

Summary

Mercury dynamics in Pond A8 and Alviso Slough have been studied in order to adaptively manage Pond A8 gate operations and concerns regarding mercury remobilization and bioaccumulation. On June 1, 2011, Pond was opened to muted tidal flows on a seasonal basis. Gates were closed on December 1 of 2011, and then 3 gates were open on June 1 of 2012. During 2012 and 2013, 3 gates were opened on June 1, and closed again on December 1. In early March of 2014, 3 gates were opened early for that year, and on September 29, 2014, 2 additional gates were opened for a total of 5 out of 8 gates being opened to muted tidal flows into Pond A8. The 5 gates have remained open since then, including for the first time remaining open past December 1. These operational changes were allowed by working with the National Marine Fisheries Service (NMFS). During 2015 researchers studied what the effects of leaving the gates open during the winter months had on mercury bioaccumulation and water quality.

The results of the 2015 study found that bird egg mercury concentrations were about the same levels found at reference areas collected during the same timeperiod. Similarly, pond and slough fish mercury levels were at levels consistent with nearby reference areas. Water samples of mercury in the pond and sloughs supported the conclusions from the fish sampling. Alviso Slough scour results show that erosion is still occurring in Alviso Slough, still mostly near the A6 breaches as had been observed previously, though more erosion is now occurring in the rest of the slough. From 2010 to October 2015 about 35kg to 39 kg total Hg remobilized over the entire length of slough – ~64 % is from the zone including the A6 breaches with about one-third of the total is immediately near A6 breaches

Overall, the results show that mercury levels of birds, fish and water have stabilized to what they would be without restoration efforts. Keeping the gates open through the winter months did not affect mercury levels. Leaving the gates open did not appreciably increase erosion in the slough; a result that is supported by scour model results which indicate limited slough erosion would occur in the short term even with all 8 gates open.

Based on the above results, researchers have indicated it would be acceptable to open all 8 gates in Mid-August of 2016. Researchers are continuing to study mercury in biota, scour and remobilization of mercury, and water levels at the southern levee, in 2016.

Background

While it is a goal of the South Bay Salt Pond Restoration Project (SBRP) to restore as much as 50% or more of the ponds to tidal marsh, concerns with legacy mercury deposits in the Alviso Complex due to historic mercury mining activities upstream, gave the managers pause in moving forward with a full tidal breach of the Pond A5/A7/A8 system (Pond A8). Pond A8 had some of the highest levels of mercury detected in sediments in the area, as well as high levels of mercury in bird eggs, fish and other organisms. The concerns with opening up Pond A8 to tidal flows were twofold: 1. Opening Pond A8 would increase the erosion of sediments in Alviso Slough, which would likely release mercury that had long been buried in the slough sediments, and 2. Opening Pond A8 might increase the methylation of mercury and result in increased uptake of mercury in birds, fish, and other aquatic life. Methyl mercury is the more toxic form of the compound and of most concern. In response, managers installed a 40' notch consisting of eight 5-foot gates that could be successively opened over time to study the effect of opening of the Pond A8 notch on wildlife within the pond itself as well as in the adjacent Alviso Slough. Starting in 2010, prior to the notch opening in 2011, and continuing every year thereafter, a range of mercury studies have been conducted to assess the effect of opening the Pond A8 notch.

2015 Bird Egg Results

Bird eggs (Forster's Tern and American Avocet) were collected by Josh Ackerman of the U.S. Geological Survey for mercury analysis. The results from the 2015 sampling, which reflect leaving the gates open during the winter months, found that tern and avocet egg mercury levels had increased in mercury by about 59% in restored ponds, and increased about 60% in reference ponds. Since there was a comparable increase in both reference and restored ponds, the increase is likely due to normal fluctuations in mercury levels, and not likely due to Pond A8 operations. For the last few years, the restored ponds and reference ponds have been consistent in their response to mercury. Essentially, bird egg mercury levels are at the levels that would be expected had no restoration actions occurred, though mercury levels are still above those associated with reproductive impairment.

2014 Slough Fish Results

In 2015 Darell Slotton and James Hobbs of University of California, Davis targeted collection of three-spined stickleback and Mississippi silverside fish from 2 locations in Alviso Slough, at the notch and at a mid-slough location. Fish were also collected from two Reference locations in Artesian Slough (aka Mallard Slough) to the east of Alviso Slough and also on the Guadalupe Slough (GUASL) to the west of Alviso Slough. Fish were collected at 4 different times between February and August. Stickleback fish had an increase in mercury levels about mid-year, but a similar increase was also observed during that time at the reference locations, so the seasonal increase could not be attributed to Pond A8 operations.

Silverside mercury levels in 2015 at the notch were within the same range as the last few years. At the mid-Alviso slough location, there appears to be a bit of an increase in Hg levels, while Mallard Slough stayed the same as in prior year. There does seem to be a divergence about mid-slough starting about mid-2015 with Hg levels going higher, while Mallard Slough appeared to be going lower. Mallard slough may not be an ideal reference location due to its influence from A16 outflows as well as outflows from the wastewater treatment plant. However, mercury levels in silverside in Guadalupe Slough also seems very variable over time, and in the same range as Alviso Slough, so the increase mid 2015 at mid-slough location are not likely due to Pond A8.

In summary, the 2015 slough fish mercury data do not appear to show major increases in mercury in relation to keeping the Pond A8 notch open during the winter months.

2015 Water Mercury Results

To coincide with collection of slough and pond fish, Mark Marvin-DiPasquale of the U.S. Geological Survey collected water samples inside Pond A8 and in 2 Reference Ponds, as well as in Alviso Slough at the A8 notch and at 2 Reference Slough locations. Samples were collected in February, May, July and August. Water was analyzed for a suite of analytes including Total Mercury (THg), and methyl-mercury (MeHg). A partitioning coefficient was developed for each sample which describes the tendency for the mercury to be absorbed onto particles, or dissolved in the water. If the particles are organic, for example algae or detritus, the mercury is more likely taken up by living organisms and bioaccumulated. However, if the particle is inorganic, for example sediment, then the mercury is likely not very available to be taken up by living organisms. Data from 2015 were compared to data from the same locations collected in earlier years.

Within the Ponds A5/7/8, there was a decrease in unfiltered (particulate and dissolved) and dissolved THg, MeHg and % MeHg after the A8 notch was opened in June of 2011. There was also a decrease in particulate MeHg and % MeHg. The only fraction within the pond complex that did not show a decrease before and after the 2011 notch opening was particulate THg, which remained unchanged.

For Alviso Slough, the analysis approach differed somewhat due to the apparent strong influence of the Pond A6 levee breach during December 2010 (as opposed to the opening of the Pond A8 notch during June 2011), particularly with respect to the mid- Alviso Slough location, which is downstream of the A8 notch but upstream of

the A6 breaches. The temporal comparison was thus mostly before versus after the breaching of Pond A6, and the mid-slough and upper slough sites were tested independently. There was a short lived, but measureable spike in unfiltered (particulate + dissolved) THg at both locations in the period following the breaching of Pond A6, which reversed to pre-breach levels by mid-2011 and have remained so since. There was a short lived (1-2 month) spike in unfiltered MeHg following the opening of the A8 notch during 2011, but concentrations have decreased to pre-opening levels or lower since that event. There was no significant change in unfiltered %MeHg, filtered THg, filtered MeHg, filtered %MeHg, particulate THg, or THg partitioning associated with the Pond A6 breach at either slough location. There was a significant and sustained decrease in MeHg, %MeHg and MeHg partitioning (towards the dissolved pool) only at the mid-slough location after the Pond A6 breach.

Overall, for the sampling years 2014-15, following the initial opening of the A8 Notch (in 2011 to 1 gate), Hg species in surface waters have remained about the same (and generally lower than the pre-notch period) as more gates have been successively opened, opened earlier in the year, and remained open during the winter months. The water sampling results, collected at the same time and location as the fish samples, are overall consistent with the fish mercury results, which indicate that although mercury levels may fluctuate, these fluctuations are not likely due to operation of the Pond A8.

2015 Bathymetry and Mercury Remobilization Results

Bathymetric studies (mapping of the seafloor) of Alviso Slough were conducted from late 2010 to October 2015 by Bruce Jaffe of the U.S. Geological Survey. Deep cores of the sediment, with interval sampling of mercury with depth were previously collected by Mark Marvin Di-Pasquale of the U.S. Geological Survey. The mercury core data were used in conjunction with the bathymetric mapping to estimate the amount of mercury that was released from the slough sediments eroding.

Continued bathymetric studies in October 2015 found that most of the erosion that has occurred since 2010 continues to be near the Pond A6 breach locations. For the first time we had gates open in winter in 2014, and there has been more erosion in the upper part of slough and rest of slough from October 2014 to April 2015. But from April 2015 to Oct 2015, there was deposition in slough in Spring and Summer, even though all 5 gates were open. Near A6 breach, the cross-section over time shows the east bank and the thalweg (the deep center of the channel) are eroding, with the west bank staying about the same. At the mid-slough cross-sections, from 2010 to Oct 2015 there is a re-distribution of sediment, with some areas erosional and some depositional. Near the notch, between 2010 and Oct 2015, there is deposition at the thalweg, but widening of banks.

From 2010 to October 2015 about 35kg to 39 kg total Hg was remobilized over the entire length of slough. About 64 % is from the zone about mid-slough down to the mouth of the slough. About one-third of the total is immediately near the A6 breaches. The least Hg remobilization is near the A8 notch (5-10% of total).

Alviso Scour Model Results

An Alviso Slough Scour Model was developed by Carlos Rey of the UNESCO-IHE Institute for Water Education. The model utilized data from U.S. Geological Survey (Bruce Jaffe, Gregg Shellenbarger, and Mark Marvin-DiPasquale) to investigate short-term sediment dynamics in Alviso Slough after opening ponds for restoration.

Five scenarios were evaluated using the model:

1. 2010 conditions with A6 breaches and A8 notch closed, but A7 gate open as intake
2. 2010 conditions with A6 breaches and A8 notch opened
3. 2012 conditions with A6 breaches and A8 notch 15 feet (3 gates open)
4. 2012 conditions with A6 breaches and A8 notch 40 feet (all 8 gates open)
5. 2012 conditions with A6 breaches and A8 notch 40 feet (all 8 gates open), and a hypothetical open breach mid slough (near existing sediment flux stations)

Each scenario was evaluated for a range of conditions to cover spring and neap tides at high and low flow river discharge levels. The model results indicate that opening both A6 to full tidal flows and A8 to muted tidal flows had a dramatic impact on sediment transport in Alviso Slough. However, the impact of opening all Pond A8 notch gates results in only a slight increase in sediment being deposited in the pond, and some increased erosion in the upper part of Alviso Slough. So the width of the notch opening does not play a major role in sediment import into Pond A8. Model results indicate that Pond A6 has the most sediment deposition, followed by A7, A5 and last A8.

The results also show how these models could be used to investigate sediment dynamics of placing one or more additional breaches in Pond A8. Adding a hypothetical breach to Pond A7 results in a dramatic increase in sediment transport and flux during almost all tide and river flow conditions, with about 2 x the amount of sediment moving bayward as in Scenario 4 (all 8 gates at the notch open). The amount of sediment delivery into Pond A8 is much greater with a hypothetical breach in Pond A7 than predicted in the other scenarios. Erosion of the slough also changes, with considerable erosion from the hypothetical breach downstream to the mouth, and deposition in the slough between the hypothetical breach upstream to the A8 notch. This model is being expanded to allow for computations over longer time frames to assess the long term effects on slough sediment dynamics.

2015 Sediment Flux Study Results

In order to characterize the amount of sediment moving between Pond A8 and Alviso Slough, a sediment flux (turbidity and velocity) and water quality (temperature, salinity, and dissolved oxygen) station was installed about midway between the Pond A8 notch and the mouth of Alviso Slough. An additional station has been installed at the confluence of Alviso Slough and Coyote Creek. Dave Schoellhamer and Maureen Downing Kunz of U.S. Geological Survey have studied the sediment movement at this location since WY2011. They continue to find that net sediment movement in the water is generally landward, or upstream, except during rainfall events. Therefore, mercury associated with the sediments would also be expected to have a net movement landward, or upstream, except during rainfall events. There are relatively high suspended-sediment concentrations (SSC) throughout the slough, especially on spring tides, suggesting it is likely that there is deposition at restoration sites. Data suggest Pond A8 is accumulating sediment since on spring tides SSC is much higher for waters entering Pond A8 from the slough than the SSC on the ebb tide.

Preliminary water quality data also indicates that opening of the Pond A8 gates through the winter of 2014/15 stabilized and slightly increased the salinity levels in Alviso Slough water. Before the March 2014 gate openings, salinity in Alviso Slough varied between less than 5 ppt to over 20 ppt, indicating watershed discharge and Bay water were alternately transported in the slough. After the gates were opened, the minimum salinity in the slough increased from 0 to 10, indicating the watershed discharge had less influence on slough water quality.

Water levels at Pond A8S landfill liner

In 2015, the Refuge became aware of erosion occurring at the southernmost extent of the Pond A5/A7/A8 complex (Pond A8S berm), adjacent to an inactive landfill. Matt Brennan and Michelle Orr of ESA were consulted to do an assessment of the erosion and make recommendations to the managers to prevent further erosion. Dave Schoellhamer and Maureen Downing-Kunz of the U.S. Geological Survey established a station near the Pond A8 levee to record water levels and wave data for use by ESA in their evaluation.

Water levels from staff gauges in Pond A5, A7 and A8 (ponds are hydraulically connected via internal levee breaches) all closely tracked each other (except for a period in 2010 when construction was occurring in A8 and water levels were lowered). It appears that water levels increased during periods when the gates were open compared to when they were closed, but opening 3 gates from 1 gate did not seem to appreciably increase water levels as observed at A5/7, and by inference Pond A8. Water levels seemed to be fairly stable at between 4 and 5 feet NAVD after the 5 gates were open, then there was fluctuation during the period when SCVWD was pumping water from A4 into A5. Water levels started to decrease when the A7 gate was changed to outflow only (there are

flapper gates to control the direction of flow). One of the two gates on the A5 structure is damaged and water flows in two directions, depending on the tide. Currently, the WCS at A7 is outflow only while that at A5 is outflow only for one gate and 2-way flow for one gate which is broken.

So it appears that while opening or closing the gates at the A8 notch influences water levels inside the Pond A5/7/8, the number of gates open does not. Changing the WCS at Ponds A5 & A7 to be outflow only as much as possible seems to have brought water levels down considerably. The most recent data indicates that though water levels have gone down since the summer and fall of 2015, there is considerable fluctuation due predominantly to spring/neap tide cycle, not gate operations. Water levels are continuing to be monitored.

Conclusion

Overall, the 2015 results continue to show that mercury levels in birds, fish, and water have decreased since the initial opening of the Pond A8 gates in 2011. Although there have been fluctuations in mercury levels year to year, these yearly fluctuations are similar between restored ponds and reference areas such that the variation cannot be attributed to Pond A8 operations. Specifically, opening all 5 gates throughout the winter of 2014/2015 did not result in any appreciable increase in mercury in Pond A8 or Alviso Slough.

Overall, researcher findings do not indicate cause for concern with opening more gates at Pond A8. However, managers decided to keep 5 gates open through mid-August, and at that time consider opening all 8 gates. Mid-August was chosen as that is when nesting within Pond A8 would be finished, and all the planned sampling for mercury studies in 2016 would also be completed. Further funding is being sought to continue the studies in 2017, which will be used to evaluate the effects of opening all 8 gates and keeping them open year round.