California North Coast Offshore Wind Studies

Feasibility of Potential Subsea Cable Corridor Scenarios

This report was prepared by H.T. Harvey & Associates. It is part of the *California North Coast Offshore Wind Studies* collection, edited by Mark Severy, Zachary Alva, Gregory Chapman, Maia Cheli, Tanya Garcia, Christina Ortega, Nicole Salas, Amin Younes, James Zoellick, & Arne Jacobson, and published by the Schatz Energy Research Center in September 2020.

The series is available online at schatzcenter.org/wind/

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This report was created under grant from the Governor's Office of Planning and Research, agreement number: OPR19100

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H.T. Harvey & Associates (2020). Feasibility of Potential Subsea Cable Corridor Scenarios. In M. Severy, Z. Alva, G. Chapman, M. Cheli, T. Garcia, C. Ortega, N. Salas, A. Younes, J. Zoellick, & A. Jacobson (Eds.) *California North Coast Offshore Wind Studies*. Humboldt, CA: Schatz Energy Research Center. schatzcenter.org/pubs/2020-OSW-R14.pdf.

Executive Summary

We conducted a preliminary assessment of the potential environmental effects of a subsea transmission cable on the marine environment. The subsea transmission cable route would run between the Humboldt Substation adjacent to the Humboldt Bay Generating Station (HBGS) and the Golden Gate Bridge. The subsea cable route is being considered as an alternative to completing terrestrial transmission line improvements (which would result in potential effects on the terrestrial environment between HBGS and 500-kilovolt transmission cables in California's Central Valley) that would be required to convey electricity generated from a commercial-scale offshore wind farm off Humboldt County to load centers in the San Francisco Bay area.

The evaluation considered two conceptual subsea transmission cable route alternatives developed with a route analysis conducted by Mott MacDonald (2020) using available information on hazards and constraints. The routes were designed to avoid or minimize hazards including seismic faults, submarine canyons, sand waves, shipping vessel traffic, bottom-oriented fishing (e.g., trawling, pots/traps), tsunami, gas hydrates, and ocean disposal sites, and constraints including existing submarine telecommunications cables, steep slopes, hard substrate, installation depth, sea state, cable installation vessel operational limitations, and designated Marine Protected Areas (MPAs).

The evaluation is a preliminary assessment of the short-term effects of site characterization studies supporting cable route siting and cable installation, and longer-term effects from cable operation and maintenance. The short-term effects during the cable decommissioning process are similar to cable installation and are not evaluated. The results of the analysis inform the discussion of environmental challenges and considerations associated with the preliminary subsea cable route alternatives, including the data and information gaps, permitting challenges, and considerations for future studies.

Our findings suggest that the long cable lengths and locations are the primary factor in determining the numbers and degree of impacts on resources of concern. In particular, cable laying operations will have greater environmental consequences, over large spatial scales, in comparison to cable operations. Cable laying will result in habitat disturbance for a short duration. However, the nearshore route includes cable burial which has an increased potential for interactions with sensitive species and habitats than the offshore cable route, even though the offshore route is longer. Without additional environmental information, such as benthic habitat conditions, it appears that any identified environmental constraints in route selection are likely far outweighed by the physical hazards and constraints identified by Mott MacDonald (2020).

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Section 1.0 Introduction

This document presents the results of a preliminary assessment of the potential environmental effects of a subsea transmission cable on the marine environment. The subsea transmission cable route would run between the Humboldt Substation adjacent to the Humboldt Bay Generating Station (HBGS) and the Golden Gate Bridge. The subsea cable route is being evaluated as an alternative to completing terrestrial transmission line improvements (which would result in potential effects on the terrestrial environment between HBGS and and 500-kilovolt transmission cables in California's Central Valley), that would be required to convey electricity generated from an offshore wind farm off Humboldt County to load centers in the San Francisco Bay area. This assessment is focused only on the two preliminary subsea cable route alternatives (offshore and nearshore) because the potential locations of the landing sites and converter stations at the ends of the cable have not been determined.

1.1 Subsea Transmission Cable Route Alternatives

The subsea transmission cable route alternatives were developed with a route analysis conducted by Mott MacDonald (2020) using available information on hazards and constraints. Hazards included seismic faults, submarine canyons, sand waves, shipping vessel traffic, bottom-oriented fishing (e.g., trawling, pots/traps), tsunami, gas hydrates, and ocean disposal sites. Constraints included existing submarine telecommunications cables, steep slopes, hard substrate, installation depth, sea state, cable installation vessel operational limitations, and designated Marine Protected Areas (MPAs). The spatial analysis of these hazards and constraints identified two conceptual alternative routes placed to avoid, to the extent possible, the identified hazards and constraints; one offshore and one nearshore, as detailed in Mott MacDonald (2020) (Figure 1) and briefly described below.

1.1.1 Offshore Route

The offshore route alternative lies to the west of the submarine canyons that occur on the continental shelf to avoid crossing any canyons, extending the route to depths as great as 9,842 feet (ft) (3,000 meters [m]) (Figure 1). This cable route also avoids many types of bottom-oriented commercial fishing activities and minimizes the length of cable in MPAs. However, the offshore route would cross major seismic faults and several telecommunication cables at great depths, thus making repairs risky. The offshore route cable length is 410 miles (660 km) and would be considerably longer (i.e., more costly) than the nearshore, more direct route.

1.1.2 Nearshore Route

The nearshore route alternative is in shallower water on the east (i.e., shore) side of submarine canyons (Figure 1). Although the nearshore route would be shorter than the offshore route, there would be a greater length of cable in or near MPAs and it would be exposed to more hazards (e.g., bottom-oriented commercial fisheries, boats anchoring). The nearshore route includes steep slopes, hard substrate, and major seismic fault crossings.

The nearshore route cable length is 260 miles (418 km), of which approximately 72 miles (116 km) is within California state waters (which extend to 3 nautical miles from the coastline).

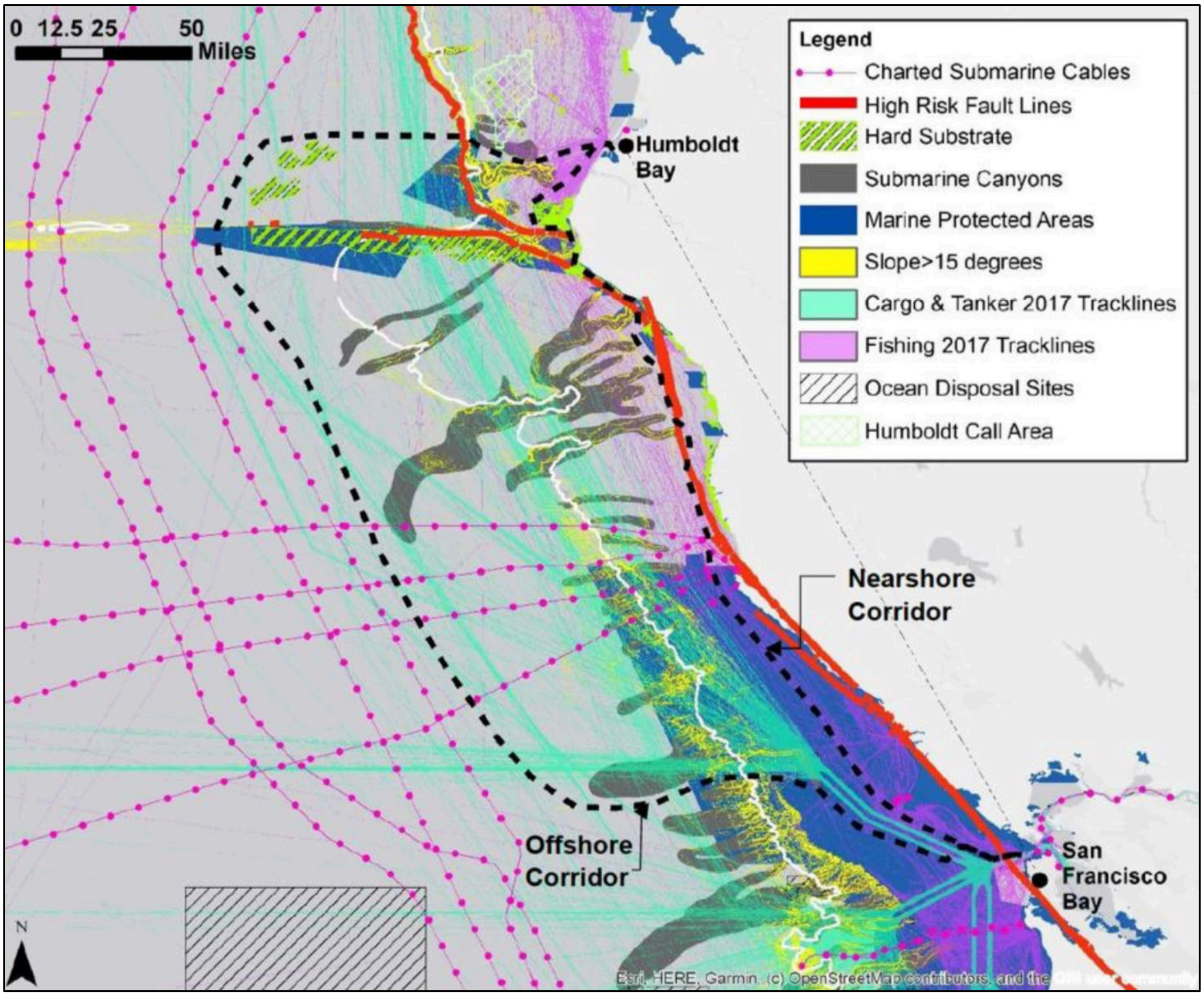

Figure 1. Existing Subsea Conditions Between Humboldt and San Francisco Bays (Mott MacDonald 2020)
Note: White line shows the 6,560-ft (2,000-m) contour.

Section 2.0 Environmental Conditions, Potential Effects, and Potential Constraints

This section describes the environmental conditions in the study area, provides a preliminary analysis of the potential environmental effects, and discusses the potential environmental constraints of the offshore and nearshore subsea cable route alternatives. The study area includes both preliminary cable route alternatives; specific characteristics of the route alternatives will be described when data or published information indicate that they differ in marine conditions (e.g., sea floor attributes, water depth). The environmental conditions consist of the physical and biological settings in the study area, including marine conditions, habitats, and species present. This evaluation will incorporate the existing environmental conditions information described in the *Northern California Coast Offshore Wind Feasibility Study—Environmental Baseline and Potential Environmental Effects Report* (H. T. Harvey & Associates 2020), and focus on environmental differences between the cable route alternatives.

Species that are listed as threatened or endangered under the federal Endangered Species Act (FESA) and/or the California Endangered Species Act (CESA) are emphasized in this section because effects on these species would require consultation with the National Marine Fisheries Service (NMFS), the U.S. Fish and Wildlife Service (USFWS), and/or California Department of Fish and Wildlife (CDFW), and could be a potential permitting challenge.

The effects analysis represents a preliminary assessment of the short-term effects of site characterization studies supporting cable route siting and cable installation, and longer-term effects from cable operation and maintenance. The short-term effects during the cable decommissioning process are similar to cable installation and are not evaluated. The results of the analysis inform the discussion of environmental challenges and considerations associated with the preliminary subsea cable route alternatives, including the data and information gaps, permitting challenges, and considerations for future studies.

2.1 Physical Environment

The marine physical environment encompasses the nearshore and offshore subsea cable route alternatives from where the routes diverge offshore of Humboldt Bay to where they converge offshore of San Francisco Bay. This section describes the regional marine conditions of the subsea cable route alternatives.

2.1.1 Marine Conditions

The marine conditions describing the environmental site characteristics for the nearshore and offshore subsea cable route alternatives include winds, upwelling, wave action, oceanic circulation (i.e., currents), and water temperature.

The marine conditions in the study area are generally similar to those described in H. T. Harvey & Associates (2020). The study area has average significant wave heights (i.e., mean wave height of the highest one-third of waves in a given location) of 5.9 to 9.8 ft (1.8 to 3 m) from the WNW (BOEM and NOAA 2020a), with average monthly wind speeds ranging from 3.9 to 19.7 mph (1.75 to 6 m/s) from the NNW/NW, with the highest average wind velocity in June (BOEM and NOAA 2020b).

Wind speeds along the nearshore subsea cable route alternative at an elevation of 295.2 ft (90 m) vary between annual averages of approximately 15.6 and 17.9 mph (7 and 8 m/s), with the highest winds at each of the three promontories: 20.1 mph (9 m/s) at Cape Mendocino; 17.9 mph (8 m/s) at Point Arena; and 15.6 mph (7 m/s) at Point Reyes (NREL 2010). Wind speed estimates further offshore (12 and 50 nautical miles offshore [22.2 and 92.6 km]) at 295.2 ft (90 m) elevation show higher wind speeds along the offshore subsea cable route of 17.9 to 19 mph (8 to 8.5 m/s) and as high as 20.1 to 22.4 mph (9 to 10 m/s) at Cape Mendocino (NREL 2010). The primary oceanic circulation patterns that directly affect the conditions offshore of northern California are described in Section 2.1.1 of H. T. Harvey & Associates (2020). Ocean circulation from the north coast at Humboldt Bay to the Gulf of the Farallones is dominated by seasonal strong, alongshore winds that result in upwelling of cold water, particularly during the upwelling season from March through July, although it can begin slightly earlier and be longer lasting (García-Reyes and Largier 2009).

Sea surface temperatures in the study area average 54°F (BOEM and NOAA 2020c), and are similar to the temperatures described in H. T. Harvey & Associates (2020). Temperatures tend to be colder in coastal waters over the continental shelf, and at features such as Point Arena and Cape Mendocino in the nearshore subsea cable route alternative, particularly during the upwelling season when cold water is more likely to be brought to the surface.

The subsea cable route alternatives avoid areas of known rocky habitat; however, the distributions of hard and soft substrate types have not been very well-characterized along the alternatives and mapping to date has been limited (Figure 2). The lack of comprehensive substrate information for each cable route alternative is a considerable data gap that needs to be addressed through geophysical and geotechnical assessment. Hard and soft substrate provide habitat for different communities of fish and benthic invertebrates. Rocky reef habitat areas of particular concern (HAPCs) have been spatially mapped and generally categorized by the Pacific Fishery Management Council (PFMC) as "either nearshore or offshore in reference to the proximity of the habitat to the coastline. [They] may be composed of bedrock, boulders, or smaller rocks, such as cobble and gravel. Hard substrates are one of the least abundant benthic habitats, yet they are among the most important habitats for groundfish." (PFMC 2005). HAPCs are discussed in more detail in Section 2.2.1. Spatial information on rocky reef HAPCs is a "first approximation of [their] extent" (PFMC 2005); however, to further refine the locations of substrate types, methods such as direct observation and geophysical/geotechnical surveys would be needed (Fugro Marine GeoServices Inc. 2017). Hard substrates would likely require additional protection for the subsea cable (e.g., concrete or other methods to stabilize) to prevent damage from abrasion.

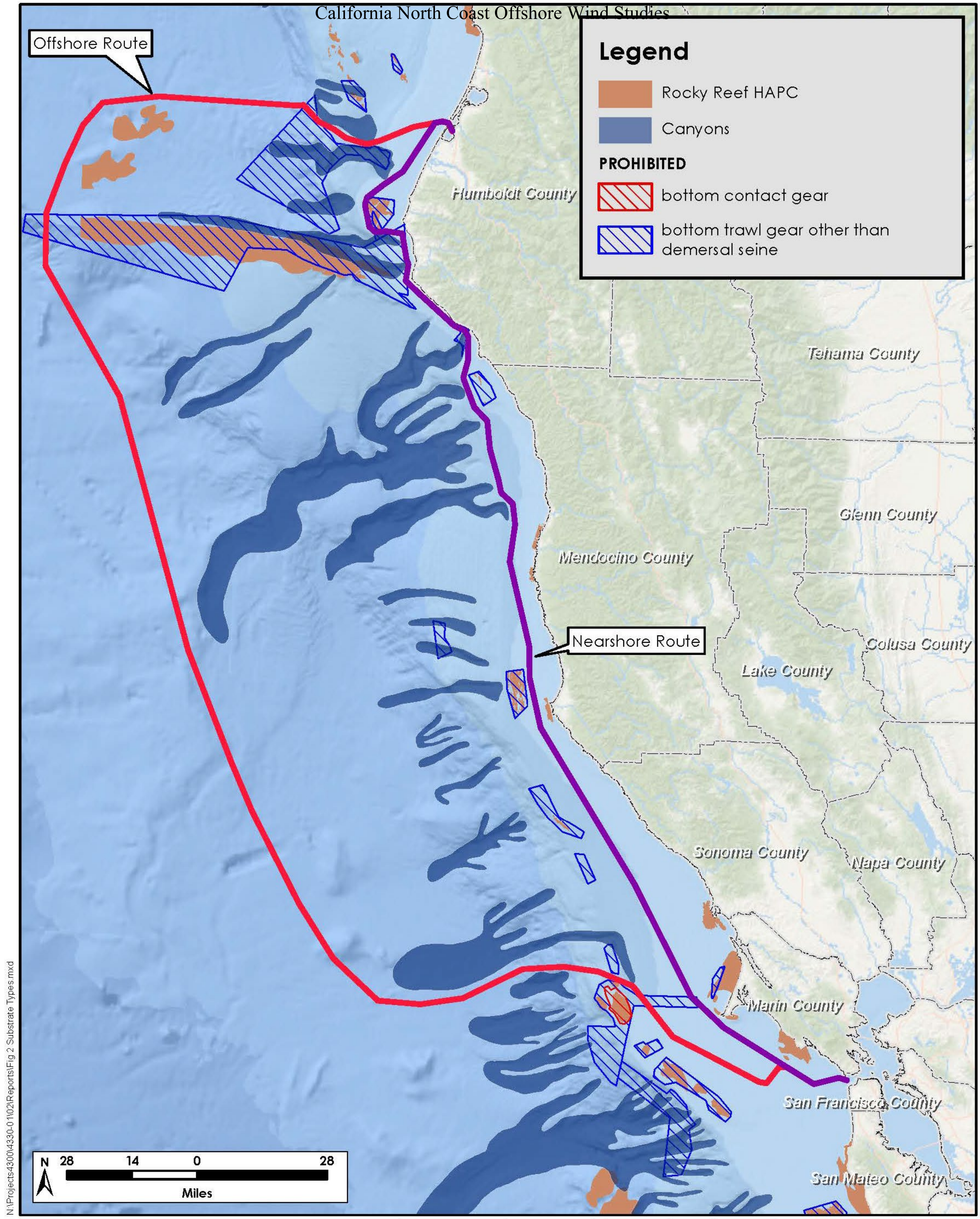

Figure 2. Subsea Cable Route Alternatives: Substrate Types

Subsea Cable Route Alternatives, Environmental Considerations (4330-02)

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2.2 Biological Environment

The biological environment is composed of the habitats and species likely to be present along the subsea cable route alternatives and shares many attributes with that described in H. T. Harvey & Associates (2020). Therefore, the discussion of the biological environment focuses on habitats and species occurring along the subsea cable route alternatives and the differences between the offshore and nearshore subsea route alternatives. Species that are listed as threatened or endangered under FESA and/or the CESA and critical habitat are described in Section 2.3, and Essential Fish Habitat (EFH) is discussed in Section 2.4.

2.2.1 Sensitive Habitats

Sensitive habitats have been identified along or adjacent to the subsea cable route alternatives (Figures 2 and 3), although the routes were developed in part to avoid them (Mott MacDonald 2020). These habitats consist of EFH Conservation Areas, rocky reef HAPC, Deep-Sea Ecosystem Conservation Area, National Marine Sanctuaries (NMSs), and MPAs designated in California state waters. These designations are summarized below. The sensitive habitats crossed by the subsea cable route alternatives are listed in Table 1, and those in the vicinity of each route alternative are listed in Table 2.

EFH Conservation Areas—designated areas that are defined by latitude and longitude coordinates, which are closed to specific types of fishing to minimize the adverse effects of fishing on EFH. Under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), these conservation areas are required to be identified in fishery management plans (FMPs) and fishery managers must evaluate both fishing and non-fishing activities in them.

Rocky Reef HAPC—designated rocky reef habitat areas that have been mapped and described by the PFMC as priorities for EFH conservation under the Magnuson-Stevens Act. According to the PFMC (2005), these areas may be nearshore or offshore; consist of bedrock, boulders, or smaller rocks; and are important habitats for groundfish. Areas that have been designated as HAPCs are not automatically subject to additional restrictions or protections. PFMC's (2005) mapping is an approximation of the extent of rocky reef habitat, and consequently, hard substrate; however, direct observation or other types of surveys would be required to further refine the locations of hard and soft substrates.

Deep-Sea Ecosystem Conservation Areas (DECA)—the areas within the exclusive economic zone (EEZ) deeper than 11,483 ft (3,500 m) that are not designated as EFH and are closed to bottom contact gear (NMFS 2019a). The DECAs were established on January 1, 2020, to contribute to the protection of deepwater habitats, including deep-sea corals (NMFS 2019a).

MPAs—designated under the Marine Life Protection Act of 1999 and subdivided into four categories with differing fishing, boating, or access regulations: State Marine Reserves (SMRs), State Marine Conservation Areas (SMCAs), State Marine Recreational Management Areas, and Special Closures. The subsea cable route alternatives cross SMRs and SMCAs. In SMRs, "damage or take of all marine resources (living, geologic, or cultural) including recreational and commercial take" is prohibited, and in SMCAs "some recreational and/or commercial take of marine resources" may be allowed, but restrictions vary (CDFW 2020).

NMSs—designated by the Secretary of Commerce under the National Marine Sanctuaries Act as "areas of the marine environment with special national significance due to their conservation, recreational, ecological, historical, scientific, cultural, archaeological, educational, or esthetic qualities" (NOAA 2020).

2.2.2 Benthic Invertebrates

Benthic community structure along the potential subsea cable corridors is similar to that described in H. T. Harvey & Associates (2020). Benthic community surveys offshore of California, Oregon, and Washington across the continental shelf indicated that depth may be the primary factor in structuring assemblages, with the inner shelf (less than 164 ft [50 m]) differentiating from the mid- to outer shelf, which is secondarily structured by sediment composition (% sand[1]) with finer resolution depth differentiation occurring within sediment types (Henkel et al. 2014). However, there is little information on benthic communities at the maximum depths of the offshore cable route alternative. Benthic surveys to evaluate existing conditions in California MPAs also indicated that benthic species composition varies with depth and substrate type, and that in soft-bottom invertebrate species composition transitions from shallower water habitats (e.g., nearshore cable route alternative) dominated by sea pens, sea whips, octopus, shrimp, and Dungeness crab (*Cancer magister*), to deep water habitats (e.g., portions of the offshore cable route from approximately 328 to 475 ft (100 to 450 m) dominated by anemones, gorgonians, and soft corals (Lauermann et al. 2017, Lindholm et al. 2014)). In rocky habitat, anemones, sea cucumbers, gorgonians, sea stars, and basket stars are the most prevalent benthic invertebrates (Lauermann et al. 2017, Lindholm et al. 2014). Deep-sea invertebrate communities in soft substrates adjacent to a lost shipping container at 4,200 ft (1,281 m) were dominated by sea pens, anemones, and echinoderms, including sea stars and sea pigs (Taylor et al. 2014). Interestingly, the organisms associated with the novel hard structure provided by the shipping container were somewhat different from those in adjacent soft substrates, and were predominantly tube worms, soft corals, amphipods, and mollusks, including sea snails and scallops (Taylor et al. 2014).

[1] In high sand environments (e.g., >84% sand), greater spatial heterogeneity in species assemblages is found in shallower sandy areas than silty areas (Henkel et al. 2014)

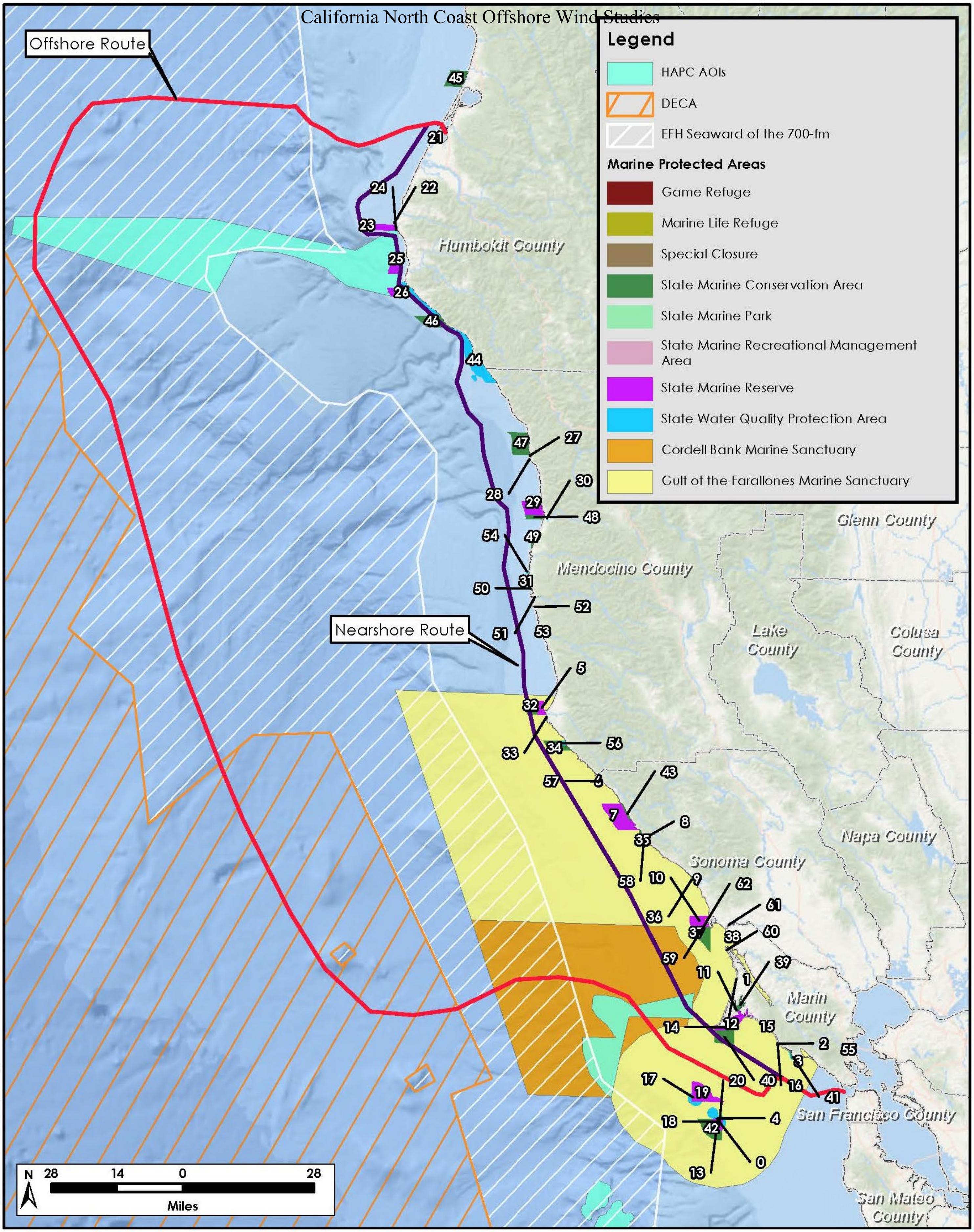

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Figure 3. Subsea Cable Route Alternatives: Sensitive Habitats

Subsea Cable Route Alternatives, Environmental Considerations (4330-02)

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Table 1. Sensitive Habitats Crossed by the Subsea Cable Route Alternatives

Sensitive Habitat Designation	Name	Regulations and Area	Offshore Route	Nearshore Route
Essential Fish Habitat	Eel River Canyon EFH Conservation Area	Bottom trawl gear prohibited except demersal seine 335.85 mi² (869.8 km²) (50 CFR 660.306 (h)(8) and 660.399 (a))	✓	
	Rocky Reef HAPC	Hard substrate habitats, including bedrock, boulders, cobble, and gravel. (Figure 2) Amendment 19 to Pacific Coast Groundfish FMP[1]		✓
	Deep-Sea Ecosystem Conservation Area	Closed to fishing with bottom-contacting gears Over 123,000 mi² (318,569 km²), and includes all federal waters (from 3 nautical miles to 200 nautical miles offshore) south of Mendocino Ridge, and seaward (west) of approximately 1,900 fathoms (3,500 m). 84 FR 63966	✓	✓
	Mendocino Ridge EFH Conservation Area	Bottom trawl gear prohibited except demersal seine 718.4 mi² (1,860.6 km²) (50 CFR 660.306 (h)(8) and 660.399 (c))	✓	✓
	Delgada Canyon EFH Conservation Area	Bottom trawl gear prohibited except demersal seine 15.7 mi² (40.7 km²) (50 CFR 660.306 (h)(8) and 660.399 (d))		✓
	Cordell Bank/Biogenic Area EFH Conservation Area	Bottom trawl gear prohibited except demersal seine 148.79 mi² (385.4 km²) ((50 CFR 660.306 (h)(8) and 660.399 (h))	✓	✓
Marine Protected Area	Mattole Canyon SMR	Damage or take of all marine resources (living, geologic, or cultural) including recreational and commercial take is prohibited. 9.79 mi² (25.4 km²) (CCR Section 632 (b) (13))		✓
	Sea Lion Gulch SMR	Damage or take of all marine resources (living, geologic, or cultural) including recreational and commercial take is prohibited. 10.41 mi² (26.9 km²) (CCR Section 632 (b) (14))		✓
	Big Flat SMCA	This area begins at the shore and extends west to include the origin of Spanish Canyon. Recreational take of salmon by trolling and of Dungeness crab (*Cancer magister*) by trap, hoop net, or hand is allowed. Commercial take of		✓

Sensitive Habitat Designation	Name	Regulations and Area	Offshore Route	Nearshore Route
Marine Protected Area		salmon (*Oncorhynchus* spp.) with troll fishing gear, and Dungeness crab by trap is allowed. 11.58 mi^2 (30.0 km^2) (CCR Section 632 (b) (15))		
	Point Arena SMCA	It is unlawful to injure, damage, take, or possess any living, geological, or cultural marine resource for recreational and/or commercial purposes; however, the recreational take of salmon by trolling is allowed and the commercial take of salmon with troll fishing gear is allowed. 6.73 mi^2 (17.4 km^2) (CCR Section 632 (b) (29))		✓
	Point Reyes SMCA	It is unlawful to injure, damage, take, or possess any living, geological, or cultural marine resource for recreational and/or commercial purposes; however, the recreational take of salmon by trolling and Dungeness crab by trap is allowed. The commercial take of salmon with troll fishing gear and Dungeness crab by trap is allowed. 12.26 mi^2 (31.8 km^2) (CCR Section 632 (b) (44))		✓
National Marine Sanctuary	Cordell Bank NMS	Regulations prohibit exploration for, developing, or producing oil, gas or other minerals, and discharging or depositing specific materials. 1,286 mi^2 (3,330.7 km^2) (80 FR 13115, and as amended at 83 FR 55967)	✓	✓
	Greater Farallones NMS	Regulations prohibit exploration for, developing, or producing oil, gas or other minerals, and discharging or depositing specific materials. Includes prohibitions on constructing structure (other than a navigation aid) on or in the submerged lands of the Sanctuary, or drilling into, dredging, or otherwise altering the submerged lands of the Sanctuary. 3,295 mi^2 (8,354.0 km^2) (80 FR 13108, and as amended at 83 FR 55966)	✓	✓

Notes:

[1] PFMC 2005

CCR = California Code of Regulations, CFR = Code of Federal Regulations, EFH = Essential Fish Habitat, FMP = fishery management plan, FR = Federal Register, HAPC = habitat area of particular concern, km^2 = square kilometers, m = meters, mi^2 = square miles, NMS = National Marine Sanctuary, SMCA = State Marine Conservation Area, SMR = State Marine Reserve

Table 2. Sensitive Habitats in the Vicinity of the Subsea Cable Route Alternatives

Figure 3 ID#	Name	Vicinity of Offshore Route	Vicinity of Nearshore Route	Level of Protection[1]	Constancy of Protection	Vessel Traffic	Anchor Use
0	Farallon Islands Game Refuge	✓		Uniform Multiple-Use	Year-round	Restricted	Unrestricted
1	Point Reyes Headlands ASBS State Water Quality Protection Area		✓	Uniform Multiple-Use	Year-round		
2	Double Point ASBS State Water Quality Protection Area		✓	Uniform Multiple-Use	Year-round		
3	Duxbury Reef ASBS State Water Quality Protection Area		✓	Uniform Multiple-Use	Year-round		
4	Farallon Islands ASBS State Water Quality Protection Area	✓		Uniform Multiple-Use	Year-round		
5	Point Arena State Marine Reserve		✓	No Take	Year-round		
6	Del Mar Landing State Marine Reserve		✓	No Take	Year-round		
7	Stewarts Point State Marine Reserve		✓	No Take	Year-round		
8	Gerstle Cove State Marine Reserve		✓	No Take	Year-round		
9	Russian River State Marine Recreational Management Area		✓	No Take	Year-round		
10	Bodega Head State Marine Reserve		✓	No Take	Year-round		
11	Estero de Limantour State Marine Reserve		✓	No Take	Year-round		
12	Point Reyes State Marine Reserve		✓	No Take	Year-round		
13	Southeast Farallon Island State Marine Reserve	✓		No Take	Year-round		
14	Point Reyes Headlands Special Closure		✓	No Access	Year-round	Prohibited	
15	Point Resistance Special Closure	✓	✓	No Access	Year-round	Prohibited	
16	Double Point/Stormy Stack Special Closure	✓	✓	No Access	Year-round	Prohibited	
17	North Farallon Islands Special Closure	✓		No Access	Year-round	Prohibited	

Figure 3 ID#	Name	Vicinity of Offshore Route	Vicinity of Nearshore Route	Level of Protection[1]	Constancy of Protection	Vessel Traffic	Anchor Use
18	Southeast Farallon Special Closure A	✓		No Access	Year-round	Prohibited	
19	North Farallon Islands State Marine Reserve	✓		No Take	Year-round		
20	Southeast Farallon Special Closure B	✓		No Access	Seasonal	Prohibited	
21	South Humboldt Bay State Marine Recreational Management Area	✓	✓	No Take	Year-round	Unrestricted	Unrestricted
22	Sugarloaf Island Special Closure		✓	No Access	Year-round	Prohibited	Prohibited
23	South Cape Mendocino State Marine Reserve		✓	No Take	Year-round	Unrestricted	Unrestricted
24	Steamboat Rock Special Closure		✓	No Access	Seasonal	Prohibited	Prohibited
25	Mattole Canyon State Marine Reserve[2]		✓	No Take	Year-round	Unrestricted	Unrestricted
26	Sea Lion Gulch State Marine Reserve[2]		✓	No Take	Year-round	Unrestricted	Unrestricted
27	Rockport Rocks Special Closure		✓	No Access	Seasonal	Prohibited	Prohibited
28	Vizcaino Rock Special Closure		✓	No Access	Seasonal	Prohibited	Prohibited
29	Ten Mile State Marine Reserve		✓	No Take	Year-round	Unrestricted	Unrestricted
30	Ten Mile Estuary State Marine Conservation Area		✓	No Take	Year-round	Unrestricted	Unrestricted
31	Point Cabrillo State Marine Reserve		✓	No Take	Year-round	Unrestricted	Unrestricted
32	Point Arena State Marine Conservation Area[2]		✓	Uniform Multiple-Use	Year-round		
33	Sea Lion Cove State Marine Conservation Area		✓	Uniform Multiple-Use	Year-round		
34	Saunders Reef State Marine Conservation Area		✓	Uniform Multiple-Use	Year-round		
35	Salt Point State Marine Conservation Area		✓	Uniform Multiple-Use	Year-round		
36	Russian River State Marine Conservation Area		✓	Uniform Multiple-Use	Year-round		

Figure 3 ID#	Name	Vicinity of Offshore Route	Vicinity of Nearshore Route	Level of Protection[1]	Constancy of Protection	Vessel Traffic	Anchor Use
37	Bodega Head State Marine Conservation Area		✓	Uniform Multiple-Use	Year-round		
38	Estero de San Antonio State Marine Recreational Management Area		✓	Uniform Multiple-Use	Year-round	Prohibited	
39	Drakes Estero State Marine Conservation Area		✓	Uniform Multiple-Use	Year-round		
40	Point Reyes State Marine Conservation Area[2]		✓	Uniform Multiple-Use	Year-round		
41	Duxbury Reef State Marine Conservation Area		✓	Uniform Multiple-Use	Year-round		
42	Southeast Farallon Island State Marine Conservation Area	✓	✓	Uniform Multiple-Use	Year-round		
43	Stewarts Point State Marine Conservation Area		✓	Uniform Multiple-Use	Year-round		
44	King Range ASBS State Water Quality Protection Area		✓	Uniform Multiple-Use	Year-round		
45	Samoa State Marine Conservation Area		✓	Uniform Multiple-Use	Year-round	Unrestricted	Unrestricted
46	Big Flat State Marine Conservation Area[2]		✓	Uniform Multiple-Use	Year-round	Unrestricted	Unrestricted
47	Double Cone Rock State Marine Conservation Area		✓	Uniform Multiple-Use	Year-round	Unrestricted	Unrestricted
48	Ten Mile Beach State Marine Conservation Area		✓	Uniform Multiple-Use	Year-round	Unrestricted	Unrestricted
49	MacKerricher State Marine Conservation Area		✓	Uniform Multiple-Use	Year-round	Unrestricted	Unrestricted
50	Russian Gulch State Marine Conservation Area		✓	Uniform Multiple-Use	Year-round	Unrestricted	Unrestricted
51	Big River Estuary State Marine Conservation Area		✓	Uniform Multiple-Use	Year-round	Unrestricted	Unrestricted

Figure 3 ID#	Name	Vicinity of Offshore Route	Vicinity of Nearshore Route	Level of Protection[1]	Constancy of Protection	Vessel Traffic	Anchor Use
52	Van Damme State Marine Conservation Area		✓	Uniform Multiple-Use	Year-round	Unrestricted	Unrestricted
53	Navarro River Estuary State Marine Conservation Area		✓	Uniform Multiple-Use	Year-round	Unrestricted	Unrestricted
54	Jughandle Cove ASBS State Water Quality Protection Area		✓	Uniform Multiple-Use	Year-round		
55	Corte Madera Marsh State Marine Park		✓	Uniform Multiple-Use	Year-round	Restricted	Unrestricted
56	Saunders Reef ASBS State Water Quality Protection Area		✓	Uniform Multiple-Use	Year-round		
57	Del Mar Landing ASBS State Water Quality Protection Area		✓	Uniform Multiple-Use	Year-round		
58	Gerstle Cove ASBS State Water Quality Protection Area		✓	Uniform Multiple-Use	Year-round		
59	Bodega ASBS State Water Quality Protection Area		✓	Uniform Multiple-Use	Year-round		
60	Bird Rock ASBS State Water Quality Protection Area		✓	Uniform Multiple-Use	Year-round		
61	Estero Americano State Marine Recreational Management Area		✓	Uniform Multiple-Use	Year-round	Prohibited	
62	Bodega Marine Life Refuge		✓	No Take	Year-round		

Notes: ASBS = Area of Special Biological Significance

[1] No Take = Damage or take of all marine resources (living, geologic, or cultural) including recreational and commercial take is prohibited.

Uniform Multiple-Use = consistent level of protection, allowable activities, or restrictions throughout the protected area. Extractive uses may be restricted for natural or cultural resources.

[2] = Marine Protected Areas that are crossed by the subsea cable route are listed in Table 1 in Section 2.2.1.

2.2.3 Fish

Fish surveys conducted by remote operated vehicle (ROV) to examine fish communities in northern California MPAs indicated that species composition varied by substrate type and with depth (Figure 4) (Lauermann et al. 2017, Lindholm et al. 2014). In mid-depth rocky habitats, rockfishes (e.g., canary, copper, yelloweye, quillback, and vermillion), lingcod, and kelp greenling were abundant, but in deeper water habitats thornyhead, sablefish, and deepwater flatfishes were dominant. Flatfishes are prevalent in soft substrates regardless of depth (Lauermann et al. 2017, Lindholm et al. 2014).

2.2.4 Sea Turtles

There are four sea turtle species that may occur in the study area: loggerhead (*Caretta caretta*), green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), and olive ridley (*Lepidochelys olivacea*). These sea turtles are rarely observed off northern California and are described in H. T. Harvey & Associates (2020). All four species are listed under FESA and discussed in Section 2.3. There is designated critical habitat for leatherback sea turtle in the study area, from Point Arena south, and offshore to the 9,842 ft (3,000 m) isobath.

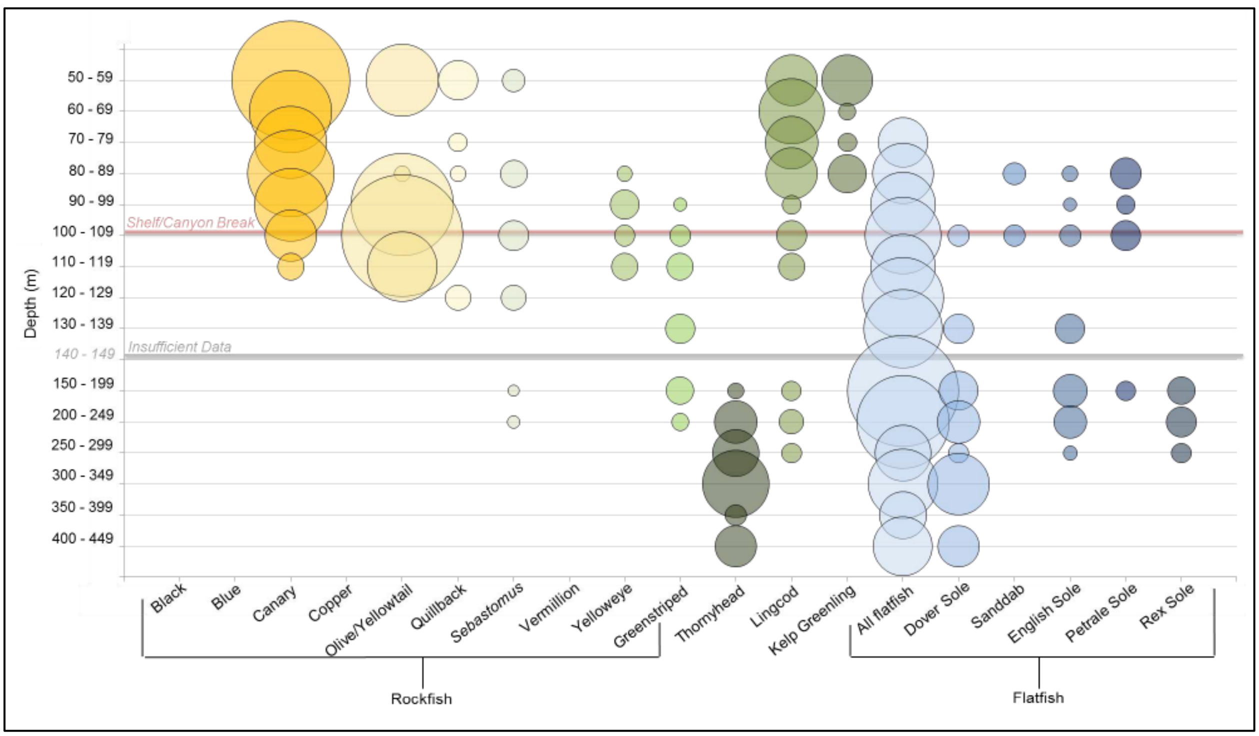

Figure 4. Fish Species Observed by ROV Transects in Different Depth Strata off MPAs in Northern California (Lauermann et al. 2017)
Notes: Bubble size represents the relative density of fish at that depth. Deep-sea fishes in soft substrates adjacent to a lost shipping container at 4,200 ft (1,281 m) were dominated by eelpout and thornyheads (Taylor et al. 2014). ROV = remotely operated vehicle. MPAs = Marine Protected Areas.

2.2.5 Birds

Numerous bird species occur in the nearshore and offshore cable routes. The special-status species and their habitat uses relative to the cable routes are listed in Table 3. More information on these species is provided in H. T. Harvey & Associates (2020).

Table 3. Special-Status Bird Species that May Occur along the Subsea Cable Route Alternatives

Common Name	Scientific Name	Status	Offshore Route	Nearshore Route
Black brant	*Branta bernicula nigricans*	CSSC		✓
Common loon	*Gavia immer*			✓
Short-tailed albatross	*Phoebastria albatrus*	FE, CSSC	✓	
Ashy storm-petrel	*Oceanodroma homochroa*	CSSC, BLM	✓	
Black storm petrel	*Oceanodroma melania*	CSSC	✓	
Fork-tailed storm-petrel	*Oceanodroma furcata*	CSSC, BLM	✓	✓
Hawaiian petrel	*Pterodroma sandwichensis*	FE	✓	
Brown pelican	*Pelecanus occidentalis californicus*	FP, USFS, BLM		✓
American peregrine falcon	*Falco peregrinus anatum*	FP, BCC		✓
Caspian tern	*Hydroprogne caspia*	BCC		✓
Marbled murrelet	*Brachyramphus marmoratus*	FT, SE		✓
Tufted puffin	*Fratercula cirrhata*	CSSC	✓	✓
Cassin's auklet	*Ptychoramphus aleuticus*	CSSC, BCC	✓	✓
Scripps's murrelet	*Synthliboramphus hypoleucus/scrippsi*	FC, ST, BLM, BCC	✓	✓
Guadalupe murrelet	*Synthliboramphus hypoleucus*	ST	✓	

Notes: CSSC=California species of special concern; SE=state listed as endangered; USFS=U.S. Forest Service sensitive species; BLM=U.S. Bureau of Land Management sensitive species; FP=California fully protected species; FT=federally listed as threatened; FE=federally listed as endangered; FC=candidate for federal listing; ST=state listed as threatened; BCC=U.S. Fish and Wildlife Service bird of conservation concern

2.2.6 Bats

The bat species that could occur in the nearshore cable route are the hoary bat (*Lasiurus cinereus*) and western red bat (*Lasiurus blossevillii*) (H. T. Harvey & Associates 2020). Although it is unlikely that bats would be present along the offshore cable route alternative, little is known about their offshore habitat use.

2.2.7 Pinnipeds

Pinnipeds (seals and sea lions) that may occur along the subsea cable route alternatives are listed in Table 4 below and discussed in H. T. Harvey & Associates (2020). The harbor seal is only associated with the nearshore cable route alternative, and the northern fur seal is unlikely to occur along either cable route alternative. None of these pinnipeds are listed under FESA or CESA.

Table 4. Pinnipeds that May Occur along the Subsea Cable Route Alternatives

Common Name	Scientific Name	Occurrence	Temporal Distribution	Offshore Route	Nearshore Route
Northern elephant seal	*Mirounga angustirostris*	L	Year-round	✓	✓
Harbor seal	*Phoca vitulina richardsi*	L	Year-round		✓
California sea lion	*Zalophus californianus*	L	Year-round	✓	✓
Northern fur seal	*Callorhinus ursinus*	U		✓	✓

Notes: L = likely to occur; U = unlikely to occur

2.2.8 Mustelids

Mustelids that may occur in the northern California area are the northern sea otter (*Enhydra lutris kenyoni*) and the marine-adapted river otter (*Lontra canadensis*) (H. T. Harvey & Associates 2020). These species are potentially present along the nearshore subsea cable route alternative but are not expected to occur in the offshore route.

2.2.9 Cetaceans

Multiple species of toothed whales (odontocetes) and baleen whales (mysticetes) occur in the continental shelf waters off the coast of northern California. The species that are not listed under the FESA or CESA are listed below in Table 5 (H. T. Harvey & Associates 2020); species listed under CESA or FESA are in Table 6 in Section 2.3. Most of the cetaceans are only potentially present along the offshore subsea cable route alternative.

Table 5. Non-Listed Cetaceans that May Occur along the Subsea Cable Route Alternatives

Common Name	Scientific Name	Offshore Route	Nearshore Route	Temporal Distribution
Bryde’s whale	*Balaenoptera edeni*	✓		Rare
Gray whale (eastern population)	*Eschrichtius robustus*		✓	Year-round BIA (migration)
Minke whale	*Balaenoptera acutorostrata*	✓	✓	Year-round
Killer whale - Bigg’s (transient)	*Orcinus orca*	✓	✓	Year-round
Killer whale - offshore	*Orcinus orca*	✓		Uncommon
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	✓		Year-round
Risso’s dolphin	*Grampus griseus*	✓		Year-round

Common Name	Scientific Name	Offshore Route	Nearshore Route	Temporal Distribution
Northern right whale dolphin	*Lissodelphis borealis*	✓		Year-round
Harbor porpoise	*Phocoena phocoena*		✓	Year-round
Dall's porpoise	*Phocoenoides dalli*	✓		Year-round
Bottlenose dolphin	*Tursiops truncatus*		✓	Uncommon
Short-beaked common dolphin	*Delphinus delphis*	✓		Rare
Long-beaked common dolphin	*Delphinus capensis*	✓		Rare
Striped dolphin	*Stenella coeruleoalba*	✓		Rare
Short-finned pilot whale	*Globicephala macrorhynchus*	✓		Rare
Pygmy sperm whale	*Kogia breviceps*	✓		Rare
Dwarf sperm whale	*Kogia sima*	✓		Rare
False killer whale	*Pseudorca crassidens*	✓		Rare
Baird's beaked whale	*Berardius bairdii*	✓		Rare
Cuvier's beaked whale	*Ziphius cavirostris*	✓		Rare
Blainville's beaked whale	*Mesoplodon densirostris*	✓		Rare
Perrin's beaked whale	*Mesoplodon perrini*	✓		Rare
Gingko-toothed beaked whale	*Mesoplodon gingkodens*	✓		Rare
Hubbs' beaked whale	*Mesoplodon carlhubbsi*	✓		Rare
Stejneger's beaked whale	*Mesoplodon stejnegeri*	✓		Rare
Pygmy beaked whale	*Mesoplodon peruvianus*	✓		Rare

Notes: BIA = Biologically Important Area (Calambokidis et al. 2015)

2.3 Threatened and Endangered Species

Species listed as threatened and endangered under the FESA and CESA are known to occur or have the potential to occur along the subsea cable route alternatives, and designated critical habitat is present for 2 of these species. The species are listed below in Table 6; species accounts, critical habitat definitions, and qualifying area descriptions are presented in H. T. Harvey & Associates (2020).

2.3.1 Essential Fish Habitat

The Magnuson-Stevens Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), requires federal agencies to consult with NMFS on activities that may adversely affect EFH. For Pacific coast species, EFH is described under four FMPs covering groundfish, coastal pelagic species, highly migratory species, and Pacific coast salmon (*Oncorhynchus* spp.). The definition and primary components of EFH, as well as discussions of the species covered under the four FMPs, are provided in H. T. Harvey & Associates (2020). The species with EFH that may occur along the offshore and nearshore subsea cable route alternatives are listed in Table 1 of H. T. Harvey & Associates (2020).

Table 6. Threatened and Endangered Species that are Known to Occur or May Occur along the Subsea Cable Route Alternatives

Common Name	Scientific Name	Federal Status	State Status	Critical Habitat Present?	Offshore Route	Nearshore Route
Fish						
Chinook salmon	*Oncorhynchus tshawytscha*					
Sacramento River winter-run ESU		E	E	N	✓	✓
Central Valley spring-run ESU		T	T	N	✓	✓
Coho salmon	*Oncorhynchus kisutch*					
Southern Oregon/ Northern California Coast ESU		T	T	N	✓	✓
Central California Coast ESU		E	E	N	✓	✓
Steelhead	*Oncorhynchus mykiss irideus*					
Northern California DPS		T		N	✓	✓
Central Valley DPS		T		N	✓	✓
Green sturgeon Southern DPS	*Acipenser medirostris*	T		Y		✓
Sea Turtles						
Loggerhead sea turtle	*Caretta caretta*	T		N	✓	
Green sea turtle	*Chelonia mydas*	E		N	✓	
Leatherback sea turtle	*Dermochelys coriacea*	E		Y	✓	✓
Olive ridley sea turtle	*Lepidochelys olivacea*	E		N	✓	
Birds						
Short-tailed albatross	*Phoebastria albatrus*	E		N	✓	
Hawaiian petrel	*Pterodroma sandwichensis*	E		N	✓	
Bald eagle	*Haliaeetus leucocephalus*		E	N		✓
Marbled murrelet	*Brachyramphus marmoratus*	T	E	N		✓

Common Name	Scientific Name	Federal Status	State Status	Critical Habitat Present?	Offshore Route	Nearshore Route
Scripps's murrelet	*Synthliboramphus scrippsi*	C	T	N	✓	
Guadalupe murrelet	*Synthliboramphus hypoleucus*	C	T	N	✓	
Mustelids						
Southern sea otter	*Enhydra lutris nereis*	T				✓
Pinnipeds						
Steller sea lion	*Eumetopias jubatus*	T			✓	✓
Guadalupe fur seal	*Arctocephalus townsendi*	T	T		✓	
Cetaceans						
Blue whale	*Balaenoptera musculus*	E, BIA (feeding)[1]		N	✓	✓
Fin whale	*Balaenoptera physalus*	E		N	✓	✓
Sei whale	*Balaenoptera borealis*	E		N	✓	
Humpback whale	*Megaptera novaeangliae*	E, BIA (feeding)[2]		N	✓	✓
North Pacific right whale	*Eubalaena japonica*	E		N		✓
Sperm whale	*Physeter macrocephalus*	E		N	✓	
Killer whale - Southern Resident	*Orcinus orca*	E		P		✓
Gray whale (Western North Pacific DPS)	*Eschrichtius robustus*	E		N		✓

Sources: USFWS 2019, CDFW 2019, Harris 2006, Shuford and Gardali 2008, and Calambokidis et al. 2015

Notes:

[1] The blue whale feeding BIAs are from Fort Bragg to Point Arena (Aug–Nov; 548 mi^2 [1,419 km^2]) and in the Gulf of the Farallones (Jul–Nov; 2024 mi^2 [5,243 km^2]).

[2] The humpback whale feeding BIAs are from Fort Bragg to Point Arena (Jul–Nov; 614 m^2 [1,591 km^2]) and from the Gulf of the Farallones to Monterey Bay (Jul–Nov; 3,769 m^2 [9,761 km^2])

BIA = Biologically Important Area, C = candidate, E = Endangered, T = Threatened, DPS = distinct population segment, ESU = evolutionarily significant unit, P=Proposed.

2.4 Potential Environmental Effects of Subsea Transmission Cable Route Alternatives

This section describes the potential environmental effects on the marine environment that were determined to be the most likely to occur from the installation, operation and maintenance, and decommissioning (i.e., removal) of the subsea transmission cable for the offshore and nearshore route alternatives. The actions associated with the installation and decommissioning of the subsea cable would potentially result in short-term effects (e.g., days to weeks at a specific site), and those for operation and maintenance would potentially result in longer-term effects (e.g., years).

2.4.1 Potential Short-Term Effects Associated with Installation

The subsea transmission cable will be buried along the nearshore route and a portion of the offshore route in shallower depths to minimize interactions with fisheries and vessels. Cable laying is typically done by specialized vessel/s with dynamic positioning (DP) to carry, lay, and (where possible) bury the miles of cable; burial usually is done by plowing or trenching equipment (Sharples 2011). It is assumed that the cable route will avoid hard bottom substrates to the extent feasible, and where unavoidable, cables would be protected with concrete mattresses, rock burial, or other types of protection (Sharples 2011, Taormina et al. 2018). Potential environmental effects include disturbance of benthic habitat, effects on water quality, increases in ambient noise and lighting from DP vessels and burial operations, and vessel collisions with marine wildlife (Table 7).

Table 7. Summary of Environmental Effects Evaluated for Installation, Operations, and Maintenance of the Subsea Cable for the Offshore and Nearshore Route Alternatives

Stressor	Receptors	Offshore Route	Nearshore Route
Short-Term Effects of Cable Installation (Section 2.4.1)			
Benthic habitat disturbance	Benthic communities (invertebrates, fish)	Low (assumes self-burial)	Moderate (mechanical burial)
Water quality degradation (turbidity from bottom disturbance, spills)	Fish, invertebrates	Low (assumes self-burial)	Moderate (assumes mechanical burial)
Increased ambient acoustic levels (vessel noise, cable lay)	Marine mammals, seabirds, fish	Moderate (assumes self-burial)	High (assumes mechanical burial)
Vessel collision	Marine mammals, sea turtles, bird flocks	Low (vessels moving slow)	Low (vessels moving slow)
Artificial lighting	Seabirds, bats	Low (lighting for 24/7 operations can be mitigated)	Low (lighting for 24/7 operations can be mitigated)
Short-Term Effects of Operations and Maintenance (Section 2.4.2.1)			
Benthic effects of cable repairs	Benthic communities, marine mammals, fish	Low (assumes short term, small area)	Low (assumes short term, small area)
Long-Term Effects of Operations and Maintenance (Sections 2.4.2.2 and 2.4.2.31)			
Benthic effects of the physical presence of the cable	Fish, invertebrates	Low (assumes cable is buried)	Low-Moderate (cable may be exposed or self-bury)
Electromagnetic fields (EMF)	Fish, invertebrates	Moderate	Moderate

Benthic Habitat Disturbance—The installation of the nearshore subsea cable would result in benthic habitat disturbance from cable laying activities, which would entail trenching or burial of the cable to a depth of 3–7 ft

(1–2 m) beneath the substrate (it assumes the majority of the offshore route in deeper waters would not be buried or trenched but allowed to self-bury over time). A cable burial risk assessment would be needed to determine the depth offshore where burial would be feasible. Displaced sediment would be placed back in the trench to cover the cable, but some sediment would be dispersed by currents and redeposited in a thin layer beyond the immediate vicinity of the trench. Ploughing and jetting methods generally have a quicker recovery of bottom topography, because the trench is filled with displaced and re-suspended material immediately after digging and cable laying (Taormina et al. 2018). This disturbance could cause small-scale topographic changes in the seafloor along the path of the subsea cable; however, the natural movements of the sediments by ocean currents would reestablish natural bottom topography. For example, a study of the Monterey Accelerated Research System cable in California that used ROV video transection and sediment samples found little detectable effect on seafloor geomorphology and no discernible change in mean grain size after cable installation at both 18 and 37 months (Kuhnz et al. 2011).

Disturbance of benthic habitat could directly affect benthic communities by displacement, damage, or crushing of organisms (Taormina et al. 2018). However, the spatial scale of disturbance is relatively localized, for example, the footprint for direct effects would be long but linear/narrow for the cable laying (e.g., on the order of 7–26 ft [2–8 m] width) (Taormina et al. 2018). Effects on benthic communities are dependent on community resilience, which is due in part to the nature and stability of the substrate, habitat depth, and life cycle of disturbed species (Taormina et al. 2018). For example, in extensive studies of benthic communities conducted offshore of California, Oregon, and Washington across the continental shelf, depth may be the primary factor in structuring assemblages, with the inner shelf (less than 164 ft [50 m]) differentiating from the mid- to outer shelf, which is secondarily structured by sediment composition (% sand) with finer resolution depth differentiation occurring within sediment types (Henkel et al. 2014). Recovery time for benthic communities disturbed in soft bottom habitats is on the order of weeks to as long as a few years, whereas disturbance associated with cable protections on hard substrates will take years to recover (Hemery 2020).

From a regulatory standpoint, benthic communities are considered sensitive ecosystems because they support fish species of concern under FESA (e.g., southern distinct population of green sturgeon [*Acipenser medirostris*]) or managed through the Magnuson-Stevens Act. Changes in benthic ecosystem functions (e.g., availability of prey resources) can adversely affect fish species. The spatial and temporal context of disturbance and recovery times are important for understanding effects on ecosystem functions.

Water Quality Degradation—Water quality would be affected during the subsea cable laying, and could also be degraded by unintentional spills or contaminants from vessels. Sediment suspended during installation, depending on sediment type, can disperse by currents and the resulting turbid plumes may last for hours to days (Taormina et al. 2018). Finer grained particles will remain in the water column and travel farther than coarser sediment particles; however, it is expected that the area affected and duration of this effect will be short term regardless of particle size. Unintentional releases of fuels or hydraulic fluids are possible, but vessels used for installation purposes have spill prevention plans in place to address these circumstances. The longer duration of subsea cable laying activities, particularly along the nearshore route alternative where much of the cable length will be trenched or buried, scaled with the length of the subsea cable route, will influence the likelihood of effects on water quality (Table 7). The nearshore cable lay, with jet plow or burial, could take approximately 84 days at a rate of approximately 3.1 miles/day (5 km/day), whereas the offshore cable lay (unburied) would take approximately 15 days at a rate of 27.6 mi/day (44.4 km/day) (Taormina et al. 2018).

Water quality effects can be indirect; for example, the resuspension of fine sediment can affect the ability of fish to feed, or for benthic invertebrates to filter feed. Turbidity increases resulting from the installation of the undersea cable are likely to constitute localized and short-term effects (Taormina et al. 2018). Direct effects from contaminants can result in death, particularly to vulnerable life stages of fish and invertebrates (e.g., larvae, eggs). Chemical contamination of water quality is considerably less likely to occur than turbidity increases, but also is expected to be localized, short term, and quickly disperse/dilute.

Increases in Ambient Acoustic Levels—In order to site a subsea cable in a conceptual route alternative, additional geophysical and geotechnical surveys will be required (Sharples 2011, DNV 2014). These surveys use specialized equipment including echosounders and side-scan sonar to develop sub-bottom profiles (DNV 2014); there is potential for interactions with acoustically sensitive species such as marine mammals, depending on the frequency of the instruments and the sensitivity and exposure thresholds for specific marine mammal groups (NMFS 2018). The level of effect cannot be determined in this evaluation without details of the timing, duration, and frequencies of instruments used to conduct surveys; however, the surveys are likely to be relatively short term (e.g., weeks to a few months).

Subsea cable installation would have short-term effects on underwater acoustic levels; underwater noise will be produced from activities associated with cable laying (e.g., jet plow, DP vessels). Intensity and propagation of underwater noise will vary according to bathymetry, seafloor characteristics (e.g., sediment type and topography), vessels and machines used, and water column properties (Taormina et al. 2018). Ambient sound in the marine environment originates from both natural (e.g., wave action, marine life, wind, and rain) and anthropogenic sources (e.g., commercial and recreational vessel traffic).

Sound in the ocean may result in a range of effects on marine species, from no discernible effect to acute, lethal effects. Increases in acoustic noise, especially higher sound pressure levels, can cause marine mammal behavior modification (150 decibels [dB]) that results in reduced growth and survival (NMFS 2019b). Physical injury for marine mammals may result from peak or cumulative sound pressure levels (SPL), depending on whether the sound is continuous or impulsive, that can result in temporary or permanent hearing threshold shifts, and varying among the marine mammal species and the hearing groups (NMFS 2018). The threshold for underwater sound to result in behavioral effects (e.g., flushing, avoidance) to marbled murrelets (*Brachyramphus marmoratus*), which are listed as threatened under FESA and endangered under CESA, is 150 dB root-mean-square pressure (USFWS 2014). For fish, guidance is available for pile driving that is primarily focused on the effects of sound pressure levels on species with swim bladders, and the thresholds for injury are typically higher than those for marine mammals (Buehler et al. 2015, Hawkins et al. 2020).

DP vessels used for cable laying would likely produce the greatest increase to ambient acoustic levels. For the Virginia Offshore Wind Technology Advancement Project on the outer continental shelf in the Atlantic Ocean offshore of Virginia, sound source-level for the DP cable-laying vessel was estimated to be 177 dB re 1 micropascal (µPa) at 3 ft (1 m) (BOEM 2015), and Deepwater Wind LLC's Block Island Wind Farm estimated the sound source-level for the DP cable-laying vessel would be 180 dB re 1 µPa at 3 ft (1 m) (NMFS 2015). Cable-laying operations will likely occur for 24 hours per day for several weeks to months, assuming no weather delays, because DP vessels move very slowly. Based on DP vessel sound levels described above, the area surrounding the vessel where sound would be reasonably certain to exceed 150 dB re 1 µPa would be up to approximately 328 ft (100 m) laterally in all directions from the vessel (NMFS 2019b). Therefore, the longer the subsea cable route, and consequently, the longer the construction period, the greater the noise effects would be on the marine environment. However, the noise is not anticipated to reach levels of injury except for adjacent to vessels, and the area around the vessels where noise may result in behavior modification (e.g., avoidance) is relatively small. In addition, compared with other anthropogenic sources of noise, such as impulsive sonar, piling, or explosions, underwater noise linked to vessels and undersea cables is spatially localized and temporary. Mitigation for noise often involves monitoring by marine mammal observers to inform when marine mammals are within a specific distance of vessels where noise levels may be harmful and stop or decrease noisy operations during that time.

Vessel Collisions with Wildlife—DP vessels are likely to be moving slowly for cable laying; however, as the amount of time during which vessels are engaged in installation increases, there may be a corresponding increase in the risk of collision. The probability of vessel collision with whales increases with ship speed, hence vessel speed restrictions are considered an approach to minimize lethal ship strikes (Vanderlaan and Taggart 2007, Rockwood et al. 2017). The Biologically Important Areas (BIAs) (Calambokidis et al. 2015) in the study area are for gray whales (*Eschrichtius robustus*), blue whales (*Balaenoptera musculus*), and humpback whales (*Megaptera novaeangliae*); the likelihood of collision is less where cetaceans are not concentrated, although vessel collision models suggest some risk to fin whales (*Balaenoptera physalus*), which are listed as endangered under FESA, along the offshore cable route alternative (Rockwood et al. 2017). Gray whales tend to be seasonally abundant during their migration, which typically occurs in nearshore coastal waters, so operating vessels that are slow, and offshore of the main migration corridor, minimize collision risks (Gende et al. 2019).

Artificial Lighting Effects—Artificial lighting would be required during cable laying activities conducted 24 hours per day. Ship lighting during nighttime construction operations will follow U.S. Coast Guard regulations for safety and navigation purposes, but may also require additional deck lighting or in-water lighting if cable laying activities involve underwater video. Artificial lighting may attract some seabird species to ships, which would increase the risks of grounding, collision with structures, and interference with night feeding. However, minimizing deck lighting and avoiding the use of bright white lights (BOEM 2019) can reduce lighting effects, especially because ships are moving and installation activities are short term.

2.4.2 Potential Long- and Short-Term Effects Associated with Operation and Maintenance

Underwater structures have the potential to result in effects on the marine environment. Direct effects include colonization by native and nonnative invertebrates, and changes to habitat and community structure such as an artificial reef (Kramer et al. 2015). Observations of colonization by invertebrates and fish attraction to fallen shipping containers and subsea cables in deep water suggest specific organisms are likely to be attracted to novel hard substrate, although biological impacts are considered minor (Taylor et al. 2014, Kogan et al. 2006).

Electromagnetic fields (EMF) are generated by current flow passing through power cables during operation and can be divided into electric fields (E-fields, volts per meter [Vm^{-1}]) and magnetic fields (B-fields, microtesla [μT]). The higher the electrical current, the stronger the emitted magnetic field and induced electric field will be for cables (Gill 2016). High voltage direct current HVDC) cables generate a magnetic field near the cable that creates a weak induced electric field of a few μVm^{-1} near the cable; cable burial does not eliminate EMF but reduces exposure to it (Taormina et al. 2018). Potential effects of EMF on marine organisms include behavioral effects such as avoidance or attraction, effects on species navigation or orientation, changes in predator/prey interactions, and physiological or developmental effects (Taormina et al. 2018). Studies conducted on cables to date indicate many marine organisms can detect EMF from cables; however, detection does not appear to result in significant behavioral changes (Gill 2016).

Operations and maintenance may require vessels to monitor and repair the subsea cable. As discussed in Section 2.4.1, vessels raise underwater noise levels, increase risks of collisions with marine mammals, and have the potential to affect water quality due to unintentional spills of contaminants.

Short-Term Benthic Effects Associated with Cable Repairs—Subsea cables are vulnerable to damage, particularly those that are unburied; in shallow water; exposed to abrasion (hard surfaces) and seabed displacement (e.g., debris flows, earthquakes); and in contact with bottom contact fishing gear (e.g., trawl nets, traps) and vessel anchors (Wang et al. 2019). The nearshore cable is anticipated to be buried in soft substrate and armored when in contact with hard substrate, whereas the offshore cable is anticipated to be unburied through the deeper section of its route. Nonetheless, at some point in the life cycle of the subsea cable, repairs may be necessary. Subsea cable repair requires specialized vessels that can find the damaged section, retrieve and repair the cable, and redeploy it (Sharples 2011). Benthic disturbance is a result of cable repairs, including potential disturbance of unburied cables to organisms that settle on or associate with the cable (Taormina et al. 2018). However, typically the repairs are short term (weeks to months) and affect a relatively small area compared to the entire cable length (Sharples 2011).

Long-Term Benthic Effects Associated with the Physical Presence of the Cable—The subsea cable, particularly where unburied, or where placed on rock and armored for protection, will have a "reef effect" by introducing novel hard structure to the seafloor (Taormina et al. 2018). Cables can change benthic community structure by providing hard surfaces for benthic invertebrates (e.g., anemones) to colonize where the cable is exposed (Kogan et al. 2006), and the cable and the organisms that colonize it may attract fish (Kogan et al.

2006, Taylor et al. 2014, Kramer et al. 2015, Taormina et al. 2018). However, this change to benthic communities is not necessarily considered an adverse environmental effect (Taormina et al. 2018, Hemery 2020).

Long-Term Electromagnetic Field Effects—EMF would be emitted by the subsea cable, which would be a 500-kilovolt HVDC cable either 260 mi (420 km) long for the nearshore route, and 410 mi (660 km) long for the offshore route. The subsea cable would be shielded and armored to prevent it from directly emitting electric fields; however, electric fields could be induced by the movement of fish and currents through the magnetic fields produced by the cable (Gill et al. 2020).

In general, the higher the electrical current transmitted through DC cables, the stronger the emitted magnetic field and induced electric field (Gill 2016). It is notable, however, that there has been remarkable consistency in the measured attenuation of DC magnetic fields (i.e., EMF strength) among several different subsea power cables (most of them associated with large offshore wind farms in the European Union) (Normandeau Associates et al. 2011, Gill et al. 2020). These cables exhibited an exponential decline in magnetic field strength that reached near-ambient levels within approximately 16 ft (5 m) of the cables (Normandeau Associates et al. 2011). Most of the length of the nearshore subsea cable would be buried approximately 3–7 ft (1–2 m) below the seafloor, and installing the cable at this depth will effectively reduce the exposure of organisms at the seafloor/seawater interface to the magnetic field produced by the cable (Normandeau Associates et al. 2011). Therefore, it is likely that EMF generated by the subsea cable will be similar to or less than those of other cables that have been measured. EMF generated by the buried nearshore subsea cable above ambient levels would not extend substantially beyond 10 ft (3 m), and those generated by the unburied offshore subsea cable would not reach beyond 16 ft (5 m). The backfilling of seafloor substrate over most of the length of the nearshore subsea cable would also minimize any likelihood that the marine environment will be exposed to EMF associated with the cable. However, the offshore subsea cable will be unburied unless it self-buries over time (Kogan et al. 2006), and will produce induced electric fields at detectable levels to electrosensitive species such as rays, skates, and sharks (Gill et al. 2020).

Electric fields are detected by fishes with specialized electroreceptors, including electroreceptive elasmobranchs (e.g., sharks, skates, and rays) and holocephalans (e.g., ratfish), as well as electrosensitive agnatha (e.g., lamprey), acipenseriformes (e.g., sturgeon), and some teleost fish (Normandeau Associates et al. 2011, Gill et al. 2014). Elasmobranchs and holocephalans are the most electroreceptive marine animals because of the Ampullae of Lorenzini, which are specialized electroreceptive organs that enable them to detect very weak electric fields (i.e., as low as 5–20 nanovolts per meter [nV/m]) (Normandeau Associates et al. 2011, Gill et al. 2014). Elasmobranchs are repelled by strong anthropogenic electric fields (Gill et al. 2014). Electroreceptive teleost fish have a minimum sensitivity threshold of about 0.01 nV/m (Normandeau Associates et al. 2011) and may respond to strong electric fields (i.e., 6–15 V/m) (Gill et al. 2014). Models suggest the induced electric field for a DC cable buried 1 m beneath the seabed in a 5 knot current would be approximately 194,000 nV/m at the surface of the seabed, and 7,130 nV/m 10 m away, well above the range of detection of electroreceptive fishes (Normandeau et al. 2011). Electroreception may be used to detect bioelectric fields emitted by prey, potential mates, and predators; it can also be used for short- and long-term movements or migration (Normandeau Associates et al. 2011, Gill et al. 2014).

Some animals use geomagnetic fields to orient during migration; animals that are considered to be capable of this behavior include cetaceans, sea turtles, certain fishes and crustaceans, and mollusks (Gill et al. 2014). For many of these species, geomagnetic fields are one of numerous cues used to influence migration (Normandeau Associates et al. 2011). For cetaceans and sea turtles, potential responses from EMF could include a temporary change in swim direction or a deviation from a migratory route (and subsequent slowing of the migration), but these are theoretical, untested responses (Normandeau Associates et al. 2011, Gill et al. 2020). The subsea cable could create a very localized change in the magnetic field, but modeling EMF from cables suggests that the likelihood of such a change affecting a large enough area to elicit a significant course alteration would be low (Normandeau Associates et al. 2011, Gill et al. 2020). Species in the nearshore cable route that may be capable of detecting magnetic fields include the Dungeness crab, green sturgeon, leatherback sea turtle, and salmonids (Normandeau Associates et al. 2011, Gill et al. 2020). Fish, in particular salmonids and scombrids (e.g., tuna), have a magnetite receptor system and respond to magnetic fields in the 10–12 μT range (Normandeau Associates et al. 2011). In the laboratory, juvenile salmon that were subjected to the magnetic field intensity and inclination angles similar to those found at the latitudinal extremes of their ocean distribution (northern and southern intensity used in laboratory experiments of 555.5 μT and 444.6 μT, respectively), changed their orientation (e.g., direction of swimming) (Putman et al. 2014). This study also found that subjecting fish to unnatural pairings of magnetic field intensity and inclination resulted in more random orientation (Putman et al. 2014). Dungeness crab have also been examined in the laboratory and only subtle changes in behavior were observed for relatively high B-fields (from ~0.05 milliTesla (mT) background to 1.0–1.2 mT DC); these changes were considered to represent the upper limits of an anthropogenic source that might be encountered based on reviewed literature (Woodruff et al. 2012).

Although it is indeterminate whether electro- and magneto-sensitive species would be capable of detecting EMF emissions from the subsea cable, as well as the type and degree of these species' responses to EMF[2], the proportion of a given population that might be exposed to EMF generated by the subsea cable is expected to be low for most of these species. This determination is based on factors such as migratory range and available habitat, and the low likelihood of exceeding biologically relevant EMF emission thresholds. Even if individuals encounter and are exposed to magnetic fields or induced electric fields, any potential effects are expected to be short term and minor because of the very localized fields (relative to the earth's geomagnetic field) potentially being used for navigation; therefore, these species are not expected to be affected by EMF. Bottom-oriented fish and invertebrates could be more exposed to EMF from the subsea cable than pelagic fish; however, the cable will be shielded and armored, and most of the length of the subsea cable will be buried (nearshore route) or may self-bury (offshore route), limiting the exposure of these organisms to EMF. Based on the low levels of EMF expected, and spatially limited exposure to fishes (e.g., in proximity to the cables but cables are very long), it is anticipated that relatively minor, short-term potential effects, if any, could occur.

[2] Ongoing research on species' responses to EMF can be queried using the Environmental Studies Program Information System available online: https://marinecadastre.gov/espis/#/

2.4.3 Potential Short-Term Effects Associated with Decommissioning

Decommissioning will entail removal of the subsea cable and any abrasion protections, and restoring or implementing mitigation for effects on the seafloor. Similar to installation effects, decommissioning will have short-term potential effects on the marine environment that include disturbance of benthic habitat, changes in water quality (e.g., sedimentation, contaminants), increased noise from DP vessels and subsea cable removal operations, and vessel interactions with marine wildlife, which are all described in Section 2.4.1.

2.5 Potential Environmental Constraints and Considerations

Based on the analyses in Section 2.4, there are some general conclusions that can be made about the relative potential environmental interactions for the two subsea cable route alternatives analyzed. The long cable lengths and locations are the primary factors in determining the numbers and degree of impacts on resources of concern. In particular, cable installation will have greater environmental consequences, over large spatial scales, although relatively short in duration, in comparison to cable operations. Cable laying will result in habitat disturbance; however, the nearshore route includes cable burial which has a higher likelihood of interactions with sensitive species and habitats than the offshore cable route, even though the offshore route is longer. Without additional environmental information, it appears that environmental constraints are likely far outweighed by the physical hazards and constraints identified by Mott MacDonald (2020).

Potential environmental constraints or considerations include the potential impacts due to cable installation associated with increased acoustic levels and collision with marine mammals, particularly cetaceans. Several FESA-listed cetaceans occur along both subsea cable route alternatives and would require FESA consultation and MMPA authorization. However, cable laying is a fairly common activity and has a permitting history, so minimization and mitigation measures have been developed. For example, cable laying typically involves protected species observers that are aboard DP vessels to monitor marine mammal interactions and determine when to enact mitigation, such as reducing vessel thruster power when marine mammals occur within a specified distance (NMFS 2014).

2.5.1 Information Gaps

The greatest information gap is the lack of detailed geotechnical and geophysical information that can be used to inform effects to benthic habitats. This information will be required to determine the route where the cable can be buried or where it needs armoring for protection. Although there is general knowledge of the benthic communities likely to be affected, site-specific information will be necessary to characterize benthic communities before the cable route is determined, which can be done with ROV and other methods (e.g., grab samples). Certain benthic species of concern (e.g., soft corals) and habitats may warrant changes to the route to minimize impacts associated with siting on these species and habitats.

Long-term effects of EMF are a potential concern; although it is likely to be spatially limited to the proximity of the cable, the cable routes are very long (260 mi [420 km] or 410 mi [660 km] for the nearshore or offshore routes, respectively). There is uncertainty about how EMF changes as wind generation changes, and many of the measurements of EMF have been taken at cables carrying less voltage than the proposed cable (Gill et al. 2020). Therefore, EMF monitoring may be required by the regulatory agencies to improve understanding of EMF levels once the cable is activated.

Other information is needed to determine the cable landing location, converter station location, and anticipated habitat changes. We did not analyze the converter station but the environmental concerns could be a constraint because approvals from multiple regulatory agencies would be required.

Lastly, there are a number of permitting challenges likely associated with the MPAs along the nearshore route, the EFH Conservation Areas along the offshore route, and the NMSs for both routes (Table 1). The regulations associated with MPAs are likely to be the greatest challenge as a subsea cable transiting an MPA would have to undergo additional scrutiny, potentially including approval by the California Fish and Game Commission. The EFH Conservation Areas and NMSs do not appear to rule out the potential for a subsea cable to be installed, but there may be additional environmental monitoring or mitigation needs.

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