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Comments on the Eden Landing Salt Pond Complex Restoration Plan Alternatives Relative to Anadromous Steelhead *(Onchorhynchus mykiss)*

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INTRODUCTION

A large purchase of solar salt production ponds in the Southern San Francisco Bay by the United States Fish and Wildlife Service and the California Department of Fish and Wildlife was done to restore the salt ponds to tidal marshes. This has become known as the South Bay Salt Pond Restoration Project. The goals of this project are to restore the salt ponds to ecologically functional tidal marshes and wetlands that provide habitat for wildlife, birds, and aquatic organisms, provide public access for wildlife viewing and recreation, and flood management in the Southern San Francisco Bay. There are three pond complexes that are undergoing restoration, Alviso, Ravenwood, and Eden Landing. The subject of this comment is the Eden Landing complex, which is currently in phase 2 of restoration planning. Phase 2 of the Eden Landing Complex is steered at restoring and enhancing ponds south of Old Alameda Creek. The purpose of this document is to provide comment on the restoration alternatives for the Eden Landing Complex on behalf of the Alameda Creek Alliance, specifically on the potential benefits and risks associated with the alternatives to steelhead (*Onchorhynchus mykiss*) and other anadromous fish that may use the restored ponds.

There is very little scientific information available that describes the use of restored salt ponds by juvenile *O. mykiss*. To prepare these comments, we reviewed literature on the use of coastal estuaries by juvenile *O. mykiss*, with a focus on systems from California, with the assumption that *O. mykiss* may utilize restored ponds similarly. Secondarily, we initiated correspondence with many of the lead authors on these papers to get their current opinion and hypotheses on the role the salt pond restoration may play in benefiting juvenile *O. mykiss* through increased growth, survival, and fitness.

First, we summarize the relative literature and expert opinions on how *O. mykiss* may use the restored salt ponds and risks to *O. mykiss* which may be associated with project alternatives. We also provide a recommendation of the preferred alternative and comment on potential changes that could be made based on the reviews of literature and expert opinion, with a focus on benefits for *O. mykiss*. We then conclude with recommendations on monitoring and research that could be done in the near term to better inform final design and implementation of Eden Landing Phase 2 that may better benefit *O. mykiss*.

SUMMARY OF LITERATURE PERTINENT TO THE USE OF TIDAL MARSHES AND RESTORED PONDS BY SALMONIDS IN THE SOUTHERN SAN FRANCISCO BAY

1) **Hobbs, J, (2015). Steelhead smolt outmigration and survival study: Year 2 Stream Surveys.**

Summary of research: Researchers attempted to determine how juvenile *O. mykiss* from Guadalupe River would utilize a water control structure on managed salt ponds in the Alviso Salt Pond Complex Restoration project. Ultimately, the goal was to understand if juvenile *O. mykiss* were at a risk of entrainment or if they successfully utilized the habitat as a rearing area that increased growth rates, survival and population. They also determined how predators such as striped bass may have utilized water control structures for predation. In 2014, 32 juvenile *O. mykiss* were PIT tagged in Guadalupe River and tracked with PIT antennae placed at 3 of the 5 slots on the water control structure at the A8 pond notch. In addition, 18 Striped Bass (*Morone saxatilis*) were tagged near the notch. Unfortunately, the antennae did not cover the entire A8 notch and one of their antenna was destroyed by high flows, thus they were only able to asses 2 of the 5 slots in the water control structure. None of the *O. mykiss* tagged in Guadalupe River were detected at the A8 notch; however, the researchers suggest that it may have been due to poor coverage (3 slots were not instrumented) of the antennae. While none of the tagged *O. mykiss* were detected, 3 different *M. saxatilis* were detected, and one of the fish was detected multiple times, suggesting it was spending significant time in the notch habitat. This provides evidence to suggest that predators will target breaches, and with only one breach per pond, the risk of predation to juvenile *O. mykiss* would be high. The researchers also interviewed anglers that frequent the notch and reported that *M. saxatilis* up to 50 lbs have been caught there and sometimes 50 fish per day.

Potential implications for the Eden Landing Complex restoration: This paper suggests that predation rates could be high at breaches and water control structures, and it is unclear if *O. mykiss* will access the restored ponds or how they could become entrained. The maximum number of breaches possible would likely dilute predation pressure at any one water control structure/breach.

2) **Hayes, S.A., et al. (2008). Steelhead growth in a small central California watershed: Upstream and estuarine rearing patterns. Transactions of the American Fisheries Society. 137:114–128.**

Summary of research: The goals of this paper were to assess and compare growth rates in stream rearing habitat and estuary rearing habitat in a typical coastal California watershed (Scott Creek). The authors tagged and recaptured juvenile *O. mykiss* to determine growth rates among habitats. The *O. mykiss* that were rearing in the stream grew at 0.01% per day during summer, while those rearing in the estuary grew at a significantly higher rate (0.2–0.8% per day). This suggests that *O. mykiss* which reared in the estuary grew larger and had a higher probability of ocean survival and returning to spawn as an adult.

Potential implications for the Eden Landing Complex restoration: This paper suggests that if juvenile *O. mykiss* could access the salt ponds effectively and with suitable habitat conditions (i.e. dissolved oxygen, salinity, and water temperature) they have the potential to grow at a higher rate. This is significant because juvenile rearing habitat is currently limiting in Alameda Creek and salt pond restoration has the potential to increase the rearing habitat available. However, there is considerable uncertainty in the salinity levels that the fish will be able to physiologically endure. The current design may not allow enough freshwater to enter the restored ponds, which may reduce the ability of *O. mykiss* to rear within the restored ponds.

3) Bond, M.H., et. al., (2008). Marine survival of steelhead (*Oncorhynchus mykiss*) enhanced by a seasonally closed estuary. Canadian Journal of Fish and Aquatic Sciences. 65: 2242–2252.

Summary of research: In this publication, the researchers continued analysis from Hayes et. al. (2008), and determined the adult spawning return rate and size of ocean entry by juveniles from estuary reared and stream reared *O. mykiss* in Scott Creek, CA. This was done using PIT tagged fish and by back calculating the size of juvenile at ocean entry from returning adults via a fish scale radius to fish length regression. Based on the tagged fish analysis, 87% of returning adults had spent time rearing in the estuary. Via the scale and length analysis, the authors estimate that 95% of the returning adults were estuary reared fish. This suggests that fish which rear in the estuary for the summer before entering the ocean in the fall grow to a significantly larger size and have a higher probability of ocean survival than those which only reared in the estuary.

Potential implications for the Eden Landing Complex restoration: This study supports a hypothesis that if juvenile *O. mykiss* can access the restored tidal pond without significant predation, entrainment associated mortality, and with favorable water quality conditions, then restoration may help alleviate a likely juvenile rearing constraint on the Alameda Creek water shed. Higher growth rates and larger size smolts will increase their probability of ocean survival and returning to spawn as adults. However, in the current design, salinity levels may be too high for juvenile *O. mykiss* to utilize the habitat.

4) Cannata, S.P. (1998). Observations of steelhead trout (*Oncorhynchus mykiss*), Coho Salmon (*O. kisutch*) and water quality of the Navarro River Estuary/Lagoon, May 1996 to December 1997.

Summary of research: This paper described the use of a coastal estuary/lagoon system in Northern California by *O. mykiss* and Coho Salmon (*Oncorhynchus kisutch)*. In addition, the research assessed dissolved oxygen, salinity, and temperature to determine if parts of the estuary became unable to sustain salmonid life (i.e. anoxic or hyper-saline environments). The research documented use of the estuary system throughout the entire year by young-of-year, age-1 and age-2 juvenile *O. mykiss*. In a comparison between estuary reared and river reared *O. mykiss* that were greater than 110 mm in length, fish from the estuary had a higher body weight. The authors also suggest that a large proportion of the juvenile *O. mykiss* population utilizes the estuary for rearing year-round.

Water quality was measured with the goal of relating temperature, dissolved oxygen, and salinity to fish abundance. They observed that once the estuary became completely closed off from tidal influences from sand bar formation, a halocline forms. A halocline forms when there is a difference in salinity levels along a depth gradient, with the warmer and denser saline water settled below the cooler and less dense freshwater is at the top. This is most apparent in the areas closest to the ocean. Because of this phenomenon, habitat can increase or decrease relative to streamflow. For example, in years with low streamflow, areas stratified by the halocline may be larger relative to years with higher streamflow, because less freshwater is delivered and the potential of the halocline breaking down decreases. When the estuary is stratified by levels of salinity, concentration of dissolved oxygen and temperature reach lethal levels for juvenile salmonids in the deeper waters and fish mush seek out refuge in surface waters, nearshore zones, or areas further upstream, which was observed by this study.

<u>Potential implications for the Eden Landing Complex restoration</u>: This study provides evidence to suggest that *O. mykiss* would utilize tidal areas if they are provided safe access. In addition, this study highlights the importance of water quality within the tidal area. Water quality models should be developed for the ponds being restored to determine if environmental conditions would be suitable for *O. mykiss* if they were in the ponds.

5) Zedonis, P.A. (1990). The biology of juvenile steelhead (*Oncorhynchus mykiss*) in the Mattole River estuary/lagoon. Master’s Thesis. Humboldt State University.

<u>Summary of research</u>: This study was similar in design and outcome to Cannata et. al. (1998). Juvenile *O. mykiss* catch per unit effort and population estimates were made for lower and upper areas along the Mattole River Estuary. Results suggest that juvenile *O. mykiss* utilize the estuary for rearing year-round. However, during summer and when the estuary becomes closed off, the formation of a halocline can limit habitat as dissolved oxygen concentration and temperature reach lethal levels in the deep-water areas closest to the ocean. This effect is particularly problematic during low streamflow years. This study also examined diet of juvenile *O. mykiss* in the estuary, which were dominated by invertebrates and there was no evidence of food limitation.

<u>Potential implications for the Eden Landing Complex restoration</u>: This study suggests that estuaries (most comparable habitat to restored salt ponds with information on *O. mykiss*) are highly fertile nursery areas, and under the right water quality conditions could increase growth rates of juvenile *O. mykiss*. Water quality modeling or monitoring would be beneficial in determining the suitability for juvenile *O. mykiss* rearing in the restored ponds. Similarly, identification of a freshwater source that would dilute salinity and create a brackish system would likely result in more suitable rearing habitat for juvenile *O. mykiss*. In the current plan, salinity maybe too high for *O. mykiss* to successfully utilize the restored ponds. Monitoring of fish movement and habitat selection would be beneficial in determine how well they could utilize the restored ponds.

SUMMARY OF EXPERT OPINIONS PERTINENT TO THE USE OF TIDAL MARSHES AND RESTORED PONDS BY SALMONIDS IN THE SOUTHERN SAN FRANCISCO BAY

1) Dr. James Hobbs (University of California – Davis)

Dr. Hobbs was the author on the first paper reviewed above which was the only study that examined use of the salt ponds by *O. mykiss*. His main concerns about design were predation risks at breach points, which was observed from his study which noted the presence of predators at breach points and water control structures. To avoid this, multiple breach points for each pond are ideal so that *O. mykiss* avoid congregating in one location where they are vulnerable to predators. Dr. Hobbs also recommends not doing any managed ponds and to use the full tidal restoration alternatives. In addition, he suggests that breaching ponds in order furthest from bay to closest to bay is recommended so that sediment does not accumulate in the closest to bay pond and block natural restoration of those furthest from the bay. Dr. Hobbs also suggests that if the ponds are designed to benefit *O. mykiss, O. tshawtscha* (Chinook Salmon) would also benefit.

2) Mike Wallace (California Department of Fish and Wildlife)

Mike Wallace has authored reports on the use of juvenile *O. kisutch* (Coho Salmon) in Humboldt Bay. Based on his observations and studies on *O. kisutch*, Mr. Wallace stressed considerable uncertainty about how *O. mykiss* may use the restored ponds, but would likely result in some use. His primary concern was about the water quality issues that may arise in the restored ponds, and that it is possible that short term anoxic conditions could be detrimental to any *O. mykiss*, and suggests that water quality be modeled. He also suggests adding deeper pools and large wood cover to the restored tidal ponds, which may act as refugia for juvenile *O. mykiss* to reduce stranding mortality and predation during the tidal cycles.

3) Dr. Morgan Bond (NOAA)

Dr. Bond was an author of one of the peer reviewed papers above (Bond et al. 2008), and suggests that there is no real comparable habitat to the tidal ponds, so finding peer-reviewed literature and white papers may be difficult. She reiterated her results from the paper and suggests there could be considerable movements between the streams and restored ponds over a large variety of time scales (i.e. from daily to annual movement). The ability to search for and forage in preferred habitat likely increases growth through increased food availability, and condition through improved water quality conditions such as temperature, DO, and salinity.

COMMENTS ON PLAN ALTERNATIVES

We feel that it is beneficial that the plan alternatives included designs that could facilitate the use of the restored ponds by juvenile *O. mykiss* as rearing habitat through breaches and tidal restoration. Based on our literature reviews and interviews, we believe that providing adequate access to the ponds and ensuring favorable water quality would likely allow juvenile *O. mykiss* to grow at a faster rate and out-migrate at a larger size, which increases the probability of ocean survival and returning to spawn. However, based on our review of literature, contact with experts, and our own opinions we do have some comments to the plan alternatives. Below we summarize our concerns with the plan alternatives: predation risk, connectivity, and water quality.

1) Predation Risk

Alternative plans B–D included various breaches and channel constructions that have the potential to be utilized by juvenile *O. mykiss* for rearing habitat. However, these plans included only one breach for each pond, which may increase the risk for predation on juvenile *O. mykiss* as predators are likely to congregate at the breaches (Hobbs 2015). We suggest that along the Alameda Creek Flood Control Channel (ACFCC) and on the bay side of the ponds, multiple breaches be put in place on each pond to decrease the potential of predation at pond breaches. The addition of the bay side breach would allow easier out migration and connectivity with the Bay, while simultaneously reducing the risk of predation. Monitoring predator use could also be done in the current Phase 1 portion of the Eden Complex to better understand the risk of predation to juvenile *O. mykiss* and help inform design of Phase 2.

2) Connectivity

The breaches and channel construction in the current plan alternatives provide only a single location in and out of each pond. Based on our literature review, we feel that multiple points of connectivity are critical for juvenile *O. mykiss* to best utilize the pond habitat when suitable environmental conditions exist. For example, Bond et al. (1998) and Cannata (1998) suggest that in most estuaries, *O. mykiss* must be able to move freely and efficiently between estuary and freshwater habitats to successfully utilize the fertile environments provided by the estuary. While salt ponds will not necessarily function the same way that an estuary will, we expect some similarities during certain seasons and hydrological conditions. Thus, we suggest creating multiple points of access to each pond along the ACFCC and the bay to increase connectivity between habitats. To help inform the design of Phase 2, monitoring of juvenile *O. mykiss* habitat use of Phase 1 could be done. This would determine the level of connectivity required to make the habitat suitable and be valuable in the design of breaches.

3) Water Quality

O. mykiss are adapted to thrive in certain temperature and dissolved oxygen ranges, and levels too far outside of those ranges can be stressful or lethal. Studies have found that *O. mykiss* utilize estuaries, but seek refuge in freshwater when conditions became unfavorable (Hayes et al. 2008, Cannata 1998). To address this concern, we suggest water quality monitoring and/or water quality modeling to determine the sub-daily levels of dissolved oxygen and temperatures that would occur in the restored ponds. The Eden Landing Phase

1 project provides a unique opportunity to conduct this type of monitoring and research. For example, water quality monitoring (particularly water temperature and salinity) could be performed to evaluate seasonal rearing habitat suitability at a nearby site to inform Phase 2 designs. We also suggest the addition of pools (with cover) with a residual depth of 2–3 feet to provide juvenile *O. mykiss* refugia should they become entrained within the ponds. Structure cover, such as large wood, should also be added to these areas to provide cover to juvenile *O. mykiss* to reduce predation risk by birds, mammals, or other fish.

RECOMMENDATIONS

Based on current information available on potential *O. mykiss* use of restored tidal marsh/ponds, Alternative B would be most likely to benefit to juvenile *O. mykiss* because it provides full tidal restoration and does not include any managed ponds, thus providing the most amount of habitat for juvenile salmonids. We would like to see uncertainties regarding predation, connectivity, and water quality can be addressed in the upcoming design phases (30% to 100% designs). We also support a phased restoration approach with an adaptive management plan and S.M.A.R.T. (specific, measurable, achievable, relevant and time-bound) goals and objectives to measure success of the first phase(s) and to inform subsequent phases of the restoration. Given the considerable uncertainty about how *O. mykiss* will utilize the newly restored habitat, we recommend monitoring and research which will aid in the adaptive management plan for the pond restorations. For example, we suggest considering fish tagging efforts on the Eden Landing Phase 1 followed by monitoring after the Phase 2 monitoring restoration project to help better understand how fish utilize the restored ponds and better inform the design and monitoring or modeling of water quality within the restored ponds to determine habitat suitability for *O. mykiss*. Directly tagging *O. mykiss* would be the most effective way of monitoring *O. mykiss* use of the restored salt ponds; however, Alameda Creek has a very small population of wild *O. mykiss*, thus any tag-induced mortality could be very detrimental. Similarly, tagging hatchery produced *O. mykiss* and releasing them would dilute the genetic pool of the current wild population, and is therefore not recommended. As an alternative, we suggest that tagging hatchery juvenile *O. tshawytscha* (Chinook Salmon) be considered to monitor the use of the restored ponds by anadromous salmonids. While *O. tshawytscha* and *O. mykiss* will likely utilize the restored habitat differently for their different life stages, monitoring juvenile *O. tshawytscha* habitat use would still provide improved understanding of how anadromous salmonids may utilize restored salt ponds.

Given the substantial amount of resources and time spent restoring the Eden Landing Complex salt ponds, we believe that it is best to review all plans in detail to best inform the design so that it will be beneficial ecologically. Based on our literature review and input from experts, this restoration project, with the appropriate design, could help support the recovery of an *O. mykiss* population in Alameda Creek, as well as benefit anadromous salmonid production from other bay area streams. We look forward to continuing our engagement in the design and plans by providing relevant scientific and design input.