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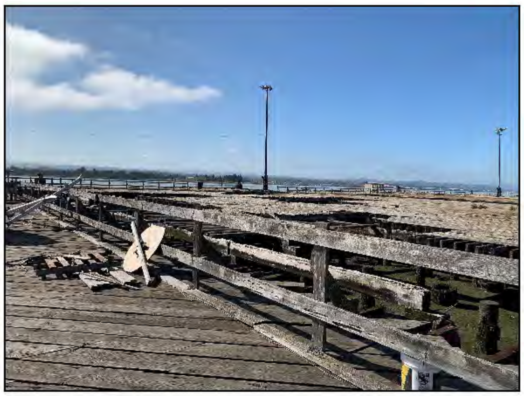

Impacts Assessment for Marine Resources at Humboldt Bay Offshore Wind Heavy Lift Multipurpose Marine Terminal Technical Memorandum

Project #4628-03

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Executive Summary

The purpose of this document is to provide an initial evaluation of the effects of the Humboldt Bay Offshore Wind Heavy Lift Multipurpose Marine Terminal Project (the Project) on marine resources in Humboldt Bay. The Project involves redeveloping a ~180-acre site on the Samoa Peninsula to construct a new multipurpose heavy-lift marine terminal facility (Redwood Marine Multipurpose Terminal [RMMT]) capable of supporting the offshore wind industry and other coastal development projects. Background information on the Project location and the Project goals are provided (Section 1.0) in addition to a description of the Project in its current design phase (Section 2.0). Existing conditions on key ecological communities, species and habitats present are outlined in detail that allows for a sufficient evaluation of potential Project impacts (Section 3.0).

The analysis provided reviews the effects of construction, habitat change, and permitted operations associated with the Project on marine resources, with a particular focus on species listed as endangered or threatened under the federal and state Endangered Species Acts and their federal designated critical habitat, protected under the Marine Mammal Protection Act, California Department of Fish and Wildlife Species of Special Status, and the Magnuson-Stevens Fishery Conservation and Management Act (Section 4.0). Impacts on eelgrass and eelgrass restoration will be addressed in a separate analysis, as are impacts on marine resources associated with the construction and operations of RMMT. Note, impacts discussed in this assessment are not determinations of significance, as they are dependent on the final Project design and will be made during local, state, and federal consultations and in compliance with the California Environmental Quality Act and National Environmental Protection Act. Lastly, appropriate avoidance and minimization measures are provided (Section 5.0) to help inform the planning process and final Project design. The following content can be used to guide future Project design and more detailed evaluations.

Disclaimer: This technical memorandum is a draft/work-in-progress and is intended to be an internal document for use by the Humboldt Bay Offshore Wind Heavy Lift Marine Terminal Project team as a part of the conceptual design process and the ongoing permitting process. This memorandum is meant to be read as a part of a comprehensive packet of technical analyses. It is not written to be a standalone document and it is assumed that the reader has substantial project knowledge and context to understand the memorandum's content. All aspects of this memorandum are subject to change and may become less accurate over time. To better understand the project, please review the more comprehensive and up to date documents posted to the Humboldt Bay Harbor District's website at https://humboldtbay.org/humboldt-bay-offshore-wind-heavy-lift-marine-terminal-project-3.

Table of Contents

Tables

Figures

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Abbreviated Terms

Abbreviation	Definition
AIS	Aquatic invasive species
ALAN	artificial light at night
BOEM	Bureau of Ocean Energy Management
dB	Decibels
CDFW	California Department of Fish and Wildlife
CESA	California Endangered Species Act
CEQA	California Environmental Quality Act
CFGC	California Fish and Game Code
cm	Centimeters
CNDDB	California Natural Diversity Database
District	Humboldt Bay Harbor, Recreation and Conservation District
CSSC	California Species of Special Concern
ECS	Ecosystem Component Species
EFH	Essential Fish Habitat
ESHA	Environmentally sensitive habitat areas
(F)ESA	(Federal) Endangered Species Act
FMP	Fisheries Management Plan
FL	Forked length
ft	Feet
GW	Gigawatts
HAPC	Habitat Area of Particular Concern
HOODS	Humboldt Open Ocean Disposal Site
IHA	Incidental Harassment Authorization
ITP	Incidental Take Permit
IPaC	Information for Planning and Consultation
kJ	Kilojoule
km	Kilometers
MBTA	Migratory Bird Treaty Act
mi	Mile
MLLW	Mean Lower Low Water
MMPA	Marine Mammal Protection Act
MOU	Memorandum of understanding
MSA	Magnuson-Stevens Act Fishery Conservation and Management Act
nDPS	Northern Distinct Population Segment

Abbreviation	Definition
NEPA	National Environmental Protection Act
NMFS	National Marine Fisheries Service
OSHA	Occupational Safety and Health Administration
OSW	Offshore wind
p.	Page
PEIR	Programmatic Environmental Impact Review
PFMC	Pacific Fishery Management Council
RMTI	Redwood Marine Terminal I
RMMT	Redwood Marine Multipurpose Terminal
RMTN	Redwood Marine Terminal North
SAV	Submerged Aquatic Vegetation
SB	Senate Bill
SCA	Stomach content analysis
sDPS	Southern Distinct Population Segment
SFBE	San Francisco Bay Estuary
SPCC	Spill Prevention Control and Countermeasure
SONCC	Southern Oregon-Northern Coastal California (coho salmon)
SSWS	Sea star wasting syndrome
SEE	Stream-estuary ecotone
S&I	Staging and integration
TL	Total length
USCG	U.S. Coast Guard
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish & Wildlife Service
WTD	Wind Turbine Device
YOY	Young-of-the-year
WTD	Wind Turbine Device
YOY	Young-of-the-year

Section 1.0 Introduction

The Federal government has established a goal of deploying 30 Gigawatts (GW) of offshore wind (OSW) energy by the year 2030 and 110 GW by the year 2050. The State of California has established goals of deploying two to five GW of offshore wind energy by 2030 and 25 GW by 2045 (Flint et al. 2022). Studies by the Federal Bureau of Ocean Energy Management (BOEM), the National Renewable Energy Laboratory, and California Energy Commission indicate that major port development will be required throughout California to reach the described goals. The AB 525 Port Readiness Plan for the California State Lands Commission provides a detailed overview of several port sites in California that can be used to help achieve the OSW planning goal of 25 GW by 20145 (Moffatt & Nichol 2023). The Humboldt Bay Harbor, Recreation and Conservation District (District) is pursuing permitting and design for Humboldt Bay Offshore Wind Heavy Lift Multipurpose Marine Terminal Project and Redwood Marine Multipurpose Terminal (RMMT) Redevelopment Project (the Project). The Project will support the offshore wind (OSW) industry and other port-based commerce by redeveloping a ~180-acre site.

The purpose of this impact assessment is to address the effects of the Project on marine resources in Humboldt Bay, California, with a particular focus on species listed as endangered or threatened under the federal Endangered Species Act (ESA) and their designated critical habitat, protected under the Marine Mammal Protection Act (MMPA), California state special status and listed species, and the Magnuson-Stevens Fishery Conservation and Management Act. The potential impacts associated with construction, habitat change, and permitted operations are addressed. Minimization and avoidance measures for potentially significant impacts that could be incorporated into the Project are also identified. This impact assessment serves to inform Project design and support California Environmental Quality Act (CEQA) and National Environmental Protection Act (NEPA) documents. Impacts on eelgrass and eelgrass restoration will be addressed in a separate analysis. The operations of RMMT and of OSW farms will be further analyzed in a separate CEQA document prepared by the California State Lands Commission and a NEPA document prepared by BOEM. Offshore wind farms and associated energy transmission are not included in the Project (District 2023).

1.1 Project Location

The proposed Project is located on the Samoa Peninsula of Humboldt Bay in Humboldt County, California (Figure 1). The site was formerly used by the forest product industry for wood processing and shipping. It is currently used for storing commercial fishing equipment, commercial fish landing and holding, limited forest product storage and mariculture. The majority of the site is currently vacant, and there are remnants from the forest product industry at the site such as utilities, buildings, docks and other structures. Most of this infrastructure is generally failing and needs to be repaired or replaced (District 2023).

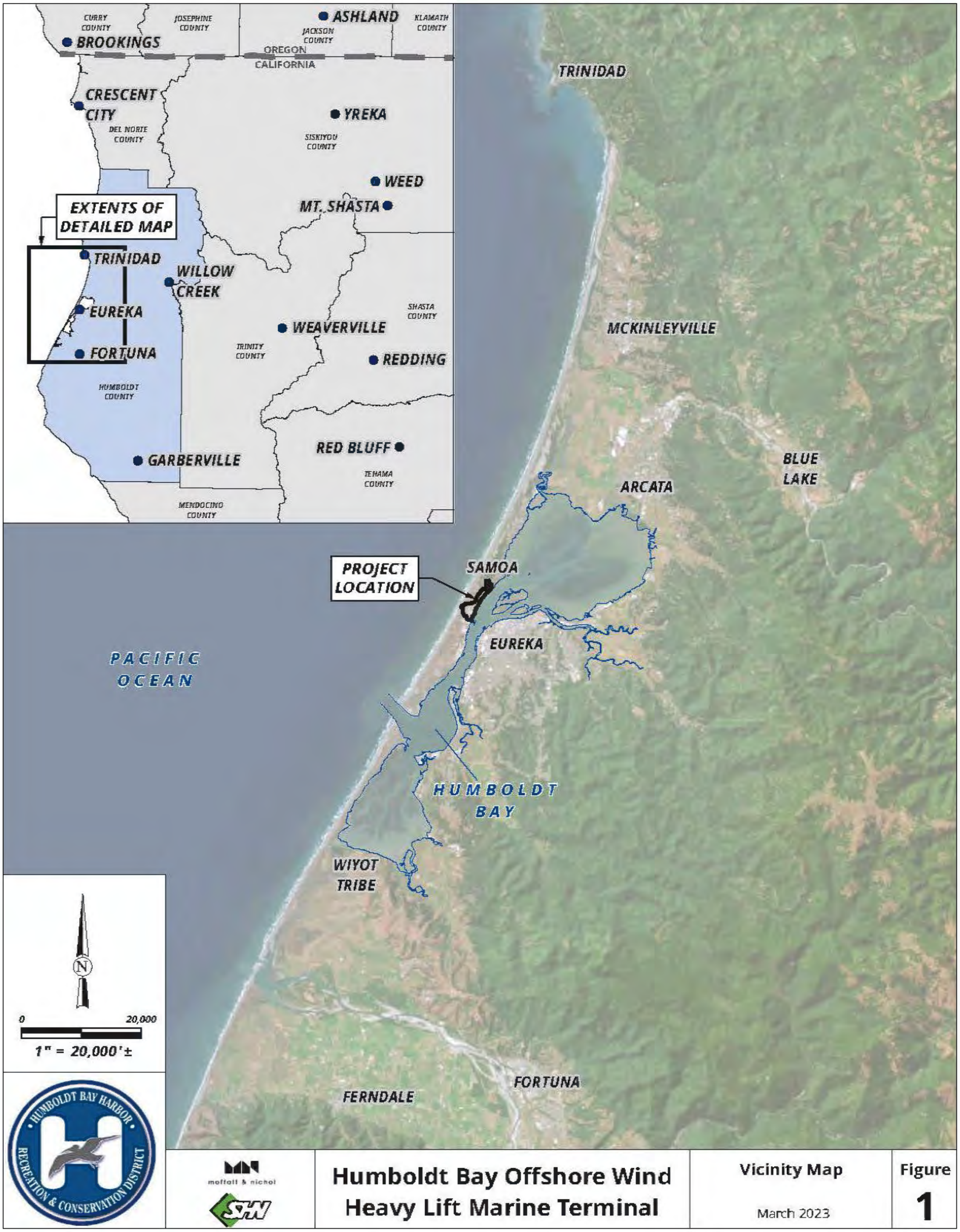

Figure 1. Humboldt Bay Offshore Wind Heavy Lift Marine Terminal Project Location
Notes: The 'Project Location' is located on the bay side of the northern spit in Humboldt Bay, California (Source = Figure 1 *in* District 2023).

1.2 Humboldt Bay Overview

The coastal zone of Humboldt County typically experiences very wet, cool winters and dry, mild foggy summers. In winter, temperatures range from highs of 40-59°F (4.4-15°C) to lows of 32-49°F (0-15°C). Coastal summers are cool to mild, with average highs of 60-69°F (15.6-20.6°C) and frequent fog. The Humboldt Bay area averages 38 inches of rain (96.5 cm), mostly falling from November through March. Humboldt Bay is located along the northern California coast, is semi-enclosed, and approximately 14 mi (22.5 km) long and 4.5 mi (7.2 km) wide at its widest point; the surface area is 38.8 mi^2 (62.4 km^2) at mean high tide and 17.4 mi^2 (28.0 km^2) at mean low tide. The bay is made up of three subbasins: South Bay, North (Arcata) Bay, and Entrance Bay (Figure 1). The entrance to the ocean is approximately in the middle of Humboldt Bay, which has a 359 mi^2 (578 km^2) drainage area from watersheds of the Coast Range (Barnhart et al. 1992).

After the bay was discovered in 1806 and settled in the 1850s, its entrance was stabilized by the construction of two jetties (north and south). In efforts to make passage safer for mariners and shipping commerce, Congress authorized dredging of the navigation channel in 1881 (Barnhart et al. 1992). Sediment management to maintain safe access to the bay entails regular dredging and is overseen by the District, which receives financial and technical assistance from the U.S. Army Corps of Engineers (USACE). The bay entrance is dredged to 48 ft (14.6 m) and the shipping channel where Redwood Marine Terminal I (RMTI; Figure 2) is located is dredged to 38 ft (11.6 m); dredged sediment is conveyed to the Humboldt Open Ocean Disposal Site (HOODS), which is north of Humboldt Bay and just offshore of the 3-nautical mile line and state waters.

Humboldt Bay's north and south jetties are the terminus to both the North Spit and the South Spit, respectively. North Spit is located along Arcata Bay, and the South Spit is located along the South Bay; both areas have maximum elevations of approximately 25 ft (7.6 m). The North and South Spits were developed during the last period of sea level rise and formed the bar-built estuary in combination with wave action (Barnhart et al. 1992).

The transition from natural to artificial shoreline within the bay primarily occurred between 1870 and 1946, and included the installation of docks and marinas, establishment of boat building and repair facilities, addition of railroad infrastructure, and conversion of wetlands to grazing lands (Barnhart et al. 1992). Present-day Humboldt Bay retains multiple docks and marinas for recreational, commercial, and marine services.

Humboldt Bay is relatively shallow, with the majority of the bay comprised of tidal flats that are exposed during low tide (Costa 1982 as cited *in* Northern Hydrology and Engineering 2015). The mud flats are predominately in North and South Bays, and only Entrance Bay and the lower portions of North Bay Channel maintain an approximate constant surface area over a tide cycle (Northern Hydrology and Engineering 2015). The sediments in Humboldt Bay vary, but they correlate to the bay floor types: mudflats, tidal channels, salt marshes that are located primarily by the tidal elevations. Currents leave coarser sediments in the channels and finer sediments in the mudflats (Barnhart et al. 1992). The nearby Eel River is a major source of sediment. Humboldt Bay habitats were evaluated by Schlosser and Eicher (2012), with 31% of the bay comprised of eelgrass or patchy eelgrass, 28% of the bay comprised of subtidal habitat, followed by 21% unconsolidated sediment, and 12% macroalgae (Table 1).

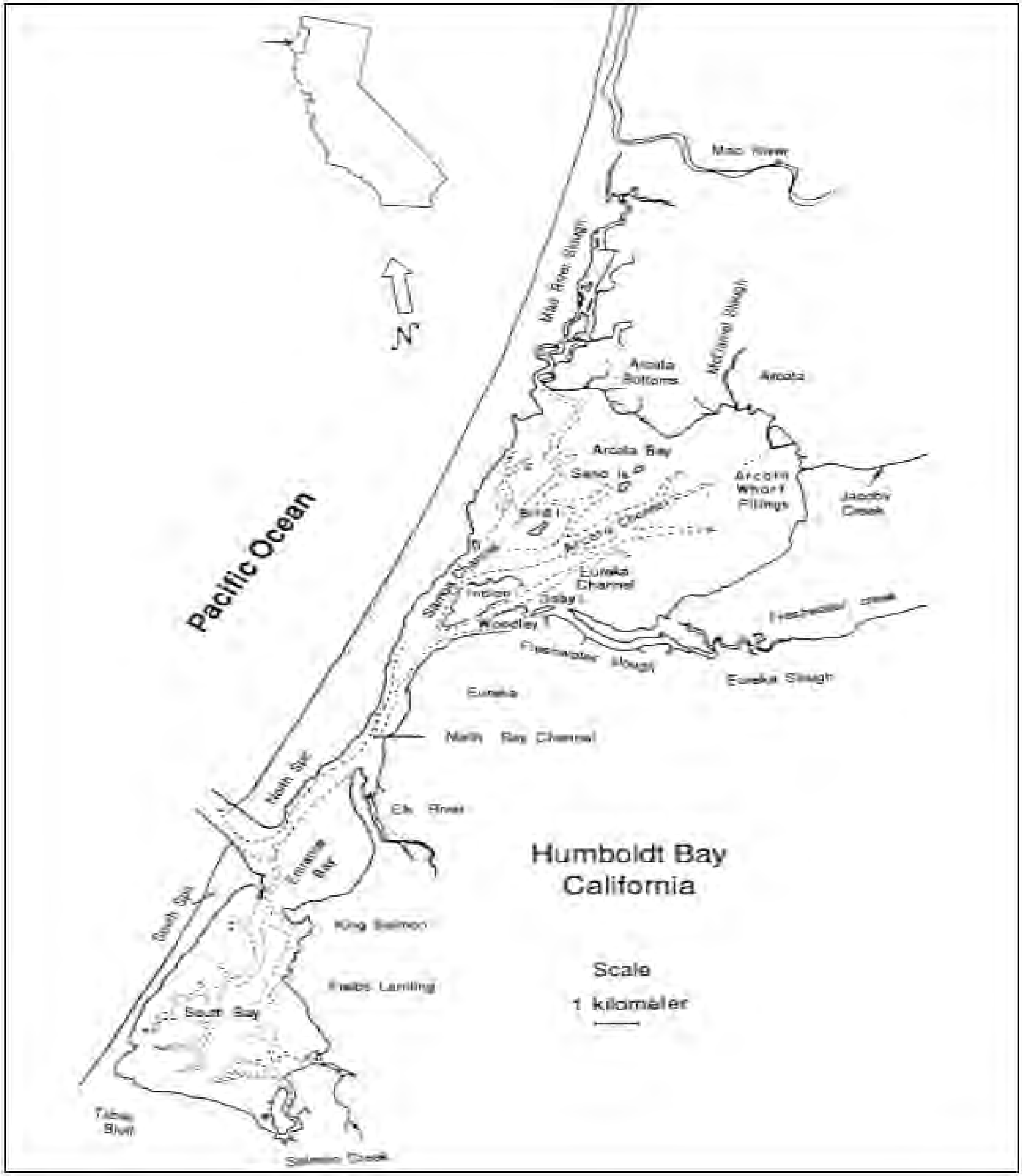

Figure 2. Humboldt Bay Overview
Notes: This map provides a general overview of key geographic features in Humboldt Bay, sourced from Barnhart et al. 1992 and modified from Costa 1982. Redwood Marine Terminal I and No Name Dock, which will be demolished for the proposed Project, are located on the bay side of the North Spit near Samoa Channel.

Table 1. Coastal Wetland Habitats in Humboldt Bay

Habitat	North Bay	Entrance Bay	South Bay	Total
Coastal Marsh	637	229	38	905
Eelgrass	1,880	96	1,638	3,614
Patchy eelgrass	1,697	26	307	2,031
Macroalgae	1,034	144	979	2,158
Oyster mariculture	287	0	0	287
Subtidal	1,380	2,928	645	4,954
Unconsolidated Sediment	2,712	224	870	3,807
Total	9,629	3,649	4,479	17,759

Notes: This table is adapted from Schlosser and Eicher (2012). The acreage of various habitat types within North Bay, Entrance Bay, and South Bay are provided. Total acreage within the bay for each habitat type is also provided.

1.3 Project Goals

The goals of the proposed Project are to:

- Redevelop and repurpose a blighted and largely unutilized industrial site that formerly operated for decades as a major regional employment center;
- Create a diversity of new jobs and stimulate regional economic development;
- Develop a project that establishes Humboldt Bay as a global leader in addressing climate change and energy decarbonization by providing a critical role in offshore wind renewable energy development;
- Develop a facility that can contribute to the Federal goal of deploying 30 GW of offshore wind energy by the year 2030, the State goal of deploying 5 GW of offshore wind energy by 2030, and the State goal of deploying 25 GW of offshore wind energy by 2045;
- Provide the facilities and infrastructure required for Humboldt Bay to serve as the first floating offshore wind "staging and integration" port in California. According to the "California Floating Offshore Wind Regional Ports Assessment" study published by BOEM in January of 2023, Humboldt Bay is the only port capable of serving all three of the primary port needs of the offshore wind industry, which are: staging and integration (S&I), onsite manufacturing/fabrication, and operations and maintenance. In addition, according to the BOEM study, only the Ports of Humboldt Bay, Los Angeles, and Long Beach are capable of conducting S&I functions. Among these three ports, only Humboldt Bay has immediately available developable space. Thus, a major purpose of the proposed project is to serve as California's initial S&I port;
- Design and construct the site in such a way that it can serve multiple purposes either simultaneous with the offshore wind energy functions described above or following the conclusion of the need for those offshore wind energy functions. Additional purposes could include breakbulk uses, dry bulk,

wood product manufacturing/shipping, cargo laydown/storage/transport, and/or other related maritime transport uses that require heavy-lift wharfs and large laydown yards;

- Develop a marine terminal site with modern environmental standards related to minimization of greenhouse gas emissions, onsite renewable energy generation, green building materials, the electrification of terminal operations, and the facilities needed to accommodate vessel shore power;
- Prepare the site for sea level rise;
- Address any residual soil contamination that currently exists at the site; and
- Generate revenue that can be used for general Harbor District purposes throughout the rest of Humboldt Bay, including year-round maintenance of channel and marine depths, conservation, ecological restoration, and recreation programs.

Section 2.0 Project Description

The District is proposing to redevelop a ~180-acre site on the Samoa Peninsula to provide a new multipurpose, heavy-lift marine terminal facility capable of supporting the offshore wind industry and other coastal development industries (District 2023). The Project includes facilities required to service the offshore wind industry, including a delivery berth for import of wind turbine components, onsite manufacturing and fabrication facilities, staging and integration, operations and maintenance facilities, and wet storage space. To accomplish this, the existing structures at Redwood Marine Terminal I (RMTI) and No Name Dock will be demolished and replaced with new port and marine terminal infrastructure (RMMT). Construction involves removing all piles and structures at the existing facility that are no longer of use. It also entails permanent shading of intertidal shoreline areas from the new wharf. A large area surrounding the new pier (RMMT) will be dredged to the same depth as the existing channel, converting intertidal habitat to deep subtidal waters. Wet storage sites will also be established where wind turbine devices (WTDs) can be temporarily moored to mitigate the risk of weather downtime, vessel traffic, entrance channel congestion, and other transportation risks (District 2023). It also involves habitat restoration at mitigation sites to convert the existing habitat to eelgrass beds (addressed in a separate analysis), with the overall purpose of offsetting the removal of eelgrass associated with construction at RMMT.

RMMT will primarily serve as a facility for the vertical integration, launching, and long-term maintenance of WTDs. It will also serve as a facility for the manufacturing, import, staging, and preassembly of various WTD components. While the offshore wind energy industry is the proposed anchor tenant of the modernized terminal project, the RMMT and its facilities could accommodate a variety of vessels and traditional port-based industries, such as breakbulk cargo and forest products. Details regarding future operations are not available at this time and effects would be speculative, thus the present assessment does not evaluate potential impacts of these future projects.

The Project components are divided into four subareas based on the type of activities that will occur (Figure 3). Each component differs in its impact on marine resources. The subareas primarily considered for this assessment include the marine development and wet storage locations, since activities in these subareas have potential to impact marine resources as summarized. The upland development and wet storage subareas are also considered, as there may be effects of construction on marine resources, although to a lesser extent. Potential conceptual project designs are provided in Figures 4 through 6.

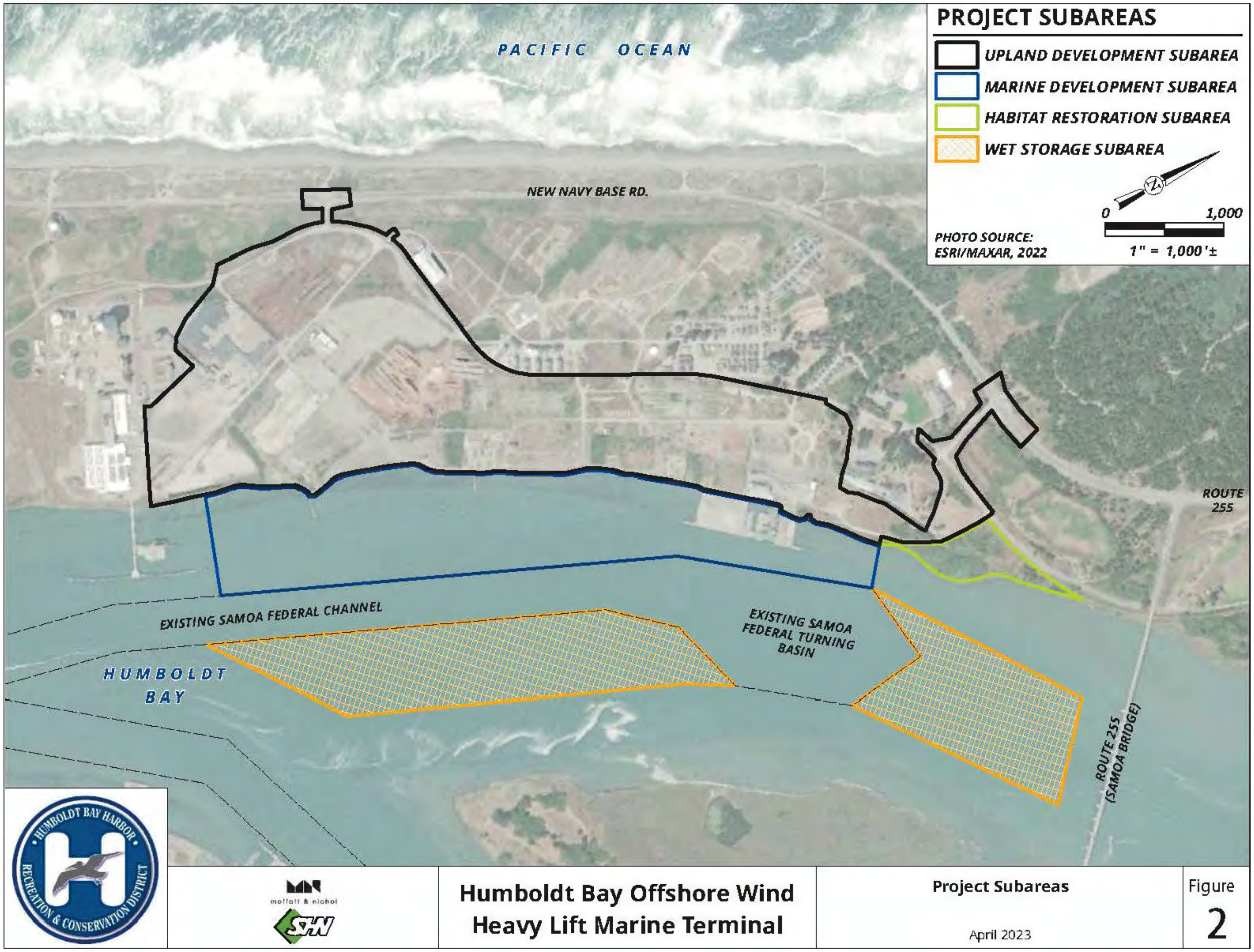

Figure 3. Project Subareas

Notes: The Project is comprised of four distinct subareas (Source = Figure 2 *in* District 2023).

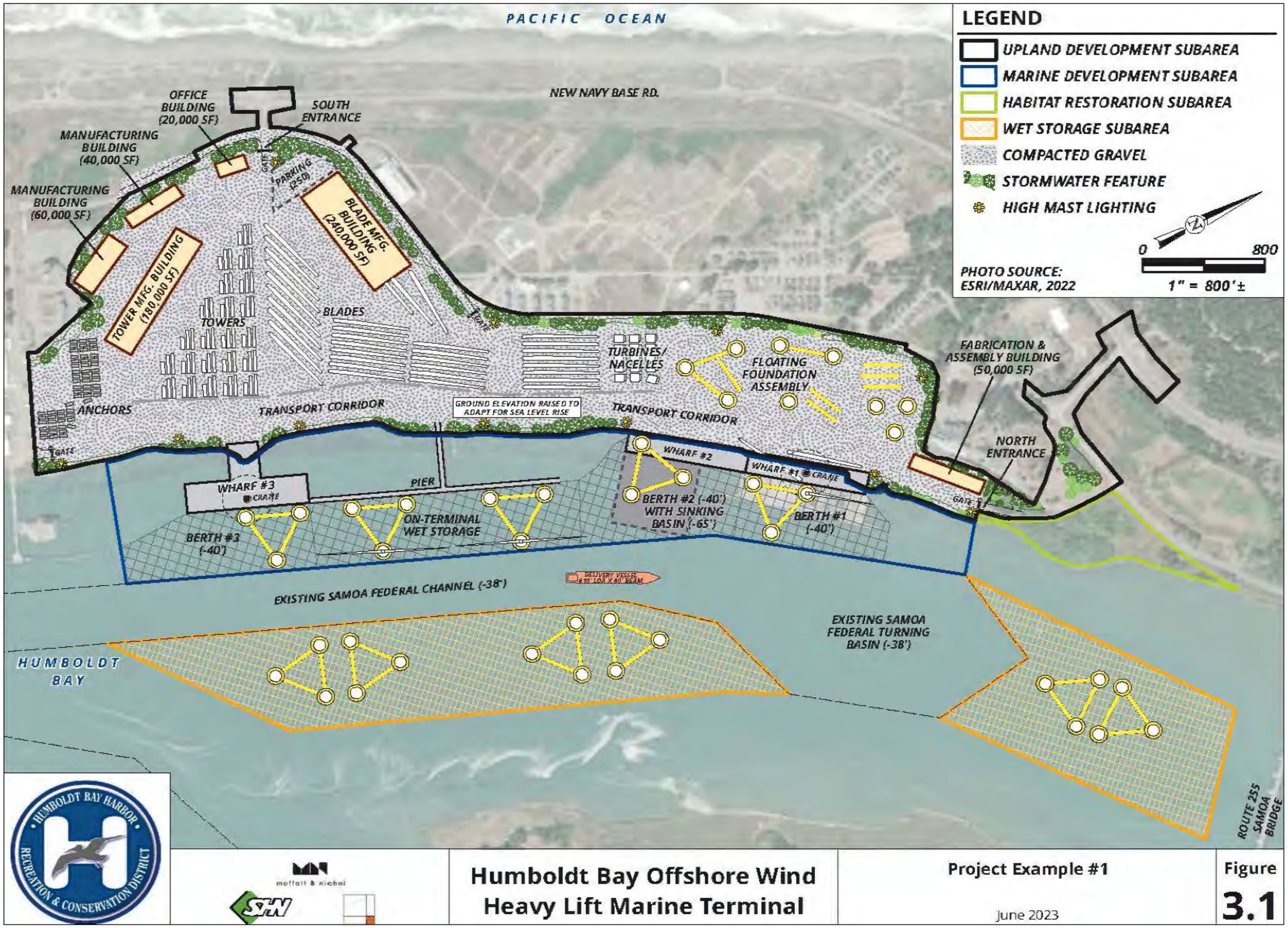

Figure 4. Conceptual Project Example #1

Notes: This figure is an example conceptual plan of how the site may be developed. It represents possible site layouts and arrangements but does not represent development alternatives or alternatives to be analyzed in the draft environmental review (DEIR). Project design will be refined concurrent with development of the DEIR and will reflect input from agencies and the public (Source = Figures 3.1 through 3.3 *in* District 2023).

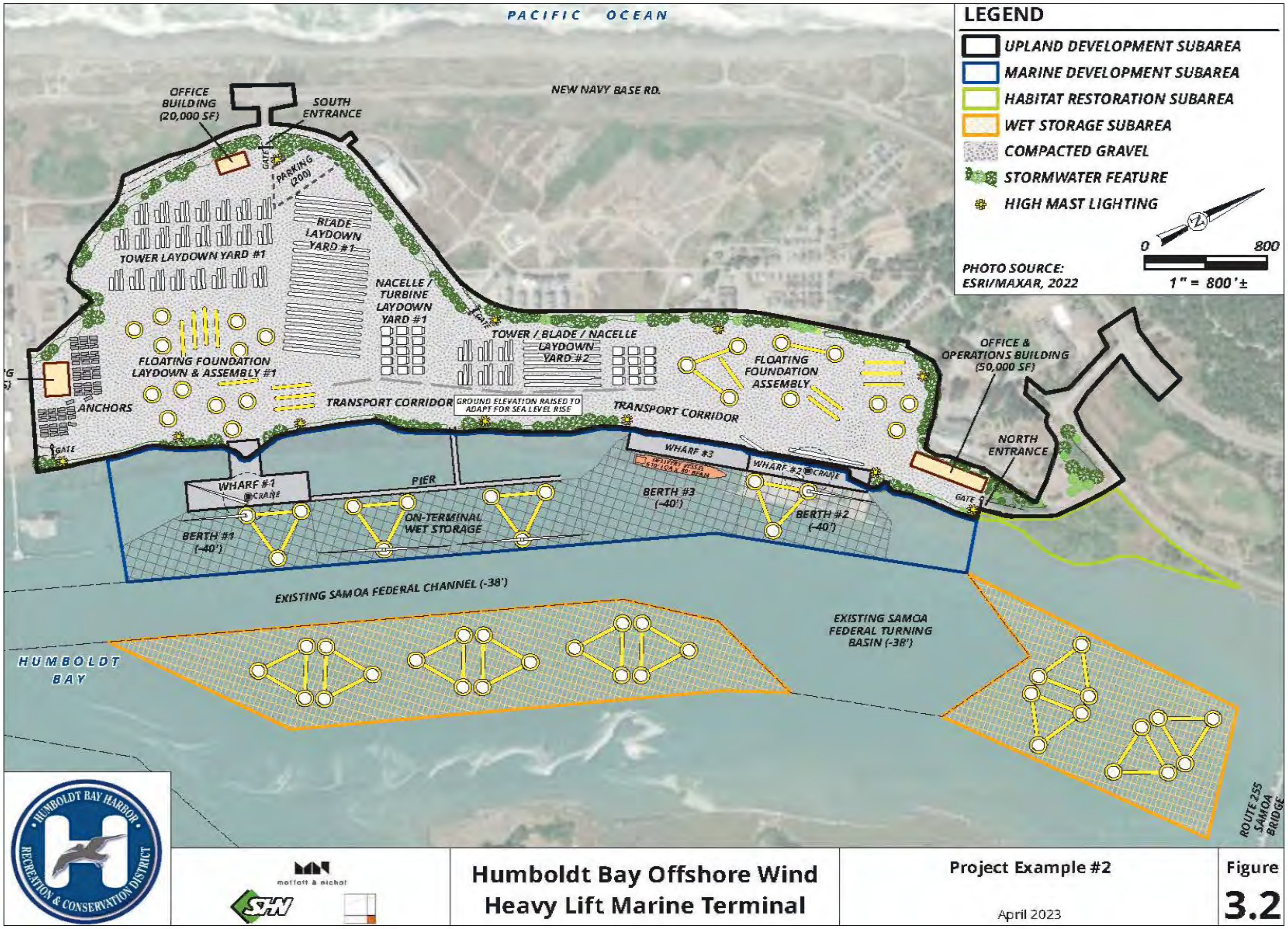

Figure 5. Conceptual Project Example #2

Notes: This figure is an example conceptual plan of how the site may be developed. It represents possible site layouts and arrangements but does not represent development alternatives or alternatives to be analyzed in the draft environmental review (DEIR). Project design will be refined concurrent with development of the DEIR and will reflect input from agencies and the public (Source = Figures 3.1 through 3.3 *in* District 2023).

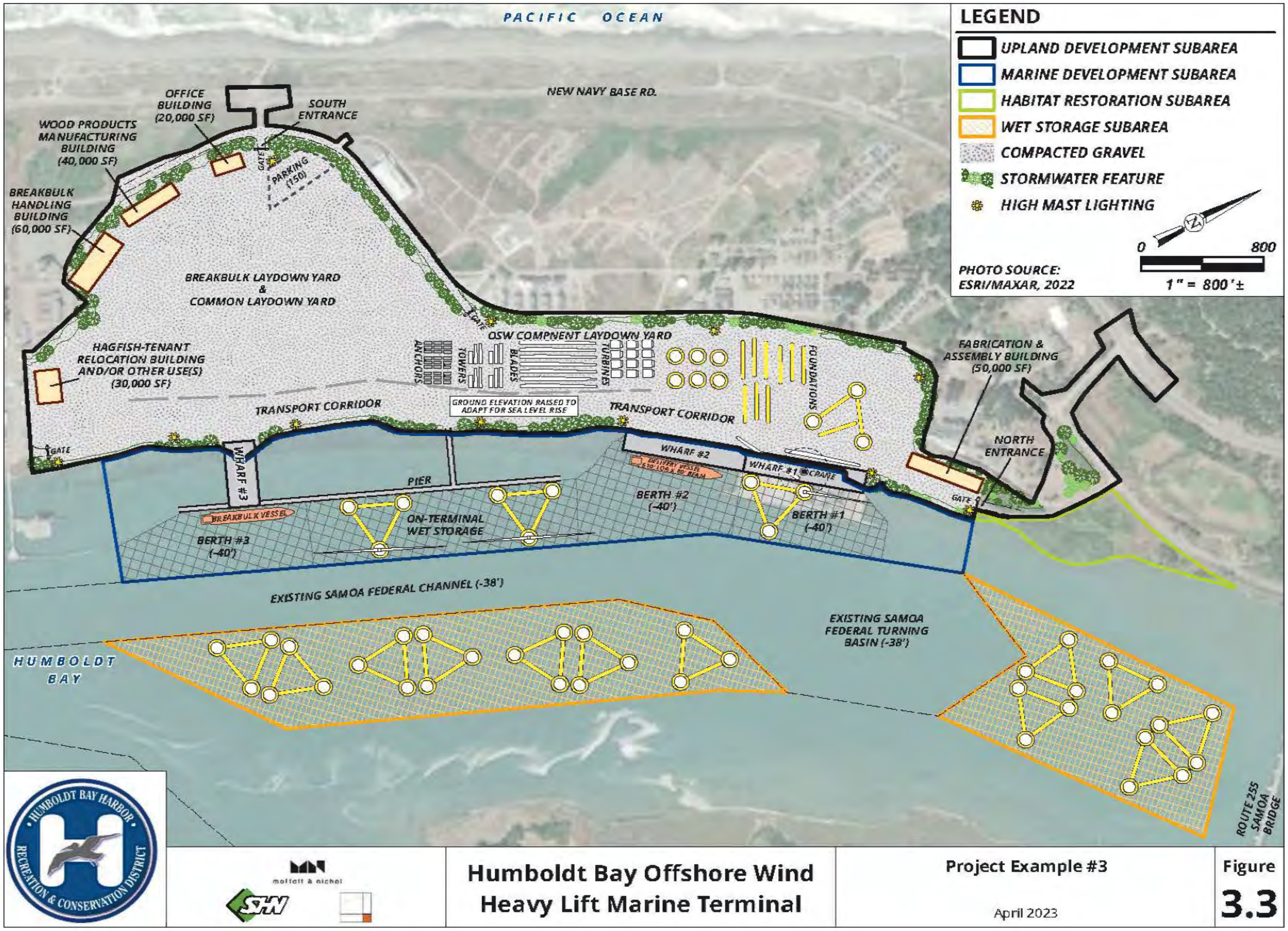

Figure 6. Conceptual Project Example #3

Notes: This figure is an example conceptual plan of how the site may be developed. It represents possible site layouts and arrangements but does not represent development alternatives or alternatives to be analyzed in the draft environmental review (DEIR). Project design will be refined concurrent with development of the DEIR and will reflect input from agencies and the public (Source = Figures 3.1 through 3.3 *in* District 2023).

2.1 Upland Development Subarea

The upland development subarea is landward (west) of Humboldt Bay. All non-marine developments will occur in this area. This area will host all offshore wind staging and integration operations, including wind turbine generator components delivery and storage, foundation delivery and storage, vertical integration, floating foundation assembly site infrastructure and operations The following construction activities may occur within the Upland Development Subarea.

- Vegetation clearing and grubbing.
- Demolition. This includes demolishing and removing existing buildings and structures. Major buildings and structures to be demolished are shown in Figure 3. It also includes demolishing existing asphalt, concrete, and remnant foundations of previously demolished buildings/structures. Some of these materials may be ground on site and re-used as fill material. Unused material will be disposed of at an appropriately permitted location.
- Remove, reuse, relocate, update, and/or modernize existing utilities including water storage tanks, power poles and lines, underground industrial, domestic and baywater lines, telecommunication lines, gas lines, sanitary sewer, and storm water systems.
- Cut, fill, and site regrading in anticipation of sea level rise to obtain final ground elevations between +13 to +17 feet NAVD88 (i.e.: +12.66 to +16.66 MLLW). Dredge material and/or upland sources may be used as imported fill.
- Import and install compacted gravel throughout the site (see the Figure 3 series for examples of where this could potentially occur) for a finished wear surface.
- Asphalt roads and parking areas in certain discrete areas (e.g., a 200-space parking lot and areas near buildings).
- Construct approximately 650,000 square feet of building space for manufacturing, repairs, offices, restrooms, and storage (see the Figure 3 series for examples of where these could potentially be sited).
- Construct internal transportation network of paved and/or compacted gravel roads.
- If needed, improve up to two intersections on New Navy Base Road and the intersection of Cookhouse Road and Vance Avenue.
- Install high mast terminal lighting (approximately 150' high) around the perimeter of the site and other, shorter lighting as needed.
- Make drainage improvements for stormwater which may include retention ponds, detention ponds, bioswales, and subsurface detention.

- Install charging infrastructure for electric vehicles and electrified construction equipment, fueling stations for land-based vehicles, connection to electricity substation currently located directly south of the Project site, and solar panels on ash landfill to connect to substation.

2.2 Marine Development Subarea

The marine development subarea extends from the top of the bank into the bay to the federal navigation channel. Assembly and launching of floating foundations will occur in this area, in addition to the vertical integration of the various OSW components into deployment-ready fully constructed floating WTDs. Most marine development occurs in this area, except for what occurs in the wet storage subarea. Specific construction activities within the marine development subarea include:

- Demolish an existing ~6-acre wooden dock at RMTI and No Name Dock (Figure 7);
- Construct up to three wharfs totaling a maximum of approximately 2,500' along the shoreline. In this case, the wharfs will consist of pile supported, vessel berth structures. This will include installation of steel and/or concrete piles. These wharfs could be discontinuous from one another or cojoined to another;
- Dredge berths between the newly constructed wharfs and the federal navigation channel to approximately - 40' MLLW for deep draft cargo vessel access and WTD construction activities. Dredged material may be disposed of at the HOODS, beneficially used or disposed of elsewhere;
- Dredge a sinking basin to approximately -60' MLLW to accommodate semi-submersible vessel operations for device float off. Dredged material may be disposed of at the HOODS, beneficially used or disposed of elsewhere;
- Construct a pier and associated gangways to an on-terminal wet storage facility. An on-terminal wet storage berth will be dredged between the pier/gangways and the federal navigation channel to a depth of up to -40' MLLW. This on-terminal wet storage area may temporarily contain floating foundations that do not yet have the towers or blades installed on them. In addition, the on-terminal wet storage area may also temporally contain fully integrated WTDs for preparation prior to towing them to sea. The pier and gangways will allow land-based access of workers and small wheeled equipment to these temporarily stored units. This new pier will be in the same general location as an existing ~160' wooden dock known as "Red Tank Dock." The new pier will either replace Red Tank Dock or will be located near Red Tank Dock. There is a bay water intake currently located at the end of Red Tank Dock, which includes a sea chest suspended into the water. If the new pier replaces Red Tank Dock, then the existing bay water intake infrastructure will be relocated to a new location or suspended from the new pier instead of from Red Tank Dock. Potential examples of the layout and infrastructure of the on-terminal wet storage pier and berth are shown in Figures 4 through 6.

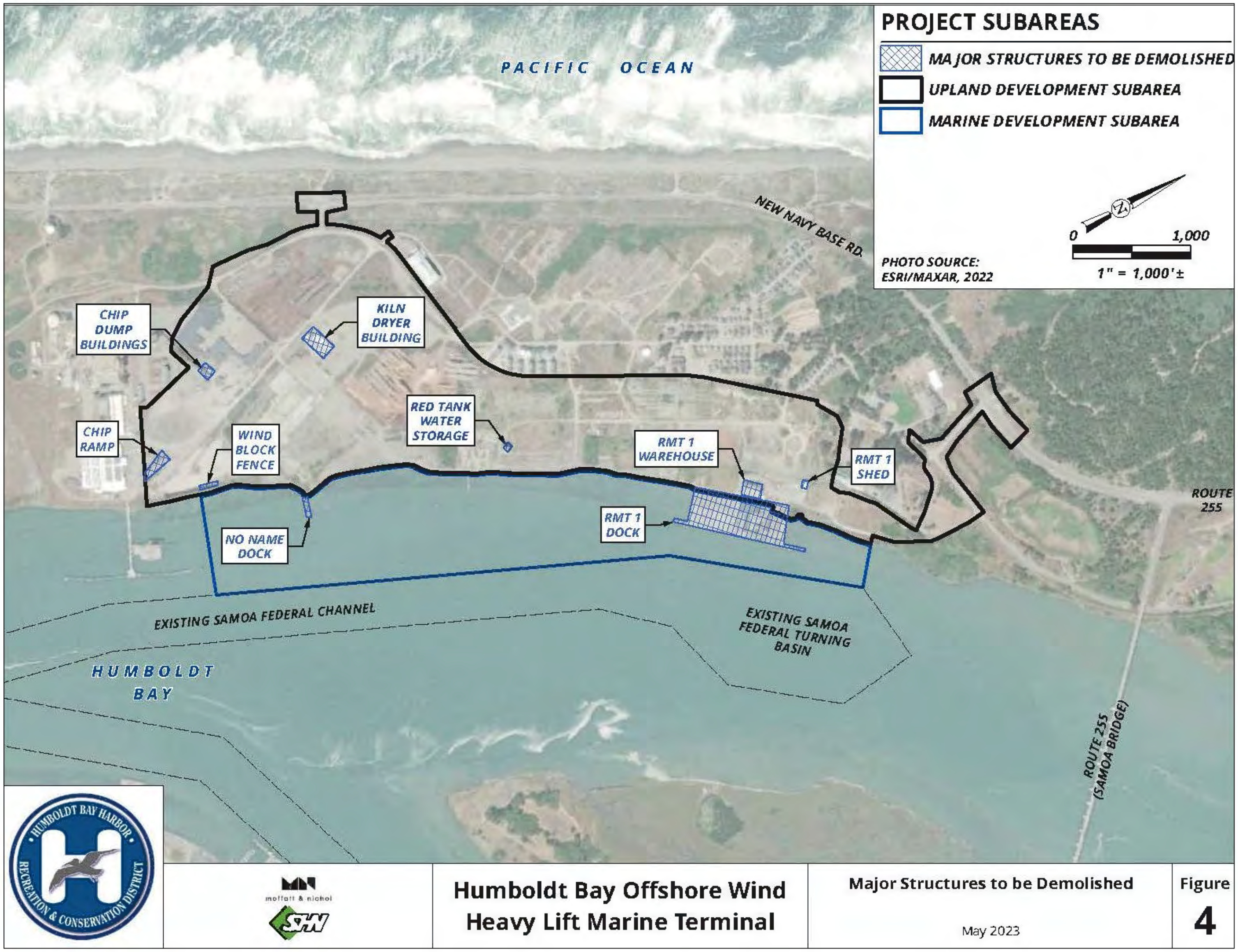

Figure 7. Structures to be Demolished in Marine Subarea

Notes: No Name Dock and Redwood Marine Terminal I (RMTI Dock) are the two structures within the marine subarea that will be demolished, and are being analyzed in this marine impacts assessment (Source = Figure 4 *in* District 2023).

2.3 Wet Storage Subarea

Facilities in the off-terminal wet storage subarea will be used for short-term temporary mooring of WTDs (Figures 4 through 6). Within the wet storage subarea, floating foundations may be temporarily stored prior to having the towers and blades installed on them. The fully assembled WTDs may also be temporarily staged in the wet storage subareas prior to towing them to sea. WTDs will also be ballasted with bay water for leveling and stabilization during offloading of floating foundations and vertical integration, and de-ballasted when towed-in from other ports for maintenance. The following activities will occur in the wet storage subarea:

- Relocate federal aids to navigation if needed;
- Install aids to navigation;
- Dredge to approximately -40 feet; and
- Install multi-point mooring structures (i.e., buoys and or pile supported dolphins).

2.4 Habitat Restoration Subarea

The habitat restoration subarea is where wetlands and environmentally sensitive habitat areas (ESHA) will be created or restored as mitigation for impact in the upland development subarea (District 2023). Habitat restoration will be conducted in areas that are ruderal and dominated by non-native invasive plant species. Habitat restoration will develop a mosaic of habitats that is significantly higher quality than what will be impacted by the Project. The activities that will occur within this subarea involve:

- Creating and enhancing wetland and ESHA habitats at a sufficient replacement ratio to Project impacts to ensure there is no net loss;
- Areas may be lowered in elevation to introduce tidal influence and develop salt marsh habitat;
- Freshwater wetlands may be created at the margins of salt marsh to mimic natural salt marsh to freshwater marsh ecotones in Humboldt Bay;
- Freshwater wetland will be developed by excavating geomorphic low points to intercept groundwater, placing clay soils in the bottom of geomorphic low points to intercept groundwater; and/or placing clay soils in the bottom of geomorphic low points to capture and retain rainwater;
- Using suitable native species when planting for salt marsh, freshwater wetlands, and ESHA;
- Biological mitigation, including but not limited to relocation of osprey nests.

Section 3.0 Existing Conditions

3.1 Ecological Communities

The existing communities in Humboldt Bay contribute to its overall function, provide a set of ecological services and support different species assemblages. The substrate, depth, and tidal and marine influence are three (of many) characteristics that define a given community. The existing conditions for intertidal coastal marsh, eelgrass, subtidal mudflats, and channels are described in this section.

3.1.1 Intertidal Coastal Marsh

Intertidal coastal marshes are dynamic habitats occupying a relatively narrow band of elevation in the upper intertidal zone of Humboldt Bay (Schlosser and Eicher 2012). Intertidal coastal marshes of Humboldt Bay are inundated at high tides and during flooding events and drain at low tide through meandering slough channels. Because tidal influence may extend further inland than saltwater intrusion, intertidal coastal marshes are fresh to brackish to saline and support a variety of different species. This stream-estuary ecotone habitat provides important habitat for early life stages of salmonids and longfin smelt, and for all life stages of tidewater goby.

Intertidal coastal marsh habitats have been heavily altered in Humboldt Bay, with only about 10% of the historic acreage currently remaining, and much of the native plant community has been replaced by invasive *Spartina densiflora* (Schlosser and Eicher 2012).

3.1.2 Eelgrass

Eelgrass (*Zostera marina*) is a seagrass that occurs in the temperate unconsolidated substrate of shallow coastal environments, enclosed bays, and estuaries, such as Humboldt Bay. It is a flowering plant, adapted to live in shallow subtidal and intertidal zones, primarily found near the level of mean low water or at tidal elevations between -21 to 0.8 m (Barnhart et al. 1992, Schlosser and Eicher 2012). Eelgrass thrives in muddy to silty sediment and is an important marine habitat in Humboldt Bay: it is highly productive and a major source of primary production, providing critical structure, habitat and food for birds, fish and invertebrates. Eelgrass influences sedimentation patterns, distribution of infaunal organisms, and the occurrence of bird species within the bay. It is an integral part of the life histories of many fish species, including steelhead, salmon, groundfish, and pelagic species (Schlosser and Eicher 2012).

Estimates suggest that Humboldt Bay eelgrass represents ~45% of the eelgrass in California, roughly 20% of intertidal habitats in the bay (Barnhart et al. 1992), and 31.8% of the coastal wetland habitats in terms of acres in the bay (Table 1, Schlosser and Eicher 2012). Both the Arcata and South Bays support large eelgrass habitats (Schlosser and Eicher 2012). Eelgrass beds in North Bay are found in dense beds along the inner channels, extending into the intertidal mudflats where distribution gets patchier (Schlosser and Eicher 2012). The North Bay generally has sparser beds than the South Bay. In the South Bay, there are large, dense beds next to the interior channels extending shoreward (Barnhart et al. 1992, Schlosser and Eicher 2012). Eelgrass is also found along the fringes of Entrance Bay, and in tidal channels and sloughs (Schlosser and Eicher 2012).

Eelgrass is present on mudflats in the project area (Merkel & Associates 2022). Merkel & Associates Inc. conducted eelgrass surveys within the project's area of potential effect to support design and planning, help avoid and minimize impacts associated with project activities, and assess anticipated mitigation needs (Merkel & Associates 2022). Eelgrass was observed broadly throughout the survey area (which included the project area and reference sites). The majority of eelgrass was distributed between +1 to -3 ft NAVD88 and plant condition and overall health was good (page [p.] 5 *in* Merkel & Associates 2022). Based on the existing conditions and historical trends, the project area could support a maximum of 10 acres of eelgrass cover by the time the Project begins construction (p. 19 *in* Merkel & Associates 2022).

3.1.3 Mudflats

In Humboldt Bay, mudflats are characterized by silt/clay mixtures (Thompson 1971, Schlosser and Eicher 2012). Intertidal mudflats are the habitats exposed by medium to low tides, and comprise roughly 2/3 of Humboldt Bay (Table 1, Schlosser and Eicher 2012). They are normally gently sloping seabeds, found in more sheltered parts of Humboldt Bay. Mudflats (and eelgrass beds) regenerate nutrients (Schlosser and Eicher 2012). Intertidal mudflats are hotspots for biological productivity: the majority of food organisms in Humboldt Bay consumed by fish and birds are produced in these habitats (p. xvii *in* Schlosser and Eicher 2012). At lower tides, mudflats also provide important foraging and loafing grounds for waterfowl and shorebirds (Barnhart et al. 1992). At higher tides, mudflats provide nursery grounds for fish, such as English sole, sanddabs and starry flounder that feed on the polychaetes, bivalves, and tidally active crustaceans (p. 124 *in* Schlosser and Eicher 2012). Seasonally and in the summer, rockfish, sculpin, and other juvenile fishes use mudflats to feed at high tide.

There are higher and lower intertidal mudflats. Higher intertidal flats (i.e., high mudflats) may be smooth and gently contoured, or hummocky with mounds separated by shallow depressions (p. 72 *in* Schlosser and Eicher 2012). Primary producers and plant life in high mudflats are dominated by algae (abundance fluctuates seasonally), microbial mats and eelgrass (Barnhart et al. 1992, Schlosser and Eicher 2012). Invertebrate assemblages are dominated by polychaetes, crustaceans and mollusks, and a large number of fish and birds feed on these invertebrates depending on the tide. Lower intertidal mudflats are much less exposed during low tide. Lower mudflats are typically smooth and gently contoured, low gradient, and often covered with dense eelgrass beds (p. 72 *in* Schlosser and Eicher 2012). The abundance of infauna increases in lower mudflats. There are also subtidal mudflats that are not exposed at low tides, and the subtidal communities are comprised of plant and animal species that are always inundated with water (Schlosser and Eicher 2012). Mudflats are often intersected by channels.

3.1.4 Channels, Bays, and Subtidal Communities

The channels in Humboldt Bay are responsible for transporting incoming and outgoing tidal flows and are characterized by sand, with the walls being comprised of more clay and sandy/silty material (Schlosser and Eicher 2012). Deeper channels are significantly more turbulent and contain coarser benthic sediment compared to the upper reaches of channels, where water flow decreased and benthic substrate is finer (Schlosser and Eicher 2012). Channels serve as a water reservoir at low tide and are regularly used by marine and resident fish for foraging and as nursery grounds (Barnhart et al. 1992). The channels in Arcata Bay range in depth from mean low water to 46 feet deep near the Samoa Bridge. The deepest and widest channels are at Entrance Bay and the entrance to North and South Bays. The channels in North and South Bays then taper into smaller, shallower and more complex channels that dissect the intertidal mudflats (Schlosser and Eicher 2012).

Each channel has a slightly different use, based on its depth and surrounding ecological community. For example, Entrance Bay (30 – 65 ft deep) is primarily used for commercial shipping, barge traffic, recreational vessels and fishing, sand surfing. Entrance Bay is between 38 and 48 feet deep and the federal navigation channel within Entrance Bay is annually dredged by the USACE to 48 ft (Schlosser and Eicher 2012). The north and south portions of Entrance Bay are stabilized by the north and south jetties. North Bay and the Samoa Federal Navigation Channels are maintained at a depth of 38 ft with a width of 400 to 600 ft. The overall subtidal portions of these channels are approximately 600 to 1800 ft wide. The Eureka and Fields Landing Federal Navigation Channels are maintained at a depth of 26 ft.

Channels in the North Bay are important for fishes, invertebrates and water birds, and support oyster farms and recreational boaters. South Bay has two main subtidal channels (Southport Channel and Fields Landing/Hookton Channel) that are regularly used by clammers and recreational boaters. These shallower subtidal channels are more natural, drain mudflats and support eelgrass on the channel banks. Tidal sloughs are secondary channels to drain tidewaters from intertidal marshes and serve the furthest reaches of the bay. These shallow channels are generally between three and 17 feet deep at low tide, whereas deep channels are considered to be > 17 feet deep at low tide (Schlosser and Eicher 2012).

3.2 Regulatory Information

3.2.1 Federal

3.2.1.1 Endangered Species Act

The Federal ESA of 1973, and subsequent amendments, provides regulations for the conservation of endangered and threatened species and the ecosystems on which they depend. The U.S. Fish and Wildlife Service (USFWS), with jurisdiction over plants, wildlife, and resident fish, and National Marine Fisheries Service (NMFS), with jurisdiction over anadromous fish, and marine fish and mammals, oversee the implementation of the ESA. Section 7 mandates all federal agencies to consult with USFWS and NMFS if they determine that a proposed action or project may affect a listed species or its habitat. Under Section 7, the federal lead agency must obtain incidental take authorization or a letter of concurrence stating that the proposed project is not likely to adversely affect federally listed species.

Endangered species and threatened species and critical habitats are defined to include the following:

- Species listed as threatened or endangered under the federal ESA;
- Areas or communities identified as critical habitat under the federal ESA;
- Candidate species for listing as threatened or endangered under federal ESA; and
- Species proposed for listing as threatened or endangered under the federal ESA.

Section 9 prohibits the take of any fish or wildlife species listed as endangered, including the destruction of habitat that prevents the species' recovery. Take is defined as any action or attempt to hunt, harm, harass, pursue, shoot, wound, capture, kill, trap, or collect a species. Section 9 prohibitions also apply to threatened species unless a special rule has been defined with regard to take at the time of listing. Under Section 9, the take prohibition applies only to wildlife and fish species; however, it prohibits the unlawful removal and possession, or malicious damage or destruction, of any endangered plant on federal land. Section 9 prohibits acts to remove, cut, dig up, damage, or destroy an endangered plant species in nonfederal areas in knowing violation of any state law or in the course of criminal trespass.

3.2.1.2 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Act (MSA) requires federal agencies to consult with NMFS on all actions that may adversely affect Essential Fish Habitat (EFH). An area within the designated EFH that is particularly important and/or sensitive is a Habitat Area of Particular Concern (HAPC). Regional Fishery Management Councils (e.g., Pacific Fishery Management Council [PFMC]), established under the MSA, are responsible for preparing and amending fishery management plans (FMPs) for each fishery under their authority that requires conservation and management. The PFMC has designated EFH for four FMPs covering groundfish, coastal pelagic species, Pacific coast salmon, and highly migratory species. The MSA established procedures designed to identify, conserve, and enhance EFH for those species regulated under an FMP. Under section 205(b) of MSA, federal agencies are required to consult with the Secretary of Commerce (represented on this issue by NMFS) on any actions that may adversely affect EFH.

EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. 1802(10)). NMFS has further added the following interpretations to clarify this definition:

- "waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate;
- "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities;

- “necessary” means the habitat required to support a sustainable fishery and the managed species’ contribution to a healthy ecosystem; and
- “spawning, breeding, feeding, or growth to maturity” covers the full lifecycle of a species (50 CFR 600.10).

HAPCs are described as subsets of EFH, and are identified based on one or more of the following considerations:

- Importance of the ecological function provided by the habitat;
- Extent to which the habitat is sensitive to human-induced environmental degradation;
- Whether and to what extend development activities are, or will be stressing the habitat type; and
- The rarity of the habitat type.

3.2.1.3 Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) of 1972 prohibits, with certain exceptions, the “take” (defined under statute to include harassment) of marine mammals in the nation’s waters and the high seas. In 1986, Congress amended both the MMPA, under the incidental take program, and the federal ESA to authorize incidental takings of depleted, endangered, or threatened marine mammals, provided the “taking” (defined under statute as actions which are or may be lethal, injurious, or harassing) was small in number and had a negligible impact on marine mammal populations.

Under MMPA Section 101(a)(5)(D), an Incidental Harassment Authorization (IHA) can be granted by NMFS if it finds that the incidental “take” would have a negligible impact on the species or stock, or would not have an unmitigable adverse impact on the availability of the species or stock for subsistence uses (where applicable). NMFS has defined “negligible impact” as “an impact resulting from the specified activity that cannot be reasonably expected to, and would not be reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival.” IHAs include permissible methods of taking and requirements for mitigation and monitoring to ensure that takings result in the lowest practicable adverse impacts on affected marine mammal species or stocks.

3.2.1.4 Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) (16 USC 703, Supp. I, 1989) prohibits killing, possessing, or trading in migratory birds except in accordance with regulations prescribed by the Secretary of the Interior. Under Executive Order 13186, “Responsibilities of Federal Agencies to Protect Migratory Birds,” Federal agencies have been directed to take certain actions to further implement the MBTA. To this end, USFWS has entered into memorandums of understanding (MOUs) with over a dozen agencies. These MOUs, generally strengthen migratory bird conservation through enhanced collaboration and to work together to reduce negative impacts of resource development projects on migratory birds.

3.2.2 California State Statutes

3.2.2.1 California Endangered Species Act

The California Endangered Species Act (CESA) (California Fish and Game Code [CFGC] Section 2050 et seq.) establishes state policy to conserve, protect, restore, and enhance threatened or endangered species and their habitats. CESA mandates that state agencies should not approve projects that jeopardize the continued existence of threatened or endangered species if reasonable and prudent alternatives are available that would avoid jeopardy. For projects that would affect a federally or state listed species, compliance with federal ESA satisfies the requirements of CESA if the California Department of Fish and Wildlife (CDFW) determines that the federal incidental take authorization is consistent with CESA under CFGC Section 2080.1. If a project would result in take of a species that is only state listed, the project proponent must apply for a Section 2081(b) Incidental Take Permit (ITP) from CDFW.

3.2.2.2 California Coastal Act

The California Coastal Act of 1976 requires any person proposing to undertake development in the Coastal Zone to obtain a Coastal Development Permit. The Coastal Zone extends inland anywhere from approximately 500 yards (457 m) in developed urban areas to 5 mi (8 km) in undeveloped areas. In addition, it provides for the transfer of permitting authority, with certain limitations reserved for the State, to local governments through adoption and certification of local coastal programs by the California Coastal Commission.

3.2.2.3 California Fish and Game Code

Protection of Birds and Raptors (Sections 3503 and 3503.5)—Section 3503 of the CFGC prohibits the killing of birds and destruction of their nests. Section 3503.5 prohibits killing of raptor species and destruction of raptor nests. Typical violations include the destruction of active bird and raptor nests caused by tree removal, and failure of nesting attempts (loss of eggs or young) as a result of disturbance of nesting pairs from nearby human activity.

Fully Protected Species (Sections 3511, 3513, 4700, and 5050)—CFGC Sections 3511, 3513, 4700, and 5050 apply to fully protected wildlife species (birds in Sections 3511 and 3513, mammals in Section 4700, and reptiles and amphibians in Section 5050) and strictly prohibit the take of these species. CDFW cannot issue a take permit for fully protected species, except under narrow conditions for scientific research or the protection of livestock, or if a Natural Community Conservation Plan has been adopted. Specifically, Section 3513 prohibits any take or possession of birds designated by the MBTA as migratory nongame birds except as allowed by federal rules and regulations pursuant to the MBTA.

On July 10, 2023, the California Senate Bill 147 (Senate Bill [SB] 147) amended Sections 395, 3511, 4700, and 5515 related to the CFGC. Per this Project, SB 147 is relevant because it removes the American peregrine falcon and brown pelican (and thicktail chub) as fully protected species. SB 147 also authorizes CDFW to issue permits under CESA, allowing for the take of fully protected species that may result specific projects if certain conditions are satisfied.

3.2.2.4 California Marine Invasive Species Act

The California Marine Invasive Species Act regulates vessel ballast water exchange and management practices to minimize spreading of invasive species from vessel hull fouling (see Public Resources Code – PRC Division 36. Marine Invasive Species Act [71200–71271]). Vessels operating within the state and arriving at California ports from a port outside of the Pacific Coast Region must employ ballast water best management practices which may include minimizing discharge, mid-ocean ballast water exchange, and regular removal of biofouling organisms. These regulations are governed by the California State Lands Commission.

3.2.3 Local Statutes and Planning Documents

3.2.3.1 Humboldt Bay Harbor, Recreation and Conservation District Act

The Humboldt Bay Harbor, Recreation and Conservation District Act empowers the board of commissioners to grant permits, franchises, and leases in areas including Humboldt Bay. In many cases, the District is also the lead agency for development projects with regard to compliance with the provisions of CEQA, and routinely works with other permitting agencies on the environmental assessment of proposed projects.

3.2.3.2 Humboldt Bay Management Plan

The Humboldt Bay Management Plan is the primary planning document used by the District to promote commerce, navigation, fisheries, recreation, and protection of natural resources. It represents the region's first ecosystem-based management approach intended to manage Humboldt Bay, identify goals and policies to address the maintenance of channels and marinas in Humboldt Bay, and balance port-related commercial and industrial uses, recreational uses, and protection of resources in the bay.

3.3 Species Presence

This section identifies birds, fish, marine mammals, and benthic invertebrates likely to occur in the marine development (intertidal and subtidal) project area, including their habitat use and timing. The species covered in this assessment are those listed as threatened or endangered by either the Federal ESA of 1973, CESA, fully protected by the CFGC, and CDFW State Species of Special Concern (CSSC). Other non-listed species are also covered, if they are of local value, ecologically or commercially.

The potential for occurrence of species was evaluated using multiple data sources. The California Natural Diversity Database (CNDDB), which provides an inventory of the status and locations of rare plants and animals throughout California, was used to identify the ESA- and CESA-listed species previously identified within a 5-mile buffer zone around Humboldt Bay (CNDDB 2023). Species and habitat information was also obtained from the NMFS EFH Mapper (NMFS 2020a) and the USFWS Information for Planning and Conservation (IPaC) (USFWS 2020). Conclusions on a species' potential for occurrence were based off a thorough literature search, using peer reviewed literature, technical reports and federal registers, and thus account for natural history records and modern scientific research.

The potentially affected species are outlined in Tables 2, 3, and 7, with one table for birds, fish, and marine mammals, respectively. Many of these are considered special-status at either a federal or state level. Information on their listing under the ESA and CESA, and level of protection by the CDFW are provided (CNDDB 2023); however, not every species included is of special status and may instead, for example, be of commercial or recreational importance. The potential for occurrence (present, possible, unlikely, absent) in the project area is noted. A select number of species from each group of taxa from these tables were examined in more detail. These species were chosen according to several factors. First, it was based on their listing status: those listed as threatened or endangered under the federal ESA, CESA, and as a California Fully Protected Species, or a CSSC by the CDFW. The likelihood of occurrence was also taken into consideration. Effort was focused on species likely to be within or adjacent to the project area. Species that are relevant to those of special status, occupy a critical trophic position, use a specific habitat for an important aspect of its life history (gritting) were also analyzed in more detail. Species managed for recreational and commercial harvest similarly were examined in more detail.

3.3.1 Special-Status Birds

A total of 20 birds are included in Table 2. These birds represent either species listed under the Federal ESA, the CESA, are listed as California Fully Protected Species, represent CDFW Species of Special Concern, are protected under the Bald and Golden Eagle Protection Act or have nesting colonies that might be of local concern. Several species that are quite rare visitors and do not breed in the region (e.g., yellow rail, *Coturnicops noveboracensis*, and mountain plover, *Charadrius montanus*) or are relatively common regionally, but are not expected to breed in the project area (sharp-shinned hawk, *Accipiter gentilis*), are not covered by additional species details beyond the information in Table 2.

3.3.1.1 Marbled Murrelet

Marbled murrelets are small alcids listed in 1992 as threatened under federal ESA (USFWS 1992) and are endangered under CESA. They occur along the Pacific coast from Alaska to California, foraging nearshore in marine subtidal and pelagic habitats for small fish and invertebrates (USFWS 1992). In California, nesting primarily occurs in Del Norte and Humboldt counties, but this species breeds as far south as Santa Cruz County. Marbled murrelets breed in redwoods greater than 200 years old. In Humboldt County, they are almost exclusively found in coastal redwoods (Harris 2006). Peak densities in northern California occur within 1 mile of shore, and they are rare but consistently present beyond 2.5 miles from shore (Hérbert and Golightly 2008, Falxa and Raphael 2016): however, a majority of sightings (in central California) occur within 10 km of shore (Ainley et al. 1995). Marbled murrelets are most commonly observed in May through September, and less likely to be observed throughout late fall, winter and early spring (Harris 2006).

Table 2. Special Status Birds with Potential to Occur in the Project Area

Common Name	Scientific Name	Federal Status	State Status	Potential Occurrence	Habitat	Timing/Comments
Western Snowy Plover*	*Anarhynchus nivosus nivosus*	T[1]	CSSC[1]	Po	Nearshore, sandy beaches on Humboldt Bay, including Clam Island.	Uncommon year-round, but numbers may increase during the winter. Historically, they could be found along the North Spit and near Samoa, but use has significantly declined (Harris 2006). Critical habitat is nearby, but not at project sites.
Great egret	*Ardea alba*	None	None	Pr	Nearshore, associated with eelgrass beds, mudflats and all types of wetlands in Humboldt Bay as well as adjacent upland fields.	Common, year-round resident and local breeder. Populations concentrated near nesting sites between March and July. Nests (and rookeries) on islands in Humboldt Bay, including Tuluwat Island (Harris 2006) and other regions in the northern part of Humboldt Bay between April and September (Barnhart et al. 1992). Can be seen foraging in shallow subtidal regions in the summer months (Harris 2006), including around Clam Island during low tide (Fowler pers. comm. 2022).
Snowy egret	*Egretta thula*	None	None	Pr	Nearshore, associated with eelgrass beds, mudflats and all types of wetlands associated in Humboldt Bay.	Common, year-round resident that becomes rather local during the breeding season. Rookeries were historically found on Tuluwat Island and Arcata marshes in the northern part of Humboldt Bay (Hunter et al. 2005, Harris 2006) and possibly at more southeastern locations between April and September (Barnhart et al. 1992).
Black-crowned night heron	*Nycticorax nycticorax*	None	None	Pr	Nearshore, associated with eelgrass beds, mudflats and all types of wetlands associated in Humboldt Bay.	Attracted to areas with aquatic vegetation (for feeding) and with forest margins (for nesting). There were no known nests nearby the project area between 2000 and 2016, but they can be found foraging at each of three locations (Fowler pers. comm. 2022). Breeds in colonies in Humboldt Bay and its tributaries, with all nests being coastal (Hunter et al. 2005). Nests are routinely found on Tuluwat Island and Table Bluff (Harris 2006). Rookeries historically found on Tuluwat Island and Samoa Spit in the northern part of Humboldt Bay between April and September (Barnhart et al.

Common Name	Scientific Name	Federal Status	State Status	Potential Occurrence	Habitat	Timing/Comments
						1992). Several pairs breed at the Hookton Slough at the far end of the South Bay (Fowler pers. comm. 2022).
Great blue heron	*Ardea herodias*	None	None	Pr	Nearshore, associated with eelgrass beds, mudflats and all types of wetlands in Humboldt Bay as well as adjacent upland fields.	Common, year-round resident. Humboldt Bay contains a wintering population of non-breeding roosts who leave in the late spring/summer (Hunter et al. 2005). Breeders found in Humboldt Bay and its tributaries. Nests and rookeries historically found on Tuluwat Island in the northern part of Humboldt Bay between April and September, and various inland locations in Humboldt County (Barnhart et al. 1992, Harris 2006)
Osprey	*Pandion haliaetus*	None	CDFW_WL[1]	Pr	Forages exclusively on fish. Occurs nearshore, open water of Humboldt Bay.	Only nesting birds tracked. Common, summer resident and breeder (Hunter et al. 2005). Rare in the winter. Typically rely on tidal regions at some point in their life-history and forage over open water. Primarily forages in the South Bay (Barnhart et al. 1992). Nests in treetops adjacent to water starting in mid-May.
Sharp-shinned hawk	*Accipiter striatus*	None	CDFW_WL[1]	U	Primarily occurs in wooded areas. Occasionally occurs around wetland habitats, primarily in migration and winter.	Only nesting birds tracked. Can use coastal marshes to forage, but prefer wooded habitats. Uncommon resident with a small summer breeding population. Migrants may arrive in September (Harris 2006). May be found anywhere in Humboldt County during the breeding season, but associated more with forested and shrubby terrestrial areas during the breeding season.
Prairie falcon	*Falco mexicanus*	None	CDFW_WL[1]	U	Open terrestrial areas Rarely occurs near Humboldt Bay.	Only nesting birds tracked. Rare winter visitor to coastal lowlands and low elevation mountain prairies (Harris 2006). Does not breed in the area. Those present do not forage in Humboldt Bay. Historically has been seen on the North Spit and near Arcata (Harris 2006). The few prairie falcons that winter in the coastal

Common Name	Scientific Name	Federal Status	State Status	Potential Occurrence	Habitat	Timing/Comments
						bottomlands forage primarily in the pasturelands of these areas and rarely forage on Humboldt Bay, unlike the peregrine falcon (Fowler pers. comm. 2022).
American peregrine falcon	*Falco peregrinus anatum*	D[1]	D[1]; CDFW_WL[1]	Pr	Occurs over nearshore, open water of Humboldt and adjacent habitats.	Only nesting birds tracked. Breeds on remote coastal sea islands, and known to breed in the vicinity of Humboldt Bay, including Samoa Bridge (Barnhart et al. 1992) and currently found nesting at Samoa Bridge almost annually (Fowler pers. comm. 2022), and near Arcata Marsh. This species forages for shorebirds, waterfowl and other avian taxa in Humboldt Bay and associated habitats.
Northern harrier	*Circus hudsonius*	None	CSSC[1]	Pr	Occurs in wetlands, fields and nearshore areas and open waters associated with Humboldt Bay.	Only nesting birds tracked. Common migrant and winter visitor, present from fall through spring. Uncommon breeder and summer resident (Harris 2006). Frequently found foraging in open areas with marsh and intertidal regions. May be found nesting on the South Spit and foraging at the mitigation sites.
Bald eagle	*Haliaeetus leucocephalus*	D[1,2]	E[1,2]; CDFW_FP[1]	Pr	Occurs nearshore, open water of Humboldt Bay. Can nests in forests.	Only nesting and wintering birds tracked. Year-round resident (locally regular, uncommon winter visitor and rare local breeder) that feed and forage in marshes, roost in forested regions, and breed in forested regions next to bodies of water (Hunter et al. 2005). Commonly seen along shorelines of Humboldt Bay (Harris 2006). There are a few pairs that breed around Humboldt Bay (Fowler pers. comm. 2022), including nests in the South Bay (Harris 2006).
Marbled murrelet	*Brachyramphus marmoratus*	T[1]	E[1]	U	Breeds in lower montane coniferous forest. Feeds coastal near-shore. Nests in old-growth redwood-dominated forests, up	Forages primarily in nearshore coastal ocean waters. Formerly occurred in small numbers (primarily in the late summer and fall) to forage in open bays and subtidal channels, and nearshore waters of Humboldt Bay (Harris 2006). These older records were primarily along the Samoa Peninsula

Common Name	Scientific Name	Federal Status	State Status	Potential Occurrence	Habitat	Timing/Comments
					to six miles inland, often in Douglas-fir.	and at the mouth of Humboldt Bay. There have been none-to-few recent records for the Bay (Fowler pers. comm. 2022). Breeds in old growth redwood/Douglas-fir along the coast and inland (Harris 2006).
Double-crested cormorant	*Phalacrocorax auritus*	None	CDFW_WL[1]	Pr	Colonial nester on coastal cliffs, offshore islands, infrastructure such as coastal riprap and wharfs and in tall trees along lake margins and riparian habitats in the interior.	Only nesting colonies tracked. Common, year-round resident, most abundant in the winter (Harris 2006). Often seen in large flocks. Large breeding and roosting efforts near Sand Island, the North Bay, Teal Island in South Bay, and remnants of Arcata Wharf (Barnhart et al. 1992, Harris 2006). Feeds primarily in deep channels and nearby mudflats.
California brown pelican	*Pelecanus occidentalis californicus*	D[1,3]	D[1,3]	Pr	Nearshore, open waters of Humboldt Bay.	Nesting colony and communal roosts tracked. Occurs year-round. Most abundant from summer through fall (Harris 2006). Rare to uncommon in winter and spring. Roosts on Sand Island (North Bay) and anthropogenic structures in Humboldt Bay. Does not breed in northern California.
Caspian tern	*Hydroprogne caspia*	None	None	Pr	Nearshore, Humboldt Bay	Only nesting colonies tracked. Common summer resident and casual in the winter. Common from late March, when present along all of Humboldt Bay, including tidal portions of nearby rivers until September or October. Nesting colonies on Sand Island in North Humboldt Bay (Harris 2006).
Yellow rail	*Coturnicops noveboracensis*	None	CSSC	U	Grassy marshes and meadows.	Accidental with only a select few records in Humboldt County, none of which have involved breeding records (Harris 2006).
Grasshopper sparrow	*Ammodramus savannarum*	None	CSSC[1]	U	Grasslands.	Only nesting birds tracked. Rare local summer resident and breeder, casual migrant in winter (Harris 2006). No documented associations with Humboldt Bay.

Common Name	Scientific Name	Federal Status	State Status	Potential Occurrence	Habitat	Timing/Comments
Mountain plover	*Charadrius montanus*	None	CSSC[2]	U	Tablelands, grasslands and desert. Agricultural fields in migration and winter.	Only wintering birds tracked. Casual, very infrequent migrant in fall and early winter (Harris 2006). No local breeding.
Harlequin duck	*Histrionicus histrionicus*	None	CSSC[1]	Po	Nearshore coastal, open water of Humboldt Bay	Present primarily in the winter, but generally rare during this time, and casual to rare in summers (Harris 2006). Individuals found near wharfs and pilings in Humboldt Bay, as they are associated with rocky shorelines. Does not breed in the area.
Black brant	*Branta bernicula nigricans*	None	CSSC[1,4]	Pr*	Humboldt Bay, eelgrass dependent, migrant offshore	Only wintering and staging birds tracked. Primarily winter and spring: dependent on Humboldt Bay as foraging grounds during their northward spring migration (Barnhart et al 1992). Most of these spring migratory foragers are found in eelgrass beds in the South Bay and some in the Eureka Channel and North Bay (Harris 2006). Present in fewer numbers in North Humboldt Bay, but increasing in numbers there in recent years. Clam Island is an important gritting site. Does not breed in the region.

Federal Status: Listing status under the federal Endangered Species Act (ESA) – E (endangered); T (threatened); C (candidate); P (proposed); MMPA-P (Protected by the national Marine Mammal Protection Act)

California Status: Listing status under the California state Endangered Species Act (CESA) - E (endangered); T (threatened); C (candidate); and CDFW Species of Special Concern (CSSC). CDFW Watch List (CDFW_WL) and CDFW Fully Protected (CDFW_P).

Potential for Occurrence in the project area, including the mitigation sites: A (absent), unlikely (U), Po (Possible), Pr (Present). * indicates there is a seasonality component to occurrence.

Other table notes:

[1] CSSC, CDFW_WL, T, E, D species during breeding only

[2] CSSC, D, E, species during wintering season only

[3] D, species communally roosting

[4] CSSC, birds staging

*Common name: Critical Habitat in Humboldt Bay

Marbled murrelets nest on naturally occurring branch platforms high in old-growth coniferous trees (Nelson 1997). For nesting, they generally require old-growth coniferous forest located close to ocean waters (typically within 81 km [50 mi]), with abundant near-shore food resources (Nelson and Singer 1994). The breeding season extends from late March through early September. Nesting begins between early April and early July. During the breeding season, marbled murrelets form congregations at dawn and dusk near the shore close to the breeding grounds (Nelson 1997).

During the summer, most marbled murrelets on the west coast are found within 5 km (3 mi) of shore in water less than 60 m (197 ft) deep (Piatt et al. 2007). Their abundance tends to drop substantially with distance from shore (Piatt et al. 2007). Offshore surveys for marbled murrelets have been conducted along the west coast, usually for the purposes of estimating local, regional, or coast-wide populations because inland surveys for marbled murrelets are difficult and there is much potential for error. Such surveys have provided data on marbled murrelet offshore distribution—where murrelets feed and rest during both the breeding and nonbreeding seasons. The offshore distribution of marbled murrelets varies within their range; in California computer simulations based on 10 years of surveys indicated that 95 percent of marbled murrelets are found within about 3 km (2 mi) of shore (Ralph and Miller 2002). At-sea abundance has been strongly correlated with proximity to inland areas containing contiguous old-growth forest with suitable nesting habitat (Raphael et al. 2016). They appear to have some degree of fidelity to their marine feeding areas, being found in the same areas year after year (Carter 1984, Sealy and Carter 1984, Carter and Sealy 1990, Lank et al. 2003, Kuletz 2005; all as cited *in* Piatt et al. 2007). Such forage site fidelity may reflect local prey distribution; familiarity with feeding areas from year to year may be one factor influencing their offshore distribution (Piatt et al. 2007).

Marbled murrelets feed closer to shore than most other members of the alcid family, usually within 3.2 km (2 miles of shore, and may also be found in bays, lagoons, and coves (Nelson 1997). They often preferentially forage either near kelp beds or at the mouths of streams. Murrelets may also forage along the ocean bottom when diving closer to shore (Carter pers. obs., as cited *in* USFWS 1997). They feed primarily on invertebrates and fish (Miller and Ralph 1995). Little data on food preferences are available for the California coast, but sand lance (*Ammodytes hexapterus*) is believed to be one of the most commonly taken prey items. Other fish taken include the Pacific herring (*Clupea harengus*), northern anchovy (*Engraulis mordax*), osmerids, and sea perch. In the southern end of the marbled murrelet's range, sardines (*Sardinops species*) and rockfish (*Scorpaenidae*) may be important.

Historically, marbled murrelets occurred in small numbers near the entrance to Humboldt Bay as foragers, particularly in the late summer and fall. They were similarly observed in the subtidal entrance portion of the bay between King Salmon (a mitigation site) and the entrance to the bay (Fowler pers. comm. 2022). Recently, sightings are minimal, and especially limited around RMTI. Marbled murrelets are unlikely to occur in the project area.

3.3.1.2 Western Snowy Plover

Western snowy plovers are small, precocial shorebirds that breed on coastal beaches, dunes and salt evaporation ponds from Washington south to Baja California, Mexico. There are larger concentrations of breeding birds in the south along the Pacific coast, and much of their coastal distribution is in southern California (Rodriguez et al. 2011). They occur along the Pacific Coast from Damon Point, Washington to Bahia Magdalena, Baja California, Mexico (USFWS 2007a). Nesting western snowy plovers are federally threatened as of 1993 due to loss of nesting habitat and declines in breeding populations and listed as a California State Species of Special Concern (USFWS 1993, CNDDB 2023). Critical habitat was revised in 2012 and there are critical habitat units in California, Oregon, and Washington, including the South Spit of Humboldt Bay (USFWS 2012), which is outside of the project area.

The breeding season for the western snowy plover is from March through September, and they nest on sand spits, dune-backed beaches, beaches at creek and river mouths, and salt pans at lagoons and estuaries from southern Washington to Baja California (USFWS 2007a). The nesting on the California coast is initiated as early as the first week of March and peaks from mid-April to mid-June (Warriner et al. 1986, Page et al. 1995, Powell et al. 1997). Chicks hatch between early April and mid-August and reach fledging age approximately 1 month after hatching (Powell et al. 1997). Some western snowy plovers remain in their coastal breeding areas year-round while others migrate south or north for winter, and most inland-nesting plovers migrate to the coast for the winter (USFWS 2007a).

The western snowy plover feeds on invertebrates in wet sand within the intertidal zone, in dry sand above high tide, on salt pans and spoil sites, and along the edges of salt marshes, salt ponds, and lagoons. The breeding season for the western snowy plover is from March through September, and they nest on sand spits, dune-backed beaches, beaches at creek and river mouths, and salt pans at lagoons and estuaries from southern Washington to Baja California (USFWS 2007a). The nesting on the California coast is initiated as early as the first week of March and peaks from mid-April to mid-June (Warriner et al. 1986, Powell et al. 1997). Small numbers of plovers have been documented nesting on gravel bars of the Eel River (Colwell et al. 2011) and can be seen (rarely) attempting to nest on the Elk River Channel (Fowler pers. comm. 2022). Nonbreeding western snowy plovers infrequently occur inside of Humboldt Bay (Colwell 1994 as cited *in* District 2015). Snowy plovers are generally uncommon-year round in the Humboldt Bay region.

When present, nonbreeders are mostly in the South Bay on sandier substrates rather than on softer substrates associated with mudflats in North Bay (Harris 2006). Foraging sometimes occurs on sand flats and mudflats on the bay side of the South Spit (Fowler pers. comm. 2022). Western snowy plovers are unlikely to be present in the project area.

3.3.1.3 California Brown Pelican

The California brown pelican, a subspecies of the brown pelican (*Pelecanus occidentalis*), ranges widely along the U.S. West Coast. The brown pelican (entire species) was federally listed as endangered, and the California subspecies was listed as endangered by the State of California but has been delisted at both the federal and state levels (USFWS 2009, CNDDB 2023). It was fully protected by the CDFW (CNDDB 2023); however, a trailer bill legislation has been passed that removes them as fully protected species (SB 147). The California brown pelican occurs widely along the U.S. West Coast, as far north as British Columbia, Canada (Jaques et al. 2008).

California brown pelicans are currently found from northwest Mexico to British Columbia. They nest in four distinct geographic areas: (1) Southern California Bight (South of Point Conception), (2) the Gulf of California, (3) southwest Baja California Coast, and (4) mainland Mexico (USFWS 2007c). About 5 to 10 percent of the population breeds in Southern California, and 90 to 95 percent in Mexico (USFWS 2007c). The species' breeding range historically extended from Mexico north to Monterey, California, while their non-breeding distribution included the entire state of California, and as far north as British Columbia. Non-breeding California brown pelicans are distributed throughout the California coast in estuarine, marine, subtidal, and marine pelagic waters (Zeiner et al. 1990). Pelicans dive for prey at varying depths with the rising tide (Zeiner et al. 1990) and feed primarily on surface-schooling marine fishes and some crustaceans (USFWS 1970).

In California, the breeding range of brown pelicans has been greatly reduced from the historic breeding range and currently breeding is restricted to the Channel Islands in the US, and the majority of the northern Pacific population breeds in Mexico. Young birds and post breeding dispersal represent the birds moving north as far as British Columbia. They feed in estuaries and nearshore ocean waters, plunge-diving to capture small schooling fishes near the water's surface. Communal roosting occurs year-round as pelicans move up and down the coast. Pelicans roost on sandbars, pilings, jetties, breakwaters, and offshore rocks, sometimes in large communal roosts that can number in the thousands.

In Humboldt Bay, roosting has been reported on Sand Island in the North Bay (high count of 350 pelicans in summer), oyster racks (high counts of just over a hundred pelicans in summer and fall), jetties, mudflats, and manmade structures (Jaques et al. 2008). They are most abundant in Humboldt Bay from summer through mid-fall, and abundance peaks between August and October (Harris 2006). California brown pelicans are less common in winter and spring, and abundance begins to decline in November (Harris 2006). California brown pelicans are present at in the project area, likely roosting on the old manmade structures, and foraging in subtidal habitats. They may be most abundant in the project area from summer through mid-fall (Nelson 1989 as cited *in* District 2015).

3.3.1.4 American Peregrine Falcon

The American peregrine falcon is a subspecies of the peregrine falcon that is widely distributed, but was nearly extirpated after World War II. American peregrine falcons were fully protected by CDFW (CNDDB 2023); however, a trailer bill legislation has been passed that removes them as fully protected species (SB 147). They are breeders in the Humboldt Bay region and there has been evidence of nesting nearby project sites: there is a nesting pair at the Samoa Bridge (Hunter et al. 2005). A pair of adult peregrine falcons was observed nearby RMTI during avian surveys conducted in 2021, however, no nesting was confirmed (SHN Consulting Engineers & Geologists 2022). They generally prefer open landscapes for foraging, and during the non-breeding season when the local Peregrine numbers are augmented by migrants and winter visitors between September and April, they are frequently found feeding on shorebirds and waterfowl in Humboldt Bay (Harris 2006, Hunter et al. 2005). American peregrine falcons likely occur as transients or foragers in the project area, given that there is a nesting pair in the North Bay at the Samoa Bridge and nonbreeders likely forage widely in the bay system during migration and winter.

3.3.1.5 Bald Eagle

Nesting and wintering bald eagles were listed as endangered in 1967 and reclassified as threatened in 1995 under federal ESA (USFWS 1995). In 2007, they were delisted because their population continued to recover (USFWS 2007b). Bald eagles remain endangered under CESA and fully protected by CDFW (CNDDB 2023). They were historically uncommon in Humboldt County (Hunter et al. 2005); however, they have been seen feeding in marshes in Humboldt Bay and the lower Eel River delta (although uncommon) during the winter (Hunter et al. 2005) and are routinely found along the shores of Humboldt Bay (Harris 2006). Current nesting sites in Humboldt Bay are not well documented, but there may be nesting pairs in North Bay, and there is a breeding pair near Salmon Creek in South Bay (Fowler pers. comm. 2022). RMTI does not contain suitable nesting habitat for the species, and they are not expected to nest in proximity to the project area.

3.3.1.6 Black Brant

The black brant is a sea goose that relies on Pacific coastal habitats and is considered a California State Species of Special Concern while wintering/staging (CNDDB 2023). They do not breed in the region. Rather, Humboldt Bay (especially eelgrass beds in the South Bay) is an important wintering area and spring staging site during their northward spring migration, between January through April. In a given year, Humboldt Bay supports a substantial proportion of the black brant population during migration, potentially because of eelgrass abundance: Based on peak use, Humboldt Bay is the most important spring staging site in California (Moore et al. 2004). During a two-year study, Humboldt Bay was estimated to support 28% of the flyway population (37,600 birds) in 2000 and 58% (77,800 birds) in 2001 (Lee et al. 2007), indicating that a substantial proportion of the population relies on Humboldt Bay. The mean stopover duration for all birds in winter and spring (January – April) was estimated to be 26 days (Lee et al. 2007).

Black brant were historically present in fewer numbers in North Humboldt Bay. Surveys conducted in Humboldt Bay each February between 1976 and 2000 found that approximately 80% of the birds were observed in South Bay during that period (Moore et al. 2004). Black brant feed almost exclusively on eelgrass (Moore et al. 2004). With eelgrass increasing in North Bay in recent years, black brant numbers have similarly increased, mostly north of the Samoa Bridge (Fowler pers. comm. 2022). They may also be seen gritting on the bay side of South Spit. Black brant have a high likelihood of being present, especially between January and April while they winter and stage.

3.3.1.7 Osprey

Ospreys have a cosmopolitan distribution. The largest populations of ospreys in California are concentrated in the northern portion of the state, particularly the northern Coast Ranges and mountains (Peeters and Peeters 2005). Their breeding range is widespread throughout North America and nesting ospreys are listed on the CDFW Watch List (CNDDB 2023). Ospreys are common (breeding) throughout the summer and rarer in the winter in Humboldt Bay (Harris 2006). Most birds arrive as spring migrants in March, start nesting in late May, and depart in early October (Harris 1991). Nests are placed on a wide variety of natural and artificial substrates including dead-topped trees, high-tension towers, telephone poles, artificial nest sites, and other human-made structures most often near water with adequate prey base (Peeters and Peeters 2005, Bierregaard et al. 2016). Nests can routinely be found in tall treetops and artificial structures around Humboldt Bay (Harris 2006). Ospreys rely on tidal regions and open water for foraging (Hunter et al. 2005, Harris 2006), specifically in the South Bay (Barnhart et al. 1992). They are commonly seen along industrial waterfronts and are habituated to existing operational industrial noise (GHD 2021). Ospreys are potentially present in the project area (not nesting) and may be most abundant in the summer.

Preliminary osprey (and bat) surveys were conducted during the breeding season in April 2022 to determine whether osprey nests were active or inactive (SHN Consulting Engineers & Geologists 2022). If a nest structure was located, it was monitored from April through June of 2022 to identify whether it was currently being used, or if it showed signs of wear and not being currently upkept. A total of 10 nests were observed within the entire project study area, all on anthropogenic structures. Six of these nests were active with pairs incubating eggs or tending young, the male bringing food to the female on the nest. By early July, osprey nests were not being frequented, and a few of the nests on the southern end of the area were occupied by resting double crested cormorants. It is expected that development may require removing some or all of these nest structures onsite, which will require coordination with CDFW to develop a nest relocation plan.

3.3.1.8 Northern Harrier

The northern harrier is a CSSC. It occurs widely throughout California, and is a common migrant and winter visitor in Humboldt County (Harris 1991, Hunter et al. 2005). Northern harriers are most commonly observed in the region from fall through the spring and can be seen foraging in open areas with marshes and intertidal zones (Harris 1991). Historically, nests have been found on the North Spit (Harris 1991). Breeding and nesting occur locally, and nesting likely occurs on the South Spit (Fowler pers. comm. 2022). Communal winter roosts have been identified in south Arcata (Hunter et al. 2005). Those observed in the summer are found in open areas with marsh or tall grass, or in more open landscapes (Hunter et al. 2005). They may possibly be found foraging in the intertidal mudflats of the project area year-round, as they tend to feed in intertidal zones and marshes. Breeding and foraging are also possible in the project area.

3.3.1.9 Double-Crested Cormorant

Nesting double-crested cormorants are on the CDFW Watch List (CNDDB 2023). Double-crested cormorants are common year-round residents and breeders, favoring estuaries bodies of water, and are most abundant during the winter (Barnhart et al. 1992, Harris 2006). Historically, large double-crested cormorants nesting colonies have been found at Teal Island in South Bay, Sand Island in North Bay, and on Old Arcata Wharf (Hunter et al. 2005, Harris 2006). These sites remain popular for nesting. The closest known nesting record is from 2009 in Samoa (GHD 2021). Currently, double-crested cormorants are routinely present in large roosts on piers in the Eureka Channel and around RMTI (Fowler pers. comm. 2022). Several hundred are regularly found feeding in deep channels throughout Humboldt Bay. Double-crested cormorants are likely present in the project area when roosting and may be found foraging in deeper channels.

3.3.2 Other Birds

The birds discussed in Section 3.4.1 focused on special-status birds likely to occur within or adjacent to the project area and potentially affected by the project, listed under the federal or state ESA, a CSSC or are fully protected by the CDFW code. There are other birds that are not special status but are of particular concern because of the particular importance of the Humboldt Bay system for breeding, migration and/or wintering for some species (see above) or species groups (e.g., shorebirds, waterfowl).

Humboldt Bay supports a rich shorebird species assemblage, largely because of the diverse foraging habitats such as sandy beaches, rocky intertidal zones, intertidal flats and seasonal wetlands (Schlosser and Eicher 2012). In fact, Humboldt Bay has been designated as a Site of International Importance in the Western Hemisphere Shorebird Reserve Network because it is an important estuary for migrating and wintering shorebirds along the Pacific flyway (District 2015). As many as 32 shorebird species have been recorded during spring migration (Colwell 1994 as cited *in* District 2015). Non-breeding shorebird species use intertidal mudflat areas of Humboldt Bay to forage, although habitat use is different based on the species' morphology, habitat conditions and substrate.

Shorebirds consume primarily a wide range of invertebrates and are opportunistic feeders, consuming prey that are available and concentrating where prey are most dense (Goss-Custard 1970, 1977, 1979 as cited *in* District 2015). As such, their distribution typically reflects the abundance of available prey. The distribution of wintering shorebirds in particular is determined by physical features of tidal flats (p. 130 *in* Schlosser and Eicher 2012), and shorebirds tend to concentrate at the edge of receding tidelines where prey including worms, crustaceans, and bivalves are near the surface and available to be consumed. Because of the tendency of shorebirds to feed in intertidal mudflats (and return to their roosts as high tides inundate mudflats), hydrological and ecological processes that support invertebrate populations are more crucial than the presence of specific species. Near the waterline, shorebird presence is dependent on the species' leg length, as well as the size and shape of their bills. Short-billed semipalmated plovers (*Charadrius semipalmatus*) and black-bellied plovers (*Pluvialis squatarola*) tend to feed on recently exposed mud and rely on visual cues to forage. Small sandpipers including the western sandpiper (*Calidris mauri*) and least sandpipers (*Calidris minutilla*) forage on recently exposed mud and in shallow water. In deeper waters, mid-sized shorebirds may be found, including the dunlin (*Calidris alpina*), long-billed dowitchers (*Limnodromus scolopaceus*), and short-billed dowitchers (*L. griseus*). These species are capable of feeding in slightly deeper waters because they probe with their bills. Even larger shorebirds may be found in deeper water (and exposed mudflats). Examples of larger shorebirds potentially present include willets (*Tringa* *semipalmaus*), long-billed curlews (*Numenius americanus*), and marbled godwits (*Limosa fedoa*), all of which have bills long enough to probe into deeper waters. A list of shorebirds that were documented during reconnaissance surveys around the project area can be found in the Shorebird Special Studies and Site Survey Technical Memorandum (H. T. Harvey & Associates 2023a).

In addition to shorebirds, Humboldt Bay supports large numbers of waterfowl. In fact, Humboldt Bay is the primary waterfowl migration stopover and wintering area between the Columbia River in Oregon and San Francisco Bay (District 2015). Examples of common waterfowl species in Humboldt Bay include dabbling ducks, such as American wigeon (*Anas americana*), green-winged teal (*A. crecca*), northern pintail (*A. acuta*), and mallard (*A. platyrhynchos*); diving ducks: greater and lesser scaup (*Aythya marila* and *A. affinis*), bufflehead (*Bucephala albeola*), and surf scoter (*Melanitta perspicillata*); and other waterbirds such as the American coot (*Fulica americana*) (Denson and Bentley 1962, Nelson 1989 as cited *in* District 2015). Wigeon are the most abundant waterfowl in North Bay, and are one of the first species to arrive in fall. Northern pintail and diving ducks are also abundant.

3.3.3 Special-Status Fish

Eight special status fish were identified as potentially present in Humboldt Bay and relevant to the project area (Table 3). These include one ESA endangered fish, the tidewater goby (*Eucyclogobius newberryi)*, three ESA threatened salmonids, and two ESA threatened, non-salmonids: eulachon (*Thaleichthys pacificus*) and southern Distinct Population Segment (sDPS) of green sturgeon (*Acipenser medirostris*). Green sturgeon are also considered a CSSC. Humboldt Bay similarly supports longfin smelt (*Spirinchus thaleichthys*), threatened under CESA. Pacific lamprey (*Entosphenus tridentatus*) are also present in Humboldt Bay and are a CSSC.

3.3.3.1 Tidewater Goby

The tidewater goby is a small fish, discontinuously distributed in bay and lagoon habitats along the California coastline (USFWS 1994). They are federally endangered and Humboldt Bay contains critical habitat along its margins (USFWS 1994, 2013). Tidewater gobies are restricted to the upper margins of tidal bays near the entrance of freshwater tributaries, and coastal lagoons. They require brackish water and occupy relatively shallow sloughs fringing Humboldt Bay. Tidewater gobies are present year-round, and their reproduction peaks in April and May. In Humboldt Bay, the upper sloughs and high marsh areas separated from the bay by tide gates or other flow barriers provide habitat for tidewater goby, despite threats from habitat fragmentation (McCraney et al. 2010). They generally are associated with quiescent water < 1m deep with sandy substrate. Due to their early larval life stage dependence on low salinity brackish water, and preference for shallower waters, tidewater gobies are unlikely to occur in the project area.

Table 3. Special Status Fish with Potential to Occur in the Project Area

Common Name	Scientific Name	Federal Status	State Status	Potential Occurrence	Habitat	Timing/Comments
Coastal cutthroat trout	*Oncorhynchus clarkii clarkii*	None	CSSC	Pr*	Humboldt Bay and its tributaries and slough channels, coastal.	Adults migrate through Humboldt Bay to feed on the coast in the spring and reenter the Bay and tributaries in the fall to spawn. Juveniles feed within Humboldt Bay.
Coho salmon - Southern Oregon/Northern California Evolutionary Significant Unit (ESU)*	*Oncorhynchus kisutch*	T	T	Pr*	Humboldt Bay and its tributaries and slough channels, coastal/oceanic.	Juveniles outmigrate through Humboldt Bay to the ocean from March through June (Pinnix et al. 2013, NMFS 2016a), and reenter in the fall as adults to spawn in tributaries to Humboldt Bay (October to January).
Steelhead – northern California DPS*	*Oncorhynchus mykiss irideus*	T	C: Summer run only.	Pr*	Humboldt Bay and its tributaries and slough channels, coastal/oceanic	Juveniles outmigrate through Humboldt Bay to the ocean in March through May (NMFS 2016a). Adults move through Humboldt Bay to spawn in tributaries in fall and winter.
Chinook salmon – California coastal ESU*	*Oncorhynchus tshawytscha*	T	None	Pr*	Humboldt Bay and its tributaries and slough channels, coastal/oceanic.	Juveniles outmigrate through Humboldt Bay to the ocean April through May. Adults migrate through Humboldt Bay to spawn in Humboldt Bay tributaries in the fall (October-January). Humboldt Bay is critical habitat at all life stages.
Green sturgeon -southern DPS*	*Acipenser medirostris*	T	None	Pr	Humboldt Bay, coastal	DPS adults and subadults originate from San Francisco Bay and enter Humboldt Bay in April to feed and depart in Oct/Nov Federal listing includes only southern DPS, for all spawning populations south of the Eel River.
Eulachon – southern DPS	*Thaleichthys pacificus*	T	None	U	Found in Klamath River, Mad River, Redwood Creek, and in small numbers in Smith River and Humboldt	Federal listing refers to this southern DPS, which spawns between from the Mad River in California to the Skeena River in Canada. Critical habitat does not include Humboldt Bay or its tributaries. Spawn in lower reaches of coastal rivers with moderate water velocities and bottom

Common Name	Scientific Name	Federal Status	State Status	Potential Occurrence	Habitat	Timing/Comments
					Bay tributaries, coastal.	of pea-sized gravel, sand, and woody debris.
Longfin smelt	*Spirinchus thaleichthys*	None	T	Pr*	Humboldt Bay and its tributaries and slough channels, coastal.	Adults spawn in Humboldt Bay tributaries December through March. Larvae/juveniles present in Humboldt Bay January-March (Garwood 2017). Subadults and adults in Humboldt Bay and coastal habitats throughout the year.
Pacific lamprey	*Entosphenus tridentatus*	None	CSSC	U	Humboldt Bay estuaries and other Klamath/North coast flowing waters, coastal.	Adults present February through July. Spawns in freshwater rivers and streams. Ammocoetes need soft sand or mud and parasitize fish as they get larger.
Western brook lamprey	*Lampetra richardsoni*	None	CSSC	Po*	Humboldt Bay and its tributaries, coastal.	Pass through Humboldt Bay during their migration to sea. Adults return through to spawn. Time spent for feeding and pre spawning is unknown.
Tidewater goby*	*Eucyclogobius newberryi*	E	None	U	Relatively shallow muted tidal sloughs fringing Humboldt Bay	Present year-round along margins of Humboldt Bay in sloughs and high marsh channels. Designated critical habitat in these fringing habitats only, and not in Humboldt Bay proper (USFWS 2013).

Federal Status: Listing status under the federal Endangered Species Act (ESA) – E (endangered); T (threatened); C (candidate); P (proposed); MMPA-P (Protected by the national Marine Mammal Protection Act)

California Status: Listing status under the California state Endangered Species Act (CESA) - E (endangered); T (threatened); C (candidate); and CDFW Species of Special Concern (CSSC). CDFW Watch List (CDFW_WL) and CDFW Fully Protected (CDFW_P).

Potential for in the project area, including the mitigation sites: A (absent), unlikely (U), Po (Possible), Pr (Present). * indicates there is a seasonality component to occurrence.

<u>Other table notes:</u>

DPS: Distinct population segment

*Common name: Critical Habitat in Humboldt Bay

3.3.3.2 Longfin Smelt (LFS)

LFS are planktivorous forage fish present in estuarine and coastal waters from San Francisco Bay Estuary (SFBE) to the Aleutian Islands in Alaska. LFS were listed as threatened under CESA in 2009 (California Department of Fish and Game 2009, Garwood 2017, CNDDB 2023). LFS from Humboldt Bay are genetically most similar to populations from the SFBE (Saglam et al. 2021). The SFBE population, although not present in Humboldt Bay, is genetically distinct (USFWS 2012) and is proposed to be listed as threatened under the federal ESA (USFWS 2022, 2023). A large portion of LFS research has focused on the SFBE population. Because the SFBE population is near to Humboldt Bay, and longfin smelt between the SFBE and Humboldt Bay share appreciable amounts of ancestry based on genetic analysis (Saglam et al. 2021), results from the numerous studies on the SFBE longfin smelt population can, within reason, be applied to the Humboldt Bay population.

Timing and Distribution—LFS have an anadromous life history, where adults migrate from coastal marine and embayment habitats in the fall to streams and estuaries to spawn (Lewis et al. 2019, Yanagitsuru et al. 2022). In the SFBE, they typically spawn between January and April, but spawning may be as early as November and as late as June (USFWS 2012). Most fish die after spawning but some females have been found to live another year. Females lay 1,900 to 18,000 adhesive eggs on sandy or grassy substrate that hatch after ~40 days (CDFW 2008). There is typically a two-year life cycle, although some individuals may spawn as one- to three-year-olds (USFWS 2012, Lewis 2021). Larvae, especially in their early stages, are surface oriented and most abundant in upper layers of the water column. Older larvae and juveniles inhabit the middle and bottom strata of the water column (page [p.] 191 *in* Baxter 1999).

Recent findings suggest their life cycle is likely more complex than simple anadromy (i.e., spawning in freshwater followed by a direct migration to sea) because optimal spawning and rearing may occur in a broader region than previously recognized, including more moderately brackish estuarine habitats and in restored wetlands (Grimaldo et al. 2017, Lewis et al. 2020, Yanagitsuru et al. 2022). Their spawning habitat is highly seasonal and linked to temperature (Lewis 2021) and their larval abundance and presence in rearing habitats is strongly correlated with salinity (Grimaldo et al. 2017, Lewis 2021, Yanagitsuru et al. 2022).

Use of Humboldt Bay—Humboldt Bay likely supports the most abundant population of LFS outside of SFBE (California Department of Fish and Game 2009). More recent, targeted efforts have increased the knowledge base of LFS inside Humboldt Bay and its tributaries, confirming their existing presence (Cole 2004, Garwood 2017, Brennan et al. 2022, Tenera Environmental 2023). General information on their existing presence in Humboldt Bay can be inferred from recent studies, although none were systematically designed to describe their distribution over their life cycle. For example, in extensive fish surveys conducted by Cole (2004), a total of 11 LFS with an average length of 126 mm were collected at four different sites. These 11 LFS contributed to <0.01% of the total number of individual fish captured in Humboldt Bay (Table 3 and 7 *in* Cole 2004). All LFS were collected via trawling in what was considered estuarine, subtidal, unconsolidated bottom, sand, and subtidal habitats. With the primary objective to conduct surveys documenting LFS larval presence in coastal estuaries north of SFBE during the spawning, Brennan et al. (2022) completed sampling tows at 16 estuarine sites with salinities between 2 and 12 ppt, from Tomales Bay north to the Smith River along the Oregon border. During these surveys, larval smelt in Humboldt Bay were limited to Eureka Slough (Figure 2 *in* Brennan et al. 2022). Shallow, tidal wetlands in large estuaries and characteristics associated with increased freshwater outflows (low salinity, high turbidity) were positively associated with larval presence (Brennan et al. 2022). Catch probabilities increased with increased turbidity and decreased salinity (Figure 5 *in* Brennan et al. 2022). More recent, specialized surveys conducted between January and December 2022 also confirm the presence of LFS, as a select few larvae were collected in plankton net tows within the Main Channel of Humboldt Bay (Tenera Environmental 2023). Although larval LFS are present in low numbers in the project area, the high salinity that occurs there makes it poor habitat for their growth and survival (Yanagitsuru et al. 2022).

Marginal and Restored Habitats—We provide additional details on the presence of LFS in marginal habitats and the importance of restoring these areas because it can inform mitigation components of the Project design. Recent studies from the SFBE highlight the importance of low-salinity, brackish waters for survival and growth. Sr isotope profiles suggest initial rearing after spawning in brackish, estuarine, low-salinity waters similar to Eureka Slough and Bay Street (Hobbs et al. 2010, Lewis et al. 2019). Sr isotope analysis specifically found that the majority of LFS spend their early lives in brackish waters between 1 and 6 PSU (Lewis et al. 2019). This was also demonstrated by Hobbs et al. (2010): to evaluate the relative contribution of larvae from waters of various salinities to sub-adult/adult populations of LFS in SFBE, Hobbs et al. (2010) compared catch surveys of larval LFS from habitats of varying salinities to corresponding salinity distributions of sub-adult/adult LFS using isotope tracing from otoliths. Results indicated that low-salinity habitats between 0.3 and 3 ppt contribute disproportionately more to recruits relative to freshwater and brackish habitat, highlighting how there is a range of habitat suitable for spawning and rearing.

In recent years, LFS have been documented in marginal regions of the bay where salinities are lower. For example, salmon monitoring at a weir upstream of Bay Street in Freshwater Creek routinely collects adult LFS (Garwood 2017, Saglam et al. 2021). Larvae (and adults in condition to spawn) have also been documented in Freshwater Creek, which drains into Eureka Channel in North Bay, between December through February (Garwood 2017). In addition to these more opportunistic observations, presence (and evidence of spawning) has been confirmed from more targeted studies: larval LFS were collected in high numbers in Eureka Slough between January and May of 2019 and 2020, which drains into Humboldt Bay (Figure 1 and 2 *in* Brennan et al. 2022). Overall, evidence suggests that LFS of all life stages use marginal habitats within Humboldt Bay and its tributaries, including brackish waters and low-salinity environments. This is especially true during years with increased freshwater outflows (Brennan et al. 2022). Since these habitats appear to be important spawning and nursery habitats for LFS (as is the case in the SFBE; Lewis et al. 2020), it may offer important opportunities for Project mitigation.

Findings from the SFBE even suggest that seasonally brackish tidal habitat restoration may benefit all stages of LFS and provide evidence that LFS use restored marshes and salt ponds when they become available, especially during periods with increased freshwater outflows. This should be taken into consideration when designing mitigation components for the Project. LFS were generally thought to spawn in upper parts of the SFBE, but recent survey data continues to find them using tributaries in the northern and southern reaches of the estuary, including restored tidal marshes and brackish wetlands for rearing and spawning (Lewis et al. 2019, 2020). Adults in late-stage spawning conditions, and the highest catches of recruits and densities of larvae are often in shallow, recently restored tidal marshes adjacent to sloughs (Lewis et al. 2019, 2020). Spawning appears to occur in restored SFBE tidal brackish wetland habitats, including restored salt ponds, during years with high freshwater outflow and further downstream in tributaries with salinities close to 12 psu (Grimaldo et al. 2017; Lewis et al. 2019, 2020; Brennan et al. 2022). The increased use of marshes and salt ponds are also documented by university-based surveys associated with evaluating restored South Bay Salt ponds (see Otolith Geochemistry and Fish Ecology Laboratory, UC Davis, https://www.ogfishlab.com/). This information suggests that if appropriate low-salinity brackish water habitats are provided, LFS will use the area.

3.3.3.3 Eulachon

Eulachon are distributed from northern California through the Bering Sea in Alaska. In 2010, the Southern DPS, which spans from the Mad River in California to the Skeena River in Canada, was listed as federally threatened (NMFS 2010). The nearest designated critical habitat to Humboldt Bay is in the mainstem Mad River (NMFS 2011). Humboldt Bay is just south of the known distribution of eulachon, so their presence is unlikely. In addition, CDFW considered eulachon to be possibly extirpated from the Mad River until recent surveys and genetic testing indicated they were present in 2020 (Halligan pers. comm. 2022). Prior to 2020, the last recorded observation of eulachon in the Mad River was in April 1976 (Gustafson et al. 2010). There is low potential (unlikely) for the southern DPS of eulachon to occur within the project area.

3.3.3.4 Pacific Lamprey

The Pacific lamprey is a California Species of Special Concern (CNDDB 2023). They are widely distributed throughout the coast of California (e.g., Klamath and Eel rivers) and inland to watersheds in the Central Valley (e.g., San Joaquin River and Putah Creek). Their historical distribution includes major rivers (e.g., Fraser, Columbia, Trinity, Eel, Sacramento, and San Joaquin Rivers) and intervening streams (Goodman and Reid 2012). Similar to salmon, lamprey populations may be anadromous or resident and have a number of distinct runs. They spawn and rear in freshwater habitats including tributaries to Humboldt Bay, the Eel and Mad Rivers. Adult migrations through Humboldt Bay and into tributary streams have been documented in the spring, but there is no information about potential fall migrations. In 2011 to 2013, upstream Pacific lamprey migrants were collected by CDFW in the Freshwater Creek fish weir between February and June, and downstream migrants were observed between March and July (Ricker et al. 2014, Anderson and Ward 2016). Estuaries may be as important to lamprey as they are to salmonids for foraging, holding, and transition from freshwater to saltwater (and vice versa). Spawning occurs in gravel nests in low-gradient stream riffles from April through July (Goodman and Reid 2012). Once eggs hatch into larvae (ammocoetes), they drift downstream to low-velocity habitats and live in silty substrates as filter feeders for 3–7 years (Goodman and Reid 2012). Larvae then transform to juveniles and migrate to the Pacific Ocean (Goodman and Reid 2012).

Pacific lamprey in marine environments are parasitic and dependent on their hosts, however, it is not clear the extent to which they change, kill, or switch hosts. Since Pacific lamprey hosts are likely highly mobile, particularly relative to the project area, the species is assumed to possibly be present only on a transitory basis, if not unlikely.

3.3.3.5 Green Sturgeon

Green sturgeon are long-lived anadromous fish, and are considered the most marine-oriented of all the sturgeon species in North America (Lindley et al. 2011). Green sturgeon are present along the U.S. West Coast, found in nearshore marine waters, bays and estuaries ranging from Mexico to the Bering Sea, Alaska (NMFS 2009). Although their consistently inhabited range is much smaller, primarily concentrating in the coastal waters of California, Washington, Oregon, and Vancouver Island. North American green sturgeon are divided into two DPS: the southern and northern DPS (nDPS). The non-spawning adult and subadult populations coexist in marine and estuarine waters from Mexico through Alaska for most of their lives (NMFS 2009, 2018a). The DPSs are differentiated by their spawning locations. The nDPS spawns in the Rogue River in Oregon south to the Klamath River in California (NMFS 2009, 2018a), but are not federally listed as threatened or endangered. The sDPS is federally threatened, and they spawn in the Sacramento River (NMFS 2006a, 2009, 2018a, 2021a). Both DPSs are seasonally present inside Humboldt Bay and the project area, but neither use tributaries of Humboldt Bay for spawning (NMFS 2021a). Critical habitat was designated for sDPS green sturgeon as of 2009, and includes certain bays and estuaries, including all of Humboldt Bay (NMFS 2009).

Timing and Distribution—Green sturgeon use riverine, estuarine, and marine habitats throughout the U.S. West Coast, and spend substantial portions of their lives in marine waters (NMFS 2018a). Since green sturgeon do not spawn in tributaries of Humboldt Bay and their presence in Humboldt Bay is as subadults and adults, the discussion on their timing and distribution in this section is limited to their adulthood. Adults (>75 centimeters [cm] TL) and subadult green sturgeon can broadly be found moving within nearshore coastal waters from Monterey Bay through Alaska. They make extensive coastal migrations in depths shallower than 80 m (Moser et al. 2016) and spend most of their lives in coastal marine waters. In the summer months specifically, subadult and adult green sturgeon may aggregate and hold in estuaries of non-natal rivers, including Grays Harbor and Willapa Bay in Washington and Humboldt Bay and San Francisco-San Pablo Bay in California (Adams et al. 2007, Moser and Lindley 2007, Lindley et al. 2008, and Heublein et al. 2009 as cited *in* Lindley et al. 2011). These aggregations in non-spawning estuaries (e.g., Humboldt Bay) occur during summer and early fall months (primarily May to October) (NMFS 2006a) and are part of their larger migratory patterns between spawning rivers, overwintering habitat in marine waters, and summer-holding and feeding habitats (Lindley et al. 2008, 2011). Adults enter their natal rivers to spawn every three to five years, and their migration to freshwater typically begins in late February.

Use of Humboldt Bay—While sDPS green sturgeon are present in Humboldt Bay, it is one of many estuaries and coastal regions used. Humboldt Bay in particular is likely used for foraging, and possibly for thermal refuge (Moser and Lindley 2007, NMFS 2021a). Adult and subadult sturgeon have been observed in Humboldt Bay (among others) in large concentrations during the summer and fall (NMFS 2021a), specifically between April and October (Lindley et al. 2011). An effort to tag 355 green sturgeon on their spawning grounds and nonspawning aggregation sites found that compared to other estuaries, fewer green sturgeon are found to be present inside Humboldt Bay (Lindley et al. 2011), further suggesting that green sturgeon may not be dependent on Humboldt Bay. That said, peaks in detection (in 2006) inside Humboldt Bay were between January and October (Lindley et al. 2011). Adults and sub-adults are regularly observed in deeper channels of Humboldt Bay, channel margins and mudflats when the tide flats are inundated during high tide, and around Sand Island in North Bay. Acoustic tag detections suggest that green sturgeon move in deep channels, and 97% of observations occurred at two detection locations: Arcata Channel and North Bay Main Channel near the Samoa Bridge (Pinnix 2008). Tracking studies in San Francisco Bay (an analogous ecosystem) suggest that sturgeon detections are associated with either movement or feeding activity and that directional movement of sturgeon is rapid. Taken together, these observations suggest that the large number of detections near the extreme north end of Arcata Channel likely represents an area where feeding is occurring.

An analysis of green sturgeon acoustic monitoring in Humboldt Bay between 2005 and 2007 highlight patterns in their residency (Pinnix 2008). The acoustic array included hydrophones through Entrance Bay, two in South Bay, one in the Main Channel and then scattered throughout North Bay (e.g., near Samoa Bridge, Sand Island, and the Mad River). Those detected in Humboldt Bay were primary tagged in either the Sacramento River or San Pablo Bay and thus part of the sDPS, but there were others coming from more northern regions (Pinnix 2008). Generally, green sturgeon entered Humboldt Bay in late spring (between April and June) and resided until September or October, supporting the idea that Humboldt Bay is a location for summer-holding. Detections were more frequent in North Bay than the South Bay; however, there were also more hydrophones deployed in North Bay (Pinnix 2008).

During studies of tagged coho salmon throughout 2006 and 2007, ~30 green sturgeon had been observed in North Bay and elsewhere throughout Humboldt Bay. As a follow up, USFWS and NMFS staff employed a directional acoustic receiver to track their movements (Goldsworthy et al. 2016). The acoustic receivers drifted for two ~60 minute transects, and the general location, number, and context of behavior was recorded from individuals detected. Those detected were individuals previously tagged in the Sacramento River, confirming those present in Humboldt Bay are part of the sDPS (Goldsworthy et al. 2016).

While green sturgeon have been observed in mudflats and along eelgrass margins, depending on distance from a main channel, they do not frequent shallow habitats and it does not appear to be their preferred habitat. Green sturgeon are likely to utilize the channel in the project area during construction and operations, but only for short periods during their movements to and from marine and freshwater habitats in the summer/fall months and they are not fully dependent on Humboldt Bay (see content on foraging behavior).

Foraging Behavior—The foraging behavior of green sturgeon (and the other ESA-listed fishes) is an important consideration to sufficiently evaluate the effects of the proposed Project because it informs whether and how the potential loss of prey items impacts their survival. Additional details on the effects analysis can be found in Section 4.2.3. Compared to the ESA-listed salmonids, there is relatively little information on the foraging behavior of green sturgeon. In the San Francisco Bay Estuary, juvenile green sturgeon feed on shrimp, amphipods, isopods, and other benthic species (NMFS 2018a). In coastal bays and estuaries, adults and subadults rely on soft substrate (Moser et al. 2016) to feed on benthic invertebrates such as shrimp, mollusks, amphipods, and sometimes small fishes (NMFS 2018a, 2021a). While no explicit foraging study has been conducted inside Humboldt Bay, foraging adult and subadult sturgeon in San Francisco Bay tend to frequent areas less than 33 feet deep, foraging in the benthos and moving on and off mudflats with tidal fluctuations (Kelly et al. 2007, Moser et al. 2016).

Green sturgeon likely use Humboldt Bay to forage (Kelly et al. 2007, Moser and Lindley 2007, Lindley et al. 2011). As discussed above, during studies of tagged coho salmon throughout 2006 and 2007, ~30 green sturgeon had been observed in North Bay and elsewhere throughout Humboldt Bay. As a follow up, USFWS and NMFS staff employed a directional acoustic receiver to track their movements (Goldsworthy et al. 2016). Based on the body positioning of green sturgeons visibly seen during this effort, it appears as though it was feeding was occurring.

While semi-adult and adult green sturgeon hold and forage inside Humboldt Bay, they are not fully dependent on Humboldt Bay. They move in and out of other estuaries along their migration, and rely on feeding in coastal oceanic waters, and their presence in the project area is likely in passing on their way to hold in North Bay.

3.3.3.6 Salmonids

Humboldt Bay supports three salmonid species that are listed as threatened under the federal ESA: coho salmon (*Oncorhynchus kisutch*) Southern Oregon-Northern Coastal California (SONCC) ESU, Northern California steelhead (*Oncorhynchus mykiss irideus*) DPS, and California coastal Chinook salmon (*Oncorhynchus tshawytscha*) ESU. Coho salmon SONCC ESU is also listed as threatened under CESA.

Salmonid life history is characterized by periods of adult upstream migration, spawning and egg development, fry and juvenile development, juvenile downstream migration, stream-estuary ecotone rearing, and oceanic foraging and growth to adulthood. This complex life history yields differential use of habitat over time. Salmonids can occur in Humboldt Bay as adults migrating from the ocean through Humboldt Bay to natal tributaries to spawn, and as smolts migrating from freshwater and brackish rearing habitat to sea to feed and grow. Each species has slightly different strategies described below.

Southern Oregon-Northern California Coastal Coho Salmon—Coho salmon are a widespread Pacific salmonid distributed across northern temperate latitudes (Moyle et al. 2008). They occupy most river basins in Northern California and spawn in streams from California to Alaska. Coho salmon from the SONCC ESU include naturally spawned coho salmon originating between Cape Blanco, Oregon and Punta Gorda, California, and spawning between Elk River in Oregon south through Mattole River, California (NMFS 2005a, 2014a, 2016b). Thus, encompassing Humboldt Bay and its watersheds, overlapping with the action. The SONCC coho salmon also includes those from the Cole Rivers Hatchery, Trinity River Hatchery, and Iron Gate Hatchery. There are several different functionally independent populations of SONCC coho salmon, and the Humboldt

Bay population is one of the largest remaining populations (NMFS 2005a, Moyle et al. 2008, NMFS 2014a). The SONCC coho salmon ESU is federally and state threatened (NMFS 2005a).

Timing and Distribution—SONCC coho salmon may be present year-round in fresh water tidal creeks and sloughs, deep and shallow tidal channels, and creeks and rivers in and around Humboldt Bay. SONCC coho salmon migrate through Humboldt Bay twice throughout their life cycle: once on their migration to sea as smolts and once on their spawning migration as adults. Coho salmon smolts are found in Humboldt Bay between April through July, but primarily move through the bay in May and June (Table 4, Pinnix et al. 2013) to feed throughout the north Pacific. Juveniles (85-240 mm fork length [FL]) use the brackish portion of the bay as a nursery (Pinnix et al. 2013), and in the summer, the adults can make brief movements into Humboldt Bay entrance with incoming tides to feed on schools of forage fish. Juvenile SONCC coho salmon have been collected in deep channel, tidal channel, and subtidal habitats in Humboldt Bay, including the Samoa Channel (Cole 2004, NMFS 2016b). Adults are expected to begin entering freshwater tributaries to spawn in mid-October. The coming paragraphs describe the migration and habitat use of juvenile SONCC coho salmon after they leave their natal Humboldt Bay tributaries, move downstream into estuarine habitats, then through Humboldt Bay to the Pacific Ocean.

Table 4. Southern Oregon/Northern California Coast Coho Salmon Life History Timing

	J	F	M	A	M	J	J	A	S	O	N	D
Adult migration into Humboldt Bay												
Upstream migration and spawning												
Juvenile freshwater rearing												
Downstream migration												
Humboldt Bay outmigrants												

Note: Peak timing indicated by dark grey.

Use of Humbolt Bay Freshwater and Brackish, and Stream-Estuary Ecotones—Adult coho salmon spawn in Humboldt Bay tributaries far upstream of Humboldt Bay. Juvenile coho salmon rear in freshwater and move into brackish water ecotones. While rearing coho salmon are not expected in the project area, discussion on the freshwater-brackish and the stream-estuary ecotone (SEE) is relevant because it highlights the potential opportunities within Humboldt Bay that can be used for designing Project mitigation. The stream-estuary ecotone (SEE), defined by Wallace et al. (2015), includes the area of low gradient streams extending from stream entrance to the valley floor, through the upper limits of tidal influence, downstream to the region where the channel borders tidal mudflats. It includes all side channels, off channel ponds, tidal channels and fringing marsh habitats that are accessible to fish for a portion of the tidal cycle.

The existing understanding of their use of the SEE within Humboldt Bay stems from multiyear field sampling efforts by the Pacific States Marine Fisheries Commission and CDFWs Natural Stocks Assessment Project. These studies are designed to describe the life history traits and habitats required for salmonids in Humboldt Bay and its tributaries, including Freshwater Slough (Wallace 2006; Wallace and Allen 2007; Wallace et al. 2015, 2018).

The information provided herein is a selection of results from annual reports that analyze certain years' worth of data from a larger sampling effort and highlight the importance of SEE for juvenile coho salmon (while also covering steelhead and chinook salmon) (Wallace 2006; Wallace and Allen 2007; Wallace et al. 2015, 2018). To document use by juvenile coho salmon and infer relative habitat quality of the SEE in tributaries throughout the Humboldt Bay Watershed, Wallace et al. (2015) analyzed sampled from various tributaries between 2003 and 2011 and provides information on movement and residence times, size and growth, and habitat use. Based on findings from this analysis, the SEE around Humboldt Bay appears to be high quality habitat. The SEE is important for the following reasons:

1. The SEE provides non-natal rearing habitat for prolonged residence. Young-of-the-year (YOY) and those 1+ reared in freshwater or tidal freshwater habitat in the SEE for an average of one to two months. Rearing was also documented to be as long as a full year.
2. The SEE supports multiple life stages (i.e., including YOY and 1+).
3. The SEE supports a large portion of the smolt population throughout the Humboldt Bay Watershed. A total of 40% of coho smolt production from Freshwater Creek, the largest tributary in the bay, originated from the SEE.
4. The ecotone allows juveniles to grow larger and faster than their cohorts rearing in stream habitat upstream of the SEE. The larger size fish in the SEE is thought to be from increased food, warmer temperatures, and lower energetic demands that result from being in lower water velocities compared to stream habitats.
5. Slow-water highly productive habitat that is generally limiting.

Wallace et al. (2015) highlights the importance of the SEE and provides evidence from nearly a decade worth of sample collections. Other reports, including those from the multiyear field sampling efforts in Freshwater Slough provide similar evidence on use within Humbolt Bay (Wallace and Allen 2007, Pinnix et al. 2013, Wallace et al. 2018). This includes Wallace and Allen (2007), which reports on data collected between January and December 2005 and 2006. In 2005, YOY coho salmon were captured in the upper slough between April to late November, with peak abundance in early May and remaining abundant through August (and from early May to early December, with peaks in late June, but remaining abundant through August in 2006). There were relatively few catches in the lower slough. A total of 314 and 237 YOY coho salmon were PIT tagged throughout the summer each year. Their mean residency time was 32 days and 97.3% were recaptured at the same site in 2005, and the mean residency time was 33 days and 94.7% of recaptures were at the tagging site in 2006, suggesting they move very little once in the slough and that it provides high quality habitat for continued use. Yearling coho salmon were present in the upper estuary from late January to early July, with peaks between April and late May in 2005, and from mid-February to mid-June, peaking in May in 2006. A total of 224 and 81 yearlings were PIT tagged in 2005 and 2006. 5.4% and 4.9% of them were recaptured respectively, all at their tagging site, similarly suggesting little movement once in the slough. The mean residence time of yearlings in the upper slough was 31 and 7 days during the two sampling years.

The results of Wallace and Allen (2007) and Pinnix et al. (2013) suggest that post freshwater rearing, coho salmon smolts spend more time in the SEE compared to lower estuarine waters. Pinnix et al. (2013), which is described in more detail below, found that the coho salmon smolts tagged in 2007 and 2008 (with an average size of 123-125 mm FL) spent an average of 10-12 days in the freshwater and brackish ecotone, before migrating into Humboldt Bay proper on their way to the ocean (Pinnix et al. 2013). Their residence time in the lower estuary averaged < 1 day. Coho salmon residency in the tidal freshwater habitat of Freshwater Slough in 2017 was typically 25 days for yearling coho salmon (106-116 mm FL), based on recaptured PIT tagged juveniles (Wallace et al. 2018).

The final two years of sampling in Freshwater Creek (and its tributaries Wood Creek and Ryan Creek), along with Salmon and Jacoby Creeks were reviewed by Wallace et al. (2018). The density dependent effect on growth of coho salmon was particularly evident, as the monthly mean FL of subyearling coho salmon was negatively correlated with their catch per unit effort. This may indicate that restoring and increasing SEE habitat could increase the size of those rearing by lowering density and increasing overwinter survival. Wallace et al. (2018) also found that PIT tagged juvenile coho salmon (and steelhead) were detected at Freshwater Creek and Ryan Creek. This suggests they rear and move through the Freshwater-Wood-Ryan SEE and highlights the importance of maintaining stream connectivity.

Use of Humboldt Bay Proper—Coho salmon are likely to be present in the project area when adults are returning to spawn and when smolts are outmigrating to the Pacific Ocean. Extensive fish surveys conducted in most of the habitat types in Humboldt Bay from September 2000 through November 2001 used a variety of gear types, including minnow traps, pole seines (sampling shallow water mostly intertidal habitats near jetties, and in mud flats), beach seines (sampling intertidal and subtidal habitats from shore), and epibenthic otter and beam trawls (sampling deeper water/channels near the bottom) (Cole 2004). A total of 67 fish species from 25 families were collected in Humboldt Bay using all methods: the 10 most abundant species accounted for 94.75% of the total catch; the three most abundant made up over 55% (threespine stickleback, shiner surfperch, and topsmelt) (Cole 2004). Only three juvenile coho salmon, one juvenile steelhead, and 89 juvenile Chinook salmon were captured, contributing to <0.01% of the total number of individual fish captured (Cole 2004). Two juvenile coho salmon were captured in estuarine, subtidal, unconsolidated and sand bottom habitat measuring 93 and 99 mm total length (TL), and one juvenile coho salmon was captured in estuarine, intertidal, unconsolidated and sand habitat measuring 127 mm TL (Cole 2004). Notably, none were captured in eelgrass habitat (Cole 2004).

More detailed information on residence time and habitat use of coho salmon within Humboldt Bay proper stems from acoustic telemetry studies specifically designed to monitor the movement of outmigrating smolts from freshwater habitats, through the estuary, into Humboldt Bay and into the ocean (Pinnix et al. 2013). A total of 32 and 48 smolts were captured and acoustically tagged at the head of Freshwater Slough in 2007 and 2008, and monitored via fixed receiver networks and mobile tracking. The acoustically tagged juvenile coho salmon smolts leaving freshwater and estuarine habitats were found to occur in Humboldt Bay itself for 15-22 days prior to entering the Pacific Ocean (Pinnix et al. 2008, 2013). Therefore, juvenile coho salmon outmigrating to the sea are only present in Humboldt Bay for a short time period (Pinnix et al. 2013). They were rarely detected near structures such as pilings or docks inside Humboldt Bay (Pinnix et al. 2008, 2013) and preferred deeper channels.

Foraging Behavior—In their freshwater stages, coho salmon feed on plankton and insects, then switch to a diet of small fishes as adults in the ocean. As juvenile coho salmon grow, their diets shift from consuming a mix of smaller invertebrates and smaller fishes to a diet comprised mostly of fish. Based on stomach content analysis (SCA), the smallest documented prey for juvenile coho salmon collected in coastal marine waters of the northern California Current are ~5 mm in length and were juvenile rockfish and sculpins (Daly et al. 2009). The length of most of their food resources are larger than this, and as juvenile coho salmon grow their ingested prey length steadily increases as well, shifting to sand lance, anchovies, and smelt (Daly et al. 2009). These prey likely provide a relatively low contribution to the energetic intake required for rapid growth. The most important period of growth and survival for juvenile coho salmon is marked by a shift to a more piscivorous diet dominated by larger fishes in coastal waters (Daly et al. 2009). Their feeding intensity peaks between 141-160 mm FL, at which point juvenile coho salmon shift towards eating larger forage fish such as northern anchovies, *Clupeidae spp.* and smelt (Daly et al. 2009). These fish provide the highest caloric quality food (Davis et al. 1998). The increase in piscivory by juveniles in coastal marine waters is also evident by the percent of fish in the diets of juvenile coho salmon increasing from 30.1% for small individuals between 100-120 mm FL to over 90% in individuals over 376 mm (Daly et al. 2009). Given the increases in piscivory and availability of larger fish in coastal waters, Humboldt Bay (and the project area) serves primarily as a migratory corridor as opposed to optimal feeding and foraging habitat.

California Coastal Chinook Salmon—The California Coastal Chinook salmon is morphologically different than other salmon species because of its large size. Like all salmon species, the California Coastal Chinook salmon is anadromous and semelparous (dies after spawning only once). The California Coastal Chinook salmon ESU includes 15 independent populations of fall-run and six independent populations of spring-run Chinook salmon. This ESU encompasses all Chinook salmon that naturally spawned from Redwood Creek in Humboldt County through the Russian River and has been listed as federally threatened since 1999, then recently updated in 2014 (NMFS 1999, 2014b). The California Coastal Chinook salmon ESU also includes fishes from Freshwater Creek, Yager Creek, Redwood Creek, Hollow Tree, Mattole Salmon Group, and Mad River Hatchery fall-run Chinook hatchery program. Critical habitat was designated in 2005 and includes Humboldt County, and river reaches from Redwood Creek in Humboldt County to the Russian River in

Sonoma County (NMFS 2005b). While the river reaches draining into Humboldt Bay are critical habitat, Humboldt Bay itself is not part of the designated critical habitat.

Timing and Distribution—The California Coastal Chinook salmon is an anadromous salmonid species that generally exhibits a relatively simple three-year life cycle. There is natural variability in the timing of their spawning runs due to changes in precipitation and its influence on stream flows and passage. They are an ocean-type race of salmon (opposed to the stream-type race, which spends longer residence in fresh water) that reside in estuaries for longer periods as fry and fingerlings, than do yearlings with stream-type race (NMFS 2016a, 2016b). In addition, ocean-type salmon spend a short time in freshwater as juveniles and migrate to sea during their first year of life, normally within three months after emerging from the spawning gravel. Generally, the California Coastal Chinook salmon ESU spawns and rears in coastal and interior rivers in Northern California and Southern Oregon, and forages in vast nearshore and marine zones of the Northern Pacific Ocean.

Coastal California Chinook salmon typically return to their natal streams between August/September and early November, after the first winter storms (Moyle et al. 2008). Juveniles may spend from 3 months to 2 years in freshwater before migrating to estuarine areas as smolts and then into the ocean to feed and mature. Historically, estuaries with summer access to the ocean are favorable habitat for juveniles because it gives them greater flexibility to leave or remain in the estuaries until storms disperse them into the ocean (Moyle et al. 2008). California Coastal Chinook salmon typically spend two growing seasons in the ocean before returning to their natal streams to spawn as three-year-olds. Some males (referred to as jacks), however, return to spawn after only three months at sea (NMFS 2016a, 2016b). Adult California Coastal Chinook salmon spend most of their lives in the open ocean.

Use of Humboldt Bay—California Coastal Chinook salmon are known to spawn and rear in the Eel and Mad rivers and in tributaries of Humboldt Bay such as Freshwater Creek, Elk River and Salmon Creek (Schlosser and Eicher 2012). Adults migrate through Humboldt Bay to freshwater tributaries to spawn in the fall. Juveniles migrate through Humboldt Bay to the Pacific Ocean during their seaward migration in the spring and summer. Unlike coho salmon and steelhead, juvenile Chinook salmon rear only a short time in freshwater habitats (they do not overwinter as juveniles in freshwater) and move into brackish and marine habitats.

While juvenile Chinook salmon migrate through Humboldt Bay on their way to the ocean, there is no specific information on residence time in Humboldt Bay because they are too small when they depart the freshwater/brackish ecotone to be implanted with acoustic tags. However, in analogous habitats in San Francisco Bay, juvenile Chinook salmon were captured by midwater trawl from RK 68 and through the bay to the Gulf of the Farallones from late April to mid-July and averaged 89 mm FL with a range from 68 to 113 mm (MacFarlane and Norton 2002). These juveniles spent approximately 40 days migrating along the 65 km length of the estuary or approximately 1.625 km/day (MacFarlane and Norton 2002). In comparison, the distance between Freshwater Slough and the entrance to Humboldt Bay is approximately 10 km, which would make residence time within Humboldt Bay on the order of 16 days, which is similar to acoustically tagged juvenile coho salmon.

Based on studies in the freshwater/brackish ecotone in Freshwater Slough, PIT-tagged sub-yearling Chinook salmon were captured from April through June (Table 5) during which time their monthly mean FL increased from 44 mm in April to 56-62 mm in May and to 72 mm in June (Wallace et al. 2018). Cole (2004) did extensive fish surveys in Humboldt Bay as noted above, and captured 89 juvenile Chinook salmon. Eighty-seven were captured in estuarine, subtidal, unconsolidated and sand bottom habitats with an average TL of 96 mm, ranging from 70 to 119 mm TL, and 2 were captured in regularly flooded intertidal mud habitat that measured 102 and 104 mm TL. Notably, none were captured in eelgrass habitat (Cole 2004). Conditions in the Humboldt Bay estuarine habitat are considered fair for adults, pre-smolts and smolts (NMFS 2016a, 2016b). This area is used for staging prior to freshwater migration, estuarine rearing, and as a transitional environment between freshwater and marine environments. While there is potential for estuarine rearing, the structure and function of habitats around Humboldt Bay have altered from natural conditions and reduced the quality of it as rearing habitat. Juveniles and adults are likely to be present in the project area for select brief periods during their migration between freshwater and ocean habitats.

Table 5. California Coastal Chinook Salmon Life History Timing

	J	F	M	A	M	J	J	A	S	O	N	D
Adult migration into Humboldt Bay												
Upstream migration and spawning												
Rearing and downstream smolt migration												
Humboldt Bay outmigrants												

Nore: Peak timing indicated by dark grey.

Foraging Behavior—During their outmigration from freshwater to marine habitats, juvenile Chinook salmon in San Francisco Bay (an analogous ecosystem) shift their prey from invertebrates to fish larvae (MacFarlane and Norton 2002). More specifically, amphipod crustaceans and insects represented the highest index of relative importance in stomach contents of those juveniles captured directly downstream of riverine freshwater habitats. As the juvenile Chinook salmon entered the central portions of the bay, fish larvae and crustaceans had the highest index of importance in their diet. Once entering coastal waters, they feed on early life stages of euphausiids/krill, and decapods, and fish (MacFarlane and Norton 2002).

Juvenile Chinook salmon consume the highest caloric quality food available and are more dependent on coastal ocean waters for food than embayment habitats. This is evident in that their most critical feeding and growth occurs outside of estuaries. An 11-year study on their energy dynamics in the San Francisco Bay versus the ocean found that energy gained in the estuary was 0.28 kilojoules (kJ)/day compared to 3.2 kJ/day in coastal waters (MacFarlane 2010). MacFarlane and Norton (2002) also support the notion that coastal waters are primary sites for growth and energy gain, as body condition declined over time in San Francisco Bay, then improved (along with increases in feeding intensity) in marine coastal waters. As juvenile Chinook salmon grow, they obtain the highest caloric quality food from fish and gradually increase the proportional contribution of fishes in their diet (by weight) from 55% to 95% (Daly et al. 2009).

Northern California Steelhead—Steelhead are taxonomically structured on a geographic basis, and several DPSs are recognized by NMFS. The Northern California steelhead DPS have potential to occur in the project area. The Northern California steelhead DPS includes those naturally spawned in California coastal river basins from Redwood Creek southward to, but not including the Russian River (NMFS 2006b). This DPS has been federally threatened since 2000 (NMFS 2000). Critical habitat consists of river reaches between Redwood Creek south to Point Arena on the Mendocino coast (NMFS 2005b).

Timing and Distribution—Steelhead enter Humboldt Bay tributaries to spawn in the late fall and winter months when there are higher flows and lower water temperatures. Adult female steelhead will prepare a redd (or nest) in a stream area with suitable gravel type composition, water depth, and velocity. The specific timing of spawning varies among streams within a region and depends on the environmental conditions. Spawning usually occurs in gravel substrates in clear, cool, perennial sections of relatively undisturbed streams. In addition, preferred streams typically support dense canopy cover that provides shade, woody debris, and organic matter, and are usually free of rooted or aquatic vegetation. The water temperature determines the length of the incubation period, and hatching can occur within three weeks to two months. Fry emerge from the gravel, and rear along the stream margins, moving gradually into pools and riffles with higher velocity as they grow. Young juveniles feed primarily on aquatic invertebrate drift. Adults feed on aquatic and terrestrial insects, mollusks, crustaceans, fish eggs, minnows, and other small fishes.

After hatching in freshwater, juvenile steelhead typically remain in their natal streams for at least their first summer (Barnhart 1991 *in* Stillwater Sciences 2006). YOY steelhead tend to use riffles with cover, while older juveniles use deeper water (such as pools) as rearing habitat. However, steelhead may also use estuaries as rearing habitat (Stillwater Sciences 2006, Bond et al. 2008). For example, a study of steelhead in Waddell Creek in Santa Cruz County, California found that some of the steelhead remained in Waddell Creek lagoon or the lower portions of the stream for a whole season before migrating to the sea (Shapovalov and Taft 1954). Juvenile steelhead typically rear in fresh water for one to three years before migrating to the ocean (Moyle 2002). Because of this multi-year rearing period, steelhead generally spawn in tributaries that maintain suitable temperature and other water quality parameters year-round.

Steelhead smolts typically migrate to marine waters after spending about two years in freshwater. Most downstream smolt migration takes place between February and June. Fukushima and Lesh (1998) report that the peak timing of steelhead smolt outmigration in Central California occurs in March, April, and May, while others report most steelhead smolts in California enter the sea in March and April. Studies have shown that salmonids (broadly, not limited to steelhead) that rear in estuaries grow faster compared to fish reared in fully riverine habitats (NMFS 2016a, 2016b).

In California, steelhead generally reside in marine waters for one to two years, with a small fraction spending a three to four years, prior to returning to their natal stream to spawn at four or five years old (NMFS 2016a, 2016b). "Half-pounders," which are sexually immature steelhead that return to fresh water after spending less than a year in the ocean, are unique to this ESU. Unlike other Pacific salmonids, steelhead are iteroparous and capable of spawning more than once before they die; adults may survive and return to the ocean after spawning, coming back to spawn for one or more additional seasons (Moyle 2002). However, it is unlikely that steelhead spawn more than twice in a lifetime (NMFS 2005b). Spawning occurs from December through April for summer and winter-runs. Peak spawning occurs between January and March (NMFS 2005b).

Use of Humboldt Bay—Northern Californian steelhead are known to rear in tributaries of Humboldt Bay and migrate through the bay itself on their seaward migration as juveniles. Northern California steelhead smolts are relatively large (150-200 mm), remain in relatively deep water, and move rapidly through the estuary to the ocean in late spring and summer (Emmett et al. 1991, Wallace 2006). After reaching the ocean in the spring, juvenile steelhead tend to move offshore quickly rather than use nearshore waters. Adults also migrate through Humboldt Bay to reach their tributaries to spawn in winter and early spring. Generally, winter-run Northern Californian steelhead enter estuaries and rivers between September and March, and begin spawning between December and early April, extending into May based on the conditions (p. 45 *in* Moyle et al. 2008).

The mean length of residence for juvenile steelhead PIT-tagged and recaptured in Freshwater Creek, a freshwater/brackish ecotone habitat of Humboldt Bay was 37 days. Their size ranged from 82 to 192 mm FL, with captures primarily between May and August. None were collected in January or December (Table 6; Table 4 *in* Wallace et al. 2018). Upon leaving this freshwater/brackish ecotone (Freshwater Creek), they move directly through Humboldt Bay into the ocean. Notably, only 1 juvenile steelhead measuring 126 mm TL was captured by Cole (2004) in extensive fish surveys in estuarine subtidal unconsolidated and sand bottom habitat. Migratory individuals are likely to occur throughout the project area for short periods of time while in transit.

Table 6. Northern California Winter-Run Steelhead Life History Timing

	J	F	M	A	M	J	J	A	S	O	N	D
Adult migration into Humboldt Bay												
Upstream migration (river entry) and spawning												
Downstream kelt migration												
Juvenile rearing												
Downstream smolt migration												
Humboldt Bay outmigrants												

Note: Peak timing indicated by dark grey.

Foraging Behavior—While information is limited on the foraging behavior of Northern California steelhead in and around Humboldt Bay, results from studies in analogous habitats serve as a proxy for the foraging behavior of Northern California Steelhead in the project area. Juvenile steelhead collected inside the Columbia River estuary (along the Oregon-Washington border) and those in marine waters outside of the brackish, estuarine water plume exhibit clear shifts in their feeding behavior and physiology. Those in marine waters offshore ate more, grew faster, and had improved body condition metrics (Daly et al. 2014), suggesting that their most important foraging and energetic gains are outside of estuaries and bays. Those in estuarine waters consumed far less food (primarily amphipods) and had decreased body condition and stomach fullness metrics (Daly et al. 2014). Any loss of prey from the proposed Project is unlikely to represent a significant loss of food resources because juvenile steelhead are more dependent on coastal waters for energetic gains that are essential to their survival. Their reliance on marine waters for growth is evident by the fact that juvenile steelhead move quickly from coastal marine waters to water further offshore (Daly et al. 2014).

It has been found that once in marine waters off Washington, the dominant prey in terms of biomass for juvenile steelhead were fish, followed by euphausiids and *Cancer spp.* larvae (55.3%, 20.3%, 9.8%; Daly et al. 2014). Miller and Brodeur (2007) also found that juvenile steelhead in northern California and Oregon may be more reliant on euphausiids compared to their trophically similar counterparts, Chinook and coho salmon. While juvenile steelhead rely heavily on euphausiids, euphausiids are abundant along the coast but none were collected in the Main Channel (near where RMMT will be constructed) during sampling efforts characterizing entrainable taxa via seawater intakes for an aquaculture facility present inside Humboldt Bay Steinbeck pers. comm. 2022).

3.3.4 Invertebrates

The sunflower sea star (*Pycnopodia helianthoides*) is the only invertebrate of interest reviewed in this section. Those with more commercial and/or recreational importance are provided in Section 3.4.6. The sunflower sea star was proposed for listing as a threatened species under the ESA on March 16, 2023 (NMFS 2023a). It was first petitioned to be listed in August 2021. It may potentially be listed as threatened within the timeline of the proposed Project. The sunflower sea star is a large, fast-moving sea star (echinoderm) that can exceed 1 m in diameter. Its documented range is from the Aleutian Islands, Alaska south to Baja California, Mexico (Lowry et al. 2022a, NMFS 2023a); however, they are most commonly present between Monterey, California and the Alaska Peninsula, thus encompassing the project area (NMFS 2023a).

Sunflower sea stars are habitat generalists, lacking clear associations with specific habitat types and/or features. They occupy a range of benthic substrate, from intertidal zones up to depths of 435 m, although are most common in waters < 25 m deep (p. 16214 *in* NMFS 2023a). Sunflower sea stars can also be found along outer coasts, inside waters including glacial fjords, sounds, and tidewater glaciers, but they tend to prefer more temperate waters. In these temperate waters, sunflower sea stars tend to inhabit kelp forests and low rocky intertidal zones. Prior to the onset of sea star wasting syndrome, which is further discussed in Section 4.5.3, it was relatively common throughout its range. Sunflower sea stars are keystone mesopredators and are generally solitary and competitive with conspecifics (Lowry et al. 2022a).

Sunflower sea stars are similar to other sea stars in that they have separate sexes that are indistinguishable externally. Each ray on an adult contains a pair of gonads. Their gonads are elongated, branched sacs. Sunflower sea stars are broadcast spawners, and observations from similar species suggest they are synchronous aggregate spawners (p. 16215 *in* NMFS 2023a). Fertilization thus occurs externally, and fertilized larvae develop through pelagic planktotrophic stages. Food availability, temperature, photoperiod, salinity, and the lunar cycle control the seasonality of their reproductive cycles. The exact timing for spawning is thus variable and they may form seasonal aggregations for spawning (Lowry et al. 2022a). Information on size at first maturity, fecundity, reproductive seasonality, and how these parameters vary throughout the species' range is limited, thus making it difficult to accurately predict reproductive output and evaluate resiliency (NMFS 2023a).

3.3.4.1 Use of Humboldt Bay

Sunflower sea stars are not commonly observed inside Humboldt Bay, and information on their distribution and abundance in the bay is scant. Barnhart et al. (1992) provides a detailed overview of the estuarine profile of Humboldt Bay, including species present. Appendix B in Barnhart et al. (1992) lists the abundance (qualitatively) and habitat preference of invertebrates in Humboldt Bay. Sunflower sea stars were considered to be occasionally present on a scale of being abundant, common, occasional or rare. Their preferred habitat type is rocky substrates that occur primarily near the bay mouth (p. 96 *in* Barnhart et al. 1992). Even though sunflower sea stars have not been documented near the project sites, their presence is possible because of their generalist behavior and use of embayments. As broadcast spawners, it is also possible that larvae occur within the project area. However, they are typically found in kelp forest and low rocky intertidal and subtidal zones in California, as opposed to shallow bays such as Humboldt Bay.

The Multi-Agency Rocky Intertidal Network's long-term monitoring program conducts surveys in rocky intertidal areas along the California coast. Their database of records indicates that sunflower sea stars had not been documented in the intertidal zone in California since before the onset of sea star wasting syndrome (SSWS) in 2013/2014. Even in subtidal zones, where they are typically more common, sunflower sea stars had not been reported since 2018. In November 2021 and July 2022, there were observations in Mendocino and Humboldt County (Multi-Agency Rocky Intertidal Network 2023). The sunflower sea star is unlikely to be found along the shore within the project area since their presence within Humboldt Bay has not been documented past Entrance Bay.

3.3.5 Marine Mammals

There are five marine mammal species that may occur in Humboldt Bay, including three pinnipeds and two cetaceans (Table 7). The pinnipeds include Steller sea lions (*Eumetopias jubatus*), Pacific harbor seals (*Phoca vitulina richardii*), and California sea lions (*Zalophus californianus*). The cetaceans include harbor porpoises (*Phocoena phocoena*) and killer whales (*Orcinus orca*). All marine mammal species are protected under the MMPA. The Southern Resident Killer Whale DPS is also federally endangered (NMFS 2005c).

Table 7. Marine Mammals with Potential to Occur in the Project Area

Common Name	Scientific Name	Federal Status	State Status	Potential Occurrence	Habitat	Timing/Comments
Steller sea lion	*Eumetopias jubatus*	D; MMPA-P	None	U	Marine (coastal, continental shelf and slope) and Bay	Occurs along the continental shelf and nearshore, but rarely enters Humboldt Bay.
California sea lion	*Zalophus californianus*	MMPA-P	None	Pr	Marine and Bay	Adults and juveniles are present year-round, occurring along the coast and over the continental shelf. Non-breeders are found along docks and manmade structures. Abundance peaks during the fall and mid-April to August. Breeding occurs between May and August at coastal beaches, but not specifically in Humboldt Bay.
Pacific harbor seal	*Phoca vitulina richardii*	MMPA-P	None	Pr	Marine and Bay	Present year-round in Humboldt Bay on mudflats and sandflats. Pupping occurs between April and June. Haul out on the mudflats of the North Bay and primarily pup in the South Bay. Abundance declines in the winter.
Harbor porpoise	*Phocoena phocoena*	MMPA-P	None	Pr	Marine (nearshore and continental shelf) and Bay	Present year-round inside Humboldt Bay, most commonly seen in deep-water channels and at the entrance to the bay.
Killer whale, Southern Resident DPS	*Orcinus orca*	E; MMPA-P	None	U	Marine	Offshore waters are used for migration and foraging. Southern Resident DPS is the only subpopulation that is federally endangered. Critical habitat located directly outside of Humboldt Bay, but not inside the bay itself.
Killer whale, West Coast Transient Stock (orca)	*Orcinus orca*	MMPA-P	None	U	Marine	Primarily present along the continental shelf and slope, and has been observed at the entrance of Humboldt Bay, but not inside the bay itself.

Federal Status: Listing status under the federal Endangered Species Act (ESA) – E (endangered); T (threatened); C (candidate); P (proposed); D (delisted); MMPA-P (Protected by the national Marine Mammal Protection Act)

California Status: Listing status under the California state Endangered Species Act (CESA) - E (endangered); T (threatened); C (candidate); and CDFW Species of Special Concern (CSSC). CDFW Watch List (CDFW_WL) and CDFW Fully Protected (CDFW_P).

Potential for Occurrence: Potential for Occurrence in the project area, including the mitigation sites - A (absent), unlikely (U), Po (Possible), Pr (Present). * indicates there is a seasonality component to occurrence.

3.3.5.1 Steller Sea Lion

Steller sea lions are distributed continuously from Russia to Alaska, and south to southern California. Within U.S. waters, there are two separate stocks. The eastern stock that extends from Southeast Alaska to southern California (Muto et al. 2021). The Steller sea lion was federally listed as threatened in 1990, and in 1997, the eastern population (i.e., east of 144° W longitude) was listed as threatened. Steller sea lions have since been delisted (NMFS 2013), however they remain protected under the MMPA.

Steller sea lions prefer nearshore coastal waters and open oceans, as well as rocks and beaches for hauling-out. Steller sea lions do not conduct deep dives and they forage over the continental shelf at night, usually within 12 miles of the colony (Loughlin 2008). Individuals rarely come ashore on the mainland except to haul-out on islands and offshore rocks. They even remain at sea during stormy weather (Kenyon and Rice 1961). The locations and distribution of the Eastern population's breeding colonies along the U.S. West Coast have shifted north, with more sites in Washington and Southeast Alaska and fewer in Southern California (NMFS 2022). Steller sea lions are most numerous at haul-out sites during their breeding season which runs from May through August and peaks in June and July. A single individual may use a variety of haul-out sites during a given season (Fuller 2012). Steller sea lions produce and detect sounds above and below the ocean surface, and their best underwater hearing ranges from 1 to 16 kHz, with maximum sensitivity occurring at 25 kHz in some individuals (Kastelein et al. 2005).

Since Steller sea lions prefer nearshore coastal waters and open oceans as opposed to river mouths, bays, or estuaries, they are unlikely to be present in Humboldt Bay.

3.3.5.2 California Sea Lion

California sea lions are found along the western coast of North America, from Baja California, Mexico, to British Columbia, Canada (Carretta et al. 2022). Commercial harvest reduced the U.S. population (from Canada to Mexico) to ~ 1,500 individuals by the 1920s (Zavala-Gonzalez and Mellink 2000); however, protection under the 1972 MMPA has allowed the species to recover, and the U.S. population was estimated at 257,606 individuals along the U.S. West Coast in 2014 (Carretta et al. 2022). There are five genetically distinct geographic populations including the Pacific Temperate, Pacific Subtropical, and Southern, Central and Northern Gulf of California (Carretta et al. 2022). The Pacific Temperate stock (i.e., U.S. Stock) is not federally or state listed. The U.S. stock includes rookeries within the U.S. waters as well as on the Coronado Islands, directly south of the U.S./Mexico border, though the majority of the U.S. population breeds on the Channel Islands, California (Lowry et al. 2022b).

At the start of the nonbreeding season in late summer, adult and subadult males migrate northward along the California coast to Washington state (Lowry and Forney 2005). Females and juveniles disperse as well, but generally stay in the southern California region. When not at rookeries, CSLs are found in the open ocean and coastal waters, over the continental shelf and slope. During the summer months, CSLs congregate near rookery islands and open-water areas (Lowry et al. 1991, Carretta et al. 2022, Lowry and Forney 2005, Lowry et al. 2017 as cited *in* NMFS 2022). Breeding colonies are established only on islands along the coast of southern California, along the western side of Baja California, and in the Gulf of California (Heath and Perrin 2008). Dispersal from breeding colonies is sex-biased with males leaving in late summer and fall and migrating as far north as British Columbia, Canada, and Alaska (Carretta et al. 2022). Female sea lions fitted with satellite positioning tags on San Nicholas Island tended to remain in the area around the Channel Islands, though some traveled as far north as Monterey Bay (Costa et al. 2007). Males from the same colonies regularly traveled along the coast to Oregon, and some traveled as far north as the southern coast of Washington as well as > 650 km offshore.

California sea lions feed on fish and cephalopods, some of which are commercially important species such as salmonids, Pacific sardines (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), Pacific mackerel (*Scomber japonicus*), Pacific whiting (*Merluccius productus*), rockfish (*Sebastes* spp.), and market squid (*Loligo opalescens*) (Weise 2000, Lowry and Forney 2005).

California sea lions do not breed along the Humboldt County coast; however, non-breeding or migrating adults (and juveniles) may occur in Humboldt Bay year-round. Two seasonal peaks of California sea lions are observed in the project area: one during the fall northward migration and one during spring (mid-April to August) as they return to breeding colonies in the south (Sullivan 1980, Griswold Jr. 1985, Lowry and Forney 2005). Non-breeders are found along docks and manmade structures, and therefore likely present at RMTI and No Name Dock.

3.3.5.3 Pacific Harbor Seal

Pacific harbor seals (*Phoca vitulina richardii*) are widely distributed throughout the northern Atlantic and Pacific oceans along coastal waters, river mouths, and bays (Lowry et al. 2008). Despite the species' continuous distribution, significant variation in mitochondrial-DNA throughout its range suggests that the global population can be divided into five subspecies, with two occurring in the Pacific Ocean (Westlake and O'Corry-Crowe 2002, O'Corry-Crowe et al. 2003). The Eastern North Pacific subspecies ranges from Baja California, Mexico, to the Pribilof Islands, Alaska (Carretta et al. 2022). There are several stocks within the eastern North Pacific Ocean subspecies, including: the California stock, the Oregon/Washington coastal stock, and the inland Washington stock (Carretta et al. 2022). Harbor seals in the project area represent the eastern North Pacific Ocean subspecies and, aside from occasional dispersing individuals, are part of the California population. Harbor seals are protected under the Marine Mammal Protection Act.

Harbor seals are the most common marine mammal within Humboldt Bay (Barnhart et al. 1992) and inhabit the coastline year-round. Their annual average population is around 200 individuals (Barnhart et al. 1992), but numbers may reach closer to 1,500 at peak season (Goley and Harvey 2010). Harbor seals use Humboldt Bay as a pupping and haul-out area and Humboldt Bay represents the largest haul-out site in northern California (Goley and Harvey 2010). Harbor seals haul-out onto mudflats exposed during ebb tides throughout North Humboldt Bay and adjacent to tidal channels in upper Arcata as well as the South Bay to rest and give birth (Barnhart et al. 1992). Two recognized haul-out sites have been identified in the southern reach of Arcata Bay, and four in mid-Arcata Bay, in addition to sandflats (Schlosser and Eicher 2012). There are also recognized haul-out sites on the North Spit, directly across from Tuluwat Island.

Harbor seal abundance and site fidelity to haul-out sites generally peak in summer during pupping and molting, and decline in winter when individuals disperse to seek areas of high prey abundance (Sullivan 1980, Herder 1986, Goley and Harvey 2010). Harbor seal tracking efforts using aerial surveys and radio telemetry have demonstrated site fidelity to haul-out sites, specifically in the southern reaches of South Bay during pupping season (Goley and Harvey 2010, Archibald 2015). South Bay is the main pupping location for harbor seals in Humboldt Bay (Laughlin 1974) between April and June, with peaks in the number of pups between the end of April and beginning of May (Archibald 2015).

Generally, harbor seals are opportunistic, nearshore coastal foragers that feed primarily on seasonally abundant benthic and epibenthic schooling fish. Their diet predominantly consists of small fish (Tallman and Sullivan 2004); however, harbor seals are also known to prey on salmon in the Pacific Northwest (Wright et al. 2007). A recent study using radiotelemetry to characterize foraging behavior by measuring the distance from haul-out sites to foraging areas in Humboldt Bay found that some harbor seals forage inside the bay itself, and others in nearshore regions directly outside the entrance (Ougzin 2013). Individuals foraging inside Humboldt Bay were concentrated in South Bay, and individuals foraging in nearshore regions were tracked to a haul-out site on the coast. Most seals traveled < 14 km from their primary haul-out sites to forage, which aligns with previous findings (Ougzin 2013), and individuals alternated between two haul-out sites on average.

Pacific harbor seals are likely present at RMTI and No Name Dock where they may haul-out to rest, or in the larger project area while in transit to haul-out sites in North Bay or while foraging.

3.3.5.4 Harbor Porpoise

Harbor porpoises are widely distributed throughout the coastal waters of the North Atlantic and North Pacific oceans, as well as the Black Sea. In the North Pacific, they occur in coastal and inland waters from Point Conception, California, northward to Alaska (Carretta et al. 2022). Harbor porpoises from Humboldt County are included in the northern California/southern Oregon population that extends from Point Arena, California, to Lincoln City, Oregon (Carretta et al. 2009). Harbor porpoises have been observed throughout the year at the entrance to and within Humboldt Bay, usually as single individuals but sometimes in pods with a maximum size of 12 individuals (Goetz 1983). Abundance of harbor porpoises in Humboldt Bay peaks between May and October, and they are most commonly seen in deep water channels and during flooding tides (Barnhart et al. 1992). Harbor porpoises are likely present in the project area due to the presence of deep channels in the vicinity.

3.3.5.5 Southern Resident Killer Whale Distinct Population Segment

The Southern Resident Killer Whale Distinct Population Segment (DPS) consists of 74 individuals from three pods or family groups, and ranges from central California to southeast Alaska. The Southern Resident DPS was federally listed as endangered in 2006 (NMFS 2005c). Areas offshore of Humboldt County in California between the 6.1-m and 200-m isobaths were declared critical habitat for Southern Resident killer whales in 2021 (NMFS 2021b), however this region excludes Humboldt Bay.

The Southern Resident DPS is considered a strategic and depleted stock under the MMPA (Carretta et al. 2022) as well as a 'spotlight species' by NMFS (NMFS 2021c). This status, established in 2015 and renewed through 2025, is part of a larger initiative to focus resources on and provide immediate, targeted efforts to halt the decline of and stabilize at-risk populations (NMFS 2021b). Southern Resident killer whales are considered one of the most at-risk species because of their high mortality and low reproduction rates. Despite the fact that other killer whale populations have increased in the last several decades, the Southern Resident DPS remains small and vulnerable and has not experienced a net increase since the 1980s (NMFS 2021b).

Since the early 1970s, the Southern Resident killer whale range has been determined from strandings or opportunistic resightings via photo-identification (Krahn et al. 2004). Some pods use different summer and winter habitats, but the amount of information to determine the extent of their seasonal ranges is limited. Satellite tagging, opportunistic observations, and acoustic recordings suggest that this population spends nearly all of their time on the continental shelf, within 34 km of the coastline and in water < 200 m deep (Carretta et al. 2022).

While Southern resident killer whales migrate and forage through waters offshore of Humboldt County, they are not known to enter Humboldt Bay itself and are unlikely to be present in the project area.

3.3.5.6 West Coast Transient Killer Whale

Separate from the Southern Resident killer whales DPS is the West Coast Transient stock of killer whales. This separate killer whale population is not federally or state listed but is protected under the MMPA (Carretta et al. 2022). Transient killer whales are known to travel long distances from California to southeast Alaska in small groups in pursuit of marine mammals, their exclusive prey (Ford et al. 1998, Herman et al. 2005, Krahn et al. 2007). The West Coast Transient killer whale population generally occupies the continental shelf and slope. Though transient killer whales have been observed at the entrance channel to Humboldt Bay (Jacobsen pers. comm. 2023), they are unlikely to be present in the project area.

3.3.6 Non-Special Status Species

The additional non-special status species that are potentially present in the project area, and with commercial and recreational importance are detailed in this section (Table 8). These include Pacific herring (*Clupea pallasii*), starry flounder (*Histrionicus histrionicus*), rockfish/rockcod (*Sebastes spp.*), lingcod (*Ophiodon elongates*), various species of smelt and surfperch, and the sand shark (*Mustelus henlei*). Benthic invertebrates and crustaceans, several of which are either burrowing or at the surface, are reviewed, including Dungeness crab (*Metacarcinus magister*), rock crab (*Family Cancridae*), and clams (*Tresus* and *Saxidomus spp.*). These species are managed for human consumption by CDFW for capture or otherwise of local concern or interest.

Table 8. Other Species of Interest with Potential to Occur at the Project Sites

Common Name	Scientific Name	Clam Island	Habitat	Timing/Comments
Pacific herring	*Clupea pallassi*	Pr*	Marine and Bay	Humboldt Bay provides spawning and nursery habitat. Spawning occurs on eelgrass beds, primarily in North Bay along the North Spit, but also South Bay. Adults hold pre-spawning in East Bay Channel and North Bay Channel. Spawning occurs between December and March.
Starry flounder*	*Histrionicus histrionicus*	Pr	Marine and Bay	Occurs on coastal and bay soft bottom substrates. Surveys have documented their presence at the Entrance Bay next to and in the eelgrass community, and in the North Bay (Garwood et al. 2013).
Rockfish/ Rockcod*	*Families: Sebastidae, Scorpaenidae*	Pr	Marine and Bay	Nursery habitats for juveniles are found in eelgrass beds and muddy habitats, and pilings. Adults are only present in deeper channels. Abundance peaks in late spring to summer.
Lingcod*	*Ophiodon elongatus*	Pr	Marine and Bay	Occupies rocky reef habitat but may occupy artificial hard substrates such as pilings. All life stages are present in Humboldt Bay, and the bay contains critical spawning and nursery habitat.
Non-listed smelt	*Family: Osmeridae. Hypomesus pretiosus, Spirinchus starksi, Atherinops affinis, Allosmerus elongatus*	Pr	Marine and Bay	Captured by recreational and commercial fishers along the coast and can be found inside Humboldt Bay.
Redtail surfperch	*Amphistichus rhodoterus*	Po	Marine and Bay	Typically found in surf-zone habitats and inside bays, including Humboldt Bay. Often found nearby jetties and piers. Increased abundance between March and April, when fish concentrate to spawn.
Sand shark*	*Mustelus henlei*	Pr	Marine and Bay	More common in bays than offshore, but highly mobile. Present most of the year, but move offshore in the winters.
Invertebrates				
Dungeness crab	*Metacarcinus magister*	Pr*	Marine and Bay	Humboldt Bay and its eelgrass communities, specifically in the South Bay, are an important nursery ground. Larvae are abundant November through February and juveniles are present from March to July and. Adults are typically off the coast and rarely seen in the bay.
Rock crab (e.g., red,	*Family Cancridae (Cancer productus, Metacarcinus*	Pr*	Marine and Bay	Tends to occur on rocky reefs and in kelp beds, and soft bottoms that interface with rocky reef habitat, but also use artificial hard substrates.

Common Name	Scientific Name	Clam Island	Habitat	Timing/Comments
yellow and brown)	*anthonyi, Romaleon antennarium*			Humboldt Bay is an important nursery ground, particularly the South Bay.
Gaper clam	*Tresus spp.*	Pr	Bay	Occur in intertidal and subtidal regions, favoring sand and mudflats. Burrow underneath sediment
Washington (butter) clam	*Saxidomus* spp.	Pr	Bay	Occur in intertidal and subtidal regions, favoring muddy habitats.

Clam Island: Potential for Occurrence in the proposed Clam Island project mitigation site - A (absent), unlikely (U), Po (Possible), Pr (Present). * indicates there is a seasonality component to occurrence.

*Common name: non-listed species that are covered by Essential Fish Habitat

3.3.6.1 Pacific Herring

Pacific herring are small, pelagic fish that represent an important prey source. Adult herring enter California bays and estuaries from October to April (peak in Humboldt Bay from December to February), remain for one to three weeks without feeding, spawn, and then leave within days (Moser and Hsieh 1992, Bollens and Sanders 2004). Adults release eggs that adhere to structure, both natural structure such as eelgrass (Schlosser and Eicher 2012) and anthropogenic structure such as piles. They will hold in deep channels prior to finding shallower grounds that are suitable. In Humboldt Bay large schools enter the bay and move up the channels to spawn, with schools accompanied by their predators (e.g., harbor seals, gulls) on their migration into the bay typically on incoming tides (Barnhart et al. 1992, Kramer pers. comm. 2023). Their spawning schools typically run up into Humboldt Bay from the ocean in December-February/March, although their larvae can be and have been documented to be present through May (Tenera Environmental 2023).

Humboldt Bay is primarily used for spawning and as a nursery, and pacific herring rely on eelgrass beds to forage and as refuge. There are not many deep areas for adult herring to remain long-term. As they mature, herring begin to spend more time in closer proximity to spawning ground and there is considerable movement of fish up into the channels of North Bay. Rabin and Barnhart (1986) reported that Pacific herring spawn in both North and South Bays, but most spawning occurs in the northern end of the bay, along the North Spit and throughout North Bay (Figure 3.5 *in* Barnhart et al. 1992). Adult Pacific herrings migrate inshore to Humboldt Bay as early as October, but primarily enter to spawn between December and March (Barnhart et al. 1992). When entering the bay, adults use subtidal channels adjacent to spawning locations, and typically spawn adhesive eggs onto eelgrass and other structures. Based on data from CDFW about past and current spawning locations, the East Bay Channel and Arcata Channel are likely locations for pre-spawning holding activities (Mello 2007) and spawning primarily occurs in the eelgrass beds in North Bay (Barnhart et al. 1992). Commercial fisheries for herring were present until 2005 (CDFW 2013).

3.3.6.2 Starry Flounder

Starry flounder are a demersal species found in coastal marine and bay habitats, supporting both commercial and recreational fisheries off Humboldt (Emmett et al. 1991). They range from Alaska to Southern California and they prefer soft bottom habitats (Haugen and Thomas 2001), are relatively common in Humboldt Bay (Barnhart et al. 1992), and have been found in low numbers in trawl surveys near the entrance. They occur to depths of 900 ft but are most common in shallower waters (Haugen and Thomas 2001). Planktonic larvae are normally found at the surface, and juveniles and adults prefer soft bottom sediments without any rocks (Emmett et al. 1991). Starry flounder are an important food source for herons, cormorants, and marine mammals (Emmett et al. 1991). Cole (2004) found starry flounder to be most abundant in subtidal estuarine habitats with unconsolidated sandy bottoms, as opposed to more intertidal habitats; however, they are still present in intertidal mudflats.

3.3.6.3 Rockfish/Rockcod

Rockfish in Humboldt Bay are a commercially- and recreationally important species routinely caught by anglers at jetties (Barnhart et al. 1992). Humboldt Bay represents an important nursery ground for several species of juveniles (Barnhart et al. 1992), which are primarily present in eelgrass and nearshore habitats from May to October (Studebaker and Mulligan 2009). Peaks in abundance occur late spring to summer (Schlosser and Eicher 2012). The juvenile life stage of certain species (e.g., black and copper rockfish) are more common within shallower depths and non-rocky substrates such as sand, mud, and areas with kelp or eelgrass (Schlosser and Bloeser 2006, Studebaker and Mulligan 2009).

A study by Schlosser and Bloeser (2006) was conducted in estuaries and nearshore sites in California and Oregon, including Humboldt Bay, in June 2003 through December 2005. The study results indicated that the most highly used habitat types by juvenile rockfish in Humboldt Bay included mud associated with drift algae and pilings. The most common species (in order of abundance) included black, copper, grass, and blue rockfish, which accounted for 91% of the 1,814 rockfish collected. Garwood et al. (2013) emphasizes the importance of eelgrass habitat for these rockfishes.

Humboldt Bay does not support much suitable adult habitat, as adults move into deeper parts of the bay, including channels, or offshore (Barnhart et al. 1992, Schlosser and Eicher 2012). Rockfish likely to occur within the bay include black rockfish (*S. melanops*), blue rockfish (*S. mystinus*), bocaccio (*S. paucispinis*), china rockfish (*S. nebulosus*), copper rockfish (*S. caurinus*), and quillback rockfish (*S. maliger*). Most of these species prefer hard rocky reef habitat, however, younger life stages (larvae) are pelagic and juveniles often settle on soft bottom habitat before moving to preferred reef habitats (Love et al. 2002). Juvenile rockfish are possibly present in the project area. Adult rockfish may possibly occur at deeper channels in the project area.

3.3.6.4 Lingcod

Lingcod range from Baja California to Alaska and occur in both hard and soft bottom habitats along the north coast of California. Lingcod are important to recreational and commercial fishers, and although not migratory are moderately motile (Adams and Starr 2001). They are most commonly associated with rocky areas in nearshore waters at depths from 30–330 ft (9–101 m) but have also been recorded in substrate from depths of 10–1,300 ft (3–396 m) (Adams and Starr 2001).

All life stages of lingcod are present in Humboldt Bay (Emmett et al. 1991). Bottom surveys reveal their presence at the entrance to Humboldt Bay and in the North Bay (Garwood et al. 2013). The entrance, seawalls and jetties represent important spawning and nursery area (Barnhart et al. 1992). Spawning occurs from November through mid-March. Eggs are generally laid in rocky subtidal areas and pelagic larvae are found in near-surface waters. Juveniles are present in the intertidal regions of the bay (Emmett et al. 1991). Lingcod are likely present in the project area. They may be more concentrated near RMTI and No Name Dock because of associations with structural habitat.

3.3.6.5 Smelt

Night and surf smelt (*Spirinchus starksi* and *Hypomesus pretiosus*) are important pelagic forage fish that support commercial and recreational fishing from the surf zone along the Humboldt County coast. Adult night smelt, and larval/juvenile smelts are locally abundant and have historically dominated commercial smelt landings (Sweetnam et al. 2001). The majority of night smelt are caught on coastal beaches around Eureka. They are schooling planktivores that represent critical prey items for marine mammals and birds. Night Smelt aggregate annually nearshore to spawn on coastal beaches in California as early as January and through September (Sweetnam et al. 2001, CDFW 2019a). Surf smelt are the most widely distributed smelt in California but are only common north of San Francisco. They are abundant schooling planktivores that generally spawn during the day, between June through September. Compared to night smelt, they occupy less of the commercial catch. The whitebait smelt (*Allosmerus elongates*) may be found in Humboldt Bay, although is generally uncommon throughout its range and little is known about their presence. Whitebait smelt larvae were collected in relatively high abundance compared to other larvae during plankton surveys between January and December 2022 (Tenera Environmental 2023). Surf smelt, night smelt, and topsmelt also occur in the surf zone (Allen and Pondella II 2006, Nielsen et al. 2017), and are likely present.

3.3.6.6 Surfperch

There are several species of surfperch (*Family Embiotocidae*) in Humboldt Bay. The redtail surfperch (*Amphistichus rhodoterus*) support commercial and recreational fisheries. As named, members of the surfperch family are typically found in coastal surf-zone habitats but also inside bays and estuaries, including Humboldt Bay (CDFW 2019b). Redtail surfperch can be fished from jetties and piers inside harbors, particularly between March and April when they concentrate to spawn (Barnhart et al. 1992). Movements of redtail surfperch of up to 20 km have been observed and they are important forage fish for harbor seals. Surfperch are likely present.

3.3.6.7 Sand Shark

Sand shark (or brown smoothhound shark), range from Oregon to Baja California and are most common in sandy or muddy bottom habitats of Humboldt Bay, and also in deeper water on the continental shelf. (CDFW 2019c). They occur in Humboldt Bay most of the year and appear to move offshore during the winter months, potentially to avoid the colder, low salinity water (CDFW 2019c). They have more recently been collected in the North Bay. Sand sharks are likely present throughout Humboldt Bay.

3.3.6.8 Dungeness Crab

Dungeness crab support an important local commercial fishery that had the highest port value of all fished species landed in Eureka, Trinidad, and Crescent City in 2019 (CDFW 2020). Dungeness crab also support a local recreational fishery. Their distribution ranges from Alaska to Point Conception, California. Because of their wide range, commercial value, and high motility, California, Oregon, and Washington coordinate on interstate management issues through the Tri-State Dungeness Crab Committee, which is overseen by the Pacific States Marine Fisheries Commission (Juhasz and Kalvass 2013).

Dungeness crab are mobile epifauna and reside on sandy to sand-mud substrate of bays, estuaries and the open coast, and most abundant at depths less than 300 ft (91 m) but can be found as deep as 750 ft (230 m). They are found in bays and estuaries from March to July (Wild and Tasto 1983), and their habitat use depends primarily on life stage and size. There are abundant crab larvae in the planktonic community of Humboldt Bay in November through February (Emmett et al. 1991). Juveniles tend to prefer eelgrass habitat in bays and estuaries (Juhasz and Kalvass 2013). The eelgrass communities, specifically in South Bay serve as nursery grounds that support dense patches of juveniles (Barnhart et al. 1992, Schlosser and Eicher 2012). Small juvenile crabs may be associated with high density eelgrass as a predator avoidance mechanism (Fernandez et al. 1993). While adults are rare in Humboldt Bay (Emmett et al. 1991), larvae and juveniles are likely present in the winter in the eelgrass throughout the Project area.

3.3.6.9 Rock Crabs

Three species of rock crab make up this complex that supports commercial and recreational fisheries: red rock crab (*Cancer productus*), yellow rock crab (*Metacarcinus anthonyi*), and brown rock crab (*Romaleon antennarium*) (CDFW 2019b). All three species are epibenthic and inhabit the intertidal area out to depths greater than 325 ft. Brown and red rock crab prefer rocky or reef-type habitat, whereas yellow rock crab habitat includes silty sand to mud substrates and sand-rock substrate of rocky reef (CDFW 2019d). Brown rock crab inhabit substrates of rocky shores subtidal reefs and coarse to silty sands and are more abundant.

Rock crabs are commercially valuable in Humboldt Bay. Humboldt Bay serves as a nursery ground, and juveniles are primarily found in dense patches in the South Bay (Barnhart et al. 1992, Schlosser and Eicher 2012). They are likely present using hard structures in the project area.

3.3.6.10 Clams

There are several species of benthic infaunal bivalves that are recreationally and commercially important in Humboldt Bay (Emmett et al. 1991, Barnhart et al. 1992). These species include gaper clams (*Tresus* spp.) and butter clams (*Saxidomus* spp.), all of which are considered deep burrowing bivalves (Barnhart et al. 1992) and critical primary consumers. Each of these clams have pelagic larval stages, so their distribution is highly dependent on tidal currents (Moore 2001). Gaper and butter clams are found in low intertidal flats with sand to muddy-sand sediments ranging from the South Bay and extending north up to Tuluwat Island (Barnhart et al. 1992). Within the low intertidal flats of Humboldt Bay (45 cm to 116 cm below MLLW), gaper clams are more common in sandy substrates, while butter clams are more frequently found in muddier regions (Emmett et al 1991, Barnhart et al. 1992).

In Humboldt Bay, gaper clams include the Pacific gaper (*T. nuttalli*) and horseneck gaper (*T. capax*), both of which are harvested subtidally and intertidally (Emmett et al. 1991). Horseneck gapers are generally more abundant (Barnhart et al. 1992). Fisheries for gaper clams are primarily sport and recreation, but they are also commercially harvested. Surveys in 1992 estimated there to be an average of 4,300 sport clammers per year and an annual take of 56,000 clams (Moore 2001).

These two species of gaper clams appear to partition resources based on burrowing depth and sediment preferences. Pacific gapers typically bury at depths between 25 and 60 cm below the surface and are most abundant in pure, fine sand or firm-sand bottoms (Emmett et al. 1991, Barnhart et al. 1992). Horseneck gapers do not typically burry as deep as Pacific gapers and are found between 25 and 50 cm below the surface (Barnhart et al. 1992), and most abundant at depths 1-5 m below MLLW (Emmett et al. 1991). Compared to Pacific gapers, horsenecks generally prefer substrate with more gravel and shells, and silty-sand as opposed to mud (Emmett et al. 1991). Within Humboldt Bat, horseneck gapers are most dense in silty-sand substrates that are covered with eelgrass. They spawn between January and March, with peaks in February (Emmett et al. 1991).

Butter (and Washington) clams (*Saxidomus* spp.) are a comparatively smaller fishery than gaper clams in Humboldt Bay (Moore 2001). They are almost exclusively a sporty fishery, but commercial operations exist. Of the *Saxidomus* spp., the Washington clam (*S. nuttalli*) is the principal species caught and significantly more abundant compared to the butter clam (*S. giganteus*). Compared to gaper clams, *Saximous* spp. are found in muddier habitats within bays, lagoons and estuaries. They also do not burry as deep, with the Washington clam burying between 16 and 30 cm, and the butter clam burying between 12 and 30 cm (Barnhart et al. 1992). Washington and butter clams spawn between the spring and fall, with warmer water temperatures being the primary determining factor.

There are also shallow burrowing, filter feeding bivalves. These include *Macoma, Protothaca,* and *Clinocardium* spp. Basket or cockles (*Clinocardium nuttallii*), which are support recreational fisheries in Humboldt Bay and inhabit intertidal and shallow subtidal sediments. Compared to *Tresus* and *Saxidomus* spp., these cockles are found significantly closer to the surface and do not burry below 3 cm deep (Barnhart et al. 1992).

Gaper and butter clams are possibly present in the project area, perhaps in lower densities, and may vary based on the sediment composition (fine sand, silt, or mud).

3.4 Essential Fish Habitat

The project area supports EFH for three of the four FMPs (excluding EFH for highly migratory species). HAPCs include estuaries and seagrass.

3.4.1 Pacific Coast Groundfish EFH

EFH for Pacific coast groundfish is defined as the aquatic habitat necessary to allow groundfish production to support long-term sustainable fisheries for groundfish and for groundfish contributions to a healthy ecosystem. The northern California coast provides groundfish habitat from the nearshore MHHW or the upstream extent of saltwater intrusion, to deep water areas (less than or equal to 3,500 meters) seaward to the boundary of the U.S. Exclusive Economic Zone (EEZ), seamounts in depths greater than 3,500 m as mapped in the EFH assessment, and areas designated as HAPCs (PFMC 2022). The groundfish FMP groups EFH into seven composite units, each of which represent a major habitat type. One of the seven components is estuarine EFH, defined as waters, substrates and associated biological communities in bays and estuaries of the U.S. Exclusive Economic Zone, from MHHW to the outer boundary of the estuary.

The PFMC made more than 400 EFH designations for 83 groundfish species, and Pacific coast groundfish represent a large number of resident species along the U.S. West Coast. The PFMC further defined important habitat by species and life stage. Within Humboldt Bay, Pacific coast groundfish EFH covers the North Bay, Entrance Bay, and South Bay, thus encompassing the project area. Pacific coast groundfish likely to occur in the project area include flatfishes (e.g., starry flounder [*Platichthys stellatus]*, speckled sanddab [*Citharichthys stigmaeus*], Pacific sanddab [*C. sordidas*]), rockfishes (e.g., black rockfish [*Sebastes melanops*], blue rockfish [*S. mystinus*]), lingcod (*Ophiodon elongates*), cabezon (*Scorpaenichthys marmoratus*), and kelp greenling (*Hexagrammos decagrammus*). Larvae of several species of groundfish are potentially present as well.

Further information on rockfish, lingcod, and starry flounder are provided in Section 3.4.6, as they may be found inside Humboldt Bay and are commercially and recreationally important.

3.4.2 Coastal Pelagic EFH

Coastal pelagic species live in the water column and are found anywhere from the surface to 3,281 feet (1,000 meters) deep. The Coastal pelagic EFH covers and actively manages six species/species groups: Northern anchovy (*Engraulis mordax*), Pacific sardine (*Sardinops sagax*), Pacific mackerel (*Scomber japonicus*), jack mackerel (*Trachurus symmetricus*), California market squid (*Loligo opalescens*), and krill (PFMC 1998, 2021). The EFH for these species includes all marine and estuarine waters along the coast of northern California and offshore to the EEZ boundary line. Of the six actively managed species/species groups, anchovies, Pacific and Jack mackerel are potentially present inside Humboldt Bay and within the project area. The EFH for these species includes all marine and estuarine waters along the coast of northern California and offshore to the EEZ boundary line. Therefore, the marine development and wetland storage subareas are in coastal pelagic EFH.

3.4.2.1 Dredging Constraints

Appendix D of the Coastal Pelagic FMP explicitly states that new dredging should be avoided, including dredging for docks, and should be sited in deep waters or designed in a manner that alleviates the need for maintenance dredging (PFMC 1998). It also states that projects should be permitted only for water dependent purposes, when there are no feasible alternatives. This Project requires deepening new areas that have not previously been dredged, and in areas that are Coastal Pelagic EFH. New dredging in the project area is necessary to support offshore wind and the Project is water dependent. Appendix D of the Coastal Pelagic FMP also states that where dredging that is expected to create significant turbidity occurs, adequate control measures should be taken to minimize turbidity. Potentially adverse impacts from dredging on water quality are addressed in Section 4.1 and will be avoided and minimized accordingly (Section 5.2.1).

Deepening new locations will be a challenge that requires additional permitting, which could take several years (Port of Long Beach 2019) and require new consultation with the regulatory agencies. This is in contrast to maintenance dredging in existing channels, which has been an ongoing activity and for which mitigation actions have been developed to minimize impacts on listed species, their designated critical habitat, and EFH.

3.4.3 Pacific Coast Salmon EFH

In the estuarine and marine environment, EFH for Pacific coast salmon extends from nearshore and tidal submerged environments in state waters to 370.4 kilometers offshore. Pacific salmonids, including coho and Chinook salmon, as well as their prey species (Northern anchovy, Pacific sardine, and Pacific herring) are potentially present within the project area and covered under this EFH. The project area contains EFH for all life stages of Chinook and coho salmon. Further information on coho and Chinook salmon may be found in Section 3.4.1.

3.4.4 Habitat Areas of Particular Concern

Humboldt Bay (and the project area) is an estuary, which is a HAPC managed under the Pacific coast groundfish FMP. Eelgrass is also designated as an EFH HAPC for various fish species within the Pacific Coast Groundfish FMP (PFMC 2008, National Oceanic and Atmospheric Administration 2014). Additional information on eelgrass, which is present on mudflats in the project area, is provided above in Section 3.1.2 (Merkel & Associates 2022).

3.4.5 Ecosystem Component Species

In 2016, a selection of forage fish species that were unfished and unmanaged were brought into the FMPs as Ecosystem Component Species (ECS). There are certain ECS shared between all four FMPs. The intention of this action was to define and prohibit directed commercial fishing because the shared ECS are prey of marine mammal, seabird and fish species and because they support the growth and development of predators (NMFS 2016c, 2016d). Future development of fisheries for shared ECS is prohibited as a method to proactively protect unmanaged, unfished forage fish crucial to species managed under the FMPs and the larger California Current. Longfin smelt are one example of a shared ECS that is potentially present in the project area. Pacific herring are also present in the project area and are an ECS covered under the coastal pelagic FMP.

Section 4.0 Review of Impacts

The potential marine environmental effects associated with construction for the Project, changes to habitat, and permitted operations result from demolishing the existing RMTI and No Name Dock, reconstructing RMMT, developing the wet storage subarea, and build-out and deployment of WTDs. Aspects of demolition and construction in the upland subarea and activities in the restoration subarea may also affect the marine environment. These impacts may be direct or indirect. The nature of direct and indirect impacts may be short-term or long-term:

- **Direct impacts** occur concurrently with a certain project-related activity; for example, habitat may be directly impacted during construction through modification, and species may be directly impacted by movement of personnel or vessels during construction, operations, or maintenance.
- **Indirect impacts** typically occur later in time than the activities that cause them; for example, the potential loss of prey due to entrainment when dredging or ballasting occurs, that may impact higher trophic levels.
- **Short-term impacts** typically only occur during the work activity, have no significant disturbance or killing of native vegetation/habitat, and the habitat values return to a pre-disturbance state within one year. Disturbance impacts to animals as a result of activities are considered temporary if the animals' behavior and/or spatial use patterns are expected to return to pre-activity conditions shortly after the disturbance ceases, so that daily behaviors necessary to meet life requisites are maintained.
- **Long-term impacts** are impacts that last over one-year, and result from the permanent replacement of natural habitat with structures or materials to developed uses, or shade or permanently convert the habitat to a different habitat/use. Long-term impacts would also include vegetation or habitat disturbance where, following the disturbance, the vegetation/habitat cannot recover to its pre-disturbance state within one-year.

A summary of the marine effects (using the definition of impacts above) associated with the Project are explained at a high level in Sections 4.1. This information is summarized in Table 9, which outlines the potential stressors and receptors, and describes the scale of effects. The stressor represents the mechanism and activity that results in a potential effect. The receptors are the taxa impacted by the associated stressor. The scale of effect from the stressor refers to the temporal or spatial scale of the impacts (direct or indirect). A more detailed explanation of the effects on given taxa, and whether the mechanism may require mitigation, are provided in Section 4.2.

4.1 Potential Stressors

This section provides a high-level explanation of the stressors and activities associated with construction, habitat change, and permitted operations that may cause potential impacts on marine resources. It provides background information to understand the magnitude and scale of impacts that are discussed in Section 4.2. Additional details on certain stressors may be provided if the impacts are expected to result in agency consultation or significant effects, although no determinations can be made prior to reviewing the final Project design and construction plans.

Table 9. Summary of Marine Effects Evaluated for Construction, Changes to Habitat, and Permitted Operations

Stressor	Receptors	Temporal and Scale of Effects
Dredging	Fish, invertebrates, birds, marine mammals	Short-term[1] and longer-term[2] effects; short term and smaller spatial scale for acoustic, habitat disturbance, entrainment, and water quality effects; long term habitat change with larger spatial scale (acres).
Benthic habitat disturbance (wharf demolition and pile removal, wharf construction, dredging)	Benthic communities (invertebrates), perching birds	Short-term, larger spatial scale for benthic effects, long-term change in perching structures.
Wharf demolition and new wharf construction (shading, disturbance, acoustic)	Fish, eelgrass, marine mammals	Short-term effects of pile driving (acoustic, water quality); long-term effects of shading and benthic disturbance.
Water quality (turbidity from bottom disturbance, spills, contaminants)	Fish, invertebrates, marine mammals, waterbirds	Short-term, small spatial scale.
Vessel traffic (ballasting and anchoring)	Fish, invertebrates, birds, marine mammals	Short-term and long-term effects: short-term increased risk of collision, nearshore habitat erosion and vessel noise; long-term effects of potential invasive species introductions.
Acoustic (dredging and terminal construction/pile driving, vessel noise)	Marine mammals, birds, fish	Short-term and long-term: Short-term pile driving, dredging and construction over a period of a few years, longer term increased vessel traffic noise, maintenance dredging.
Artificial lighting	Fish, birds	Short-term for construction (pile driving, dredging).
WTD ballasting	Fish, planktonic communities, invertebrates	Short-term effects of entrainment on planktonic communities and larval fish; potential long-term effects with invasive species introductions

Notes: The potential effects of the Project on the marine environment result from various stressors. These stressors (listed in the first column) are associated with specific activities. The receptors (second column) are the organisms that may experience potential impacts from the associated stressors. The temporal and scale of effects (final column) indicates whether these effects may be short or long-term.

Definitions: [1]Short-term impacts typically occur only during work activity and are temporary. [2]Long-term impacts are impacts that last over a year, resulting from permanently replacing natural habitat with structures or materials with developed uses. converts habitat to development uses.

4.1.1 Construction

Construction for the Project involves demolishing and removing the current RMTI and No Name Dock, removing numerous old creosote piles along the shore (the area south of the current wharf has hundreds of piles slated for removal). Construction also involves building stronger overwater structures to support the weight of offshore wind turbine assembly, which requires the driving of new piles. Dredging within the marine development and wet storage subareas will be required.

4.1.1.1 Dredging

Dredging will occur between the newly constructed wharfs and the federal navigation channel to approximately - 40' MLLW for deep draft cargo vessel access and WTD construction activities (at the berths themselves). A sinking basin will be dredged to approximately -60' MLLW to accommodate semi-submersible vessel operations for device float off. Dredging to approximately -40' additionally takes place in the wet storage subarea.

The effects of dredging generally include:

- Deepening by removal of substrate in certain areas resulting in long-term changes to habitat type and species assemblage;
- Short-term effects of elevated levels of suspended sediment and turbidity and potential spills on water quality;
- Effects on species assemblage from entrainment (e.g., removal of benthic organisms during dredging);
- Long-term changes to circulation and sedimentation patterns;
- Short-term potential for entrainment if hydraulic suction dredging is used; and
- Short-term dredging vessel noise and potential for collision with marine mammals.

Entrainment—Entrainment occurs when aquatic organisms are trapped in the uptake of sediments or water being removed by dredging machinery, in particular the suction field generated by hydraulic dredges (Reine et al. 1998). Entrainment may result in direct (removal of aquatic organisms themselves) and indirect impacts (removal of food resources and potential prey).

4.1.1.2 Pile Removal and Pile Driving

Pile removal and pile driving result in short-term impacts on water quality and underwater sound. The effects of pile removal on water quality may be relatively similar to the water quality effects associated with dredging. The effect of pile driving on underwater sound is expected to be substantial due to the sheer volume of piles being placed. There are also long-term impacts associated with pile removal (removing available habitat) and the drilling of new piles (providing new substrate for native and non-native species to colonize).

4.1.1.3 Underwater Noise

The underwater noise (anthropogenic sources) associated with the Project that is pertinent for this impact assessment results from in-water construction. Short-term, direct effects of elevated noise can be expected from dredging (e.g., vessel and pump noise), and pile removal and driving (e.g., from vibrating and impact hammers, and vessels use).

In general, impacts from noise depend on i) sound frequency relative to the hearing frequency range of the animal and ii) sound source intensity, energy, duration received by an animal and type. The type of sound source determines the appropriate acoustic thresholds for animals. Impulsive sound sources produce sound that is typically transient, brief, broadband, and consist of high peak sound pressure with rapid rise and decay times (NMFS 2023b). Impulsive sounds such as impact pile driving can occur in repetition, or as a single event. In contrast, non-impulsive sounds can be continuous or intermittent, produce sounds that are broadband, narrowband or tonal, and may be brief or prolonged. These sources do not have the high peak sound pressure with rapid rise times that are typical of impulsive sounds. Per the Project, non-impulsive sound sources may result from vibratory pile driving. Sound may also be continuous (i.e., emit sound with a sound pressure level that remains above ambient sound) or intermittent (i.e., interrupted levels of low or no sound or burst of sound separated by silent periods) (NMFS 2023b).

Underwater sound also has a particle motion component (Nedelec et al. 2016, Popper and Hawkins 2018). Marine mammal hearing is based on detection of sound pressure, whereas fish and invertebrates sense sound using particle motion (other than those fish species with swim bladders that may also be sensitive to sound pressure). Particle motion provides information about their environment (e.g., detection of an approaching predator, the presence of a potential mate), but is also used for communication or navigation.

Exposure to sound can constitute a large area based on the frequency, duration, and magnitude of sound produced and the fact that sound travels far underwater. Acoustic impacts from the Project will depend on noise generated by construction equipment, the timing and duration of noise-generating activities, and the distance between construction noise sources and noise sensitive areas. Noise impacts from construction primarily result when construction activities occur in the vicinity of marine animals, in areas next to sensitive habitats, or when construction lasts for extended periods of time (Appendix J *in* GHD 2021).

Underwater sound may result in a range of effects on marine species, from no discernible effect to acute, lethal effects. The effect of noise may have significant impacts (taxa dependent). There may also be increased vessel traffic during construction, although Humboldt Bay has vessel traffic already contributing to the acoustic background in the bay.

4.1.1.4 Vibration

Vibration refers to the motion of an object that produces sound and consists of rapidly fluctuating motions or waves (Appendix J *in* GHD 2021). Energy produced from an object that is vibrating leaves its source and travels through a medium (e.g., surrounding water) as an acoustic wave.

Construction activities result in vibration of varying intensities, and vibration can be expected from all aspects of construction for the proposed Project. The sources of vibration will be from pile driving, and to a lesser extent, pile removal and dredging. The overall impact of vibration and intensity of vibration levels on marine resources, from pile driving in particular, depend on the construction method and equipment used, and soil and sediment conditions. Impact from pile driving generates vibration in the substrate that re-radiates underwater sound pressure back into the water, and the larger the pile, the more vibration is generated (Molnar et al. 2020). The type of vibration also differs based on the equipment used (Andrews et al. 2020). Continuous vibration may result from using vibratory pile drivers and pile-extraction and vibratory compaction equipment. Impact pile drivers and blasting results in low-rate repeated vibration.

Since substrate vibration propagates to produce particle motion in the water column, the acoustic environment of marine resources (e.g., animals) near substrate includes vibration signals (Hawkins et al. 2021). Organisms that use their sensory systems to perform key life functions, depending on the distance to the source are expected to be exposed to the vibration.

4.1.1.5 Vessel Related Effects

Vessel Collision—Vessel collisions with wildlife, particularly marine mammals, are possible; however, construction vessels are likely to move slowly for pile removal and dredging, as well as the transport of construction materials inside the bay. For active dredgers, existing research on vessel strikes and injuries on marine mammals suggests that risk of collision is minimal if well managed, especially because these dredgers are often rather stationary or moving slowly (Todd et al. 2015). Humboldt Bay also already has significant boat traffic, and risk of direct collision, especially with larger cetaceans, is more problematic offshore and unassociated with Project activities. Collisions with vessels are not being considered for the remainder of this assessment because at this stage of design, we do not know how many or where boats will be transiting to and from.

Non-Indigenous Species—The introduction of non-indigenous species (NIS) is another potential effect of vessel use during construction. Since they are non-native, the introduction of aquatic NIS threatens the diversity and abundance of native species, natural communities, water quality, and commercial and recreational activities that depend on aquatic environments (CDFW 2008). NIS spread quickly from their point of introduction. NIS and non-native, invasive organisms are typically introduced into aquatic environments such as bays through ballast water and after settling and growing on boat hulls. Transoceanic shipping is also a major source of NIS in the aquatic environment (CDFW 2008). Other vectors include organisms on recreational gear, fishing equipment, drilling platforms and docks (CDFW 2008).

An extensive survey-based study was conducted throughout Humboldt Bay in 2000 to identify the presence of NIS and provides reliable baseline data for future studies and monitoring of NIS that may arrive from maritime trade and other activities (Boyd et al. 2002). The study collected and identified 95 potentially NIS inside Humboldt Bay (Boyd et al. 2002). The NIS covered a wide range of taxa from vascular plants to fish, although most were invertebrates. Boyd et al. (2002) indicated that most organisms were potentially present in the bay for >100 years; however, new introductions that were identified are primarily associated with commercial shipping activity, and data on co-occurrence in other bays suggest that vessels transiting from San Francisco Bay are an important source for introducing NIS.

The introduction of aquatic NIS through vessels and equipment may be a potential effect of the Project construction. At this stage of design, the origin of the vessels and equipment required for construction is unknown, which limits the ability to determine the specific species of concern and potential effects. As a result, the potential effects of NIS are not being considered for the remainder of the species-specific assessment. Avoidance and minimization efforts are provided (Section 5.7).

4.1.1.6 Water Quality

Water quality is expected to be impacted from the demolition of RMTI and No Name Wharf, dredging activities, and construction of RMMT. Water quality effects from these activities are short-term. Sediment suspended during pile removal, dredging and construction, depending on sediment type, can be dispersed by currents and the resulting turbid plumes may last for hours to days. Specifically for dredging, research has demonstrated that effects of dredging on sediment plumes are short-term and typically last a maximum of four to five tidal cycles (Newell et al. 1998 and Hitchcock and Bell 2004, as cited *in* Todd et al. 2015). Water quality effects can also be direct: water quality can be degraded by unintentional spills or contaminants from the sediment, or vessels and other project components, and contaminants can result in death, particularly to vulnerable life stages (e.g., larvae, eggs). Longer-term effects on water quality may be beneficial because demolition will remove creosote treated pilings.

4.1.1.7 Artificial Lighting

The current Project design indicates that dredging may occur continuously 24 hours a day, 7 days a week (Humboldt Bay Offshore Wind Heavy Lift Marine Terminal Project: Draft Project Description [April 2024]). It is possible that other components of construction, particularly pile driving and activities in the upland development subarea will also occur at night. Thus, artificial light at night (ALAN) will likely occur during construction.

4.1.2 Habitat Change

In-water construction disturbs the existing habitat and is expected to result in long-term habitat change.

4.1.2.1 Removal of Intertidal and Shallow Subtidal Mudflats

Dredging along the mudflats adjacent to Samoa Peninsula in the marine development subarea and the subtidal soft bottom habitat in the wet storage subarea will result in a complete physical alteration of habitat and convert intertidal and shallow subtidal mudflats (that contain eelgrass) into deeper subtidal habitat. The effects of converting intertidal mudflats to subtidal habitats that are relevant for this assessment include changes to EFH, productivity, and species assemblages. Effects on EFH may be expected because mudflats provide substrate used for spawning, breeding, feeding, or growth will be altered. Submerged aquatic vegetation (SAV) will be completely removed leading to a loss of productivity. The re-establishment of SAV may be unlikely because the deepening of the habitat reduces available light to the seafloor. The conversion to deeper habitat can be expected to support a different species assemblage, although the effects are expected to be species specific and based on habitat preferences and requirements.

The removal of eelgrass itself from dredging intertidal and shallow subtidal mudflats is a major concern and addressed in a separate analysis. The habitat change is also expected to have physical impacts on the hydrodynamics and circulation within Humboldt Bay. These effects are also analyzed elsewhere.

4.1.2.2 Pile Removal and Driving

During the construction process, pile removal may create initial disturbance by removing hard substrate that species have developed associations with. The additional piles that will be driven throughout the course of the Project can be expected to provide new structure that can be colonized by native and non-native invertebrates.

4.1.3 Permitted Operations

The effects of permitted operations that will occur at the Project site are associated with increased vessel traffic, ballasting and de-ballasting of WTD foundations, onshore build-out, and anchoring activities.

4.1.3.1 Vessel traffic

Increased vessel traffic is a given with a new industry to Humboldt Bay; however, the types of vessels, frequency of transit, and need for additional dock space will depend on the build-out scenario. Increased vessel traffic will: 1) increase vessel traffic noise, which could affect use of Humboldt Bay by marine mammals; 2) increase the risk of collision with marine mammals that occur in the bay; 3) increase propeller turbulence and wake, which may affect nearshore habitat by increasing erosion; and 4) potential to introduce marine invasive species. In addition, increased vessel traffic may increase disturbance to waterbirds and shorebirds associated with Humboldt Bay. Humboldt Bay is already a port with existing vessel traffic, so ambient conditions include vessel activities that may currently be more seasonal in nature (e.g., during Dungeness crab commercial fishing season, or summer recreational salmon fishing season).

4.1.3.2 Ballasting of WTD foundations

Ballasting with supply bay water will be required to level and stabilize WTDs during offloading of the WTD floating foundations and during vertical integration. Potential environmental concerns associated with ballast include entrainment of larval fish and other small organisms into the ballast tanks. Species listed under the ESA will be a priority concern, including longfin smelt; there may be times of year when ballasting activities should be avoided to minimize effects on these species, or measures can be taken to screen species from ballast water intakes.

De-ballasting of WTD foundations and fully integrated WTDs may occur during maintenance of units towed in from offshore, or during tow-in delivery from another port. Ballast water released has the potential to introduce new invasive species and marine viruses that could harm the surrounding environment. Impacts associated with the introduction of non-indigenous species (NIS) are detailed in Section 4.1.1.5 above.

4.1.3.3 Collision

The port facilities will support assembly of the turbines prior to deployment offshore. During assembly, several activities can have environmental effects, depending on the scenario. When the turbines are being assembled at dock facilities, there is an increased risk of collision with shorebirds and other bird species known to use the bay.

4.1.3.4 Anchoring

Anchoring of vessels and platforms will locally affect benthic habitat and organisms, although the effects are likely to be small in scale and localized. The current project description outlines the use of fixed mooring systems in the wet storage subarea due to limited available space, which may reduce the effect of constant benthic habitat disturbance.

4.2 Impacts on EFH and Species of Interest

This section reviews the potential impacts of construction, habitat change, and permitted operations on EFH. It also describes how the mechanism of effect (activity and potential stressor) may impact birds, fish, marine mammals, and non-listed/benthic organisms. A range of potential impacts are briefly mentioned, with a primary focus on activities that we expect to have the most substantial impact, implications for Project design or require agency consultation.

4.2.1 EFH Analysis

EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. 1802(10)). For this EFH effects analysis, the ways construction and habitat change impact the waters and substrate necessary for the full lifecycle of a species is considered (Section 3.3 contains more detailed definitions of these terms). The information in this section includes content that can support EFH consultation, where formal impact determinations and assessments will be made. The potential impacts of construction, habitat change, and permitted operations on EFH may result from construction itself (removal of prey, including entrainment from dredging, and increased turbidity from dredging and pile related activities), long-term habitat change, and increased vessel traffic and WTD ballasting during operations. The potential impacts associated with maintenance dredging in the federal navigation channels in Humboldt Bay are reviewed in NMFS (2016e, 2021d). While the scale of dredging for the proposed Project will be more extensive, the determinations from previous biological opinions provide useful context on potential stressors and is used as a reference throughout this section.

4.2.1.1 Pacific Coast Salmon

The proposed project is not necessarily expected to adversely modify the waters and substrate necessary for species managed under the Pacific coast salmon FMP to spawn. The feeding, growth, and maturity of species under this FMP has potential to be compromised. There will also be impacts to water quality from dredging, including periods of turbidity (NMFS 2021d), which can also be expected during pile removal and driving.

There may also be turbidity from propeller wash and synergistic effects that lead to increased risk of predation (NMFS 2021d). Direct entrainment may occur depending on the type of dredge used and WTD ballasting. It is possible that Pacific coast salmon EFH may even benefit to some degree: the removal of piles treated with creosote may improve habitat conditions and water quality long-term inside Humboldt Bay, although this cannot be determined until plans are finalized.

4.2.1.2 Pacific Coast Groundfish

Potentially adverse impacts to species covered under this FMP include increased turbidity during construction. Species managed under the Pacific coast groundfish FMP may be subject to entrainment during dredging (depending on the dredging methods) and WTD ballasting in addition to habitat loss. Many of the species managed under the Pacific coast groundfish FMP (i.e., rockfish, flatfish) that are potentially present in the project area forage on benthic organisms and organisms associated or attached to eelgrass or the existing structures at RMTI. These include benthic and infauna prey species including polychaetes and amphipods. Species known to use shallow water embayments such as Humboldt Bay as nursery areas include English sole and several rockfish species (Cole 2004, Tenera Environmental 2023). These organisms may be directly removed during construction. The elimination of infaunal, demersal and pelagic prey organisms could be permanent, although species may be able to recolonize long-term. There may be long-term beneficial impacts associated with pile removal on water quality.

4.2.1.3 Coastal Pelagic Species

EFH for the species/species groups managed under the coastal pelagic FMP that are potentially present in Humboldt Bay, which include anchovies, and Pacific and jack mackerel could be expected to be affected by the proposed Project. That said, any impacts on coastal pelagic species EFH would not necessarily have a measurable because these species do not necessarily rely on Humboldt Bay as primary habitat for spawning, breeding, feeding, or growth to maturity. Species/species groups managed under coastal pelagic FMP are more reliant on coastal waters outside of estuaries; however, they are potentially present in the Main Channel and may be foraging, in which case entrainment from dredging (depending on the methods used) and WTD ballasting is possible. All construction activities have potential to result in increased turbidity and result in a loss of habitat. Dredging and pile removal in particular may also result in removal of demersal and pelagic prey, although recolonization long-term may be possible. It is possible that coastal pelagic EFH may experience benefits from pile removal activities (and the removal of toxic material), which could improve habitat conditions and water quality inside Humboldt Bay long-term.

Pacific herring are classified as an ECS in the coastal pelagic FMP. Construction or dredging activities may affect these runs. Adult herring may avoid the area, be held back or slowed from moving up the channels during incoming tides or may delay spawning. Construction or dredging activities may also interfere with successful spawning since they deposit their eggs on eelgrass blades. In the SFBE, dredging was identified as potentially having negative effects on the reproductive success when in the vicinity of herring spawning activities and/or deposits (p. 49 and 52 *in* USACE 2004).

4.2.1.4 HAPC

Eelgrass is a HAPC that provides substrate (specifically bottom structures) necessary for the survival of various organisms. It is ecologically important foraging and spawning habitat, sensitive to disturbance and does not easily recolonize. The existing presence of eelgrass in the project area will be completely removed due to habitat change. Impacts will be mitigated, and the mitigation is reviewed in a separate analysis.

Estuaries (including Humboldt Bay) are similarly considered an HAPC (PFMC 2020). This designation for estuaries is based on the importance of highly productive shallow waters within estuaries to groundfish and their prey. Construction may result in short-term impacts on water quality from increased turbidity. The long-term impacts would result from habitat change, and the loss of intertidal and subtidal mudflats, which are highly productive systems. Since the marine development and wet storage subarea, where habitat change is expected to occur due to disturbance from construction, represent only a portion of the larger estuary (i.e., Humboldt Bay), the potential impacts may not necessarily be significant. The potentially significant impacts from the proposed Project on the estuary will be minimized through BMPs and appropriate minimization measures, which are addressed in Section 5.0.

4.2.2 Birds

The Project may impact birds (land birds that use the bay to forage, seabirds, and shorebirds) in the project area. Birds in the project area may experience effects from changes to their habitat during the construction phase (from dredging, demolition and reconstruction, and shoreline adjustments), and long-term changes to habitat.

4.2.2.1 Artificial Lighting

Artificial lighting may directly impact birds by attracting them, thus increasing the risk of grounding and predation, collision with structure, disorientation, and interference with night feeding. These effects are species dependent and may only be problematic if Project related activities produce ALAN; however, it is possible that ALAN has potentially significant impacts. With proper consideration, potentially significant impacts associated with ALAN can be avoided and minimized (Section 5.6).

Nocturnal Migrants—Nocturnal migrants collide primarily with towers and other structures that are lit with constant white light (Gauthreaux and Belser 2006). These birds also collide with buildings that have lit windows at night during migration. In addition, static red light disrupts magnetic orientation of migratory birds (Wiltschko et al. 1993.) This phenomenon is most pronounced in eastern and central North America (likely due to increased numbers of migrant birds relative to western North America) (Horton et al. 2019) and, with respect to towers, collision typically occurs when guy wires secure the towers. Strobe lights and colored lights (especially green) substantially reduce the collision rates of migrants with lit structures (Gauthreaux and Belser 2006). A field study in the in the North Sea found that nocturnally migrating birds were disoriented and attracted by red and white light, whereas they were "clearly less disoriented by blue and green light" (Poot et al. 2008).

The use of constant white or red lighting sources during nighttime construction could increase the likelihood of collision or energetic expenditure for nocturnally migrating birds, especially during foggy or stormy nights. Static white and red light seems to be the most impactful to nocturnally migrating birds, while dynamic lighting (e.g., blinking) is much less impactful (e.g., see Gauthreaux and Belser 2006).

Seabirds—Phototactic seabirds such as shearwaters, petrels, storm-petrels, auklets, and murrelets could be attracted to U.S. Coast Guard (USCG) required navigational lighting on Project structures, and servicing and support vessels associated with construction, and could collide with or land on Project structures or vessels or become exhausted by continual circling around the lights (Montevecchi 2006). Phototactic seabirds have been shown to be highly attracted to artificial light in the marine environment; typical sources of light include boats, lighthouses, oil and gas platforms, coastal development, and commercial fishery operations. Nocturnal seabirds are most susceptible to light attraction in cloudy, foggy, or hazy conditions, in light rain, and when the moon is absent or obscured. Immature and nonbreeding nocturnal seabirds tend to be more attracted to light than breeding adults (Montevecchi 2006, Miles et al. 2010). Most of these species occur offshore and do not occur in the Bay (Harris 2006).

Uplighting may also affect migratory birds such as songbirds and shorebirds, especially during nighttime foggy or light rain conditions during migration. These birds can be attracted to light, especially static white light (Gauthreaux and Belser 2006), resulting in entrainment. In addition, nighttime lighting that spills over into habitats can result in interference with biological circadian rhythms, increased predation, and ecosystem perturbations (Jagerbrand and Bouroussis 2021).

Light Temperature—As indicated above, higher CCTs generally have greater effects on wildlife (Longcore et al. 2018). Currently, recommendations for reducing effects on biota vary from less than or equal to 3000 to 2700 or less (e.g., Longcore et al 2018; International Dark Sky Association: https://www.darksky.org/). Potential impacts of light temperature and exact recommendations to minimize impacts will depend on the construction plans.

4.2.2.2 Perching and Roosting Birds

Pile removal and construction in the marine development area has the potential to cause impacts to special-status roosting birds by removing roosting structures if such structures are important and roosting sites are regionally limited. Species such as the brown pelican and the double-crested cormorant roost on jetties, pilings, and other manmade structures. Brown pelicans and cormorants are known to roost on existing structures including piers and pilings in and around RMTI.

Over time and once construction is complete, roosting birds can return to new structures at RMTI. Potential impacts on nesting birds are covered in documents focused on terrestrial surveys and impacts.

4.2.2.3 Habitat Change

The conversion of intertidal and subtidal mudflats into deeper subtidal zones is expected to have effects on birds, particularly shorebirds, that forage in these existing shallow habitats. Birds such as herons and egrets and shorebirds that forage around the existing RMTI and No Name Wharf or on exposed shoreline may be permanently displaced by the changes the Project will have on the shoreline areas, new overwater structures that cover previously open and/or intertidal /shallow subtidal habitat, and the deepening of nearby habitat. Two memos were written documenting preliminary findings from reconnaissance surveys in the project area (H. T. Harvey & Associates 2023a, 2023b). Based on these initial surveys and our existing understanding of shorebird use in Humboldt Bay, removing intertidal mudflats in the project area is not expected to be particularly problematic for shorebirds, as there are higher quality habitats elsewhere in Humboldt Bay and eelgrass restoration will provide more high-quality habitat than is currently available at the project site (H. T. Harvey & Associates 2023b).

4.2.2.4 Acoustic Impacts

In-water and upland construction could result in noise that disturbs special status and protected birds in the Project area. The significance of acoustic disturbance will depend on many factors such as the type, magnitude and duration of sound, proximity of birds and their habitats to sound sources, and the levels (and nature) of background ambient sound, and the ability of birds to habituate to new noise.

The primary impact would be on bird behavior. For example, above water sound may disturb roosting, nesting, or foraging birds directly and cause them to flush from the area. Also, underwater sounds could disturb foraging behavior or disturb prey that water birds, especially diving birds, forage on, or result in auditory and non-auditory injury for species such as marbled murrelet (Science Applications International Corporation 2011). This may be a less direct effect, but an impact that occurs concurrently with the Project activities.

There is not a clear threshold of underwater sound level that will result in behavioral effects for most bird species and the threshold for sound from various activities may vary among species. For marbled murrelets, guidelines for a threshold for underwater sound (from activities such as pile driving) that results in behavioral effects such as flushing and avoidance is 150 decibels (dB) root-mean-square pressure (USFWS 2014), and for auditory injury is 202 dB sound exposure level (Science Applications International Corporation 2011).

Noise and boat traffic may also disturb roosting and foraging birds and cause them to flush from the area. For example, acoustic effects from increased boat traffic during construction could disturb marbled murrelets that forage in the subtidal entrance channel and near King Salmon (Fowler pers. comm. 2022); however, they currently forage in regions that have significant existing boat traffic. It is possible they may become accustomed to additional noise from vessel use. Other foraging shorebirds and roosting birds are similarly habituated to existing industrial noise.

4.2.3 Fish

During the construction phase of the Project, fish inside Humboldt Bay may experience effects of dredging, and pile removal and driving (i.e., habitat disturbance, changes to water quality, noise, entrainment impacts). They may also experience the effects of upland related activities, particularly related to lighting, and effects from anchoring and ballasting of wind platforms (e.g., habitat disturbance, entrainment impacts). These potential effects can be reduced by incorporating proper minimization and mitigation measures. The potential effects may vary based on the species and life stage.

4.2.3.1 Habitat Change

Activities in the marine development and wet storage subarea functionally alter the existing habitat. Dredging removes sediment, including any epibenthic and benthic invertebrates that are incapable of swimming away (e.g., polychaetes, clams) (NMFS 2016e). Pile removal has similar impacts, in that organisms colonized on and nearby the piles are removed. Such changes may influence the short term (benthic) prey available for special-status fish in Humboldt Bay, in particular green sturgeon; however, the degree of impacts depend on species recolonization rates, which vary based on the spatial scale of disturbance, sediment grain size, sediment compaction, water depth and edge to surface area (NMFS 2016e). It also depends on the speed and success of adult migration and/or larval recruitment (USACE 2004). Recolonization of dredged sites could take place quickly, although the re-establishment of more stable benthic communities could take several months to years post dredging (p. 45 *in* USACE 2004).

Fish may also experience longer term impacts of habitat change because intertidal and shallow subtidal mudflats will be converted into deeper subtidal zones, and the existing channel will be dredged to a deeper depth (approximately -60' as measured at MLLW tide for a sinking basin in the marine development subarea and -40' for berths and wet storage subarea). The change in habitat type has potential to alter species distribution and habitat use. There may also be indirect effects: the changes in habitat type may affect productivity, which may drive changes to the food web.

Green Sturgeon—Adult and subadult green sturgeon are temporary residents inside Humboldt Bay. Based on acoustic monitoring efforts with receivers throughout Entrance Bay, one in the Main Channel, and several throughout North Bay, they move through the project area and are detected in greatest numbers in North Bay (Pinnix 2008) to access known holding grounds. They specifically use North Bay and North Bay Channel near Samoa Bridge to hold in the summer/fall months (Pinnix 2008, Lindley et al. 2011).

There may be short-term effects of habitat change on green sturgeon because construction activities, primarily dredging, will directly remove potential prey (green sturgeon are primarily benthic feeders). Green sturgeon may shift their distribution within the bay as a result. However, impacts may be temporary because benthic species can recolonize over time. Green sturgeon are also not fully dependent on Humboldt Bay: they move in and out of other estuaries and natal rivers along the west coast before migrating to spawning rivers, (e.g., Sacramento River) (Lindley et al. 2008, 2011). Any temporary loss of benthic prey and redistribution within

Humboldt Bay is not likely to impact their population long-term. The deepening of habitat from dredging may even increase the available habitat for them to forage and hold in the long term (green sturgeon appear to forage in deeper channels of bays, and in Humboldt Bay they forage primarily around North Bay Main Channel and Arcata Channel [Kelly et al. 2007, Moser and Lindley 2007, Lindley et al. 2011]).

Salmonids—Unlike green sturgeon, salmonids primarily use the bay as a migratory corridor. Species-specific information on the life-stages, timing and duration in Humboldt Bay and diets for salmonids are described in depth in Section 3.0. Salmonids are less likely to experience effects of the (temporary) loss of benthic prey from construction and longer term habitat change. Juvenile salmonids migrate relatively quickly through the bay to coastal waters once they undergo the physiological transition to survive in the marine environment. Since salmonids are using the bay primarily as a corridor and exposure to the project area would only be for a short duration, the loss of direct feeding opportunities due to construction (short-term) and habitat change (long-term) would not impede key foraging. This is in part because salmonids feed in the water column and are not benthic foragers. Their prey are not being removed from dredging as may be the case with green sturgeon. Salmonid migrations also occur during coastal upwelling, when waters are highly productive and critical food resources for growth and survival are most abundant outside of the bay.

A deeper channel and removal of existing pilings and pier may benefit coho salmon long term, as acoustic detections found that tagged coho salmon smolts in Humboldt Bay prefer deeper channels and channel margins inside Humboldt Bay compared to structures such as pilings or docks (Pinnix et al. 2008, 2013). Similarly, steelhead may benefit from the channel deepening: those moving through the project area are in their second and third year of life. They are relatively large and remain in relatively deep water as they move (rapidly) through the estuary (Wallace and Allan 2007, NMFS 2021d). Long term, there may be indirect impacts on the critical habitat of salmonids. The deepening of the habitat may affect the prey species that juvenile salmonids forage on during their outmigration, however, because salmonids are using the bay as a migratory corridor and food resources are greater on the open coast, impacts are unlikely to be significant.

Longfin Smelt—LFS larvae are unlikely to be present in the project area. This is in part because the habitat does not support larval rearing as the water is too saline. Direct effects of habitat change on larvae are thus not expected. Adult and juvenile LFS may be present in the project area and subject to effects of habitat change. Since they are not strictly benthic foragers, the potential short-term impacts of habitat change and loss of benthic prey are unlikely to be significant. There may be impacts from longer term changes in depth, however. The exact impacts and degree of significance remain unknown and have not been studied within Humboldt Bay. Based on long-term sampling in the SFBE and subsequent analyses on their population dynamics and distribution, depth influences their distribution (Rosenfield and Baxter 2007). More specifically, catch per unit effort was significantly higher at 'deepwater' sampling stations in channels > 7 m deep compared to shallow, shoal stations with waters <7 m deep (Table 5 and Figure 6 *in* Rosenfield and Baxter 2007). This pattern of bathymetric distribution of postlarval LFS aggregating in deeper habitats has also been found in the Lake Washington population (Chigbu et al. 1998 and 2000, as cited *in* Rosenfield and Baxter 2007).

4.2.3.2 Entrainment from Dredging

There is risk for direct entrainment of fishes depending on the dredging methods used (e.g., hydraulic dredging) Benthic infauna are vulnerable to entrainment via dredging, as dredging removes the top layer of seafloor habitat. Mobile epibenthic and demersal organisms such as crabs are also vulnerable. Fish are susceptible to direct entrainment by the dredge itself or the operations of the dredge pump, but it depends on their presence in the water column and the exact dredging methodology.

The direct removal of state and/or federal ESA-listed species such as the longfin smelt, coho salmon, Chinook salmon and steelhead, would require a CDFW ITP and/or NMFS Section 7 Consultation. Entrainment rates for LFS have historically been estimated as the number of individuals per volume of dredged material monitored (U.S. Army Engineer Research and Development Center 2013). There are important technical design and biological factors that contribute to the direct removal of fishes: for hydraulic dredging, the volume of material removed, frequency and duration, and intake velocity, among other factors, contribute to estimated take. It is also important to consider that fishes have a sensory apparatus that allow them to detect and avoid dredge equipment (p. 28 *in* USACE 2021). Larger-bodied species and life stages often are strong swimmers as well. Those potentially present near the dredging site would be able to avoid becoming entrained in the dredge because they can outswim the suction approach velocities. This is discussed in more detail in Section 5.2.

Entrainment effects can be avoided and minimized through BMPs; however, mitigation would be required to compensate for incidental take of state-listed species and impacts on ESA-listed fishes or their critical habitat (See Section 5.2).

4.2.3.3 Water Quality

Dredging creates both short-term (e.g., decreased water quality) and long-term changes to the ecosystem (e.g., habitat change). The effects of annual maintenance dredging and disposal in Humboldt Bay on salmonids was reviewed by NMFS in a Biological Opinion (NMFS 2016e, 2021d). It was determined that annual maintenance dredging and disposal can occur in a manner that i) allows the federally threatened coho salmon and federally and state threatened Chinook salmon to not be exposed, spatially or temporally, to effects of routine dredging, ii) will not negatively impact adults on their spawning migration, and iii) will not modify their critical habitat (NMFS 2016e, 2021d). To meet these needs, annual maintenance dredging has seasonal restrictions, and was limited between March through September. It was also determined that annual maintenance dredging of the navigational channels and disposal would not adversely affect steelhead and green sturgeon, nor their critical habitat. While the Biological Opinion focuses on maintenance dredging in the main channels, the mechanisms of effect and considerations for avoidance and minimization provide useful information for understanding the effects of dredging for the proposed Project.

Dredging temporarily changes water quality by increasing turbidity and resuspending sediments. For fish in particular, increased turbidity and suspension of fine sediment reduces dissolved oxygen levels, decreases visibility for foraging, and impairs oxygen exchange by clogging gills. These anticipated short-term, indirect effects of dredging on water quality may potentially be manageable by employing work windows.

Activities in the upland subarea also have potential to impact water quality, if proper stormwater management and erosion control measures are not implemented.

4.2.3.4 Artificial Lighting

Historically, aquatic biota were adapted to natural nighttime light, only affected by the moon, stars, cloud cover, biological luminescence, and aquatic biota (Nightingale et al. 2006). Within the last ~100 years, fish have been exposed to ALAN and the impacts have become a focus of scientific research.

According to current Project design, construction activities in the upland and marine development, and wet storage subareas will likely result in ALAN. Fishes can potentially be affected by ALAN in several ways: changes to essential behaviors such as feeding, schooling, and migration, increased predation, and effects on metabolic processes and reproduction (Nightingale et al. 2006, Longcore et al. 2018, Longcore 2018, Brayley et al. 2021). The Project is not expected to affect spawning, since salmonid, green sturgeon, and longfin smelt do not spawn in the project area. The Project is also not expected to delay upstream migration of adult salmonids, because Humboldt Bay is a corridor, and adults are likely using water quality cues to move quickly through the channel to freshwater tributaries to spawn. The Project could increase susceptibility of outmigrating juvenile salmonids to predation since light disrupts their movements and attracts their predators.

Recent studies cover topics, including, for example, assessments of ALAN impacts on predator density and predation (Nelson et al. 2021) and experiments related to differential attraction of fish to lights with varying wavelengths (Tabor et al. 2021). These studies continue to support findings on spawning, predation, timing and movements:

- Adults likely use water quality cues to move quickly into tributaries used for spawning;
- Changes in light levels from shading or dock lights may interrupt salmonid movement (Johnson et al. 2005, Rondorf et al. 2010), but the greatest impact affecting the movement of juveniles and their susceptibility to predation are from the dramatic changes in light levels during the day, from bright light to shading;
- Strobes deter fish from swimming into portions of dams or navigational locks where there is increased risk of injury or mortality. These strobes are powerful, synchronously flashing lights, not equivalent to light levels reaching the water surface; and
- The activity of certain salmonids in San Francisco Bay (an analogous ecosystem), including green sturgeon, are independent of light level without discernable peaks in activity throughout the day or based on light level (Kelly et al. 2007).

4.2.3.5 Underwater Sound and Vibration

In-water construction activities may result in noise that has short-term (and potentially long-term) effects on fish. Exposure of fish to underwater sound (generally) can result in physical, physiological or behavioral effects (Hawkins et al. 2020, Molnar et al. 2020). Caltrans provides a technical guidance manual for assessing the hydroacoustic effects of pile driving on fish and related to feasible attenuation options (Molnar et al. 2020). Information on the latter is summarized in Section 5.4, and we recommend the manual be reviewed in detail throughout the Project design and permitting phase (Molnar et al. 2020).

The type of acoustic effect is determined by whether sound is from a long-term accumulation of increased sound, or an acute, singular event. Acute events above a certain sound threshold may result in physical injury. Impacts to fish are primarily related to effects of sound pressure levels on species with swim bladders (Hawkins et al. 2020). Tissue damage from underwater sound may occur when sound passes through muscle into a gas void (e.g., swim bladder), since gas is more compressible. When exposed to sound pressure, gas in the swim bladder may expand more than the surrounding tissue and may contract during periods of overpressure. This expansion and contraction may result in swim bladder tissue damage and even a ruptured swim bladder (page [p.] 3-4 *in* Molnar et al. 2020). These physical injuries have short or long-term effects, depending on whether the individual fish can recover. Salmon have ducted swim bladders connected to the esophagus via a thin tube, thus allowing them to expel air from their swim bladder and out of the mouth (p. 3-3 *in* Molnar et al. 2020). Their swim bladders are more distant from the ear and are more sensitive to particle motion, which may protect them from acute sound events (Hawkins et al. 2020).

Physiological impacts on fish from underwater sound also include changes in stress levels and metabolism, and reduced energy reserves, which may negatively impair their key life functions. Behavioral responses and physiological effects are most detrimental if fishes become more exposed to predators, are displaced from feeding or spawning grounds, and disrupted during migration or communication between individuals (Hawkins et al. 2020).

The scale of construction (particularly pile driving) is expected to result in sound pressure, particle motion, and vibration that may have a significant impact on fishes in the project area. Proper avoidance and minimization measures and BMPs should be employed to minimize the potential for interactions.

4.2.4 Marine Mammals

4.2.4.1 Foraging

Dredging, pile removal, and pile driving could indirectly impact the ability for marine mammals to rely on their routine foraging locations. Harbor seals, California sea lions, and harbor porpoises feed on crustaceans, mollusks, squid, and fish in deep channels throughout Humboldt Bay (Barnhart et al. 1992). These marine mammals are known to alter their foraging behavior in response to seasonal prey pulses in the area. If construction were to cause a short-term redistribution of their prey items, we would expect marine mammals to adjust their foraging behavior in the vicinity of the project area. Construction activities also result in suspended sediment and turbid plumes. This may temporarily reduce visibility to feed; however, there is minimal information to suggest that increased turbidity from dredging specifically would have a substantial direct impact on marine mammals because they often inhabit naturally dark and turbid environments, and rely on multiple senses to forage (Todd et al. 2015). It is also possible their prey redistribute outside of highly turbid plumes. Marine mammals are typically most impacted by dredging indirectly because dredging removes potential prey (Todd et al. 2015). Finally, it is expected that marine mammals can compensate for small-scale changes in prey abundance and that their food resources are unlikely to be removed to a degree that significantly impacts their long-term survival.

Effects of construction (from changes in water quality, or removal/redistribution of prey items) on the foraging behavior of marine mammals would be short-term. Any impacts would not extend past the construction work windows and are not expected to cause significant impacts to individuals or the larger populations.

4.2.4.2 Underwater Sound and Vibration

Marine mammals produce and use sound (or vocalizations) for various biological functions, including social interactions, foraging, orientation, and predator detection. Cetaceans in particular have highly developed acoustic abilities and can detect underwater sounds at great distances. Anthropogenic sound sources, especially at higher sound pressure levels (>150 dB), can cause behavior modifications that may reduce long-term growth and survival (NMFS 2018b). Interference with producing or receiving sounds could have adverse consequences on individuals, including impaired foraging efficiency from masking (occurs when environmental noise is great enough to cover or mask other sounds including those used for communications between individuals or for locating prey), altered movement of prey (due to avoidance of sound sources by prey), difficulty detecting prey, increased energetic expenditures, and temporary or permanent hearing threshold shifts (Southall et al. 2019, 2021). It can also cause physical injury. Detailed technical guidelines for assessing the effects of underwater sound on marine mammals (NMFS 2018b) and a summary document outlining current marine mammal acoustic thresholds (NMFS 2023c) are key references for identifying effects of acoustic stressors on marine mammals.

Disturbance from underwater sound, especially from pile driving, is expected. Acoustic disturbance may be limited in scale because of the configuration of the bay (e.g., narrow channel). Any present marine mammals are highly mobile and could disperse from the noise. Regardless, effects of pile driving on marine mammals may be considered an impact because even though construction is temporary, it will take several years to complete the pile driving activities. Acoustic disturbance should be minimized and avoided using appropriate BMPs (Section 5.0). Acoustic impacts to Southern Resident killer whales are unlikely because they do not enter Humboldt Bay.

Todd et al. (2015) provides an extensive and detailed literature review of the direct and indirect impacts associated with dredging, including noise production. Noise production from dredging depends on the type of dredger and its state of operations, local sound propagation conditions, and the receiver sensitivity and hearing bandwidth (the latter two are also factors associated with effects of other construction noise). Based on the overlap between dredging noise and hearing sensitivity, it is assumed that all marine mammals are prone to noise impacts from dredging. Potential effects are more acute for baleen whales, none of which are potentially present in the project area, and seals. These effects may include behavioral reactions and masking.

4.2.4.3 Haul-Out Sites

Construction activities for the Project will occur near known pinniped haul-out sites. A more detailed description on haul-out sites can be found in Section 3.3.4. Harbor seals are also known to haul-out at various locations in Humboldt Bay (Schlosser and Eicher 2012), including the southern reaches of Arcata Bay, mid-Arcata Bay, and throughout South Bay. Known harbor seal haul-out sites in Arcata Bay are further north of RMMT, and long-term changes to these habitats represent a small portion of the potential haul-out areas in the North Bay (harbor seals primarily haul-out at sites in the far reaches of North Bay).

Section 5.0 Measures to Minimize and Avoid Impacts

Potential impacts of construction, habitat change, and permitted operations from the Project can be minimized and avoided through Project design and there are a variety of measures to be considered. Since the Project is currently in its early design phase, the information presented throughout this section represents potential options to be considered and further explored as the Project develops. Much of the information presented was sourced from consultation documents for other projects.

5.1 Temporal Avoidance—Work Windows

A key component to avoiding (and thus minimizing) potential effects of construction for the Project on marine resources is to limit the potential interactions with the resource itself. By employing temporal restrictions (i.e., work windows) and timing disturbances outside of species' important life stages, considering seasonality, and avoiding certain criteria, significant direct and indirect effects of construction can be avoided. An in-water work window represents the time period with the least potential for a species, or a particular life history stage of a species, to be present in areas of the project that may be affected (p. 4-7 *in* Molnar et al. 2020). The seasonal criteria to avoid are taxa-specific and to some extent life-stage dependent. Tables 4 through 6 include information on a species' use of the project area can be referenced to determine sensitive periods.

In summary, to minimize impacts (particularly for pile driving and dredging), the ideal work window to reduce potential impacts on breeding birds is September through January. This is similar to the ideal work window for marine mammals, December through March; however, the ideal work window for salmonids is May/June through September. Green sturgeon are present in Humboldt Bay June-October, and longfin smelt may be present in Humboldt Bay year-round. The conflicting work windows between birds and marine mammals, and salmonids make it impossible to minimize impacts to each group through seasonal work restrictions (Table 10). Typically, the in-water work window for salmonids is followed because the potential impacts to fish species may be less avoidable than to birds and marine mammals, which can be monitored for presence and if present, operations can be adjusted to avoid impacts. Additionally, by operating only from May/June through September, impacts to salmonids can often be fully avoided. Under current project design, in-water construction will occur between July 1 – October 15 of each year (Humboldt Bay Offshore Wind Heavy Lift Marine Terminal Project: Draft Project Description [April 2024]). The following subsections outline key considerations for developing work windows.

Table 10. Idealized Work Windows for In-Water Work Including Pile Removal and Driving, and Dredging

	J	F	M	A	M	J	J	A	S	O	N	D
Land birds	■	■	■	■							■	■
Marine Mammals	■	■	■									
Salmonids					■	■	■	■	■			

5.1.1 Birds

Disturbance to nesting or roosting birds can be minimized. Initial direct disturbance to roosting birds can be minimized by removing piles and roost structures outside of the roosting season, which peaks between August and October for brown pelicans and May through July for cormorants (Barnhart et al. 1992, Hunter et al. 2005, Harris 2006).

Standard procedures should be followed to avoid disturbance to nesting birds protected under the MBTA. These include:

- **Avoidance of the Nesting Season—**To the extent feasible, commencement of demolition and construction activities should be scheduled to avoid the nesting season. If demolition and construction activities are scheduled to take place outside the nesting season, potential demolition/construction impacts on nesting birds protected under the MBTA and California Fish and Game Code will be avoided.
- **Pre-Activity/Pre-Disturbance Surveys—**If it is not possible to schedule demolition and construction activities between September 1 and January 31, then pre-activity surveys for nesting birds shall be conducted by a qualified biologist to ensure that no nests will be disturbed during project implementation. These surveys shall be conducted no more than seven days prior to the initiation of demolition or construction activities. During this survey, the biologist will inspect all trees and other potential nesting habitats (e.g., trees, shrubs, and buildings) in and immediately adjacent to the impact areas for nests.
- **Non-Disturbance Buffers—**If an active nest is found sufficiently close to work areas to be disturbed by these activities, the biologist will determine the extent of a construction-free buffer zone to be established around the nest (typically 300 feet for raptors and 100 feet for other species), to ensure that no nests of species protected by the MBTA and California Fish and Game Code will be disturbed during project implementation.
- **Nesting Deterrence—**If construction activities will not be initiated until after the start of the nesting season, all potential nesting substrates (e.g., bushes, trees, grasses, and other vegetation) that are scheduled to be removed by the project may be removed prior to the start of the nesting season (e.g., prior to February 1). This will preclude the initiation of nests in this vegetation and minimize the potential delay of the project due to the presence of active nests in these substrates.

5.1.2 Fish

Both NMFS 2016e and 2021d analyzed effects of maintenance dredging in federal channels in Humboldt Bay on listed salmonids and green sturgeon, with dredging occurring between March 15 and September 30. While this window minimizes impacts to steelhead and green sturgeon, there is still overlap with coho and Chinook salmon in March, April and May. To avoid impacts to all listed salmonids, a more conservative in-water construction window (May/June through September) for the proposed Project could minimize potential effects on most fishes; however, there may still be coho and Chinook salmon migrating through the area during this window.

If a May through September work window is used, potential impacts from will be minimized by timing in-water construction outside of periods when (most) juvenile salmonids and smolts are on their seaward migration and adult salmonids migrate into and through Humboldt Bay on their spawning migration. Specific details on timing of fish presence throughout the project area and Humboldt Bay to develop work windows can be found in Section 3.4.3 and the species use tables (Tables 4 through 6). Adult Pacific herring are likely present in or near the project area spawning between December through February/March and would be avoided when following a May/June through September work window (note, their larvae may be present through May. Adults leave directly after spawning). Several other fish species with vulnerable larval stages are in the bay during the avoidance windows for salmonids and longfin smelt, including other species of larval smelt/osmerids (Tenera Environmental 2023), and adult green sturgeon.

5.1.3 Marine Mammals

The presence and abundance of pinnipeds in Humboldt Bay peaks during pupping and molting season (spring through summer). For example, harbor seal abundance and site fidelity to haul-out sites peak in the summer during pupping and molting, and decline in winter when individuals disperse to forage in offshore waters (Sullivan 1980, Herder 1986, Goley and Harvey 2010). California sea lions follow a similar pattern, though they do not breed in the bay. Marine mammals, especially harbor seals, opportunistically feed on Pacific herring runs and will feed on the dense adult herring schools when the fish are spawning in the bay (Kramer pers. comm. 2023). Since activities will occur during periods of peak presence of marine mammals, proper monitoring and BMPs for construction operations should be followed, including following recommendations for in-water work windows for salmonids (see Section 5.1.2).

5.1.4 Work Window Recommendations

As the Project design advances, we recommend considering the benefits of extending work windows beyond those typically requested. There may be benefits to extending construction work windows if it allows construction activities to be consolidated into fewer years because fewer age classes will be affected. For example, by extending a typical work window, construction can be completed over a shorter period. The impacts would be more concentrated rather than spread out over years. This could be particularly important for migratory salmonids, where, for example, completing a specific activity over a longer work window rather than shorter work windows over several years, would impact fewer year classes. Alternatively, it is possible to prioritize spreading out potential impacts over a greater time frame and working within a typical window, although this may mean that more year classes would be exposed to stressors.

In addition to considering the species impacted by using certain construction work windows and the length of exposure, extended work windows could be used for specific activities, with the activities posing lesser impacts taking place during the ends of the window to minimize impact. For example, vibratory piles could be set in the extended window, and finished during the main window. This also relates to Project phasing. It will be important to consider the impacts from various activities that may occur on either end of the work window for various taxa when determining if work windows should be extended to consolidate construction into fewer years.

Another aspect of work window recommendations relates to efficiency. Due to the scale of construction and known conditions in Humboldt Bay, it is critical to maximize weather windows and drive (and dredge) when conditions allow. For example, rather than having daily restrictions on the number of piles driven per day, it might be best to base restrictions off the entire available work window, as pile driving is highly weather dependent. It may also be preferable for pile driving to occur before dredging because pile driving is more difficult to complete (due to logistical constraints and the need for ideal weather) and has the greatest acoustic impacts. Therefore, completing pile driving prior to dredging ensures the activity with the greatest logistical challenges and greatest disturbance are prioritized. Compared to pile driving work windows, it is also easier to extend the work windows for dredging.

5.2 Dredging and Pile Removal Best Management Practices

In addition to temporal avoidance, BMPs should be incorporated into the Project design to minimize potentially significant effects of in-water construction. The BMPs outlined in this section are general, have been followed for other projects in Humboldt Bay, and represent options to be considered as the Project design develops.

5.2.1 Dredging

The following general avoidance and minimization measures are followed for maintenance dredging of the federal navigation channels in Humboldt Bay (NMFS 2016e, 2021d), and could be implemented for the proposed Project:

- Limit the duration of overflow to the extent practicable during each dredge cycle;
- Standard best-management practices will be applied to protect species and their habitat(s) from pollution because of fuels, oils, lubricants, and other harmful materials. Equipment that is used during the proposed project will be fueled and serviced in a manner that will not affect federally protected species in the project area or their habitats;
- A Spill Prevention Control and Countermeasure (SPCC) plan will be prepared and implemented to address the emergency cleanup of any hazardous material and will be available on site. The SPCC plan will incorporate measures to address hazardous waste, stormwater, and other emergency planning requirements;
- Well-maintained equipment will be used to perform the work, and, except in the case of a failure or breakdown, equipment maintenance will be performed off site. Equipment will be inspected daily by the operator for leaks or spills. If leaks or spills are encountered, the source of the leak will be identified,

leaked material will be cleaned up, and the cleaning materials will be collected and properly disposed of;

- Fueling of marine-based equipment will occur at designated safe locations adjacent to the proposed project. Spills will be cleaned up immediately using spill-response equipment. Exercise every reasonable precaution to protect listed species, critical habitats, and EFH from pollutants and other deleterious materials.

Different types of dredging methodologies result in different ecological effects based on the equipment used and how it operates. Regardless of the dredging method, BMPs should be employed to minimize potentially significant effects. General dredging BMPs used by the District include:

- In water work is scheduled to be implemented between July 1 and October 15 when no salmonids are present thereby avoiding impacts on these species;
- Vessel operators will follow designated speed zones to and from the project area;
- The contractor will use GPS until to ensure that material is removed from the correction locations;
- Contractors will not be allowed to dredge beyond the permitted dredge depth or outside the designated limits of work;
- Over-dredging at the base of the slope will not be allowed;
- Equipment and vessel operators will be certified accordingly and experienced with the dredging means and methods;
- Project dredging activities will be conducted as efficiently as possible to reduce navigation delays within for vessels;
- A debris boom will be installed during in-water construction. Any debris accidentally entering into the water will be recovered and transported to a disposal site, or recycled, if appropriate;
- Prepare and implement a spill prevention and management plan;
- Prepare and implement a dredge slurry and hazardous materials spill contingency plan.

If suction dredging is proposed for the final Project design, the following BMPs should be considered:

- A debris boom will be installed during in-water construction. Any debris accidentally entering into the water will be recovered and transported to a disposal site, or recycled, if appropriate;
- Adaptive management measures will be taken (i.e., monitoring to determine whether dredging/ placement rate needs to be adjusted based on efficacy of dewatering);
- Dredge pump will be primed close to the bottom of the channel to reduce potential for longfin smelt entrainment;

- The cutter head location will be monitored to ensure that it maintains contact with the bay floor;
- No dredging will occur in the 5-ft buffer area outside of the designated dredge footprint;
- Impacts on eelgrass in the buffer area will be limited to turbidity and settling of suspended sediment, which will clear in a few tidal cycles;
- The dredging elevation will not extend below the permitted 1-foot over-dredge within the dredging limits.

If clamshell or excavator dredging is proposed for the final Project design, the following BMPs should be considered:

- Closed clamshell buckets will be used to reduce sediment mobilization and turbidity;
- Bottom stockpiling or multiple bites of the clamshell will not be allowed;
- Sediment volume will be monitored to ensure the excavator or clamshell bucket will not be overfilled;
- The bucket will swing directly to the barge after it breaks the water surface to minimize the distance the material is transported over water.

5.2.1.1 Humboldt Bay Sediment Management Plan

The Programmatic Environmental Impact Report (PEIR) for the Humboldt Bay Sediment Management Plan explores alternatives and analysis dredging methods, sediment processing, and sediment placement at beneficial-use sites (p. 2-1 *in* ICF 2020). Section 3.11 in the PEIR describes the environmental and regulatory settings for biological resources and evaluates potential impacts on biological resources. It also presents mitigation measures to reduce potential impacts. Section 5.3 in the PEIR outlines all mitigation measures for potentially significant impacts, listing the proposed avoidance, minimization and/or mitigation measures. The following measures from the PEIR include the following:

- Hydrology and Water Resources
    - HWR-1: Minimize turbidity during maintenance dredging;
    - HWR-2: Prepare and implement spill prevention and management plan;
    - HWR-3: Prepare and implement dredge slurry and hazardous materials spill contingency plan;
    - HWR-4: Implement erosion and sediment control measures;
    - HRR-5: Implement BMPs during operation of dredged material processing sites;
    - HWR-6: Implement measures at dredged material processing sites and beneficial-use sites to protect groundwater quality;
    - HWR-7: Design and implement dredged material beneficial use projects to avoid adverse alterations of onsite drainage.

- Biological Resources
    - BIO-1: Establish an environmental work window for all dredge operations;
    - BIO-2: Avoid equipment staging and/or anchoring within eelgrass beds;
    - BIO-8: Utilize offshore anchoring of the dredge slurry pipeline;
    - BIO-9: Implement tide limitations for in-water work.

5.2.1.2 Hydraulic Dredging Recommendations

As mentioned previously, fish have sensory apparatus that allow them to detect and avoid dredge equipment. Larger-bodied species and life stages often are strong swimmers as well. Those potentially present near the dredging operations would be able to avoid entrainment in a hydraulic dredge because they can outswim the suction approach velocities. It is particularly important for the final Project design to reduce the likelihood of entraining CESA-listed longfin smelt and coho salmon (as it has implications for compensatory mitigation required to obtain a CDFW Incidental Take Permit).

The dredging components of the Project can be designed in a manner that minimizes entrainment risk by considering the discussion on longfin smelt and their ability to outswim the suction approach velocity. This is well summarized on page 18 in Stillwater Sciences (2016): Clausner (2005) studied the water intake velocities for seven different-sized hydraulic dredge suction pipes from 12 to 36". The study confirmed that a 12" suction pipe has the lowest water velocity of roughly 22 cm/s (0.75 feet per second [fps]) at 0.5 m from the cutterhead. The velocity increases to 5 cm/s (0.16 fps) at a 1 m distance from the cutterhead (Figure 8). There is no data available on LFS swim speeds; however, there is information on other smelt species that are used as surrogates: U.S. Army Engineer Research and Development Center (2013) used swim speed data for European smelt (*Osmerus eperlanus*) as a surrogate. Their swim speeds are conservatively estimated to be between 25 and 40 cm/second. If hydraulic cutter suction dredging is used, the suction pipe diameter should be considered because it determines intake velocity, which contributes to take estimates. For example, using an intake velocity of a 12" hydraulic dredge pipe, a smelt would need to be < 0.5 m (1.6 ft) from the cutterhead, disregard the turbidity in the immediate vicinity, and not be otherwise disturbed by the cutterhead or Water Suction Jet to be entrained. In this scenario, as long as the dredge, when operational, remains < 0.5 (1.6 ft) m from the bottom, the velocity of the intake is less than the swim speed, preventing entrainment.

5.2.2 Pile Removal

BMPs should also be implemented to minimize impacts from hazardous materials resulting from spills or leakage from machinery during near or in-water construction activities. The following two BMPs may also be relevant for dredging activities.

- All equipment will be checked before use to minimize risk of a release to the bay. A spill response kit, including oil absorbent pads will be on-site to collect any product that is accidentally released; and

- The District will implement a spill prevention and response plan to minimize the potential for project-related contamination of bay waters. The dredge and support vessels will contain spill kits.

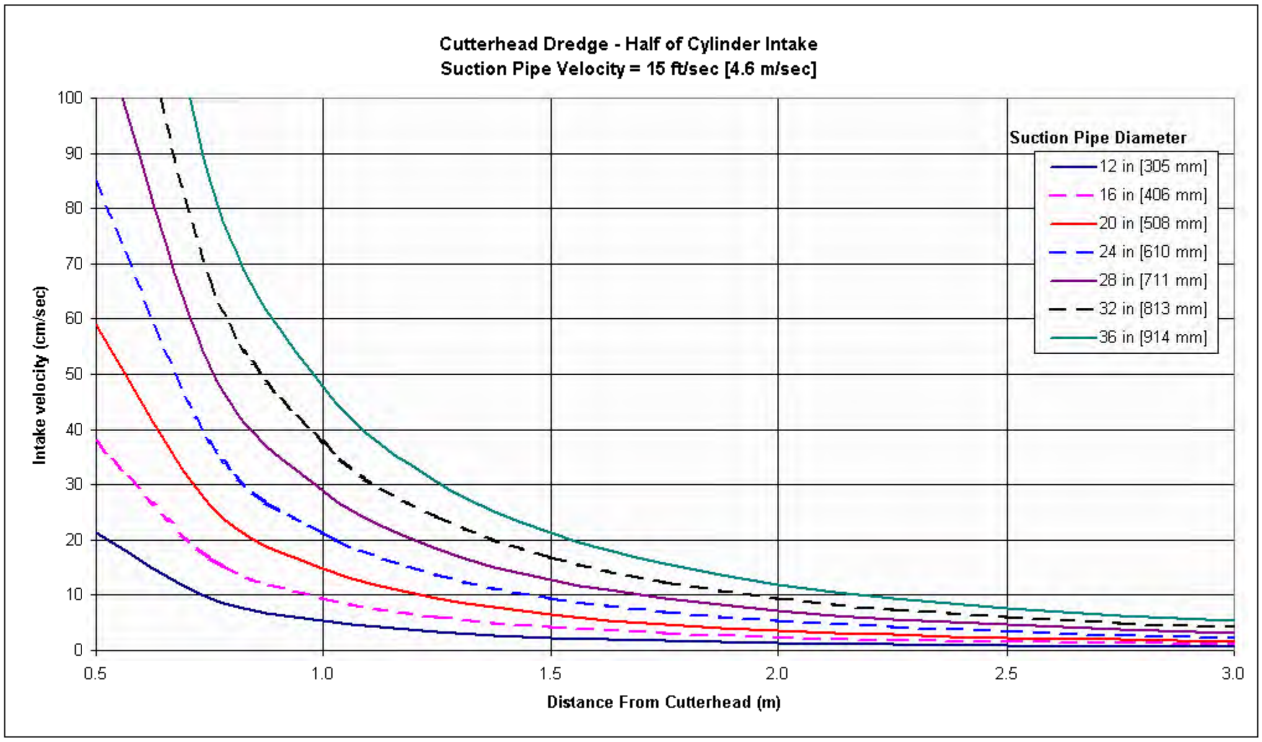

Figure 8. Cutterhead Suction Pipe Approach Velocities
Source: Clausner 2005 *in* Stillwater Sciences 2016

A series of BMPs specifically for pile removal should be employed to avoid the mobilization of contaminants during pile removal activities (and impacts to eelgrass), as many of the piles being removed are expected to contain toxic materials (i.e., creosote). The potentially relevant BMPs may include:

- Neither the barge nor the tug will anchor during the project. The barge may attach to existing piles to maintain its position;
- During the barge method, piles will be removed at a tide of sufficient elevation to float the barge and tugboat adjacent to the piles being removed without scarring the mudflats or injuring eelgrass;
- Grounding of the barge will not be permitted;
- A floating containment boom will surround each pile being removed to collect any debris suspended during removal. To collect debris that floats below the surface but does not sink to the bottom, weighted plastic mesh (similar to orange construction fencing) will be attached to the boom and extended across the area surrounding the pile. If debris sinks to the bottom, then it will be removed by a diver;

- All equipment will be checked before use to minimize risk of petroleum product releasing to the bay. A spill response kit, including oil absorbent pads will be onsite to collect any petroleum product that is accidently released;
- The crane and tug operators will be experienced with vibratory pile removal;
- The crane operator will break the soil/pile bond prior to pulling to limit pile breakage and sediment adhesion;
- All work should be confined to within the floating containment boom;
- Piles will be removed slowly to limit sediment disturbance;
- Piles will not be hosed off, scraped, or otherwise cleaned once they are removed from the sediment;
- Piles will be placed in a containment area on the barge to capture sediment attached to the piles;
- The containment area will be lined with plastic sheeting to not allow sediment or residual water to reenter the bay;
- Sawdust or woody debris generated from pilings that are cut 1 foot below the mudline using a saw are to be retrieved and placed in the containment area;
- Holes left in the sediment by the pilings will not be filled. They are expected to naturally fill;
- Piles and debris will be removed from the barge carefully and moved to designated site for disposal preparation. Prior to disposal, the piles and debris will be stored on a paved surface, covered with tarps, and surrounded by an erosion boom, straw waddle, or hay bale perimeter; and
- All removed piles or portions of piles will be disposed of at an authorized facility. No piles or portions of piles will be re-used in Humboldt Bay or along shoreline areas;
- Land operations will not be conducted in wetlands in proximity to the staging site.

5.3 Pile Driving BMPs—Sound Level Minimization

Due to the sheer volume of driving necessary for the Project (upwards of 1200 in-water piles per wharf) and because pile driving is expected to have adverse effects, sound level minimization techniques must be considered. For fish species in particular, avoidance and minimization measures must be considered because CESA (and ESA) require Caltrans to avoid and minimize impacts to listed species when it is reasonable and feasible (p. 2-17 *in* Molnar et al. 2020). Molnar et al. (2020) provides detailed technical guidance related to assessing pile driving related engineering methods and potential species impacts, environmental permitting of pile driving projects, and feasible sound minimization options. These guidelines are provided in the context of fish, but the information can be applied to marine mammals as well. Many of the BMPs and sound level minimization techniques summarized in this section should be referenced for greater detail as permitting and Project design continues.

There are several ways to minimize underwater sound from pile driving. These include reducing the noise at its source, absorbing it, or breaking its transmission path (Wochner 2019). Various avoidance and minimization methods and devices, referred to as attenuation measures, have been developed for deployment and designed to reduce underwater sound pressure. The measures below are commonly used to reduce sound levels of pile related activities and should be considered for the Project.

The feasibility of attenuation methods depends on operational constraints and cost. There is a trade-off between cost, sound minimization methods, and time to complete pile driving activities (so that work windows are not exceeded). A more detailed analysis will be required to identify the most feasible options.

5.3.1 General BMPs

To minimize impacts to marine resources and critical habitat (particularly fish and marine mammals) in the project area during in-water construction, particularly pile related activities, the following general measures could be taken (Molnar et al. 2020):

- **Project Timing—**Establish in-water work windows and conduct all in-water work within the work windows established to avoid and/or minimize effects of construction on species or sensitive habitats.
- **Vessel Traffic—**Most of the effects associated with increased vessel traffic can be minimized; for example, low speed limits can reduce the noise from vessels, risk of collision, and the effects of propeller turbulence and wake.
- **Pile Placement—**Land-based piles and innovative design should consider whether in-water pile driving is unavoidable. Details on innovative design for pile placement and protocols for Project design and permitting are available on p. 8 in Molnar et al. 2020.
- **Pile Driving Equipment and Soft Start Technique—**It may be possible to use alternative pile driving equipment that produces lower peak sound levels. For example, it may be possible to use vibratory hammers for the initial start. The potential to use alternative methods depends on the pile size and composition, the bearing capacity necessary for the pile, and substate conditions, and should be considered as the construction design advances. Pile driving with an impact hammer can be employed with a 'soft start' technique. This requires that the initial strikes of a piling with an impact hammer are not performed at full force, but at a reduced force that slowly builds to full force over several strikes.
- **Assessment and Monitoring—**Develop and implement a hydroacoustic assessment and monitoring plan that provides details on the sound attention system and the methods used to monitor and verify sound levels during pile driving activities (more details in Section 5.4).

5.3.2 Bubble Curtains

Bubble curtains generally minimize sound levels and break the transmission path of noise (Wochner 2019). Bubble curtains change the local impedance in the area where bubbles are introduced, which can have two effects (p. 2-21 *in* Molnar et al. 2020). Change in impedance can act as a barrier for sound to pass through once the sound is radiated from the pile. It can also reduce the radiation of sound from the pile into the water by having low-density bubbles close to the pile itself. Air bubble curtains can be confined or unconfined. In the former, bubbles are confined to the area around the pile and would be most useful for this Project because of the strong tidal currents nearby, and the potential for bubbles to be swept away from the pile itself.

Bubble curtains are relatively costly, can greatly reduce the productivity of pile driving, and may only reduce sound levels negligibly (Ansingh pers. comm. 2023). In fact, a project in Puget Sound that involved replacing an old dock with a regional multimodal transportation hub found that bubble curtains provided negligible change to sound levels (~4 dB), were too costly, and greatly reduced the productivity of pile driving (Ansingh pers. comm. 2023). Since the Project may have short work-windows and given the total amount of driving required, further analysis considering costs, the timeline of the Project, and degree to which bubble curtains minimize acoustic effects must be considered.

5.3.3 Coffer Dams

Coffer dams are a method of sound attenuation designed to break the transmission path of noise. They are primarily for pile driving methods that require excavation for footing arrays or to dig below the mudline during in-water pile driving (p. 2-29 *in* Molnar et al. 2020). The typical application of coffer dams is for them to be dewatered down to or beneath the mudline. By isolating the water, underwater pile driving sound pressure can be substantially reduced (although not fully eliminated). Coffer dams may be constructed with constructed with sheet piles or water bladders, with discrete areas during pile installation.

5.3.4 Double-Walled Piles

As the design of the Project develops, the use of double-walled piles should be considered. Double wall isolation casings around piles are hollow casings slightly larger than the pile itself being driven. The airspace between the inner and outer pile breaks the transmission path of noise while the inner pile is being driven. The diameter of the pile and blow energy used during pile driving will be factors to consider as well.

5.3.5 Pile Installation Methods

Underwater sound from pile driving is generated based on the type and diameter of piles, types of hammer, and substrate (p. 7.37 *in* Washington State Department of Transportation [WSDOT] 2020). Depending on the configuration of the construction design, different noise levels and waveform characteristics will be produced (p. 7.37 *in* WSDOT 2020).

There are various methods of pile installation, including continuous vibratory hammers and impact hammers. Vibratory methods drive piles into the sediment using an oscillating hammer and placing it on top of the pile itself. The vibration causes the sediment surrounding the pile to liquefy, thus allowing the pile to be driven into the sediment (p. 7.37 *in* WSDOT 2020). Vibratory methods produce non-impulsive sound of less pressure compared to impulsive sound from pile driving and can be used for certain soil types. This is a way to reduce noise from the source. Vibratory hammers avoid peak single strikes and minimize the strike count during placement of piles to depths of 20 to 30 feet (p. 2-30 *in* Molnar et al. 2020). While their peak sound levels are substantially less than what is produced via impact hammers, vibratory methods operate continuously, require more time for installation, and may require an impact hammer to reach its final depths. Vibratory methods are generally considered to be the least harmful and preferred method, but the feasibility of pile driving methods must be determined through geotechnical surveys and cost analyses, identifying the potential tradeoffs between efficiency, and consideration of work windows.

To the extent possible, piles could be driven during low tide periods in intertidal and shallow subtidal areas to prevent injuries (to fish and marine mammals). While vibratory hammers may be recommended to drive steel piles, in conditions where impact hammers are required, it is recommended that piles are driven as deep as possible with the vibratory hammer prior to using an impact hammer. A block of wood could be placed between the impact hammer and the piling to attenuate sound.

5.3.6 Performance Standards

Performance standards for pile driving would include monitoring the actual pile driving activity to verify the estimated underwater sound pressure levels at various distances (p. 4-15 *in* Molnar et al. 2020). Pile driving logs compiled during pile driving activities can be useful for performance evaluations. Data recorded may include activity date, location of the pile, type of pile driver, depth, type and diameter of the pile, blow counts, among others (4-15 *in* Molar et al. 2020). This would all be encompassed in the hydroacoustic monitoring assessment and plan.

5.3.7 Phasing and Self-Mitigation

In addition, the phasing of in-water construction is critical, and it is possible there will be a degree of self-mitigation (Gall et al. 2023). Gall et al. (2023) investigated the effects of pre-piling activities on the occurrence of harbor porpoises and the local soundscape during the construction of two OSW farms in Scotland. The overall detection rate was reduced by up to 33% from 48 hours before using acoustic deterrent devices and soft start techniques, and prior to pile driving. This provides evidence of displacement and the need to account for disturbances from multiple sources (there are differences in vessel and operational procedures that influence the soundscape) to reduce impacts on marine mammals and optimize mitigation. More importantly, it demonstrates how pile driving activities can be self-mitigating, as pre-piling activities using vessels can displace animals and reduce potential interactions with noise once pile driving starts.

5.4 Marine Mammal Specific Required Measures

Work windows for in-water construction will follow the suggestion for salmonids (May/June through September). To avoid and minimize potential impacts to marine mammals, other standard operating procedures (SOPs), including BMPs, should be incorporated into the Project design. The BMPs outlined in Section 5.2 related to pile driving are particularly pertinent to marine mammals because pile driving is expected to significantly elevate underwater noise.

ESA consultation is not expected to be required for marine mammals because none of the species likely to occur in the project area are listed; however, additional measures that ensure compliance with the MMPA, including measures that address harassment, may be expected. Harassment is defined as any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild (i.e., Level A harassment), or that has potential to disturb a marine mammal or stock in the wild by causing disruption to behavior (e.g., migration, breathing, nursing, breeding, feeding or sheltering but which does not have the potential to injure; known as Level B harassment) (NMFS 2018b). Criteria for assessing auditory injury for Level A harassment is provided by NMFS (2018b, 2020b). These criteria are based on the hearing sensitivity of different marine mammal groups to impulsive and non-impulsive noise exposure. An IHA can be granted if NMFS determines that the incidental take would have a negligible impact on the marine mammal species or stock (as outlined in Section 3.2.1) and will serve as the primary means to avoid and minimize potentially significant effects of the Project on marine mammals.

An IHA will likely be required for the proposed Project due to potential behavioral harassment associated with construction activities, and to a lesser extent, long-term habitat change after project completion. The IHA will outline permissible take methods in addition to requirements for mitigation, monitoring, and reporting of take.

The following information and measures were compiled from notices for issuances of IHAs for other projects that included pile driving, and useful CEQA and permit conditions from mitigation, monitoring, and reporting programs (Molnar et al. 2020, NMFS 2023d). The information presented herein represents examples of avoidance and minimization BMPs that can be expected to be incorporated into the IHA for this Project. The exact measures and requirements for the Project will continue to be developed and will ultimately depend on the final Project design. Compliance with the IHA is expected.

5.4.1 Shutdown Zones

The purpose of shutdown zones (i.e., exclusion zone) is to define an area where a shutdown of an activity will occur upon sighting a marine mammal. If a marine mammal enters the defined shutdown zone (there is a standard minimum radius of 10 m for a shutdown zone during in-water construction activities, but this will depend on final Project design and IHA), in-water activities may be stopped and cannot commence until there is visual confirmation that the animal has left the zone and has not been resighted in the zone for 15 minutes. The channel where construction activities will be taking place is narrow. As a result, it is possible that the shutdown area will be relatively confined, even though sound may travel throughout the channel.

5.4.2 Pre-Activity Monitoring

Before starting daily in-water activities (or whenever a break in pile driving of 30 minutes or longer occurs), a qualified biologist or protected species observers (PSOs) may conduct a preconstruction survey and observe the shutdown and monitoring zone for a total of 30 minutes. The zone is typically considered clear if a marine mammal has not been observed within the zone for a 30-minute period. Pile driving and other in-water construction activities may be delayed or halted if a marine mammal is observed within the shutdown zone.

Pre-construction monitoring may also take place over the course of several days prior to the start of in-water construction activities. The purpose of this would be to update occurrence information on marine mammals in the project area.

5.4.3 Protected Species Observers

During Project activities, PSOs will ensure that the entire shutdown zone is visible. If the entire shutdown zone is not visible (e.g., due to weather), in-water construction activities should be delayed until the PSO is confident that marine mammals could be detected and are not within the shutdown zone. It is expected that a qualified biologist or PSO will be present during pile installation, although the extent to which a PSO is required as well as their responsibilities will depend on the final Project design and installation methods. A biologist or PSO may also be required for marbled murrelets, which are federally threatened and known to forage in Humboldt Bay (Section 3.3.1; USFWS 2014). Construction may be limited to daylight hours when marine mammal monitors can be present. Other potential responsibilities of PSOs are outlined in the monitoring and reporting section.

5.4.4 Soft-Start Procedures

Soft-start techniques (including ramp-up and dry fire) provide additional protection to marine mammals. By gradually starting pile driving (e.g., move around the project area and start equipment sequentially), soft-start procedures avoid startling marine mammals with sound and provide a warning and/or a chance for the animals to leave the area. Soft-start pile driving requires contractors to provide an initial set of strikes at reduced energy, followed by a 30-second waiting period, then two subsequent reduced-energy strikes prior to operating at full capacity. Soft-start procedures are recommended by NMFS for vibratory and impact pile driving. Depending on final Project design, a soft-start should be implemented at the start of each day and at any time following a 30-min or longer cessation of impact driving (NMFS 2023d).

5.4.5 Monitoring and Reporting

The monitoring and reporting requirements established by NMFS for issuing an IHA must be followed. The purpose of monitoring and reporting is to increase knowledge of the species and the level of harassment on individuals and populations of marine mammals that is expected during Project activities. Visual monitoring will be conducted by PSOs and may be expected to be required, especially during pile installation, to determine presence of marine mammals and whether individuals are displaying avoidance behavior or other signs of being negatively affected by installation activities. Marine mammal monitoring reports are required to be submitted to NMFS within a certain time frame after the completion of a certain activity. The monitoring report may include a description of the work completed, a narrative of marine mammal sightings, and datasheets from the PSO.

5.4.6 Hydroacoustic Monitoring

For the issuance of an IHA, a means of accomplishing the necessary monitoring and reporting is required, and a hydroacoustic monitoring plan may be expected. The overall goal of hydroacoustic monitoring is to ensure compliance with the IHA and ensure authorized take is not being exceeded (and can be used for fish as well). Hydroacoustic monitoring is needed to verify estimated sound levels and effectiveness of minimization measures, to provide details on the sound attenuation system, to monitor and verify sound levels during pile driving activities, and to avoid and minimize marine mammal (fish and bird) acoustic thresholds from being exceeded. Such a monitoring program would begin with desktop studies to model sound and estimate distances where pile driving thresholds may be exceeded. The results from these studies will then be used to determine potential effects on marine mammals, fish and turtles exposed to elevated levels of underwater sound from pile driving using tools developed by National Oceanic and Atmospheric Administration and NMFS (NMFS 2018b, 2020b, 2023b).

Based on suggestions from a project in Puget Sound that involved replacing an old dock with a regional multimodal transportation hub, a pilot study on in-water monitoring should be conducted as early as possible in the pile driving process to determine the number of PSOs required for the duration of the pile driving activities (Ansingh pers. comm. 2023).

In-water hydroacoustic monitoring would then serve as a pilot study to verify how far sound travels and confirm the sound propagation distances estimated by the desktop studies. In-water hydroacoustic monitoring would involve deploying hydrophones, collecting data to calculate the attenuation rate and distances, and comparing the data collected to relative marine mammal (fish and bird) thresholds. Technical guidance on thresholds for marine mammals can be obtained from NMFS (NMFS 2018b, 2020b, 2023b, 2023c).

5.5 Upland Activities and Habitat Restoration

Upland demolition and construction activities have the potential to impact water quality, primarily through erosion and stormwater runoff, and the mobilization of contaminants. To minimize the effect of terrestrial based Project activities on marine resources, measures should be followed to avoid and minimize effects. The measures outlined below also serve as avoidance and minimization for potential effects of habitat restoration on marine resources. The following conditions provide a framework for establishing BMPs that could be employed for the current Project.

5.5.1 Maintain Hydrologic Conditions and Protect Water Quality

Conditions can be established to set programmatic BMPs, performance standards, and control measures to minimize increases of peak discharge of stormwater and to reduce runoff of pollutants to protect water quality. These requirements may include preconstruction and construction site actions. Preconstruction conditions are site design planning approaches that protect water quality by preventing and reducing the significant impacts of stormwater pollutants and increases in peak runoff rate and volume. They include hydrologic source control measures that focus on the protection of natural resources. Construction site conditions include source and treatment control measures to prevent pollutants from leaving the construction site and minimizing site erosion and sedimentation during construction.

5.5.2 Avoidance and Minimization for Near-Water Activities

Specific conditions can be identified to design requirements and construction practices for near-water projects to minimize impacts to riparian and aquatic habitat. Construction BMPs could be implemented to address construction staging, sediment management, vegetation management, bank protection, drainage, and ground disturbance, as applicable. The design requirements and BMPs shall be implemented to minimize impacts to covered species, natural communities, and wildlife movement.

5.5.3 BMPs

All BMPs should be designed and developed in conjunction with local management plans. The BMPs employed for upland development activities also serve as avoidance and minimization measures for the potential impact of habitat restoration on marine resources. Potential examples of BMPs are reviewed in Table 11.

Table 11. Examples of Avoidance and Minimization Measures for Terrestrial-Based Project Activities

Avoidance and Minimization Measure
Erosion and Stormwater Drainage
Sediment control measures on site can be established prior to constriction, and kept available on site at all times, especially in anticipation of rain events.
Manage soil and groundwater, stormwater runoff (and accidental spills) in accordance with local management plans.
Minimize the potential impacts on covered species most likely to be affected by changes in hydrology and water quality.
Personnel shall implement measures to ensure that hazardous materials are properly handled and the quality of water resources is protected by all reasonable means when removing sediments from the streams.
Any sediment removed from a project site shall be stored and transported in a manner that minimizes water quality impacts.
Use flow control structures such as swales, retention/detention areas, and/or cisterns to maintain the existing (pre- project) peak runoff.
Direct downspouts to swales or gardens instead of storm drain inlets.
All projects will be conducted in conformance with applicable County and/or city drainage policies.
Prepare and implement sediment erosion control plans.
No stockpiling or placement of erodible materials in waterways or along areas of natural stormwater flow where materials could be washed into Humboldt Bay.
Stabilize stockpiled soil with geotextile or plastic covers.
Maintain construction activities within a defined project area to reduce the amount of disturbed area.
Dispose of all construction waste in designated areas and prevent stormwater from flowing onto or off of these areas.
Appropriate erosion control measures (e.g., fiber rolls, filter fences, vegetative buffer strips) will be used on site to reduce siltation and runoff of contaminants into Humboldt Bay. Erosion control measures will be placed between the outer edge of the buffer and the project site.

Avoidance and Minimization Measure
Contamination
Personnel shall prevent the accidental release of chemicals, fuels, lubricants, and non-storm drainage water into channels.
Spill prevention kits shall always be in close proximity when using hazardous materials (e.g., crew trucks and other logical locations).
To minimize the spread of pathogens all staff working in aquatic—including site monitors, construction crews, and surveyors—will adhere to the most current guidance for equipment decontamination provided by the Wildlife Agencies at the time of activity implementation.

5.6 Artificial Lighting

During periods of construction, potentially significant effects from ALAN on birds and fishes can be addressed by minimizing lighting and avoiding the use of bright white lights (BOEM 2019). The number of light towers needed (if required for the final Project design) depends on the equipment that is required and the number of construction personnel present, in accordance with Occupational Safety and Health Administration (OSHA) requirements, for the specific construction activities that are being performed. The OSHA minimum illumination intensities in foot-candles are presented in Table 12. For reference, a foot-candle is equivalent to one lumen per square foot. While five foot-candles are considered sufficient for general construction, a minimum of 10 foot-candles is preferred when working around heavy equipment.

Table 12. OSHA Minimum Illumination Intensities

Foot-Candles	Area of Operation
5	General construction area lighting
3	General construction areas, concrete placement, excavation and waste areas, access ways, active storage areas, loading platforms, refueling, and field maintenance areas
5	Indoors: warehouses, corridors, hallways, and exit ways
5	Tunnels, shafts, and general underground work areas. Exception: minimum of 10 foot-candles is required at tunnel and shaft heading during drilling, mucking, and scaling. Bureau of Mines-approved cap lights shall be acceptable for use in the tunnel heading.
10	General construction plant and shops (e.g., batch plants, screening plants, mechanical and electrical equipment rooms, carpenter shops, rigging lofts and active storerooms, mess halls, and indoor toilets and workrooms.)
30	First aid stations, infirmaries, and offices

If lighting at night is required for the Project, the impacts could be minimized by utilizing temporary lighting equipment that is manually operated, directing lights downward into the work area, shielding lights using cowls to limit off-site spillover and nighttime illumination, and minimizing the number of lights to only those necessary. Ship and wharf lighting during nighttime construction operations will follow U.S. Coast Guard regulations for safety and navigation purposes.

If lighting at night is required for the Project, it should be appropriately shielded and directed to minimize artificial light attraction and prevent potential injury or mortality to seabirds. Proper shielding can also minimize off site glare and avoid water light spillage. While allowing for public safety, lighting should be minimized to the maximum extent practicable. Motion-sensing lighting could also be used to the extent feasible to reduce the amount of time lights are on.

Examples of BMPs to minimize any potential effects of the Project on seabirds that have been employed for other projects include:

- Using low-intensity flashing lights and bird-friendly wavelengths on the Project structures to minimize seabird attraction and follow the specifications for Project lighting developed in consultation with the USFWS and USCG. This may be particularly important because multiple studies have found that flashing or blinking lights are less attractive to migrating birds relative to continuous light (Gauthreaux and Belser 2006, Gehring et al. 2009) and several have found that numbers of birds around blinking modes (intermittent, continuous) did not differ from numbers of birds under darkness conditions (Rebke et al. 2019);
- Minimizing lighting (e.g., use low intensity, bird-friendly wavelengths, shielded lighting not providing upward-pointing light or light directed at the sea surface) used at night by service and support vessels to reduce the potential for seabird attraction. A field study in the in the North Sea found that nocturnally migrating birds were disoriented and attracted by red and white light, whereas they were "clearly less disoriented by blue and green light" (Poot et al. 2008);
- Requiring vessel operators to follow USFWS instructions regarding appropriate handling and release of seabirds in the event of seabird fallout;
- Requiring vessel operators to remain 500 feet away from seabird colonies during the nesting season to minimize disturbance to nesting seabirds;
- Develop and implement an Emergency Response and Recovery Plan with spill prevention, response actions and control protocols, as well as provisions for recording types and amounts of hazardous fluids contained in Project components, to minimize the potential for and, if needed, respond to accidental release of oils and toxic chemicals into the marine environment.

These BMPs employed for birds may also be expected to minimize effects on fishes.

5.7 Aquatic Invasive Species Management

The CDFW Aquatic Invasive Species (AIS) Management Plan (2008) proposes management actions to address the threat of aquatic invasive species to California state. The goal of AIS Management Plan is to minimize the harmful ecological, economic and human health impacts of aquatic invasive species (p. 50 *in* CDFW 2008). It specifically focuses on non-native algae, crabs, clams, fish, plants, and other species that may invade bays (and other waters in California). There are eight major objectives to meet this goal. The most relevant per this Project is prevention. The objective of prevention is to minimize and prevent the introduction and spread of AIS throughout the waters of California, and revolves around intercepting the AIS at the point of entry or release into a system (p. 50 and 63 *in* CDFW 2008). Prevention relies on managing at the species and vector level.

As outlined in CDFW's AIS Management Plan, the California State Lands Commission (CSLC) oversees management of AIS introductions as directed by the 2003 Marine Invasive Species Act. This program implements regulations governing ballast water and biofouling on all vessels entering California ports, requiring ballast water management and removal of biofouling organisms from all wetted portions of a vessel on a regular basis (Public Resources Code Division 36). CSLC additionally adopted regulatory amendments that implement the federal ballast water discharge standards for vessels arriving at California ports, effective January 1, 2022 (2 CCR Article 4.7). These amendments, in part, establish operational monitoring and recordkeeping requirements for vessels that use a ballast water treatment system to meet ballast water discharge performance standards. Ships arriving in Humboldt Bay delivering construction and wind turbine components will be expected to follow these state and federal standards to reduce the introduction of marine AIS. This includes ballasting of WTDs.

The AIS Management Plan outlines multiple strategies with sub actions to be followed as means of prevention. The most relevant per the project are those included in Table 13. This management plan, along with state and federal regulations, should be consulted and thoroughly reviewed to identify the BMP to be incorporated into the Project to avoid and minimize potential effects of AIS and NIS on Humboldt Bay.

Table 13. Aquatic Invasive Species Management

Strategy: Regional Vector Assessment
Identify possible vectors and pathways of AIS introductions into and throughout California and assess the risks and impacts of each
Action: Develop comprehensive regional vector assessments
Strategy: Commercial Vessels and Maritime Activities
Reduce the introduction and transfer of marine AIS via ballast water, ballast sediment and hull fouling from commercial vessels and maritime structures
Action: Quantify the ballast water and fouling vectors, and assess risk of introduction and dispersal of AIS from these vectors
Continue to implement and improve California's current ballast water inspection and enforcement program
Implement performance standards for the discharge of treated ballast water
Identify and address gaps in the Marine Invasive Species Program not addressed by either federal or state law
Strategy: Construction (and Restoration)
Limit new introductions of AIS as a result of restoration, landscaping and construction activities
Action: Quantify and assess the role of construction activities as an AIS vector and identify potential management options
Work with industry and consultants to develop guidelines for decontamination of construction equipment, tools and protective clothing

5.8 Habitat Change

The long-term effects on marine resources from habitat change can be avoided and minimized through Project design. Mitigation will be required to offset the changes to functional habitat that are expected to significantly impact marine resources, and due to the sheer size and scale of dredging operations. Potential mitigation efforts to be incorporated into Project design include eelgrass mitigation, tidal marsh restoration and the development of living shoreline. These will be evaluated separately.

5.9 WTD Ballasting

In addition to the introduction of invasive species (see Section 5.7), potential entrainment effects of WTD ballasting can likely be managed. Without information on the amount of water needed to ballast the WTDs, and pumping rate and opening sizes, and frequency and timing of ballasting, there is uncertainty about the level of effect. However, it is recognized that the final Project design will provide information to understand entrainment risk and to incorporate measures to reduce the likelihood of entraining CESA-listed larval longfin smelt (as it has implications for compensatory mitigation required to obtain a CDFW Incidental Take Permit). Reduction of entrainment is possible through BMPs for ballast water intake, such as the use of screens to filter out organisms from supply bay water. Filtration of incoming seawater also allows for more effective ballast water treatment under state regulations. Entrainment effects can be avoided and minimized through BMPs; however, mitigation would be required to compensate for incidental take of state-listed species and impacts on ESA-listed fishes or their critical habitat.

Section 6.0 References

Adams, P. B., and R. M. Starr. 2001. Lingcod. Pages 191–194 *in* W. S. Leet, C. M. Dewees, R. Klingbeil, and E. J. Larson, editors, California's Living Marine Resources: A Status Report. California Department of Fish and Game, Sacramento.

Ainley, D. G., S. G. Allen, and L. Spear. 1995. Offshore occurrence patterns of marbled murrelets in Central California. Pages 361-369 *in* C. J. Ralph, G. L. Hunt, M. G. Raphael, and J. F. Piatt, Ecology and Conservation of the Marbled Murrelet. General Technical Report PSW-GTR-152.

Allen, L. G., and D. J. Pondella II. 2006. Surf zone, coastal pelagic zone, and harbors. Pages 149–166 *in* L. G. Allen, D. J. Pondella II, and M. H. Horn, editors, The Ecology of Marine Fishes, California and Adjacent Waters. University of California Press, Berkeley and Los Angeles.

Anderson, C. W., and D. Ward. 2016. Results of Freshwater Creek Salmonid Life Cycle Monitoring Station 2015-2016. Arcata, California. Prepared by Humboldt State University, Department of Fisheries Biology.

Andrews, J., D. Buehler, H. Gill, and W. L. Bender. 2020. Transportation and Construction Vibration Guidance Manual. California Department of Transportation Technical Report No. CT-HWANP-RT-20-365.01.01. Sacramento, California.

Ansingh, I. 2023. Personal communication regarding NMFS Requirements and Lessons Learned from Coleman Dock Pile Driving. July 7.

Archibald, W. H. 2015. Seasonal Changes in the Distribution and Abundance of Pacific Harbor Seals (*Phoca vitulina richardii*) in South Humboldt Bay, California and Its Newly Enacted Marine Protected Area. Master's thesis. Humboldt State University, Arcata, California.

Barnhart, R. A., M. J. Boyd, and J. E. Pequegnat. 1992. The Ecology of Humboldt Bay, California: An Estuarine Profile. January. Biological Report 1. U.S. Fish and Wildlife Service, Washington, D.C.

Baxter, R. D. 1999. Osmeridae. *In* Report on the 1980-1995 Fish, Shrimp, and Crab Sampling in the San Francisco Estuary, California. 63. Interagency Ecological Program for the Sacramento-San Joaquin Estuary Technical Report. Sacramento, California.

Bierregaard, R. O., A. F. Poole, M. S. Martell, P. Pyle, and M. A. Patten. 2016. Osprey (*Pandion haliaetus*). *In* The Birds of North America. Cornell Lab of Ornithology, Ithica, New York.

Bollens, S. M., and A. Sanders. 2004. Ecology of larval Pacific herring *Clupea pallasi* in the San Francisco Estuary: Seasonal and interannual abundance, distribution, diet and condition. American Fisheries Society Symposium 36:15–35.

Bond, M. H., S. A. Hayes, C. V. Hanson, and R. B. MacFarlane. 2008. Marine survival of steelhead (*Oncorhynchus mykiss*) enhanced by a seasonally closed estuary. Canadian Journal of Fisheries and Aquatic Sciences 65:2242–2252.

Boyd, M. J., T. J. Mulligan, and F. J. Shaugnessy. 2002. Non-Indigenous Marine Species of Humboldt Bay, California. February 28. Arcata, California. Prepared for the California Department of Fish and Game.

Brayley, O. D., A. Wakefield, and M. J. How. 2021. The biological effects of light pollution on terrestrial and marine organisms. International Journal of Sustainable Lighting 13–38.

Brennan, C. A., J. L. Hassrick, A. Kalmbach, D. M. Cox, M. Sabal, R. Zeno, L. F. Grimaldo, and S. Acuña. 2022. Estuarine recruitment of longfin smelt (*Spirinchus thaleichthys*) north of the San Francisco Estuary. San Francisco Estuary and Watershed Science 20(3):1–15.

[BOEM] Bureau of Ocean Energy Management. 2019. Draft Proposed Guidelines for Providing Information on Lighting and Marking of Structures Supporting Renewable Energy Development. <https://www.boem.gov/sites/default/files/documents/renewable-energy/Lighting-and-Marking-Guidelines.pdf>. Accessed October.

California Department of Fish and Game. 2009. A Status Review of the Longfin Smelt (*Spirinchus thaleichthys*) in California. January 23. Report to the Fish and Game Commission.

[CDFW] California Department of Fish and Wildlife. 2008. California Aquatic Invasive Species Management Plan. January 2008. State of California Resource Agency Department of Fish and Game, Invasive Species Program.

[CDFW] California Department of Fish and Wildlife. 2013. Pacific Herring Commercial Fishing Regulations (Sections 163 and 164, Title 14, California Code of Regulations. Final Supplemental Environmental Document. SCH No. 98052052. State of California, Natural Resources Agency.

[CDFW] California Department of Fish and Wildlife. 2019a. Night Smelt, *Spirinchus starksi*, Enhanced Status Report. <https://marinespecies.wildlife.ca.gov/nightsmelt/the-species/>. Accessed October 2020.

[CDFW] California Department of Fish and Wildlife. 2019b Barred Surfperch, *Amphistichus argenteus*, and Redtail Surfperch, *Amphistichus rhodoterus*, Enhanced Status Report.

[CDFW] California Department of Fish and Wildlife. 2019c. Brown Smoothhound Shark, *Mustelus henlei*, Enhanced Status Report. <https://marinespecies.wildlife.ca.gov/brown-smoothhound-shark/true/>. Accessed October 2020.

[CDFW] California Department of Fish and Wildlife. 2019d. Red, Yellow, and Brown Rock Crab, *Cancer productus*, *Metacarcinus anthonyi*, and *Romaleon antennarium*, Enhanced Status Report. <https://marinespecies.wildlife.ca.gov/red,-yellow,-andbrown-rock-crab/true/>. Accessed October 2020.

[CDFW] California Department of Fish and Wildlife. 2020. Final California Commercial Landings for 2019. <https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=178025&inline>.

[CNDDB] California Natural Diversity Database. 2023. Special Animals List. April. California Department of Fish and Wildlife, Sacramento.

Carretta, H. V., K. A. Forney, and S. R. Benson. 2009. Preliminary Estimates of Harbor Porpoise Abundance in California Waters from 2002 to 2007. NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-435.

Carretta, J. V., E. M. Oleson, K. A. Forney, M. M. Muto, D. W. Weller, A. R. Lang, J. Baker, et al. 2022. U.S. Pacific Marine Mammal Stock Assessments: 2021. NOAA Technical Memorandum. July. NMFS-SWFSC-663. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Cole, M. E. 2004. Distribution of Fish Species in Humboldt Bay, Humboldt County, California, USA: A GIS Perspective. Thesis. Humboldt State University, Arcata, California.

Colwell, M. A., J. J. Meyer, M. A. Hardy, S. E. McAllister, A. N. Transou, R. R. LeValley, and S. J. Dinsmore. 2011. Western snowy plovers *Charadrius alexandrinus nivosus* select nesting substrates that enhance egg crypsis and improve nest survival. Ibis 153:303–311.

Costa, D. P., C. Kuhn, and M. Weise. 2007. Foraging Ecology of the California Sea Lion: Diet, Diving Behavior, Foraging Locations, and Predation Impacts on Fisheries Resources. Research Completion Reports. Paper Coastal 07-03. California Sea Grant College Program, San Diego.

Daly, E. A., R. D. Brodeur, and L. A. Weitkamp. 2009. Ontogenetic shifts in diets of juvenile and subadult Coho and Chinook salmon in coastal marine waters: Important for marine survival? Transactions of the American Fisheries Society 138(6):1420–1438.

Daly, E. A., J. A. Scheurer, R. D. Brodeur, L. A. Weitkamp, B. R. Beckman, and J. A. Miller. 2014. Juvenile steelhead distribution, migration, feeding, and growth in the Columbia River Estuary, Plume, and Coastal Waters. Marine and Coastal Fisheries 6(1):62–80.

Davis, N. D., K. Aydin, and Y. Ishida. 1998. Diel Feeding Habits and Prey Consumption of Sockeye, Chum, and Pink Salmon in the Behring Sea in 1997. NPAFC Doc. 363. FRI-UW-9816. Fisheries Research Institute, University of Washington, Seattle; National Research Institute of Far Seas Fisheries, Shimizu.

Emmett, R. L., S. A. Hinton, S. L. Stone, and M. E. Monaco. 1991. Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries, Volume II: Species Life History Summaries. August. ELMR Report No. 8. NOAA/NOS Strategic Environmental Assessments Division, Rockville, Maryland.

Falxa, G. A., and M. G. Raphael. 2016. Northwest Forest Plan—The First 20 Years (1994–2013): Status and Trend of Marbled Murrelet Populations and Nesting Habitat. May. General Technical Report PNW-GTR-933. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, Oregon.

Fernandez, M., O. Iribarne, and D. Armstrong. 1993. Habitat selection by young-of-the-year Dungeness crab *Cancer magister* and predation risk in intertidal habitats. Marine Ecology Progress Series 92:171–177.

Flint, S., R. deMesa, P. Doughman, and E. Huber. 2022. Offshore Wind Development off the California Coast: Maximum Feasible Capacity and Megawatt Planning Goals for 2030 and 2045. August 2022. CEC-8002022-001-REV. Prepared for California Energy Commission.

Ford, J. K. B., G. M. Ellis, L. G. Barrett-Lennard, A. B. Morton, R. S. Palm, and K. C. Balcomb. 1998. Dietary specialization in two sympatric populations of killer whales (*Orcinus orca*) in coastal British Columbia and adjacent waters. Canadian Journal of Zoology 76(8):1456–1471.

Fowler, R. 2022. Email communications with Sharon Kramer, Scott Terrill and Sophie Bernstein from H. T. Harvey & Associates, regarding observations of listed and sensitive species in Humboldt Bay. June.

Fukushima, L., and E. W. Lesh. 1998. Adult and juvenile anadromous salmonid migration timing in California streams. California Fish and Game 84:133–145.

Fuller, A. R. 2012. Spatial and Temporal Distribution, Haulout Use and Movement Patterns of Stellar Sea Lions (*Eumetopias jubatus*) in Northern California. Master's thesis. Humboldt State University, Arcata, California.

Gall, A. B., P. Thompson, N. Merchant, and I. Graham. 2023. Vessel noise prior to pile driving at offshore windfarm sites deters harbour porpoises from potential injury zones. Environmental Impact Assessment Review 103(107271).

Garwood, R. S., T. J. Mulligan, and E. P. Bjorkstedt. 2013. Ichthyological assemblage and variation in a northern California *Zostera marina* eelgrass bed. Northwestern Naturalist 94:35–50.

Garwood, R. S. 2017. Historic and contemporary distribution of longfin smelt (*Spirinchus thaleichthys*) along the California coast. California Fish and Game 103(3):96–117.

Gauthreaux S.A., Jr., and G. Belser. 2006. Effects of artificial night lighting on migrating birds. Pages 67–93 *in* C. Rich and T. Longcore, editors. Ecological Consequences of Artificial Night Lighting. Island Press, Washington, DC.

Gehring, J., P. Kerlinger, and A. M. Manville II. 2009. Communication towers, lights, and birds: Successful methods of reducing the frequency of avian collisions. Ecological Applications 19(2):505–514.

GHD. 2021. Draft Program Environmental Impact Report for Samoa Peninsula Land-based Aquaculture Project. December. SCH #11205607. Prepared for Humboldt Bay Harbor Recreation and Conservation District, Eureka, California.

Goetz, B. J. 1983. Harbor Porpoise (*Phocoena phocoena*) Movements in Humboldt Bay, California and Adjacent Ocean Waters. Master’s thesis. Humboldt State University, Arcata, California.

Goldsworthy, M., W. D. Pinnix, M. Barker, L. Perkins, A. David, and J. Jahn. 2016. Green Sturgeon Feeding Observations in Humboldt Bay, California. October 24. Field Note.

Goley, D., and J. T. Harvey. 2010. Retrospective Analysis of Marine Mammal Ecological Data and Baseline Marine Mammal Monitoring in Northern California. Final report to CH 2 M Hill.

Goodman, D. H., and S. B. Reid. 2012. Pacific Lamprey (*Entosphenus tridentatus*) Assessment and Template for Conservation Measures in California. August. U.S. Fish and Wildlife Service, Arcata, California.

Grimaldo, L. F., F. Feyrer, J. Burns, and D. Maniscalco. 2017. Sampling uncharted waters: Examining rearing habitat of larval longfin smelt (*Spirinchus thaleichthys*) in the upper San Francisco Estuary. Estuaries and Coasts 40:1771–1784.

Griswold, M. D., Jr. 1985. Distribution and Movements of Pinnipeds in Humboldt and Del Norte Counties, California. Master's thesis. Humboldt State University, Arcata, California.

Gustafson, R. G., M. J. Ford, D. Teel, and J. S. Drake. 2010. Status Review of Eulachon (*Thaleichthys pacificus*) in Washington, Oregon, and California. March. NOAA Technical Memorandum NMFS-NWFSC-105. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Halligan, D. 2022. Email communications with Sharon Kramer from H. T. Harvey & Associates, regarding observations of listed and sensitive species in the Mad River, and new genetic analyses confirming presence of eulachon.

Harris, S. W. 1991. Northwestern California Birds. Humboldt State University Press, Arcata, California.

Harris, S. W. 2006. Northwestern California Birds. Third edition. Living Gold Press, Klamath River, California.

Haugen, C. W., and D. Thomas. 2001. Starry flounder. Pages 199–200 *in* W. S. Leet, C. M. Dewees, R. Klingbeil, and E. J. Larson, editors, California's Living Marine Resources: A Status Report. California Department of Fish and Game, Sacramento.

Hawkins, A. D., C. Johnson, and A. N. Popper. 2020. How to set sound exposure criteria for fishes. Journal of the Acoustical Society of America 147(3):1762–1777.

Hawkins, A. D., R. A. Hazelwood, A. N. Popper, and P. C. Macey. 2021. Substrate vibrations and their potential effects upon fishes and invertebrates. Journal of Acoustical Society of America 149:2782–2790.

Heath, C. B., and W. F. Perrin. 2008. California, Galapagos, and Japanese sea lions, *Zalophus californianus, Z. wollebaeki, and Z. japonicus*. Pages 170-176 *in* W. F. Perrin, B. Wursig, and J. G. M. Thewissen, The Encyclopedia of Marine Mammals. Academic Press, San Diego, California.

Hébert, P. N., and R. T. Golightly. 2008. At-sea distribution and movements of nesting and non-nesting marbled murrelets *Brachyramphus marmoratus* in northern California. Marine Ornithology (36):99–105.

Herder, M. J. 1986. Seasonal Movements and Hauling Site Fidelity of Harbor Seals, *Phoca vitulina richardsi*, Tagged at the Klamath River, California. Master's thesis. Humboldt State University, Arcata, California.

Herman, D. P., D. G. Burrows, P. R. Wade, J. W. Durban, C. O. Matkin, R. G. LeDuc, L. G. Barrett-Lennard, and M. M. Krahn. 2005. Feeding ecology of eastern North Pacific killer whales *Orcinus orca* from fatty acid, stable isotope, and organochlorine analyses of blubber biopsies. Marine Ecology Progress Series 302:275–291.

Hobbs, J., L. S. Lewis, N. Ikemiyagi, T. Sommer, and R. D. Baxter. 2010. The use of otolith strontium isotopes (87Sr/86Sr) to identify nursery habitat for a threatened estuarine fish. Environmental Biology of Fishes 89:557–567.

Horton K. G., C. Nilsson, B. M. Van Doren, F. A. La Sorte, A. Dokter, and A. Farnsworth. 2019. Bright lights in the big cities: Migratory birds' exposure to artificial light. Frontiers in Ecology and the Environment 17:209–214.

H. T. Harvey & Associates. 2023a. Humboldt Offshore Wind Port Upgrades, Shorebird Special Studies and Site Surveys. Memorandum. November 1. Arcata, California. Prepared for Moffatt & Nichol.

H. T. Harvey & Associates. 2023b. Humboldt Offshore Wind Port Upgrades, Shorebird Special Studies and Site Surveys. Memorandum. May 30. Arcata, California. Prepared for Moffatt & Nichol.

[District] Humboldt Bay Harbor Recreation and Conservation. 2015. Coast Seafoods Company Humboldt Bay Shellfish Aquaculture Permit Renewal and Expansion Project Humboldt County, California. 1-292. SCH #2015082051. Eureka, CA. Draft Environmental Impact Report.

[District] Humboldt Bay Harbor Recreation and Conservation District. Notice of Preparation of Draft Environmental Impact Report for Humboldt Bay Offshore Wind Heavy Lift Multipurpose Marine Terminal Project. June 26, 2023. Eureka, California.

Hunter, J. E., D. Fix, G. A. Schmidt, and J. C. Power. 2005. Atlas of the Breeding Birds of Humboldt County, California. Redwood Region Audubon Society, Eureka, California.

ICF. 2020. Draft Program Environmental Impact Report for Humboldt Bay Sediment Management. Draft. November. SCH #2018012052. Eureka, California. Prepared for Humboldt Bay Harbor Recreation and Conservation District, Eureka, California.

Jacobsen, J. 2023. Personal communication regarding presence of transient killer whales.

Jagerbrand, A. K., and C. A. Bouroussis. 2021. Ecological impact of artificial light at night: effective strategies and measures to deal with protected species and habitats. Sustainability 13(11):5991.

Jaques, D. L., H. R. Carter, and P. J. Capitolo. 2008. A Brown Pelican Roost Site Atlas for Northern and Central California. Pacific Eco Logic, Astoria, Oregon, and Carter Biological Consulting, Victoria, British Columbia. Prepared for California Department of Fish and Game, Office of Spill Prevention and Response.

Johnson, P. R., K. Bouchard, and F. A. Goetz. 2005. Effectiveness of strobe lights for reducing juvenile salmonid entrainment into a navigation lock. North American Journal of Fisheries Management 25(2):491–501.

Juhasz, C., and P. Kalvass. 2013. Dungeness crab, *Metacarcinus magister*. Chapter 2 *in* Status of the Fisheries Report: An Update through 2011. Report to the California Fish and Game Commission. California Department of Fish and Wildlife, Marine Region.

Kastelein, R. A., R. van Schie, W. C. Verboom, and D. de Haan. 2005. Underwater hearing sensitivity of a male and a female Steller sea lion (*Eumetopias jubatus*). Journal of Acoustical Society of America 118(3):1820–1829.

Kelly, J. T., A. P. Klimley, and C. E. Crocker. 2007. Movements of green sturgeon, *Acipenser medirostris*, in the San Francisco Bay estuary, California. Environmental Biology of Fishes 79:281–295.

Kenyon, K. W., and D. W. Rice. 1961. Abundance and distribution of the Steller sea lion. Journal of Mammalogy 42(2):223–234.

Krahn, M. M., M. J. Ford, W. F. Perrin, P. R. Wade, R. P. Angliss, M. B. Hanson, B. L. Taylor, et al. 2004. 2004 Status Review of Southern Resident Killer Whales (*Orcinus orca*) under the Endangered Species Act. NOAA Technical Memorandum NMFS-NWFSC-62. U. S. Department of Commerce, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Krahn, M. M., D. P. Herman, C. O. Matkin, J. W. Durban, L. Barrett-Lennard, D. G. Burrows, M. E. Dahlheim, et al. 2007. Use of chemical tracers in assessing the diet and foraging regions of eastern North Pacific killer whales. Marine Environment Research 63:91–114.

Kramer, S. 2023. Communications with Sophie Bernstein from H. T. Harvey & Associates, regarding observations herring spawning and food web effects in Humboldt Bay. December.

Laughlin, T. R. 1974. The Distribution and Ecology of the Harbor Seal in Humboldt Bay, California.

Lee, D. E., J. M. Black, J. E. Moore, and J. S. Sedinger. 2007. Age-specific stopover ecology of black brant at Humboldt Bay, California. The Wilson Journal of Ornithology 119(1):9–22.

Lewis, L. S., A. Barros, M. Willmes, C. Denney, C. Parker, M. Bisson, J. Hobbs, et al. 2019. Interdisciplinary Studies on Longfin Smelt in the San Francisco Estuary. 2018-2019 Annual Report Contract # 4600011196. October 2019. Davis, California. California Department of Water and Resources, IEP Longfin Smelt Technical Team.

Lewis, L. S., M. Willmes, A. Barros, P. K. Crain, and J. A. Hobbs. 2020. Newly discovered spawning and recruitment of threatened Longfin Smelt in restored and underexplored tidal wetlands. Ecology 101(1):1–3.

Lewis, L. S. 2021. Longfin Smelt: USFWS Population Assessment Session 1. August 27. Davis, California. Conference Presentation.

Lindley, S. T., M. Moser, L., D. L. Erickson, M. Belchik, D. W. Welch, E. Rechisky, J. T. Kelly, et al. 2008. Marine migration of North American green sturgeon. Transactions of the American Fisheries Society 137:182–194.

Lindley, S. T., D. L. Erickson, M. Moser, L., G. Williams, O. P. Langness, B. McCovey Jr., M. Belchik, et al. 2011. Electronic tagging of green sturgeon reveals population structure and movement among estuaries. Transactions of the American Fisheries Society 140(1):108–122.

Longcore, T., A. Rodriguez, B. Witherington, J. F. Penniman, L. Herf, and M. Herf. 2018. Rapid assessment of lamp spectrum to quantify ecological effects of light at night. Journal of Experimental Zoology 1–11.

Longcore, T. 2018. Hazard or hope? LEDs and wildlife. LED Professional Review (70):52–57.

Loughlin, T. R. 2008. Steller sea lion *Eumetopias jubatus*. Pages 1107-1110 *in* W. F. Perrin, B. Wursig, and J. G. M. Thewissen, The Encyclopedia of Marine Mammals. Second edotopm. Academic Press, San Diego, California.

Love, M. S., M. Yoklavich, and L. Thorsteinson. 2002. The Rockfishes of the Northeast Pacific. University of California Press, Berkeley and Los Angeles, California.

Lowry, M. S., and K. A. Forney. 2005. Abundance and distribution of California sea lions (*Zalophus californianus*) in central and northern California during 1998 and summer 1999. Fishery Bulletin 103(2):331–343.

Lowry, M. S., J. V. Carretta, and K. A. Forney. 2008. Pacific harbor seal census in California during May-July 2002 and 2004. California Fish and Game 94(4):180–193.

Lowry, D., S. Wright, M. Neuman, D. Stevenson, J. Hyde, M. Lindenberg, N. Tolimieri, et al. 2022a. Endangered Species Act Status Report: Sunflower Sea Star (*Pycnopodia helianthoides*). October 2022. Prepared for the National Marine Fisheries Service, Office of Protected Resources.

Lowry, D., S. E. Nehasil, and J. E. Moore. 2022b. Spatio-temporal diet variability of the California sea lion Zalophus californianus in the southern California Current Ecosystem. Marine Ecology Progress Series 692:1–21.

MacFarlane, R. B., and E. C. Norton. 2002. Physiological ecology of juvenile chinook salmon (*Oncorhynchus tshawytscha*) at the southern end of their distribution, the San Francisco Estuary and Gulf of the Farallones, California. Fisheries Bulletin 100(2):244–257.

MacFarlane, R. B. 2010. Energy dynamics and growth of Chinook salmon (*Oncorhynchus tshawytscha*) from the Central Valley of California during the estuarine phase and first ocean year. Canadian Journal of Fisheries and Aquatic Sciences 67(10):1549–1565.

McCraney, W. T., G. Goldsmith, D. K. Jacobs, and A. P. Kinziger. 2010. Rampant drift in artificially fragmented populations of the endangered tidewater goby (*Eucyclogobius newberryi*). Molecular Ecology 19:3315–3327.

Mello, J. J. 2007. Summary of 2006-2007 Pacific Herring Spawning-Ground Surveys and Commercial Catch in Humboldt Bay and Crescent City. California Department of Fish and Game, Marine Region, Eureka, California.

Merkel & Associates. 2022. Redwood Marine Multipurpose Terminal Preliminary Eelgrass Survey. Survey Report. September 23. M&A #21-074-01. Eureka, California. Prepared for the Humboldt Bay Harbor Recreation and Conservation District.

Miles, W., S. Money, R. Luxmoore, and R. W. Furness. 2010. Effects of artificial lights and moonlight on petrels at St. Kilda. Bird Study 57:244–251.

Miller, S. L., and C. J. Ralph. 1995. Relationship of marbled murrelets with habitat characteristics at inland sites in California. Pages 205-215 *in* Ecology and Conservation of the Marbled Murrelet. General Technical Report PSW-152. Pacific Southwest Research Station. Forest Service, U.S. Department of Agriculture. Albany, California.

Miller, T. W., and R. D. Brodeur. 2007. Diets of and trophic relationships among dominant marine nekton within the northern California Current ecosystem. Fisheries Bulletin 105(4):548–559.

Moffatt & Nichol. 2023. AB 525 Port Readiness Plan Final Report. July 7. 221194/02. Oakland, California. Prepared for California State Lands Commission.

Molnar, M., D. Buehler, R. Oestman, J. Reyff, K. Pommerenck, and B. Mitchell. 2020. Technical Guidance for the Assessment of Hydroacoustic Effects of Pile Driving on Fish. October. CTHWANP-RT-20-365.01.04. Sacrament, California. Prepared by the California Department of Transportation, Division of Environmental Analysis.

Montevecchi, W. A. 2006. Influences of artificial light on marine birds. Chapter 5 *in* C. Rich and T. Longcore, Editors. Ecological Consequences of Artificial Night Lighting. Island Press, Washington, D.C.

Moore, T. O. 2001. Gaper clams. Pages 445–446 *in* W. S. Leet, C. M. Dewees, R. Klingbeil, and E. J. Larson, editors, California's Living Marine Resources: A Status Report. California Department of Fish and Game, Sacramento.

Moore, J. E., M. A. Colwell, R. L. Mathis, and J. M. Black. 2004. Staging of Pacific flyway brant in relation to eelgrass abundance and site isolation, with special consideration of Humboldt Bay, California. Biological Conservation 115:475–486.

Moser, M., and J. Hsieh. 1992. Biological tags for stock separation in Pacific herring *Clupea harengus pallasi* in California. Journal of Parasitology 78(1):54–60.

Moser, M. L., and S. T. Lindley. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environmental Biology of Fishes 79:243–253.

Moser, M. L., J. A. Israel, M. Neuman, S. T. Lindley, D. L. Erickson, B. W. McCovey, and A. P. Klimley. 2016. Biology and life history of green sturgeon (*Acipenser medirostris* Ayres, 1854): State of the science. Journal of Applied Ichthyology 32(S1):67–86.

Moyle, P. B. 2002. Inland Fishes of California. University of California Press, Berkeley.

Moyle, P. B., J. A. Israel, and S. E. Purdy. 2008. Salmon, Steelhead, and Trout in California. Status of Emblematic Fauna. Center for Watershed Sciences, University of California, Davis.

Multi-Agency Rocky Intertidal Network. 2023. SSWS Updates. University of California, Santa Cruz. <https://marine.ucsc.edu/data-products/sea-star-wasting/updates.html>. March.

Muto, M. M., V. T. Helker, B. J. Delean, N. C. Young, J. C. Freed, R. P. Angliss, N. A. Friday, et al. 2021. Alaska Marine Mammal Stock Assessments, 2020. NOAA Technical Memorandum. July. NMFS-AFSC-421. Seattle, WA. Prepared by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center.

[NMFS] National Marine Fisheries Service. 1999. Endangered and threatened species; threatened status for two Chinook salmon evolutionary significant units (ESUs) in California. Federal Register 64(179):50394–50415.

[NMFS] National Marine Fisheries Service. 2000. Endangered and threatened species; threatened status for one steelhead evolutionary significant unit (ESU) in California. Federal Register 65(110):36074–36094.

[NMFS] National Marine Fisheries Service. 2005a. Endangered and threatened species: Final listing determinations for 16 ESUs of west coast salmon, and final 4(d) protective regulations for threatened salmonid ESUs. Federal Register 70(123):37160–37204.

[NMFS] National Marine Fisheries Service. 2005b. Endangered and threatened species: Designation of critical Habitat for seven evolutionarily significant units of Pacific salmon and steelhead in California. Federal Register 70(170):52488–52613.

[NMFS] National Marine Fisheries Service. 2005c Endangered and threatened wildlife and plants: Endangered status for southern resident killer whales. Federal Register 70(222):69903–69912.

[NMFS] National Marine Fisheries Service. 2006a. Endangered and threatened wildlife and plants: Threatened status for southern distinct population segment of North American green sturgeon. Federal Register 71(67):17757–17766.

[NMFS] National Marine Fisheries Service. 2006b. Endangered and threatened species: Final listing determinations for 10 distinct population segments of west coast steelhead. Federal Register 71(3):834–862.

[NMFS] National Marine Fisheries Service. 2009. Endangered and threatened wildlife and plants: Final rulemaking to designate critical habitat for the threatened southern distinct population segment of North American green sturgeon. Federal Register 74(195):52300–52351.

[NMFS] National Marine Fisheries Service. 2010. Endangered and threatened wildlife and plants: Threatened status for southern distinct population segment of eulachon. Federal Register 75(52):13012–13024.

[NMFS] National Marine Fisheries Service. 2011. Endangered and threatened species; designation of critical habitat for the southern distinct population segment of eulachon. Federal Register 76(203):65324–65352.

[NMFS] National Marine Fisheries Service. 2013. Endangered and Threatened Species; Delisting of the Eastern Distinct Population Segment of Steller Sea Lion Under the Endangered Species Act; Amendment to Special Protection Measures for Endangered Marine Mammals. Federal Register 78(213):66140.

[NMFS] National Marine Fisheries Service. 2014a. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (*Oncorhynchus kisutch*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, West Coast Region, Arcata, California.

[NMFS] National Marine Fisheries Service. 2014b. Endangered and threatened wildlife; final rule to revise the code of federal regulations for species under the jurisdiction of the National Marine Fisheries Service. Federal Register 79(71):20802–20817.

[NMFS] National Marine Fisheries Service. 2016a. Final Coastal Multispecies Recovery Plan. October. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, West Coast Region, Santa Rosa, California.

[NMFS] National Marine Fisheries Service. 2016b. 2016 5-Year Review: Summary and Evaluation of California Coastal Chinook Salmon and Northern California Steelhead. April. National Marine Fisheries Service, West Coast Region, Santa Rosa, California.

[NMFS] National Marine Fisheries Service. 2016c. Proposed rule: Fisheries off West Coast states; Comprehensive ecosystem-based amendment 1; Amendments to the fishery management plans for coastal pelagic species, Pacific Coast groundfish, U.S. West Coast highly migratory species, and Pacific Coast salmon. Federal Register 81(2):215–218.

[NMFS] National Marine Fisheries Service. 2016d. Final rule: Fisheries off West Coast states; Comprehensive ecosystem-based amendment 1; Amendments to the fishery management plans for coastal pelagic species, Pacific Coast groundfish, U.S. West Coast highly migratory species, and Pacific Coast salmon. Federal Register 81(64):19054–19058.

[NMFS] National Marine Fisheries Service. 2016e. Endangered Species Act Section 7(a)(2)Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Humboldt Harbor and Bay Operations and Maintenance (O&M) Dredging in Humboldt Bay, Humboldt County, California. WCR-2015-3779.

[NMFS] National Marine Fisheries Service. 2018a. Recovery Plan for the Southern Distinct Population Segment of North American Green Sturgeon *(Acipenser medirostris*). August 8. National Marine Fisheries Service, Sacramento, California.

[NMFS] National Marine Fisheries Service. 2018b. 2018 Revisions 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. U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-59.

[NMFS] National Marine Fisheries Service. 2020a. NOAA Essential Fish Habitat Mapper. <https://www.habitat.noaa.gov/protection/efh/efhmapper/>. Accessed May 2022.

[NMFS] National Marine Fisheries Service. 2020b. Manual for Optional WEB CALCULATOR Tool (Version 1.0) for: 2018 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. National Oceanic and Atmospheric Administration, Office of Protected Resources, National Marine Fisheries Service, Silver Spring, Maryland.

[NMFS] National Marine Fisheries Service. 2021a. Southern Distinct Population Segment of North American Green Sturgeon (*Acipenser medirostris*) 5-Year Review: Summary and Evaluation. Sacramento, California.

[NMFS] National Marine Fisheries Service. 2021b. Endangered and threatened wildlife and plants: Revision of critical habitat for the southern resident killer whale distinct population segment. Federal Register 86(145):41668–41698.

[NMFS] National Marine Fisheries Service. 2021c. Species in the Spotlight: Priority Actions 2021-2025. March. Prepared by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Silver Spring, Maryland.

[NMFS] National Marine Fisheries Service. 2021d. Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Humboldt Harbor and Bay Operations and Maintenance Dredging Project (2021-2025) in Humboldt County, California. Biological Opinion. April 14. WCRO-2021-00670. Santa Rosa, California.

[NMFS] National Marine Fisheries Service. 2022. Takes of marine mammals incidental to specific activities; Taking marine mammals incidental to weapons testing at Vandenberg Air Force Base, California. Federal Register 87(4):762–776.

[NMFS] National Marine Fisheries Service. 2023a. Proposed rule to list the sunflower sea star as threatened under the Endangered Species Act. Federal Register 88(51):16212–16220.

[NMFS] National Marine Fisheries Service. 2023b. National Marine Fisheries Service: Summary of Endangered Species Act Acoustic Thresholds (Marine Mammals, Fishes, and Sea Turtles). January.

[NMFS] National Marine Fisheries Service. 2023c. Summary of Marine Mammal Protection Act Acoustic Thresholds. Prepared by the U.S. Department of the Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

[NMFS] National Marine Fisheries Service. 2023d. Takes of marine mammals incidental to specified activities; Taking marine mammals incidental to construction activities associated with the Murray St. Bridge Seismic Retrofit Project in Santa Cruz, California. Federal Register 88(84):27452–27462.

National Oceanic and Atmospheric Administration. 2014. California Eelgrass Mitigation Policy and Implementing Guidelines. NOAA Fisheries West Coast Region Technical Report. October.

Nedelec, S. L., J. Campbell, A. N. Radford, S. D. Simpson, and N. D. Merchant. 2016. Particle motion: The missing link in underwater acoustic ecology. Methods in Ecology and Evolution 7:836–842.

Nelson, S. K., and S. Singer. 1994. Marbled murrelet. Pages 188–190 *in* C.G. Thelander and M. Crabtree, editors. Life on the Edge: A Guide to California's Endangered Natural Resources: Wildlife. Biosystems Books, Santa Cruz, California.

Nelson, S. K. 1997. Marbled murrelet (*Brachyramphus marmoratus*). No. 276 in A. Poole and F. Gill, editors, The Birds of North America. The Academy of Natural Sciences, Philadelphia, Pennsylvania and The American Ornithologists' Union, Washington, D.C.

Nelson, T. R., C. J. Michel, M. Gary, P., B. M. Lehman, and N. J. Demetras. 2021. Effects of artificial lighting at night on predator density and salmonid predation. Transactions of the American Fisheries Society 150:147–159.

Nielsen, K. J., J. E. Dugan, T. Mulligan, D. M. Hubbard, S. F. Craig, R. Laucci, M. E. Wood, et al. 2017. Final Report: Baseline Characterization of Sandy Beach Ecosystems along the North Coast of California.

Nightingale, B., T. Longcore, and C. A. Simenstad. 2006. Artificial night lighting and fishes. Chapter 11, 257-277 *in* Ecological Consequences of Artificial Night Lighting. Island Press, Washington DC.

Northern Hydrology and Engineering. 2015. Humboldt Bay: Sea Level Rise, Hydrodynamic Modeling, and Inundation Vulnerability Mapping. Prepared for State Coastal Conservancy and Coastal Ecosystems Institute of Northern California. Final Report. April.

O'Corry-Crowe, G. M., K. K. Martien, and B. L. Taylor. 2003. The Analysis of Population Genetic Structure in Alaskan Harbor seals, *Phoca vitulina*, as a Framework for the Identification of Management Stocks. Southwest Fisheries Science Center Administrative Report. LJ-03-08.

Ougzin, A. M. 2013. Foraging Behavior of the Pacific Harbor Seal (*Phoca vitulina richardsi*) in Humboldt Bay, California. Master's thesis. Humboldt State University, Arcata, California.

[PFMC] Pacific Fishery Management Council. 1998. Appendix D Description and Identification of Essential Fish Habitat for the Coastal Pelagic Fishery Management Plan.

[PFMC] Pacific Fishery Management Council. 2008. Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington Groundfish Fishery as Amended through Amendment 19. Pacific Fishery Management Council, Portland, Oregon.

PFMC] Pacific Fishery Management Council. 2020. Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington Groundfish Fishery. Pacific Fishery Management Council, Portland, Oregon.

[PFMC] Pacific Fishery Management Council. 2021. Pacific Coast Coastal Pelagic Fishery Management Plan. January. Pacific Fishery Management Council, Portland, Oregon.

[PFMC] Pacific Fishery Management Council. 2022. Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington Groundfish Fishery. August. Pacific Fishery Management Council, Portland, Oregon.

Page, G. W., J. S. Warriner, J. C. Warriner, and P. W. C. Paton. 1995. Snowy plover (*Charadrius alexandrinus*). No. 154 *in* A. Poole and F. Gill, editors, The Birds of North America. The American Ornithologists' Union, Washington, D.C.

Peeters, H., and P. Peeters. 2005. Raptors of California. California Natural History Guide Series No. 82. University of California Press, Berkeley and Los Angeles.

Piatt, J. F., K. J. Kuletz, A. E. Burger, S. A. Hatch, V. L. Friesen, T. P. Birt, M. L. Arimitsu, et al. 2007. Status Review of the Marbled Murrelet (*Brachyramphus marmoratus*) in Alaska and British Columbia. Open-File Report 2006-1387. U.S. Geological Survey.

Pinnix, W. D. 2008. Green Sturgeon Monitoring - Humboldt Bay Acoustic Telemetry. February 15. Arcata, California. Presentation.

Pinnix, W. D., P. A. Nelson, G. Stutzer, and K. A. Wright. 2013. Residence time and habitat use of coho salmon in Humboldt Bay, California: An acoustic telemetry study. Environmental Biology of Fishes 96:315–323.

Poot, H., B. J. Ens, H. de Vries, M. A. H. Donners, M. R. Wernand, and J. M. Marquenie. 2008. Green light for nocturnally migrating birds. Ecology and Society 13(2):47.

Popper, A. N., and A. D. Hawkins. 2018. The importance of particle motion to fishes and invertebrates. The Journal of the Acoustical Society of America 143(1):470–488.

Port of Long Beach. 2019. Port of Long Beach Deep Draft Navigation Feasibility Study and Channel Deepening Project EIR - Draft EIR, October 25.

Powell, A. N., J. M. Terp, C. L. Collier, and B. L. Peterson. 1997. The Status of Western Snowy Plovers (*Charadrius alexandrinus nivosus*) in San Diego County, 1997. Report to the California Department of Fish and Game, Sacramento, and U.S. Fish and Wildlife Service, Carlsbad, California.

Rabin, D. J., and R. A. Barnhart. 1986. Population characteristics of Pacific herring, *Clupea harengus pallasi*, in Humboldt Bay, California. California Fish and Game 72(1):4–16.

Ralph, C. J., and S. L. Miller. 2002. Zones 4 and 5: Coos Bay, Oregon, to Humboldt/Mendocino county line, California, and from Humoldt/Mendocino county line to San Francisco Bay. Pages 40-49 *in* N. Bentivoglio, J. Baldwin, P. G. R. Jodice, D. E. Mack, T. Max, S. Miller, S. Kim Nelson, K. Ostrom, C. J. Ralph, M. Raphael, C. Strong, C. Thompson, and R. Wilk, editors. Northwest Forest Plan Marbled Murrelet Effectiveness Monitoring: 2000 Annual Report. U.S. Fish and Wildlife Service, Portland, Oregon.

Raphael, M. G., G. A. Falxa, D. Lynch, S. K. Nelson, S. Pearson, A. Shirk, and R. D. Young.2016. Status and Trend of Nesting Habitat for the Marbled Murrelet Under the Northwest Forest Plan. In Northwest Forest Plan – The First 20 Years (1994-2013): Status and Trend of Marbled Murrelet Populations and Nesting Habitat. General Technical Report PNW-GTR-933. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, Oregon.

Rebke, M., V. Dierschke, C. N. Weiner, F. Aumuller, K. Hill, and R. Hill. 2019. Attraction of nocturnally migrating birds to artificial light: The influence of colour, intensity and blinking mode under different cloud cover conditions. Biological Conservation 233:220–227.

Reine, K., D. Clarke, and R. Engler. 1998. Entrainment by Hydraulic Dredges – A Review of Potential Impacts. Technical Note DOER-E1.

Ricker, S. J., D. Ward, C. W. Anderson, and M. Reneski. 2014. Results of Freshwater Creek Salmonid Life Cycle Monitoring Station 2010-2013. Fisheries Restoration Grant P0910513. California Department of Fish and Wildlife, Anadromous Fisheries Resource Assessment and Monitoring Program.

Rodriguez, A., G. Chapman, and R. Cartwright. 2011. Shorebird Abundance and Distribution on Beaches of Ventura County, California 2007-2010. December. BOEM OCS Study 2010-24. Camarillo, California. California State University Channel Islands.

Rondorf, D. W., G. L. Rutz, and J. C. Charrier. 2010. Minimizing Effects of Over-Water Docks on Federally Listed Fish Stocks in McNary Reservoir: A Literature Review for criteria. Report No. 2010-W68SBV91602084. U.S. Army Corps of Engineers, Walla Walla, Washington.

Rosenfield, J. A., and R. D. Baxter. 2007. Population dynamics and distribution patterns of longfin smelt in the San Francisco Estuary. Transactions of the American Fisheries Society 136:1577–1592.

Saglam, I. K., J. Hobbs, R. D. Baxter, L. S. Lewis, A. Benjamin, and A. Finger. 2021. Genome-wide analysis reveals regional patterns of drift, structure, and gene flow in longfin smelt (*Spirinchus thaleichthys*) in the northeastern Pacific. Canadian Journal of Fisheries and Aquatic Sciences 78:1793–1804.

Schlosser, S., and J. Bloeser. 2006. The Collaborative Study of Juvenile Rockfish, Cabezon, and Kelp Greenling Habitat Associations between Morro Bay, California and Newport, Oregon. February. Pacific States Marine Fisheries Commission.

Schlosser, S., and A. Eicher. 2012. The Humboldt Bay and Eel River Estuary Benthic Habitat Project. August. California Sea Grant Publication T-075. California Sea Grant College Program, La Jolla. Final report to the California State Coastal Conservancy, Agreement No. 06-085.

Science Applications International Corporation. 2011. Final Summary Report - Environmental Science Panel for Marbled Murrelet Underwater Injury Threshold. September 7. Prepared for U.S. Navy, NAVFAC Northwest, Bothell, Washington.

Shapovalov, L., and A. C. Taft. 1954. The Life Histories of the Steelhead Rainbow Trout (*Salmo gairdneri gairdneri*) and Silver Salmon (*Oncorhynchus kisutch*) with Special Reference to Waddell Creek, California, and Recommendations Regarding their Management. Fish Bulletin 98. California Department of Fish and Game.

SHN Consulting Engineers & Geologists. 2022. Preliminary Osprey and Bat Survey Results Report, Redwood Multipurpose Marine Terminal, Samoa, California. Survey Report. September 2. Prepared for Moffat & Nichol. Prepared by SHN Consulting Engineers & Geologists, Eureka, California.

Southall, B. L., J. J. Finneran, C. Reichmuth, P. E. Nachtigall, D. R. Ketten, A. E. Bowles, W. T. Ellison, et al. 2019. Marine mammal noise exposure criteria: Updated scientific recommendations for residual hearing effects. Aquatic Mammals 45(2):125–232.

Southall, B. L., D. P. Nowacek, A. E. Bowles, V. Senigaglia, L. Bejder, and P. L. Tyack. 2021. Marine mammal noise exposure criteria: Assessing the severity of marine mammal behavioral responses to human noise. Aquatic Mammals 47(5):421–464.

Steinbeck, J. 2022. Personal communication regarding euphausiid collections in Humboldt Bay, California during 2022 sampling efforts to characterize potential for entrainment of longfin smelt. December 8.

Stillwater Sciences. 2006. Upper Penitencia Creek Limiting Factors Analysis. Final Technical Report. August 18. Prepared for Santa Clara Valley Urban Runoff Pollution Prevention Program, Oakland, California.

Stillwater Sciences. 2016. California Endangered Species Act Incidental Take Permit Application for the Fisherman's Channel Dredging Project. August. Arcata, California. Prepared for Humboldt Bay Harbor, Recreation, and Conservation District and California Department of Fish and Wildlife.

Studebaker, R. S., and T. J. Mulligan. 2009. Feeding habits of young-of-the-year black and copper rockfish in eelgrass habitats of Humboldt Bay, California. Northwestern Naturalist 90:17–23.

Sullivan, R. M. 1980. Seasonal occurrence and haul-out use in pinnipeds along Humboldt County, California. Journal of Mammalogy 61(4):754–760.

Sweetnam, D. A., R. D., Baxter, and P. B. Moyle. 2001. True smelt. Pages 472-479 *in* W. S. Leet, C. M. Dewees, R. Klingbeil, and E. J. Larson, editors, California's Living Marine Resources: A Status Report. California Department of Fish and Game, Sacramento.

Tabor, R. A., E. K. Perkin, D. A. Beauchamp, L. L. Britt, R. Haehn, J. Green, T. Robinson, et al. 2021. Artificial lights with different spectra do not alter detrimental attraction of young Chinook salmon and sockeye salmon along lake shorelines. Lake and Reservoir Management 37:313–322.

Tallman, J., and C. Sullivan. 2004. Harbor seal (*Phoca vitulina*) predation on a male harlequin duck (*Histrionicus histrionicus*). Northwestern Naturalist 85:31–32.

Tenera Environmental. 2023. Intake Assessment of the Potential Effects on Ichthyoplankton and other Meroplankton Due to Entrainment at Proposed Samoa Peninsula Water Intakes. May 1. ESLO2023-001.2. San Luis Obispo, California.

Thompson, R. W. 1971. Recent Sediments of Humboldt Bay, Eureka, California. Final Report PRF 789-G2.

Todd, V. L. G., I. B. Todd, J. C. Gardiner, E. C. N. Morrin, S. L. MacPherson, N. A. DiMarzio, and F. Thomsen. 2015. A review of impacts of marine dredging activities on marine mammals. ICES Journal of Marine Science 72(2):328–340.

[USACE] U.S. Army Corps of Engineers. 2004. Framework for Assessment of Potential Effects of Dredging on Sensitive Fish Species in San Francisco Bay. Final Report. August 5. 001-09170-00. San Francisco, California. Prepared for U.S. Army Corps of Engineers, San Francisco District.

[USACE] U.S. Army Corps of Engineers. 2021. Draft Environmental Assessment and FONSI - Humboldt Harbor and Bay Operations and Maintenance Dredging (FY 2021-25). March. Humboldt Bay, Humboldt County, California. Prepared by U.S. Army Corps of Engineers, San Francisco District.

U.S. Army Engineer Research and Development Center. 2013. Entrainment of Smelt in San Francisco Bay by Hydraulic Dredges: Rates, Effects, and Mitigation. October 24. Prepared for the US Army Engineer San Francisco District.

[USFWS] U.S. Fish and Wildlife Service. 1970. Conservation of endangered species and other fish or wildlife: List of endangered foreign fish and wildlife. Federal Register 35(233):18319–18322.

[USFWS] U.S. Fish and Wildlife Service. 1992. Endangered and threatened wildlife and plants; Determination of threatened status for the Washington, Oregon, and California population of the marbled murrelet. Federal Register 57(191):45328–45337.

[USFWS] U.S. Fish and Wildlife Service. 1993. Endangered and threatened wildlife and plants; Determination of threatened status for the Pacific coast population of the western snowy plover. Federal Register 58(42):12864–12874.

[USFWS] U.S. Fish and Wildlife Service. 1994. Endangered and threatened wildlife and plants; Determination of endangered status for the tidewater goby. Federal Register 59(24):5494–5498.

[USFWS] U.S. Fish and Wildlife Service. 1995. Endangered and threatened wildlife and plants; Final rule to reclassify the bald eagle from endangered to threatened in all of the lower 48 states. Federal Register 60(133):3600–3610.

[USFWS] U.S. Fish and Wildlife Service. 1997. Recovery Plan for the Threatened Marbled Murrelet (*Brachyramphus marmoratus*) in Washington, Oregon, and California. USFWS, Portland, Oregon.

[USFWS] U.S. Fish and Wildlife Service. 2007a. Recovery Plan for the Pacific Coast Population of the Western Snowy Plover (*Charadrius alexandrinus nivosus*). Sacramento, California.

[USFWS] U.S. Fish and Wildlife Service. 2007b. Endangered and threatened wildlife and plants; Removing the bald eagle in the lower 48 states from the list of endangered and threatened wildlife. Federal Register 72(130):37345–37372.

[USFWS] U.S. Fish and Wildlife Service. 2007c. Listed Distinct Population Segment of the Brown Pelican (*Pelecanus occidentalis*). 5-year Review: Summary and Evaluation. USFWS, Southwestern Regional Office, Albuquerque, New Mexico.

[USFWS] U.S. Fish and Wildlife Service. 2009. Endangered and threatened wildlife and plants; Removal of the brown pelican (*Pelecanus occidentalis*) from the federal list of endangered and threatened wildlife. Federal Register 74(220):59444–59472.

[USFWS] U.S. Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants; Revised designation of critical habitat for the Pacific Coast population of the western snowy plover. Federal Register 77(118):36728–36869.

[USFWS] U.S. Fish and Wildlife Service. 2013. Endangered and threatened wildlife and plants; Designation of critical habitat for tidewater goby. Federal Register 78(25):8746–8819.

[USFWS] U.S. Fish and Wildlife Service. 2014. Monitoring for marbled murrelets during marine pile driving – Certification training. Port Townsend Marine Science Center, June 16. PowerPoint Presentation.

[USFWS] U.S. Fish and Wildlife Service. 2020. IPaC - Information for Planning and Consultation. Department of the Interior, U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California. <https://ecos.fws.gov/ipac/>. Accessed May 2022.

[USFWS] U.S. Fish and Wildlife Service. 2022. Endangered and threatened wildlife and plants; Endangered species status for the San Francisco Bay-Delta distinct population segment of the longfin smelt. Federal Register 87(194):60957–60975.

[USFWS] U.S. Fish and Wildlife Service. 2023. Endangered and threatened wildlife and plants; Endangered species status for the San Francisco Bay-Delta distinct population. Federal Register 88(38):12304–12306.

Wallace, M. 2006. Juvenile Salmonid Use of Freshwater Slough and Tidal Portion of Freshwater Creek, Humboldt Bay, California: 2003 Annual Report. Inland Fisheries Administrative Report No. 2006-04. California Department of Fish and Game.

Wallace, M., and S. Allen. 2007. Juvenile Salmonid Use of the Tidal Portions of Selected Tributaries to Humboldt Bay, California. June. Final Report for Contract No. P0410504. California Department of Fish and Game, Pacific States Marine Fisheries Commission.

Wallace, M., S. Ricker, A. Garwood, A. Frimodig, and S. Allen. 2015. Importance of the stream estuary ecotone to juvenile coho salmon (*Oncorhynchus kisutch*) in Humboldt Bay, California. California Fish and Game 101:241–266.

Wallace, M., E. Ojerholm, A. Scheiff, and S. Allen. 2018. Juvenile Salmonid Use and Restoration Assessment of the Tidal Portions of Selected Tributaries to Humboldt Bay, California, 2015–2017. January. Fisheries Restoration Grant Program Final Report for Grant P1310520.

Warriner, J. S., J. C. Warriner, G. W. Page, and L. E. Stenzel. 1986. Mating system and reproductive success of a small population of polygamous snowy plovers. Wilson Bulletin 98(1):15–37.

[WSDOT] Washington State Department of Transportation. 2020. Biological Assessment Preparation Manual. Chapter 7.0 Construction Noise Impact Assessment. <https://wsdot.wa.gov/sites/default/files/2021-10/Env-FW-BA_ManualCH07.pdf>. Accessed May 2023.

Weise, M. J. 2000. Abundance, Food Habits, and Annual Fish Consumption of California Sea Lion (*Zalophus californianus*) and Its Impact on Salmonid Fisheries in Monterey Bay, California. M. S. thesis. Moss Landing Marine Lab, San Jose State University. Moss Landing, California.

Westlake, R. L., and G. M. O'Corry-Crowe. 2002. Macrogeographic structure and patterns of genetic diversity in harbor seals (*Phoca vitulina*) from Alaska to Japan. Journal of Mammalogy 83(4):1111–1126.

Wild, P. W., and R. N. Tasto. 1983. Life History, Environment, and Mariculture Studies of the Dungeness Crab, *Cancer magister*, with Emphasis on the Central California Fishery Resource. Fish Bulletin 172. California Department of Fish and Game, Sacramento.

Wiltschko, W., U. Munro, H. Ford, and R. Wiltschko. 1993. Red light disrupts magnetic orientation of migratory birds. Nature: 364:525–527.

Wochner, M. 2019. Pile driving noise reduction approaches. Journal of Ocean Technology 14(3):146–147.

Wright, B. E., S. D. Riemer, R. F. Brown, A. M. Ougzin, and K. A. Bucklin. 2007. Assessment of harbor seal predation on adult salmonids in a Pacific northwest estuary. Ecological Applications 17(2):228–351.

Yanagitsuru, Y. R., I. Y. Daza, L. S. Lewis, J. A. Hobbs, T. C. Hung, R. E. Connon, and N. A. Fangue. 2022. Growth, osmoregulation and ionoregulation of longfin smelt (*Spirinchus thaleichthys*) yolk-sac larvae at different salinities. Conservation Physiology 10(1).

Zavala-Gonzalez, A., and E. Mellink. 2000. Historical exploitation of the California sea lion, *Zalophus californianus*, in Mexico. Marine Fisheries Review 62(1):35–40.

Zeiner, D. C., W. F. Laudenslayer Jr., K. E. Mayer, and M. White, editors. 1990. California's Wildlife. Volume II. Birds. California Statewide Habitat Relationships System. California Department of Fish and Game.