Appendix N

Tenera Humboldt Bay Piling Removal Restoration for Longfin Smelt and other Marine Resources

The Use of Piling Removal for Mitigating Effects of Entrainment Losses to Longfin Smelt and Other Marine Resources Resulting from Operation of the Proposed Samoa Peninsula Intakes in Humboldt Bay

December 13, 2021

Document SLO2021-019

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Introduction

This technical memorandum provides information on the use of piling removal as a method for mitigating the effects of a project that will include two ocean water intakes on the Samoa Peninsula in Humboldt Bay (the Bay) on Longfin Smelt (LFS), other fishes, marine resources, and overall biological productivity. This information was requested by the Humboldt Bay Harbor Recreation and Conservation District (the District) to assist in permitting requirements for the project. The permitting requirements will likely include a California Department of Fish and Wildlife (CDFW) Incidental Take Permit (ITP) for estimated entrainment effects on the larval populations of LFS and mitigation for effects of the project on other fishes, marine resources, and overall biological productivity required for the Coastal Development, NPDES, and Army Corp of Engineers permits. The two intakes will be modernized, owned, and operated by the District. The information in this memorandum could also be used for developing larger mitigation projects that might require information on effects on LFS or that may include piling removal as a component of a mitigation package.

The piling removal project proposed by the District as mitigation for the effects of potential entrainment on LFS is located along the eastern shore of the South Bay portion of Humboldt Bay (**Figure 1**). The abandoned pilings were previously part of a structure referred to as the Kramer Dock and extend over an area of approximately two acres of shoreline. At the upcoast end of the abandoned dock, the pilings are more numerous and extend further out from the shoreline, while at the downcoast end they only extend a short distance from the shore. All of the pilings have been cut off and extend various lengths above the surface of the water. There are over 1,400 pilings below the high tide line and several hundred additional pilings, not proposed for removal, that occur along the shoreline above the high tide line that helped support a retaining wall.

Removal of the pilings in the water will restore the habitat to support aquatic vegetation, such as eelgrass, and associated invertebrates and fishes, including LFS and result in the removal of creosote laden piles out of the bay.

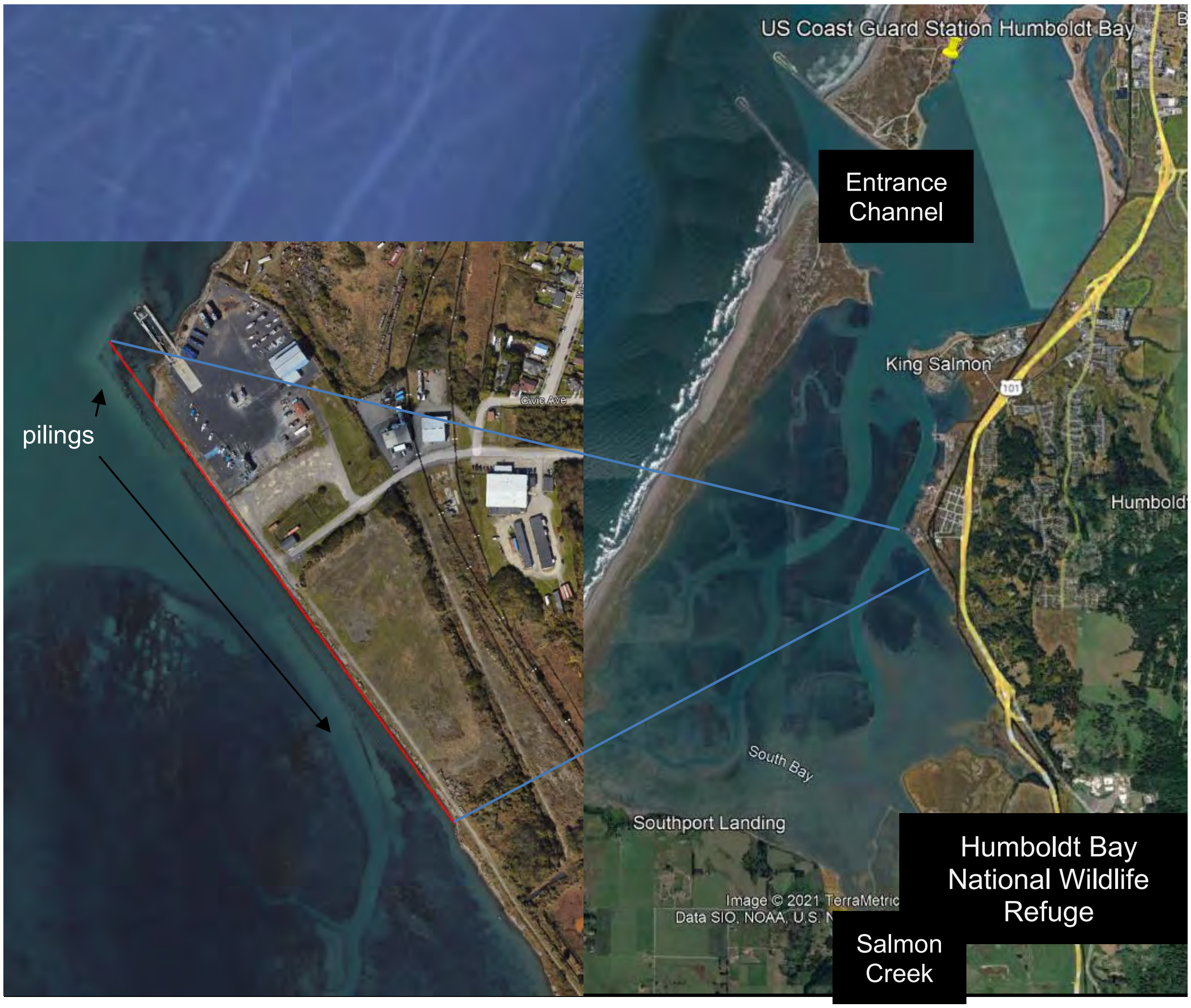

Figure 1. Map of South Bay area of Humboldt Bay with inset showing detail of pilings from the abandoned Kramer Docks. The red line in the inset is 560 m (0.35 mi) long and shows the extent of the pilings along the shoreline.

Benefits of Piling Removal

Removal of derelict and existing pilings in marine and estuarine areas has been a goal of agencies responsible for the stewardship of marine resources in several areas along the west coast (CSCC 2010, Werme et al. 2010, ESA 2020, ICF 2019). One of the restoration objectives in the San Francisco Bay Subtidal Habitat Goals Report (CSCC 2010) is to "Where feasible, remove artificial structures from San Francisco Bay that have negative or minimal beneficial habitat functions and to promote pilot projects to remove artificial structures and creosote pilings at targeted sites in combination with a living shoreline restoration design that will use natural bioengineering techniques (such as native oyster reefs, stone sills, and eelgrass plantings) to replace lost habitat structure." The report lists several other benefits to the removal of old and derelict pilings including:

- Reduced substrate for introduced species;
- Reduced shading of the bottom and water column;
- Reduced toxic effects of creosote and other contaminants;
- Reduced restrictions to flow and sediment movement;
- Restoration, re-creation, or realignment of intertidal mudflats, sand flats, rock, and shellfish, eelgrass, and macroalgal beds;
- Reduced navigational hazards; and
- Improved aesthetics.

An issue mentioned in the report that inventoried pilings for Snohomish County (ESA 2020) is the restriction on growth of eelgrass or other submerged vegetation (SUV) in the areas around pilings, that they term as a "halo" around each piling. Depressions around the base of pilings are common and are most likely the result of increases in the speeds of ambient currents around the pilings that pull away sediment. In an area where there are numerous pilings closely spaced, such as the abandoned Kramer Dock, this effect would likely be expected to severely limit growth of eelgrass and SUV in the area. Therefore, the removal of a piling results in the restoration of a much larger area than just the area occupied by the piling.

Probably the most often cited reason for removal of old pilings is from the use of creosote as a preservative that was a way to reduce the effects of marine boring organisms on the wood pilings. Creosote was used as a preservative treatment for wood pilings up until 1993 when the CDFW stopped approving its use in state waters (Werme et al. 2010). Other states such as Washington have also initiated programs to eliminate creosote treated pilings (see https://www.dnr.wa.gov/programs-and-services/aquatics/restoring-washingtons-waterways). Many of these programs have compiled maps of the derelict pilings and have developed programs for the phased removal of the pilings.

Creosote is derived from coal tars and is made up of hundreds of thousands of chemical compounds with various forms of polycyclic aromatic hydrocarbons (PAH) accounting for up to 90% of the creosote mixture (Werme et al. 2010). Previously, it was thought that the leaching of these compounds occurred at such low rates that no effects could occur to marine organisms. Studies resulting from the Exxon Valdez oil spill in Prince William Sound in Alaska related to the crash of the Pacific Herring fishery and sharp declines in the Pink Salmon fishery showed that very low levels of PAHs (~1.0 ppb) could affect developing fish embryos and potentially affect adult populations (see Heintz 2007). Further research verified the impacts that exposure to

PAHs in natal habitats could have on the adult population size of Pink Salmon (Heintz 2007). More recent research also showed that exposure to trace levels of oil affects the development of cardiac muscle in salmon and herring and reduces cardiorespiratory function in juvenile and adults, which is likely a key factor in survival and population recruitment (Incardona et al. 2015).

Therefore, even very low levels of leaching of PAHs from the weathered pilings in Humboldt Bay may still represent a risk to fishes and other marine organisms. Assuming that the total lengths of the pilings average 30 ft (9.14 m) that includes a length above the seabed that averages 10 ft (3.05 m) and an average diameter of 12” (0.3 m), the total average surface area of each piling would be approximately 94.25 ft^2 (8.75 m^2) (2*π*radius*length). Based on these assumptions, the removal of all 1,400 pilings would result in the removal from the environment of 131,947 ft^2 (12,258 m^2) or approximately 3.0 acres of surface contaminated with PAHs.

Benefits to Longfin Smelt.

Longfin Smelt would be most susceptible to the effects of PAHs in the habitats where spawning occurs, which are areas upstream from Humboldt Bay. Freshwater deltas and bays provide important habitat for LFS spawning. Although, specific locations of spawning events vary with a multitude of conditions (Rosenfield 2010), shallow brackish tidal marshes and sloughs are identified as important spawning and recruitment areas (Lewis et al. 2020), because the newly hatched larvae have a salinity tolerance of 2–6 practical salinity units (psu) (Baxter et al. 2010). In Humboldt Bay, these are likely areas such as the Eureka Slough and the marsh areas around Salmon Creek and Hookton Slough in the South Bay.

Figure 2. Locations of all life stages of Longfin Smelt collections in Humboldt Bay, its tributaries, the Eel River, and offshore waters from 1931 to 2016 (from Garwood 2017).

Developing larvae would also be expected to be highly susceptible to the effects of PAHs. Although recent sampling for ichthyoplankton in Humboldt Bay in 2019 and 2020 only found LFS larvae in areas near the Eureka Slough (Brennan 2021), historical data presented by Garwood (2017) showed that LFS were collected in Salmon Creek and Hookton Slough, and also in the area around the abandoned Kramer Dock (**Figure 2**). These data are attributed to M. Wallace (unpublished data) by Garwood (2017). Larvae exported out of Salmon Creek and Hookton Slough that occurred in the area of the Kramer Docks would be especially susceptible to any effects of PAHs leaching from the pilings.

The abandoned pilings at the Kramer Dock might be expected to attract fishes and other marine organisms due to the structure they provide, which tend to attract fishes, as evidenced by the report of LFS in that area in Garwood (2017). While these structures may attract fishes, the benefits to LFS and other marine organisms would be much greater if the pilings were removed, and the area restored to more natural conditions. The removal of the pilings would return natural current flow to the area allowing the reestablishment of eelgrass and other SUV in the area. The piling removal and resulting restoration of the area will provide all of the benefits listed previously that were identified by the San Francisco Bay Subtidal Habitat Goals Report (CSCC 2010). Most importantly, the restoration removes potential contaminants that could affect populations of fishes and other marine organisms in the Bay.

Calculating Mitigation for Longfin Smelt and Other Marine Resources

Habitat restoration is the most common approach to mitigation used for LFS. The ITP permit application for incidental take of LFS due to the construction and operation of the various components of the State Water Project (SWP) in the Sacramento-San Joaquin Delta (the Delta) uses habitat restoration as a means to compensate for any take that cannot be addressed by other mitigation measures (ICF 2016). The SWP is being managed by the State Department of Water Resources (DWR) and involves the construction of intakes and underground conveyance tunnels for a water storage and delivery system that extends more than 705 miles and provides water to 27 million residents, 750,000 acres of farmland, and businesses throughout California. The SWP was designed to deliver nearly 4.2 million acre-feet of water per year. The total construction period will be approximately 13 years, from 2018 to 2031. The proposed mitigation of over 1,800 acres of habitat was largely required to offset effects on access to shallow water habitats (~1,700 acres) with a smaller amount required to offset construction activities (~100 acres). Even though entrainment was listed as potentially occurring at several of the Bay Delta pumping facilities, no mitigation for those impacts was required.

The smaller pumping facilities for the SWP in the north Delta that could entrain larval LFS were required to include screening that would exclude fishes greater than ~ one inch (25 mm) and monitoring of LFS would be conducted to determine if operations of those facilities needed to be adjusted to minimize impacts. The screening requirements for these intakes were the same as the requirements in the Humboldt Bay Master Water Intakes Special Conditions of Approval (10/12/21 Draft) for the project (Conditions of Approval) and were developed by the National Marine Fisheries Service (NMFS 1997). The slot openings on the two intakes for the Humboldt Bay project has been further reduced to 0.0394 inches (1.0 mm) which exceeds the design requirement in the Conditions of Approval that the slot opening for the screens not exceed 0.0689 inches (1.75 mm). The reduced slot openings for the Humboldt intakes will help eliminate the entrainment of larger, later stage larvae of LFS and other species.

Calculating the required mitigation for losses of LFS larvae and other marine resources could proceed by calculating an estimate of the habitat necessary to compensate for the take of LFS as a requirement of the ITP for the project and also as the habitat necessary to replace the estimated loss of productivity in the Bay resulting from the final calculations of the Empirical Transport Model (ETM) estimates of Area of Production Foregone (APF) resulting from the Intake Assessment Study. We would propose that any of the calculations of required mitigation include the area of PAH contamination removed. As shown above, the average surface area of contamination removed with each piling would be approximately 94.25 ft^2 (8.75 m^2). The total surface area of contamination removed would more than double the estimated two acres of habitat currently occupied by the abandoned Kramer Dock pilings. Therefore, we would propose that the District receive four acres of mitigation credit for each acre of habitat restoration at the Kramer Dock. This would also help recognize the multiple benefits of piling removal listed from the project report for San Francisco Bay above, and the importance of removing a source of contamination from the Bay.

The proposed mitigation to compensate for the estimated annual take of LFS larvae for the CDFW ITP will be based on the results of the planned Intake Assessment Study on the effects of entrainment at the two intakes. Life history information available for LFS from scientific literature and reports will be used to calculate the context for the annual entrainment losses of larval LFS as follows. Females lay 1,900 to 18,000 adhesive eggs on sandy or grassy substrate that will hatch after ~40 days (CDFW 2009). The average fecundity for an average sized female (~4 inches [100 mm]) is approximately 5,000 eggs (Figure 3 in CDFW 2009). Data on laboratory studies from Yuzo et al. (2021) found hatching success for LFS eggs averaged 59% resulting in the hatching of 2,950 larvae from the 5,000 eggs. The average length of the larvae collected from the recent CDFW sampling (James Ray unpublished data) at the two locations closest to the proposed intakes was 0.29 inches (7.4 mm). Data in Yuzo et al. (2021) was used to calculate an average length at hatching of 0.22 inches (5.5 mm). Using the differences in lengths between hatching and the larvae collected near the intakes and a daily growth rate of 0.0055 inches (0.14 mm) per day (CDFW 2009) results in an estimated age of these fishes of 13.6 d. Yuzo et al. (2021) estimate a mortality of approximately 90% for these early-stage larvae. Chigbu (2000) provides several estimates of instantaneous mortality for LFS from Lake Washington in the state of Washington over periods of 5–7 months. Using the mortality estimate (Z=0.149) for the shortest period to eliminate some of the bias due to decreased mortality of larger juvenile fishes results in a daily survival estimate of 0.862. The estimated survival over 13.6 days is 0.132 ($0.862^{13.6}$; survival = 13.2 %, mortality = 86.7%). This estimate is close to the mortality estimate from Yuzo et al (2021). Since the 90% mortality from Yuzo et al (2021) applies directly to early stage LFS larvae, it was used to estimate that 295 13.6-day old larvae would result for each average size female LFS. Assuming that the lengths of the LFS larvae collected at the intake locations during the Intake Assessment Study are similar to the results from the CDFW sampling (James Ray unpublished data), the take associated with the entrainment of 295 LFS larvae would represent the annual production of one female.

The approach of using piling removal as an approach for mitigation for the potential take of life stages such as larval LFS due to entrainment at the project intakes is consistent with other mitigation approaches of using habitat restoration to cover a wide range of impacts that may not specifically address the life stage impacted. While the piling removal will not specifically benefit the spawning habitat for LFS, it does provide specific benefits to all life stages that may be affected by increased levels of PAHs in the vicinity of the Kramer Dock. Therefore, we believe that this approach is reasonable for this project because it is unlikely that spawning habitat for LFS is limited in the marsh areas associated with Humboldt Bay. A greater concern is the presence of contaminated surfaces that may result in the direct mortality on the larvae of LFS and other fishes and the leaching of PAHs that, as described above, have been shown to affect adult and juvenile stages of fishes, and organisms living in the sediments where the pilings are buried. Also, the proposed mitigation ratio of four acres of restoration credit for each acre of habitat restoration at the Kramer Dock reflects the multiple benefits of piling removal from the project report for San Francisco Bay listed above, that go beyond the restoration of the habitat previously occupied by the pilings.

Example Mitigation Calculations

The information provided in the previous sections is used in this section to provide example calculations for estimating mitigation that may be required for the effects of entrainment at the two intakes. Mitigation for the annual take of LFS larvae may be required in the CDFW ITP that will be issued for the project. It is also likely that mitigation will be required for the estimated loss of productivity in the Bay due to entrainment that would be calculated using Empirical Transport Model (ETM) estimates of Area of Production Foregone (APF). The final mitigation calculations will be based on the data collected from the Intake Assessment Study that will be completed in early 2023.

Mitigation for ITP Permit for LFS Larvae

As detailed above, available life history data can be used to estimate the number of adult female LFS necessary to produce the estimated annual entrainment of LFS larvae. Based on the life history information provided above and assuming that the lengths of the LFS larvae collected at the intake locations during the Intake Assessment Study are similar to the results from the CDFW sampling (James Ray unpublished data), the take associated with the entrainment of 295 LFS larvae would represent the annual production of one female. The necessary spawning habitat for a single LFS is likely small and less than a few square meters. Therefore, if we assume that the annual take of LFS larvae in the ITP is set at 200 larvae, the required mitigation would need to compensate for the annual production loss of less than one female.

We would propose to use a more conservative 1:1 mitigation ratio for the take of larval LFS that does not include the benefits associated with the removal of contaminated surfaces of the pilings. Assuming that the area of the bottom affected by each piling represents an area of approximately one square meter (10.8 ft^2), the removal of four pilings would provide restoration of four square meters (43.1 ft^2) of habitat, an estimate that likely exceeds the habitat required for spawning of a single female LFS and would fully compensate for the annual take of 200 larval LFS.

Mitigation for Loss of Production using APF

The estimated loss of productivity will result from the final calculations of the Empirical Transport Model (ETM) estimates of Area of Production Foregone (APF) resulting from the results of the study. The Preliminary Intake Assessment report dated May 13, 2021 analyzed potential entrainment losses for larval populations in Humboldt Bay potentially affected by entrainment. The period of time that the larvae are subject to entrainment will vary by species, but for all the ETM models that used periods of exposure of up to 30 days, the losses to the larval populations were estimated to be 0.1% or less when any form of tidal exchange was included in the model. These levels would likely not result in any impacts on the resulting adult populations due to the high levels of natural mortality of small fish larvae and the potential that larger larvae that are more likely to survive to adult age would be protected from entrainment due to the 0.0394 inch (1.0 mm) slot opening used in the wedgewire intake screens.

Although no effects on adult populations may not result from the effects of entrainment, APF can be used to estimate the amount of habitat necessary to compensate for the loss of production to all forms of marine life due to entrainment. This would include benthic and demersal invertebrates that may be directly impacted by PAH contamination from the pilings. Therefore, for calculating the mitigation required to compensate for the estimated APF we would propose to use the 4:1 mitigation ration described above which accounts for the removal of the contaminated surface area of each of the pilings.

As an example, using the estimated proportional mortality (P_M) estimate of 0.00104 (0.104%) from Table 4.1 of the ETM Model (M3), the methodology to calculate the APF will be as follows:

1. Using the estimated area of source water population (SWP) of 10,000 acres
2. The *APF* is calculated as 10,000 acres x the P_M estimate of 0.00104 = 10.4 acres

Using the proposed 4:1 mitigation ratio an area of piling removal equivalent to 2.6 acres would be required to compensate for the loss of productivity due to the operation of the intake.

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