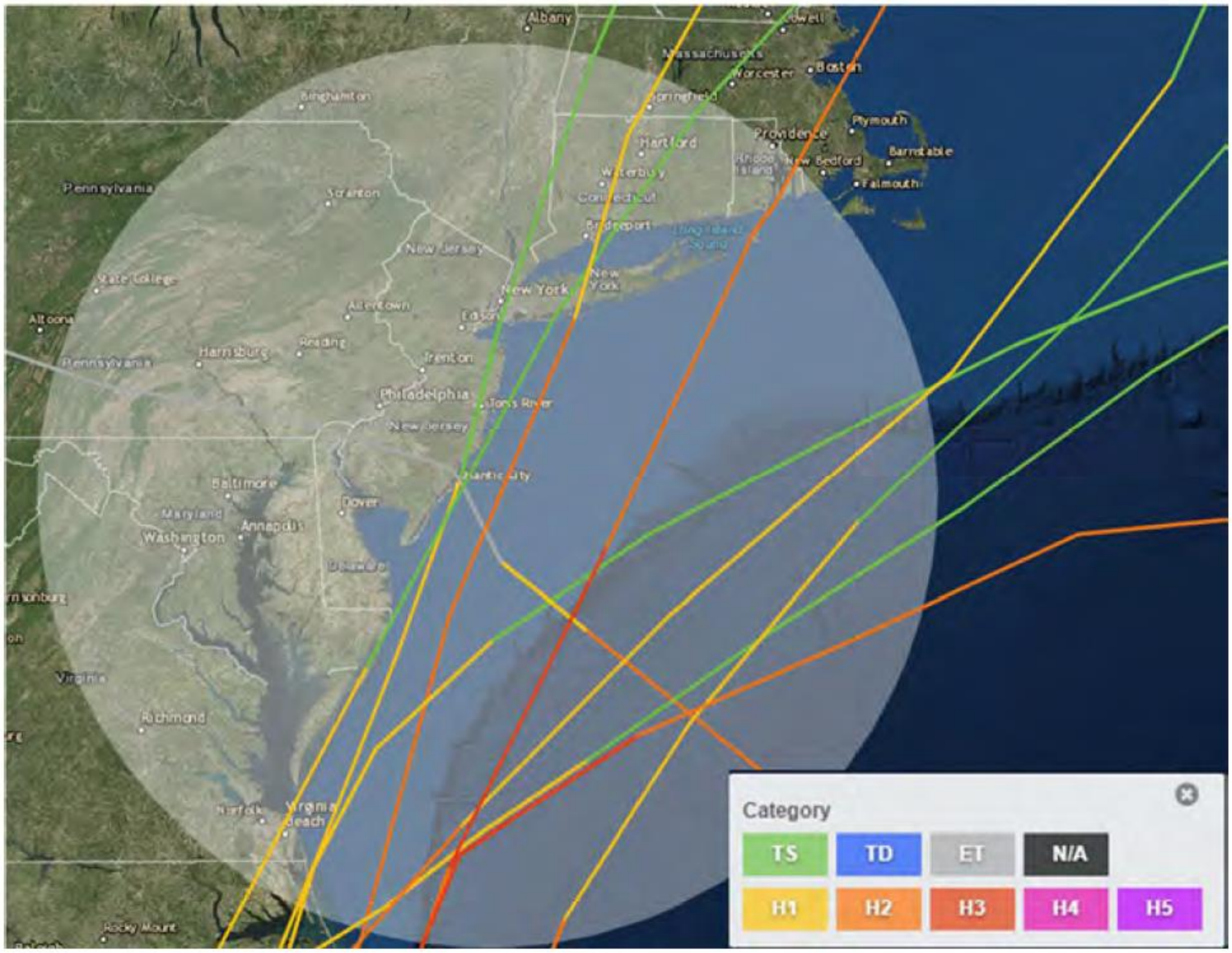
Given the cold air temperatures experienced during many mid-Atlantic winters, there is potential for icing of equipment and vessels above the water line in the Lease Area. Cook and Chatterton (2008) analyzed icing events in Delaware Bay for winters from 1997 to 2007 and found that icing events are a common occurrence during the months of January, February, and March. The worst winter, as far as icing is concerned, experienced by the Delaware Bay region from 1997 through 2007 was in 2002 to 2003, during which 21 icing events occurred. Delaware Bay experiences approximately eight events annually where the variables favoring icing are consistent for 3 or more hours.

The occurrence of fog in the mid-Atlantic states is driven by regional-scale weather patterns and local topographic and surface conditions. The interaction between various weather systems and the physical state of the local conditions is complex. Ward and Croft (2008) found that high-pressure systems result in heavy fog over the Delaware Bay and nearby Atlantic coastal areas. During the 2006–2007 winter season (December–February), Sussex County Airport, Delaware, reported 45 fog events, 4 of which were described as dense fog (Ward and Croft 2008).

B.1.4 Hurricanes and Tropical Storms

Coastal New Jersey is subject to extratropical and tropical storm systems. Records of cyclone track locations, central pressures, and wind speeds are documented by several government agencies. Extratropical storms, including northeasters, are common in the Lease Area from October to April. These storms bring high winds and heavy precipitation, which can lead to severe flooding and storm surges. Most hurricane events within the Atlantic generally occur from mid-August to late October, with the majority of all events occurring in September (Donnelly et al. 2004). On average, hurricanes occur every 3 to 4 years within 90 to 170 miles (145 to 274 kilometers) of the New Jersey coast (NJDEP 2010).

Figure B.1-2 identifies the hurricane tracks within the Lease Area and surrounding areas since 1979 (NOAA 2018). The category for each storm is designated by a color for each track. Extratropical storms are captured by gray line segments, tropical depressions are captured in blue, tropical storms are depicted in green, Category 1 storms are yellow line segments, Category 2 storms are in light orange, and Category 3 storms are dark orange.



Source: NOAA 2018.

Figure B.1-2. Overview of storm tracks since 1979 in the vicinity of the Lease Area

Although data on tropical systems go back to 1851, the quality and consistency of the data are lacking the further back one looks. The storm period was selected based on the availability of consistent wind data for tropical and extratropical systems. The majority of historical cyclones affecting the Project area are tropical storms, and storms as powerful as Category 3 hurricanes have affected the area.

Regional storm events are recorded in NOAA's National Centers for Environmental Information Storm Events Database (NOAA 2018). Notable events are recorded when there is sufficient intensity to cause loss of life, injuries, significant property damage, or disruption to commerce. Table B.1-4 indicates storms that have occurred within 200 nautical miles (370 kilometers) of the Lease Area in 1979–2018.

Table B.1-4. Named storms that have occurred within 200 nautical miles of the Lease Area in 1979–2018

Storm Name	Date	Storm Category (within 200 nautical miles of Lease Area)
Gloria	1985	Category 1 and Category 2 Hurricane
Bob	1991	Category 2 and Category 2 Hurricane
Emily	1993	Category 2 and Category 2 Hurricane
Charley	1998	Tropical Storm and Category 1 Hurricane
Floyd	1999	Tropical Storm and Category 1 Hurricane
Earl	2010	Tropical Storm and Category 1 Hurricane
Irene	2011	Tropical Storm and Category 1 Hurricane
Sandy	2012	Extratropical Cyclone, Category 1 and Category 2 Hurricane
Arthur	2014	Category 1 Hurricane

Source: NOAA 2018.

Hurricane Sandy occurred in 2012 and caused the highest storm surges and greatest inundation on land in New Jersey. The storm surge and large waves from the Atlantic Ocean meeting up with rising waters from back bays such as Barnegat Bay and Little Egg Harbor caused barrier islands to be completely inundated (Blake et al. 2013). In Atlantic City and Cape May, tide gauges measured storm surges of 5.8 and 5.2 feet (1.8 and 1.6 meters), respectively (Blake et al. 2013). Atlantic City International Airport recorded maximum sustained wind speeds of 44.3 knots (82 kilometers per hour) and a peak wind speed of 55.6 knots (103 kilometers per hour) on the coast (NOAA 2012). Marine observations at the Cape May National Ocean Service (CMAN4) recorded sustained wind speeds at 52 knots (96 kilometers per hour) and an estimated inundation of 3.5 feet (1.1 meter) (Blake et al. 2013).

B.1.5 Mixing Height

The mixing height is the altitude above ground level to which air pollutants vertically disperse. The mixing height affects air quality because it acts as a lid on the height pollutants can reach. Lower mixing heights allow less air volume for pollutant dispersion and can lead to higher ground-level pollutant concentrations than do higher mixing heights. Table B.1-5 presents atmospheric mixing height data from the nearest measurement location to the Project area (Atlantic City, New Jersey). As shown in the table, the minimum average mixing height is 390 meters (1,279 feet), while the maximum average mixing height is 1,218 meters (3,996 feet). The minimum average mixing height is much higher than the height of the top of the proposed WTG rotors (262 meters [860 feet]).

Table B.1-5. Representative seasonal mixing height data

Season	Data Hours Included[1]	Atlantic City, New Jersey Average Mixing Height (meters)
Winter (December, January, February)	Morning: no-precipitation hours	624
	Morning: all hours	617
	Afternoon: no-precipitation hours	774
	Afternoon: all hours	390
Spring (March, April, May)	Morning: no-precipitation hours	545
	Morning: all hours	640
	Afternoon: no-precipitation hours	1,196
	Afternoon: all hours	499
Summer (June, July, August)	Morning: no-precipitation hours	511
	Morning: all hours	566
	Afternoon: no-precipitation hours	1,218
	Afternoon: all hours	695
Fall (September, October, November)	Morning: no-precipitation hours	484
	Morning: all hours	649
	Afternoon: no-precipitation hours	988
	Afternoon: all hours	476
Annual Average	Morning: no-precipitation hours	539
	Morning: all hours	620
	Afternoon: no-precipitation hours	1,052
	Afternoon: all hours	508

Source: USEPA 2021.
[1] Missing values are not included.

B.1.6 References Cited

Atlantic Shores Offshore Wind, LLC (Atlantic Shores). 2023. *Atlantic Shores Offshore Wind: Construction and Operations Plan*. Lease Area OCS-A 0499. May. Available: https://www.boem.gov/renewable-energy/state-activities/atlantic-shores-south.

Blake, E. S., T. B. Kimberlain, R. J. Berg, J. P. Cangialosi, and J. L. Beven II. 2013. *Tropical Cyclone Report Hurricane Sandy (AL182012).* Available: https://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf.

Cook, J. C., and M. N. Chatterton. 2008. *The Effects of Icing on Commercial Fishing Vessels*. Worcester Polytechnic Institute. Interactive Qualifying Project Number 47-CXP-0805. Available: https://digitalcommons.wpi.edu/cgi/viewcontent.cgi?article=1512&context=iqp-all. Accessed: March 2020.

Donnelly, J. P., J. Butler, S. Roll, M. Wengren, and T. Webb III. 2004. A Backbarrier Overwash Record of Intense Storms from Brigantine, New Jersey. *Marine Geology* 210:107–121.

National Climatic Data Center (NCDC). 2021a. *New Jersey Data Normals, 1981–2010: Brant Beach, Beach Haven, NJ*. Available: https://www.ncdc.noaa.gov/cdo-web/datatools/normals. Accessed: September 2021.

National Climatic Data Center (NCDC). 2021b. *New Jersey Data Normals, 1981–2010: Atlantic City Marina, NJ*. Available: https://www.ncdc.noaa.gov/cdo-web/datatools/normals. Accessed: September 2021.

National Data Buoy Center (NDBC). 2018. Lighted buoy 44009 data: Station 44009 (LLNR 168) – DELAWARE BAY 26 NM Southeast of Cape May, NJ. National Oceanic and Atmospheric Administration. Available: https://www.ndbc.noaa.gov/station_history.php?station=44009. Accessed: March 2020.

National Data Buoy Center (NDBC). 2022. Station ACYN4 Historical Data. Available: https://www.ndbc.noaa.gov/station_history.php?station=ACYN4. Accessed: March 2022.

National Oceanic and Atmospheric Administration (NOAA). 2012. National Environmental Satellite, Data, and Information Service. Daily Summary October 2012. Generated on April 13, 2020. Station: Atlantic City International Airport, NJ WBAN: 72407093730.

National Oceanic and Atmospheric Administration (NOAA). 2018. Historical Hurricane Mapper. Available: https://coast.noaa.gov/hurricanes/.

National Oceanic and Atmospheric Administration (NOAA). 2021. *Location of US Climate Divisions*. Physical Sciences Laboratory. Available: https://psl.noaa.gov/data/usclimate/data/map.html#New%20York. Accessed: September 2021.

New Jersey Department of Environmental Protection (NJDEP). 2010. *Ocean/Wind Power Ecological Baseline Studies*. Available: https://www.nj.gov/dep/dsr/ocean-wind/Ocean%20Wind%20Power%20Ecological%20Baseline%20Studies_Volume%20One.pdf. Accessed: September 2021.

New Jersey Geological Society. 2003. *Physiographic Provinces of New Jersey*. Available: https://www.state.nj.us/dep/njgs/enviroed/infocirc/provinces.pdf. Accessed: September 2020.

New Jersey State Climatologist, Rutgers University. 2020. *New Jersey Climate Publications*. Available: https://climate.rutgers.edu/stateclim_v1/njclimoverview.html. Accessed: September 2020.

Schofield, O., R. Chant, B. Cahill, R. Castelao, D. Gong, A. Kahl, J. Kohut, M. Montes-Hugo, R. Ramadurai, P. Ramey, X. Yi, and S. Glenn. 2008. The Decadal View of the Mid-Atlantic the Inner Continental Shelf of the Middle Atlantic Bight, USA. *Marine and Coastal Fisheries* 2:277–298.

U.S. Environmental Protection Agency (USEPA). 2021. SCRAM Mixing Height Data. Index page available: https://www.epa.gov/scram/scram-mixing-height-data. Data file available: https://gaftp.epa.gov/Air/aqmg/SCRAM/met_files/mixing_hghts/njmix.zip. Accessed: September 2021.

Ward, B., and P. J. Croft. 2008. Use of GIS to Examine Winter Fog Occurrences. *Electronic Journal of Operational Meteorology* 9:1–33.

Western Regional Climate Center (WRCC). 2020. *Period of Record Monthly Climate Summary: Lewes, Delaware*. Available: https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?de5320. Accessed: March 2020.

B.2 Wetlands

Table B.2-1 summarizes NWI wetland communities in the geographic analysis area. This table is equivalent to Table 3.5.8.1-1 in Section 3.5.8, *Wetlands*, but shows NWI data instead of NJDEP wetland data.

Table B.2-1. NWI wetland communities in the geographic analysis area

Wetland Community	Acres	Percent of Total
Estuarine and Marine Wetland	20,695	48.8
Freshwater Emergent Wetland	884	2.1
Freshwater Forested/Shrub Wetland	20,830	49.1
Total	**42,408**	**100.0**

Source: USFWS 2021.

Figures B.2-1 through B.2-8 show NJDEP and NWI mapped wetlands in the Cardiff and O&M facility study areas. Figures B.2-9 through B.2-17 show NJDEP and NWI mapped wetlands within the Larrabee study area.

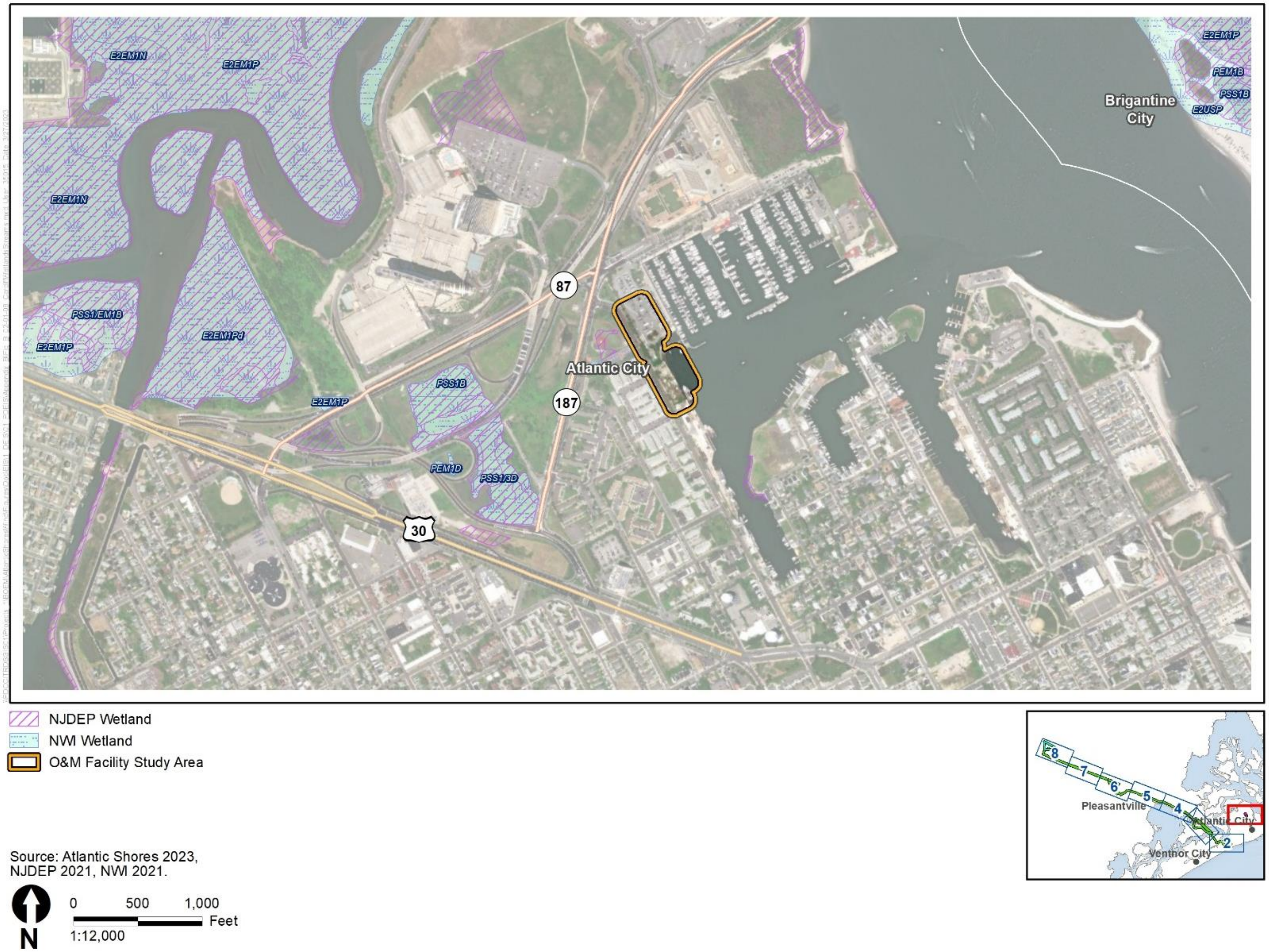


Figure B.2-1. NJDEP/NWI mapped wetlands in the Cardiff and O&M facility study areas

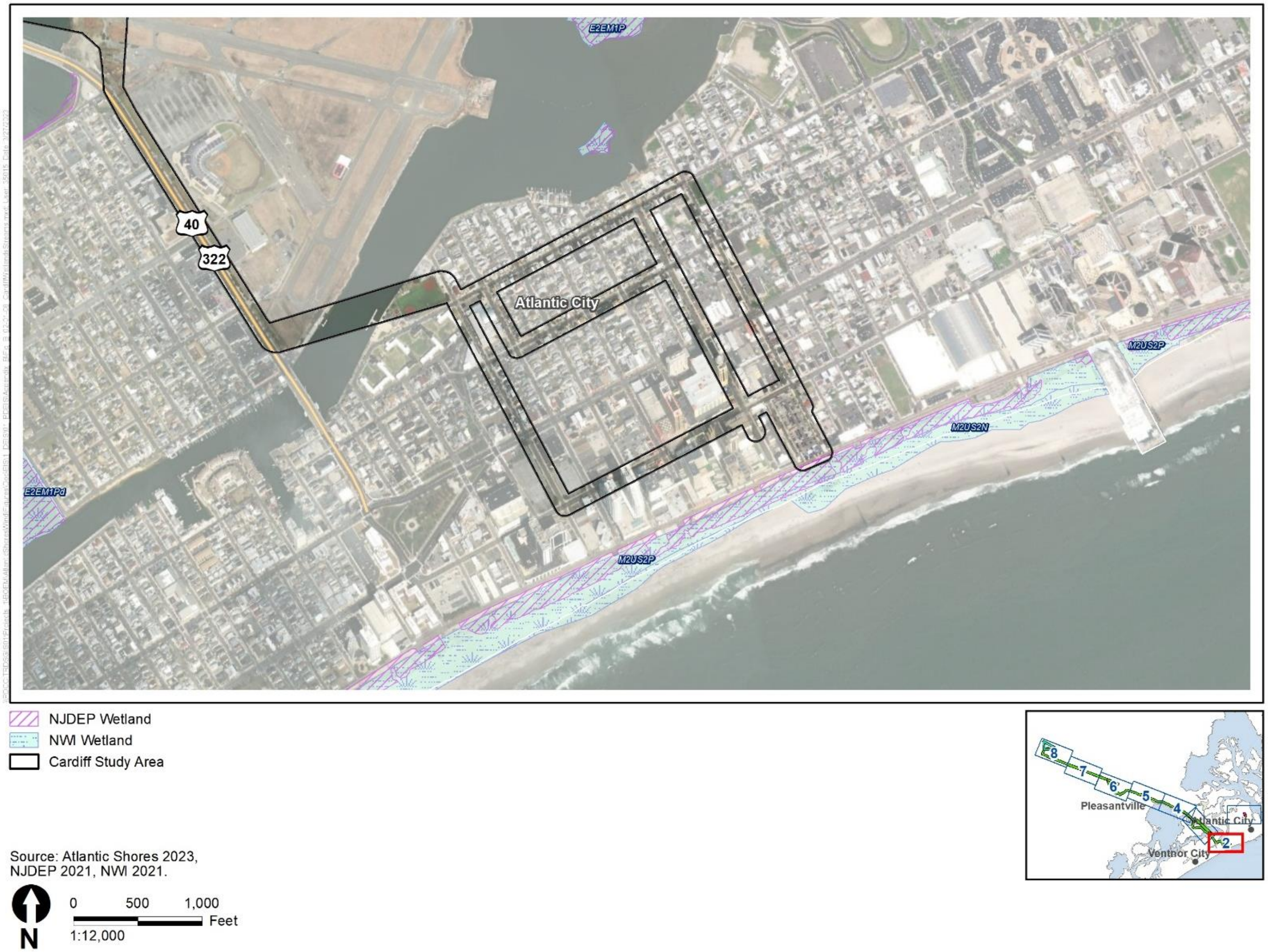
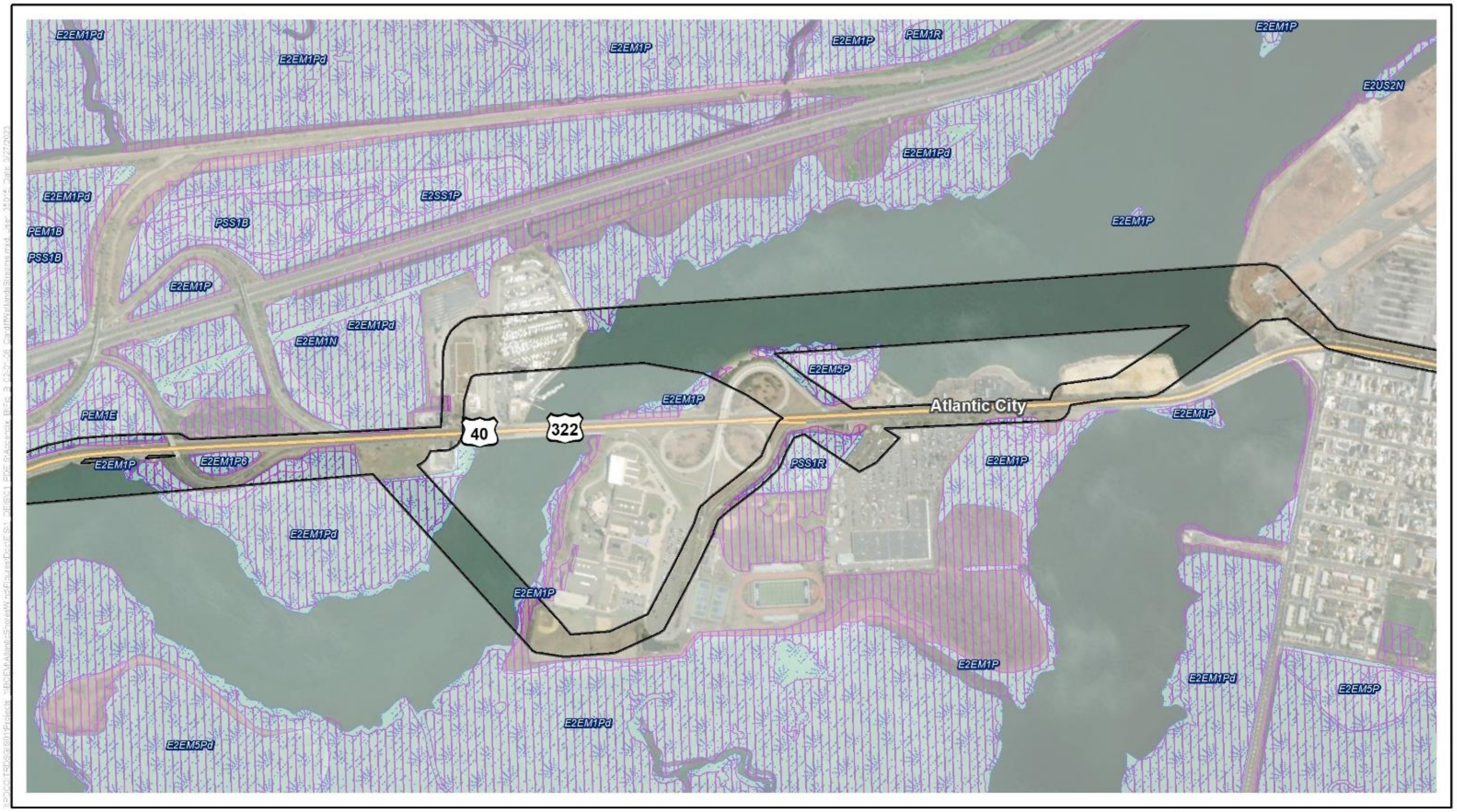
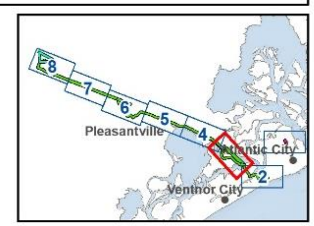


Figure B.2-2. NJDEP/NWI mapped wetlands in the Cardiff and O&M facility study areas



NJDEP Wetland
NWI Wetland
Cardiff Study Area



Source: Atlantic Shores 2023,
NJDEP 2021, NWI 2021.

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Figure B.2-3. NJDEP/NWI mapped wetlands in the Cardiff and O&M facility study areas

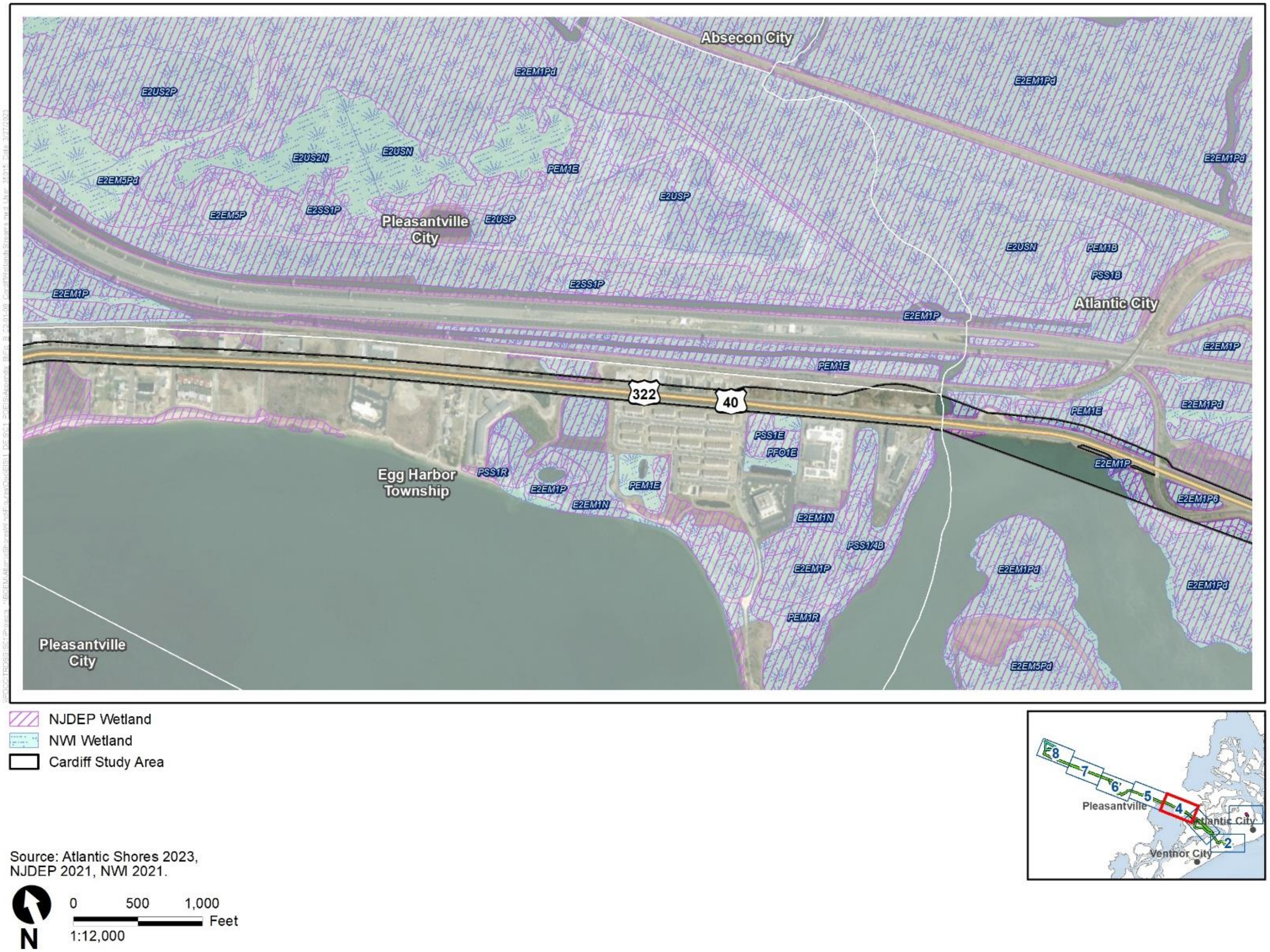

Figure B.2-4. NJDEP/NWI mapped wetlands in the Cardiff and O&M facility study areas

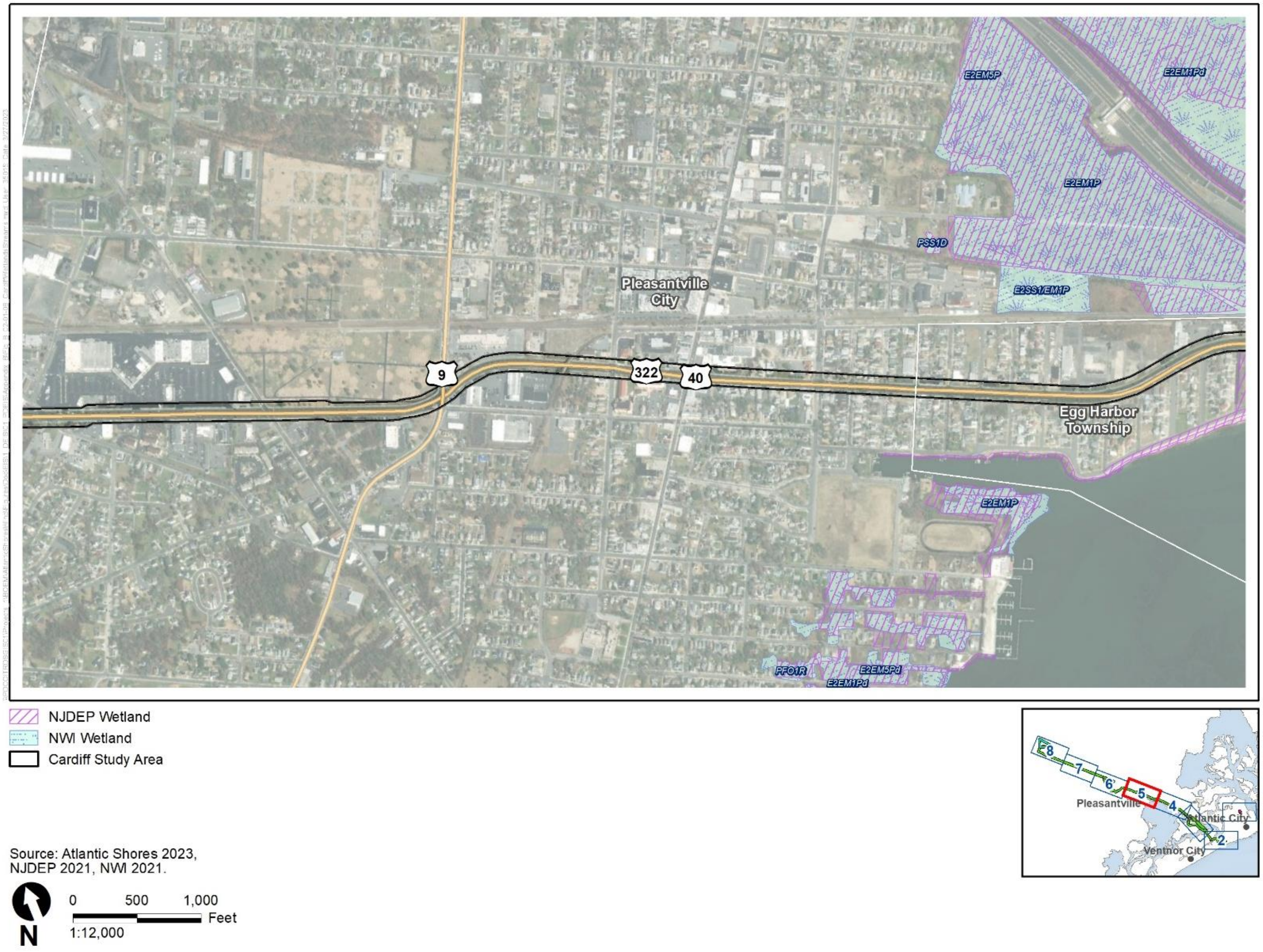

Figure B.2-5. NJDEP/NWI mapped wetlands in the Cardiff and O&M facility study areas

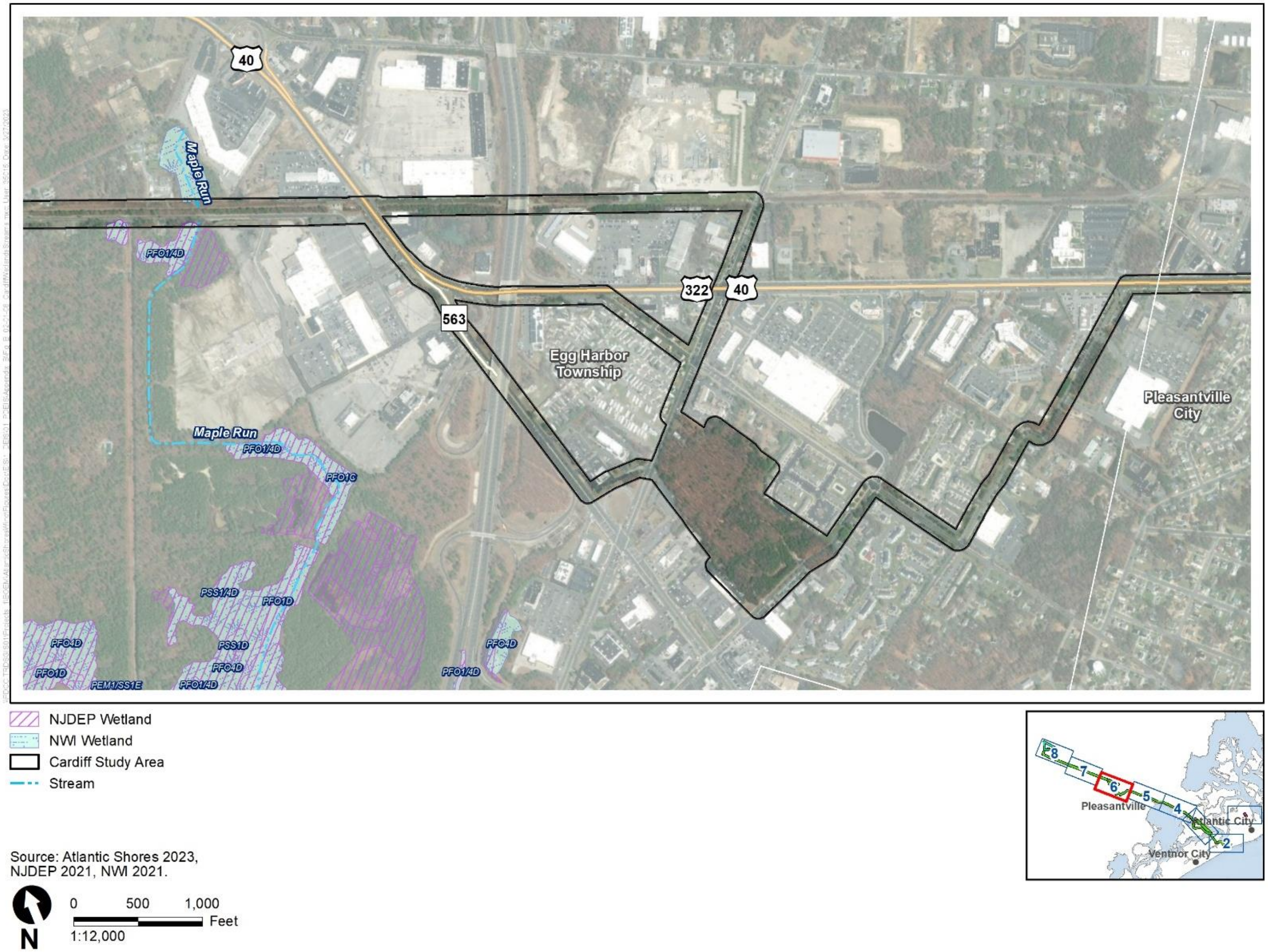

Figure B.2-6. NJDEP/NWI mapped wetlands in the Cardiff and O&M facility study areas

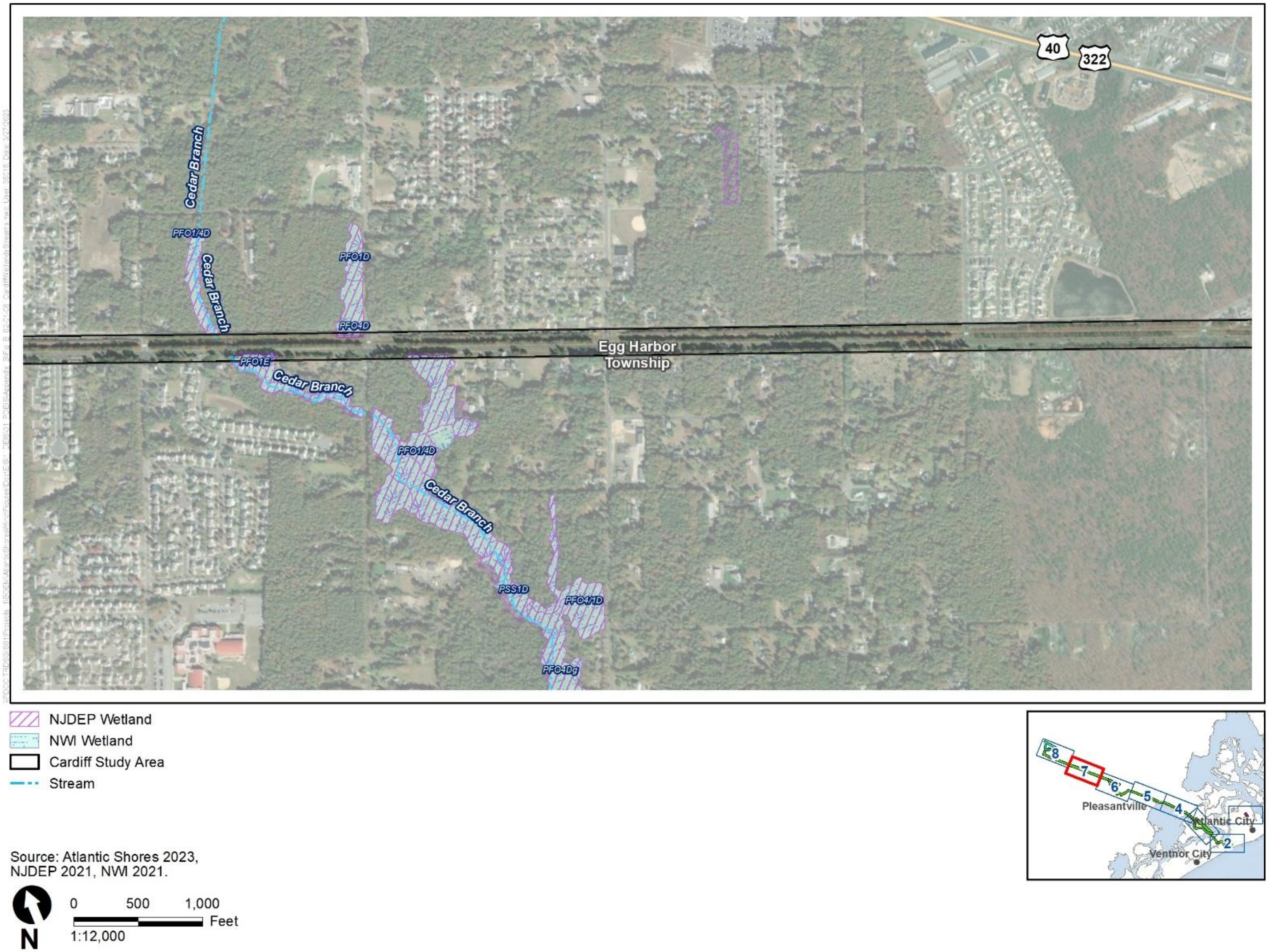

Figure B.2-7. NJDEP/NWI mapped wetlands in the Cardiff and O&M facility study areas

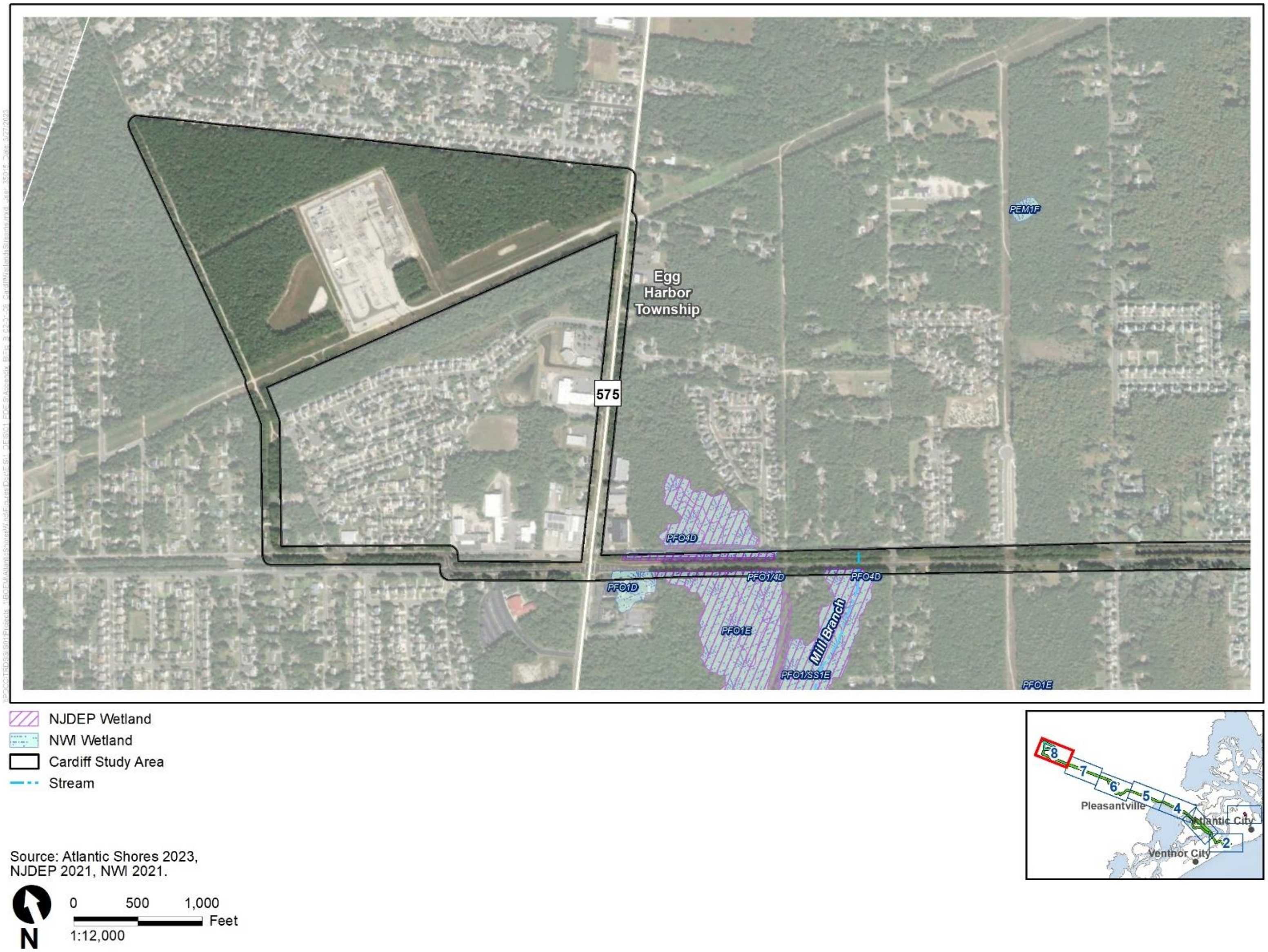

Figure B.2-8. NJDEP/NWI mapped wetlands in the Cardiff and O&M facility study areas

Figure B.2-9. NJDEP/NWI mapped wetlands in the Larrabee study area

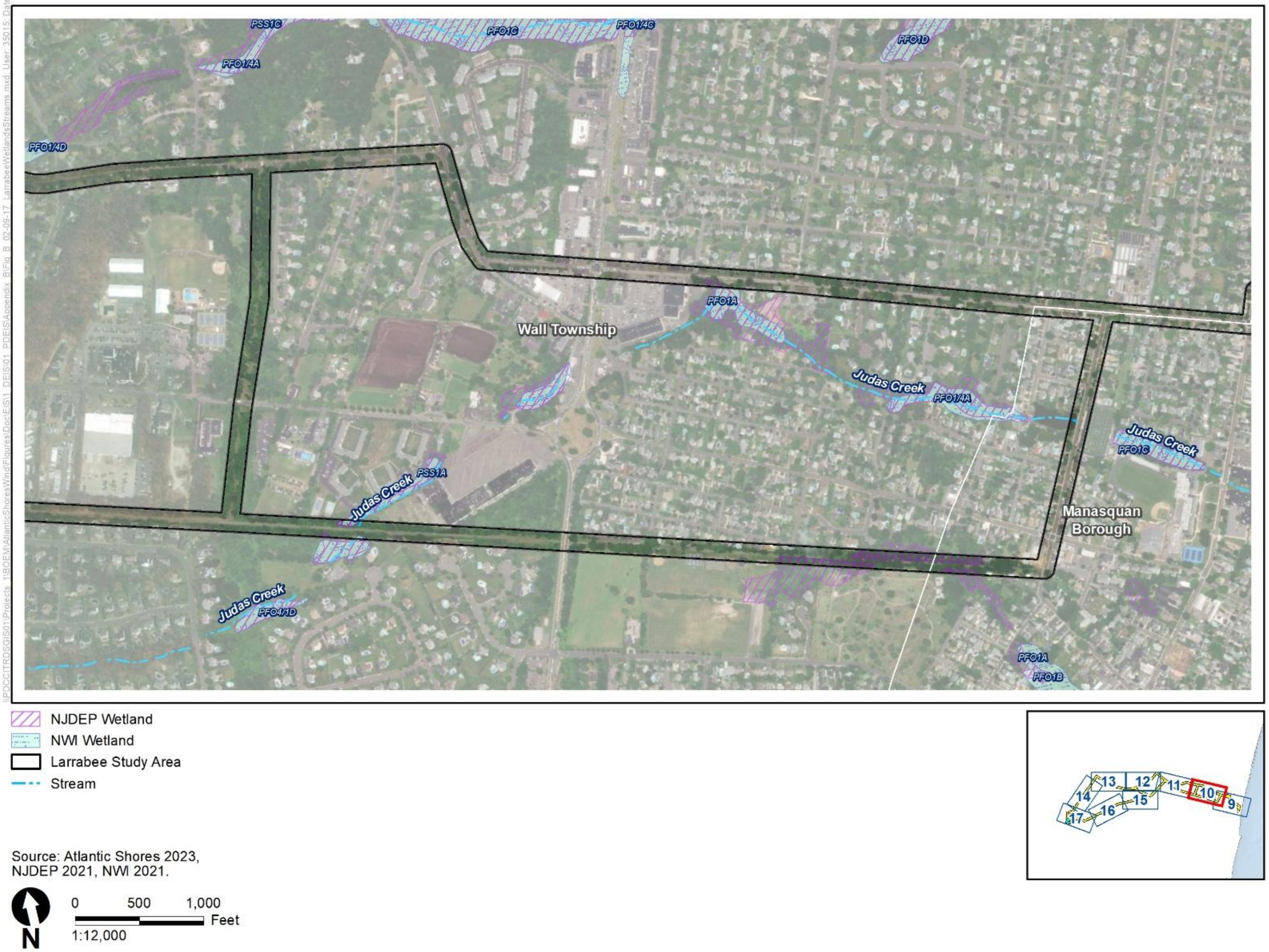

Figure B.2-10. NJDEP/NWI mapped wetlands in the Larrabee study area

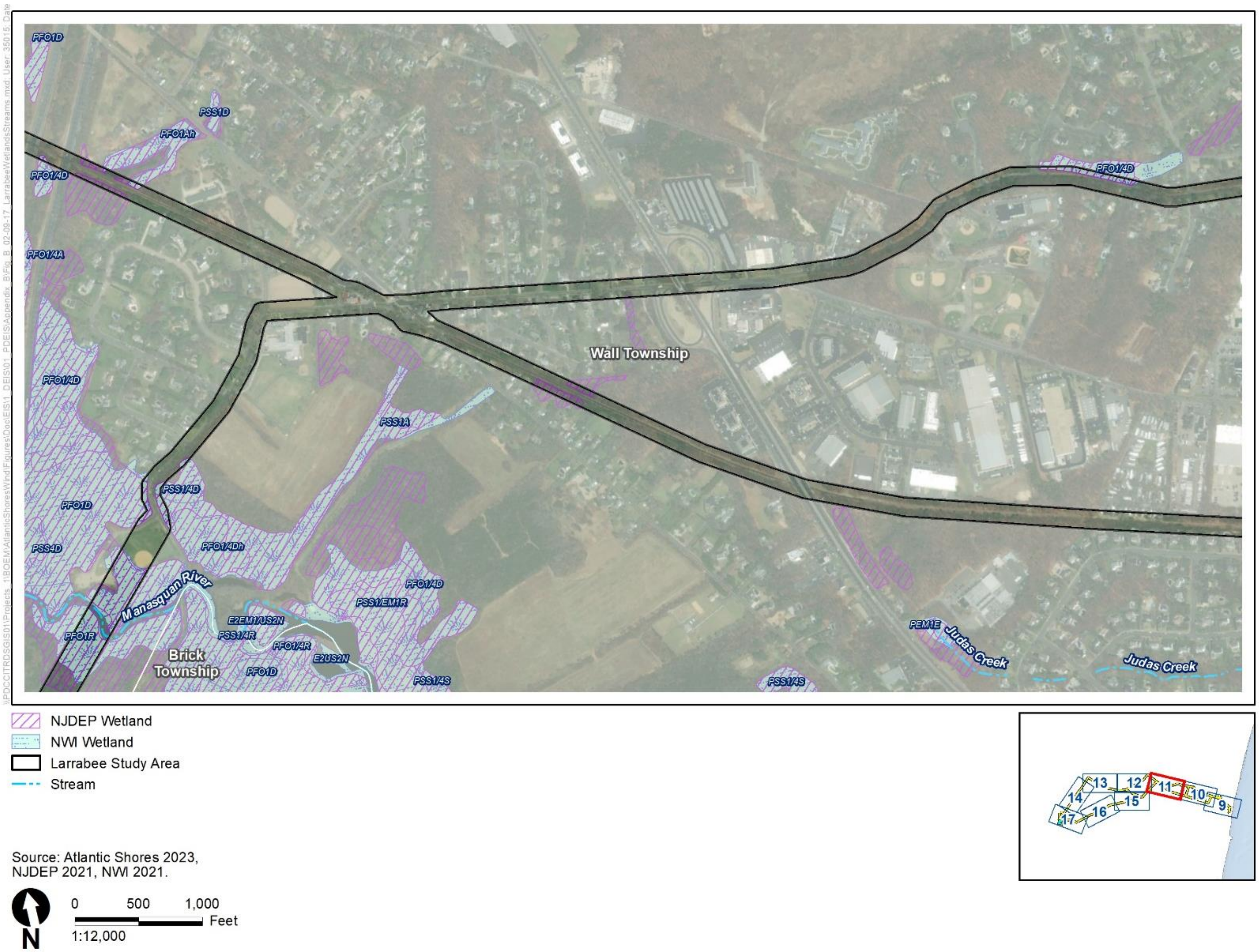

Figure B.2-11. NJDEP/NWI mapped wetlands in the Larrabee study area

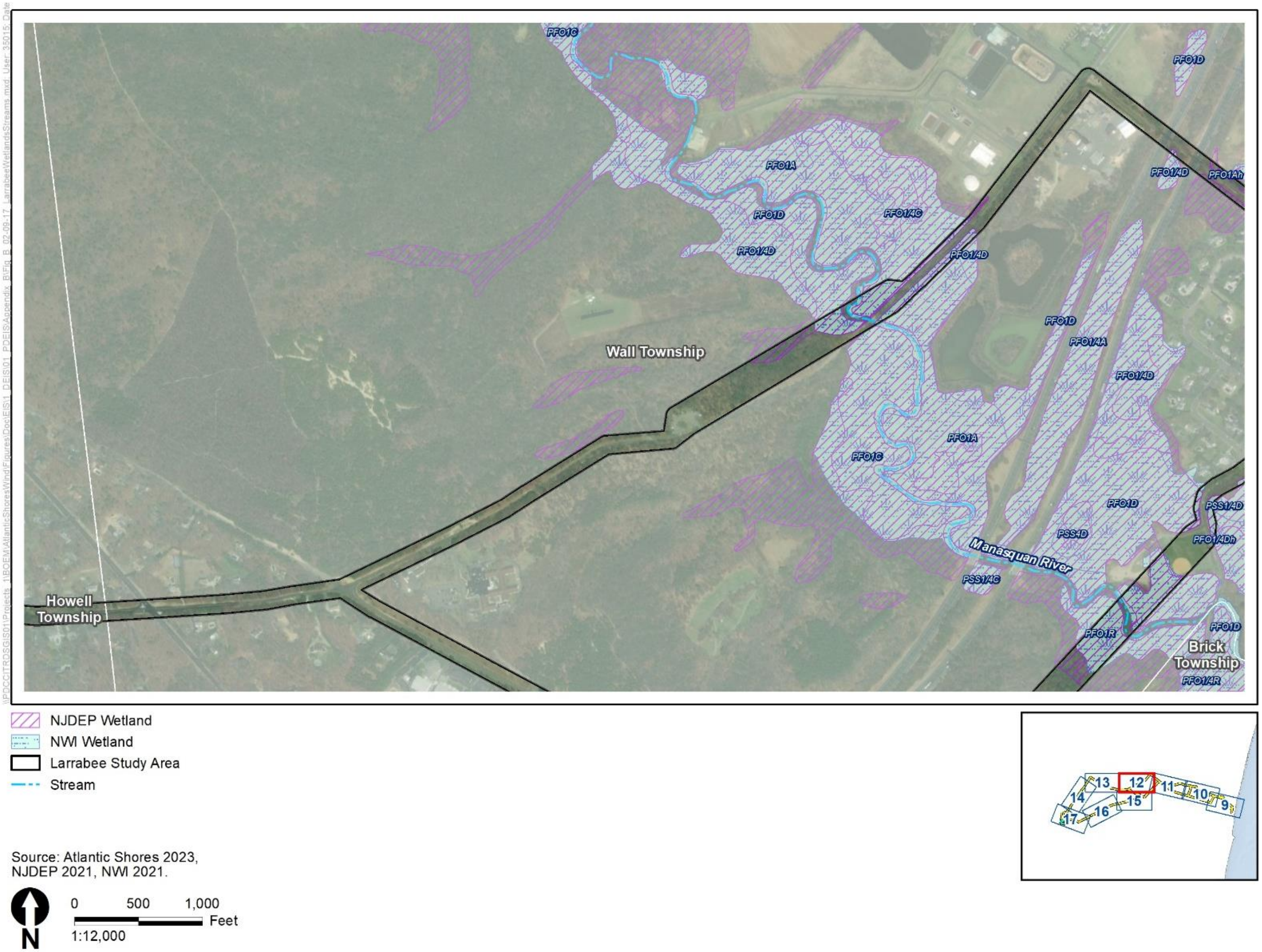

Figure B.2-12. NJDEP/NWI mapped wetlands in the Larrabee study area

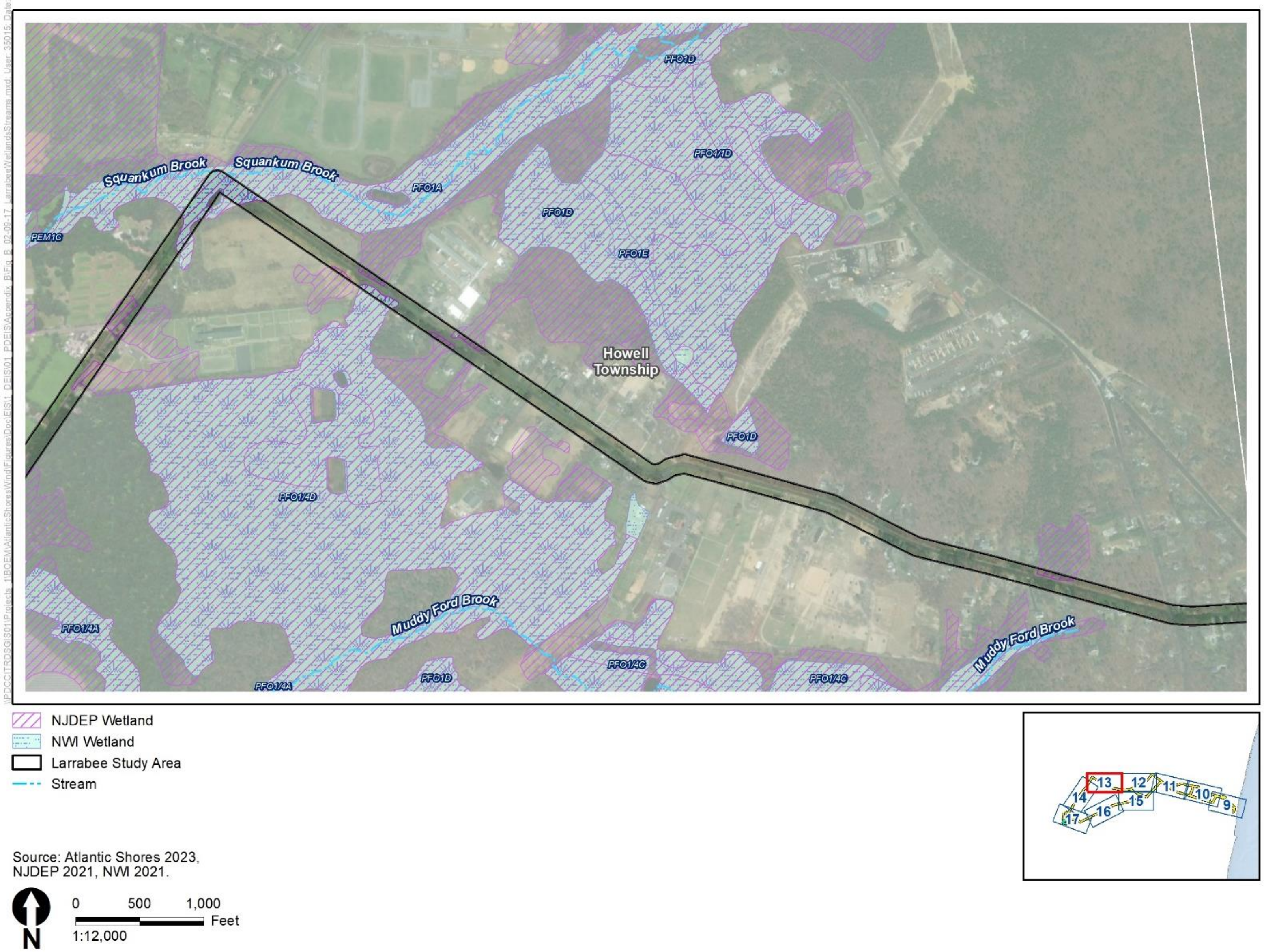

Figure B.2-13. NJDEP/NWI mapped wetlands in the Larrabee study area

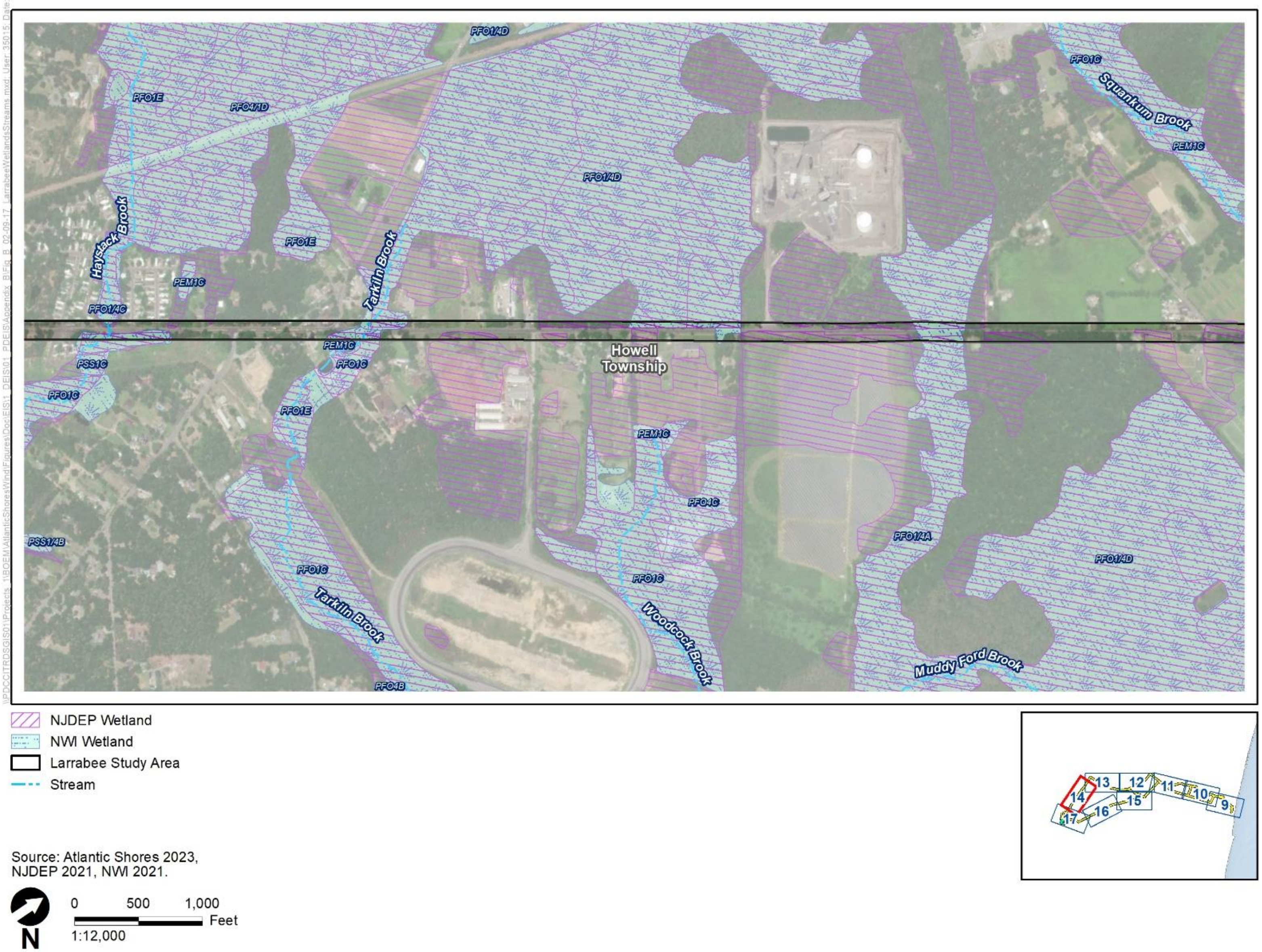

Figure B.2-14. NJDEP/NWI mapped wetlands in the Larrabee study area

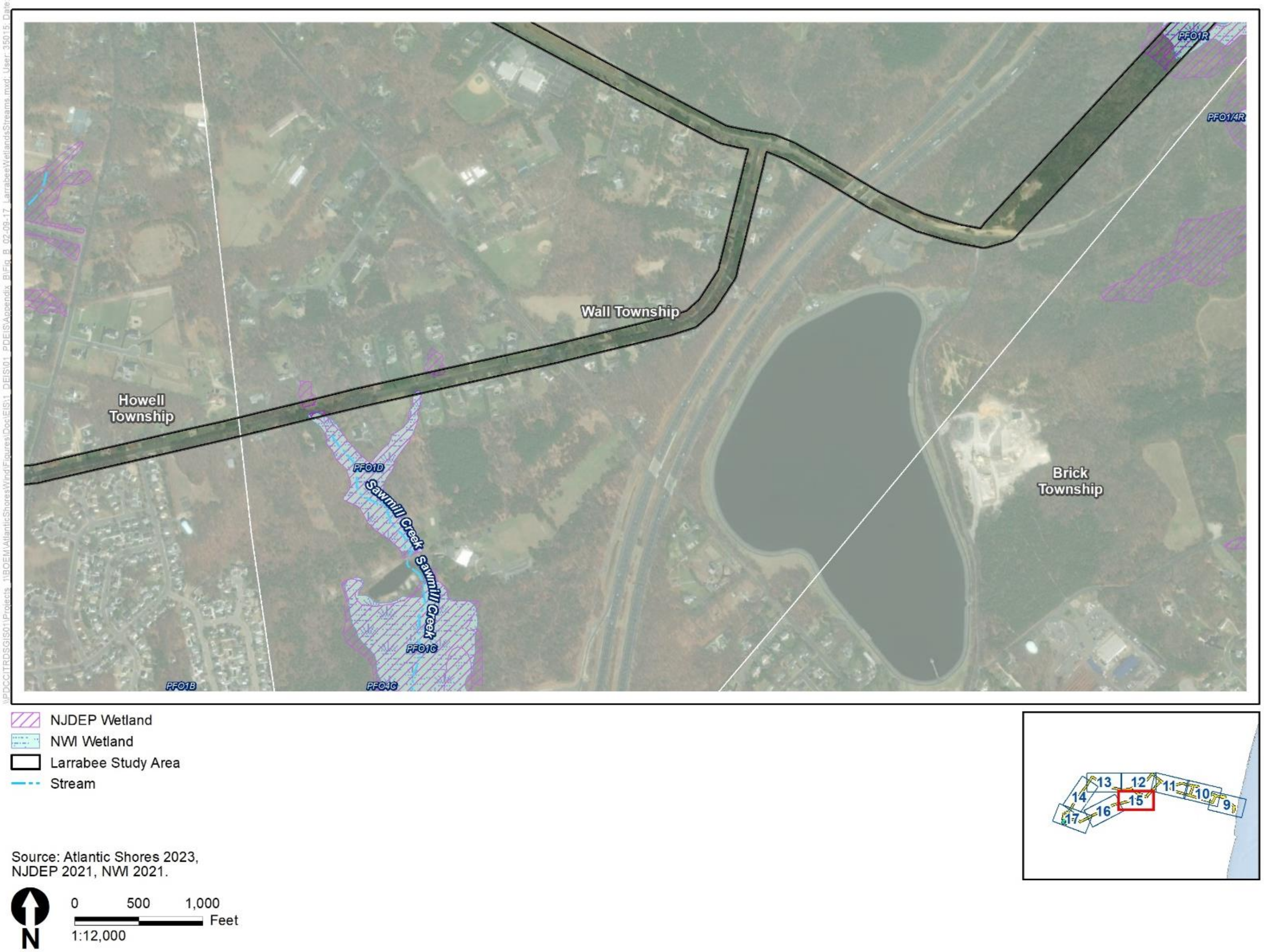

Figure B.2-15. NJDEP/NWI mapped wetlands in the Larrabee study area

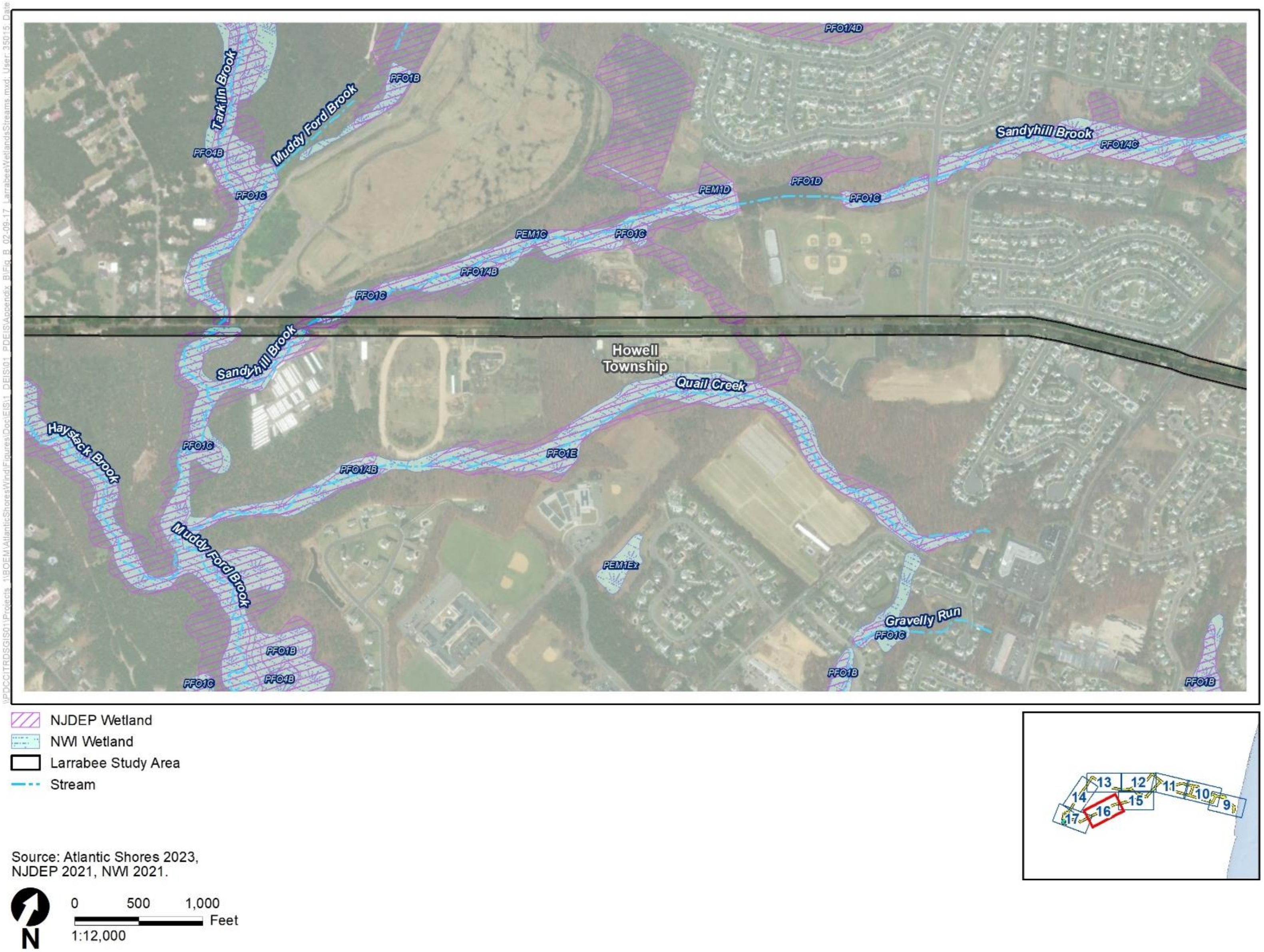

Figure B.2-16. NJDEP/NWI mapped wetlands in the Larrabee study area

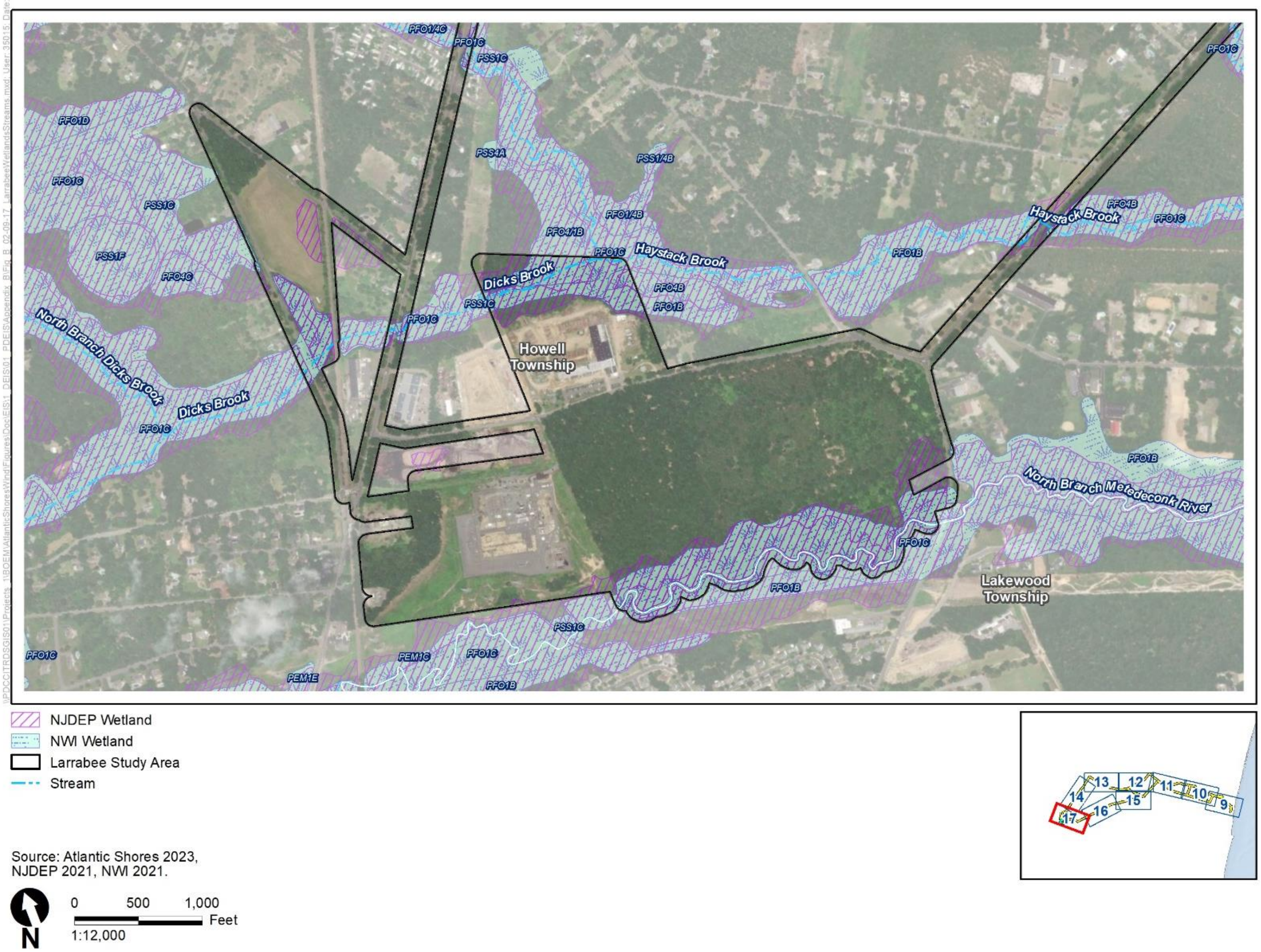

Figure B.2-17. NJDEP/NWI mapped wetlands in the Larrabee study area

B.2.1 References Cited

Atlantic Shores Offshore Wind, LLC (Atlantic Shores). 2023. *Atlantic Shores Offshore Wind: Construction and Operations Plan*. Lease Area OCS-A 0499. May. Available: https://www.boem.gov/renewable-energy/state-activities/atlantic-shores-south.

New Jersey Department of Environmental Protection (NJDEP). 2021. Wetlands of New Jersey GIS. Available: https://gisdata-njdep.opendata.arcgis.com/datasets/wetlands-of-new-jersey-from-land-use-land-cover-2012-update/explore?location=40.143284%2C-74.755600%2C8.71. Accessed: March 2023.

U.S. Fish and Wildlife Service (USFWS). 2021. National Wetland Inventory GIS data. Available: https://www.fws.gov/wetlands/Data/State-Downloads.html. Accessed: March 2022.

B.3 Commercial Fisheries and For-Hire Recreational Fishing

Table B.3-1. Number of commercial fishing vessel trips to the Project 1 WEA by species and year, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Surfclam	199	121	136	71	131	241	297	184	130	145	166
Black sea bass	129	113	145	134	87	83	77	93	77	75	101
Summer flounder	134	106	95	118	119	59	56	60	64	55	87
Longfin squid	139	108	83	117	75	85	55	65	78	49	85
Monkfish	128	130	113	109	89	72	46	56	54	38	84
Sea scallop	135	122	112	81	86	98	66	37	21	49	81
American lobster	63	66	61	59	65	64	66	67	45	61	62
Channeled whelk	0	87	53	8	21	33	72	62	58	84	48
Bluefish	73	84	71	63	34	33	27	10	19	19	43
Butterfish	53	47	44	50	18	28	26	38	43	19	37
Scup	51	40	59	52	17	22	17	23	28	26	34
Shortfin squid	68	32	24	31	16	29	17	24	26	20	29
Jonah crab	22	35	41	27	40	25	29	12	0	15	25
John dory	33	33	28	19	24	32	24	16	0	0	21
Silver hake	22	17	21	35	8	11	20	23	26	21	20
Skates	12	19	15	28	64	10	12	11	0	7	18
Smooth dogfish	20	23	14	17	14	9	20	18	10	17	16
Atlantic mackerel	21	7	6	14	5	5	9	26	24	10	13
Atlantic croaker	23	21	20	27	15	10	0	0	0	0	12
Spiny dogfish	18	14	21	0	25	4	0	0	0	0	8
All species[1]	**1,499**	**1,373**	**1,294**	**1,141**	**1,057**	**1,001**	**991**	**921**	**774**	**734**	**1,079**

Source: NMFS 2022.
[1]Includes 43 species that were caught by commercial fishing vessels in the Project 1 WEA.

Table B.3-2. Number of commercial fishing vessels that visited the Project 1 WEA by species and year, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Sea scallop	68	55	60	54	41	69	56	32	19	32	49
Summer flounder	74	57	54	67	50	39	31	37	39	34	48
Monkfish	79	66	53	62	50	44	28	35	32	30	48
Longfin squid	49	44	36	58	45	37	27	35	40	33	40
Black sea bass	43	40	50	55	40	35	23	30	32	25	37
Bluefish	44	44	38	41	28	24	19	10	14	14	28
Scup	35	28	35	38	16	18	12	17	22	22	24
Butterfish	25	20	19	24	13	15	15	20	27	16	19
Surfclam	20	16	14	12	10	15	16	15	13	11	14
Silver hake	14	7	14	24	5	8	13	17	20	15	14
John dory	16	16	14	10	8	13	14	13	0	0	10
American lobster	9	11	10	7	6	12	9	9	11	8	9
Atlantic mackerel	14	5	5	9	4	5	8	12	16	7	9
Skates	11	11	10	12	11	6	9	7	0	6	8
Shortfin squid	11	9	7	8	5	7	8	7	8	6	8
Smooth dogfish	7	10	7	9	9	5	7	10	4	6	7
Channeled whelk	0	7	5	4	9	8	8	7	10	6	6
Weakfish	14	9	18	0	6	0	0	0	8	7	6
Atlantic croaker	14	10	9	11	9	8	0	0	0	0	6
Jonah crab	4	6	6	4	5	7	6	4	0	5	5
All species	**615**	**530**	**529**	**548**	**395**	**410**	**333**	**365**	**357**	**293**	**438**

Source: NMFS 2022.

[1]Includes 43 species that were caught by commercial fishing vessels in the Project 1 WEA.

Table B.3-3. Number of commercial fishing vessel trips to the Project 2 WEA by species and year, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Surfclam	297	121	153	81	0	266	347	193	143	145	175
Black sea bass	127	116	147	141	88	88	70	78	77	67	100
Sea scallop	183	154	140	100	86	117	81	39	20	53	97
Monkfish	142	152	139	123	89	88	52	60	58	45	95
Longfin squid	135	109	88	126	80	91	57	66	77	48	88
Summer flounder	132	113	114	123	81	69	53	63	68	61	88
American lobster	55	57	43	56	58	59	58	55	39	50	53
Bluefish	67	80	82	72	32	38	27	10	15	22	45
Scup	58	50	73	59	20	30	22	23	30	34	40
Butterfish	50	35	40	45	19	29	26	39	43	19	35
Shortfin squid	64	30	23	31	16	29	19	24	25	20	28
Channeled whelk	0	0	0	6	13	0	67	47	48	74	26
Silver hake	24	17	21	38	11	12	23	22	30	23	22
John dory	33	32	26	19	25	29	24	17	0	0	21
Jonah crab	18	25	30	23	30	16	22	8	14	15	20
Atlantic mackerel	22	7	8	14	5	0	10	23	24	10	12
Skates	9	16	23	21	13	9	11	9	0	8	12
Smooth dogfish	6	10	14	9	12	3	8	10	9	14	10
Atlantic croaker	20	12	18	22	12	10	0	0	0	0	9
Conger eel	0	0	0	7	7	11	14	12	21	0	7
All species	**1,554**	**1,227**	**1,292**	**1,156**	**725**	**1,017**	**1,024**	**834**	**763**	**742**	**1,033**

Source: NMFS 2022.

[1]Includes 43 species that were caught by commercial fishing vessels in the Project 2 WEA.

Table B.3-4. Number of commercial fishing vessels that visited the Project 2 WEA by species and year, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Summer flounder	78	62	58	69	54	46	33	39	42	37	52
Monkfish	80	73	61	68	52	48	30	36	33	35	52
Sea scallop	74	66	66	57	42	74	50	34	18	33	51
Longfin squid	53	47	38	62	48	43	29	35	40	33	43
Black sea bass	48	44	51	61	41	41	28	31	31	28	40
Bluefish	46	46	39	45	28	26	21	9	11	15	29
Scup	39	34	40	43	17	21	16	17	23	27	28
Butterfish	24	20	18	24	12	16	16	21	28	16	20
Silver hake	17	8	15	24	6	9	16	17	23	17	15
Surfclam	20	16	14	11	0	15	16	15	13	11	13
John dory	15	16	15	10	8	13	12	14	0	0	10
American lobster	9	15	10	7	6	12	10	7	6	8	9
Atlantic mackerel	14	6	5	9	3	0	9	11	18	7	8
Shortfin squid	11	9	8	9	5	7	7	8	9	6	8
Skates	9	11	9	12	8	6	10	5	0	8	8
Smooth dogfish	5	8	7	8	9	3	5	8	4	9	7
Atlantic croaker	14	7	8	10	8	8	0	0	0	0	6
Jonah crab	4	6	5	3	4	5	6	3	3	5	4
King whiting	9	9	5	8	0	0	0	7	0	5	4
Weakfish	0	9	16	0	4	0	0	0	0	9	4
All species	**613**	**553**	**539**	**563**	**376**	**414**	**345**	**346**	**335**	**324**	**441**

Source: NMFS 2022.

[1]Includes 43 species that were caught by commercial fishing vessels in the Project 2 WEA.

Table B.3-5. Number of commercial fishing vessel trips to the combined Project 1 and Project 2 WEAs species and year, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Surfclam	297	121	153	81	131	266	347	193	143	145	188
Black sea bass	129	116	147	141	88	88	77	93	77	75	103
Sea scallop	183	154	140	100	86	117	81	39	21	53	97
Monkfish	142	152	139	123	89	88	52	60	58	45	95
Summer flounder	134	113	114	123	119	69	56	63	68	61	92
Longfin squid	139	109	88	126	80	91	57	66	78	49	88
American lobster	63	66	61	59	65	64	66	67	45	61	62
Channeled whelk	0	87	53	8	21	33	72	62	58	84	48
Bluefish	73	84	82	72	34	38	27	10	19	22	46
Scup	58	50	73	59	20	30	22	23	30	34	40
Butterfish	53	47	44	50	19	29	26	39	43	19	37
Shortfin squid	68	32	24	31	16	29	19	24	26	20	29
Jonah crab	22	35	41	27	40	25	29	12	14	15	26
Silver hake	24	17	21	38	11	12	23	23	30	23	22
John dory	33	33	28	19	25	32	24	17	0	0	21
Skates	12	19	23	28	64	10	12	11	0	8	19
Smooth dogfish	20	23	14	17	14	9	20	18	10	17	16
Atlantic mackerel	22	7	8	14	5	5	10	26	24	10	13
Atlantic croaker	23	21	20	27	15	10	0	0	0	0	12
Spiny dogfish	18	14	21	0	25	4	0	0	0	11	9
All species	**1,669**	**1,450**	**1,426**	**1,228**	**1,071**	**1,105**	**1,075**	**942**	**815**	**785**	**1,157**

Source: NMFS 2022.
[1]Includes 45 species that were caught by commercial fishing vessels in the combined Project 1 and 2 WEAs.

Table B.3-6. Number of commercial fishing vessels that visited the combined Project 1 and Project 2 WEAs by species and year, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Sea scallop	74	66	66	57	42	74	56	34	19	33	52
Summer flounder	78	62	58	69	54	46	33	39	42	37	52
Monkfish	80	73	61	68	52	48	30	36	33	35	52
Longfin squid	53	47	38	62	48	43	29	35	40	33	43
Black sea bass	48	44	51	61	41	41	28	31	32	28	41
Bluefish	46	46	39	45	28	26	21	10	14	15	29
Scup	39	34	40	43	17	21	16	17	23	27	28
Butterfish	25	20	19	24	13	16	16	21	28	16	20
Silver hake	17	8	15	24	6	9	16	17	23	17	15
Surfclam	20	16	14	12	10	15	16	15	13	11	14
John dory	16	16	15	10	8	13	14	14	0	0	11
American lobster	9	15	10	7	6	12	10	9	11	8	10
Atlantic mackerel	14	6	5	9	4	5	9	12	18	7	9
Skates	11	11	10	12	11	6	10	7	0	8	9
Shortfin squid	11	9	8	9	5	7	8	8	9	6	8
Smooth dogfish	7	10	7	9	9	5	7	10	4	9	8
Channeled whelk	0	7	5	4	9	8	8	7	10	6	6
Weakfish	14	9	18	0	6	0	0	0	8	9	6
Atlantic croaker	14	10	9	11	9	8	0	0	0	0	6
Jonah crab	4	6	6	4	5	7	6	4	3	5	5
All species	**644**	**577**	**559**	**581**	**408**	**450**	**358**	**375**	**372**	**330**	**465**

Source: NMFS 2022.

[1]Includes 45 species that were caught by commercial fishing vessels in the combined Project 1 and 2 WEAs.

Table B.3-7. Number of commercial fishing vessel trips to the Project 1 WEA by fishing port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Atlantic City, NJ	396	306	239	150	233	314	365	231	171	194	260
Cape May, NJ	77	77	77	85	59	72	65	38	48	48	65
Barnegat, NJ	42	7	73	22	22	8	14	39	0	34	26
Point Judith, RI	20	14	15	17	6	21	13	14	23	16	16
New Bedford, MA	22	12	14	5	6	23	20	13	20	23	16
Newport News, VA	38	25	29	12	0	0	7	7	4	0	12
Hampton, VA	17	26	23	0	4	10	5	0	12	7	10
Sea Isle City, NJ	14	0	43	0	0	11	0	0	0	0	7
Beaufort, NC	0	0	0	10	10	5	7	11	6	5	5
Point Pleasant, NJ	11	6	4	0	8	6	10	4	0	5	5
Ocean City, MD	11	6	0	10	0	5	0	5	4	0	4
North Kingstown, RI	37	0	0	0	0	0	0	0	0	0	4
Davisville, RI	0	0	17	18	0	0	0	0	0	0	4
Wanchese, NC	10	0	0	12	0	6	0	0	0	0	3
Chincoteague, VA	0	9	7	0	0	0	0	0	0	0	2
Montauk, NY	3	0	0	0	0	0	0	0	0	0	0
Wildwood, NJ	0	0	0	0	0	0	0	3	0	0	0
All ports	**698**	**488**	**541**	**341**	**348**	**481**	**506**	**365**	**288**	**332**	**439**

Source: NMFS 2022.

Table B.3-8. Number of commercial fishing vessels that visited the Project 1 WEA by fishing port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Cape May, NJ	32	35	38	41	35	37	30	24	20	25	32
Atlantic City, NJ	28	26	18	17	16	16	18	19	14	12	18
New Bedford, MA	14	8	13	4	5	18	20	8	9	15	11
Point Judith, RI	6	3	7	12	3	11	9	10	17	13	9
Newport News, VA	24	17	19	12	0	0	6	7	4	0	9
Barnegat, NJ	9	6	12	9	6	6	8	10	0	10	8
Hampton, VA	10	14	11	0	4	8	5	0	6	7	7
Beaufort, NC	0	0	0	9	10	5	6	9	6	5	5
Point Pleasant, NJ	8	6	4	0	5	4	10	4	0	5	5
Ocean City, MD	6	5	0	3	0	4	0	4	3	0	3
Wanchese, NC	8	0	0	9	0	5	0	0	0	0	2
Chincoteague, VA	0	5	5	0	0	0	0	0	0	0	1
Sea Isle City, NJ	4	0	3	0	0	3	0	0	0	0	1
Davisville, RI	0	0	3	4	0	0	0	0	0	0	1
Montauk, NY	3	0	0	0	0	0	0	0	0	0	0
North Kingstown, RI	3	0	0	0	0	0	0	0	0	0	0
Wildwood, NJ	0	0	0	0	0	0	0	3	0	0	0
All ports	**155**	**125**	**133**	**120**	**84**	**117**	**112**	**98**	**79**	**92**	**112**

Source: NMFS 2022.

Table B.3-9. Number of commercial fishing vessel trips to the Project 2 WEA by fishing port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Atlantic City, NJ	492	313	274	179	242	356	432	241	186	197	291
Cape May, NJ	65	71	72	82	46	75	48	36	36	45	58
Barnegat, NJ	0	13	73	15	22	8	14	35	0	36	22
Point Judith, RI	20	14	17	17	0	22	14	16	27	15	16
New Bedford, MA	20	13	17	5	6	23	18	13	20	22	16
Newport News, VA	40	30	32	13	0	0	6	6	3	0	13
Hampton, VA	20	31	25	0	4	11	8	0	12	10	12
Point Pleasant, NJ	12	6	7	8	8	7	10	4	22	7	9
Beaufort, NC	0	0	0	10	10	8	11	11	7	3	6
Ocean City, MD	11	6	0	11	0	3	0	0	4	5	4
North Kingstown, RI	38	0	0	0	0	0	0	0	0	0	4
Davisville, RI	0	0	17	18	0	0	0	0	0	0	4
Wanchese, NC	11	0	3	15	0	6	0	0	0	0	4
Chincoteague, VA	0	10	8	0	0	0	0	0	0	0	2
Oriental, NC	4	0	0	0	0	0	0	0	0	0	0
Sea Isle City, NJ	4	0	0	0	0	0	0	0	0	0	0
Montauk, NY	3	0	0	0	0	0	0	0	0	0	0
Wildwood, NJ	0	0	0	0	0	0	0	3	0	0	0
All ports	**740**	**507**	**545**	**373**	**338**	**519**	**561**	**365**	**317**	**340**	**461**

Source: NMFS 2022.

Table B.3-10. Number of commercial fishing vessels that visited the Project 2 WEA by fishing port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Cape May, NJ	30	32	38	43	29	39	28	24	19	25	31
Atlantic City, NJ	28	27	17	17	18	16	18	19	15	12	19
New Bedford, MA	15	9	16	4	5	18	17	9	8	15	12
Newport News, VA	25	21	20	12	0	0	5	6	3	0	9
Point Judith, RI	7	3	7	12	0	12	9	10	17	12	9
Hampton, VA	12	16	11	0	4	9	7	0	6	8	7
Barnegat, NJ	0	8	11	8	7	6	7	9	0	10	7
Point Pleasant, NJ	8	6	7	8	5	4	10	4	4	7	6
Beaufort, NC	0	0	0	9	10	7	10	9	7	3	6
Wanchese, NC	9	0	3	12	0	5	0	0	0	0	3
Ocean City, MD	6	5	0	3	0	3	0	0	3	3	2
Chincoteague, VA	0	5	5	0	0	0	0	0	0	0	1
Davisville, RI	0	0	3	4	0	0	0	0	0	0	1
Montauk, NY	3	0	0	0	0	0	0	0	0	0	0
North Kingstown, RI	3	0	0	0	0	0	0	0	0	0	0
Oriental, NC	3	0	0	0	0	0	0	0	0	0	0
Sea Isle City, NJ	3	0	0	0	0	0	0	0	0	0	0
Wildwood, NJ	0	0	0	0	0	0	0	3	0	0	0
All ports	**152**	**132**	**138**	**132**	**78**	**119**	**111**	**93**	**82**	**95**	**113**

Source: NMFS 2022.

Table B.3-11. Number of commercial fishing vessel trips to the combined Project 1 and Project 2 WEAs by fishing port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Atlantic City, NJ	492	313	274	179	242	356	432	241	186	197	291
Cape May, NJ	77	77	77	85	59	75	65	38	48	48	65
Barnegat, NJ	42	13	73	22	22	8	14	39	0	36	27
Point Judith, RI	20	14	17	17	6	22	14	16	27	16	17
New Bedford, MA	22	13	17	5	6	23	20	13	20	23	16
Newport News, VA	40	30	32	13	0	0	7	7	4	0	13
Hampton, VA	20	31	25	0	4	11	8	0	12	10	12
Point Pleasant, NJ	12	6	7	8	8	7	10	4	22	7	9
Sea Isle City, NJ	14	0	43	0	0	11	0	0	0	0	7
Beaufort, NC	0	0	0	10	10	8	11	11	7	5	6
Ocean City, MD	11	6	0	11	0	5	0	5	4	5	5
North Kingstown, RI	38	0	0	0	0	0	0	0	0	0	4
Davisville, RI	0	0	17	18	0	0	0	0	0	0	4
Wanchese, NC	11	0	3	15	0	6	0	0	0	0	4
Chincoteague, VA	0	10	8	0	0	0	0	0	0	0	2
Oriental, NC	4	0	0	0	0	0	0	0	0	0	0
Montauk, NY	3	0	0	0	0	0	0	0	0	0	0
Wildwood, NJ	0	0	0	0	0	0	0	3	0	0	0
All ports	**806**	**513**	**593**	**383**	**357**	**532**	**581**	**377**	**330**	**347**	**482**

Source: NMFS 2022.

Table B.3-12. Number of commercial fishing vessels that visited the combined Project 1 and Project 2 WEAs by port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Cape May, NJ	32	35	38	43	35	39	30	24	20	25	32
Atlantic City, NJ	28	27	18	17	18	16	18	19	15	12	19
New Bedford, MA	15	9	16	4	5	18	20	9	9	15	12
Newport News, VA	25	21	20	12	0	0	6	7	4	0	10
Point Judith, RI	7	3	7	12	3	12	9	10	17	13	9
Barnegat, NJ	9	8	12	9	7	6	8	10	0	10	8
Hampton, VA	12	16	11	0	4	9	7	0	6	8	7
Point Pleasant, NJ	8	6	7	8	5	4	10	4	4	7	6
Beaufort, NC	0	0	0	9	10	7	10	9	7	5	6
Wanchese, NC	9	0	3	12	0	5	0	0	0	0	3
Ocean City, MD	6	5	0	3	0	4	0	4	3	3	3
Chincoteague, VA	0	5	5	0	0	0	0	0	0	0	1
Sea Isle City, NJ	4	0	3	0	0	3	0	0	0	0	1
Davisville, RI	0	0	3	4	0	0	0	0	0	0	1
Montauk, NY	3	0	0	0	0	0	0	0	0	0	0
North Kingstown, RI	3	0	0	0	0	0	0	0	0	0	0
Oriental, NC	3	0	0	0	0	0	0	0	0	0	0
Wildwood, NJ	0	0	0	0	0	0	0	3	0	0	0
All ports	**164**	**135**	**143**	**133**	**87**	**123**	**118**	**99**	**85**	**98**	**119**

Source: NMFS 2022.

Table B.3-13. Number of commercial fishing vessel trips to the Project 1 WEA by fishing gear type and year, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Dredge-clam	256	161	172	75	163	258	308	189	137	156	188
Trawl-bottom	215	139	154	182	147	98	70	86	118	90	130
Pot-other	71	54	64	56	65	55	52	64	41	70	59
Dredge-scallop	70	70	71	68	35	55	36	21	12	16	45
Gillnet-sink	30	36	0	35	0	9	0	13	0	0	12
Pot-lobster	5	6	4	0	0	4	19	10	0	0	5
All gears	**647**	**466**	**465**	**416**	**410**	**479**	**485**	**383**	**308**	**332**	**439**

Source: NMFS 2022.

Table B.3-14. Number of commercial fishing vessels that visited the Project 1 WEA by fishing gear type and year, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Trawl-bottom	78	58	62	76	54	47	40	45	50	47	56
Dredge-scallop	53	42	50	43	21	36	34	18	11	13	32
Dredge-clam	22	20	14	12	11	15	16	16	13	11	15
Pot-other	4	5	5	5	5	5	3	6	5	8	5
Gillnet-sink	6	5	0	6	0	3	0	6	0	0	3
Pot-lobster	4	5	3	0	0	3	5	5	0	0	3
All gears	**167**	**135**	**134**	**142**	**91**	**109**	**98**	**96**	**79**	**79**	**113**

Source: NMFS 2022.

Table B.3-15. Number of commercial fishing vessel trips to the Project 2 WEA by fishing gear type and year, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Dredge-clam	384	161	198	91	170	296	375	199	152	156	218
Trawl-bottom	209	147	171	193	114	112	75	91	118	90	132
Dredge-scallop	86	98	90	83	37	60	35	22	11	17	54
Pot-other	63	44	46	52	57	47	45	48	37	59	50
Pot-lobster	5	5	0	0	0	0	16	9	0	0	4
Gillnet-sink	0	6	0	9	0	0	0	5	0	0	2
All gears	**747**	**461**	**505**	**428**	**378**	**515**	**546**	**374**	**318**	**322**	**459**

Source: NMFS 2022.

Table B.3-16. Number of commercial fishing vessels that visited the Project 2 WEA by fishing gear type and year, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Trawl-bottom	81	64	67	82	57	55	42	46	52	45	59
Dredge-scallop	57	52	55	45	22	38	30	19	10	14	34
Dredge-clam	22	20	14	11	14	15	16	16	14	11	15
Pot-other	4	5	4	4	4	3	3	3	3	6	4
Pot-lobster	4	4	0	0	0	0	5	4	0	0	2
Gillnet-sink	0	5	0	5	0	0	0	3	0	0	1
All gears	**168**	**150**	**140**	**147**	**97**	**111**	**96**	**91**	**79**	**76**	**116**

Source: NMFS 2022.

Table B.3-17. Number of commercial fishing vessel trips to the combined Project 1 and Project 2 WEAs by gear type and year, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Dredge-clam	384	161	198	91	170	296	375	199	152	156	218
Trawl-bottom	215	147	171	193	147	112	75	91	118	90	136
Pot-other	71	54	64	56	65	55	52	64	41	70	59
Dredge-scallop	86	98	90	83	37	60	36	22	12	17	54
Gillnet-sink	30	36	0	35	0	9	0	13	0	0	12
Pot-lobster	5	6	4	0	0	4	19	10	0	0	5
All gears	**791**	**502**	**527**	**458**	**419**	**536**	**557**	**399**	**323**	**333**	**485**

Source: NMFS 2022.

Table B.3-18. Number of commercial fishing vessels that visited the combined Project 1 and Project 2 WEAs by gear type and year, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Trawl-bottom	81	64	67	82	57	55	42	46	52	47	59
Dredge-scallop	57	52	55	45	22	38	34	19	11	14	35
Dredge-clam	22	20	14	12	14	15	16	16	14	11	15
Pot-other	4	5	5	5	5	5	3	6	5	8	5
Gillnet-sink	6	5	0	6	0	3	0	6	0	0	3
Pot-lobster	4	5	3	0	0	3	5	5	0	0	3
All gears	**174**	**151**	**144**	**150**	**98**	**119**	**100**	**98**	**82**	**80**	**120**

Source: NMFS 2022.

Table B.3-19. Commercial fishing landings (pounds) in the Project 1 WEA by species and year, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Surfclam	331,913	277,578	214,498	73,577	69,208	317,554	309,548	298,893	136,282	152,388	218,144
Sea scallop	8,177	7,648	8,062	5,538	7,119	8,826	4,550	4,122	2,061	14,647	7,075
Shortfin squid	28,576	4,533	638	1,692	1,649	4,104	2,461	2,711	10,369	13,865	7,060
Longfin squid	5,097	3,064	4,737	2,209	2,490	5,417	1,897	4,982	4,196	3,739	3,783
Menhaden	0	10,701	0	15,039	0	0	0	4,311	0	0	3,005
Black sea bass	3,054	2,846	2,822	2,778	1,850	1,631	1,134	2,265	3,337	1,272	2,299
Summer flounder	3,128	1,739	1,822	1,646	2,014	366	460	288	484	627	1,257
Atlantic herring	1,377	0	1,454	6,917	443	0	0	0	0	0	1,019
American lobster	692	632	867	1,406	1,686	1,072	1,488	915	689	501	995
Channeled whelk	0	3,826	2,758	202	18	66	1,732	239	248	676	977
Smooth dogfish	102	923	99	64	96	78	3,157	2,452	202	628	780
Atlantic mackerel	80	99	34	216	839	5	287	4,503	1,004	576	764
Atlantic croaker	527	651	1,724	931	2,193	9	0	0	0	0	604
Scup	610	58	1,278	260	1,964	159	45	25	455	895	575
Skates	569	54	218	1,905	371	839	36	1,322	0	23	534
Ocean quahog	4,870	0	0	0	0	0	0	0	0	0	487
Jonah crab	448	353	902	666	517	305	481	55	0	59	379
Dogfish spiny	429	812	502	0	797	186	0	0	0	0	273
Silver hake	77	1,607	9	16	1	2	9	23	27	37	181
All others	9,072	2,657	9,418	3,619	43,153	1,122	389,242	3,825	57,785	11,367	53,126
All species	**399,608**	**320,473**	**252,722**	**119,399**	**137,510**	**342,742**	**717,050**	**331,628**	**217,674**	**201,638**	**304,044**

Source: NMFS 2022.
[1]Includes 43 species that were caught by commercial fishing vessels in the Project 1 WEA.

Table B.3-20. Commercial fishing revenue (2019 dollars) in the Project 1 WEA by species and year, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Surfclam	$248,368	$189,378	$151,355	$38,283	$40,340	$155,856	$178,183	$181,846	$68,869	$83,762	$133,624
Sea scallop	$86,663	$83,462	$99,756	$70,166	$92,445	$114,018	$43,747	$39,014	$18,402	$177,026	$82,470
Channeled whelk	$0	$27,195	$20,218	$1,846	$125	$498	$14,316	$2,269	$1,939	$5,073	$7,348
Black sea bass	$8,471	$6,820	$7,558	$7,840	$4,661	$4,432	$2,860	$5,633	$7,774	$2,700	$5,875
American lobster	$2,895	$2,639	$4,099	$6,763	$8,025	$5,320	$7,249	$4,899	$3,679	$2,471	$4,804
Longfin squid	$6,185	$3,998	$5,772	$2,373	$2,706	$7,794	$2,547	$5,770	$5,475	$4,567	$4,719
Shortfin squid	$17,579	$2,416	$245	$632	$560	$2,612	$1,289	$1,799	$6,734	$8,422	$4,229
Summer flounder	$5,232	$3,983	$4,973	$4,668	$6,924	$1,094	$2,076	$1,178	$1,688	$1,780	$3,360
Smooth dogfish	$59	$921	$60	$53	$53	$62	$3,720	$1,565	$197	$560	$725
Menhaden	$0	$1,178	$0	$2,416	$0	$0	$0	$554	$0	$0	$415
Ocean quahog	$4,108	$0	$0	$0	$0	$0	$0	$0	$0	$0	$411
Atlantic mackerel	$43	$57	$17	$145	$653	$1	$111	$1,629	$399	$303	$336
Scup	$341	$49	$730	$120	$848	$114	$32	$12	$368	$617	$323
Atlantic croaker	$365	$231	$760	$187	$1,328	$8	$0	$0	$0	$0	$288
Jonah crab	$182	$152	$811	$332	$508	$256	$453	$56	$0	$90	$284
Skates	$225	$20	$121	$1,348	$147	$248	$7	$526	$0	$6	$265
Monkfish	$314	$325	$468	$451	$489	$198	$74	$41	$93	$10	$246
Tautog	$286	$0	$200	$0	$1,148	$0	$0	$205	$0	$0	$184
Atlantic herring	$190	$0	$417	$872	$148	$0	$0	$0	$0	$0	$163
All others	$19,223	$5,967	$6,125	$2,651	$31,867	$885	$44,657	$2,150	$27,159	$1,898	$14,258
All species	**$401,786**	**$330,722**	**$304,168**	**$141,538**	**$193,459**	**$293,636**	**$301,641**	**$249,547**	**$143,196**	**$289,570**	**$264,926**

Source: NMFS 2022.

[1]Includes 43 species that were caught by commercial fishing vessels in the Project 1 WEA.

Table B.3-21. Commercial fishing landings (pounds) in the Project 2 WEA by species and year, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Surfclam	370,757	142,977	406,535	117,624	0	526,981	423,057	241,191	143,419	180,922	255,346
Sea scallop	6,531	10,983	8,626	6,056	2,777	6,545	2,390	3,475	1,288	6,034	5,471
Shortfin squid	19,254	3,147	443	1,295	1,134	2,725	1,236	2,917	7,142	9,796	4,909
Longfin squid	3,998	2,073	3,438	1,626	1,886	3,859	1,414	4,082	3,278	2,705	2,836
Summer flounder	2,544	1,356	989	1,927	1,143	445	277	272	384	451	979
Atlantic mackerel	59	940	25	146	337	0	226	5,454	689	395	827
Ocean quahog	7,576	0	0	0	0	0	0	0	0	0	758
Menhaden	0	0	0	5,055	0	0	0	2,113	0	0	717
Black sea bass	731	679	874	869	434	530	312	637	1,074	441	658
Atlantic croaker	234	420	2,496	526	1,955	11	0	0	0	0	564
Scup	537	61	1,384	308	1,422	148	60	23	323	768	503
Skates	94	30	70	1,090	43	1,788	29	227	0	13	338
Smooth dogfish	39	612	35	10	23	2	739	373	138	617	259
American lobster	132	106	179	357	308	286	307	191	162	78	211
Dogfish spiny	62	382	4	0	0	0	0	0	0	1,309	176
Clearnose skate	0	0	0	0	43	1,162	0	0	0	0	121
Monkfish	206	152	219	94	68	183	45	43	90	6	111
Silver hake	109	880	6	12	1	1	10	18	22	30	109
Butterfish	108	21	63	56	84	74	177	84	129	178	97
All others	1,834	1,475	4,709	6,394	129,906	466	233,040	3,941	13,690	6,505	40,196
All species	**415,080**	**166,585**	**430,725**	**143,651**	**141,756**	**545,311**	**663,982**	**265,140**	**172,020**	**210,457**	**315,471**

Source: NMFS 2022.

[1]Includes 43 species that were caught by commercial fishing vessels in the Project 2 WEA.

Table B.3-22. Commercial fishing revenue (2019 dollars) in the Project 2 WEA by species and year, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Surfclam	$245,072	$95,117	$283,140	$57,628	$0	$269,997	$255,532	$151,342	$75,750	$90,889	$152,447
Sea scallop	$71,407	$117,017	$107,039	$76,055	$37,104	$85,075	$22,553	$32,156	$11,577	$67,075	$62,706
Longfin squid	$4,844	$2,725	$4,204	$1,728	$2,076	$5,544	$1,891	$4,751	$4,349	$3,307	$3,542
Shortfin squid	$11,852	$1,677	$171	$487	$385	$1,748	$743	$1,945	$4,609	$5,959	$2,958
Summer flounder	$4,273	$3,181	$2,265	$5,879	$3,591	$1,522	$1,217	$1,053	$1,359	$1,285	$2,563
Black sea bass	$2,169	$1,905	$2,664	$2,636	$1,138	$1,514	$765	$1,585	$2,682	$762	$1,782
American lobster	$600	$450	$834	$1,693	$1,469	$1,431	$1,513	$1,050	$846	$385	$1,027
Ocean quahog	$6,844	$0	$0	$0	$0	$0	$0	$0	$0	$0	$684
Channeled whelk	$0	$0	$0	$346	$15	$0	$4,140	$698	$199	$1,119	$652
Atlantic mackerel	$32	$543	$12	$99	$261	$0	$94	$1,991	$274	$208	$351
Atlantic croaker	$168	$144	$1,130	$117	$1,209	$7	$0	$0	$0	$0	$278
Scup	$266	$48	$730	$136	$578	$104	$43	$10	$232	$536	$268
Monkfish	$454	$397	$541	$200	$162	$380	$129	$78	$177	$9	$253
Smooth dogfish	$23	$640	$19	$11	$13	$2	$887	$235	$133	$550	$251
Skates	$38	$13	$39	$665	$8	$523	$7	$87	$0	$3	$138
Menhaden	$0	$0	$0	$873	$0	$0	$0	$268	$0	$0	$114
Silver hake	$136	$533	$3	$5	$1	$1	$12	$13	$21	$27	$75
Jonah crab	$32	$22	$291	$39	$67	$50	$62	$6	$24	$21	$61
Butterfish	$54	$12	$40	$29	$56	$37	$92	$60	$66	$117	$56
All others	$1,878	$6,605	$9,745	$1,302	$59,367	$387	$26,183	$2,147	$34,520	$953	$14,309
All species	**$350,437**	**$231,273**	**$413,140**	**$150,017**	**$107,706**	**$368,503**	**$315,932**	**$199,495**	**$136,973**	**$173,490**	**$244,696**

Source: NMFS 2022.

[1]Includes 43 species that were caught by commercial fishing vessels in the Project 2 WEA.

Table B.3-23. Commercial fishing landings (pounds) in the combined Project 1 and Project 2 WEAs by species and year, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Surfclam	611,046	346,777	546,454	161,835	69,208	701,340	624,054	465,728	240,417	279,337	404,620
Sea scallop	12,622	16,052	13,201	9,501	8,935	13,066	5,934	6,451	2,815	18,523	10,710
Shortfin squid	41,415	6,423	937	2,453	2,406	5,858	3,219	4,473	15,101	20,036	10,232
Longfin squid	7,868	4,399	6,955	3,280	3,758	7,943	2,828	7,608	6,228	5,542	5,641
Menhaden	0	10,701	0	18,070	0	0	0	5,606	0	0	3,438
Black sea bass	3,493	3,246	3,329	3,235	2,086	1,924	1,316	2,592	3,868	1,560	2,665
Summer flounder	4,884	2,697	2,478	3,065	2,790	703	655	476	726	938	1,941
Atlantic mackerel	121	958	51	313	1,001	5	395	8,487	1,464	840	1,364
Ocean quahog	11,410	0	0	0	0	0	0	0	0	0	1,141
American lobster	770	696	963	1,565	1,840	1,235	1,657	1,000	767	540	1,103
Channeled whelk	0	3,826	2,758	223	19	66	2,037	293	248	758	1,023
Atlantic herring	1,377	0	1,454	6,917	443	0	0	0	0	0	1,019
Atlantic croaker	686	928	3,566	1,269	3,317	18	0	0	0	0	978
Scup	978	103	2,220	470	2,979	261	87	40	655	1,405	920
Smooth dogfish	132	1,219	122	71	112	78	3,527	2,590	304	836	899
Skates	632	75	262	2,286	389	2,305	58	1,420	0	32	746
Dogfish spiny	463	1,010	502	0	797	186	0	0	0	1,309	427
Jonah crab	487	381	1,122	666	560	339	512	55	21	67	421
Silver hake	166	2,046	13	24	2	3	16	34	40	57	240
All others	10,171	3,165	12,578	7,487	141,013	1,405	436,727	6,707	67,225	15,239	70,172
All species	**709,922**	**405,665**	**600,215**	**223,609**	**242,942**	**738,898**	**1,083,749**	**514,353**	**340,656**	**347,511**	**520,752**

Source: NMFS 2022.

[1]Includes 45 species that were caught by commercial fishing vessels in the combined Project 1 and Project 2 WEAs.

Table B.3-24. Commercial fishing revenue (2019 dollars) in the combined Project 1 and Project 2 WEAs by species and year, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Surfclam	$426,350	$233,734	$382,066	$81,323	$40,340	$353,239	$371,229	$289,150	$123,699	$142,672	$244,380
Sea scallop	$135,598	$172,658	$164,071	$119,842	$116,705	$169,136	$56,649	$60,784	$25,173	$220,253	$124,087
Channeled whelk	$0	$27,195	$20,218	$2,034	$134	$498	$16,913	$2,784	$1,939	$5,720	$7,743
Longfin squid	$9,530	$5,764	$8,484	$3,507	$4,106	$11,427	$3,795	$8,822	$8,148	$6,769	$7,035
Black sea bass	$9,791	$7,976	$9,141	$9,297	$5,289	$5,287	$3,287	$6,436	$9,146	$3,152	$6,880
Shortfin squid	$25,482	$3,445	$361	$922	$817	$3,748	$1,763	$2,975	$9,792	$12,181	$6,149
American lobster	$3,254	$2,909	$4,544	$7,520	$8,760	$6,140	$8,081	$5,364	$4,088	$2,663	$5,332
Summer flounder	$8,186	$6,267	$6,450	$9,077	$9,338	$2,272	$2,935	$1,903	$2,548	$2,691	$5,167
Ocean quahog	$10,039	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,004
Smooth dogfish	$77	$1,229	$72	$61	$62	$62	$4,163	$1,651	$295	$745	$842
Atlantic mackerel	$65	$553	$25	$212	$777	$1	$164	$3,086	$582	$442	$591
Scup	$521	$84	$1,227	$214	$1,257	$185	$64	$19	$510	$982	$506
Menhaden	$0	$1,178	$0	$2,936	$0	$0	$0	$718	$0	$0	$483
Atlantic croaker	$481	$325	$1,603	$261	$2,026	$14	$0	$0	$0	$0	$471
Monkfish	$683	$622	$829	$579	$604	$504	$173	$106	$231	$16	$435
Skates	$251	$30	$146	$1,532	$150	$677	$12	$562	$0	$8	$337
Jonah crab	$200	$164	$995	$332	$545	$285	$482	$56	$24	$101	$318
Tautog	$286	$0	$272	$0	$1,221	$0	$0	$205	$0	$0	$198
Atlantic herring	$190	$0	$417	$872	$148	$0	$0	$0	$0	$0	$163
All others	$20,168	$8,776	$11,819	$3,430	$76,191	$1,121	$50,315	$3,748	$54,971	$2,474	$23,301
All species	**$652,548**	**$475,254**	**$613,367**	**$244,418**	**$269,030**	**$555,005**	**$520,445**	**$388,826**	**$241,721**	**$401,516**	**$436,213**

Source: NMFS 2022.

[1]Includes 45 species that were caught by commercial fishing vessels in the combined Project 1 and Project 2 WEAs.

Table B.3-25. Commercial fishing landings in the Project 1 WEA as a percentage of commercial fishing landings in the geographic analysis area by species, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Surfclam	0.803	0.701	0.527	0.184	0.165	0.791	0.836	0.838	0.406	0.560	0.581
American eel	0.213	0.137	1.076	0.000	0.000	0.000	0.045	0.008	0.038	0.000	0.152
Black sea bass	0.228	0.214	0.159	0.149	0.106	0.081	0.036	0.086	0.125	0.040	0.122
Channeled whelk	0.000	0.330	0.232	0.021	0.002	0.008	0.270	0.028	0.035	0.126	0.105
Smooth dogfish	0.006	0.073	0.008	0.006	0.011	0.011	0.377	0.287	0.027	0.106	0.091
Conger eel	0.000	0.000	0.000	0.109	0.486	0.040	0.081	0.061	0.107	0.000	0.088
Tautog	0.133	0.000	0.062	0.000	0.383	0.000	0.000	0.146	0.000	0.000	0.072
Clearnose skate	0.000	0.000	0.000	0.016	0.083	0.351	0.000	0.000	0.000	0.000	0.045
Shortfin squid	0.067	0.018	0.008	0.009	0.031	0.028	0.005	0.005	0.017	0.022	0.021
Atlantic croaker	0.010	0.017	0.046	0.022	0.073	0.000	0.000	0.000	0.000	0.000	0.017
Sea scallop	0.014	0.013	0.020	0.017	0.020	0.022	0.009	0.007	0.003	0.031	0.016
Longfin squid	0.023	0.011	0.019	0.009	0.010	0.014	0.011	0.020	0.015	0.019	0.015
Triggerfish	0.000	0.000	0.000	0.100	0.000	0.000	0.036	0.014	0.000	0.000	0.015
Rock crab	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.132	0.000	0.000	0.013
Summer flounder	0.020	0.015	0.016	0.016	0.021	0.005	0.009	0.005	0.006	0.008	0.012
Menhaden	0.000	0.015	0.000	0.047	0.000	0.000	0.000	0.008	0.000	0.000	0.007
Bluefish	0.005	0.008	0.004	0.009	0.002	0.001	0.004	0.001	0.021	0.009	0.006
Swordfish	0.017	0.002	0.006	0.018	0.000	0.000	0.000	0.000	0.018	0.000	0.006
Atlantic mackerel	0.006	0.001	0.000	0.002	0.007	0.000	0.002	0.023	0.009	0.003	0.005
John dory	0.004	0.003	0.005	0.006	0.009	0.011	0.009	0.004	0.000	0.000	0.005

Source: NMFS 2022.

Table B.3-26. Commercial fishing revenue in the Project 1 WEA as a percentage of commercial fishing revenue in the geographic analysis area by species, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Surfclam	0.776	0.591	0.475	0.124	0.119	0.482	0.582	0.631	0.258	0.388	0.443
Smooth dogfish	0.005	0.094	0.007	0.006	0.008	0.011	0.563	0.225	0.032	0.110	0.106
Channeled whelk	0.000	0.339	0.258	0.024	0.001	0.007	0.263	0.028	0.032	0.102	0.105
Black sea bass	0.164	0.133	0.117	0.118	0.072	0.057	0.029	0.061	0.085	0.036	0.087
Conger eel	0.000	0.000	0.000	0.074	0.465	0.026	0.063	0.045	0.089	0.000	0.076
Tautog	0.066	0.000	0.049	0.000	0.370	0.000	0.000	0.080	0.000	0.000	0.057
Clearnose skate	0.000	0.000	0.000	0.015	0.051	0.257	0.000	0.000	0.000	0.000	0.032
Shortfin squid	0.078	0.020	0.009	0.010	0.033	0.034	0.006	0.008	0.024	0.035	0.026
Sea scallop	0.013	0.013	0.020	0.016	0.020	0.023	0.008	0.007	0.003	0.038	0.016
American eel	0.092	0.021	0.006	0.000	0.000	0.000	0.026	0.000	0.006	0.000	0.015
Triggerfish	0.000	0.000	0.000	0.112	0.000	0.000	0.019	0.016	0.000	0.000	0.015
Longfin squid	0.021	0.012	0.020	0.009	0.008	0.015	0.010	0.015	0.013	0.018	0.014
Summer flounder	0.017	0.014	0.018	0.016	0.024	0.004	0.009	0.005	0.007	0.009	0.012
Rock crab	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.117	0.000	0.000	0.012
Atlantic croaker	0.011	0.008	0.027	0.006	0.058	0.000	0.000	0.000	0.000	0.000	0.011
Atlantic mackerel	0.008	0.001	0.001	0.004	0.016	0.000	0.003	0.037	0.015	0.006	0.009
Menhaden	0.000	0.018	0.000	0.059	0.000	0.000	0.000	0.009	0.000	0.000	0.009
Bluefish	0.005	0.008	0.004	0.009	0.003	0.002	0.004	0.001	0.016	0.011	0.006
Swordfish	0.015	0.001	0.004	0.018	0.000	0.000	0.000	0.000	0.021	0.000	0.006
Other fish	0.000	0.000	0.000	0.000	0.000	0.000	0.054	0.000	0.000	0.000	0.005

Source: NMFS 2022.

Table B.3-27. Commercial fishing landings in the Project 2 WEA as a percentage of commercial fishing landings in the geographic analysis area by species, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Surfclam	0.897	0.361	1.000	0.295	0.000	1.312	1.143	0.676	0.427	0.664	0.678
Clearnose skate	0.000	0.000	0.000	0.000	0.029	0.577	0.000	0.000	0.000	0.000	0.061
Black sea bass	0.055	0.051	0.049	0.046	0.025	0.026	0.010	0.024	0.040	0.014	0.034
Smooth dogfish	0.002	0.048	0.003	0.001	0.003	0.000	0.088	0.044	0.018	0.104	0.031
American eel	0.025	0.013	0.135	0.000	0.000	0.000	0.011	0.000	0.000	0.000	0.018
Atlantic croaker	0.004	0.011	0.066	0.013	0.065	0.000	0.000	0.000	0.000	0.000	0.016
Shortfin squid	0.045	0.012	0.005	0.007	0.021	0.019	0.002	0.006	0.012	0.016	0.014
Conger eel	0.000	0.000	0.000	0.017	0.055	0.004	0.021	0.007	0.020	0.000	0.012
Sea scallop	0.011	0.019	0.021	0.018	0.008	0.016	0.005	0.006	0.002	0.013	0.012
Channeled whelk	0.000	0.000	0.000	0.004	0.000	0.000	0.076	0.009	0.004	0.027	0.012
Longfin squid	0.018	0.008	0.014	0.006	0.007	0.010	0.008	0.016	0.012	0.013	0.011
Summer flounder	0.017	0.012	0.009	0.019	0.012	0.006	0.005	0.005	0.005	0.006	0.010
Tautog	0.000	0.000	0.017	0.000	0.051	0.000	0.000	0.000	0.000	0.000	0.007
Atlantic mackerel	0.005	0.008	0.000	0.001	0.003	0.000	0.001	0.028	0.006	0.002	0.005
Swordfish	0.012	0.001	0.003	0.012	0.000	0.011	0.000	0.000	0.013	0.000	0.005
Triggerfish	0.000	0.000	0.000	0.033	0.000	0.000	0.006	0.000	0.000	0.000	0.004
Scup	0.004	0.001	0.009	0.002	0.010	0.001	0.000	0.000	0.003	0.007	0.004
John dory	0.003	0.002	0.005	0.004	0.006	0.007	0.007	0.003	0.000	0.000	0.004
Bluefish	0.005	0.004	0.003	0.002	0.001	0.001	0.003	0.000	0.012	0.006	0.004
Butterfish	0.009	0.002	0.003	0.001	0.002	0.003	0.002	0.002	0.002	0.003	0.003

Source: NMFS 2022.

Table B.3-28. Commercial fishing revenue in the Project 2 WEA as a percentage of commercial fishing revenue in the geographic analysis area by species, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Surfclam	0.765	0.297	0.889	0.187	0.000	0.835	0.835	0.525	0.284	0.421	0.504
Smooth dogfish	0.002	0.065	0.002	0.001	0.002	0.000	0.134	0.034	0.021	0.108	0.037
Clearnose skate	0.000	0.000	0.000	0.000	0.018	0.344	0.000	0.000	0.000	0.000	0.036
Black sea bass	0.042	0.037	0.041	0.040	0.018	0.020	0.008	0.017	0.029	0.010	0.026
Shortfin squid	0.053	0.014	0.007	0.008	0.023	0.023	0.003	0.008	0.016	0.025	0.018
Sea scallop	0.011	0.019	0.021	0.017	0.008	0.017	0.004	0.006	0.002	0.014	0.012
Channeled whelk	0.000	0.000	0.000	0.005	0.000	0.000	0.076	0.009	0.003	0.023	0.012
Atlantic croaker	0.005	0.005	0.040	0.004	0.053	0.000	0.000	0.000	0.000	0.000	0.011
Conger eel	0.000	0.000	0.000	0.011	0.050	0.005	0.016	0.006	0.018	0.000	0.011
Longfin squid	0.016	0.008	0.015	0.006	0.006	0.011	0.007	0.012	0.010	0.013	0.011
Summer flounder	0.014	0.011	0.008	0.021	0.012	0.006	0.006	0.005	0.006	0.006	0.009
Atlantic mackerel	0.006	0.012	0.001	0.003	0.007	0.000	0.002	0.045	0.010	0.004	0.009
Tautog	0.000	0.000	0.024	0.000	0.046	0.000	0.000	0.000	0.000	0.000	0.007
Swordfish	0.010	0.000	0.003	0.011	0.000	0.014	0.000	0.000	0.015	0.000	0.005
Other fish	0.000	0.000	0.000	0.000	0.000	0.000	0.045	0.000	0.000	0.000	0.004
Triggerfish	0.000	0.000	0.000	0.037	0.000	0.000	0.003	0.000	0.000	0.000	0.004
Bluefish	0.006	0.005	0.003	0.002	0.001	0.001	0.002	0.000	0.009	0.007	0.004
Scup	0.004	0.001	0.008	0.002	0.006	0.001	0.000	0.000	0.003	0.007	0.003
Ocean quahog	0.027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
Menhaden	0.000	0.000	0.000	0.021	0.000	0.000	0.000	0.004	0.000	0.000	0.003

Source: NMFS 2022.

Table B.3-29. Commercial fishing landings in the combined Project 1 and Project 2 WEAs as a percentage of commercial fishing landings in the geographic analysis area by species, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Surfclam	1.478	0.876	1.344	0.405	0.165	1.746	1.686	1.306	0.716	1.026	1.075
American eel	0.224	0.150	1.141	0.000	0.000	0.000	0.045	0.008	0.038	0.000	0.161
Black sea bass	0.261	0.244	0.188	0.173	0.119	0.096	0.042	0.099	0.145	0.049	0.142
Channeled whelk	0.000	0.330	0.232	0.023	0.002	0.008	0.318	0.035	0.035	0.141	0.112
Smooth dogfish	0.007	0.096	0.010	0.006	0.013	0.011	0.422	0.303	0.040	0.141	0.105
Conger eel	0.000	0.000	0.000	0.117	0.515	0.042	0.093	0.064	0.116	0.000	0.095
Clearnose skate	0.000	0.000	0.000	0.016	0.097	0.815	0.000	0.000	0.000	0.000	0.093
Tautog	0.133	0.000	0.072	0.000	0.409	0.000	0.000	0.146	0.000	0.000	0.076
Shortfin squid	0.097	0.025	0.011	0.013	0.045	0.040	0.006	0.008	0.025	0.032	0.030
Atlantic croaker	0.013	0.024	0.095	0.030	0.111	0.001	0.000	0.000	0.000	0.000	0.027
Sea scallop	0.022	0.028	0.032	0.029	0.025	0.033	0.012	0.011	0.005	0.039	0.024
Longfin squid	0.036	0.016	0.029	0.013	0.015	0.021	0.016	0.031	0.023	0.028	0.023
Summer flounder	0.032	0.023	0.022	0.031	0.029	0.010	0.013	0.009	0.009	0.011	0.019
Triggerfish	0.000	0.000	0.000	0.117	0.000	0.000	0.042	0.014	0.000	0.000	0.017
Rock crab	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.132	0.000	0.000	0.013
Swordfish	0.025	0.002	0.008	0.026	0.000	0.011	0.000	0.000	0.026	0.000	0.010
Atlantic mackerel	0.009	0.008	0.001	0.002	0.008	0.000	0.003	0.044	0.013	0.005	0.009
Bluefish	0.008	0.011	0.006	0.010	0.003	0.002	0.005	0.001	0.029	0.013	0.009
Menhaden	0.000	0.015	0.000	0.057	0.000	0.000	0.000	0.011	0.000	0.000	0.008
John dory	0.006	0.005	0.008	0.008	0.013	0.015	0.013	0.006	0.000	0.000	0.007

Source: NMFS 2022.

Table B.3-30. Commercial fishing revenue in the combined Project 1 and Project 2 WEAs as a percentage of commercial fishing revenue in the geographic analysis area by species, 2011–2020

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Surfclam	1.332	0.730	1.200	0.263	0.119	1.092	1.213	1.003	0.463	0.661	0.808
Smooth dogfish	0.007	0.125	0.008	0.007	0.010	0.011	0.630	0.238	0.047	0.146	0.123
Channeled whelk	0.000	0.339	0.258	0.027	0.001	0.007	0.311	0.034	0.032	0.115	0.112
Black sea bass	0.190	0.156	0.141	0.139	0.082	0.068	0.033	0.069	0.100	0.043	0.102
Conger eel	0.000	0.000	0.000	0.080	0.492	0.028	0.071	0.048	0.097	0.000	0.082
Tautog	0.066	0.000	0.067	0.000	0.394	0.000	0.000	0.080	0.000	0.000	0.061
Clearnose skate	0.000	0.000	0.000	0.015	0.060	0.531	0.000	0.000	0.000	0.000	0.061
Shortfin squid	0.113	0.029	0.014	0.014	0.048	0.049	0.008	0.012	0.035	0.050	0.037
Sea scallop	0.021	0.028	0.032	0.027	0.025	0.033	0.011	0.011	0.004	0.047	0.024
Longfin squid	0.032	0.017	0.029	0.013	0.013	0.022	0.015	0.023	0.019	0.027	0.021
Summer flounder	0.027	0.021	0.023	0.032	0.032	0.009	0.013	0.009	0.010	0.013	0.019
Atlantic croaker	0.014	0.011	0.057	0.009	0.089	0.001	0.000	0.000	0.000	0.000	0.018
Triggerfish	0.000	0.000	0.000	0.130	0.000	0.000	0.022	0.016	0.000	0.000	0.017
American eel	0.096	0.022	0.006	0.000	0.000	0.000	0.026	0.000	0.006	0.000	0.016
Atlantic mackerel	0.011	0.012	0.001	0.006	0.019	0.000	0.004	0.070	0.021	0.009	0.015
Rock crab	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.117	0.000	0.000	0.012
Menhaden	0.000	0.018	0.000	0.071	0.000	0.000	0.000	0.012	0.000	0.000	0.010
Swordfish	0.021	0.001	0.006	0.025	0.000	0.014	0.000	0.000	0.031	0.000	0.010
Bluefish	0.010	0.011	0.006	0.010	0.003	0.002	0.005	0.001	0.022	0.015	0.008
Other fish	0.000	0.000	0.000	0.000	0.000	0.000	0.081	0.000	0.000	0.000	0.008

Source: NMFS 2022.

Table B.3-31. Commercial fishing landings (pounds) in the Project 1 WEA by fishing port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Atlantic City, NJ	344,284	286,702	218,685	78,600	98,169	315,573	312,747	302,517	140,453	153,045	225,078
Cape May, NJ	33,244	17,752	11,714	26,084	24,731	8,944	390,478	7,921	17,885	12,825	55,158
New Bedford, MA	840	955	3,606	143	337	1,570	3,326	1,223	2,085	15,399	2,948
Barnegat, NJ	380	877	4,373	2,667	927	2,330	3,422	5,123	0	2,252	2,235
Newport News, VA	3,319	3,147	1,310	1,639	0	0	301	188	156	0	1,006
Point Judith, RI	842	416	1,160	771	177	491	414	462	682	837	625
Davisville, RI	0	0	3,336	2,885	0	0	0	0	0	0	622
Hampton, VA	1,156	747	896	0	1,877	284	76	0	507	137	568
Sea Isle City, NJ	79	0	3,317	0	0	565	0	0	0	0	396
Ocean City, MD	812	1,546	0	430	0	746	0	123	113	0	377
Point Pleasant, NJ	646	58	27	0	27	1,842	61	116	0	512	329
North Kingstown, RI	2,143	0	0	0	0	0	0	0	0	0	214
Beaufort, NC	0	0	0	131	176	76	133	98	112	56	78
Wanchese, NC	274	0	0	251	0	60	0	0	0	0	59
Chincoteague, VA	0	259	98	0	0	0	0	0	0	0	36
Montauk, NY	111	0	0	0	0	0	0	0	0	0	11
Wildwood, NJ	0	0	0	0	0	0	0	48	0	0	5
All others	11,560	8,022	4,204	5,816	11,098	10,265	6,111	13,815	55,715	16,605	14,321
All ports	**399,690**	**320,481**	**252,726**	**119,417**	**137,519**	**342,746**	**717,069**	**331,634**	**217,708**	**201,668**	**304,066**

Source: NMFS 2022.

Table B.3-32. Commercial fishing revenue (2019 dollars) in the Project 1 WEA by fishing port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Atlantic City, NJ	$285,647	$238,230	$164,506	$53,053	$63,783	$162,160	$188,419	$192,291	$79,785	$88,835	$151,671
Cape May, NJ	$40,493	$31,035	$23,938	$27,791	$86,763	$48,283	$48,828	$16,111	$14,747	$15,369	$35,336
New Bedford, MA	$5,453	$8,106	$39,900	$1,047	$1,501	$17,235	$32,248	$5,381	$6,370	$153,052	$27,029
Newport News, VA	$18,767	$28,288	$11,689	$18,537	$0	$0	$2,743	$706	$1,157	$0	$8,189
Barnegat, NJ	$439	$1,143	$7,248	$3,209	$1,034	$28,772	$6,734	$14,232	$0	$5,887	$6,870
Sea Isle City, NJ	$214	$0	$20,665	$0	$0	$345	$0	$0	$0	$0	$2,122
Hampton, VA	$4,321	$2,060	$1,883	$0	$4,946	$2,262	$189	$0	$1,136	$127	$1,692
Point Pleasant, NJ	$1,305	$301	$72	$0	$370	$2,026	$269	$135	$0	$3,831	$831
Point Judith, RI	$874	$570	$1,273	$918	$207	$625	$647	$593	$978	$910	$760
Ocean City, MD	$1,098	$1,473	$0	$1,711	$0	$510	$0	$477	$361	$0	$563
Davisville, RI	$0	$0	$1,741	$1,475	$0	$0	$0	$0	$0	$0	$322
Beaufort, NC	$0	$0	$0	$297	$535	$171	$562	$229	$403	$110	$231
North Kingstown, RI	$1,549	$0	$0	$0	$0	$0	$0	$0	$0	$0	$155
Wanchese, NC	$376	$0	$0	$573	$0	$94	$0	$0	$0	$0	$104
Chincoteague, VA	$0	$476	$172	$0	$0	$0	$0	$0	$0	$0	$65
Wildwood, NJ	$0	$0	$0	$0	$0	$0	$0	$351	$0	$0	$35
Montauk, NY	$96	$0	$0	$0	$0	$0	$0	$0	$0	$0	$10
All others	$41,169	$19,052	$31,084	$32,951	$34,330	$31,172	$21,006	$19,044	$38,319	$21,450	$28,958
All ports	**$401,801**	**$330,732**	**$304,170**	**$141,561**	**$193,470**	**$293,657**	**$301,645**	**$249,549**	**$143,256**	**$289,571**	**$264,941**

Source: NMFS 2022.

Table B.3-33. Commercial fishing landings (pounds) in the Project 2 WEA by fishing port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Atlantic City, NJ	380,026	145,625	407,737	119,010	120,558	514,818	423,618	242,588	144,823	181,172	267,998
Cape May, NJ	18,999	5,219	4,631	13,524	12,886	7,825	233,980	4,411	2,414	7,895	31,178
New Bedford, MA	611	963	3,765	425	408	1,344	1,131	1,173	1,638	5,925	1,738
Barnegat, NJ	0	757	5,084	920	2,360	414	1,072	1,356	0	2,585	1,455
Newport News, VA	2,910	5,987	1,217	1,985	0	0	219	152	42	0	1,251
Point Pleasant, NJ	246	68	32	41	83	7,214	79	276	131	544	871
Ocean City, MD	430	449	0	603	0	5,716	0	0	115	69	738
North Kingstown, RI	6,370	0	0	0	0	0	0	0	0	0	637
Point Judith, RI	626	357	935	577	0	447	333	555	786	708	532
Davisville, RI	0	0	2,302	2,051	0	0	0	0	0	0	435
Hampton, VA	878	637	816	0	657	299	107	0	379	100	387
Beaufort, NC	0	0	0	147	152	74	94	105	77	42	69
Wanchese, NC	264	0	64	215	0	43	0	0	0	0	59
Chincoteague, VA	0	165	98	0	0	0	0	0	0	0	26
Montauk, NY	93	0	0	0	0	0	0	0	0	0	9
Wildwood, NJ	0	0	0	0	0	0	0	70	0	0	7
Oriental, NC	19	0	0	0	0	0	0	0	0	0	2
Sea Isle City, NJ	8	0	0	0	0	0	0	0	0	0	1
All others	3,616	6,368	4,045	4,165	4,654	7,128	3,360	14,458	21,643	11,439	8,088
All ports	**415,096**	**166,595**	**430,726**	**143,663**	**141,758**	**545,322**	**663,993**	**265,144**	**172,048**	**210,479**	**315,482**

Source: NMFS 2022.

Table B.3-34. Commercial fishing revenue (2019 dollars) in the Project 2 WEA by fishing port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Atlantic City, NJ	$264,907	$115,154	$290,157	$62,824	$59,332	$264,305	$257,649	$154,349	$78,725	$91,984	$163,939
Cape May, NJ	$24,155	$25,360	$21,442	$27,831	$28,193	$45,121	$30,960	$8,541	$6,921	$11,525	$23,005
New Bedford, MA	$4,174	$8,770	$42,596	$3,055	$3,290	$15,299	$10,985	$6,860	$5,201	$44,897	$14,513
Newport News, VA	$18,020	$57,044	$11,523	$22,241	$0	$0	$1,918	$385	$333	$0	$11,146
Barnegat, NJ	$0	$2,035	$9,124	$1,195	$3,846	$4,927	$3,305	$7,107	$0	$4,183	$3,572
Point Pleasant, NJ	$1,037	$379	$212	$59	$1,048	$5,393	$288	$277	$291	$4,170	$1,315
Hampton, VA	$3,222	$1,851	$1,675	$0	$1,732	$2,503	$257	$0	$850	$96	$1,218
Ocean City, MD	$571	$459	$0	$2,520	$0	$4,149	$0	$0	$378	$81	$816
Point Judith, RI	$659	$492	$1,040	$684	$0	$588	$569	$680	$1,129	$738	$658
North Kingstown, RI	$4,573	$0	$0	$0	$0	$0	$0	$0	$0	$0	$457
Davisville, RI	$0	$0	$1,197	$1,057	$0	$0	$0	$0	$0	$0	$225
Beaufort, NC	$0	$0	$0	$294	$461	$178	$356	$269	$281	$78	$192
Wanchese, NC	$366	$0	$97	$474	$0	$76	$0	$0	$0	$0	$101
Wildwood, NJ	$0	$0	$0	$0	$0	$0	$0	$560	$0	$0	$56
Chincoteague, VA	$0	$306	$171	$0	$0	$0	$0	$0	$0	$0	$48
Montauk, NY	$86	$0	$0	$0	$0	$0	$0	$0	$0	$0	$9
Oriental, NC	$30	$0	$0	$0	$0	$0	$0	$0	$0	$0	$3
Sea Isle City, NJ	$18	$0	$0	$0	$0	$0	$0	$0	$0	$0	$2
All others	$28,636	$19,438	$33,910	$27,808	$9,816	$25,980	$9,642	$20,462	$42,906	$15,740	$23,434
All ports	**$350,453**	**$231,289**	**$413,144**	**$150,042**	**$107,718**	**$368,520**	**$315,931**	**$199,490**	**$137,015**	**$173,491**	**$244,709**

Source: NMFS 2022.

Table B.3-35. Commercial fishing landings (pounds) in the combined Project 1 and Project 2 WEAs by fishing port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Atlantic City, NJ	631,232	357,611	551,396	167,546	190,303	687,878	627,566	470,329	245,391	280,161	420,941
Cape May, NJ	45,908	20,915	14,667	34,261	32,686	14,463	438,449	10,705	19,371	17,715	64,914
New Bedford, MA	1,226	1,664	5,353	425	641	2,440	3,905	2,016	3,126	19,315	4,011
Barnegat, NJ	380	1,289	8,214	2,667	2,360	2,515	4,013	5,868	0	4,064	3,137
Newport News, VA	5,250	8,024	2,132	3,001	0	0	411	291	156	0	1,927
Point Pleasant, NJ	819	106	52	41	83	8,481	122	317	131	710	1,086
Ocean City, MD	994	1,567	0	885	0	6,152	0	123	184	69	997
Point Judith, RI	1,252	667	1,782	1,156	177	791	635	808	1,149	1,300	972
Davisville, RI	0	0	4,880	4,272	0	0	0	0	0	0	915
Hampton, VA	1,743	1,180	1,463	0	2,260	486	163	0	753	192	824
North Kingstown, RI	6,370	0	0	0	0	0	0	0	0	0	637
Sea Isle City, NJ	79	0	3,317	0	0	565	0	0	0	0	396
Beaufort, NC	0	0	0	229	281	126	201	171	158	85	125
Wanchese, NC	446	0	64	404	0	89	0	0	0	0	100
Chincoteague, VA	0	367	161	0	0	0	0	0	0	0	53
Montauk, NY	172	0	0	0	0	0	0	0	0	0	17
Wildwood, NJ	0	0	0	0	0	0	0	91	0	0	9
Oriental, NC	19	0	0	0	0	0	0	0	0	0	2
All others	14,123	12,289	6,741	8,744	14,158	14,923	8,310	23,642	70,290	23,942	19,716
All ports	**710,013**	**405,679**	**600,222**	**223,631**	**242,949**	**738,909**	**1,083,775**	**514,361**	**340,709**	**347,553**	**520,780**

Source: NMFS 2022.

Table B.3-36. Commercial fishing revenue (2019 dollars) in the combined Project 1 and Project 2 WEAs by fishing port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Atlantic City, NJ	$479,888	$296,736	$400,377	$99,042	$107,970	$353,312	$382,663	$301,313	$136,126	$148,379	$270,581
Cape May, NJ	$55,765	$47,104	$38,140	$44,742	$104,677	$78,601	$57,522	$21,822	$19,076	$23,009	$49,046
New Bedford, MA	$8,136	$14,696	$59,347	$3,055	$4,110	$27,081	$37,871	$10,325	$9,601	$182,951	$35,717
Newport News, VA	$30,607	$74,940	$19,448	$33,585	$0	$0	$3,674	$956	$1,157	$0	$16,437
Barnegat, NJ	$439	$2,598	$14,512	$3,209	$3,846	$30,890	$8,811	$18,946	$0	$8,501	$9,175
Hampton, VA	$6,489	$3,309	$2,936	$0	$5,955	$3,883	$399	$0	$1,692	$186	$2,485
Sea Isle City, NJ	$214	$0	$20,665	$0	$0	$345	$0	$0	$0	$0	$2,122
Point Pleasant, NJ	$1,887	$561	$260	$59	$1,048	$6,727	$485	$335	$291	$5,085	$1,674
Ocean City, MD	$1,336	$1,516	$0	$3,625	$0	$4,428	$0	$477	$601	$81	$1,206
Point Judith, RI	$1,305	$916	$1,962	$1,374	$207	$1,026	$1,023	$1,022	$1,653	$1,399	$1,189
Davisville, RI	$0	$0	$2,540	$2,192	$0	$0	$0	$0	$0	$0	$473
North Kingstown, RI	$4,573	$0	$0	$0	$0	$0	$0	$0	$0	$0	$457
Beaufort, NC	$0	$0	$0	$492	$852	$291	$816	$419	$573	$163	$361
Wanchese, NC	$616	$0	$97	$906	$0	$149	$0	$0	$0	$0	$177
Chincoteague, VA	$0	$677	$281	$0	$0	$0	$0	$0	$0	$0	$96
Wildwood, NJ	$0	$0	$0	$0	$0	$0	$0	$693	$0	$0	$69
Montauk, NY	$151	$0	$0	$0	$0	$0	$0	$0	$0	$0	$15
Oriental, NC	$30	$0	$0	$0	$0	$0	$0	$0	$0	$0	$3
All others	$61,136	$32,220	$52,808	$52,168	$40,377	$48,306	$27,184	$32,518	$71,040	$31,764	$44,952
All ports	**$652,572**	**$475,272**	**$613,372**	**$244,449**	**$269,044**	**$555,038**	**$520,448**	**$388,825**	**$241,810**	**$401,517**	**$436,235**

Source: NMFS 2022.

Table B.3-37. Commercial fishing landings in the Project 1 WEA as a percentage of commercial fishing landings in the geographic analysis area by fishing port, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Atlantic City, NJ	1.150	1.036	0.782	0.262	0.369	1.285	1.260	1.200	0.600	0.870	0.881
Cape May, NJ	0.037	0.020	0.027	0.053	0.044	0.016	0.515	0.009	0.024	0.019	0.076
Sea Isle City, NJ	0.010	0.000	0.409	0.000	0.000	0.076	0.000	0.000	0.000	0.000	0.050
Barnegat, NJ	0.005	0.015	0.061	0.049	0.020	0.039	0.054	0.103	0.000	0.048	0.039
Newport News, VA	0.044	0.056	0.030	0.061	0.000	0.000	0.015	0.008	0.006	0.000	0.022
Hampton, VA	0.020	0.017	0.018	0.000	0.051	0.007	0.001	0.000	0.009	0.003	0.013
Ocean City, MD	0.010	0.028	0.000	0.009	0.000	0.016	0.000	0.003	0.003	0.000	0.007
Beaufort, NC	0.000	0.000	0.000	0.009	0.007	0.004	0.005	0.004	0.005	0.003	0.004
Davisville, RI	0.000	0.000	0.016	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.004
New Bedford, MA	0.001	0.001	0.003	0.000	0.000	0.002	0.003	0.001	0.002	0.014	0.003
Point Pleasant, NJ	0.003	0.000	0.000	0.000	0.000	0.011	0.000	0.001	0.000	0.003	0.002
Point Judith, RI	0.002	0.001	0.002	0.001	0.000	0.001	0.001	0.001	0.002	0.002	0.001
Chincoteague, VA	0.000	0.009	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
North Kingstown, RI	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Wanchese, NC	0.003	0.000	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.000	0.001
Wildwood, NJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.001
Montauk, NY	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Source: NMFS 2022.

Table B.3-38. Commercial fishing revenue in the Project 1 WEA as a percentage of commercial fishing revenue in the geographic analysis area by fishing port, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Atlantic City, NJ	1.076	0.898	0.643	0.215	0.289	0.769	0.942	0.988	0.461	0.698	0.698
Sea Isle City, NJ	0.011	0.000	1.040	0.000	0.000	0.019	0.000	0.000	0.000	0.000	0.107
Cape May, NJ	0.033	0.035	0.053	0.041	0.117	0.052	0.060	0.022	0.017	0.019	0.045
Newport News, VA	0.034	0.081	0.054	0.101	0.000	0.000	0.020	0.004	0.007	0.000	0.030
Barnegat, NJ	0.001	0.004	0.026	0.013	0.004	0.110	0.029	0.061	0.000	0.028	0.028
Hampton, VA	0.022	0.014	0.022	0.000	0.036	0.011	0.001	0.000	0.009	0.001	0.012
Ocean City, MD	0.015	0.026	0.000	0.026	0.000	0.008	0.000	0.007	0.005	0.000	0.009
New Bedford, MA	0.001	0.002	0.010	0.000	0.000	0.005	0.008	0.001	0.001	0.042	0.007
Beaufort, NC	0.000	0.000	0.000	0.008	0.008	0.003	0.007	0.004	0.007	0.002	0.004
Davisville, RI	0.000	0.000	0.015	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.003
Point Pleasant, NJ	0.004	0.001	0.000	0.000	0.001	0.006	0.001	0.000	0.000	0.013	0.003
Point Judith, RI	0.002	0.001	0.003	0.002	0.000	0.001	0.001	0.001	0.002	0.002	0.002
Wanchese, NC	0.006	0.000	0.000	0.007	0.000	0.001	0.000	0.000	0.000	0.000	0.001
Chincoteague, VA	0.000	0.009	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
North Kingstown, RI	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Wildwood, NJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.001
Montauk, NY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Source: NMFS 2022.

Table B.3-39. Commercial fishing landings in the Project 2 WEA as a percentage of commercial fishing landings in the geographic analysis area by fishing port, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Atlantic City, NJ	1.270	0.526	1.458	0.397	0.453	2.096	1.706	0.962	0.618	1.030	1.052
Cape May, NJ	0.021	0.006	0.010	0.028	0.023	0.014	0.309	0.005	0.003	0.012	0.043
Newport News, VA	0.038	0.106	0.028	0.073	0.000	0.000	0.011	0.007	0.002	0.000	0.027
Barnegat, NJ	0.000	0.013	0.071	0.017	0.050	0.007	0.017	0.027	0.000	0.055	0.026
Ocean City, MD	0.005	0.008	0.000	0.012	0.000	0.125	0.000	0.000	0.003	0.003	0.016
Hampton, VA	0.015	0.015	0.017	0.000	0.018	0.007	0.002	0.000	0.007	0.002	0.008
Point Pleasant, NJ	0.001	0.000	0.000	0.000	0.001	0.043	0.000	0.002	0.001	0.004	0.005
Beaufort, NC	0.000	0.000	0.000	0.010	0.006	0.004	0.004	0.005	0.004	0.002	0.004
North Kingstown, RI	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
Davisville, RI	0.000	0.000	0.011	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.003
New Bedford, MA	0.001	0.001	0.003	0.000	0.000	0.001	0.001	0.001	0.002	0.005	0.002
Point Judith, RI	0.002	0.001	0.002	0.001	0.000	0.001	0.001	0.001	0.002	0.002	0.001
Wildwood, NJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000	0.001
Wanchese, NC	0.003	0.000	0.002	0.004	0.000	0.001	0.000	0.000	0.000	0.000	0.001
Chincoteague, VA	0.000	0.005	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Oriental, NC	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sea Isle City, NJ	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Montauk, NY	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Source: NMFS 2022.

Table B.3-40. Commercial fishing revenue in the Project 2 WEA as a percentage of commercial fishing revenue in the geographic analysis area by fishing port, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Atlantic City, NJ	0.998	0.434	1.134	0.255	0.269	1.253	1.289	0.793	0.455	0.722	0.760
Newport News, VA	0.033	0.164	0.053	0.121	0.000	0.000	0.014	0.002	0.002	0.000	0.039
Cape May, NJ	0.020	0.029	0.048	0.041	0.038	0.049	0.038	0.012	0.008	0.014	0.030
Barnegat, NJ	0.000	0.006	0.032	0.005	0.015	0.019	0.014	0.031	0.000	0.020	0.014
Ocean City, MD	0.008	0.008	0.000	0.039	0.000	0.063	0.000	0.000	0.005	0.001	0.012
Hampton, VA	0.017	0.012	0.020	0.000	0.013	0.012	0.001	0.000	0.006	0.001	0.008
Point Pleasant, NJ	0.003	0.001	0.001	0.000	0.003	0.015	0.001	0.001	0.001	0.014	0.004
New Bedford, MA	0.001	0.002	0.010	0.001	0.001	0.004	0.003	0.002	0.001	0.012	0.004
Beaufort, NC	0.000	0.000	0.000	0.008	0.007	0.003	0.004	0.005	0.005	0.001	0.003
North Kingstown, RI	0.027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
Davisville, RI	0.000	0.000	0.010	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Wanchese, NC	0.005	0.000	0.003	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Point Judith, RI	0.002	0.001	0.002	0.001	0.000	0.001	0.001	0.001	0.002	0.002	0.001
Wildwood, NJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000	0.001
Chincoteague, VA	0.000	0.006	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Oriental, NC	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sea Isle City, NJ	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Montauk, NY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Source: NMFS 2022.

Table B.3-41. Commercial fishing landings in the combined Project 1 and Project 2 WEAs as a percentage of commercial fishing landings in the geographic analysis area by fishing port, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Atlantic City, NJ	2.109	1.292	1.972	0.560	0.716	2.801	2.528	1.865	1.047	1.592	1.648
Cape May, NJ	0.052	0.023	0.033	0.070	0.058	0.026	0.579	0.012	0.027	0.026	0.091
Barnegat, NJ	0.005	0.022	0.115	0.049	0.050	0.042	0.064	0.118	0.000	0.087	0.055
Sea Isle City, NJ	0.010	0.000	0.409	0.000	0.000	0.076	0.000	0.000	0.000	0.000	0.050
Newport News, VA	0.069	0.143	0.049	0.111	0.000	0.000	0.020	0.012	0.006	0.000	0.041
Ocean City, MD	0.013	0.028	0.000	0.018	0.000	0.135	0.000	0.003	0.004	0.003	0.020
Hampton, VA	0.031	0.027	0.030	0.000	0.062	0.011	0.003	0.000	0.014	0.005	0.018
Point Pleasant, NJ	0.004	0.001	0.000	0.000	0.001	0.051	0.001	0.002	0.001	0.005	0.006
Beaufort, NC	0.000	0.000	0.000	0.016	0.011	0.007	0.008	0.008	0.008	0.004	0.006
Davisville, RI	0.000	0.000	0.023	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.005
New Bedford, MA	0.001	0.001	0.004	0.000	0.001	0.002	0.004	0.002	0.003	0.018	0.004
North Kingstown, RI	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
Point Judith, RI	0.004	0.002	0.004	0.002	0.000	0.002	0.002	0.002	0.003	0.003	0.002
Chincoteague, VA	0.000	0.012	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Wanchese, NC	0.005	0.000	0.002	0.007	0.000	0.002	0.000	0.000	0.000	0.000	0.002
Wildwood, NJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.000	0.000	0.001
Oriental, NC	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Montauk, NY	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Source: NMFS 2022.

Table B.3-42. Commercial fishing revenue in the combined Project 1 and Project 2 WEAs as a percentage of commercial fishing revenue in the geographic analysis area by fishing port, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Atlantic City, NJ	1.807	1.119	1.565	0.401	0.489	1.674	1.914	1.549	0.786	1.165	1.247
Sea Isle City, NJ	0.011	0.000	1.040	0.000	0.000	0.019	0.000	0.000	0.000	0.000	0.107
Cape May, NJ	0.045	0.053	0.085	0.066	0.141	0.085	0.070	0.030	0.022	0.028	0.063
Newport News, VA	0.056	0.215	0.089	0.183	0.000	0.000	0.027	0.006	0.007	0.000	0.058
Barnegat, NJ	0.001	0.008	0.052	0.013	0.015	0.118	0.037	0.081	0.000	0.041	0.037
Ocean City, MD	0.018	0.027	0.000	0.056	0.000	0.067	0.000	0.007	0.008	0.001	0.018
Hampton, VA	0.033	0.022	0.035	0.000	0.043	0.019	0.002	0.000	0.013	0.001	0.017
New Bedford, MA	0.002	0.003	0.014	0.001	0.001	0.008	0.009	0.002	0.002	0.050	0.009
Beaufort, NC	0.000	0.000	0.000	0.013	0.012	0.005	0.010	0.007	0.010	0.003	0.006
Davisville, RI	0.000	0.000	0.022	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.005
Point Pleasant, NJ	0.005	0.002	0.001	0.000	0.003	0.019	0.001	0.001	0.001	0.017	0.005
North Kingstown, RI	0.027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
Point Judith, RI	0.003	0.002	0.005	0.003	0.000	0.002	0.002	0.002	0.003	0.003	0.003
Wanchese, NC	0.009	0.000	0.003	0.011	0.000	0.001	0.000	0.000	0.000	0.000	0.002
Chincoteague, VA	0.000	0.013	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Wildwood, NJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.000	0.000	0.001
Oriental, NC	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Montauk, NY	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Source: NMFS 2022.

Table B.3-43. Commercial fishing landings (pounds) in the Project 1 WEA by fishing gear type and year, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Dredge-clam	337,113	279,410	214,594	73,577	97,553	317,616	310,015	299,377	136,322	152,394	221,797
All others	9,609	15,698	14,253	21,508	9,575	1,543	393,966	5,552	56,692	12,110	54,051
Trawl-bottom	39,524	12,887	11,654	10,987	18,798	11,624	4,755	14,736	18,495	20,072	16,353
Dredge-scallop	8,188	7,648	8,124	5,594	6,820	8,580	4,526	4,136	2,038	14,545	7,020
Pot-other	4,418	3,634	3,921	5,272	4,768	2,773	2,698	3,768	4,163	2,548	3,796
Gillnet-sink	778	1,191	0	2,476	0	245	0	3,846	0	0	854
Pot-lobster	64	13	102	0	0	365	1,110	220	0	0	187
All gears	**399,694**	**320,481**	**252,648**	**119,414**	**137,514**	**342,746**	**717,070**	**331,635**	**217,710**	**201,669**	**304,058**

Source: NMFS 2022.

Table B.3-44. Commercial fishing revenue (2019 dollars) in the Project 1 WEA by fishing gear type and year, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Dredge-clam	$255,734	$191,391	$152,072	$38,287	$54,171	$155,998	$178,768	$182,293	$68,947	$83,820	$136,148
Dredge-scallop	$82,252	$81,655	$99,121	$70,259	$88,027	$111,157	$43,481	$39,009	$18,177	$175,873	$80,901
All others	$19,678	$33,289	$27,685	$4,997	$6,321	$1,915	$60,241	$2,201	$28,911	$3,448	$18,869
Trawl-bottom	$32,329	$14,346	$14,256	$10,083	$14,670	$14,374	$5,465	$10,743	$16,300	$16,004	$14,857
Pot-other	$11,297	$8,979	$10,598	$16,088	$30,280	$9,592	$9,050	$12,291	$10,924	$10,429	$12,953
Pot-lobster	$197	$37	$429	$0	$0	$522	$4,642	$672	$0	$0	$650
Gillnet-sink	$314	$1,036	$0	$1,847	$0	$99	$0	$2,341	$0	$0	$564
All gears	**$401,801**	**$330,733**	**$304,161**	**$141,561**	**$193,469**	**$293,657**	**$301,647**	**$249,550**	**$143,259**	**$289,573**	**$264,941**

Source: NMFS 2022.

Table B.3-45. Commercial fishing landings (pounds) in the Project 2 WEA by fishing gear type and year, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Dredge-clam	378,845	143,451	406,658	117,627	120,363	527,131	423,107	242,121	143,773	180,933	268,401
All others	1,164	1,255	6,097	9,411	5,657	1,057	234,452	3,848	13,253	8,708	28,490
Trawl-bottom	27,910	9,669	8,476	8,604	12,352	10,141	3,353	14,842	13,173	14,458	12,298
Dredge-scallop	6,332	10,994	8,699	6,137	2,566	6,222	2,372	3,481	1,262	5,921	5,399
Pot-other	809	616	723	1,197	820	770	507	375	588	462	687
Gillnet-sink	0	612	0	686	0	0	0	369	0	0	167
Pot-lobster	37	2	0	0	0	0	203	108	0	0	35
All gears	**415,097**	**166,599**	**430,653**	**143,662**	**141,758**	**545,321**	**663,994**	**265,144**	**172,049**	**210,482**	**315,476**

Source: NMFS 2022.

Table B.3-46. Commercial fishing revenue (2019 dollars) in the Project 2 WEA by fishing gear type and year, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Dredge-clam	$256,955	$95,826	$284,191	$57,663	$56,460	$270,405	$255,781	$152,279	$76,142	$90,986	$159,669
Dredge-scallop	$65,591	$115,425	$106,184	$76,185	$33,788	$81,015	$22,322	$32,071	$11,311	$65,767	$60,966
Trawl-bottom	$23,829	$11,377	$9,518	$10,220	$9,200	$11,566	$3,788	$10,122	$12,038	$11,630	$11,329
All others	$1,839	$6,438	$11,245	$1,843	$4,038	$2,875	$31,502	$3,377	$36,090	$3,136	$10,238
Pot-other	$2,122	$1,577	$1,998	$3,650	$4,233	$2,658	$1,700	$1,174	$1,437	$1,974	$2,252
Gillnet-sink	$0	$638	$0	$484	$0	$0	$0	$223	$0	$0	$134
Pot-lobster	$109	$8	$0	$0	$0	$0	$839	$244	$0	$0	$120
All gears	**$350,445**	**$231,288**	**$413,137**	**$150,045**	**$107,718**	**$368,519**	**$315,931**	**$199,491**	**$137,018**	**$173,493**	**$244,709**

Source: NMFS 2022.

Table B.3-47. Commercial fishing landings (pounds) in the combined Project 1 and Project 2 WEAs by fishing gear type and year, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Dredge-clam	623,197	348,633	546,654	161,838	189,585	701,527	624,558	467,040	240,793	279,351	418,318
All others	10,251	16,350	18,541	27,115	13,176	2,278	442,116	8,142	65,903	17,648	62,152
Trawl-bottom	58,363	19,141	17,291	16,793	26,499	18,747	7,030	24,817	27,077	29,404	24,516
Dredge-scallop	12,459	16,084	13,287	9,609	8,504	12,558	5,899	6,465	2,775	18,375	10,602
Pot-other	4,883	3,978	4,271	5,798	5,182	3,188	2,971	3,768	4,163	2,781	4,098
Gillnet-sink	778	1,483	0	2,476	0	245	0	3,846	0	0	883
Pot-lobster	85	13	102	0	0	365	1,203	284	0	0	205
All gears	**710,016**	**405,682**	**600,146**	**223,629**	**242,946**	**738,908**	**1,083,777**	**514,362**	**340,711**	**347,559**	**520,774**

Source: NMFS 2022.

Table B.3-48. Commercial fishing revenue (2019 dollars) in the combined Project 1 and Project 2 WEAs by gear type and year, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Dredge-clam	$443,666	$235,919	$383,669	$81,358	$96,948	$353,728	$371,984	$290,436	$124,135	$142,794	$252,464
Dredge-scallop	$126,720	$169,874	$162,661	$120,014	$110,167	$162,952	$56,243	$60,696	$24,773	$218,502	$121,260
All others	$20,584	$36,258	$34,505	$6,120	$8,877	$4,387	$69,148	$4,784	$57,962	$5,088	$24,771
Trawl-bottom	$48,489	$21,980	$20,536	$17,420	$20,671	$22,305	$8,066	$17,491	$24,022	$23,664	$22,464
Pot-other	$12,537	$9,867	$11,563	$17,693	$32,381	$11,047	$9,981	$12,291	$10,924	$11,473	$13,976
Pot-lobster	$255	$37	$429	$0	$0	$522	$5,028	$790	$0	$0	$706
Gillnet-sink	$314	$1,338	$0	$1,847	$0	$99	$0	$2,341	$0	$0	$594
All gears	**$652,566**	**$475,273**	**$613,363**	**$244,452**	**$269,045**	**$555,039**	**$520,450**	**$388,828**	**$241,816**	**$401,522**	**$436,235**

Source: NMFS 2022.

Table B.3-49. Commercial fishing landings in the Project 1 WEA as a percentage of commercial fishing landings in the geographic analysis area by fishing gear type, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Pot-other	0.425	0.437	0.424	0.745	0.792	0.438	0.369	0.518	0.542	0.222	0.491
Dredge-clam	0.459	0.372	0.291	0.101	0.135	0.444	0.448	0.439	0.233	0.320	0.324
Dredge-scallop	0.015	0.014	0.021	0.018	0.040	0.064	0.021	0.030	0.012	0.116	0.035
Trawl-bottom	0.052	0.044	0.007	0.007	0.027	0.008	0.037	0.009	0.010	0.012	0.021
Gillnet-sink	0.002	0.003	0.000	0.007	0.000	0.001	0.000	0.014	0.000	0.000	0.003
Pot-lobster	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.001	0.000	0.000	0.001

Source: NMFS 2022.

Table B.3-50. Commercial fishing revenue in the Project 1 WEA as a percentage of commercial fishing revenue in the geographic analysis area by fishing gear type, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Pot-other	0.456	0.396	0.416	0.760	1.734	0.449	0.434	0.571	0.542	0.309	0.607
Dredge-clam	0.431	0.307	0.254	0.061	0.089	0.237	0.278	0.295	0.135	0.193	0.228
Dredge-scallop	0.013	0.014	0.020	0.017	0.040	0.066	0.020	0.029	0.012	0.142	0.037
Trawl-bottom	0.031	0.045	0.009	0.006	0.017	0.008	0.010	0.007	0.009	0.011	0.015
Gillnet-sink	0.001	0.003	0.000	0.006	0.000	0.000	0.000	0.011	0.000	0.000	0.002
Pot-lobster	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.001	0.000	0.000	0.001

Source: NMFS 2022.

Table B.3-51. Commercial fishing landings in the Project 2 WEA as a percentage of commercial fishing landings in the geographic analysis area by fishing gear type, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Dredge-clam	0.516	0.191	0.552	0.162	0.166	0.737	0.611	0.355	0.246	0.380	0.392
Pot-other	0.078	0.074	0.078	0.169	0.136	0.122	0.069	0.054	0.077	0.042	0.090
Dredge-scallop	0.011	0.020	0.022	0.019	0.021	0.046	0.015	0.031	0.007	0.041	0.023
Trawl-bottom	0.039	0.039	0.005	0.005	0.017	0.007	0.024	0.009	0.007	0.008	0.016
Gillnet-sink	0.000	0.002	0.000	0.002	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Pot-lobster	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000

Source: NMFS 2022.

Table B.3-52. Commercial fishing revenue in the Project 2 WEA as a percentage of commercial fishing revenue in the geographic analysis area by fishing gear type, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Dredge-clam	0.433	0.154	0.474	0.092	0.093	0.412	0.398	0.246	0.149	0.210	0.266
Pot-other	0.086	0.070	0.078	0.172	0.242	0.124	0.081	0.063	0.071	0.055	0.104
Dredge-scallop	0.011	0.020	0.022	0.018	0.021	0.048	0.014	0.029	0.007	0.046	0.024
Trawl-bottom	0.024	0.041	0.006	0.006	0.010	0.007	0.008	0.006	0.007	0.008	0.012
Gillnet-sink	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Pot-lobster	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000

Source: NMFS 2022.

Table B.3-53. Commercial fishing landings in the combined Project 1 and Project 2 WEAs as a percentage of commercial fishing landings in the geographic analysis area by fishing gear type, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Dredge-clam	0.849	0.465	0.743	0.223	0.261	0.981	0.902	0.685	0.411	0.586	0.611
Pot-other	0.469	0.478	0.462	0.819	0.861	0.503	0.406	0.518	0.542	0.245	0.531
Dredge-scallop	0.023	0.030	0.034	0.030	0.054	0.091	0.030	0.051	0.017	0.144	0.050
Trawl-bottom	0.078	0.069	0.011	0.010	0.037	0.013	0.050	0.015	0.015	0.017	0.032
Gillnet-sink	0.002	0.004	0.000	0.007	0.000	0.001	0.000	0.014	0.000	0.000	0.003
Pot-lobster	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.001	0.000	0.000	0.001

Source: NMFS 2022.

Table B.3-54. Commercial fishing revenue in the combined Project 1 and Project 2 WEAs as a percentage of commercial fishing revenue in the geographic analysis area by fishing gear type, 2011–2020

Gear	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Pot-other	0.506	0.435	0.454	0.836	1.854	0.517	0.478	0.571	0.542	0.337	0.653
Dredge-clam	0.748	0.378	0.640	0.129	0.160	0.538	0.578	0.470	0.243	0.329	0.421
Dredge-scallop	0.021	0.029	0.033	0.028	0.054	0.096	0.029	0.048	0.016	0.173	0.053
Trawl-bottom	0.047	0.072	0.013	0.011	0.023	0.013	0.015	0.011	0.014	0.016	0.023
Gillnet-sink	0.001	0.003	0.000	0.006	0.000	0.000	0.000	0.011	0.000	0.000	0.002
Pot-lobster	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.001	0.000	0.000	0.001

Source: NMFS 2022.

Table B.3-55. Number of for-hire recreational fishing vessel trips to the Project 1 WEA by fishing port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Atlantic City, NJ	49	30	0	0	39	0	0	0	0	0	12
Other Ports, NJ	6	4	23	31	4	17	14	8	2	2	11
Long Beach, NJ	5	0	0	0	0	0	0	0	0	0	1
Total	**60**	**34**	**23**	**31**	**43**	**17**	**14**	**8**	**2**	**2**	**23**

Source: NMFS 2022.

Table B.3-56. Number of for-hire recreational angler trips to the Project 1 WEA by fishing port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Other Ports, NJ	55	97	186	197	18	128	153	58	12	11	92
Atlantic City, NJ	307	180	0	0	266	0	0	0	0	0	75
Long Beach, NJ	43	0	0	0	0	0	0	0	0	0	4
Total	**405**	**277**	**186**	**197**	**284**	**128**	**153**	**58**	**12**	**11**	**171**

Source: NMFS 2022.

Table B.3-57. Number of for-hire recreational fishing vessel trips to the Project 2 WEA by fishing port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Other Ports, NJ	2	5	4	2	5	2	2	1	0	0	2

Source: NMFS 2022.

Table B.3-58. Number of for-hire recreational angler trips to the Project 2 WEA by fishing port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Other Ports, NJ	11	27	81	12	51	21	53	8	0	0	26

Source: NMFS 2022.

Table B.3-59. Number of for-hire recreational fishing vessel trips to the combined Project 1 and Project 2 WEAs by fishing port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Other Ports, NJ	8	8	25	31	8	18	14	8	2	2	12
Atlantic City, NJ	49	30	0	0	39	0	0	0	0	0	12
Long Beach, NJ	5	0	0	0	0	0	0	0	0	0	1
Total	**62**	**38**	**25**	**31**	**47**	**18**	**14**	**8**	**2**	**2**	**25**

Source: NMFS 2022.

Table B.3-60. Number of for-hire recreational angler trips to the combined Project 1 and Project 2 WEAs by fishing port and year, 2011–2020

Port	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annual Average
Other Ports, NJ	66	118	257	197	63	132	153	58	12	11	107
Atlantic City, NJ	307	180	0	0	266	0	0	0	0	0	75
Long Beach, NJ	43	0	0	0	0	0	0	0	0	0	4
Total	**416**	**298**	**257**	**197**	**329**	**132**	**153**	**58**	**12**	**11**	**186**

Source: NMFS 2022.

B.3.1 References Cited

National Marine Fisheries Service (NMFS). 2022. Socioeconomic Impacts of Atlantic Offshore Wind Development. Available: https://www.fisheries.noaa.gov/resource/data/socioeconomic-impacts-atlantic-offshore-wind-development. Accessed: May 2022.

B.4 Demographics, Employment, and Economics

Table B.4-1. Population trends, 2000–2020

Jurisdiction	Population 2000	Population 2010	Population 2020	% Change 2000–2020	% Change 2010–2020
State of New Jersey	**8,414,350**	**8,791,881**	**9,288,994**	**10.4**	**5.7**
Atlantic County	252,552	274,549	274,534	8.7	0.01
Cape May County	102,326	97,265	95,263	-6.9	-2.1
Gloucester County	254,673	288,274	302,294	18.7	4.9
Monmouth County	615,301	630,364	643,615	4.6	2.1
Ocean County	510,916	576,551	637,229	24.7	10.5
Salem County	64,285	66,084	64,837	0.9	-1.9
Commonwealth of Virginia	**7,078,515**	**8,001,024**	**8,631,393**	**21.9**	**7.9**
Portsmouth City	100,565	95,535	97,915	-2.6	2.5
State of Texas	**20,851,820**	**25,145,558**	**29,145,505**	**39.8**	**15.9**
Nueces County	313,645	340,223	353,178	12.6	3.8
San Patricio County	67,138	64,804	68,755	2.4	6.1

Source: U.S. Census Bureau 2000, 2010, 2020.

Table B.4-2. Demographic data, 2020

Jurisdiction	Population 2020	Population Density (persons per square mile)	Population 18 Years and Over	% of Population 18 Years and Over	% of Population Under 18
State of New Jersey	**9,288,994**	**1,262.99**	**7,281,310**	**78.4**	**21.6**
Atlantic County	274,534	494.20	217,993	79.4	20.6
Cape May County	95,263	378.75	78,971	82.9	17.1
Gloucester County	302,294	43.54	237,281	78.5	21.5
Monmouth County	643,615	1,374.71	511,670	79.5	20.5
Ocean County	637,229	1,014.23	482,600	75.7	24.3
Salem County	64,837	195.37	50,538	77.9	22.1
Commonwealth of Virginia	**8,631,393**	**218.62**	**6,745,054**	**78.1**	**21.9**
Portsmouth City	97,915	2,940.34	76,164	77.8	22.2
State of Texas	**29,145,505**	**111.55**	**21,866,700**	**75.0**	**25.0**
Nueces County	353,178	420.92	270,056	76.5	23.5
San Patricio County	68,755	99.15	51,377	74.7	25.3

Source: U.S. Census Bureau 2020.

Table B.4-3. Age distribution, 2019

Jurisdiction	0–17	18–34	35–64	65+	Median Age
State of New Jersey	**22.1%**	**21.5%**	**40.5%**	**15.9%**	**40**
Atlantic County	21.5%	21.1%	40.0%	17.5%	42
Cape May County	17.6%	17.6%	38.9%	25.8%	50
Gloucester County	22.1%	21.2%	41.3%	15.4%	41
Monmouth County	21.4%	19.1%	42.3%	17.1%	43
Ocean County	23.9%	18.3%	35.4%	22.4%	43
Salem County	21.7%	19.6%	40.4%	18.3%	42
Commonwealth of Virginia	**22.1%**	**23.5%**	**39.4%**	**15.0%**	**38**
Portsmouth City	23.4%	26.2%	35.9%	14.5%	35
State of Texas	**26.0%**	**24.6%**	**37.2%**	**12.3%**	**35**
Nueces County	24.8%	24.6%	36.6%	14.1%	36
San Patricio County	27.0%	22.4%	36.0%	14.6%	36

Source: U.S. Census Bureau 2015–2019.

Table B.4-4. Housing data, 2020

Jurisdiction	Housing Units	Occupied (%)	Vacant (%)
State of New Jersey	**3,761,229**	**91.1**	**8.9**
Atlantic County	132,038	80.8	19.2
Cape May County	99,606	41.2	58.8
Gloucester County	117,208	94.3	5.7
Monmouth County	268,912	91.0	9.0
Ocean County	294,429	81.1	18.9
Salem County	27,763	90.9	9.1
Commonwealth of Virginia	**3,618,247**	**91.8**	**8.2**
Portsmouth City	43,164	91.6	8.4
State of Texas	**11,589,324**	**90.5**	**9.5**
Nueces County	151,255	86.4	13.6
San Patricio County	29,424	84.3	15.7

Source: U.S. Census Bureau 2020.

Table B.4-5. Housing unit data, 2019

Jurisdiction	Housing Units	Seasonal Vacant Units	Vacant Units (Non-Seasonal)	Non-Seasonal Vacancy Rate	Median Value (Owner-Occupied)	Median Monthly Rent (Renter-Occupied)
State of New Jersey	**3,616,614**	**135,990**	**248,750**	**6.9%**	**$335,600**	**$1,334**
Atlantic County	128,251	17,190	11,211	8.7%	$217,900	$1,120
Cape May County	99,312	50,452	8,689	8.7%	$300,500	$1,169
Gloucester County	113,485	320	8,257	7.3%	$219,700	$1,225
Monmouth County	261,579	12,459	13,758	5.3%	$421,900	$1,399
Ocean County	283,297	39,171	17,966	6.3%	$279,000	$1,428
Salem County	27,595	190	3,472	12.6%	$184,600	$1,019
Commonwealth of Virginia	**3,514,032**	**87,550**	**275,437**	**7.8%**	**$273,100**	**$1,234**
Portsmouth City	40,907	87	4,450	10.9%	$170,900	$1,048
State of Texas	**10,937,026**	**247,358**	**998,021**	**9.1%**	**$172,500**	**$1,045**
Nueces County	149,287	4,704	15,132	10.1%	$138,700	$1,017
San Patricio County	28,226	1,035	4,293	15.2%	$122,100	$975

Source: U.S. Census Bureau 2015–2019.

Table B.4-6. Economic data, 2019

Jurisdiction	Per Capita Income (2019)[1]	Total Employment (2019)[2]	Unemployment Rate (2019)[1]	Population Living Below Poverty Level (2019)[1]
State of New Jersey	**$42,745**	**4,018,511**	**5.5%**	**10.0%**
Atlantic County	$33,284	126,385	8.4%	13.3%
Cape May County	$40,389	33,031	6.8%	9.8%
Gloucester County	$39,337	113,722	5.5%	7.4%
Monmouth County	$51,700	261,181	4.9%	6.9%
Ocean County	$36,100	166,205	5.1%	10.1%
Salem County	$34,047	20,602	6.0%	12.4%
Commonwealth of Virginia	**$39,278**	**3,793,011**	**4.6%**	**10.6%**
Portsmouth City	$26,312	32,490	7.8%	16.8%
State of Texas	**$31,277**	**12,433,128**	**5.1%**	**14.7%**
Nueces County	$27,740	159,956	5.7%	16.6%
San Patricio County	$26,054	19,117	5.1%	15.9%

Sources: 1. U.S. Census Bureau 2015–2019; 2. U.S. Census Bureau 2019.

Table B.4-7. At place employment by industry data, 2019

Industry	Atlantic County	Cape May County	Gloucester County	Monmouth County	Ocean County	Salem County	New Jersey	Portsmouth City	Virginia	Nueces County	San Patricio County	Texas
Agriculture, Forestry, Fishing and Hunting	0.4%	0.8%	1.3%	0.2%	0.1%	1.9%	0.2%	0.0%	0.3%	0.3%	1.7%	0.5%
Mining, Quarrying, and Oil and Gas Extraction	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.2%	2.1%	2.4%	2.0%
Utilities	0.9%	0.6%	0.4%	0.7%	0.8%	8.6%	0.5%	0.3%	0.5%	0.9%	1.2%	0.7%
Construction	4.7%	7.7%	5.8%	5.7%	5.9%	6.6%	4.0%	6.6%	5.6%	11.1%	31.2%	6.5%
Manufacturing	2.0%	2.7%	7.6%	3.5%	3.4%	8.9%	6.2%	5.0%	6.5%	4.2%	4.4%	7.4%
Wholesale Trade	2.2%	1.9%	7.5%	3.0%	2.7%	2.9%	5.3%	1.7%	2.9%	3.3%	1.2%	4.9%
Retail Trade	10.5%	15.2%	16.3%	13.9%	15.2%	7.9%	11.0%	9.8%	10.8%	9.8%	10.6%	10.6%
Transportation and Warehousing	1.8%	1.7%	6.4%	1.9%	2.2%	10.3%	5.0%	6.7%	3.5%	3.0%	1.8%	4.3%
Information	0.7%	0.5%	1.2%	2.6%	0.7%	0.2%	1.8%	1.2%	1.9%	0.8%	0.8%	1.7%
Finance and Insurance	1.6%	2.5%	1.6%	3.7%	2.4%	1.8%	4.6%	1.3%	3.7%	2.6%	1.3%	4.4%
Real Estate and Rental and Leasing	1.2%	2.1%	1.0%	1.5%	1.9%	0.8%	1.5%	1.2%	1.5%	1.8%	0.7%	1.9%
Professional, Scientific, and Technical Services	3.8%	3.4%	3.0%	7.4%	5.3%	4.0%	7.8%	4.0%	11.5%	5.3%	2.9%	6.7%
Management of Companies and Enterprises	0.7%	0.4%	0.4%	1.4%	0.4%	0.0%	2.2%	0.1%	2.3%	0.4%	0.4%	1.3%
Administration & Support, Waste Management and Remediation	4.3%	3.4%	5.1%	4.7%	4.6%	4.1%	7.1%	8.1%	6.6%	5.2%	2.0%	6.6%
Educational Services	8.7%	10.4%	11.9%	10.2%	12.1%	11.8%	10.0%	9.9%	9.9%	10.2%	14.1%	10.2%
Health Care and Social Assistance	15.6%	10.6%	13.5%	18.2%	21.7%	15.6%	15.5%	24.7%	13.4%	20.8%	5.7%	13.6%
Arts, Entertainment, and Recreation	1.6%	3.2%	1.4%	3.2%	2.6%	0.8%	1.6%	0.8%	1.7%	1.6%	1.2%	1.4%
Accommodation and Food Services	31.1%	18.8%	8.8%	9.9%	8.9%	6.3%	7.7%	7.3%	9.0%	11.2%	11.3%	9.6%

Source: U.S. Census Bureau 2019.

Table B.4-8. Ocean Economy data, 2019

Jurisdiction	Ocean Economy GDP, All Ocean Sectors	Ocean Economy GDP, Tourism and Recreation Sector	Ocean Economy GDP, Living Resources Sector	Total County GDP (Coastal Economy, Employment Data) Total, All Industries	Ocean Economy GDP, as Percent of Total County GDP (%)
State of New Jersey	**$11,855,762,000**	**$4,584,513,000**	**$310,616,000**	**$634,784,000,000**	**1.9**
Atlantic County	$599,487,000	$574,345,000	$2,833,000	$14,869,684,000	4.0
Cape May County	$627,835,000	$540,831,000	$7,955,000	$3,979,220,000	15.8
Gloucester County	$416,820,000	$50,790,000	Suppressed	$13,148,549,000	3.2
Monmouth County	$835,236,000	$770,634,000	$9,783,000	$36,419,565,000	2.3
Ocean County	$707,612,000	$613,039,000	$17,688,000	$19,076,848,000	3.7
Salem County	$118,903,000	$22,180,000	Suppressed	$2,925,815,000	4.1
Commonwealth of Virginia	**$10,254,369,000**	**$2,452,373,000**	**$641,763,000**	**$556,905,000,000**	**1.8**
Portsmouth City	$1,451,595,000	$76,143,000	Suppressed	$6,275,901,104	23.1
State of Texas	**$81,318,858,000**	**$1,916,764,000**	**$447,138,000**	**$1,843,800,000,000**	**4.4**
Nueces County	$1,436,117,000	$570,971,000	Suppressed	$20,547,623,264	7.0
San Patricio County	$519,919,000	$64,370,000	$0	$2,301,102,556	22.6

Source: NOAA 2019.

Table B.4-9. Tourism and recreation economic value, 2019

Jurisdiction	Establishments	Employment	Wages (millions)	GDP (millions)
State of New Jersey	**8,020**	**98,790**	**$2,347,078,000**	**$4,584,513,000**
Atlantic County	633	11,018	$287,650,000	$574,345,000
Cape May County	1,001	10,407	$266,641,000	$540,831,000
Monmouth County	1,346	18,483	$403,532,000	$770,634,000
Ocean County	1,164	14,597	$311,252,000	$613,039,000

Source: NOEP 2019.

Table B.4-10. Ocean Economy employment, 2019

Jurisdiction	Marine Construction	Living Resources	Offshore Mineral Extraction	Ship and Boat Building	Tourism and Recreation	Marine Transportation	Total, All Sectors
State of New Jersey	**2,775**	**2,528**	**631**	**1,405**	**98,790**	**63,525**	**169,656**
Atlantic County	Suppressed	16	Suppressed	Suppressed	11,017	85	11,254
Cape May County	100	112	Suppressed	Suppressed	10,407	62	11,139
Gloucester County	314	Suppressed	Suppressed	Suppressed	1,522	6,384	8,293
Monmouth County	133	109	Suppressed	0	18,483	280	19,042
Ocean County	213	148	Suppressed	Suppressed	14,597	38	15,342
Salem County	0	Suppressed	0	0	716	1,226	1,955
Commonwealth of Virginia	**2,032**	**2,594**	**322**	**41,147**	**64,547**	**21,456**	**132,100**
Portsmouth City	441	Suppressed	0	11,247	2,438	Suppressed	15,246
State of Texas	**7,289**	**4,028**	**78,687**	**3,697**	**49,517**	**34,668**	**177,888**
Nueces County	Suppressed	Suppressed	2,417	Suppressed	13,516	579	17,514
San Patricio County	Suppressed	0	443	Suppressed	1,821	Suppressed	4,368

Source: NOAA 2019.

Table B.4-11. Jobs during development and construction, and operations and maintenance

Jobs (FTE)[1]	Atlantic Shores South 1 (1,510 MW)	Atlantic Shores South 2 (1,200 MW)	Total
Direct (Development and Construction Phase)	7,445	5,915	**13,360**
Direct (Operation and Decommissioning Phase)	11,105	8,820	**19,925**
Indirect (All Phases)	9,830	7,810	**17,640**
Induced (All Phases)	12,350	9,815	**22,165**
Total	**40,730**	**32,360**	**73,090**

Source: IMPLAN modelling tool drawing from validated government and industry sources including the U.S. Bureau of Economic Analysis, the U.S. Census Bureau, and the Bureau of Labor Statistics: 2019 (COP Volume II; Atlantic Shores 2023.)

[1] Full Time Equivalent (FTE) job-years assuming full-time work of 35 hours a week (1,820 hours per year).

B.4.1 References Cited

Atlantic Shores Offshore Wind, LLC (Atlantic Shores). 2023. *Atlantic Shores Offshore Wind: Construction and Operations Plan*. Lease Area OCS-A 0499. May. Available: https://www.boem.gov/renewable-energy/state-activities/atlantic-shores-south.

National Ocean Economics Program (NOEP). 2019. Market Economy: Ocean and Coastal Economy Data. Available: https://www.oceaneconomics.org/. Accessed: May 2022.

National Oceanic and Atmospheric Administration (NOAA). 2019. Quick Report Tool of Socioeconomic Data. Available: https://coast.noaa.gov/quickreport/#/index.html. Accessed: May 2022.

U.S. Census Bureau. 2000. U.S. Decennial Census 2000. Available: http://socialexplorer.com. Accessed: February 2022.

U.S. Census Bureau. 2010. U.S. Decennial Census 2010. Available: http://socialexplorer.com. Accessed: February 2022.

U.S. Census Bureau. 2015–2019. American Community Survey 5-Year Estimates. Available: http://socialexplorer.com. Accessed: February 2022.

U.S. Census Bureau. 2019. OnTheMap Application and LEHD Origin-Destination Employment Statistics (Beginning of Quarter Employment, 2nd Quarter of 2002–2019), All Jobs, Where Workers Work, 2019. Available: https://onthemap.ces.census.gov/. Accessed: February 2022.

U.S. Census Bureau. 2020. U.S. Decennial Census 2020. Available: http://socialexplorer.com. Accessed: February 2022.

B.5 Underwater Acoustics

B.5.1 Sources of Underwater Sound

Ocean sounds originate from a variety of sources. Some come from non-biological sources such as wind and waves, while others come from the movements or vocalizations of marine life (Hildebrand 2009). In addition, humans introduce sound into the marine environment through activities like oil and gas exploration, construction, use of military sonars, and vessel traffic (Hildebrand 2009). The acoustic environment, or "soundscape," of a given ecosystem comprises all such sounds, including biological, geophysical, and anthropogenic (Pijanowski et al. 2011). Soundscapes are highly variable across space, time, and water depth, among other factors, due to the properties of sound transmission and the types of sound sources present in each area. A soundscape is sometimes called the "acoustic habitat," as it is a vital attribute of a given area where an animal may live (i.e., habitat) (Hatch et al. 2016).

B.5.2 Physics of Underwater Sound

Sounds are created by the vibration of an object within its medium. When the object's vibration is coupled to the medium (water in the case of underwater sound), that vibration travels as a propagating wave away from the sound source (Figure B.5-1). As this wave moves through the water, the water particles undergo tiny back-and-forth movements (i.e., particle motion), essentially oscillating in roughly the same location. When the particle motion results in more particles in one location (depicted as the area of compression in Figure B.5-1), that location has relatively higher pressure. Particles are then accelerated away from the higher-pressure region, causing the particles to transfer their energy to surrounding particles and propagating the wave. Acoustic pressure is a non-directional (scalar) quantity, whereas particle motion is an inherently directional quantity (a vector). The total energy of the sound wave includes the potential energy associated with the sound pressure as well as the kinetic energy from particle motion.

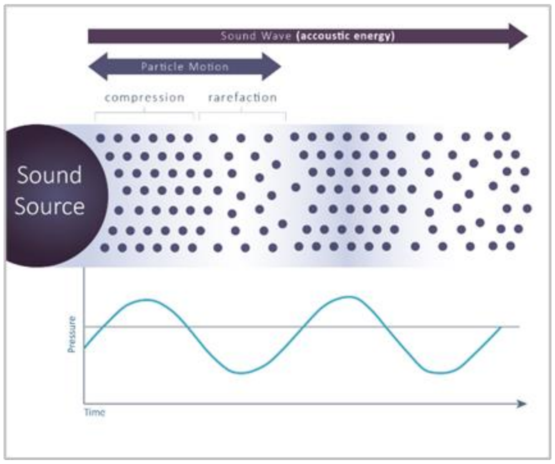

Figure B.5-1. Basic mechanics of a sound wave

B.5.3 Units of Measurement

Sound can be quantified and characterized based on a number of physical parameters. A complete description of the units can be found in ISO 18405:2017. Some of the major parameters (in bold) and their SI units (in parentheses) are:

Acoustic pressure (pascal, Pa): The values used to describe the acoustic (or sound) pressure are peak pressure, peak-to-peak pressure, and root-mean-square (rms) pressure deviation. The peak sound pressure is defined as the maximum absolute sound pressure deviation within a defined time period and is considered an instantaneous value. The peak-to-peak pressure is the range of pressure change from the most negative to the most positive pressure amplitude of a signal (Figure B.5-2). The rms sound pressure represents a time-averaged pressure and is calculated as the square root of the mean (average) of the time-varying sound pressure squared over a given period (Figure B.5-2). The peak level (L_{pk}), peak-to-peak level ($L_{pk\text{-}pk}$), and sound pressure level (L_{rms} or SPL) are computed by multiplying the logarithm of the ratio of the peak or rms pressures to a reference pressure (1 µPa in water) by a factor of 20 and are reported in decibels; see **Sound levels**.

Particle velocity (meter per second, m/s): Particle velocity describes the change in position of the oscillating particle about its origin over a unit of time. Similar to sound pressure, particle velocity is dynamic and changes as the particles move back and forth. Therefore, peak particle velocity and root-mean-square particle velocity can be used to describe this physical quantity. One major difference between sound pressure and particle velocity is that the former is a scalar (i.e., without a directional component) and the latter is a vector (i.e., includes both magnitude and direction). Particle acceleration can also be used to describe particle motion and is defined as the rate of change of velocity of a particle with respect to time. It is measured in units of meters per second squared, or m/s^2.

Sound exposure (pascal-squared second, or Pa^2-s): Sound exposure is proportional to the acoustic energy of a sound. It is the time-integrated squared sound pressure over a stated period or acoustic event (see Figure B.5-2). Unlike sound pressure, which provides an instantaneous or time-averaged value of acoustic pressure, sound exposure is cumulative over a period of time.

Acoustic intensity (watts per square meter, or W/m^2): Acoustic or sound intensity is the amount of acoustic energy that passes through a unit area normal to the direction of propagation per second. It is the product of the sound pressure and the sound velocity. With an idealized constant source, the pressure and particle velocity will vary in proportion to each other at a given location, but the intensity will remain constant.

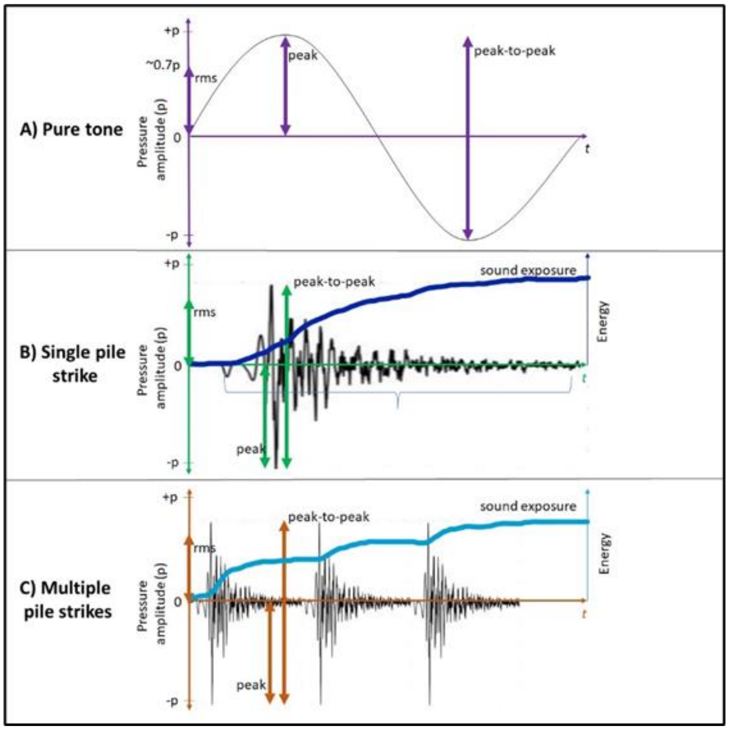

Figure B.5-2. Sound pressure wave representations of four metrics: root-mean-square (L_{rms}), peak (L_{pk}), peak-to-peak (L_{pk-pk}), and sound exposure (SEL).

A) A sine wave of a pure tonal signal with equal positive and negative peaks, so peak-to-peak is exactly twice the peak and rms is approximately 0.7 x peak.
B) A single pile-driving strike with one large positive pulse and a large negative pulse that is not necessarily the same magnitude. In this example, the negative pulse is more extreme so is the reported peak value, and peak-to-peak is less than double that. Sound exposure is shown as it accumulates across the time window. The final sound exposure would be considered the "single-shot" exposure, and the rms value is that exposure divided by the duration of the pulse.
C) Three consecutive pile-driving strikes with peak and peak-to-peak assessed the same way as in (B). Sound exposure is shown accumulating across all three strikes, and rms is the total sound exposure divided by the entire time window shown. The cumulative sound exposure for this series of signals would be considered the total energy from all three pile-strikes.

Sound levels: There is an extremely wide dynamic range of values when measuring acoustic pressure in pascals, so it is customary to use a logarithmic scale to compress the range of values. Aside from the ease it creates for comparing a wide range of values, animals (including humans) perceive sound on a logarithmic scale. These logarithmic acoustic quantities are known as sound levels and are expressed in decibels (dB), which is the logarithm of the ratio of the measurement in question to a fixed reference value. Underwater acoustic sound pressure levels are referenced to a pressure of 1 µPa[1] (equal to 10^{-6} Pa or 10^{-11} bar).

[1] Airborne sound pressure levels have a different reference pressure: 20 µPa.

The metrics previously described (sound pressure, particle velocity, sound exposure, and intensity) can also be expressed as levels, and are commonly used in this way:

- root-mean-square sound pressure level (L_{rms} or SPL, in dB referenced to [re] 1 µPa)
- peak pressure level (L_{pk}, in dB re 1 µPa)
- peak-to-peak pressure level ($L_{pk\text{-}pk}$, in dB re 1 µPa)
- particle velocity level (SVL in dB re 1 nanometer per second)
- sound exposure level (SEL, in dB re 1 $\mu Pa^2 \cdot s$)[2]

Source level: Source level is a representation of the amount of acoustic power radiated from the sound source being described. It describes how loud a particular source is in a way that can inform expected received levels at various ranges. It can be conceptualized as the product of the pressure at a particular location and the range from that location to a spherical (omnidirectional) source in an idealized infinite lossless medium. The source level is the sum of the received level and the propagation loss to that receiver. It is often discussed as what the received level would be 1 meter (m) from the source, but this can lead to confusion as an actual measurement at 1 meter is likely to be impossible for large and/or non-spherical sources. The most common type is an SPL source level in units of dB re 1 µPa-m, though in some circumstances an SEL source level (in dB re 1 $\mu Pa^2 \cdot s\text{-}m^2$) may be expressed; peak source level (in units of dB re 1 µPa-m) may also be appropriate for some sources.

B.5.4 Propagation of Sound in the Ocean

Underwater sound can be described through a source-path-receiver model. An acoustic source emits sound energy that radiates outward and travels through the water and the seafloor. The sound level decreases with increasing distance from the acoustic source as the sound travels through the environment. The amount by which the sound levels decrease between the theoretical source level and a receiver is called propagation loss. Among other things, the amount of propagation loss that occurs depends on the source-receiver separation, the geometry of the environment the sound is propagating through, the frequency of the sound, the properties of the water column, and the properties of the seafloor and sea surface.

When sound waves travel through the ocean, they may encounter areas with different physical properties that will likely alter the propagation pathway of the sound, compared to a homogenous and boundaryless environment. For example, near the ocean’s surface, water temperature is usually higher, resulting in relatively fast sound speeds. As temperature decreases with increasing depth, the sound

[2] There are a few time periods commonly used for SEL, including a 24-hour period (used in the U.S. for the regulation of noise impacts to marine mammals [SEL_{24}]), or the duration of a single event, such as a single pile-driving strike or an airgun pulse, called the single strike SEL (SEL_{ss}). A sound exposure for some other period of time, such as the entire installation of a pile, may be written without a subscript (SEL), but in order to be meaningful, should always denote the duration of the event.

speed decreases. Sounds bend toward areas with lower speeds (Urick 1983). Ocean sound speeds are often slowest at mid-latitude depths of about 1,000 meters, and because of sound's preference for lower speeds, sound waves above and below this "deep sound channel" often bend towards it. Sounds originating in this layer can travel great distances. Sounds can also be trapped in the mixed layer near the ocean's surface (Urick 1983). Latitude, weather, and local circulation patterns influence the depth of the mixed layer, and the propagation of sounds near the surface is highly variable and difficult to predict.

At the boundaries near the sea surface and the sea floor, acoustic energy can be scattered, reflected, or attenuated depending on the properties at the surface (e.g., roughness, presence of wave activity, or bubbles) or seafloor (e.g., bathymetric features, substrate heterogeneity). For example, fine-grain sediments tend to absorb sounds well, while hard-bottom substrates reflect much of the acoustic energy back into the water column. The presence of ice on the ocean's surface can also affect sound propagation. For example, the presence of solid ice may dampen sound levels by scattering incident sounds. The effect will also depend on the thickness and roughness of the ice, among many other factors related to the ambient conditions. As a sound wave moves from a source to a receiver (i.e., an animal), it may travel on multiple pathways that may be direct, reflected, refracted, or a combination of these mechanisms, creating a complex pattern of transmission across range and depth. The patterns may become even more complicated in shallow waters due to repeated interactions with the surface and the bottom, frequency-specific propagation, and more heterogenous seafloor properties. All of these variables contribute to the difficulty in reliably predicting the sound field in a given marine environment at any particular time.

B.5.5 Sound Source Classification

In the current regulatory context, anthropogenic sound sources are categorized as either impulsive or non-impulsive, and either continuous or intermittent, based on their differing potential to affect marine species (NMFS 2018). Specifically, when it comes to potential damage to marine mammal hearing, sounds are classified as either impulsive or non-impulsive, and when considering the potential to affect behavior or acoustic masking, sounds are classified as either continuous or intermittent.

Impulsive noises are characterized as having (ANSI S1.13-2005, Finneran 2016):

- broadband frequency content
- fast rise-times and rapid decay times
- short durations (i.e., < 1 second)
- high peak sound pressures

Characterization of non-impulsive noises is less clear. Characteristics of non-impulsive sound sources may include:

- variable in spectral composition (i.e., broadband, narrowband, or tonal)

- longer rise-times/decay times and total durations compared to an impulsive sound
- continuous (e.g., vessel engine radiated noise) or intermittent (e.g., echosounder pulses)

It is generally accepted that sources like explosions,[3] airguns, sparkers, boomers, and impact pile driving are impulsive and have a greater likelihood of causing hearing damage than non-impulsive sources. Impulsive sounds are more likely to induce physiological effects, including TTS and PTS, than non-impulsive sounds with the same energy. This binary, at-the-source classification of sound types, therefore, provides a conservative framework upon which to predict potential adverse hearing impacts on marine mammals.

For behavioral effects of anthropogenic sound on marine mammals, NMFS classifies sound sources as either intermittent or continuous (NMFS 2018). Continuous sounds, such as drilling or vibratory pile driving, remain "on," i.e., producing sound, for a given period of time, though this is not well-defined. An intermittent sound typically consists of bursts or pulses of sound on a regular on-off pattern, also called the duty-cycle. Examples of intermittent sounds are those from scientific echosounders, sub-bottom profilers, and even impact pile driving. It is important to recognize that these delineations are not always practical in application, as a continuous yet moving sound source (such as a vessel passing over a fixed receiver) could be considered intermittent from the perspective of the receiver.

In reality, animals will encounter many signals in their environment, which may contain many or all of these sound types, called *complex sounds*. And even for sounds that are impulsive at the source, as the signal propagates through the water, the degree of impulsiveness decreases (Martin et al. 2020). While there is evidence, at least in terrestrial mammals (Hamernik and Hsueh 1991), that complex sounds can be more damaging than continuous sounds of the same energy, there is not currently a regulatory category for this type of sound. One approach for assessing the impulsiveness of a sound that has gained attention is to compute the kurtosis of that signal. *Kurtosis* is a statistical measure that describes the prevalence of extreme values within a distribution of observations, in other words the "spikiness" of the data. By definition, a sound with a kurtosis value of 3 or less has very few extreme values and is generally considered Gaussian (I.e., normally distributed) noise. Martin et al. (2020) showed that a kurtosis value greater than 40 represents a distribution of observations with many extreme values and is very spiky. This generally describes an impulsive noise. A distribution of sound level observations from a time series with a kurtosis value somewhere in between these two values would be considered a complex sound.

B.5.6 Sound Sources Related to Offshore Wind Development

B.5.6.1 Geophysical and Geotechnical Surveys

Geophysical and geotechnical surveys are conducted to characterize the bathymetry (depth), sediment type, and benthic habitat characteristics of the marine environment. They may also be used to identify archaeological resources or obstacles on the seafloor. These types of surveys occur in the site

[3] Explosions are further considered for non-auditory injury.

assessment phase in order to inform the placement of offshore wind foundations but may also occur intermittently during and after turbine construction to identify, guide, and confirm the locations of turbine foundations.

The suite of HRG sources that may be used in geophysical surveys includes side-scan sonars (SSS), multibeam echosounders (MBES), magnetometers and gradiometers, parametric SBP, compressed high-intensity radiated pulses SBP, boomers, and/or sparkers. Seismic airguns are not expected to be used for offshore wind applications. These HRG sources may be towed behind a ship, mounted on a ship's hull, or deployed from remotely operated vehicles or autonomous underwater vehicles. Many HRG sources are active acoustic sources, meaning they produce sound deliberately in order to obtain information about the environment. With the exception of some MBES and SSS, they produce sounds below 180 kHz and thus may be audible to marine species. Source levels vary widely depending on source type and operational power level used, from approximately 145 dB re 1 µPa-m for towed SBP up to 245 dB re 1 µPa-m for some MBES (Crocker and Fratantonio 2016). Generally speaking, sources that emit sound in narrow beams directed at the seafloor are less likely to affect marine species because they ensonify a small portion of the water column, thus reducing the likelihood that an animal encounters the sound. While sparkers are omnidirectional, most other HRG sources have narrower beamwidths (e.g., MBES: up to 6°, parametric SBP: 30°, boomers: 30–90°) (Crocker and Fratantonio 2016). Most HRG sources emit short pulses of sound, with periods of silence in between. This means that only several "pings" emitted from a vessel towing an active acoustic source would reach an animal below, even if the animal was stationary (Ruppel et al. 2022). HRG surveys may occur throughout the construction area with the potential for greater effort in some areas.

Geotechnical surveys may use vibracores, jet probes, bottom-grab samplers, deep borings, or other methods to obtain samples of sediments at each potential turbine location and along the cable route. For most of these methods, source levels have not been measured, but it is generally assumed that low-frequency, low-level noise will be introduced as a byproduct of these actions. It is likely that the sound of the vessel will exceed that generated by the geotechnical method itself.

B.5.6.2 Unexploded Ordnance Detonations

Unexploded Ordnances (UXOs) may be discovered on the seabed in offshore wind lease areas or along export cable routes. While non-explosive methods may be employed to lift and move these objects, some may need to be detonated. Underwater explosions of this type create shock waves characterized by extreme changes in pressure, followed by a series of symmetrical bubble pulses. Shock waves are supersonic, so they travel faster than the speed of sound. The explosive sound field is extremely complex, especially in shallow waters. In 2015, (von Benda-Beckmann et al.) measured received levels of explosions in shallow waters at distances ranging from 100–2000 meters from the source, in water depths ranging from 6–22 meters. The measured SEL from the explosive removal of a 263 kilogram charge was 216 dB re 1 μPa^2s at a distance of 100 meters and 196 dB re 1 μPa^2s at 2,000 meters. They found that SELs were lower near the surface than near the seafloor or in the middle of the water column, suggesting that if an animal is near the surface, the effects may be less damaging. Most of the acoustic energy for underwater explosions is below 1000 Hz.

As an alternative to traditional detonation, a newer method called deflagration allows for the controlled burning of underwater ammunition. Typically, a remotely operated vehicle uses a small, targeted charge to initiate rapid burning of the ordnance; once this process is complete, the remaining debris can be cleared away. Recent work has demonstrated that both peak sound pressure (Lpk) and SEL measured from deflagration events may be as much as 20 dB lower than equivalently sized high-order detonations (Robinson et al. 2020).

B.5.6.3 Construction and Installation Activities

Impact and Vibratory Pile Driving

At present, the installation of turbine foundations is largely done using pile driving. There are several techniques, including impact and vibratory driving, and many pile designs and sizes, including monopile and jacket foundations. Impact pile driving employs a hammer to strike the pile head and force the pile into the sediment with a typical hammer strike rate of approximately 30 to 50 strikes per minute. Typically, force is applied over a period of less than 20 milliseconds, but the pile can generate sound for upwards of 0.5 second. Impact pile driving noise is characterized as impulsive because of its high peak pressure, short duration, and rapid onset time. Underwater sound levels generated during impact pile driving depend on many factors, including the pile material and size, characteristics of the substrate, penetration of the pile in the seabed, hammer energy and size, and water depth. Currently the design envelope for most offshore wind turbine installations anticipates hammer energy between 2,500 and 4,000 kilojoules (kJ), but generally speaking, with increasing pile diameter, greater hammer energy is used. The propagation of pile-driving sounds depends on factors such as the sound speed in the water column (influenced by temperature, salinity, and depth), the bathymetry, and the composition of sediments in the seabed and will therefore vary among sites. Due to variation in these features, sounds may not radiate symmetrically outward from a pile.

BOEM has invested in the Realtime Opportunity for Development of Environmental Observations (RODEO) efforts to measure sound during installation and operation of Block Island Wind Farm (BIWF) and Coastal Virginia Offshore Wind (CVOW). Similar studies have been completed at multiple facilities in Europe. Measurements of sounds from impact pile driving at CVOW were conducted at ranges between 0.5 and 19 miles (0.75 and 30 kilometers) from the two 25.6-foot (7.8-meter) diameter monopiles. Results showed that without any noise abatement method in place, the maximum broadband peak sound pressure (L_{pk}) at 0.5 mile (750 meters) from the pile was 190 dB re 1 µPa, and the maximum single strike sound exposure level (SEL_{ss}) at that range was 170 dB re 1 $\mu Pa^2 \cdot s$. Most of the acoustic energy occurred between 30 and 300 Hz (BOEM 2019). At a 4.7-mile (7.5-kilometer) distance, the maximum measured L_{pk} was 174 dB re 1 µPa, and at 15.5 miles (25 kilometers), it fell to 144 dB re 1 µPa. The peak particle velocity on the seabed, measured 0.3 mile (500 meters) from the foundation, was 114 dB re 1 nanometer per second (Amaral et al. 2021).

Jacket foundations are also common, if not for the main turbine structures, for other structures associated with the wind farm such as the offshore substations. Jacket foundations are installed using pin piles which are generally significantly smaller than monopiles, on the order of 7 to 16 feet (2 to

5 meters) in diameter, but more pin piles are needed per foundation. The sound levels generated will vary depending on the pile material, size, whether the piles are installed with the jacket in place, substrate, hammer energy, and water depth. At BIWF, the 4.5-foot (1.4-meter) pin piles were installed using less than 160 kJ of energy, compared to the 25.6-foot (7.8-meter) monopiles installed at CVOW, which required more than 320 kJ, sometimes as much as 700 kJ, to install. The maximum SEL_{ss} measured at 0.5 mile (750 meters) from the jacket foundations at BIWF ranged from 160 to 168 dB re 1 $\mu Pa^2 \cdot s$, nearly 10 dB lower than CVOW. Using measurements combined with acoustic modeling, the peak-to-peak source levels for pile driving at BIWF were estimated to be between 233 and 245 dB re 1 µPa-m (Amaral et al. 2018).

Vibratory hammers may be used as an alternative to impact pile driving. The vibratory hammer continuously exerts vertical vibrations into the pile, which causes the sediment surrounding the pile to liquefy, allowing the pile to penetrate the substrate. The vibratory hammer typically oscillates at a frequency of 20 to 40 Hz (Matuschek and Betke 2009) and produces most of its acoustic energy below 2 kHz. Vibratory pile driving is a non-impulsive sound source, but because the hammer is on continuously, underwater sound introduced would be into the water column for a longer period of time than with impact pile driving. While measurements of vibratory pile driving of large monopiles have not been reported, Buehler et al. (2015) measured sound levels at 33 feet (10 meters) distance from a 6-foot (1.8-meter) steel pile and found them to be 185 dB re 1 µPa. Vibratory pile-driving is a non-impulsive sound source, and the hammer produces sound continuously, so is assessed using different criteria than impact pile driving for behavioral and physiological effects on marine mammals.

Various noise abatement technologies, such as bubble curtains, arrays of enclosed air resonators, or segmented nets of rubber or foam, may be employed to reduce noise from impact pile driving. Measurements from European wind farms have shown that a single noise abatement system can reduce broadband sound levels by 10 to 15 dB, while using two systems together can reduce sound levels as much as 20 dB (Bellmann et al. 2020). Based on RODEO measurements from CVOW, double Big Bubble Curtains (dBBC) are shown to be most effective for frequencies above 200 Hz, and greater noise reduction was seen in measurements taken in the middle of the water column compared to those near the seabed. Approximate sound level reduction associated with dBBC is 3 to 5 dB below 200 Hz, and 8 to 20 dB above 200 Hz, depending on the characteristics of the bubble curtain (Amaral et al. 2020).

Vessel Traffic

During construction, vessels and aircraft may be used to transport crew and equipment. See Section B.5.6.3, *Operations and Maintenance Activities*, for further detail about sounds related to those activities. Large vessels will also be used during the construction phase to conduct pile driving, and these vessels may use Dynamic Positioning (DP) systems. DP is the process by which a vessel holds station over a specific seafloor location for some time period using input from gyrocompasses, motion sensors, GPS, active acoustic positioning systems, and wind sensors to determine relative movement and environmental forces at work. Generally speaking, most acoustic energy is below 1,000 Hz, often below 50 Hz, with tones related to engine and propeller size and type. The sound can also vary directionally, and this directionality is much more pronounced at higher frequencies. Because this is a dynamic operation, the sound levels produced will vary based on the specific operation, DP system used (e.g., jet or propeller rotation, versus a rudder or steering mechanism), and factors such as the blade rate and cavitation, in some cases. Representative sound field measurements from the use of DP are difficult to obtain because the sound transmitted is often highly directional and context specific. The direction of sound propagation may change as different DP needs requiring different configurations are applied.

Many studies have found that the measured sound levels of DP alone are, counterintuitively, higher than those of DP combined with the intended activities such as drilling (Jiménez-Arranz et al. 2020; Kyhn et al. 2011; Nedwell and Edwards 2004) and coring (Warner and McCrodan 2011). Nedwell and Edwards (2004) reported that DP thrusters of the semi-submersible drill rig Jack Bates produced periodic noise (corresponding to the rate of the thruster blades) with most energy between 3 and 30 Hz. The received SPL measured at 328 feet (100 meters) from the vessel was 188 dB re 1 µPa. Warner and McCrodan (2011) found that most DP related sounds from the self-propelled drill ship, R*/V Fugro Synergy* were in the 110 to 140 Hz range, with an estimated source level of 169 dB re 1 µPa-m. Sounds in this frequency range varied by 12 dB during DP, while the broadband levels, which also included diesel generators and other equipment sounds, varied by only 5 dB over the same time period. All of the above sources report high variability in levels with time. This is due in part to the intermittent usage and relatively slow rotation rates of thrusters used in DP. It is also difficult to provide a realistic range of source levels from the data thus far because most reports do not identify the direction from which sound was measured relative to the vessel, and DP thrusters are highly directional systems.

The active acoustic positioning systems used in DP can be additional sources of high frequency sound. These systems usually consist of a transducer mounted through the vessel's hull and one or more transponders affixed to the seabed. Kongsberg High Precision Acoustic Positioning systems produce pings in the 10 to 32 kHz frequency range. The hull-mounted transducers have source levels of 188 to 206 dB re 1 µPa-m depending on adjustable power settings (Kongsberg Maritime AS 2013). The fixed transponders have maximum source levels of 186 to 206 dB re 1 µPa-m depending on model and beam width settings from 15 to 90° (Jiminez-Arranz et al. 2020). These systems have high source levels, but beyond 1.2 miles (2 kilometers), they are generally quieter than other components of the sound from DP vessels for various reasons including: their pulses are produced in narrowly directed beams, each individual pulse is very short, and their high frequency content leads to faster attenuation.

Dredging, Trenching, and Cable Laying

The installation of cables can be done by towing a tool behind the installation vessel to simultaneously open the seabed and lay the cable, or by laying the cable and following with a tool to embed the cable. Possible installation methods for these options include jetting, vertical injection, control flow excavation, trenching, and plowing. Burial depth of the cables is typically 3.3 to 6.6 feet (1 to 2 meters). Cable installation vessels may use utilize DP to lay the cables (see Section B.5.6.2(b)).

Nedwell et al. (2003) recorded underwater sound at 525 feet (160 meters) from trenching, in water depths of 23 to 36 feet (7 to 11 meters), and back-calculated the source level to be 178 dB re 1 µPa-m. They describe trenching sound as generally broadband in nature, but variable over time, with some tonal machinery noise and transients associated with rock breakage. McQueen et al. (2018) summarized results from several studies measuring the sounds of dredging operations. They report source levels from hydraulic and mechanical dredges typically used to excavate sand or rock. Source levels from cutterhead suction dredges range from 168 to 175 dB re 1 µPa-m, and trailing suction hopper dredge source levels are typically 172 to 190 dB re 1 µPa-m. Most of the energy from dredging is below 1,000 Hz (McQueen et al. 2018).

B.5.6.4 Operation and Maintenance Activities

Aircraft Traffic

Manned aircraft consist of fixed-wing aircraft with propellers or jet engines, as well as helicopters. Unmanned systems also exist. For jet engine aircraft, the engine is the primary source of sound. For propeller driven aircraft and helicopters, the propellors and rotors also produce noise. Aircraft generally produce low-frequency sound below 500 Hz (Richardson et al. 1995). While aircraft noise can be substantial in air, penetration of aircraft noise into the water is limited because much of the noise is reflected off the water's surface (Richardson et al. 1995). The noise that does penetrate into the water column does this via a critical incident angle or cone. With an idealized flat sea surface, the maximum critical incident angle is approximately 13° (Urick 1983); beyond this, sound is reflected off the surface. When the sea surface is not flat, there may be some additional penetration into the water column in areas outside of this 13° cone. Nonetheless, the extent of noise from passing aircraft is more localized in water than it is in air.

Jiménez-Arranz et al. (2020) reviewed Richardson et al.'s (1995) sound measurements recorded below passing aircraft of various models. These SPL measurements included 124 dB re 1 µPa (dominant frequencies between 56 and 80 Hz) from a maritime patrol aircraft with an altitude of 249 feet (76 meters), 109 dB re 1 µPa (dominant frequency content below 22 Hz) from a utility helicopter with an altitude of 500 feet (152 meters), and 107 dB re 1 µPa (tonal, 82 Hz) from a turbo propeller with an altitude of 1,500 feet (457 meters). Recent published levels associated with unmanned aircraft (Christiansen et al. 2016; Erbe et al. 2017) indicate source levels around or below 100 dB re 1 µPa-m.

Vessel Traffic

During operations, small vessels may be used to transport crew and supplies. Noise from vessel transit is considered to be continuous, with a combination of broadband and tonal sounds (Richardson et al. 1995; Ross 1976). Transiting vessels generate continuous sound from their engines, propeller cavitation, onboard machinery, and hydrodynamics of water flows (Ross 1976). The actual radiated sound depends on several factors, including the type of machinery on the ship, the material conditions of the hull, how recently the hull has been cleaned, interactions with the sea surface, and shielding from the hull, which reduces sound levels in front of the ship.

In general, vessel noise increases with ship size, power, speed, propeller blade size, number of blades, and rotations per minute. Source levels for large container ships can range from 177 to 188 dB re 1 µPa-m (McKenna et al. 2013) with most energy below 1 kHz. Smaller vessels typically produce higher-frequency sound concentrated in the 1 to 5 kHz range. Kipple and Gabriele (2003) measured underwater sound from vessels ranging from 14 to 65 feet (4.3 to 19.8 meters) long (25 to 420 horsepower) and back-calculated source levels to be 157 to 181 dB re 1 µPa-m. Similar levels are reported by Jiménez-Arranz et al. (2020), who provide a review of measurements for support and crew vessels, tugs, rigid hulled inflatable boats, icebreakers, cargo ships, oil tankers, and more.

During transit to and from shore bases, survey vessels typically travel at speeds that optimize efficiency, except in areas where transit speed is restricted. The vessel strike speed restrictions that are in place along the Atlantic OCS are expected to offer a secondary benefit of underwater noise reduction. For example, recordings from a speed reduction program in the Port of Vancouver (689 to 820 feet [210 to 250 meter] water depths) showed that reducing speeds to 11 knots reduced vessel source levels by 5.9 to 11.5 dB, depending on the vessel type (MacGillivray et al. 2019). Vessel noise is also expected to be lower during geological and geophysical surveys, as they typically travel around 5 knots when towing instruments.

Wind Turbine Generator Operation

Once windfarms are operational, low-level sounds are generated by each WTG, but sound levels are much lower than during construction. This type of sound is considered to be continuous, omnidirectional radially from the pile, and non-impulsive. Most of the energy associated with operations is below 120 Hz. Sound levels from wind turbine operations are likely to increase somewhat with increasing generator size and power ratings, as well as with wind speeds. Recordings from BIWF indicated that there was a correlation between underwater sound levels and increasing wind speed, but this was not clearly influenced by turbine machinery; rather it may have been explained by the natural effects that wind and sea state have on underwater sound levels (Elliott et al. 2019; Urick 1983).

A recent compilation of operational noise from several wind farms (Tougaard et al. 2020), with turbines up to 6.15 MW in size, showed that operational noise generally attenuates rapidly with distance from the turbines (falling to near ambient sound levels within approximately 0.6 mile [1 kilometer] from the source), and the combined noise levels from multiple turbines is lower or comparable to that generated by a small cargo ship. Tougaard et al. (2020) developed a formula predicting a 13.6 dB increase for every 10-fold increase in WTG power rating. This means that operational noise could be expected to increase by 13.6 dB when increasing in size from a 0.5 MW turbine to a 5 MW one, or from 1 MW to 10 MW. The least squares fit of that dataset would predict that the SPL measured 328 feet (100 meters) from a hypothetical 15 MW turbine in operation in 10 m/s (19 knots or 22 miles per hour) wind would be 125 dB re 1 µPa. However, all of the 46 data points in that dataset, with the exception of the two from BIWF, were from WTGs operated with gear boxes of various designs rather than the newer use of direct drive technology, which is expected to lower underwater noise levels significantly. Stöber and Thomsen (2021) make predictions for source levels of 10 MW turbines based on a linear extrapolation of maximum received levels from WTGs with ratings up to 6.15 MW. The linear fit is likely inappropriate, and the resulting predictions may be exaggerated. Tougaard et al. (2020) point out that received level differences among different pile types could be confounded by differences in water depth and turbine size. In any case, additional data is needed to fully understand the effects of size, foundation type properties (e.g., structural rigidity and strength), and drive type on the amount of sound produced during turbine operation.

B.5.6.5 Decommissioning Activities

The methods that may be used for decommissioning are not well understood at this time. It is possible that explosives may be used. However, given the general trend of reducing the use of underwater explosives that has been observed in the oil and gas industry, it is likely that offshore wind structures will instead be removed by cutting. While it is difficult to extrapolate directly, we can glean some insights from a recent study that measured received sound levels during the mechanical cutting of well conductor casings on oil and gas platforms in California. The cutters operated at 60 to 72 revolutions per minute (RPM), and the cutting time varied widely between cuts (on the order of minutes to hours). At distances of 348 to 384 feet (106 to 117 meters) from the cutting, received SPLs were 120 to 30 dB re 1 µPa, with most acoustic energy falling between 20 and 2,000 Hz (Fowler et al. 2022). This type of sound is considered to be non-impulsive and intermittent (i.e., continuous while cuts are actually being made, with quieter periods between cuts). Additional noise from vessels (see *Vessel Traffic in* Sections B.5.6.2 and B.5.6.3) and other machinery may also be introduced throughout the decommissioning process.

B.5.7 Regulation of Underwater Sound

B.5.7.1 Marine Mammals

Marine mammal species have been classified into functional hearing groups based on similar anatomical auditory structures and frequency-specific hearing sensitivity obtained from hearing tests on a subset of species (Finneran 2015a; NMFS 2018; Southall et al. 2019). Hearing groups utilized in the U.S. regulatory process, identified in the NMFS (2018) technical guidance, include low-, mid-, and high-frequency cetaceans, phocid pinnipeds underwater, and otariid pinnipeds underwater.

The current NMFS (2018) injury thresholds consist of dual criteria of L_{pk} and 24 hour-cumulative SEL (SEL_{24h}) thresholds (Table B.5-1). These criteria are used to predict the potential range from the source within which injury may occur. The criterion that results in the larger physical impact range is generally used to be most conservative. The SEL thresholds are frequency-weighted for each functional hearing group, which means that the sound is essentially filtered based on the group's frequency-specific hearing sensitivity, de-emphasizing the frequencies at which species are less sensitive. The frequency weighting functions are described in detail in Finneran (2016).

NMFS currently uses a threshold for behavioral disturbance of 160 dB re 1 µPa SPL for non-explosive impulsive sounds (e.g., airguns and impact pile driving) and intermittent sound sources (e.g., scientific and non-tactical sonar), and 120 dB re 1 µPa SPL for continuous sounds (e.g., vibratory pile driving, drilling) (NMFS 2022). This is an "unweighted" criterion that is applicable for all marine mammal functional hearing groups. Unlike with sound exposure level-based thresholds, the accumulation of acoustic energy over time is not relevant for this criterion – meaning that behavioral disturbance can occur even if an animal experiences a received SPL of 160 dB re 1 µPa very briefly just once.

While the behavioral disturbance criterion is generally applied in a binary fashion, as alluded to previously, there are numerous factors that determine whether an individual will be affected by a sound, resulting in substantial variability even in similar exposure scenarios. In particular, it is recognized that the context in which a sound is received affects the nature and extent of responses to a stimulus (Ellison et al. 2012; Southall et al. 2007). Therefore, a “step function” concept for behavioral disturbance was introduced by Wood et al. (2012) whereby proportions of exposed individuals experience behavioral disturbance at different received levels, centered at an SPL of 160 dB re 1 µPa. These probabilistic thresholds reflect the higher sensitivity that has been observed in beaked whales and migrating mysticetes (Table B.5-2). The M-weighting functions, described by Southall et al. (2007) and used for the Wood et al. (2012) probabilistic disturbance step thresholds, are different from the weighting functions by Finneran (2016), previously mentioned. The M-weighting was specifically developed for interpreting the likelihood of audibility, whereas the Finneran (2016) weighting functions were developed to predict the likelihood of auditory injury.

In order to predict the number of individuals of a given species that may be exposed to harmful levels of sound from a specific activity, a series of modeling exercises are conducted. First, the sound field of a sound-generating activity is modeled based on characteristics of the source and the physical environment. From the sound field, the range to the U.S. regulatory acoustic threshold isopleths can be predicted. This approach is referred to as acoustic modeling. By overlaying the marine mammal density information for a certain species or population in the geographical area of the activity, the number of animals exposed within the acoustic threshold isopleths is then predicted. This is called *exposure modeling*. Some models further incorporate animal movement to make more realistic predictions of exposure numbers. Animal movement models may incorporate behavioral parameters including swim speeds, dive depths, course changes, or reactions to certain sound types, among other factors. Exposure modeling may be conducted for a range of scenarios including different seasons, energy (e.g., pile driving hammers), mitigation strategies (e.g., 6 dB versus 10 dB of attenuation), and levels of effort (e.g., number of piles per day).

Table B.5-1. Acoustic thresholds for onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) for marine mammals

Functional Hearing Group	Effect	Impulsive Sound Source: L_{pk} (dB re 1 µPa)	Impulsive Sound Source: Weighted SEL_{24h} (dB re 1 µPa²·s)	Non-Impulsive Sound Source: Weighted SEL_{24h} (dB re 1 µPa²·s)
Low-frequency cetaceans	PTS	219	183	199
	TTS	213	168	179
Mid-frequency cetaceans	PTS	230	185	198
	TTS	224	170	178
High-frequency cetaceans	PTS	202	155	173
	TTS	196	140	153
Phocid pinnipeds underwater	PTS	218	185	201
	TTS	212	170	181
Otariid pinnipeds underwater	PTS	232	203	199
	TTS	226	188	199

Source: NMFS 2018.

Table B.5-2. M-weighted probabilistic disturbance thresholds (SPL) used to predict a behavioral response in marine mammals

Marine Mammal Group	Probability of Disturbance at M-Weighted SPL_{rms} Thresholds (db re 1 µPa): 120	140	160	180
Porpoises and beaked whales	50%	90%		
Migrating mysticetes	10%	50%	90%	
Other		10%	50%	90%

Source: Wood et al. 2012.
Note: Probabilities are not additive and reflect single points on a theoretical response curve.

B.5.7.2 Fishes and Invertebrates

During construction of the Bay Bridge in California, researchers observed dead fish near pile-driving operations, suggesting that fish could be killed when in very close proximity (within 33 feet [10 meters]) to the pile (Caltrans 2004). Further work around this construction project led to the formation of dual interim acoustic criteria by the Fisheries Hydroacoustic Working Group (2008), which were later adopted by NMFS. With these interim criteria, the maximum permitted peak SPL for a single pile-driving strike is 206 dB re 1 µPa, and the maximum accumulated SEL is 187 dB re 1 µPa²·s for fishes greater than 2 grams, and 183 dB re 1µPa²·s for fishes below 2 grams (Table B.5-3). These criteria remain in use by NMFS, but given the new information obtained since 2008, the appropriateness of these thresholds is being reconsidered (Popper et al. 2019).

These early findings prompted a suite of laboratory experiments in which a special testing apparatus was used to simulate signals from pile driving that a fish would encounter around 33 feet (10 meters) from a pile (Casper et al. 2012, 2013a, 2013b; Halvorsen et al. 2011, 2012a, 2012b). An important component of this work was the ability to simulate both the pressure and particle motion components of the sound field, which is rarely done in laboratory experiments. These studies showed that effects are greater in fishes with swim bladders than those without, and that species with closed swim bladders experienced greater damage than those with open swim bladders. Evidence of barotrauma was observed starting at peak pressures of 207 dB re 1 μPa (Halvorsen et al. 2012a). Larger animals seem to have a higher susceptibility to injury than smaller animals (Casper et al. 2013a). The researchers found that most of the species tested showed recovery from injury within 10 days of exposure, but they note that injured animals may be more vulnerable to predation while they are recovering, and these secondary effects have not been studied. The authors also conclude that SEL alone is not enough to predict potential impacts on fishes; the energy in a given strike and the total number of strikes are also important factors. These studies formed the foundation of the *Guidelines for Fish and Sea Turtles* by Popper et al. (2014), which became ANSI standard (#ASA S3/SC1.4 TR-2014) and have become widely accepted hearing thresholds for fishes and turtles.

No studies have directly measured TTS in fishes as a result of exposure to pile driving noise. Popper et al. (2005) exposed caged fish to sounds of seismic airguns (an impulsive signal which can serve as a proxy), and tested their hearing sensitivity afterwards. Three species with differing hearing capabilities were exposed to five pulses at a mean received L_{pk} of 207 dB re 1 μPa (186 dB re 1 $\mu Pa^2 \cdot s$ SEL). None of the fish showed evidence of barotrauma or tissue damage, nor was there damage to the hearing structures (Song et al. 2008). The species with the least-sensitive hearing—the broad whitefish—showed no evidence of TTS. The northern pike and lake chub, species with more sensitive hearing, did exhibit TTS after exposure to seismic pulses, but showed recovery after 18 hours. The findings suggest that there is a relationship between hearing sensitivity and level of impact, and that species without a connection between the swim bladder and ear are unlikely to experience TTS. Nonetheless, Popper et al. (2014) propose 186 dB re 1 $\mu Pa^2 \cdot s$ SEL as a conservative TTS threshold for all fishes exposed to either seismic airguns or pile driving, regardless of hearing anatomy. They acknowledge that research is needed on potential TTS due to exposure to pile-driving noise, and that future work should measure particle motion as the relevant cue.

A handful of studies have directly investigated the effects of impulsive sounds on eggs and larvae of marine fishes and invertebrates, and most have taken place in the laboratory. Bolle et al. (2012) used a device similar to Halvorsen et al. (2012a) to simulate pile-driving sounds and found no damage to larvae of common sole (which has a swim bladder at certain larval stages) from an SEL of 206 dB re 1 $\mu Pa^2 \cdot s$, which the authors surmise is equivalent to the received level at approximately 328 feet (100 meters) from a 13-foot (4-meter) diameter pile. Further work by Bolle et al. (2014) tested larvae of seabass and herring (both species have swim bladders). Several different life stages were tested, but none of the species showed a difference in mortality between control and exposed animals. The seabass were exposed to SELs up to 216 dB re 1 $\mu Pa^2 \cdot s$ and maximum L_{pk} of 217 dB re 1 μPa, while herring were exposed to SELs up to 212 dB re 1 $\mu Pa^2 \cdot s$ and maximum L_{pk} of 207 dB re 1 μPa. Together, the tested larvae represent the entire range of swim bladder shape types described by Popper et al. (2014). There was no difference in impacts experienced by species with and without a swim bladder, or between those with open or closed swim bladders. Based on this work, Popper et al. (2014) use 210 dB re 1 $\mu Pa^2 \cdot s$ SEL as a threshold for mortality after exposure to both pile driving and seismic airguns.

Popper et al. (2014) provide thresholds for non-recoverable injury, recoverable injury (i.e., mild forms of barotrauma), and TTS for three hearing groups, fish without a swim bladder, fish with a swim bladder not involved in hearing, and fish with a swim bladder involved in hearing, plus an additional category for eggs and larvae (Table B.5-3). Unlike with marine mammals, Popper et al. (2014) do not distinguish between impulsive and non-impulsive sounds; instead they provide thresholds for each sound type (explosions, pile driving, seismic airguns, sonars, and continuous sounds). That said, studies focused on pile driving are sometimes used to draw conclusions about impacts from seismic airguns, and vice versa. This is simply due to a lack of comprehensive data for each source type. The thresholds are all given in terms of sound pressure, not particle motion, though many have acknowledged that particle motion thresholds would be more appropriate (Popper and Hawkins 2018). Currently, there are no underwater noise thresholds for invertebrates, but the effect ranges are expected to be similar to those predicted for fish without a swim bladder.

Table B.5-3. Acoustic thresholds for injury for fishes exposed to pile-driving sound

Fish Hearing Group	Mortality and Non-Recoverable Injury		Recoverable Injury		TTS
	L_{pk} (dB re 1 µPa)	SEL (dB re 1 µPa²·s)	L_{pk} (dB re 1 µPa)	SEL (dB re 1 µPa²·s)	SEL (dB re 1 µPa²·s)
Fish without swim bladder[1]	213	219	213	216	186
Fish with swim bladder not involved in hearing[1]	207	210	207	203	186
Fish with swim bladder involved in hearing[1]	207	207	207	203	186
Eggs and larvae[1]	207	210	--	--	--
Fish ≥ 2 grams[2]			206	187	
Fish < 2 grams[2]			206	183	

[1] Source: Popper et al. 2014.
[2] Source: Fisheries Hydroacoustics Working Group 2008.

NMFS currently uses an SPL criterion of 150 dB re 1 µPa for the onset of behavioral effects in fishes (GARFO 2020). The scientific rationale for this criterion is not well supported by the data (Hastings 2008), and there has been criticism about its use (Popper et al. 2019). Most notably, the differences in hearing anatomy among fishes suggest the use of a single criterion may be too simplistic. Furthermore, a wide range of behavioral responses has been observed in the empirical studies thus far (ranging from startle responses to changes in schooling behavior), and it is difficult to ascertain which, if any, of those responses may lead to significant biological consequences. Interestingly, several recent studies on free-ranging fishes (e.g., Hawkins et al. 2014; Roberts et al. 2016) have observed the onset of different behavioral responses at similar received levels ($L_{pk\text{-}pk}$ of 152 to 167 dB re 1 µPa), and Popper et al. (2019) suggest that a received level of 163 dB re 1 µPa $L_{pk\text{-}pk}$ might be more appropriate than the current SPL criterion of 150 re 1 µPa. Finally, given that most species are more sensitive to particle motion and not acoustic pressure, the criteria should, at least in part, be expressed in terms of particle motion. However, until there is further empirical evidence to support a different criterion, the 150 dB re 1 µPa threshold remains in place as the interim metric that regulatory agencies have agreed upon.

B.5.7.3 Sea Turtles

Injury thresholds for sea turtles were developed for use by the U.S. Navy (Finneran et al. 2017) (Table B.5-4). These thresholds consist of dual criteria of L_{pk} and SEL thresholds. The SEL thresholds are weighted based on auditory weighting functions developed by Finneran et al. (2017). NMFS currently recommends a threshold for behavioral disturbance of 175 dB re 1 μPa SPL for both impulsive and non-impulsive sources based on exposure studies conducted by McCauley et al. (2000), which demonstrated that sea turtles noticeably increased their swimming activity at received levels above an SPL of 166 dB re 1 μPa and became erratic in their swimming, potentially indicating agitation, when received levels exceeded an SPL of 175 dB re 1 μPa.

Table B.5-4. Recommended acoustic thresholds for onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) for sea turtles

Effect	Impulsive Sound Source L_{pk} (dB re 1 μPa)	Impulsive Sound Source SEL (dB re 1 $\mu Pa^2 \cdot s$)	Non-Impulsive Sound Source SEL (dB re 1 $\mu Pa^2 \cdot s$)
PTS	232	204	220
TTS	226	189	200

Source: Finneran et al. 2017.

To predict the number of individuals of a given sea turtle species that may be exposed to harmful levels of sound from a specific activity, acoustic modeling and exposure modeling are conducted, as described for marine mammals in Section B.5.7.1. These modeling efforts take into account sea turtle densities in the geographical area of the activity and available sea turtle behavioral parameters to predict their movements within that geographical area.

B.5.8 References Cited

Amaral, J. L., R. B. Beard, R. J. Barham, A. G. Collett, J. Elliot, A. Frankel, D. Gallien, C. Hager, A. A. Khan, Y. T. Lin, T. Mason, J. H. Miller, A. E. Newhall, G. R. Potty, K. Smith, and K. J. Vigness-Raposa. 2018. *Field Observations during Wind Turbine Foundation Installation at the Block Island Wind Farm, Rhode Island*. OCS Study 2018-029.

Amaral, J. L., J. H. Miller, G. R. Potty, K. J. Vigness-Raposa, A. S. Frankel, Y. T. Lin, A. E. Newhall, D. R. Wilkes, and A. N. Gavrilov. 2020. Characterization of Impact Pile Driving Signals during Installation of Offshore Wind Turbine Foundations. *Journal of the Acoustical Society of America* 147:2323.

Amaral, J. L., K. Ampela, A. Frankel, A. A. Khan, Y. T. Lin, T. Mason, J. H. Miller, A. E. Newhall, and G. R. Potty. 2021. *Field Observations During Offshore Wind Structure Installation and Operation, Volume 1*. OCS Study BOEM 2021-025.

Bellmann, M. A., A. M. Eng, T. Wendt, S. Gerlach, P. Remmers, and J. Brinkmann. 2020. Underwater noise during percussive pile driving: Influencing factors on pile-driving noise and technical possibilities to comply with noise mitigation values. 128 pp.

Bolle, L. J., C. A. de Jong, S. M. Bierman, P. J. van Beek, O. A. van Keeken, P. W. Wessels, C. J. van Damme, H. V. Winter, D. de Haan, and R. P. Dekeling. 2012. Common Sole Larvae Survive High Levels of Pile-driving Sound in Controlled Exposure Experiments. *PLoS One* 7:e33052.

Bolle, L., C. de Jong, E. Blom, P. W. Wessels, C. J. van Damme, and H. V. Winter. 2014. Effect of pile-driving sound on the survival of fish larvae.

Buehler, D, P. E. Rick Oestman, J. Reyff, K. Pommerenck, and B. Mitchell. 2015. *Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish*. State of California, Department of Transportation. Report No.: CTHWANP-RT-15-306.01.01.

Bureau of Ocean Energy Management (BOEM). 2019. *Underwater Acoustic Monitoring Data Analyses for the Block Island Wind Farm, Rhode Island.* (OCS Study BOEM 2019-029). May.

California Department of Transportation (Caltrans). 2004. *Fisheries and Hydroacoustic Monitoring Program Compliance Report for the San Francisco-Oakland Bay Bridge East Span Seismic Safety Project*. Report No.: EA 012023.

Casper, B. M., A. N. Popper, F. Matthews, T. J. Carlson, and M. B. Halvorsen. 2012. Recovery of Barotrauma Injuries in Chinook Salmon, *Oncorhynchus tshawytscha* from Exposure to Pile Driving Sound. *PLoS ONE* 7:e39593.

Casper, B. M., M. B. Halvorsen, F. Matthews, T. J. Carlson, and A. N. Popper. 2013a. Recovery of Barotrauma Injuries Resulting from Exposure to Pile Driving Sound in Two Sizes of Hybrid Striped Bass. *PLoS ONE* 8:e73844.

Casper, B. M., M. E. Smith, M. B. Halvorsen, H. Sun, T. J. Carlson, and A. N. Popper. 2013b. Effects of Exposure to Pile Driving Sounds on Fish Inner Ear Tissues. *Comparative Biochemistry and Physiology, Part A* 166:352–360.

Christiansen, F., L. Rojano-Doñate, P. T. Madsen, and L. Bejder. 2016. Noise Levels of Multi-rotor Unmanned Aerial Vehicles with Implications for Potential Underwater Impacts on Marine Mammals. *Frontiers in Marine Science* 3:1–9.

Crocker, S. E., and F. D. Fratantonio. 2016. *Characteristics of Sounds Emitted during High-resolution Marine Geophysical Surveys*. OCS Study BOEM 2016-044 NUWC-NPT Technical Report 12, 203.

Elliott, J., A. A. Khan, Y. T. Lin, T. Mason, J. H. Miller, A. E. Newhall, G. R. Potty, and K. Vigness-Raposa. 2019. *Field Observations during Wind Turbine Operations at the Block Island Wind Farm, Rhode Island*. OCS Study BOEM 2019-028.

Ellison, W. T., B. L. Southall, C. W. Clark, and A. S. Frankel. 2012. A New Context-based Approach to Assess Marine Mammal Behavioral Responses to Anthropogenic Sounds. *Conservation Biology* 26:21–28.

Erbe, C., M. Parsons, A. J. Duncan, S. Osterrieder, and K. Allen. 2017. Aerial and Underwater Sound of Unmanned Aerial Vehicles (UAV, drones). *Journal of Unmanned Vehicle Systems* 5:92–101.

Finneran J.J. 2015. Noise-Induced Hearing Loss in Marine Mammals: A Review of Temporary Threshold Shift Studies from 1996 to 2015. *J Acoust Soc Am*. 2015 Sep;138(3):1702-26. doi: 10.1121/1.4927418. PMID: 26428808.

Finneran, J.J. 2016. *Auditory Weighting Functions and TTS/PTS Exposure Functions for Marine Mammals Exposed to Underwater Noise*. Technical Report #3026.

Finneran, J. J., E. E. Henderson, D. S. Houser, K. Jenkins, S. Kotecki, and J. Mulsow. 2017. *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III).* Technical report by Space and Naval Warfare Systems Center Pacific (SSC Pacific). 183 pp.

Fisheries Hydroacoustic Working Group. 2008. *Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving Activities*.

Fowler, K, P. Pellerin, and A. Zoidis. 2022. *Characteristics and Contributions of Noise Generated by Mechanical Cutting during Conductor Removal Operations*. OCS Study BOEM 2022-029.

Greater Atlantic Regional Fisheries Office (GARFO). 2020. Section 7: Consultation technical guidance in the greater Atlantic region. Available: https://www.fisheries.noaa.gov/new-england-mid-atlantic/consultations/section-7-consultation-technical-guidance-greater-atlantic. Accessed: October 25, 2022.

Halvorsen, M. B., B. M. Casper, C. M. Woodley, T. J. Carlson, and A. N. Popper. 2011. *Hydroacoustic Impacts on Fish from Pile Installation*. National Cooperative Highway Research Program Transportation Research Board.

Halvorsen, M. B., B. M. Casper, F. Matthews, T. J. Carlson, and A. N. Popper. 2012a. Effects of Exposure to Pile-driving Sounds on the Lake Sturgeon, Nile Tilapia and Hogchoker. *Proceedings of the Royal Society B* 279:4705–4714.

Halvorsen, M. B., B. M. Casper, C. M. Woodley, T. J. Carlson, and A. N. Popper. 2012b. Threshold for Onset of Injury in Chinook Salmon from Exposure to Impulsive Pile Driving Sounds. *PLoS ONE* 7:e38968.

Hamernik, R. P., and K. D. Hsueh. 1991. Impulse Noise: Some Definitions, Physical Acoustics and Other Considerations. *The Journal of the Acoustical Society of America* 90:189–196.

Hastings, M. 2008. Sound Exposure Metrics for Aquatic Animals. *Bioacoustics* 17:118–120.

Hatch, L. T., C. M. Wahle, J. Gedamke, J. Harrison, B. Laws, S. E. Moore, J. H. Stadler, and S. M. Van Parijs. 2016. Can You Hear Me Here? Managing Acoustic Habitat in US Waters. *Endangered Species Research* 30:171–186.

Hawkins, A. D., L. Roberts, and S. Cheesman. 2014. Responses of Free-living Coastal Pelagic Fish to Impulsive Sounds. *The Journal of the Acoustical Society of America* 135:3101–3116.

Hildebrand, J. A. 2009. Anthropogenic and Natural Sources of Ambient Noise in the Ocean. *Marine Ecology Progress Series* 395:5–20.

Jiménez-Arranz, G., N. Banda, S. Cook, and R. Wyatt. 2020. Review on existing data on underwater sounds produced by the oil and gas industry. 182 pp.

Kipple, B., and C. Gabriele. 2003. *Glacier Bay Watercraft Noise*. Technical Report NSWCCD-71-TR-2003/522. 62 pp.

Kongsberg Maritime AS. 2013. APOS for HiPAP Instruction Manual. 131 pp. Available: https://www.kongsberg.com/globalassets/maritime/km-products/product-documents/319957_apos_for_hipap_complete_manual.pdf.

Kyhn, L. A., J. Tougaard, and S. Sveegaard. 2011. Underwater Noise from the Drillship Stena Forth in Disko West, Baffin Bay, Greenland.

MacGillivray, A. O., Z. Li, D. E. Hannay, K. B. Trounce, and O. M. Robinson. 2019. Slowing Deep-sea Commercial Vessels Reduces Underwater Radiated Noise. *Journal of the Acoustical Society of America* 146:340.

Martin, S. B., K. Lucke, and D. R. Barclay. 2020. Techniques for Distinguishing between Impulsive and Non-impulsive Sound in the Context of Regulating Sound Exposure for Marine Mammals. *The Journal of the Acoustical Society of America* 147:2159–2176.

Matuschek, R., and K. Betke. 2009. Measurements of Construction Noise during Pile Driving of Offshore Research Platforms and Wind Farms. Proceedings of the International Conference on Acoustics NAG/DAGA, Rotterdam, March 23-26.

McCauley, R. D., J. Fretwell, A. J. Duncan, C. Jenner, M.-N. Jenner, J. D. Penrose, R. I. T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000. *Marine seismic surveys: analysis and propagation of air-gun signals: and effects of air-gun exposure on humpback whales, sea turtles, fishes, and squid.* REPORT R99-15, Centre for Marine Science and Technology, Curtin University.

McKenna, M. F., S. M. Wiggins, and J. A. Hildebrand. 2013. Relationship between Container Ship Underwater Noise Levels and Ship Design, Operational and Oceanographic Conditions. *Scientific Reports* 3:1–10.

McQueen, A. D., B. C. Suedel, J. L. Wilkens, and M. P. Fields. 2018. Evaluating Biological Effects of Dredging-induced Underwater Sounds. Pages 202–213 in D. F. Hayes (ed.), Proceedings of the Dredging Summit and Expo 2018.

National Marine Fisheries Service (NMFS). 2018. *2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0). Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts*. NOAA Tech. Memo. NMFS-OPR-59.

National Marine Fisheries Service (NMFS). 2022. National Marine Fisheries Service: Summary of Marine Mammal Protection Act Acoustic Thresholds. Available: https://media.fisheries.noaa.gov/2022-05/MM%20Acoustic%20Thresholds%20%28508%29_secure%20%28May%202022%29.pdf. Accessed: May 2022

Nedwell, J. R., and B. Edwards. 2004. A Review of Measurements of Underwater Man-made Noise Carried out by Subacoustech Ltd, 1993 – 2003.136 pp.

Nedwell, J., J. Langworthy, and D. Howell. 2003. *Assessment of Sub-sea Acoustic Noise and Vibration from Offshore Wind Turbines and Its Impact on Marine Wildlife. Initial Measurements of Underwater Noise during Construction of Offshore Windfarms, and Comparison with Background Noise*. COWRIE Report No. 544 R 0424.

Pijanowski, B. C., L. J. Villanueva-Rivera, S. L. Dumyahn, A. Farina, B. L. Krause, B. M. Napoletano, S. H. Gage, and N. Pieretti. 2011. Soundscape Ecology: The Science of Sound in the Landscape. *BioScience* 61:203–216.

Popper, A. N., and A. D. Hawkins. 2018. The Importance of Particle Motion to Fishes and Invertebrates. *Journal of the Acoustical Society of America* 143:470.

Popper, A. N., M. E. Smith, P. A. Cott, B. W. Hanna, A. O. MacGillivray, M. W. Austin, and D. A. Mann. 2005. Effects of Exposure to Seismic Airgun Use on Hearing of Three Fish Species. *The Journal of the Acoustical Society of America* 117:3958–3971.

Popper, A. N., A. D. Hawkins, R. R. Fay, D. A. Mann, S. Bartol, T. J. Carlson, S. Coombs, W. T. Ellison, R. L. Gentry, M. B. Halvorsen, S. Løkkeborg, P. H. Rogers, B. L. Southall, D. G. Zeddies, and W. M. Tavolga. 2014. *Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report Prepared by ANSI-accredited Standards Committee S3/SC1 and Registered with ANSI*. ASA S3/SC1.4 TR-2014.

Popper, A. N., A. D. Hawkins, and M. B. Halvorsen. 2019. *Anthropogenic Sound and Fishes*. Report No. WA-RD 891.1. 170 pp.

Richardson, W. J., C. R. Greene, C. Malme, and D. H. Thompson. 1995. *Marine Mammals and Noise*. San Diego, CA: Academic Press.

Roberts, L., S. Cheesman, and A. D. Hawkins. 2016. Effects of Sound on the Behavior of Wild, Unrestrained Fish Schools. *Advances in Experimental Medicine and Biology* 875:917–924.

Ross, D. 1976. *Mechanics of Underwater Noise*. New York, NY: Pergamon Press.

Ruppel, C. D., T. C. Weber, E. R. Staaterman, S. J. Labak, and P. E. Hart. 2022. Categorizing Active Marine Acoustic Sources based on Their Potential to Affect Marine Animals. *Journal of Marine Science and Engineering* 10:1278.

Song, J., D. A. Mann, P.A. Cott, B. W. Hanna, and A. N. Popper. 2008. The Inner Ears of Northern Canadian Freshwater Fishes following Exposure to Seismic Air Gun Sounds. *The Journal of the Acoustical Society of America* 124:1360–1366.

Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. Greene, Jr., D. Kastak, D. R. Ketten, J. H. Miller, P. E. Natchigall, W. J. Richardson, J. A. Thomas, and P. L. Tyack. 2007. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. *Aquatic Mammals* 33:411–521.

Southall, B.L., J.J. Finneran, C. Reichmuth, P.E. Nachtigall, D.R. Ketten, A.E. Bowles, W.T. Ellison, D.P. Nowacek, and P.L. Tycak. 2019. Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. *Aquatic Mammals* 45(2):125–232.

Stöber, U., and F. Thomsen. 2021. How Could Operational Underwater Sound from Future Offshore Wind Turbines Impact Marine Life? *Journal of the Acoustical Society of America* 149:1791.

Tougaard, J., L. Hermannsen, P. T. Madsen. 2020. How Loud is the Underwater Noise from Operating Offshore Wind Turbines? *Journal of the Acoustical Society of America* 148:2885.

Urick, R. J. 1983. *Principles of Underwater Sound*. Los Altos Hills, CA: Peninsula Publishing.

Warner, G., and A. McCrodan. 2011. Underwater Sound Measurements. In K. G. Hartin, L. N. Bissen, S. A. Case, D. S. Ireland, and D. Hannay (eds.), *Marine Mammal Monitoring and Mitigation during Site Clearance and Geotechnical Surveys by Statoil USA E&P Inc. in the Chuckchi Sea, August-October 2011: 90-day Report*.

Wood, J., B. L. Southall, and D. J. Tollit. 2012. *PG&E Offshore 3-D Seismic Survey Project EIR.* Marine Mammal Technical Draft Report. SMRU Ltd.

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