Appendix C. Summaries of Primarily Non-OWEB funded tide gate projects in Oregon, and tide gate projects in Washington and California, 2006 – 2016.

***Lower Columbia River Region* (OR, WA)**

Coastal Oregon

***Puget Sound* (WA)**

Humboldt Region (CA)

Other – New South Wales (AUS)

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Lower Columbia	**Name**: Grays River/Seal Slough Kandoll Farm property
Type: Removed or replaced with large culverts	**Total Cost**:

Summary: Grays Bay-Kandoll Farm Acquisition and Restoration: Restoration at the Kandoll Farm site is part of the Columbia Land Trust (CLT) and other conservation partners' larger Gray's Bay Conservation Effort, which began in 2003. Most of the work has been completed; on-going maintenance and monitoring will continue for many years. The Grays Bay project has these overall goals: 1) permanently protect 880 acres of habitat, including spruce swamp forested wetlands, inter-tidal floodplain channels and emergent/scrub-shrub wetlands; 2) restore floodplain connectivity to 500 acres of tidal backwater, riparian and wetland forested habitat; 3) restore over 300 acres of potential salmonid rearing habitat; 4) enhance approximately 3 miles of riparian shoreline and; 5) protect 3 bald eagle nests and over 100 acres of potential marbled murrelet nesting habitat.

The Kandoll Farm Property is located 2 miles from the mouth of the Grays River confluence with Grays Bay and the Columbia River. Most of the property is influenced by Seal Slough, a major lower Grays River tributary. Dikes and tidegates were constructed around the property in the early 1900s to protect it from regular tidal inundation and provide pasture for grazing. The property remained in agricultural use until summer 2005. Existing drain ditches have been filled, tide gates have been removed or replaced with large aluminum culverts, and portions of the levees have been removed. The property is now open to free tidal influence.

The focus of the Kandoll Farm project is on estuarine and riparian wetland habitats. Expected results include protection, reconnection and restoration of 163 acres of riparian floodplain habitat to benefit salmon production in the entire Columbia River basin. The project seeks to provide a rich and productive nursery, rearing and over-wintering habitat, and an anchor point for stabilizing the entire system. Long-term benefits also include increased flood storage capacity, improved sediment dynamics, and improved water quantity and quality conditions for salmonids.

Two complementary monitoring programs have been underway since 2005. The Kandoll Farm property was integrated into the Cumulative Effects (CE) study funded by the USACE and implemented by Pacific Northwest National Laboratory, which focused on assessing impacts of restoration projects on the overall health of the Columbia River estuary. Project effectiveness monitoring by CLT for the Grays Bay projects is based on the protocols developed by PNNL for their study. PNNL shares data and analysis so that this information can be integrated into CLT's effectiveness monitoring analysis and adaptive management approach.

The Kandoll project is a multiphase project involving multiple funding sources. Project phases: 1) Phase 1 acquisition (163 acres) in 2002; 2) Phase 1 additional acquisition (20 acres) in 2003; Phase 1 initial restoration of 163 acres in 2004; and Phase 2 follow up restoration of 163 acres in 2012. [Schwartz et al. 2013.] Phase I restoration (2005) included: 1) replacement of a small tide gate with 2 large 13-foot culverts at the end of Seal Slough; 2) breaching of the Grays River dike in 3 locations; and 3) tree and shrub plantings in locations throughout the site. Phase 2 restoration is planned for late summer 2013 and includes channel excavation, along-channel mounding, filling, and dike removal.

Aerial Images: Restoration projects in the Grays River and Deep River confluence, WA (3/20/2016).

Restoration Metrics: Acres protected, acres restored, acres of potential salmonid rearing habitat restored.	
Monitoring Focus:	**Study Design** NOTE: This is an extensively studied site, with numerous reports. At least some of the available monitoring data was gathered using a Before/After/Reference/Restoration (BARR) study design, comparing the Kandoll Farm site with a reference site in Seal Slough. [Johnson et al. 2012] Fish abundance was monitored before (2005) and after (2006–2009) tide gate removal. From 2005 through 2007, we compared the fish community inside the Kandoll Farm site to sites in Seal Slough. During 2008 and 2009, we concentrated on fish distributions at dual trap net locations within the KF wetland. [Monitoring history from Schwartz et al. 2013; vegetation composition, terrestrial macroinvertebrates.] The US Army Corps of Engineers' Cumulative Effects Team intensively sampled the Kandoll Farm Restoration Site in 2005 (pre-restoration),

	2006 (year 1), and 2009 (year 4). Additional metrics (and more intensive sampling of standard metrics) were also sampled in dissertation research by Heida Diefenderfer at this site starting in 2005. Kandoll Reference Site (Seal Slough Swamp): The Corps of Engineers' Cumulative Effects Team intensively sampled Kandoll Reference Site 2005-2009 as a paired site for Kandoll Farm Restoration Site. The 2009 sampling was also included as part of an LCRE-wide suite of sites for the Estuary Partnership/BPA Reference Sites project. Additional metrics (and more intensive sampling of standard metrics) were also sampled in dissertation research by Heida Diefenderfer at this site starting in 2005.
Parameters: Juvenile salmonids, vegetation, terrestrial macroinvertebrates	**Species Monitored**: coho, chum, Chinook salmon
Project Findings: NOTE: Selected results from Johnson et al. 2012. This is an extensively studied and documented site. These are selected results, not a complete summary. [Location and synthesis of of all available data is beyond scope of this review.] Before the Kandoll Farm (KF) tide gate removal, no fish other than stickleback were found inside the tide gate controlled area (Figure 2.36), while at Seal Slough reference sites we captured seven species, including coho (N = 418, H' = 0.92). In 2006, after tide gate removal at the KF site, trap net samples yielded nine species, three of which were salmonids (N = 19575, H' = 0.07). Diversity remained low due to the high numbers of stickleback. Species counts and total individuals decreased at trap net sites in 2007 with the loss of incidental species and decline in the number of stickleback (N = 1330, S = 6, H' = 0.72). In comparison, the mean values of S and H' from beach seine samples at lower Columbia River main stem freshwater sites from 2002 to 2008 were 13.1 and 0.55, respectively. However, note that overall salmonid abundance remained relatively high in the restoration sites. During the post-breach period from 2006-2009, chum and coho made extensive use of the reconnected wetland. Chinook, chum, and coho exhibited different patterns of habitat use. Chinook were not abundant in the wetland in any year, but had a relatively wide temporal window extending from February-June. Chum were very abundant each year, especially during 2009 when over 1000 individuals per tide were captured in one trap net. We likely sampled during the peak migration period. Chum had a relatively narrow window lasting ~6 weeks each year; overall occupation of the wetland was from mid-February-late April with a maximum in early April. Coho were moderately abundant each year with a variable maximum. Overall distribution was wide and extended from March-June (and possibly later). Chinook were present at 7-DAM temperatures between 6 and 21°C, chum in the range 7 to 16°C, while coho exhibited the warmest and narrowest range between 13 and 21°C.	
System Effects:	
Lessons Learned:	
Funders: Bonneville Power Administration, Columbia River Estuary Partnership, Multiple other funders	
Partners:	
Project Documentation: 2005 Annual and final report. Grays Bay Conservation/Restoration Project. Wahkiakum County, Washington LCREP Contract #04-2004-2.	

http://www.estuarypartnership.org/sites/default/files/restoration_site/files/Grays%2520Bay%2520Final%2520REPORT_0.pdf

NOTE: Includes a good overall site map, and finer scale maps of individual properties. Also lists specific types of data being gathered, as of 2005.

Roegner, C. (NOAA Fisheries). 2009. Linking juvenile salmon use to habitat restoration: An example from the lower Columbia River. 3rd National Conference on Ecosystem Restoration, Los Angeles CA, 24 July 2009.

https://conference.ifas.ufl.edu/NCER2009/PPTPDF_pres/4-Thursday/2-Emerald%20Bay/PM/0200%20C%20Roegner.pdf

NOTE: 2009 Powerpoint; includes before and after images of the tide gate removal/replacement

G. Curtis Roegner, Earl W. Dawley, Micah Russell, Allan Whiting, and David J. Teel. 2010. Juvenile Salmonid Use of Reconnected Tidal Freshwater Wetlands in Grays River, Lower Columbia River Basin. Transactions of the American Fisheries Society Vol. 139 , Iss. 4. 2010

https://www.salmonrecovery.gov/Files/APR/Section%201%20Literature%20Cited/Roegner%20et%20al%202010_TAFS.pdf

Diefenderfer, H.L., A.M. Coleman, A.B. Borde and I.A. Sinks. 2008. Hydraulic geometry and microtopography of tidal freshwater forested wetlands and implications for restoration, Columbia River, U.S.A. Ecohydrology and Hydrobiology 8(2):339-361 · December 2008.

Diefenderfer, H.L. 2009. Tidal Wetland Restoration in the Lower Columbia River and Estuary. The Water Center Seminar, May 12, 2009. Marine Sciences Laboratory Pacific Northwest National Laboratory. https://digital.lib.washington.edu/researchworks/bitstream/handle/1773/16420/DiefenderferS09.pdf;jsessionid=0086D85854018B791CCF2ECB6329D04B?sequence=2

NOTE: Powerpoint on same topic as Diefenderfer et al. (2008) paper above. Discusses Kandoll site and TG removal; cumulative effects monitoring.

Diefenderfer, H. L., G. E. Johnson, R. M. Thom, K. E. Buenau, L. A. Weitkamp, C. M. Woodley, A. B. Borde, and R. K. Kropp. 2016. Evidence-based evaluation of the cumulative effects of ecosystem restoration. Ecosphere 7(3):e01242. 10.1002/ecs2.1242

NOTE: Includes Kandoll Farm monitoring findings.

Borde, A.B. S.A. Zimmerman, V.I. Cullinan, J. Sagar, H.L. Diefenderfer, K.E. Buenau, R.M. Thom C Corbett and R.M. Kaufmann. 2012. Lower Columbia River and Estuary Ecosystem Restoration Program Reference Site Study: 2011 Restoration Analysis Final Report. Batelle Pacific Northwest National Laboratory. Prepared for Lower Columbia River Estuary Partnership and Bonneville Power Administration under the Non-Federal Work for Others Program with the U.S. Department of Energy Contract DE-AC05-76RL01830.

Schwartz M.S., A.B. Borde, A. Silva, J. Smith. 2014. Action Effectiveness Monitoring for the Lower Columbia River Estuary Habitat Restoration Program. September/2012 – September 2013, Project Number: 2003-007-00.

http://www.estuarypartnership.org/sites/default/files/resource_files/Year%209%20AEM%20Report_Final.pdf

Johnson, G.E., Thom, R.M., Ebberts, B.D., Borde, A.B., Coleman, A.M., Breithaupt, S.A., Corbett, C.A., Jay, D.A., Leffler, K.E. and Studebaker, C.A., 2012. Evaluation of cumulative ecosystem response to restoration projects in the lower Columbia River and Estuary, 2010 (No. PNNL-20296). PACIFIC NORTHWEST NATIONAL LAB RICHLAND WA.

http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20296.pdf

Craig, B.E., Simenstad, C.A. and Bottom, D.L., 2014. Rearing in natural and recovering tidal wetlands enhances growth and life-history diversity of Columbia Estuary tributary coho salmon Oncorhynchus kisutch population. Journal of Fish Biology, 85(1), pp.31-51.

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Lower Columbia	**Name**: Tenasillahe Island Slough, Julia Butler Hansen NWR
Type: Replacement (3 gates)	**Total Cost**:

Summary: Tenasillahe Island is located in the Columbia River Estuary in Clatsop County, OR. It is downstream of Puget Island and the town of Cathlamet, WA, separated from the mainland and the unincorporated community of Clifton, OR by the Clifton Channel, and from nearby Welch Island by the Red Slough. In 2007 the U.S. Army Corps of Engineers (USACOE) replaced the three top-hinge steel tide gates controlling tidal action on the largest Tenasillahe Island slough with side-hinge aluminum gates equipped with a manually controlled fish orifice. This action was to improve aquatic habitat conditions and to improve fish passage for juvenile salmonids while balancing the needs of the endangered white-tailed deer found on the island.

Data collected March-June 2006 and March-May 2007, before gates were replaced, show elevated gated slough water temperatures, more non-native species present in gated sloughs, and limited opportunity for juvenile salmonids to enter gated sloughs. Activities in 2008 focused on collecting post-construction data needed to assess effects of the new tide gates. Objectives addressed during 2008 field season: 1. Assess fish passage conditions; 2. Describe fish distribution among treatment and reference sloughs; 3. Characterize aquatic habitats of treatment and reference sloughs; 4. Measure juvenile salmonid growth rate and residence time in treatment and reference sloughs.

Aerial Images:

Restoration Metrics: Water temp, juv Chinook #s, TG opening parameters	
Monitoring Focus: Biological, fish passage at tide gates	**Study Design**: BACI study design. Monte Carlo and Randomized Intervention Analysis (RIA) were used to determine if tide gate replacement affects water temperature. Also used Spearman Rank Correlation to get correlation values for water temp up and downstream, in CVS, in Clifton channel, air temp, precip, Col. R discharge. Also used for hourly temp and depth at all sites.
Parameters: Water temp, juv Chinook, TG opening frequency, duration, width	**Species Monitored**: Chinook
Project Findings: Ennis thesis: Tide gate replacement had no significant effect on mean water temperature or on the difference between control sites and the section upstream of the tide gate. However, the change in difference between the downstream temps and the control temps was significant. Mean temperature and minimum tempurature decreased at all sites after replacement. The number of days in which water temp exceeded EPA limits decreased in all sections after replacement. This may have been due to La Nina conditions present in 2008. The main change caused by replacement was an increase in frequency, duration and width of tide gate openings during ebb tides. The new gates may have increased drainage, including warm surface waters - the old gates mostly drained cooler water at depth because they were top-hinged. More Chinook salmon juveniles were detected (PIT tag array) moving upstream of tide gates after replacement. 2013 PNW National Lab report: At Tenasillahe Island replacement of top-hinged gates with side-hinged tide gates with manual fish orifices did not improve fish passage or water quality. There were no differences in temperature pre and post replacement. No juvenile salmon were collected in gated sloughs. 2008 USFWS monitoring report: Replacement side-hinged tide gates opened on 64% of the low tides and were open an average of 3.4 hour per opening. No salmon were collected entering Large Tenasillahe Slough, however juvenile Chinook and coho were caught exiting the slough. PIT-tagged fish released in LTS remained throughout the summer and grew well. Water quality differed for some factors and was similar for others. Gated sloughs had higher water temperature, lower percent dissolved oxygen, and more emergent aquatic vegetation. However, pH was similar in all sloughs and turbidity and transparency ranges overlapped. Conductivity was similar among sloughs except Large Tenasillahe Slough, which had much higher values. The reference sloughs on Welch Island had larger proportions of native species. At Tenasillahe Island replacement of top-hinged gates with side-hinged tide gates with manual fish orifices did not improve fish passage or water quality. There were no differences in temperature pre and post replacement. No juvenile salmon were collected in gated sloughs.	
System Effects: The following reference incorporated findings from monitoring at this site with other sites to address the following objective: "Objective 3, Estuary Scale – Prepare a compendium of tag release-recapture technologies to inform planning for future action effectiveness studies." Johnson GE, NK Sather, AJ Storch, J Johnson, JR Skalski, DJ Teel, T Brewer, AJ Bryson, EM Dawley, DR Kuligowski, T Whitesel, C Mallette. 2013. Multi-Scale Action Effectiveness Research in the Lower Columbia River and Estuary, 2012. PNNL-22481, final annual report submitted to U.S. Army Corps of Engineers, Portland District, Portland, OR, by Pacific Northwest National Laboratory, Richland, WA.	

http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22481.pdf
Lessons Learned:
Funders: U.S. Army Corps of Engineers
Partners: U.S. Army Corps of Engineers
Project Documentation: Ennis, Sara. Effects of Tide Gate Replacement on Water Temperature in a Freshwater Slough in the Columbia River Estuary. 2009. Dept. of Environmental Science and Management, Portland State University. Fall 2009. http://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?article=1016&context=mem_gradprojects Lower Columbia River Channel Improvement: Assessment of Salmonid Populations and Habitat on Tenasillahe and Welch Islands 2008 Project Report. Jeffrey Johnson, Sara Ennis , Jennifer Poirier, Timothy A. Whitesel, U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Population & Habitat Assessment Program, 1211 S.E. Cardinal Court, Suite 100, Vancouver, Washington 98683. Johnson GE, NK Sather, AJ Storch, J Johnson, JR Skalski, DJ Teel, T Brewer, AJ Bryson, EM Dawley, DR Kuligowski, T Whitesel, C Mallette. 2013. Multi-Scale Action Effectiveness Research in the Lower Columbia River and Estuary, 2012. PNNL-22481, final annual report submitted to U.S. Army Corps of Engineers, Portland District, Portland, OR, by Pacific Northwest National Laboratory, Richland, WA. Thom, R., Sather, N., Roegner, G.C. and Bottom, D.L., 2013. Columbia Estuary Ecosystem Restoration Program. 2012 Synthesis Memorandum (No. PNNL-21477). PACIFIC NORTHWEST NATIONAL LAB RICHLAND WA. http://www.dtic.mil/get-tr-doc/pdf?AD=ADA586179 http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22481.pdf

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Lower Columbia	**Name**: Mainland Unit Restoration, Julia Butler Hansen NWR
Type: Replacement (3 gates)	**Total Cost**:
Summary: In 2010 the Corps worked with the USFWS to replace three tide gates and repair a failing culvert at the Julia Butler NWR at RM 36 in Wahkiakum County, near Cathlamet WA. The project replaced a derelict top-hinged tide gate with a hydraulically-efficient side-hinged tide gate to provide improved fish passage and water quality. In addition, the Corps installed two new side-hinged tide gates on a blind slough on the Refuge, restoring a muted tidal signal and facilitating fish passage in shallow-water habitat. The project restored 110 acres of slough/wetland habitat and 210 acres of riparian forest habitat. NOTE: Listed in Lower Columbia Estuary Partnership site as having been done in 2003 to 2009. http://www.estuarypartnership.org/restorationsite/1386	

Aerial Images:

Restoration Metrics: acres of slough/wetland habitat restored (110); acres of riparian forest habitat restored (210)	
Monitoring Focus:	**Study Design**:
Parameters:	**Species Monitored**:

Project Findings:
System Effects:
Lessons Learned:
Funders:
Partners:
Project Documentation: Johnson, J. and T.A. Whitesel. 2011. Julia Butler Hansen National Wildlife Refuge: Post-Construction Assessment of Fishes, Habitats, and Tide Gates in Sloughs on the Mainland. 2011 Annual Report. U.S. Fish and Wildlife Service Columbia River Fisheries Program Office, Population & Habitat Assessment Program, 1211 S.E. Cardinal Court, Suite 100, Vancouver, WA 98683. https://www.salmonrecovery.gov/Files/2011%20APR%20files/New%20Folder%203/Johnson_and_Whitesel_2012_JBH_NWR_2011Monitoring.pdf NOTE: This report is listed as a DRAFT. Thom, R., Sather, N., Roegner, G.C. and Bottom, D.L., 2013. Columbia Estuary Ecosystem Restoration Program. 2012 Synthesis Memorandum (No. PNNL-21477). PACIFIC NORTHWEST NATIONAL LAB RICHLAND WA. http://www.dtic.mil/get-tr-doc/pdf?AD=ADA586179 https://energy.gov/sites/prod/files/2016/07/f33/EA-2006_FEA-2016.pdf http://www.estuarypartnership.org/restorationsite/1386

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Lower Columbia	**Name**: Ft. Clatsop, South Slough
Type: Removal (replaced by a bridge)	**Total Cost**:
Summary: In 2007, Lower Columbia River Estuary Partnership (EP) and its partners replaced a failing tide gate with a bridge at Lewis and Clark National Historic Park's Fort Clatsop in order to reconnect South Slough (and 45 acres of diked pastureland) with the tidal influence of the Columbia River. Water velocities in the culvert were elevated, potentially limiting fish passage into the slough. A reconnection of the tidal influence to the slough had the potential to both open up access to the habitats in the slough for fish and improve those habitats.	

Aerial Images:

Restoration Metrics: Salmonid abundance, proportion of non-native species, water quality (temp)	
Monitoring Focus: Fish community assemblages, size class, and residency; for water quality conditions including temperature, tidal range/depth, dissolved oxygen and conductivity.	**Study Design**: BACI. In 2007 the Columbia River Estuary Study Taskforce (CREST) implemented pre-project monitoring as a baseline for characterizing CREST performed post-project effectiveness monitoring in 2008, 2009, 2010, and 2011 as part of the EP's Action Effectiveness Monitoring Program. (From methods section) This synthesis

	report summarizes monitoring results between 2007 and 2011 from South Slough and discusses South Slough before and after restoration, and in the context of Alder Creek, its reference site. (2012 annual report is also available.) Pre-restoration sampling 2007. Post-restoration sampling 2008, 2009, 2010, 2011. Jan - Aug 2007-2011. 2007, 2008, 2011 sampled twice per month. 2009, 2010 sampled once per month. Some sampling in 2012
Parameters: From 2007-2010, a trap-net was employed at Ft Clatsop South Slough. Sampling from high tide to low tide we capture upriver salmon stocks, marine and freshwater fishes as well as resident juvenile salmon that use the off-channel habitat during the flood tide and return to the mainstem Lewis and Clark River on the ebb.	**Species Monitored**:
Project Findings: Abundance of salmonids and other native fishes increased at South Slough after restoration. The proportion of non-natives decreased at both the restoration and reference sites; the fish community at South Slough fluctuated similarly to the reference site. Peak abundance was later post restoration, however, a distinct trend was not described because sampling methods did not capture fish holding in the tidal channels during all years. Multiple size classes of Chinook and coho were caught in South Slough post-restoration indicating the presence of at least two life-histories. Chum salmon were most abundant in March-April as at other sites in the lower Columbia River Estuary. Chinook and coho were much more abundant in South Slough than Alder Creek and peak abundance was later. The two species' prey prefrences overlapped potentially indicating competition. Restoration increased tidal inundation, lowered temperatures, and altered channel morphology increasing available habitat spatially and temporally. [Notes from Powerpoint] "Salmonid mean lengths, post-restoration, Ft. Clatsop South Slough, 2008. After restoration, more natural sized Chum are using the system. Encouraging since Chum were once thought to be absent from the system. Source unknown; too small to be hatchery strays from Gray's Bay; no fin clips either. Obviously establishing some spawning in the system again, but only genetics would enable stock identification. Some yearling Chinook in the system early and again late; all naturally produced and pelvic fin clips genetic analysis will determine stock source. Subyearling coho and some yearling steelhead also using the system. No genetics as of yet, but despite the lack of adipose fin clips, which would suggest these are naturally produced fish, the proximity to CEDC net pens in Young's Bay prevents the application of 'wild' rear type. Salmonids more numerous after bridge installation, and species more diverse (steelhead and cutthroat trout new this year)."	
System Effects:	
Lessons Learned:	
Funders:	
Partners: "Lower Columbia River Estuary Partnership and its partners"	
Project Documentation: http://www.estuarypartnership.org/monitoringsite/231	

NOTE: Lower Columbia River Estuary Partnership web page with site and project description.

Columbia River Estuary Study Taskforce. 2011. Habitat, Salmon, and Salmon Prey Effectiveness Monitoring Ft. Clatsop South Slough & Alder Creek Synthesis Report 2007–2011. Prepared for the Lower Columbia River Estuary Partnership. NOTE: Obtained via email query to Keith Marcoe/CREST. Keith also provided annual reports for 2008, 2009, 2010, 2011, and a 2012 summary completed after the 2007-2011 synthesis report. Posted online and available as of 8-26-2017: http://s458607291.onlinehome.us/FTP/Jeff_Behan_OSU/

Project Level Effectiveness Monitoring in the Estuary and Response in Fish Communities (CREST)

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=12&ved=0ahUKEwiT1s6yp6fVAhWBWT4KHdJqB-Y4ChAWCCowAQ&url=https%3A%2F%2Fwww.nwcouncil.org%2Fmedia%2F6653809%2FCREST_NWPCC.ppt&usg=AFQjCNEydVVG7B6w31jeqyeeFVxXx0MNww

NOTE: Powerpoint presentation with pictures of the TG removal site and new bridge, and discussion of monitoring results. Presented to Northwest Power & Conservation Council(?)

Estuary: Lower Columbia	**Name**: South Tongue Point Restoration - Liberty Lane
Type: TG removal	**Total Cost**: $70,772

Summary: The South Tongue Point Restoration site is located along the southwest shoreline directly off Cathlamet Bay in the Columbia River Estuary (mile 18) and is owned by the State of Oregon (DSL). The site was historically a brackish wetland fed by a 95-acre tributary basin to the southeast. During the late 1940s, the site was partially disconnected from the bay by placement of dredge spoils to expand the fleet facility at the Tongue Point Naval Base. Later, Liberty Lane was constructed as an access road to buildings and docks on the eastern portion of the dredge materials. Installation of a tide gate and culvert under a road at the entrance disconnected the wetland complex from the bay, severely restricting tidal connection and eliminating fish access. The project restored tidal connection to a 10-acre diked tidal wetland [BPA-USACE EA says 15 acres]. The project included installation of a 10' diameter countersunk HDPE culvert under Liberty Lane, removal of the existing tide gate and undersized culvert, excavation of the wetland channels and large woody debris placements in the new channels. The existing 36" culvert was plugged and abandoned in place. Culvert replacement, large wood placement and wetland grading took place July-October 2012. Planting and invasive controls took place 2012-2013. The culvert invert was lowered from 5.8' to 0.5' outside the tide gate. Stream bed rock was placed in the culvert to create a low flow channel at elevation 3.5', the existing channel elevation downstream of Liberty Lane. Concrete masonry head walls were installed to minimize the length of channel enclosed in culvert. Approximately 950' of inter-tidal channels were excavated below the existing marsh surface. These channels range from a thalweg elevation of 3.5' at the upstream culvert end to 5.0' at the south end of the channels and from 4-6' in depth from the marsh surface. Channel bottom width ranges from 3-6'.

Aerial Images:

Restoration Metrics: Acres of wetland with restored tidal connection Feet of intertidal channels restored Elevation of culvert invert	
Monitoring Focus:	**Study Design**: No pre-project or post-project monitoring data was located for this project.
Parameters: N/A	**Species Monitored**:
Project Findings:	
System Effects:	
Lessons Learned:	
Funders: Lower Columbia River Estuary Partnership (LCREP) and Bonneville Power Administration (BPA)	
Partners: Columbia River Estuary Study Taskforce (primary contractor); LCREP; Oregon Department of State Lands; Actual work done by Thompson Brothers Excavating	
Project Documentation: http://www.estuarypartnership.org/restorationsite/1339 Final Project Report: South Tongue Point Restoration Project Final Design Phase LCREP Grant # 19-2012 http://www.estuarypartnership.org/sites/default/files/restoration_site/files/South_Tongue_Point_Final%20Report_LCREP_2012.pdf NOTE: This source includes several photos and and an aerial photo/map of the project site.	

https://energy.gov/sites/prod/files/2016/07/f33/EA-2006_FEA-2016.pdf

NOTE: This source mentions the project in a table summarizing restoration projects in the LCRE. States that 15 total acres were restored.

Estuary: Lower Columbia	**Name**: Wallooskee-Youngs Confluence Restoration Project
Type: Removal (two tide gates, as part of levee breaching)	**Total Cost**: $7,600,000 (Source says $4,500,00 expended as of 7-31-17) https://www.cbfish.org/Contract.mvc/Summary/62692

Summary: Wallooskee-Youngs Confluence Restoration Project is located at the confluence of the Wallooskee and Youngs Rivers five miles from the Columbia River near Astoria, Oregon. The project will involve modifying a levee to inundate historic wetlands, creating a network of tidal channels within the project site, and restoring native vegetation. The project will enhance estuary rearing habitat for juvenile salmon and steelhead, as well as provide habitat for wildlife such as deer, elk, and river otter. The project will also help BPA meet its obligations under the Endangered Species Act. An existing BPA transmission line and access road on the property will be modified to withstand the new tidal regime. Structures on the property - a house, barn, and out buildings - will be removed and the upland area returned to a natural condition.

Levee was breached in June 2017, and included removal of two tide gates.

EA p. 2-11: The levee would be breached in five locations. Each breach would have a main breach opening, with benches at the floodplain elevation on either side, before sloping to meet the top of levee elevation (8.5 feet in areas next to the breaches following restoration activities). Both of the site's tide gates are located at proposed breach locations and would be removed during the levee breaching. The Crosel Creek tide gate under OR 202 would not be modified.

Aerial Images: see next page.

Restoration Metrics: [Inferred] Acres of tidal wetland restored; Acres of native plant communities restored; Acres of off-channel salmonid habitat restored	
Monitoring Focus:	**Study Design**:
Parameters:	**Species Monitored**:
Project Findings:	

System Effects: NO ACTION: Sea-level rise would likely still affect the project area and the likelihood that the site would convert to mud flats or open water, in a self-breaching scenario due to sea level rise, would be much greater since soils would continue to be lost through the tide gates. (EA P. 2-39)

PROPOSED ACTION: The proposed action would better position the site to respond to sea level rise since tidal process would be restored and the site would begin to accrete sediment. (EA P. 2-39)

The restored tidal wetland would act as a carbon sink and capture carbon through increased vegetation growth and accretion. Restoration of a functioning wetland plant community would help buffer the effect of rising sea levels by attenuating wave action and storm surges. (EA P. 2-39)

Lessons Learned:

Funders: Bonneville Power Administration (BPA)

Partners: Astoria Wetlands, LLC, an environmental resources company, currently owns the property and will conduct the restoration work. The Cowlitz Indian Tribe will assist in project implementation and provide long-term stewardship to ensure permanent protection of the property.

Project Documentation: Wetland Restoration Project Improves Tidal Marsh For Salmon, Steelhead In

Columbia River Estuary. http://www.cbbulletin.com/439305.aspx

Dated 7-21-2017. Mentions that levee breach, including removal of 2 tide gates, occurred in June 2017.

Bonneville Power Administration. 2014. Wallooskee-Youngs Confluence Restoration Project Draft Environmental Assessment. DOE/EA-1974.

https://energy.gov/sites/prod/files/2015/01/f19/EA-1974-DEA-2015_0.pdf

NOTE:

Bonneville Power Administration. 2014. Wallooskee-Youngs Confluence Restoration Project Final Environmental Assessment. DOE/EA-1974.

NOTE: Includes nice map of project area

https://www.bpa.gov/efw/Analysis/NEPADocuments/nepa/WallooskeeYoungs/Wallooskee_4D_FONSI_Final_EA.pdf

NOTE: 16-page addendum to draft EA.

https://www.bpa.gov/efw/Analysis/NEPADocuments/Pages/WallooskeeYoungs.aspx

NOTE: BPA web page for the project. Includes project overview and links to NEPA docs, including EA.

Wallooskee/Youngs Restoration

https://www.cbfish.org/Contract.mvc/Summary/62692

NOTE: Columbia Basin F&W Program contract page. Lots of detailed project information; looks like it was written prior to most of the work.

Wallooskee-Youngs Confluence, pre-project (7/30/2014).

Wallooskee-Youngs Confluence, mid-project prior to dike breaching (3/20/2016)

Estuary: Lower Columbia	**Name**: Chinook River Restoration
Type: Tide gate upgrades (2)	**Total Cost**:

Summary: The Chinook River flows into the north side of the Columbia River 5 miles upstream from the Pacific Ocean. The project area is located at the mouth of the Chinook River and consists of approximately 1,050 acres of estuarine and riparian wetlands surrounding a complex network of tidal channels. Historically, the Chinook River supported populations of five anadromous salmonid species, and its estuary is an important rearing habitat for juvenile salmonids from the Columbia River basin. The reduction in species abundance from historic levels is attributed to elimination of the tidal action since the construction of a tide-gate at the mouth of the Chinook River in the 1920s. The objective of the Chinook River Restoration Project is to recover the natural estuarine and riparian wetlands habitat by restoring tidal flows through the study area.

Washington Department of Fish and Wildlife began developing a restoration concept for this area in 1997. In 2001, the Columbia Land Trust acquired a large parcel of land, which was transferred to WDFW to become the Chinook unit of the St Johns Wildlife Area. Partial restoration including retrofit of internal tidegates was undertaken from 2005-2007. New restoration planning and implementation is being undertaken from 2011-2014, including an additional acquisition to the north (Mattson property).

[Juel doc] In September of 2006, two large GH-52SC tide gates were installed where the Chinook River passes beneath Hwy 101 southeast of Ilwaco WA. This tide gate is essentially a top-hinged flap gate mounted on a frame with a mechanical lift that allows the flap gate to be raised and lowered. When fully raised, the flap gate is completely above the opening in the headwall, allowing unimpeded tidal exchange. When partially raised, the flap gate allows throttled backflow through a submerged orifice when the tidal water level downstream is higher than the water level upstream from the flap gate. When completely lowered, this is simply a top hinged flap gate that allows no backflow. The aluminum flap gate is very light weight and opens wide under moderate out flow. Golden Harvest does not show this tide gate in their on-line tide gate catalog. (It does not function well at the Chinook River, so they presumably do not market this design.)

Aerial Images:

Restoration Metrics:	
Monitoring Focus: Chinook - Lower Columbia River ESU; Coho - Lower Columbia River ESU; Chum - Columbia River ESU; Cutthroat Trout, Coastal - Southwest Washington/Columbia River ESU; Steelhead - Lower Columbia River DPS	**Study Design**: Hydrologic and hydrodynamic modeling were conducted by Pacific Northwest National Lab to assess project feasibility and alternatives. A follow-up modeling study was apparently done to assess various scenarios and combinations of operating the new tide gates.
Parameters:	**Species Monitored**: Chinook, coho, coastal cutthroat trout.
Project Findings: In 2003, PNNL staff conducted a hydrodynamic and hydrologic modeling analysis to evaluate the feasibility of restoring natural estuarine functions and tidal marine wetlands habitat in the Chinook River estuary, located near the mouth of the Columbia River in Washington. The reduction in salmonid populations is attributable primarily to the construction of a Highway 101 overpass across the mouth of the Chinook River in the early 1920s with a tide gate under the overpass. This construction, which was designed to eliminate tidal action in the estuary, has impeded the upstream passage of salmonids. The goal of the Chinook River Restoration Project is to restore tidal functions through the estuary, by removing the tide gate at the mouth of the river, filling drainage ditches, restoring tidal swales, and reforesting riparian areas. The hydrologic model (HEC-HMS) was used to compute Chinook River and tributary inflows for use as input to the hydrodynamic model at the project area boundary. The hydrodynamic model (RMA-10) was used to generate information on water levels, velocities, salinity, and inundation during both normal tides and 100-year	

storm conditions under existing conditions and under the restoration alternatives. The RMA-10 model was extended well upstream of the normal tidal flats into the watershed domain to correctly simulate flooding and drainage with tidal effects included, using the wetting and drying schemes. The major conclusion of the hydrologic and hydrodynamic modeling study was that restoration of the tidal functions in the Chinook River estuary would be feasible through opening or removal of the tide gate. Implementation of the preferred alternative (removal of the tide gate, restoration of the channel under Hwy 101 to a 200-foot width, and construction of an internal levee inside the project area) would provide the required restorations benefits (inundation, habitat, velocities, and salinity penetration, etc.) and meet flood protection requirements. The alternative design included design of storage such that relatively little difference in the drainage or inundation upstream of Chinook River Valley Road would occur as a result of the proposed restoration activities

System Effects:

Lessons Learned: [Clip from a newspaper story about a project in a nearby area] "...a dispute about modifying the tide gates at the mouth of the Chinook River. There were serious concerns raised about some aspects of that project. 'We had some initial public hearings held at the Sea Resources classrooms,' said Osborner, 'And we had some lower river homeowners that got their hackles raised when they thought the whole Lower Chinook River was going to be flooded.'"

Link: http://www.chinookobserver.com/20101109/crest-works-to-restore-chinook-wetlands

Funders:

Partners:

Project Documentation: http://www.estuarypartnership.org/restorationsite/1376

http://www.jueltide.com/images/New%20PDF%20files/Tide%20Gate%20Alternatives.pdf

Khangaonkar, T.P., S.A. Breithaupt and F.C.Kristanovich. 2006. Restoration of Hydrodynamic and Hydrologic Processes in the Chinook River Estuary, Washington Feasibility Assessment. Pacific Northwest National Lab., Richland, WA. US Department of Energy. 3 Aug 2006; vp; 9. International Conference on Estuarine and Coastal Modeling; Charleston, SC, 31 Oct - 2 Nov 2005; AC06-76RL01830. Available from American Society of Civil Engineers, Reston, VA. p734-751.

https://inis.iaea.org/search/searchsinglerecord.aspx?recordsFor=SingleRecord&RN=38005860

https://www.cbfish.org/Contract.mvc/Summary/26934%20REL%2035

NOTE: Describes a post-project effort 2011-2012 to refine the model discussed above to assess various scenarios for managing the new tide gates. We did not locate a report from this work.

https://fortress.wa.gov/ecy/eap/flows/station.asp?sta=24N070

NOTE: Telemetry station for Chinook River tide gates. Uncertain if these are the new gates. Includes contact info for persons managing the station.

Estuary: Bear River (WA)	**Name**: Greenhead Slough Restoration, Willapa NWR
Type: Removal	**Total Cost**: According to NOAA Fisheries: $752,284 (Willapa Bay NWR: $1,009,524)

Summary: Greenhead Slough is located in Pacific County, WA, Willapa Bay, just east of Bear River. The project is part of an overall Bear River Estuary plan to restore 649 acres and 6 streams. This area historically supported large numbers of chum, coho, Chinook, cutthroat trout and steelhead; their numbers have dramatically decreased due to poor land management. Since 2003, Willapa Bay National Wildlife Refuge (NWR) worked with partners to remove fish travel barriers in the 3.74 square mile (2,317 acre) watershed from tributaries to Willapa Bay Estuary. Culverts on 4 streams (North, Lost, Chum and South Creeks) were replaced by bridges and 10 miles of stream habitat were enhanced. The last partial obstacle, a culvert/tide gate on Greenhead Slough was removed in 2015.

Greenhead Slough was modified in the 1940s when the WA State Dept of Transportation (WDOT) re-routed four streams along State Route 101. A culvert/tide gate was later installed to allow road access to private timberlands. In 2003, Willapa NWR purchased the property with an existing NRCS Wetland Reserve Program easement as well as a right-of-way easement to WDOT for State Route 101 and to Bonneville Power Administration (BPA) for power lines and transmission towers.

Project work (June-August 2015) included abandoning the blocking culvert/tide gate, realigning the existing channel and adding wood for habitat complexity, re-sloping a portion of a steep bank to ensure stabilization, and installing a 70-foot, single lane, steel bridge over the new channel for access to uplands. Native trees will be planted later this year [2016?]. Also, the BPA access road was realigned and the old road was decommissioned. Post-project, the daily influence of tides, mix of fresh and salt water, and growth of salt-tolerant plants, algae, and phytoplankton will create cycles of rich nutrients that provide essential food, spawning, and nursery habitat for chum, coho and cutthroat. Hundreds of other species will also benefit, such as invertebrates, migratory and resident birds and mammals. Tributaries- North, Chum, Lost and South Creeks- are monitored by Refuge staff and volunteers. Annual spawning surveys have consistently documented chum, coho, and cutthroat.

Aerial Images: (3/20/2016)

Restoration Metrics: Length of stream made accessible; Length of stream treated/protected; Instream pools created/added; Number of structures placed in channel; Number of blockages/barriers removed	
Monitoring Focus:	**Study Design**:
Parameters:	**Species Monitored**:
Project Findings: Reopened several hundred acres of former saltwater marsh to full hydrology, and improved fish passage to several streams. Chum and coho salmon returned to these streams in 2016. Anecdotal Nov. 2016 [http://columbiacoast.blogspot.com/2016/11/]: "Chum salmon came back to their natal streams this season in large numbers. Commercial fishermen caught their quota, and still the salmon kept coming. Last year, refuge stream walkers did not see any chum or coho salmon. This year, chum have returned to all the streams they monitor. Today I saw two streams with chum in them, splashing as they mated and dug out redds to lay eggs. There were dead fish too; I could smell the dead fish as I approached."	
System Effects:	
Lessons Learned: Daily Astorian article on need to be opportunistic with funding for large-scale projects; may have to get them done piecemeal: [Willapa NWR] "…over the years has picked away at fish passage projects upstream when money [was] available, restoring four different streams…10-miles of spawning habitat for…salmonids. But the final piece, the old culvert, was more complicated. Various groups held easements or right-of-ways…BPA and WDOT…also, over the years, people interested in pushing the project through have come and gone..was the same for funding…"Ideally we	

would have proceeded from downstream to upstream [with habitat] improvements," [Sustainable Fisheries Foundation's Cleve Steward] "But because of funding and mechanics of getting all this work done, it didn't work out that way. With these kinds of large, expensive, long-term projects, you have to be opportunistic."

Funders: Willapa NWR:
WA State Salmon Recovery Funding Board- $373,524
Willapa Bay Regional Fisheries Enhancement Group- $86,000
WA Coast Restoration Initiative- $75,000.
Willapa Bay NWR- about $475,000 in funds and in-kind labor
NOAA Fisheries site:
State $534,255; Other $143,300; In-Kind Other $74,729; Report Total: $752,284

Partners: Sustainable Fisheries Foundation managed this phase. Nehalem Marine Manufacturing, Inc.

Project Documentation: Willapa Bay NWR web page for the project

https://www.fws.gov/refuge/willapa/conservation/greenhead_slough_restoration.html

https://secure.rco.wa.gov/prism/search/projectsnapshot.aspx?ProjectNumber=14-1158

NOTE: WA state Recreation and Conservation Office/PRISM web page for project, with description and links to numerous images and project documents

https://www.webapps.nwfsc.noaa.gov/apex/f?p=309:19:::::P19_PROJECTID:39589811

NOTE: NOAA Fisheries web page and project summary. Includes funding details and a scalable map of the project location.

http://www.dailyastorian.com/news/20150731/remaking-greenhead-relinking-2317-acre-watershed-with-willapa-bay

NOTE: Story in Daily Astorian. Includes a photo during construction, and details regarding politics of getting project done.

http://www.chinookobserver.com/co/outdoors/20160913/greenhead-slough-habitat-for-birds-and-other-wildlife

NOTE: Short write-up in the Chinook Observer. Includes a photo of the slough from the new bridge.

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Tillamook	**Name**: Southern Flow Corridor Project-Wilson River
Type: Removal (setback levee)	**Total Cost**: $10,645,736

Summary: Construction began in summer 2016; completion is slated for late September 2017. The primary intent of Southern Flow Corridor (SFC) Landowner Preferred Alternative Project is to remove manmade impediments to flood flows to the maximum extent possible in the lower Wilson River floodplain by extensive removal of existing levees and fill. New setback tidal dikes are required to protect adjacent private lands from inundation from daily tides. The SFC creates a "natural overland floodway" by removal of numerous old levees, dikes and fill (including 15 tide gates) around the Trask and Wilson Rivers and the smaller sloughs and setting back remaining levees in order to provide an unobstructed flow corridor. This is expected to reduce flood levels over a wide area in the lower Wilson floodplain and, to some degree, the lower Trask and Tillamook River systems. Although the SFC was developed as a flood project, it also restores tidal wetland habitats and ecological function as a direct consequence of removing levees and reconnecting 14 miles of ancient channels to the river systems.

Areas outside the setback levees were restored to tidal marsh. Working with a diverse set of partners, Tillamook County permanently protected and restored 522 acres of tidal marsh habitats at the confluence of the Bay's two most productive salmon systems, the Wilson and Trask Rivers. This represents 10% of the watershed's historic tidal acreage and a far greater percentage of "restorable" tidal lands. Prior to restoration the site contained an expansive mosaic of tidal wetlands, disconnected freshwater wetlands and drained pasture lands. Once restored to a tidal regime, the resulting habitats (mud flats, aquatic beds, emergent marsh, scrub-shrub wetlands, forested wetlands and sloughs) will provide substantial habitat benefits to not only threatened coho, but also chum and Chinook salmon, and cutthroat trout.
Further questions may be directed to Project Manager Aaron Palter at 503 842-2413 x116.

Southern Flow Corridor project area at beginning of construction, showing locations of new tide gates (8/23/2016):

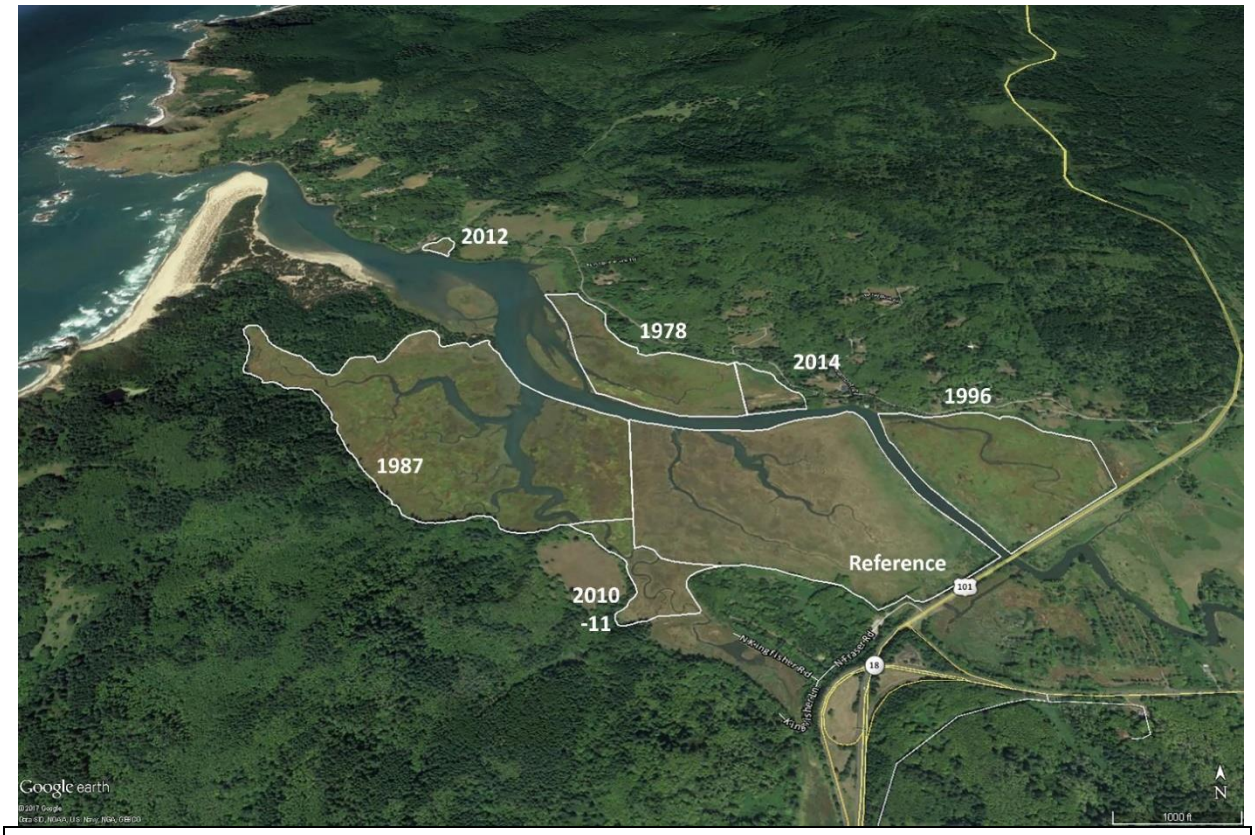
Restoration Metrics: Levee/road Removal-9 miles; levee, dredge spoil, & fill removal-195,000 yd^3; levee modification-2.8 miles; new levee-1.5 miles; tide gates removed -15; new floodgate/drainage tide gates-1/8; structures removed-1 house, 3 barns; ditches filled-4.6 miles; channel reconnections-18; channel construction-5.5 miles; natural channel restoration-14 miles.	
Monitoring Focus:	**Study Design**:
Parameters:	**Species Monitored**:
Project Findings: The Southern Flow Corridor has successfully restored more than 500-acres of tidal wetland and reopened nearly 14 miles of historical tributaries that will serve as important wintering habit for juvenile salmon. The project has resulted in significant flood reduction benefits over a 3,000-acre area, giving the Tillamook community a projected $9.2 million in avoided flood damages over 50 years. ODFW estimates that the restored wetland will annually produce 6,000-9,000 adult coho salmon (average) and 9,000-14,000 with good ocean conditions. Long-term ecological and socio-economic outcomes include 1) reduced flooding in the Highway 101 business corridor and adjacent residential/agricultural lands, including measureable reductions in flood elevation and duration; 2) improved freshwater and estuarine water quality, including reductions in temperature, dissolved oxygen, and turbidity; 3) increased habitat complexity and availability across the range of tidal wetland habitats; and 4) enhanced ecological function benefitting other aquatic, terrestrial, and avian species.	

System Effects: In addition to salmonid habitat benefits, project provides substantial public benefits via reduction of flood risks to life and property, and improvement of water quality. Over time, should also provide sea-level rise and climate change adaptation benefits.
Lessons Learned: Tillamook Fire Department conducted a practice burn on the house slated for removal on project site. SFC project managers and Thompson Bros. Excavating actively monitored the site over winter [2016/17] and responded to minimal storm-related impacts during that time. During the lifetime of the project it provided an estimated 50 jobs to the area.
Funders: FEMA-$3,225,000; NOAA-$2,700,000; OWEB-$1,522,144; OR State Lottery Bonds-$1,075,000; OR Business Development Dept-$1,050,974; USFWS-$822,618; Loren Parks Foundation -$250,000 [Total: $10,645,736]
Partners: Work completed by: "On April 27 [2016] contract was signed with Thompson Brothers Excavating, Inc. (TBE) of Vancouver, WA for $5,500,930." [Tillamook Herald 6/2016] TBE has completed similar projects along the Columbia River and elsewhere, including work for ODOT.
Project Documentation: https://tillamookoregonsolutions.com/ NOTE: Project web page, updated 7-17-2017. https://tillamookoregonsolutions.com/resources-4/ NOTE: Project web page with list of linked supporting documents https://www.tillamookheadlightherald.com/news/southern-flow-corridor-landowner-preferred-alternative/article_5c9b7e64-3314-11e6-88d8-df2c02cb6755.html NOTE: Newspaper article (6-2016) w/project details.

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Salmon	**Name**: Salmon River Estuary, Oregon
Type: Dikes removed 1978, 1987, 1996. At least two TGs removed 1987, 1996. TG removed at Tamara Quays 2008. TG removed at Pixieland 2011.	**Total Cost**:
Summary: NOTE: Restoration from 1978-1996 appears to have been funded by the US Forest Service. Restoration at Tamara Quays and Pixieland was funded by OWEB. So this project area is included in both OWEB funded and non-OWEB funded summaries. The Salmon River Estuary has been extensively restored in distinct periods of activity over several decades. Between 1954 and 1974 most of the estuary had been diked and ditched to create pastures, with the majority of dike building in the early 1960s. From 1978 to 1996 a series of land acquisitions and intertidal marsh restoration projects restored 339 acres of tidal marsh and over 3 miles of sinuous tidal marsh channels. A dike was removed in 1978; a dike and tide gate were removed in 1987, and another dike and tide gate were removed in 1996. Projects from 2007-2014 (which included OWEB funding) were more complex - included Rowdy Creek marsh restoration and dismantling a trailer park housing development (Tamara Quays, 2008-2009) and an amusement park (Pixieland, 2010-2011) built directly on tidal marsh land. Projects from 2007-2014 restored tidal influence to 108 acres; restoring 2.5 miles of stream channel and floodplain; removing 2 miles of dikes, failing septic systems, underground infrastructure and 3 tide gates, multiple complex ditches, and a boat basin carved into the marsh floor and restoration of native marsh and upland plants.	

Aerial Images (after Flitcroft et al., 2016):



Restoration Metrics:	
Monitoring Focus:	**Study Design**:
Parameters:	**Species Monitored**:
Project Findings: [2014 Powerpoint] Restoring estuary habitat has enhanced life history expression in both Chinook and coho salmon. Coho that leave natal streams as subyearlings are not lost to the population but use the estuary. Estuary life histories linked to restored wetlands contributed 25-40% of adult Chinook and 20-35% of adult Coho produced in Salmon River. Life history diversity (and the habitat opportunities that support it) is fundamental to the productivity as well as the resilience of salmon populations.	
System Effects:	
Lessons Learned:	
Funders: USFS in 1978-1996(?)	
Partners:	
Project Documentation: Ellingson, K.S. and B.J. Ellis-Sugai. 2014. Restoring the Salmon River Estuary: Journey and Lessons Learned Along the Way 2006-2014. Report to Siuslaw National Forest, Corvallis: OR. https://conference.ifas.ufl.edu/CEER2014/Speaker Presentations/July 29, Tuesday_Sessions 01 - 30/Salon K_sessions_10_20_30/1140_Daniel Bottom.pdf	

NOTE: Powerpoint presentation, circa 2014?

Gray, A., Simenstad, C.A., Bottom, D.L. and Cornwell, T.J., 2002. Contrasting functional performance of juvenile salmon habitat in recovering wetlands of the Salmon River estuary, Oregon, USA. Restoration Ecology, 10(3), pp.514-526.

Gray, A., 2005. The Salmon River estuary: restoring tidal inundation and tracking ecosystem response (Doctoral dissertation, University of Washington).

Hering, D.K., 2009. Growth, residence, and movement of juvenile Chinook salmon within restored and reference estuarine marsh channels in Salmon River, Oregon (Doctoral dissertation).

Jones, K.K., Cornwell, T.J., Bottom, D.L., Campbell, L.A. and Stein, S., 2014. The contribution of estuary-resident life histories to the return of adult Oncorhynchus kisutch. Journal of Fish Biology, 85(1), pp.52-80.

NOTE: This paper is mainly focused on estuary rearing coho life history, but links that to restoration of habitat in the Salmon River estuary.

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Siuslaw	**Name**: Phey Lane Tide Gate Replacement
Type: Replacement with MTR addition	**Total Cost**:
Summary: The Phey Lane tide gate is a project on the Siuslaw River (approximately two miles west of Mapleton, Oregon). Phey Lane was funded by the Phey Lane Homeowners Association. [Greg Apke-ODFW] "ODFW purchased and deployed equipment to monitor hydraulic and water chemistry parameters on the tide gate system to further ODFW's understanding of fish passage hydraulics in tide gate controlled water bodies. The project has been collecting data for two and a half months and we are observing good results that are revealing how tidal cycles and stream flows interact and we are able to draw conclusions about the time available for fish to pass into and out of the impounded water body."	

Aerial Image (8/17/2016):

Restoration Metrics:	
Monitoring Focus: Biological – fish; tidal exchange and hydraulics	**Study Design**:
Parameters:	**Species Monitored**:
Project Findings: 2012 monitoring (Kuntz PP) indicates system is meeting ODFW water velocity requirement of 2fps. Also presents data with and without the MTR.	
System Effects:	

Lessons Learned:
Funders: Phey Lane Homeowners Association
Partners: Oregon Department of Fish & Wildlife
Project Documentation: https://static1.squarespace.com/static/54ee04bce4b067ff94f0c5a8/t/54ee10d1e4b06d374ec01da5/1424888017949/narratedPrsnttn_05-20-13.pdf NOTE: Leo Kuntz PowerPoint presentation; includes 2012 data for water velocity and water level at which gate closes. Also presents data with and without the MTR.

Estuary: Coos Bay	**Name**: Kentuck Slough Tide Gate Replacement
Type: 4 tide gates replaced with MTR addition	**Total Cost**: $2,321, 000

Summary: The Kentuck sub-basin is oriented east to west, with 2 major tributaries, Kentuck and Mettman Creeks. These streams converge in the lowlands to form Kentuck Slough, which drains into the Coos estuary. The watershed drainage area is about 10,637 acres, with about 60 miles of streams. From the tide gate at East Bay Drive, Kentuck main stem is approximately 13 km (8.1 mi) long, and Mettman Creek main stem is 5.47 km (3.4 mi) long. The elevation in the basin ranges up to 406.60 m (1,334 ft) above sea level.

The Kentuck Slough Bridge is located along the northeastern side of Coos Bay near North Bend, OR. The existing bridge did not meet current design standards and needed to be replaced. Attached to the downstream side of the existing bridge was a set of three 7.5-ft wide by 10-ft high top-hinged tide gates. One of the tide gates was wedged in the gate slot and completely inoperable. The other two gates functioned, but leaked significantly during flood tides. Additionally, the gates were frequently overtopped during high tides.

The leaky gates have allowed for salt-water intrusion into the slough, which has re-created an important estuarine habitat. However, this has also resulted in an increase in the amount of salt water that intrudes into adjacent land via groundwater flow. This has negatively affected the quality of the soil during the summer months when there is little freshwater inflow to the slough to help dilute the salt concentrations from the bay water. The local landowners have indicated that the current volume of saltwater influx to the slough is tolerable, but any increase would not be acceptable. WEST developed an HEC-RAS unsteady flow hydraulic model of the tide gate designs to accommodate and improve upon conditions that encourage the estuarine habitat, while at the same time, will not increase the volume of salt-water influx to the slough over the existing conditions.

The old tide gates were replaced in 2007 by 4 Nehalem Marine gates.

Aerial Images (5/1/2015):

Restoration Metrics:	
Monitoring Focus: Tidal exchange and hydraulics; water quality (temperature, salinity)	**Study Design**:
Parameters:	**Species Monitored**:
Project Findings:	
System Effects:	
Lessons Learned:	
Funders: Oregon Transportation Investment Act	
Partners: Coos County Road Department, Nehalem Marine.	
Project Documentation: http://www.westconsultants.com/services/hydraulics/kentuck-slough-tide-gate-replacement-project--or- NOTE: WEST Consultants. Project description and photo of site. Written before project was completed? West Coast Salmon Summit, May 16-17, 2013. Leo Kuntz/Nehalem Marine PowerPoint presentation. https://static1.squarespace.com/static/54ee04bce4b067ff94f0c5a8/t/54ee10d1e4b06d374ec01da5/1424888017949/narratedPrsnttn_05-20-13.pdf NOTE: includes 2011 tide gate operation and fish passage monitoring data for Kentuck.	

ftp://webserver.lcd.state.or.us/Uploads/Federal_Consistency/Pipeline/Exhibit%20B/Appendix%20P%20-%20DEQ%20responses/R51%20NMFS%20Kentuck%20Mitigation%20TM%202010-11-04%20.pdf

NOTE: 2010 proposal to re-establish tidal connections between Kentuck Inlet and abandoned golf course by replacing the 4 tide gates installed in 2007 with a bridge to offset impacts to mudflat habitat at proposed Jordan Cove gas terminal. Discusses proposed mitigation concept for intertidal mud flats, short-term impacts and long-term benefits on listed Oregon Coast Coho and Essential Fish Habitat.

http://www.co.coos.or.us/Portals/0/Planning/AP-15-02/exhibit%208.pdf

NOTE: 14-page public comment letter circa 2014(?) detailing environmental and other concerns about mitigation project proposed above. (2007 TG project cost figure listed above came from this document.)

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Coos Bay	**Name**: Matson Creek Wetland Preserve (Rose Dairy)
Type: 3 tide gates removed, one replaced with mitigator; tidal reconnection; freshwater stream restoration.	**Total Cost**:

Summary: A former dairy was purchased in 2000 using a USFWS Coastal Wetlands grant combined with an OWEB restoration grant, with title turned over to The Wetlands Conservancy. Subsequent to this purchase, Phase 1 tidal reconnection covered about 75 acres; Phase 2 upper valley stream restoration involved about 24 acres.

The Coos Bay North Bend (CB/NB) Water Board completed the project under a MOU with Oregon DFW as mitigation for waivers of fish passage at Lower and Upper Pony Creek Dams, also located in the Coos Watershed. Fish passage has not been present along Pony Creek above the lower dam since it was erected in the 1930s. Pony Creek below the dam is now being encroached upon by urban development and is listed as a 303d stream for high temperatures. Occasional cutthroat trout are the only migratory species observed in Pony. To provide mitigation with a net benefit to coastal cutthroat and other migratory species, the CB/NB Water Board and ODFW selected and designed the restoration at Matson Creek after years of exhaustive searching in the Coos Watershed.

ODFW believes this project represents the only fully functional headwaters to ocean system in the Coos Bay system. Matson Creek drains into the site and provides potential spawning habitat for coho and chinook in its upper reaches, which were inaccessible prior to removal of the tide gates. The wetland pastures have the potential to provide significant salmonid juvenile summer and winter rearing habitat.

The project area encompasses 97 acres of fresh and estuarine habitat adjacent to Catching Slough off of Coos Bay. Phase 1 included replacing undersized and failing culverts and tide gates with a bridge for full natural hydraulic connectivity between Matson Creek and Catching Slough, and abandonment of ditches and re-establishment of the main stem of Matson Creek through the lower valley. Activities in 2015 included: 1) removal of non-native vegetation; 2) abandoning 10,000 cubic yards of ditches installed in the 1930's along the north and south valley edges; 3) re-establishment of 5,900' feet of naturally meandering stream bed and side channels; 4) placement of ~130 large wood structures; and 5) four acres of stream bank, riparian and floodplain plantings.

After Phase 1 restoration – tidal reconnection in lower valley (5/1/2015):

Before restoration at time of purchase (8/7/2000):

Restoration Metrics:	
Monitoring Focus: Biological – marsh vegetation	**Study Design**: Permanent plots.
Parameters:	**Species Monitored**:
Project Findings:	
System Effects:	
Lessons Learned:	
Funders:.	
Partners: The Wetlands Conservancy, Coos Bay – North Bend Water Board, ODFW, Coos Watershed Association.	
Project Documentation: http://wetlandsconservancy.org/restoration-of-matson-creek/ NOTE: Wetlands Conservancy project summary. http://www.cooswatershed.org/wp-content/uploads/2017/01/Coastal_Wetlands_Report.pdf	

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

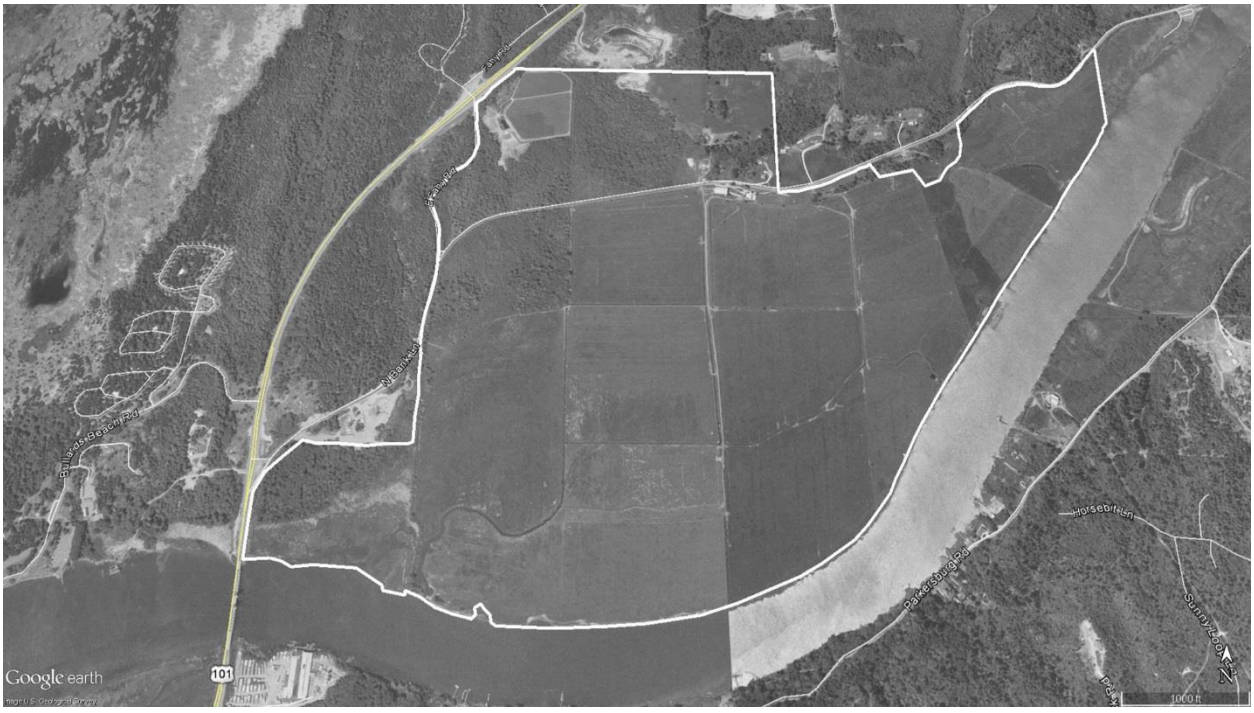
Estuary: Coquille River	**Name**: Bandon Marsh Restoration Monitoring
Type: Removal	**Total Cost**: $9,500,000+

Summary: The Ni-les'tun Unit of Bandon Marsh contains portions of floodplain lowlands from three drainages, Fahys, Redd, and Overlook creeks. The restoration was undertaken to restore over 400 acres of marsh habitat in the Coquille River estuary. Short term goals included providing habitat for juvenile salmon and reintroduce unresticted tidal inundation. Long term goals were to create estuary-wide improvements in water quality and estuarine marsh habitat and to increase the amount of wetland habitat in the estuary. Restoration actions included removing tide gates, lowering or removing dikes, filling large ditches, disrupting small ditches, installing upgraded culverts, and excavating 5 miles of tidal channels. Monitoring was performed to determine changes in aquatic species communities after restoration.

Fish were collected in each of the three tributaries to the marsh, newly created tidal channels, reference streams and tidal channels, and the Coquille River. All fish were identified and counted and up to twenty of each species were measured. Up to twenty of each salmonid species were also weighed. Macroinvertebrates were collected in surface and water column nets in Fahys Creek and one reference creek.

This project focused on fish and wildlife. Plant community responses were documented in an OWEB-funded study. Those results are available in Brophy et al. 2014 and Brown et al. 2016, which are included in Appendix A and Appendix B.

Bandon Marsh Restoration – Before (5/26/1994):



Bandon Marsh Restoration – After (5/21/2015):

Restoration Metrics:	
Monitoring Focus: Biological, Chemical	**Study Design**: BACI
Parameters: Species frequency and abundance, species richness, community similarity, salmonid age-classes (assigned by length-frequency). Frequency categories for fish species: dominant, common, occasional, and rare.	**Species Monitored**: Chinook and coho salmon, cutthroat trout, sculpins, stickleback, additional fish species and aquatic macroinvertebrates
Project Findings: Twenty-one fish species were collected over the course of the study. Of these, 13 were collected both before and after restoration. Three species were only collected prior to restoration and five were only collected after restoration. Of the species only collected after restoration, 80% (4/5) were estuarine. Fish distributions differed after restoration. Species richness increased in upstream areas and decreased in tidally influenced areas. The fish communities in the treatment and reference marshes differed before and after the restoration. However, the degree of difference was smaller post-restoration.	
System Effects:	
Lessons Learned:	
Funders: USFWS	
Partners:	
Project Documentation: Silver, B.P., J.M. Hudson, and T.A. Whitesel. 2015. Bandon Marsh National Wildlife Refuge Restoration Monitoring, Final Report. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA. 49 pp.	

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Skagit	**Name**: Crescent Harbor Salt Marsh Restoration Project, Skagit River
Type: Removal (replaced by a bridge)	**Total Cost**: Original project: $894,862

Summary: Crescent Harbor Salt Marsh was once the largest barrier salt marsh on Whidbey Island. Such habitats are important for juvenile salmon, particularly Chinook. Historically, the site was connected to Crescent Harbor by a channel in the SW portion of the marsh. Around 1910, the marsh was diked for agriculture, and the channel inlet was filled and replaced with a tide gate in the SE portion allowing seasonal management of on-site water levels and blockage of flood tides. Site drainage was improved through ditching. Subsequently, muted tidal volumes and sediment transport have led to marsh surface subsidence to about 3' below natural marsh elevations due to soil decomposition and compaction. Although the Navy partially opened the tide gate in 1993 to allow some tidal exchange, the small opening, small-diameter culverts, and blockage by mussels and barnacles led to extremely muted tidal flow to marsh surfaces. Partnering with Naval Air Station Whidbey Island, SRSC secured Salmon Recovery Funding Board (SRFB) and Estuary and Salmon Restoration Program (ESRP) funding to build upon an initial assessment (Island County Public Works and Philip Williams & Associates 2003) to implement (2008-2009) the following restoration actions: 1) Creating notched weirs at the sewer intake dike separating the SW and NW salt marsh cells to allow tidal circulation; 2) breaching a sewer intake dike connecting the east and NW marsh cells to increase tidal volume and fish access; 3) replacing a small culvert currently connecting the SW and east marsh cells to improve fish access and tidal circulation; and 4) reconnecting the existing channel network to Crescent Harbor by replacing the outlet channel tide gate with a Mabey-Johnson bridge [portable pre-fab truss bridge used by military]. Site monitoring and adaptive management are ongoing.

Aerial Images: Crescent Harbor after tidal reconnection (photo image 8/3/2016).

Crescent Harbor, before restoration (7/31/2005).

Restoration Metrics: Juvenile Chinook salmon density; Total amount of estuarine / nearshore acres treated; Acres opened to fish passage through tidegate alteration/removal; Number of tidegates altered/removed to allow fish passage	
Monitoring Focus: Biological - fish, vegetation Water quality	**Study Design**: FISH: Sampled every 2 weeks Feb-May. Beach seining was completed in 3 distinct areas of the marsh and in adjacent nearshore waters. Electrofishing was used to sample Crescent Creek. All fish were ID'd and counted. Measured T, salinity, DO, velocity, set depth, vegetation, substrate type. VEGETATION: Botanical inventories conducted as part of Crescent Harbor Salt Marsh Restoration monitoring. Veg surveys of the marsh surface conducted in July 2009 (pre-project), June 2011, Sept 2013, June 2014 and Aug 2015. Cited ref ouTlines results from 2013 to 2015 surveys.
Parameters: juv Chinook density. Recorded fish catch #'s by species, water temp, salinity, DO, seine depths, velocity. Vegetation ground cover, species composition	**Species Monitored**: Fish: recorded all species, focused on juv Chinook Vegetation: Seaweed species- green tuft, witch's hair, sea lettuce, green string lettuce, nori. Salt marsh species- pickleweed, seashore saltgrass,

	brass buttons

Project Findings: FISH: Prior to restoration only stickleback were caught in Crescent Marsh. After restoration 10-16 species were caught including subyearling Chinook (wild and hatchery), subyearling and yearling coho, pink, chum, yearling sockeye, cutthroat, and native char (Salvelinus sp). Pink salmon fry timing did not differ inside and outside the marsh. Chum fry abundance peaked inside the marsh earlier than the adjacent beaches but densities were similar inside and outside. Wild Chinook were collected mainly in the adjacent beaches and main marsh, but were also collected in the creek. Fish size was negatively correlated with outmigrant abundance. Density was higher in the marsh than at adjacent beaches, which follows a pattern seen at natural pocket marshes in Puget Sound but the difference is smaller.

VEGETATION: Pre-project communities had mix of high and low estuarine salt marsh, and upland vegetation. Reintroduction of tidal influence resulted in large dieback of existing vegetation. By 2014, most of site was in mudflats that supported various types of seaweed and large shellfish populations. Channel size has increased, which could be allowing more water to enter during tidal inundation. The increased energy could be scouring the marsh surface, removing sediment faster than it is being replaced. Pickleweed and saltgrass dominate the highest sites, but brass buttons- an annual and pioneer species- has been encroaching further onto the mudflats. It remains to be seen if the site will continue to be dominated by bare ground, or if the marsh surface will continue to expand as soil organic matter lost through scouring builds-up in the remaining substrate over time.

System Effects: Electrofished and sampled water quality in Crescent Creek above the salt marsh

Project also examined vegetation effects

Lessons Learned: In Crescent Harbor Salt Marsh, there is a declining order of wild juvenile Chinook salmon density associated with connectivity of marsh lobes. Water quality data and juvenile Chinook results suggest that restrictions in hydraulic connectivity between marsh lobes may be driving this. Hydraulic connectivity improvements within Crescent Harbor Salt Marsh (i.e., between marsh lobes) would likely allow for improved water quality and better use of this habitat by fish.

Salt marsh formation after restoration was limited by elevation. Post-restoration vegetation conditions are still changing in response to restoration of tidal flow, and appear not to have stabilized yet.

The Crescent Harbor Salt Marsh Restoration project, constructed during the summers of 2008-2009 using SRFB and other funding, has restored more than 200 acres of pocket estuary habitat to tidal inundation and fish access. During the initial project design, great care was taken to model post-restoration conditions. However, the dynamic nature of the natural processes interacting within the site make it difficult to account for all the ways in which conditions will evolve following exposure to tidal and wave processes.

Although, the site largely functions as intended, unforeseen erosion, caused by wave action in the interior of the salt marsh, has threatened infrastructure critical to the operation of a wastewater treatment plant (WWTP) located within the project site. Addressing this erosion will allow continued function of newly restored pocket estuary habitat while greatly reducing the risk of damage to treatment plant infrastructure from storm events. In 2010, adaptive management actions were implemented in 2 locations in the eastern portion of the site: 1) elevate 300' of driveway leading the WWTP and soft-armor 100 feet to mitigate for temporarily decreased soil retention due to vegetation community shift from fresh to salt water species; 2) construct a bridge to connect the east and southwest cells of the salt marsh.

Funders: Puget Sound Nearshore Ecosystem Restoration Project (PSNERP)- $417,722; SRFB - Salmon Recovery Funding Board- $221,127; Estuary Salmon Restoration Program (ESRP)- $183,013; DOD/US

Navy- $73,000. Follow-up monitoring: $150,000.
Partners: Skagit River System Cooperative (SRSC)
Project Documentation: Beamer, E., B. Brown, K. Wolf, R. Henderson and C. Ruff. 2016. Juvenile Chinook salmon and nearshore fish use in habitat associated with Crescent Harbor Salt Marsh, 2011-2015. Skagit River System Cooperative Research Program. http://skagitcoop.org/wp-content/uploads/Crescent-Harbor-Fish-Report-Final_2016-05-09.pdf https://salishsearestoration.org/images/8/82/Mickelson_et_al_2009_crescent_harbor_monitoring_plan.pdf Clifton, B. 2015. Crescent Harbor Salt Marsh Restoration: 2013-2015 Vegetation Monitoring Report. http://skagitcoop.org/wp-content/uploads/2013-2015VegetationMonitoring-Report.pdf Crescent Bay Salt Marsh and Salmon Habitat Restoration Plan. Prepared by Philip Williams & Associates, Ltd. and the University of Washington Wetland Ecosystem Team (UW-WET). July 14, 2003. http://skagitcoop.org/programs/restoration/crescent-harbor-salt-marsh/ NOTE: Skagit River System Coop web page with site history, project description, pre- and post-restoration air photos. http://hws.ekosystem.us/project/200/7054 NOTE: Habitat Work Schedule web page describing 2010 adaptive management actions to mitigate erosion.

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Skagit	**Name**: Fisher Slough Restoration Project, Skagit River Estuary
Type: Replacement	**Total Cost**: $8 million
Summary: Located in the south fork Skagit River tidal delta near the town of Conway, WA, the Fisher Slough Restoration Project was a collaborative effort to reconnect natural freshwater tidal hydrology to approximately 50 acres of currently diked floodplain; restore historical tidal marsh vegetation communities; provide juvenile Chinook rearing habitat, remove fish passage barriers and improve fish passage to several miles of tributary spawning areas; increase watershed connectivity for coho, chum and other native fish species; and improve floodwater and sediment storage conditions for the tributary levee system. Restoration of Fisher Slough site was a priority in the Skagit Chinook Recovery Plan to help recover 6 populations of wild Chinook in the Skagit River and its natal estuary. The project broke a long-standing deadlock between agriculture and conservation interests over estuary restoration, restored critical Chinook rearing habitat and improved fish access to the 22 square mile Carpenter Creek Watershed. In 2009, NOAA awarded $5.7 million of Recovery Act funding to The Nature Conservancy (TNC) to restore the Fisher Slough marsh site. Construction began in fall 2009, when 3 antiquated, wooden paired tide gates were replaced with aluminum self-regulating gates to improve salmon access to Fisher Slough. The new floodgates [TNC prefers this term] are managed by season: fall/winter flood control, spring salmon migration, summer irrigation. The seven-year project was completed in October 2011, with dike setback that increased marsh area from 9.8 to 55.7 acres. Additionally, Big and Little Fisher creeks were rerouted and tidal channels were excavated. Long-term benefits include reduced risk of structural failure, road damage and lost farming opportunities caused by flooding, as well as lower maintenance and operation costs. There were also human and social capital gains: conservation organizations, engineering and construction companies, tribes, and drainage and diking districts gained experience in tackling complex problems and finding win-win solutions. Long-standing social barriers and conflicts were overcome, leading to greatly improved relationships and potential for future collaborations.	

Aerial Images: Fisher Slough after project (8/3/2016).

Fisher Slough, before restoration activities, (6/25/2009).

Restoration Metrics: Habitat area, Chinook abundance, density, size. Flood storage capacity (acre/ft). % of time tide gates are open. Acres of freshwater marsh restored. Stream-miles of improved salmon passage. Number of Blockages/Impediments/Barriers Removed

Monitoring Focus: Biological; Water quality Monitoring from 2009-2014 allowed researchers to distinguish the fish and environmental effects of tide gate operation from dike setback restoration. Fish were collected up and downstream of the tide gates in main channel and blind slough habitats using beach seines and fyke traps. ID'd and counted all fish, measured up to 20 of each spp. Measured water elevation, T, and/or DO, velocity.	**Study Design**: BACI
Parameters: Chinook density, water elevations, tidal amplitudes, water temps, DO, veg cover, sediment accretion.	**Species Monitored**: Chinook
Project Findings: After tide gate replacement and before dike setback the Fisher Slough sites did not follow the pattern of higher abundance with increased connectivity seen at long term monitoring sites in the Skagit River delta. However, after dike set back the Fisher Slough sites demonstrated this positive relationship. Water temperature influenced Chinook abundance only in 2015. When fish abundance was expressed as a percent of carrying capacity the 2015 data was consistent with other monitored years and all years fell close to the 1:1 line between Fisher Slough and Skagit River delta with outmigrant population as a percent carrying capacity. Restoration from dike setback increased juvenile Chinook salmon abundance upstream of the floodgate approximately 10x relative to abundance during pre-dike setback. Weekly variability in floodgate operation influenced the number of juvenile Chinook salmon upstream of the floodgate by up to a factor of three (3x). Longer periods of the floodgate doors being open during the non-ebb stage of the tidal cycle resulted in more juvenile Chinook salmon upstream of the floodgate. Monitoring shows that floodgates and tide gates do have a strong influence on fish utilization of habitat and thus need to be designed and operated properly for fish if fish benefits are an important project goal. [From NOAA web page] 2014: Success for fish. Fish are benefiting even more from the restoration than expected. Ecological surveys indicate that the site can support as many as 21,800 juvenile Chinook salmon—5,000 more than hoped for.	
System Effects: [Climate change & flood protection benefits] In addition to better fish passage and habitat, the Fisher Slough Project also provides flood protection, as described by the Farms, Fish and Floods Initiative (3FI), a landscape-scale effort in the Skagit Delta based on an MOU between NOAA, Skagit Conservation District, Skagit County, Skagit County Dike and Drainage Partnership, Skagitonians to Preserve Farmland, TNC, WA Dept of Fish and Wildlife and Western WA Agricultural Association. 3FI focuses on advancing mutually beneficial strategies that support the long-term viability of agriculture and salmon while reducing risks of destructive floods. 3FI complements the WA state Tidegate Fish Initiative (TFI). The Skagit Delta Hydrodynamic Model Project (SHDP) is supported by and contributes to the goals of 3FI. The SDHP Team initiated hydrodynamic modeling and alternatives analysis to identify and prioritize mutually beneficial large scale flood risk reduction and estuarine habitat restoration projects to achieve the Skagit Chinook Recovery Plan 2005 goal. The SHDP listed the Fisher Slough Project in an inventory of projects that provide these multiple benefits. A related 3FI document notes that flood protection benefits will be even more important with climate change related sea level rise and storm surges.	
Lessons Learned: [From report on entire Skagit] Projects using dike setback, dike breach, or fill removal had juv Chinook densities within the restored area consistent with the levels in nearby reference sites.	

Projects using self-regulating tidegates (SRTs) had much lower juv Chinook densities than nearby reference sites. Self-regulating tidegates were better for juv Chinook salmon than the traditional flapgate they often replace (by ~2X), but SRTs averaged an order of magnitude lower in juv Chinook density compared to nearby reference sites. One combination project, at Fisher Slough (dike setback w/floodgate replacement) performed well. We detected a 10X increase in habitat use by juv Chinook salmon in Fisher Slough upstream of the tidegate, consistent with habitat use observed at other Skagit tidal delta reference sites. This increase was predominantly associated with the dike setback and current operation of the tidegate to allow fish passage during both slack and flood stages of the tide cycle.

Research on social and economic benefits of the project suggest that the $8 million invested in restoration will save the community $9-$21 million over the next 50 years, reducing flooding on as many as 600 acres nearby. Project employed 300 workers.

"The success of the monitoring work at Fisher Slough is largely due to a well thought out monitoring and adaptive management plan, a hypothesis based research approach and critical funding and support from NOAA, ESRP and private funders."

Funders: In 2009, NOAA awarded $5.7 million of Recovery Act funding to The Nature Conservancy (TNC) to restore the Fisher Slough marsh site.

Partners: The Nature Conservancy;Skagit River System Cooperative; Dike District 3; Drainage and Irrigation District 17; Environmental Protection Agency; National Fish & Wildlife Foundation; National Oceanic and Atmospheric Administration; Skagit County; Washington Department of Fish and Wildlife/Estuary and Salmon Restoration Program; Washington State Recreation and Conservation Office/Salmon Recovery Funding Board; and Western Washington Agricultural Association

Project Documentation: Greene, C., E. Beamer, J. Anderson. 2016. Skagit River Estuary Intensively Monitored Watershed Annual Report April 2016.

Beamer, E., R. Henderson and C. Ruff. 2016. Juvenile Chinook response to Fisher Slough restoration and floodgate operation: An update including 2015 results. Skagit River System Cooperative. Prepared for The Nature Conservancy under contract # WA-S-150106-034-1-2.

Beamer, E., R. Henderson, K. Wolf. 2013. Juvenile salmon, estuarine, and freshwater fish utilization of habitat associated with the Fisher Slough Restoration Project in 2012. Skagit River System Cooperative. Prepared for The Nature Conservancy, Seattle WA. (Contract # WAFO-136-020410).

Henderson R., G. Hood, E. Beamer, and K. Wolf. 2016. Fisher Slough tidal marsh restoration 2015 monitoring report. Skagit River System Cooperative, LaConner, WA. Prepared for The Nature Conservancy, contract # WA-S-150106-034-1-2.

Beamer, E, R. Henderson, and K. Wolf. 2010. Juvenile salmon, estuarine, and freshwater fish utilization of habitat associated with the Fisher Slough Restoration Project, Washington 2009. Unpublished report prepared for The Nature Conservancy, Washington. 63 p.

Beamer, E. and R. Henderson. 2013. Fisher Slough Floodgate Report for Water Year 2012. Skagit River System Cooperative, LaConner, WA. Report prepared for The Nature Conservancy under Grant Agreement # WA-S-0216-061-0

http://skagitcoop.org/wp-content/uploads/FisherSloughFGReportWY2012Final.pdf

Beamer, E. and R. Henderson. 2014. Fisher Slough Floodgate Report for Water Year 2013. Skagit River System Cooperative, LaConner, WA. Report prepared for The Nature Conservancy under Grant Agreement # WA-S-0216-061-0

http://skagitcoop.org/wp-content/uploads/FisherFGReport2013_FINAL.pdf

Henderson, R. and E. Beamer. 2015. Fisher Slough Floodgate Report for Water Year 2014. Skagit River

System Cooperative, LaConner, WA. Report prepared for The Nature Conservancy under Grant Agreement #WA-S-130122-001-2.

http://skagitcoop.org/wp-content/uploads/EB2822_Henderson-Beamer_2015.pdf

Henderson, R. and E. Beamer. 2016. Fisher Slough Floodgate Report for Water Year 2015. Skagit River System Cooperative, LaConner, WA. Report prepared for The Nature Conservancy under Grant Agreement #WA-C-150106-034-1.

http://skagitcoop.org/wp-content/uploads/Floodgate-Report-WY2015_final_022516.pdf

Weinerman, M., M. Buckley and S. Reich. 2012. Socioeconomic Benefits of the Fisher Slough Restoration Project. Prepared by ECONorthwest for The Nature Conservancy and National Oceanic and Atmospheric Administration.

https://www.pdx.edu/sustainability/sites/www.pdx.edu.sustainability/files/Fisher-Slough-Benefits_Final%20reduced%20Buckley%202012.pdf

NOTE: ECONorthwest is a PNW economic consulting firm that uses analytical methods to examine the benefits, costs, and other economic effects of environmental and natural resource topics.

Greene, C., Hall, J., Beamer, E., Henderson, R., Brown, B. and LaConner, W.A., 2012. Biological and physical effects of “fish-friendly” tide gates. National Oceanic and Admospheric Administation, National Marine Fisheries Service, Watersheds Program, Northwest Fisheries Science Center, and Skagit River System Cooperative, LaConner, Washington.

http://skagitcoop.org/wp-content/uploads/EB2673_Greene-et-al_2012.pdf

NOTE: Discusses Fisher Slough pre- and post project monitoring results and compares with a reference slough in a BACI design.

https://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/washington/explore/fisher-slough-noaa-factsheet.pdf

NOTE: Fisher Slough NOAA Fact Sheet

http://www.restoration.noaa.gov/fisher_slough_project/#

NOTE: Includes slideshow

https://secure.rco.wa.gov/prism/search/ProjectSnapshot.aspx?ProjectNumber=07-1914

NOTE: Washington Recreation and Conservation Office, PRoject Information SysteM (PRISM) website; many linked documents, restoration metrics.

https://salishsearestoration.org/images/b/bb/Beamer_2016_fisher_slough_restoration_effectiveness.pdf

NOTE: Eric Beamer letter (March 2016) to Fisheries and Environmental Services Management for the Sauk Suiattle and Swinomish Indian Tribes: "Juvenile Chinook

salmon response to Fisher Slough restoration: effectiveness monitoring results"

https://www.skagitcounty.net/Departments/PlanningAndPermit/FisherSloughProject.htm

NOTE: Skagit county Planning and Development services web page for the project. Includes design plans

http://www.skagitriverhistory.com/PDFs/Fisher%20Slough%20placemat_SERNW%20tour.pdf

NOTE: two-page schematic with site diagram

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Skagit	**Name**: Wiley Slough Restoration Project, Skagit River Estuary
Type: Removal and replacement	**Total Cost**: $4,623,999 Another source says $4,768,975

Summary: Restoration in 2008-2009 aimed at restoring tidal inundation and fish access to ~156 acres of estuarine wetlands. Included construction of 2,840 LF of set-back dikes along the pre-1956 levee footprint, and addition 2,200 LF of previously existing dikes around the site perimeter. An existing tide gate on Wiley Slough was removed, and a new, larger tide gate was constructed at the new diked perimeter. Lastly, 3,470 LF of borrow ditches were filled to promote sheet flow and drainage to historic channels. In 2009-2010, following completion of major construction activities, native plants were installed on 3.8 acres in zones adjacent to acres impacted by tidal flows. Restoration of estuarine functions to the Wiley Slough site provide significant benefits to Chinook, chum, coho, pink, sockeye, bull trout, steelhead and cutthroat by creating important rearing habitat. The Skagit Chinook Recovery Plan estimates that 2,750 acres of tidal marsh restoration are required for Chinook recovery, the highest priority habitat problem in the watershed. Wiley Slough accounts for 5.8 percent of this goal.

[WA Dept of Fish & Wildlife] Historically the site was managed to provide agricultural enhancements for winter waterfowl forage. With the ESA listing of many salmonid species such as Chinook salmon, habitat management shifted to restore estuary habitat. The restoration design which included building setback levees, relocating the Wiley Slough tide gate farther inland, and removing part of the perimeter levee allow tidal and river flows to recreate channels and provide additional natural estuary habitat.

Aerial Images: Wiley Slough tide gate relocation and tidal reconnection (8/3/2016).

Wiley Slough, before restoration activities (7/9/2009).

Restoration Metrics: Delta-rearing Chinook smolt production. (Each recovery action is evaluated for its potential smolt production as determined by an empirical smolt production model.) Acres of estuarine wetland habitat restored.

Monitoring Focus: Fish monitoring was conducted within restored habitat area of the Wiley Slough Restoration Project during the juvenile Chinook salmon outmigration seasons (Feb-Aug) of 2012 and 2013 in order to compare results at Wiley Slough with long term monitoring (reference) sites in the Skagit delta.

Monitoring questions:

1. How does local environment vary by year, season, and lobe (Wiley, Teal) within the Wiley Slough Restoration Project?
2. What fish species are present within the restored area?
3. How does juvenile Chinook density vary by year, season, and lobe (Wiley, Teal) within the Wiley Slough Restoration Project?
4. How does seasonal juvenile Chinook density in the restored area compare to reference sites throughout the Skagit River estuary?
5. What is the carrying capacity of the restored area for juvenile Chinook rearing?

Study Design: The monitoring design primarily consisted of a post-treatment (i.e., after restoration) stratified random design using beach seines to capture fish.

Parameters:	**Species Monitored**: Fish: recorded all species, focused on juv Chinook
Project Findings: Depth less in Wiley lobe and in 2013, but did not change with month. Velocity lower in Wiley and did not differ with month or year. T greater in Wiley than Teal and increased with month in both lobes and both years. Salinity increased in Wiley and in 2013. DO decreased in Wiley and decreased with month. Wiley shows more tidal influence and Teal more river influence. Depth, velocity, salinity, DO not likely influencing Chinook rearing between sites but T might be. Collected >22,000 fish (7 spp salmonids; mostly juv Chin, chum, and even yr pink). Stickleback, starry flounder, peamouth most abundant non-salmonids. Chin density greaer in Wiley, and did not vary by habitat or between channel/impoundment but did vary by year and week. Density highest Mar-Jun. Significant factors were T (positive) and salinity (negative). Landscape connectivity explained 53-85% of Chin density at longterm sites. Wiley ('12, '13) and Teal ('13) values plotted in the long term site scatter. In both years the juv Chin pop was higher than the estimated carrying capacity based on tidal channel, but lower than the estimate based on wetted area.	
System Effects: [Climate change & flood protection benefits] In addition to better fish passage and habitat, the Wiley Slough Project also provides flood protection, as described by the Farms, Fish and Floods Initiative (3FI), a landscape-scale effort in the Skagit Delta based on an MOU between NOAA, Skagit Conservation District, Skagit County, Skagit County Dike and Drainage Partnership, Skagitonians to Preserve Farmland, TNC, WA Dept of Fish and Wildlife and Western WA Agricultural Association. 3FI focuses on advancing mutually beneficial strategies that support the long-term viability of agriculture and salmon while reducing risks of destructive floods. 3FI complements the WA state Tidegate Fish Initiative (TFI). The Skagit Delta Hydrodynamic Model Project (SHDP) is supported by and contributes to the goals of 3FI. The SDHP Team initiated hydrodynamic modeling and alternatives analysis to identify and prioritize mutually beneficial large scale flood risk reduction and estuarine habitat restoration projects to achieve the Skagit Chinook Recovery Plan 2005 goal. The SHDP listed the Wiley Slough Project in an inventory of projects that provide these multiple benefits. A related 3FI document notes that flood protection benefits will be even more important with climate change related sea level rise and storm surges.	
Lessons Learned: From newspaper articles and some other sources, it appears there was some pre-project controversy regarding conversion of habitat to wetland because the area had been managed for game bird habitat and hunting opportunities, which were reduced post-construction. Also appeared to be some increased flooding of adjacent agricultureal lands post-construction, which was mitigated via pumping.	
Funders: Salmon Recovery Funding Board $2,327,294; NRCS $1,290,000; USFWS $568,872; Puget Sound Nearshore Ecosystem Restoration Project $52,003; andEstuary Salmon Restoration Program $130,806	
Partners: WDFW – Washington Department of Fish and Wildlife; PSNERP – Puget Sound Nearshore Ecosystem Restoration Project; Ducks Unlimited; Skagit Dike and Drainage District #22; UWFWS – US Fish and Wildlife Service; NRCS – Natural Resources Conservation Service; NOAA Fisheries; and SCL – Seattle City Light.	
Project Documentation: http://waconnect.paladinpanoramic.com/Project/280/1592 NOTE: This site- seems to be same info as below- states that 6 tide gates were removed. http://hws.ekosystem.us/project/280/1592 NOTE: WA state Habitat Work Schedule web page with project description, restoration metrics,	

funding information. This site- seems to be same info as above- also states that 6 tide gates were removed.

http://www.rco.wa.gov/documents/press/2006/021-SRFBGrants.pdf?pressRelease=224&newsType=1

NOTE: Pre-project press release stating that "entire $2.8 million project involves removing 6,500 feet of dike, six tide gates and one culvert to restore tide and river flooding over 160 acres of former tidelands." May be original source of info listed on web pages above? (Post-project docs say one TG was removed and a new one installed in a different location farther inland.)

Beamer, E., R. Henderson and B. Brown. 2015. Juvenile Chinook salmon utilization of habitat associated with the Wiley Slough Restoration Project, 2012-2013. Skagit River System Cooperative, LaConner, WA.

http://skagitcoop.org/wp-content/uploads/Wiley-Slough-2012-2013-Final.pdf

NOTE: This report was included in literature review.

Hinton, S, J Blank, A McKain, G Hood, et al. 2005. Wiley Slough Estuarine Design Report. (Draft: Not Intended for Distribution) 154p.

http://skagitcoop.org/wp-content/uploads/Wiley-Design-Report_Final-Draft.pdf

NOTE: Includes details on history of project area land ownership, development and management.

https://www.usgs.gov/media/images/2016-flooding-wiley-slough-dike-and-new-tide-gate

NOTE: Two images: "Marine flooding of Wiley Slough dike and new tide gate structure March 10, 2016." Photograph credit: John Wolden, Skagit Dike District 22.

http://wdfw.wa.gov/lands/wildlife_areas/skagit/Headquarters%20(Skagit)/

NOTE: Washington Dept of Fish and Wildlife web page describing changes in wildlife management for Wiley Slough area.

http://www.goskagit.com/news/wiley-slough-compromise-could-move-project/article_3807ef7b-180b-59ae-a9c8-602ea92f2519.html

NOTE: 2008 story in Skagit Valley Herald detailing various debates about project before it was implemented.

Estuary: Skagit	**Name**: Swinomish Channel/Fornsby Creek/Smokehouse Floodplain Project, Skagit River Estuary
Type: Replacement	**Total Cost**: $658,666

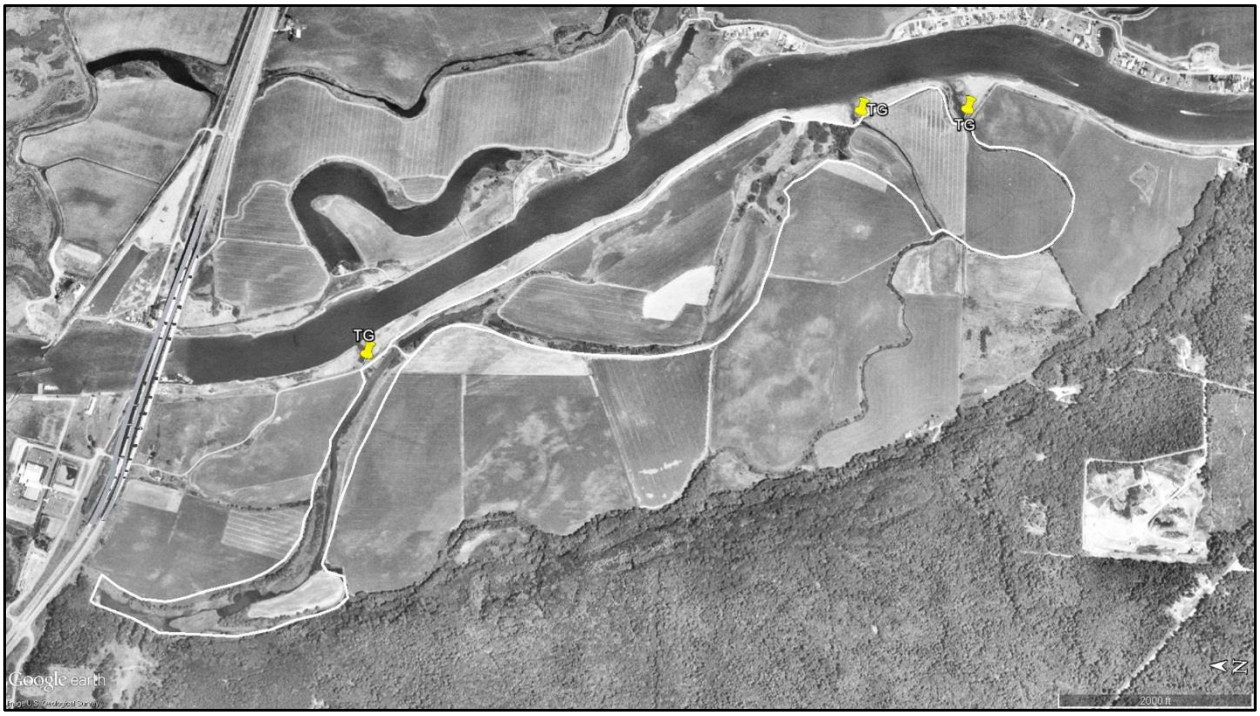
Summary: [Skagit River System Cooperative SRSC] The Smokehouse tidelands- a network of intertidal blind and distributary channels with areas of salt marsh, mud flats, intertidal wetlands, and uplands- are located on Swinomish Indian Tribal Community reservation lands along the Swinomish Channel of the N. Fork Skagit River. Once a complex distributary for the river, the Smokehouse tidelands were significantly degraded by development of the Swinomish Navigation Channel via an Army Corps of Engineers dredging project in 1937, which converted the tidelands to a diked and drained landscape. Fish access was blocked by tide gates and dikes, and much of the intertidal habitat was buried under dredge spoils. For many years the SRSC, the Swinomish Tribe, and other project partners have worked to restore this estuarine habitat. Between 2005-2008, four top hinged “flap style” tide gates—which inhibit fish and water movement—were replaced with self-regulating tide gates (SRTs)—which restore tidal flushing—opening more than 5 miles of intertidal channel habitat to fish. Three new bridges were also installed across the tidal channels to replace non-functioning or partially blocked culverts, further improving fish access. In 2008, 3.5 acres of intertidal salt marsh habitat were restored at the mouths of the tidal channel networks through excavation and removal of dredge spoils, which buried the landscape during the maintenance of the navigation channel. Site revegetation and stewardship has been ongoing since the tidelands were reopened to tidal hydrology. Between 2006 and 2009, 16.7 acres of riparian corridors were actively replanted with native vegetation and 7 acres were passively restored to salt marsh. In 2014 and 2015, 15.9 acres of riparian corridors were planted, with plans to revegetate an additional 28.8 acres in upcoming seasons.

[WA Habitat Work Schedule website] The Fornsby Creek SRT/Smokehouse Floodplain project is located along the Swinomish Channel of the Skagit River delta, west of Mt. Vernon, WA. The site was once an expansive estuarine emergent marsh over 900 acres in size. Hydraulic modifications including installation of flap-style tide gates converted the area to arable uplands. The site still contains a significant network of remnant slough channels, simplified by decades of agriculture, with small freshwater tributary streams but isolated from tidal influence. Phase I (2003-09) restored about 50 acres of former estuarine marsh along the Swinomish Channel, with 6 distinct components: 1a) removal of wood culvert and installation of steel bridge; 1b) installation of second "Aberdeen-Style" tide gate; 2) blind channel development; 3) oxbow slough restoration (former control reach); 4) north old slough channel restoration; 5) fill removal near LaConner. The project will restore natural functions and processes within the project area. Restoration of tidal marsh, blind sloughs and distributary channels will provide important rearing habitat for Skagit basin Chinook salmon, and several other salmonid species. Replacement of a flap gate with a side-hinged SRT at South Fornsby occurred in late summer 2005.

Phase II of the Smokehouse Floodplain Project as outlined in the Chinook Recovery Plan is levee removal. With Phase I opening the floodplain to fish passage this project seeks to set back levees through key areas of the Smokehouse floodplain, allowing expression of larger emergent marsh communities and associated blind channel networks. [NOTE: Phase II does not appear to have been completed as of 7/2017.]

Aerial Images Smokehouse Floodplain reconnection and Fornsby Creek tide gate replacements (8/3/2016). Note image is oriented with North on the left.

Figure _. Smokehouse Floodplain reconnection before restoration activities (7/31/2005).



Restoration Metrics: Annual smolt production of delta-rearing juvenile Chinook; Total Amount of Estuarine / Nearshore Acres Treated; Yards of Channel Modified/Created; Number of Tidegates

Altered/Removed To Allow Fish Passage; Acres of Estuary Created.	
Monitoring Focus:	**Study Design**: [Greene et al.]Fornsby was monitored using a BACI design starting two years before SRT installation and for at least two years post-SRT installation. Monitored both above and below the tide gate using data loggers and a combination of beach seine and fyke trapping methods.
Parameters:	**Species Monitored**:
Project Findings: [Greene et al 2012] At S. Fornsby, replacement of a flap gate with an SRT increased connectivity measures: the percentage of time that gate doors were open increased from 28% to 40%, while the percentage of time fish could move upstream changed from 0% to 14%. Tidal muting declined from 66% to 47%, resulting in a nearly 40% increase in the effective mean higher high water (MHHW). Top hinged flap gate replacement with a side hinged SRT was followed by a 6X increase in cumulative Chinook salmon densities, but these densities were still 8X lower than its hydraulically unimpeded reference site.	
System Effects: [Climate change & flood protection benefits] In addition to better fish passage and habitat, the Smokehouse Floodplain Project also provides flood protection, as described by the Farms, Fish and Floods Initiative (3FI), a landscape-scale effort in the Skagit Delta based on an MOU between NOAA, Skagit Conservation District, Skagit County, Skagit County Dike and Drainage Partnership, Skagitonians to Preserve Farmland, TNC, WA Dept of Fish and Wildlife and Western WA Agricultural Association. 3FI focuses on advancing mutually beneficial strategies that support the long-term viability of agriculture and salmon while reducing risks of destructive floods. 3FI complements the WA state Tidegate Fish Initiative (TFI). The Skagit Delta Hydrodynamic Model Project (SHDP) is supported by and contributes to the goals of 3FI. The SDHP Team initiated hydrodynamic modeling and alternatives analysis to identify and prioritize mutually beneficial large scale flood risk reduction and estuarine habitat restoration projects to achieve the Skagit Chinook Recovery Plan 2005 goal. The SHDP listed the Smokehouse Floodplain Project in an inventory of projects that provide these multiple benefits. A related 3FI document notes that flood protection benefits will be even more important with climate change related sea level rise and storm surges.	
Lessons Learned:	
Funders: WA Recreation & Conservation Office, Salmon Recovery Funding Board (SRFB)- total $658,666. Two grants/funding instruments: Fornsby Creek SRT (02-1563) $291,533/ and Swinomish Channel Restoration (04-1626) $367,133. Seattle City Light Non-Flow Coordinating Committee? Another source (Conservation Registry) has this info: WA Recreation & Conservation Office, SFRB (2003): $291,532.86; and Swinomish Tribe (2003): $329,700.65	
Partners: Skagit River System Cooperative; Swinomish Indian Tribal Community; USDA – Natural Resources Conservation Service; Washington State RCO – Salmon Recovery Funding Board	
Project Documentation: http://skagitcoop.org/programs/restoration/smokehouse/ NOTE: Skagit River System Cooperative (SRSC) project web page, with project description, photos. http://waconnect.paladinpanoramic.com/Project/280/11837 NOTE: Seems to be root for WA Habitat Work Schedule website. Project description, funding, restoration metrics, several photos of project area and construction.	

Fornsby Creek SRT. http://www.conservationregistry.org/projects/2321?printable=true

NOTE: Conservation Registry page c. 2009. Includes project summary; funding sources.

Mitchell, T.A., K.J.R. Mitchell, R. Lovellford and L. Klein. 2005. Fornsby Creek Project: Self-regulating tide gates and estuary restoration. Swinomish Indian Tribal Community, Planning Department, Water Resources Program; P.O. Box 817, LaConner, WA 98257. Proceedings of the 2005 Puget Sound Georgia Basin Research Conference. tmitchell@swinomish.nsn.us; 360.466.7201

http://www.swinomish-nsn.gov/media/5298/p3_mitch.pdf

NOTE: Pre-project site description, and summary of ecological conditions. Includes a good air photo based site map.

Greene, C., Hall, J., Beamer, E., Henderson, R., Brown, B. and LaConner, W.A., 2012. Biological and physical effects of “fish-friendly” tide gates. National Oceanic and Admospheric Administation, National Marine Fisheries Service, Watersheds Program, Northwest Fisheries Science Center, and Skagit River System Cooperative, LaConner, Washington.

http://skagitcoop.org/wp-content/uploads/EB2673_Greene-et-al_2012.pdf

NOTE: Discusses results from pre- and post project monitoring in Fornsby Slough, and compares to a reference slough in a BACI design.

Estuary: Skagit	**Name**: Fir Island Farms Estuary Restoration Project
Type: Removal	**Total Cost**: $16.4 million

Summary: The Skagit Wildlife Area-Fir Island Farms Reserve Unit is managed agricultural land (225 acres on the south side of Fir Island Road) purchased in 1995 to create an upland snow goose reserve. This non-hunted game reserve is managed to provide a winter feeding and resting area for snow geese adjacent to the Skagit Bay estuary. Management of this site occurs through a lease agreement with a local farmer who plants a commercial agricultural crop that is harvested, and an over-wintered cover crop of winter wheat for snow goose forage. The area is part of the tidal delta of the Skagit River flanked by Dry Slough on the east and Brown's Slough on the west.

In the late 1800's, following human settlement, dikes were built and the land was converted to agricultural uses. Following the ESA listing of Chinook salmon as threatened in 1999, and subsequent development of the Skagit Chinook Recovery Plan, this site was identified as a prime location for the implementation of a restoration project to improve salmon habitat.

The Fir Island Farms Estuary Restoration project is located on the WDFW Snow Goose Reserve on Fir Island in the Skagit River Delta. Initial work on the Fir Island Farms project started in 2009; feasibility studies started in 2011; construction began in 2014 and was largely completed when the old dike was breached in fall 2016. Project goals: 1) restore the tidal processes that bring water, sediment, and nutrients to the marsh, supporting and maintaining habitat for fish and wildlife; 2) protect surrounding agricultural lands from flooding and saltwater; 3) provide parking and access for people viewing snow geese, shorebirds, and other waterfowl at the Fir Island Farms Snow Goose Reserve and provide winter forage and a reserve where hunting is prohibited.

The project set back approximately 5,800' of an existing dike and restored 131 acres of tidal marsh and tidal channels, important for juvenile Chinook salmon. Two existing 48" tide gates were removed along with the old dike, and two new 48" tide gates were built into the setback dike. In addition to habitat restoration, this project incorporates protections to reduce flooding, maintain drainage, and prevent saltwater intrusion on surrounding farmland. WDFW worked closely with Consolidated Drainage and Diking District 22 to ensure the final project meets the District's flood protection and agricultural drainage standards.

The new habitat is expected to support an additional 65,000 young Chinook a year.

Aerial Images:

Restoration Metrics:	
Monitoring Focus:	**Study Design**:
Parameters:	**Species Monitored**:
Project Findings:	
System Effects: Climate change and sea level rise predictions were also incorporated into the final project design.	
Lessons Learned: The Western Washington Agricultural Association (WWAA) backed the project as part of the Skagit Delta Tidegates and Fish Initiative (SFI). [WWAA director] said there is general support for the project, but some farmers remain concerned with conversion of farmland to other uses. "We are still losing farmlands," he said. The SFI requires fish projects in the Skagit to have	

minimal impacts to neighboring farms. "Our support for salmon recovery and these projects in general is linked up with how drainage infrastructure such as tide gates are replaced," Roozen said. "When infrastructure is removed, like the dike and tide gate in this project, those have to be replaced." The Fir Island Farms project included putting in new dikes and tideg ates, we well as a pump house, at no cost to the area dike district.

Funders: Puget Sound Acquisition and Restoration Fund provided $13.4 million.

Partners: Washington State Department of Fish & Wildlife; The Nature Conservancy; Salmon Recovery Funding Board; NOAA; Puget Sound Partnership; US Fish & Wildlife Service; Skagit Watershed Council

Project Documentation:
http://wdfw.wa.gov/lands/wildlife_areas/skagit/fir_island/final_design/fig_alt_2a.pdfNOTE: Shows location of 2 new and 2 old tide gates.

http://www.djc.com/news/ae/12096694.html

NOTE: American Council of Engineering Companies writeup of project. Mentions 5 tide gates.

http://www.goskagit.com/news/fir-island-dike-breach-pivotal-moment-for-fish-project/article_00d104a4-4477-5a6f-bb53-fba589ac095e.html

NOTE: This document mentions that tide gate was removed as part of the dike removal, and that new tide gates were part of the setback dike.

Fir Island Farms Estuary Restoration Project
http://wdfw.wa.gov/lands/wildlife_areas/skagit/fir_island_estuary_restoration.php

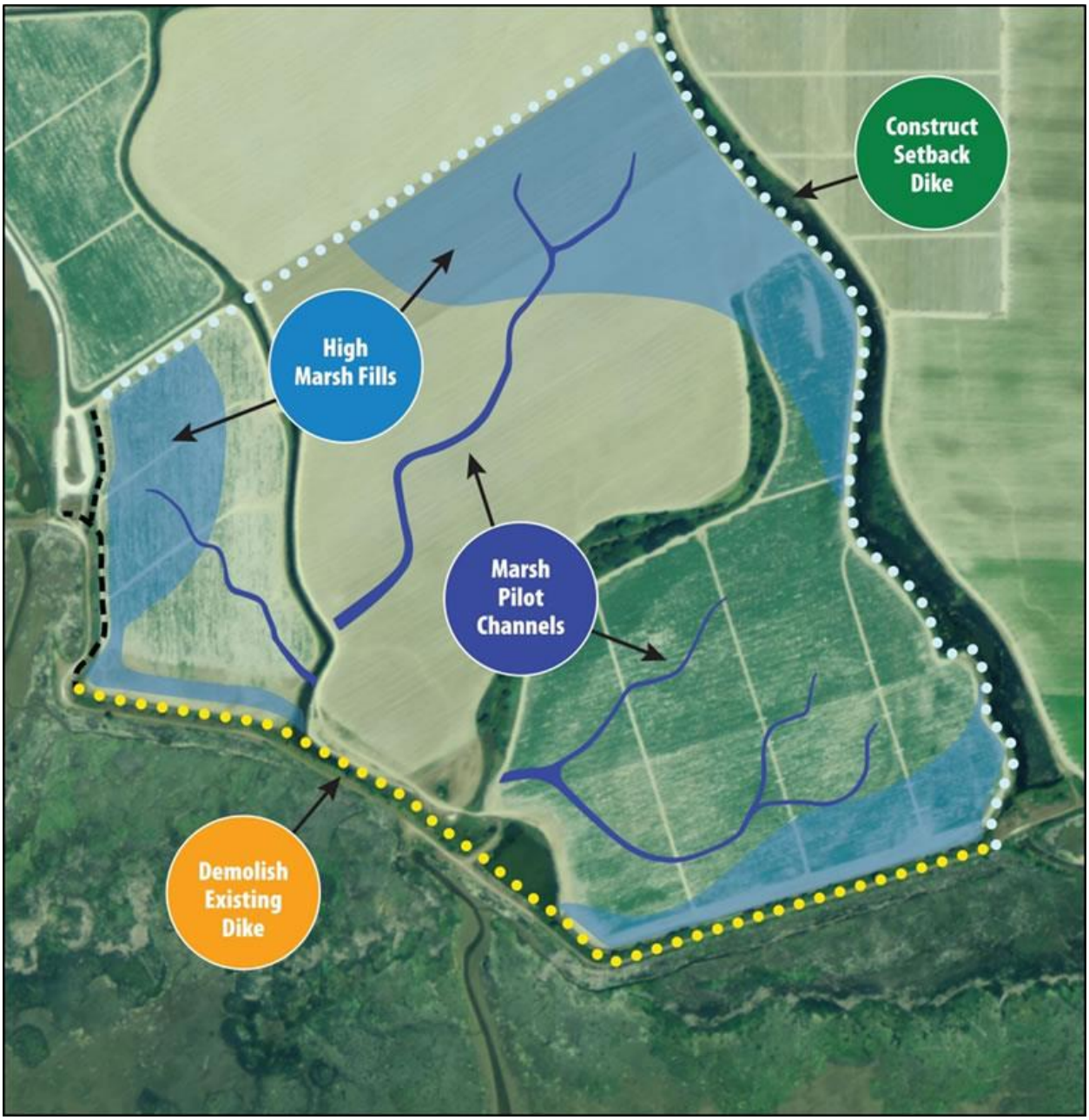
NOTE: WA Dept of Fish & Wildlife project page.

Fir Island Farms Estuary Restoration Project-Year One Construction
http://wdfw.wa.gov/lands/wildlife_areas/skagit/fir_island_construction_year_one.php

NOTE: Includes several photos, including new tide gate structure

http://www.psp.wa.gov/blog/?p=664

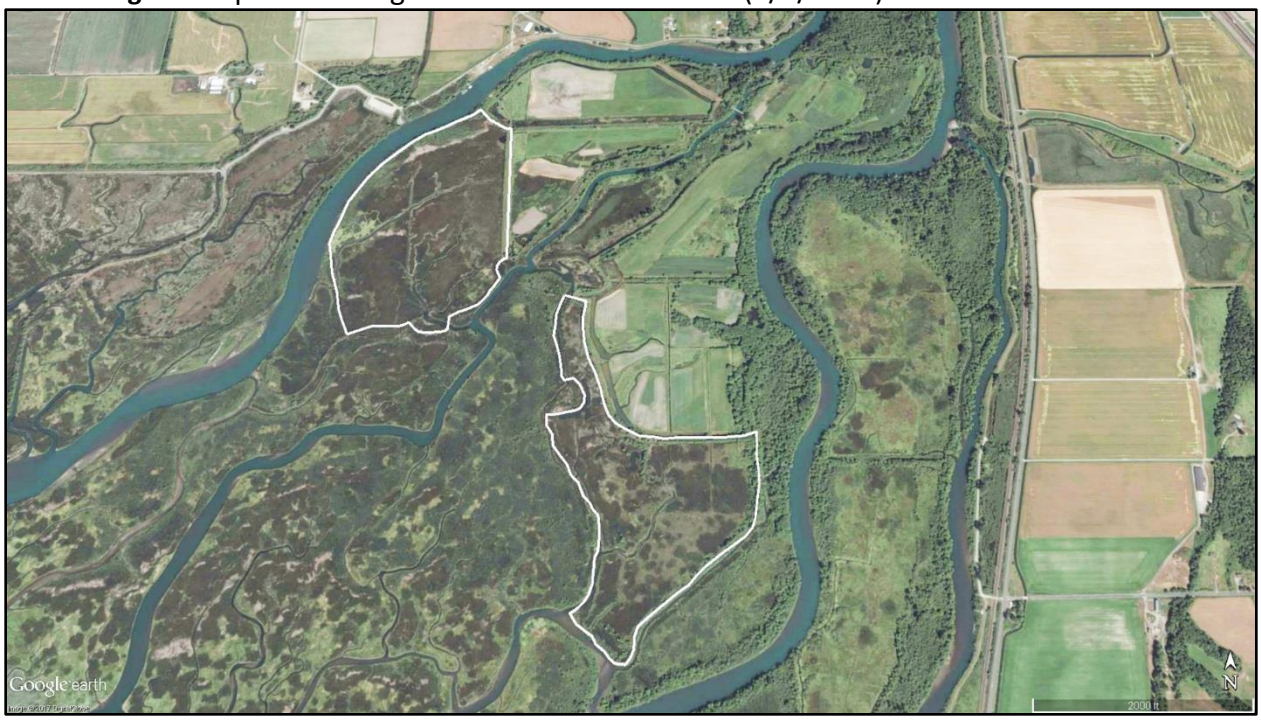
NOTE: Puget Sound Partnership web page for project.


Construct
Setback
Dike
High
Marsh Fills
Marsh
Pilot
Channels
Demolish
Existing
Dike

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Skagit	**Name**: Deepwater Slough Restoration
Type:	**Total Cost**: $2.3 million
Summary: Can't find any reference to tide gates for this project. Dike setback, dike removal, dike breach. "Dikes were removed in 2000 to reestablish valuable estuary habitat." The Deepwater Slough Project is a 204 acre estuary restoration project located on Washington Department of Fish and Wildlife land at the mouth of the South Fork of the Skagit River. The project removed dikes to restore river and tidal influence to the project area creating critical juvenile habitat for threatened Puget Sound chinook salmon. The Skagit System Cooperative is the lead on this project.	

Aerial Images: Deepwater Slough after tidal reconnection (8/3/2016).



Deepwater Slough, before restoration activities (11/5/2003).

Restoration Metrics:	
Monitoring Focus:	**Study Design**:
Parameters:	**Species Monitored**:
Project Findings:	
System Effects:	
Lessons Learned:	
Funders: Army Corps of Engineers (75%)	
Partners:	
Project Documentation: Deepwater Slough Project http://skagitcoop.org/programs/restoration/deepwater-slough/ http://www.pugetsoundnearshore.org/factsheets/DeepwaterSlough.pdf http://hws.ekosystem.us/project/280/11818 http://djcoregon.com/news/2000/10/23/dike-removal-project-finished-on-deepwater-slough/	

Estuary: Skagit	**Name**: McElroy Slough Estuary Restoration Project
Type: Replacement	**Total Cost**: $841,461

Summary: McElroy Slough is an independent drainage on the coast of Puget Sound in NW Skagit County adjacent to Samish Bay and the town of Blanchard. It drains and links three salmon bearing creeks (Colony, Whitehall, and Harrison) with Samish Bay. This 100-acre (historically) estuary was diked, drained and tide-gated since the early 1940s to facilitate agricultural use. The project (2006) replaced the 3 existing McElroy Slough culverts with TGs at Blanchard Road with four 6' x 6' box culverts and TGs. Three of these TGs are traditional gates with top hinges and one TG is side hinged and is self-regulating to allow saltwater into the slough at certain tide levels. The new gates have a combined total area of 144 sf; the old gates had 69 sf. The project also removed two culverts under Flinn Road (1/3 mile upstream) and replaced the crossing with a 45' bridge.

The project has improved tidal processes, fish passage and estuary rearing area for Chinook, coho, chum and cutthroat in the Colony Creek watershed. More than 26 acres along the historic slough channel have been placed under permanent easement via the Federal Wetland Reserve Program. This project re-opened 1 river mile and 4.75 acres of estuary for anadromous fish use, plus improved access to 5 miles of Colony Creek, 1 mile of Harrison Creek, and 1/2 mile of Whitehall Creek, all used by anadromous fish. The project also provided flood relief and drainage benefits to the Blanchard community. Project partners include Skagit County, US Fish and Wildlife Service and Washington Department of Fish and Wildlife. Skagit Fisheries Enhancement Group (SFEG) concluded long-term monitoring of fish use, vegetation and channel conditions at McElroy Slough in 2014. Fish sampling was led by Bruce Brown of the Skagit River System Cooperative (SRSC) under contract to SFEG. SRSC, SFEG staff, and volunteers sampled fish use upstream and downstream of the tide gates at 2-week intervals from February through the end of June. Funding for monitoring was provided by a private settlement.

Aerial Images (5/2/2015):

Restoration Metrics: tidal processes, fish passage and estuary rearing area for Chinook, coho, chum and cutthroat	
Monitoring Focus: All	**Study Design**: [Beamer 2014] Fifty-four beach seine sets were made in McElroy Slough from Feb-June 2014. Sites up- and downstream of the tidegate site were sampled and are consistent with sites sampled in previous years. Sampling frequency was once in February and 2X/month in March-June. The sampling period is designed to capture the entire period when juvenile Chinook salmon use estuarine habitats in Puget Sound. In 2014, per a recommendation after 2011 beach seining, we installed data loggers up and downstream of the tidegate in order to measure variables influenced by tidegate operation: 1) water surface elevation (WSE) when the tidegate doors close, 2) WSE up and downstream of the tidegate, 3) water temperature up and downstream of the tidegate, and 4) water salinity up and downstream of the tidegate. [Thom et al. 2007] Prior to project implementation, a monitoring plan was initiated to collect baseline data related to surface and ground water levels, and salinity. Before

	construction commenced, the Skagit Fisheries Enhancement Group (SFEG) implemented components of the monitoring plan to collect baseline data both inside and outside of the tide gate. Other activities included documenting juvenile fish usage, channel cross sections, establishment of vegetation plots, and an aerial imagery to document baseline conditions.
Parameters: Juvenile chinook; water surface elevation (WSE) when TG doors close; WSE up- and downstream of TG; Water temp and salinity up- and downstream of TG	**Species Monitored**: Focus on Chinook, but also coho, chum, pink, cutthroat
Project Findings: [Beamer 2014] Juvenile Chinook appear to be able to move upstream through the tide gate and occupy tidal habitat upstream. But is unknown whether 2006-2014 results represent an improvement over the old tide gate because there are no "before tide gate replacement" fish monitoring data. Juvenile Chinook density is clearly lower upstream of the tide gate than downstream. Reference site tidal channels show the reverse relationship (i.e., more juvenile Chinook upstream than downstream) so it is reasonable to conclude the tide gate, as currently installed and operated, is a partial impediment to upstream juvenile Chinook movement. Tide gate operations that increase the time doors are open on flooding tide stage would likely improve juvenile Chinook access to habitat upstream of the tidegate. Tide gate door closure results could be used to determine whether the SRT setting could be changed so the doors closed at a higher WSE, thus leaving the doors open longer on flood tides. NOTE: Contrary to Beamer 2014, Thom et al. 2007 state that Skagit Fisheries Enhancement Group collected pre-project fish data. JRB contacted SFEG to ask about this; no response.	
System Effects: [SFEG 2006-2007 Annual Report] Restoring the estuary functions to McElroy Slough will greatly enhance the fish and wildlife use of this watershed as well as reduce flood hazards to the Blanchard Community.	
Lessons Learned: By the end of 2001, the project was fully funded and permitted, and ready for construction bidding. Project partners and Blanchard residents anticipated that project implementation would commence during 2002. A solid monitoring plan had been created by the committee to look at both physical and biological changes and baseline data related to adult fish use, surface water and ground water levels were monitored. However, complications occurred which postponed project implementation. Political and engineering issues related to replacing tide gates on a Skagit County road with a tide gate that allows tidal inundation delayed the project for 4 years. Monitoring continued over this time, while project partners patiently (yet frustratingly) waited for resolution of these complicated issues through additional analysis and design review and modification. In May 2006 Skagit County finally put the project out for bid; in July 2006, the McElroy Slough Project construction bid was awarded. [Skagit County Board of Commissioners Record of Proceedings Dec. 6, 2004] "Lynn Lennox, 3634 Legg Road, Bow, spoke of the need to move forward with the McElroy Slough Project. She explained that she personally worked very hard on this project and that much of the recent flooding in Blanchard could have been avoided if the project had been built. David Allen, 15547 Flinn Road, Blanchard, expressed concerns regarding property that he owns that is surrounded by private dikes. When he purchased the property, Mr. Allen said he was unaware that these dikes were to be maintained by the	

owner. However, he has obligingly done so for the past 6 years in order to keep his road passable. Approximately three years ago, adjacent property was sold to a new owner who has the mindset that if he doesn't maintain the dikes, then the government will. Mr. Allen's argument is about the right to protect his property from floodwaters without being threatened. Commissioner Dahlstedt explained to Ms. Lennox that he and others recently met with local diking district folks and the Dept of Fish and Wildlife regarding the McElroy Slough Project. He is hopeful that a proposal will be brought forth very soon that is agreeable to all parties. Chairman Anderson asked Skagit County Public Works Administrator, Dave Brookings, to have staff survey the right-of-way on Flinn Road in order to provide Mr. Allen with a straight answer as to who is responsible for dike maintenance."

Funders: Salmon Recovery Funding Board $549,461; PRISM $292,000

(SFEG docs say budget was "over $2 million including in-kind contributions")

Partners: Skagit Fisheries Enhancement Group (SFEG); Skagit County

Project Documentation: http://www.hws.ekosystem.us/project/280/11805

http://www.skagitfisheries.org/Documents/Map/McElroy_Summary.pdf

NOTE: Site description and project summary.

Skagit Fisheries Enhancement Group's Annual Report for 2006-2007

http://www.skagitfisheries.org/Documents/Annual%20Report%202006-07.pdf

NOTE: Summary of project. Mentions budget of "$2 million"

Beamer, E. McElroy Slough beach seine summary results for unmarked juvenile Chinook salmon: 2014.

http://skagitcoop.org/wp-content/uploads/EB2818_Beamer_2014.pdf

NOTE: Post-project monitoring data, with discussion of results.

Greene, C., Hall, J., Beamer, E., Henderson, R., Brown, B. and LaConner, W.A., 2012. Biological and physical effects of "fish-friendly" tide gates. National Oceanic and Admospheric Administation, National Marine Fisheries Service, Watersheds Program, Northwest Fisheries Science Center, and Skagit River System Cooperative, LaConner, Washington.

http://skagitcoop.org/wp-content/uploads/EB2673_Greene-et-al_2012.pdf

NOTE: McElroy Slough post-project monitoring results are discussed in this paper.

Thom R.M., N.K. Sather, M.G. Anderson and A.B. Borde. 2007. Monitoring and Adaptive Management Guidelines for Nearshore Restoration Proposals and Projects. Marine Sciences Laboratory, Sequim, WA. Prepared for the Puget Sound Nearshore Ecosystem Restoration Program (PSNERP) and the Estuarine Salmon Restoration Program (ESRP) under a Related Services Agreement between Washington Dept of Fish and Wildlife and the U.S. Department of Energy Contract DE-AC05-76RL01830 Pacific Northwest National Laboratory, Richland, Washington, 99352. PNWD-3861.

NOTE: Summary of monitoring at McElroy Slough says pre-project fish data was gathered by Skagit Fisheries Enhancement Group, which conflicts with Beamer 2014.

Studley, A. 2007. McElroy Slough Tide Gates Replaced. The Redd, The newsletter of the Skagit Fisheries Enhancement Group. http://www.skagitfisheries.org/Newsletter/F06McElroySlough.htm

NOTE: Link is dead.

Estuary: Puget Sound	**Name**: Shoal Bay Tide Gate Removal Project, Lopez Island, WA
Type: Removal	**Total Cost**: $116,000 (Islands Weekly article says $125,000)

Summary: Shoal Bay lagoon, NE Lopez Island, WA. Restoration objectives: remove derelict tide gate that constricted tidal flow to restore adequate tidal flushing of the lagoon to enhance salmonid utilization of the shallow water habitat for both forage and refuge from predation, ameliorate water quality and help to maintain acceptably low water temperatures in the lagoon.

Work (Oct. 14-16, 2009) was authorized under San Juan County, WDFW, and the US Army Corps of Engineers. concrete TG removed to restore tidal water flow and velocity, fish passage, and improve water quality. TG originally installed around 1982-83 and apparently only used for a few months to enhance conditions for an aquaculture project in the lagoon. TG comprised of a flood box, a mostly open, 13'-wide box structure and 4 additional deflecting "wing walls", all concrete. The doors were gone and the gate had not been properly functioning for years prior to removal. Four 12" corrugated plastic culverts beneath the gate drained the lagoon when water levels were slightly lower than the gate. These culverts were largely clogged or broken. Prior to removal, the tide channel measured ~12' wide (2 separate 6' openings). A scour hole was located on the landward side of the structure (maximum depth of +3.9 ft MLLW, or 1' lower than the base of the gate). Both ebb and flood tidal deltas were present on either side of the gate, indicative of impeded flushing.

Tide channel geometry was altered by widening the tide channel as well as slightly increasing its minimum depth. This more open geometry will enhance flushing of tidal waters in and out of the lagoon, which is reflected in lower water levels during low tides. The altered channel geometry will also decrease flow velocities through the tidal channel, which will likely result in more natural rates of sedimentation in the lagoon. Prior to excavation, all large areas of saltmarsh vegetation were selected for transplanting to the finished inlet banks. Clumps of mixed patches of pickleweed (Salicornia virginica) and salt grass (Distichlis spicata) were removed by the excavator with roots intact, temporarily stored on-site, and placed into the ground by machine and hand following grading.

[Project] removed a derelict tide gate, reconnecting nearly 5 acres of high-quality coastal lagoon habitat to San Juan County nearshore. A large cement and metal tide gate is in the tide channel of the Shoal Bay lagoon. This derelict structure is constricting flow, impeding fish passage at low tides, creating water quality problems within the lagoon and eroding the upper beach and estuarine wetland habitat. Removal of the gate will provide improved areas for salmon and their food sources to feed and rest. The diverse nearshore marine environment of Shoal Bay off Lopez Island includes surf smelt, spawning habitat for Pacific herring, eelgrass prairies, shellfish beds, a sand spit and a coastal lagoon. Juvenile Chinook, coho and chum salmon use Shoal Bay and juvenile salmon have been observed in the lagoon. Friends of the San Juans is partnering with the Coastal Geologic Services, Wyllie-Echeverria Fisheries, landowners and community volunteers.

Aerial Image (5/2/2015):

Restoration Metrics: Reducing inflow and outflow velocity; habitat utilization by juvenile salmonids, water temperature	
Monitoring Focus: Water temperature	**Study Design**:
Parameters: Water temp assessed post-removal	**Species Monitored**:
Project Findings: From Island Weekly article (2010) "Where fish used to get trapped in channel scour holes on either side of the structure at mid level tides, fish are now travelling in and out of the lagoon at minus tides..water temp sensors recorded a drop in summer temps within the lagoon of nearly 5 degrees (F). No fish kills were observed in summer 2010 as they had been in previous years." [FRIENDS Science Director Tina Whitman]."This past year we have seen an astounding increase in both the number and species diversity of fish in the lagoon. This spring entire schools of juvenile pink salmon regularly prowled the lagoon on incoming tides. In six years of shell fish operations we have never seen this before. During the summer we saw large numbers of Ling cod, Tom cod and other species we have never observed in the lagoon.," [Property owner Nick Jones.]	
System Effects: Island Weekly article: "An unanticipated outcome of the project included improved shellfish growing conditions." [Site is near a shellfish farm.]	
Lessons Learned: Islands Weekly article: "Benefits associated with this project include…new information to inform researchers, policy-makers and other land owners, and a framework for ongoing cooperative models in our community. We were delighted to be engaged in a truly collaborative process that improved the health of the bay for fish, wildlife and shellfish growers." [Stephanie Buffum Field, Executive Director at FRIENDS.]	
Funders: $59,000 from Salmon Recovery Funding Board, Also National Fish and Wildlife Foundation	

Community Salmon Fund and WA State Department of Ecology.
Partners: Friends of the San Juans, Coastal Geologic Services, Wyllie-Echeverria Fisheries
Project Documentation: http://hws.ekosystem.us/project/190/11119 NOTE: Links to 2 PDF project reports from this page: Shoal Bay Tidegate Restoration Report (Pre-project) http://waconnect.paladinpanoramic.com/services/project/file?sid=190&pid=11119&id=8776 Shoal Bay Tidegate As Built http://waconnect.paladinpanoramic.com/services/project/file?sid=190&pid=11119&id=8775 http://www.islandsweekly.com/news/one-year-later-shoal-bay-project-a-success/ NOTE: Includes anecdotal post-project results. http://www.islandssounder.com/news/san-juans-1-8-million-for-salmon-recovery-where-does-it-go/ NOTE: Project description, funding sources and amount.

Estuary: Puget Sound	**Name**: Port Stanley Lagoon Tide Gate Retrofit, Lopez Island, WA
Type: Replacement	**Total Cost**:

Summary: In 2006 San Juan Islands Conservation District (SJICD) completed a 3-year effort to install of a new, hydraulically-operated tide gate at the Port Stanley Lagoon outlet, restoring daily tidal flow into the lagoon for the first time in over 40 years. The SJICD and project partner San Juan County Dept of Public Works (DPW) have seen improvement in lagoon water quality, improved wildlife habitat and reduced flooding during severe winter storms.

After the original tide gate was installed in the early 1960s the lagoon gradually filled with sediment until only a shallow stagnant puddle remained each summer. At the request of the lagoon owners SJICD received a USFWS grant in 2003 to evaluate ways to restore some tidal exchange while improving the winter drainage and flooding situation. After a hydraulic modeling study and field-testing, SJICD presented options to the lagoon owners and neighbors. They favored allowing partial tidal exchange into the lagoon, but only up to a level that would not impact lawns, drain fields and other property. SJICD next received a WA Dept of Fish and Wildlife grant to design and implement the plan.

The project began with dredging the outlet channel and modifying the beach out-fall pipe. The DPW Lopez Island Road Crew installed the new tide gate that opens and closes at pre-set tidal elevations in June 2006. The upland portion of the beach was disturbed and compacted by heavy machinery. Beach vegetation was restored in April 2007 by planting 500 dune wild rye and 200 beach pea on the 2500 sf site. Plant choice was based on species currently present along undisturbed beach areas and suggestions by Coastal Geologic Services beach restoration specialist Jim Johannessen. Funding for this phase was provided by Ducks Unlimited, SJICD and DPW. The tide gate is managed by DPW Lopez Island Road Crew and can be viewed inside a grated vault along Port Stanley Road.

Aerial Image

Restoration Metrics:	
Monitoring Focus:	**Study Design**:
Parameters:	**Species Monitored**:
Project Findings:	
System Effects:	
Lessons Learned:	
Funders: USFWS, WA Dept of Fish and Wildlife, Ducks Unlimited, San Juan Islands Conservation District, San Juan County Department of Public Works	
Partners: San Juan Islands Conservation District, San Juan County Dept of Public Works	

Project Documentation:
https://depts.washington.edu/uwconf/psgb/proceedings/papers/p6_Slocum.pdf

NOTE: Project was identified from this source. Looks like a poster for a conference poster session.

https://www.sanjuanislandscd.org/video-project/

NOTE: San Juan Islands Conservation District press release; has good project description.

CONTACT: San Juan Islands Conservation District | PO BOX 1728| Friday Harbor, WA 98250 | 360-378-6621

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Skagit	**Name**: Maxwelton Creek Tidegate Retrofit
Type: Replacement (3 flap gates)	**Total Cost**: $24,000
Summary: Whidbey Island Drainage District No.2 operated a set of three dilapidated flap gates across the mouth of Maxwelton Creek, one of Whidbey Island's two salmon producing watersheds. Local farm owners oppose extensive estuary habitat restoration efforts, but agreed to replace the old gates to improve drainage and fish passage. Replaced the old gates with an array of 3 well-balanced, side-hinged gates, set at different invert elevations to optimize the opening period under low flow conditions. Nehalem Marine Manufacturing, Inc. fabricated and installed the gates for about $24,000. Project funded by a NFWF grant. Installation completed Sept. 2007. Coho redds observed in the creek upstream of the project site in 2007 and 2008. Satisfactory drainage for farms is maintained. NOTE: This project was found at link cited, using search terms ""Aberdeen-Style" tide gate" NOTE: Evidence at this link suggests coho were spawning in the creek prior to TG replacement: http://whidbeywatersheds.org/about/history/	

Aerial Image (7/10/2014):

Restoration Metrics: salmonid reproduction	
Monitoring Focus: Biological	**Study Design**:2012/2013 Spawning Survey: On Dec 12 and 18, Whidbey Watershed Stewards (WWS) conducted salmonid spawning/pre-spawn mortality surveys on previously selected index reaches of mainstem Maxwelton Cr. Annual survey since 2006

	conducted by WWS staff and Wild Fish Conservancy-trained volunteers. Objectives: characterize current state of salmonid spawning and in-stream conditions in Maxwelton Watershed. 2012/13 survey covered parcels established in previous seasons that previously had spawning activity. Survey is limited to lower reaches but sites have been consistent each year. Quade trib was not surveyed in 2012/2013 since habitat and culvert conditions deteriorated there over past 2 years. Sediment now covers all gravels in the lower Quade reach; culvert is now a complete barrier to fish; 50% filled with sand. Returning salmon have been reported as early as end of Oct in the past, and the 2012/2013 survey was particularly short, occurring only in Dec. No spawning adults were found during previous 2 seasons, and funding limited effort during 2012/2013. Fish carcasses are often reported to WWS by local residents, and this did not occur at any locations for previous 2 years. 2013 Spring Smolt Count: WWS conducted smolt counts on main stem Maxwelton Cr at the French Rd. culvert from 2005-2013. Trap constructed in 2004, kept in good repair, generally installed May 1; removed June 1. The French Rd culvert system has two 24" culvert pipes. The trap flume is attached to the eastern-most pipe. The western pipe is closed off with plywood, diverting all flow through the eastern pipe and trap. It is often necessary to allow water to bypass the trap by removing the plywood from the western pipe due to high flows or to remove the flume from the culvert entirely to avoid damaging the trap. Thus, the effort has never been able to capture 100% of outmigrating smolt, but represents a relative measure of the population with conditions being somewhat variable each year.
Parameters: Spawning, outmigrating smolt counts (coho, cutthroat)	**Species Monitored**: coho, cutthroat
Project Findings: No population augmentation has been conducted in the Maxwelton system since 2003, when school groups last released fry from WDFW egg rearing program. Salmonid population levels are extremely low given the healthy habitat present throughout 19 miles of stream and wetland in the watershed. Given that fish utilization investigations are intended to gauge fish passage at the TG, it is clear that functioning of the TG has not increased fish passage and further monitoring of the gate is needed. Recommendations by WFC in 2007 have not been implemented, and should be considered before the population disappears entirely.	

Fish appear very limited in ability to access the watershed. Historic reproductive population was 10's of thousands of fish for this system; population is far below sustainable levels today. The only way to assess TG functioning would be to monitor the gate itself, and assess if salmon are able to get through the outlet pipe and TG vaults. Also, outflow pipe and door function improvements may be possible without detrimental effect on flooding. At present, the only proxy available to judge TG passability is to find adult salmon in the creek, and to make assumptions about the natal population. In 2010 spawning activity was found in the Quade Cr trib, and further investigation there was recommended. A blocking culvert on Wildes Rd. was identified, and listed on the Island County replacement list. In 2011 condition of spawning habitat in Quade Cr deteriorated significantly; spawning gravels were covered by 6-8" of sand. The culvert was nearly entirely blocked by sand until county crews cleared it in fall of 2012. This culvert is undersized; a bottomless culvert should be a priority for this site. Also, the sediment problems in the system should be identified and remedied if possible. Other culverts identified as partial blockages or velocity blockages have changed since 2003 monitoring. These culverts should be re-evaluated and further fish passage projects in the valley identified. This evaluation should be compared with the county structural condition report and priorities established. In particular, the mainstem Maxwelton culverts under French Rd and Erikson Rd have both deteriorated, and should be evaluated.

System Effects:

Lessons Learned:

Funders: National Fish and Wildlife Foundation

Partners: Nehalem Marine Manufacturing, Inc.

Project Documentation:
https://depts.washington.edu/uwconf/psgb/proceedings/papers/p6_Slocum.pdf

NOTE: Project was identified from this link, which appears to be a poster from a conference.

Fish Use within the Maxwelton Creek Watershed, Island County, Washington – A baseline for monitoring fish passage improvements at the Maxwelton tidegates. July 27, 2007. Wild Fish Conservancy Baseline Fish Use Report – Maxwelton Creek, Island County. 22p.

http://wildfishconservancy.org/resources/library/research-monitoring/past-projects/Fish%20Use%20within%20the%20Maxwelton%20Creek%20watershed_final.pdf

Greenbank Marsh Wetland Reconnaissance. Greenbank, WA. Island County Tax Parcel #S7050-00-00A03-0 and S7050-00-00A04-0. Submitted to Rob Hallbauer, Whidbey Island Conservation District June 22, 2016. Submitted by: Element Solutions, 1812 Cornwall Avenue Bellingham, WA 98225. 360.671.9172. info@elementsolutions.org

http://www.whidbeycd.org/uploads/1/1/6/8/11683986/greenbank_marsh_wetland_recon_report_6-22-2016.pdf

NOTE: Assessment of restoration potential for this property, including tide gate replacement or removal. Includes photos of Maxwelton tide gate and states that it has been "working well since 2006"; Appendix F, p. 13/p.115 .

Estuary: Skagit	**Name**: Schneider Creek (Ditch) Floodgate Retrofit, Nooksak River
Type: Replacement, two gates. One side-hinged, one MTR.	**Total Cost**: $40,000 (or $45,000)

Summary: Whatcom County Drainage & Irrigation District No. 2 operates a pair of 5' flood gates across the mouth of Schneider Cr, a small, lowland tributary of the Nooksack River to prevent flooding of local farm fields. The existing flap gates blocked coho from access to upstream spawning habitat. Project replaced one flap gate with a side-hinged gate and the other with a muted tidal regulated (MTR) gate. The side-hinged gate opens easily under low head. The MTR stays open until the upstream w.s.e. reaches the "ordinary high water level", then closes to prevent backflow from the Nooksack. Nehalem Marine Manufacturing fabricated and installed the gates for about $40,000. Project funded by a NFWF grant. Installation completed January 2009. Effectiveness monitoring has begun. Permitting requirements favored retrofit of existing structure, but full-replacement of the structure would have been simpler and cheaper.

Objective: Improve fish access to 20,000 feet of flood plain tributary channel, associated wetlands, and ponds. The targeted species and life stage are juvenile chinook expected to use the transition flood plain habitats between the Nooksack River and Schneider Ditch; adult and juvenile coho, steelhead, and cutthroat expected to use the entire Schneider ditch drainage.

Aerial Image (5/30/2016):

Restoration Metrics:	
Monitoring Focus:	**Study Design**:

Parameters:	**Species Monitored**:
Project Findings:	
System Effects:	
Lessons Learned:	
Funders: National Fish and Wildlife Foundation	
Partners: Nehalem Marine Manufacturing, Inc.	
Project Documentation: https://depts.washington.edu/uwconf/psgb/proceedings/papers/p6_Slocum.pdf NOTE: Project was identified from this source. Looks like a poster for a conference poster session. http://www.whatcomcd.org/engineering NOTE: Whatcom Conservation District web page, includes a good photo of one of the new tide gates at this site Nooksack Water Resource Inventory Area 2007-2009 work plan. http://www.sharedsalmonstrategy.org/watersheds/3-year/Nooksack3yrWorkPlan_current.pdf NOTE: See page 18 for short description of the site and restorations goals. http://www.whidbeycd.org/uploads/1/1/6/8/11683986/wicd_engineering_soq_and_website_8-14.pdf NOTE: Short description, project cost and photo of the TG (p.3)	

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Qwuloolt Estuary, Snohomish River	**Name**: Qwuloolt Ecosystem Restoration Project
Type: TG removal (Levee breach, 3 TGs filled in)	**Total Cost**: $3.73 million (Not including pre- and post-project monitoring)

Summary: The Snohomish River drains 1,856 mi2 of the western Cascades and is the second largest river draining to Puget Sound. The river supports significant runs of coho, Chinook, chum, and pink salmon; and steelhead, cutthroat and bull trout. The Qwuloolt Estuary lies in the Snohomish River floodplain about 3 miles upstream from the Snohomish outlet to Puget Sound. Historically, the area was tidal emergent marsh and forest scrub-shrub wetland, interlaced by tidal channels and streams. In the early 1900s a levee was constructed on Ebey Slough and tide gates were installed at the mouth of Allen and Jones Creeks to convert the land to agriculture, preventing tidal access and destroying the estuary's marsh habitats. As a result, salmon and other estuarine-dependent species were unable to use the highly-productive environment. Prior to restoration the area was fallow agricultural land covered by invasive reed canary grass, thistle, and blackberries.

The Qwuloolt project area is about 360 acres of former estuarine wetland. Restoration of the site is intended, in part, to help compensate the public for injuries to natural resources as a result of the Tulalip Landfill, a Superfund site. Restoration planning began in 1997. Since 2006, project partners worked to refine the preferred alternative to enhance ecological and biological objectives and to reduce overall project impacts and costs. Final designs were completed in 2012 through collaboration between the US Army Corps of Engineers, the Tulalip Tribes, and ESA-Adolfson.

The US Army Corps of Engineers and Tulalip Tribes signed an agreement in 2012. The Corps awarded a $3.73 million, two-phase construction contract to Sealaska, of Auburn, WA. Phase I involved stream channel and upland re-contouring, wave attenuation berm construction, and native vegetation restoration. Over 1.5 miles of lower Allen and Jones Creeks were restored to natural alignment. Interior site work included filling of relict agricultural drainage ditches and excavating channels to facilitate natural tidal function. A new outlet channel connecting Jones Creek with the inboard side of the Ebey Slough levee was completed in August 2013. Construction of wave attenuation berms spanned 2012-2015. Most (7.5 acres) native vegetation planting along the eastern and northern edges of project area was completed in 2012. Three stormwater filtration ponds were constructed west of the setback levee to improve the quality of stormwater runoff from the nearby industrial park.

In October 2015, three tide gates were decommissioned and sealed at the SW end of Jones Creek, assisting in the final step of restoring natural hydrology to the site.

The most important phase involved the hydrologic reconnection (return of tidal inundation) of the Qwuloolt site. Construction of a 4,000' setback levee on the western edge of the project area, to protect Brashler Industrial Park, the Marysville Wastewater Treatment Plant and residents surrounding the area, was completed in 2015. Once the western setback levee was completed, 1,400' of the Ebey Slough levee was lowered and then a 270-foot breach was excavated in it to allow tidal inundation. Estuarine water circulation has provided for natural hydrologic processes that sustain salmon and wildlife, as well as facilitate the transport and deposition of sediment and seeds for successional native plant restoration.

Monitoring targeted primarily at Chinook salmon was conducted before and after the dike breach, 2013-2016. Following the breach, scientists will monitor changes including elevation, sediment dynamics, water temperature and salinity, nutrient and food availability, fish population and diversity,

and wildlife abundance and diversity. There appears to be system-wide monitoring of fish and water quality for the Snohomish Estuary, with a particular focus on understanding the effects of restoration at Qwuloolt. Pre-project monitoring was initiated in 2010, and continued through at least 2016 (one year post-project). As of Sept 2017, there does not appear to be much available in the way of post-project synthesis of results.

Aerial Images: Before restoration (6-23-2006)

After restoration (8-4-2016)

<table>
<tr><td colspan="2">Restoration Metrics: Chinook salmon access and numbers, water quality, topographic elevation, establishment of native plant communities</td></tr>
<tr><td>Monitoring Focus: Juvenile Chinook</td><td>Study Design: [2016 monitoring]: Juvenile validation monitoring in the estuary is categorized into two different sampling bins, Estuary System-wide, and Qwuloolt Monitoring. 185 beach seine samples were taken across the estuary as part of the Estuary System-wide effort and 430 beach seine samples and 27 fyke net samples were taken at both in the Qwuloolt Restoration site and at reference sites that are part of the Qwuloolt Restoration project effectiveness monitoring effort. All monitoring data has been entered into a database and is undergoing QA/QC by NOAA Northwest Fisheries Science Center staff. The amount of monitoring was scaled back from 2015 due to reduction in funding to project partners.</td></tr>
<tr><td>Parameters:</td><td>Species Monitored: Juvenile Chinook</td></tr>
<tr><td colspan="2">Project Findings: The project has returned natural hydrologic processes to the ecosystem and resulted in a re-inhabiting of the site by native salmon, wildlife, and plant communities.</td></tr>
<tr><td colspan="2">System Effects:</td></tr>
<tr><td colspan="2">Lessons Learned:</td></tr>
<tr><td colspan="2">Funders: US Army Corps of Engineers (construction); Pacific Coast Salmon Restoration Fund (monitoring)</td></tr>
<tr><td colspan="2">Partners: Tulalip Tribes, NOAA, U.S. Fish and Wildlife Service, Washington Department of Ecology, US Army Corps of Engineers, Natural Resource Conservation Service, City of Marysville. Other partners: Snohomish Basin Salmon Recovery Forum, Washington State Department of Fish and Wildlife, Puget Sound Partnership, Sound Transit. ESA-Adolfson (contractor)</td></tr>
<tr><td colspan="2">Project Documentation:
Rice, C., J. Chamberlin, J. Hall, T. Zackey, J. Schilling, J. Kubo, M. Rustay, F. Leonetti and G. Guntensperge. 2014. Monitoring ecosystem response to restoration and climate change in the Snohomish River Estuary: Field operations and data summary. Report to Tulalip Tribes December 31, 2014. http://blogs.nwifc.org/psp/files/2015/04/2014EPA_Snohomish_Estuary_Monitoring_Report.pdf
NOTE: Pre-breach monitoring; fish, water quality, birds. Not much interpretation or discussion.
http://www.qwuloolt.org/RestorationPlan/Overview
NOTE: Project homepage, with extensive description of project
http://www.qwuloolt.org/Content/Documents/Qwuloolt-Project-Poster.pdf
NOTE: Project map
https://apps.nmfs.noaa.gov/preview/applicationpreview.cfm?RecType=Project&RecordID=17927&ProjectID=17927&view=01000000001000100000
NOTE: Describes monitoring protocols in detail.
https://www.webapps.nwfsc.noaa.gov/apex/f?p=309:19:::::P19_PROJECTID:40247108</td></tr>
</table>

NOTE: 2016 monitoring summary.
https://www.youtube.com/watch?v=vbzSF3V7KXE
NOTE: Short youtube video explaining project and showing dike breach. Mentions tide gates.
http://www.heraldnet.com/news/qwuloolt-estuary-projects-goal-return-of-the-wild-salmon/
NOTE: Newspaper article with history behind project; quotes from agency staff familiar with project
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/wa/home/?cid=nrcseprd400627
NRCS web page. Discusses funding; partnership details, project history. Mentions TG decommissioning.

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Humbolt Bay	**Name**: Rocky Gulch Habitat Restoration Project
Type: Replacement	**Total Cost**:

Summary: Overarching goal for Rocky Gulch (6 mi N of Eureka, CA, trib to Humboldt Bay) is to restore anadromous fish access and naturally reproducing anadromous salmonid populations (coho and steelhead) from Humboldt Bay to approximately the Rock Quarry 0.9 miles upstream of Old Arcata Road. Freshwater stream, borders tidal zone, tidal inundation in first 1700'. Existing TG at 600' leaked so seawater passes but all anadromous fish passage was blocked.

Objectives: 1) provide unimpeded fish passage through the tidegate; 2) increase tidal marshes and slough channels in lower Rocky Gulch to provide juv salmonid rearing habitat and possibly tidewater goby habitat; 3) widen the creek channel and re-create a floodplain, rehabilitate dikes to better contain winter floods and protect pasture; 4) restore riparian and conifer vegetation on the newly created floodplain along Rocky Gulch; 5) freplace the barrier culvert to restore fish access to upstream habitat (Phase II of restoration).

Project Description: Replace old TG with fish friendly TG to re-establish muted tidal prism coupled with channel habitat restoration (addition of instream wood, riparian planting, cattle exclusion) in the stream-estuary ecotone upstream of tide gate. Side-hinged aluminum TG with adjustable 'guillotine' aux door mounted on existing wingwalls (reinforced w/aluminum sheets) in Dec 2004 to replace a top-hinged wooden TG. Excavated aggraded fines, reconstructed/rerouted 2,800' of channel, relocated some dikes and rehabbed others, installed riparian fencing, planted native species. Monitoring: Post project monitoring of juvenile salmonids in Rocky Gulch and limited WQ data.

Aerial Image (5/26/2016):

Restoration Metrics: Spawning by coho, steelhead, and anadromous cutthroat	
Monitoring Focus: N/A	**Study Design**:
Parameters:	**Species Monitored**:
Project Findings: New populations of coho salmon moved into Rocky Gulch and Gannon Slough after impassable tidegates were replaced by fish friendly tidegates. [Project benefits, according to Mierau/McBain & Trush] 1) fish passage at tide gate at all times during tide cycle, either through main tide gate during ebb tide or through the 1'x2' auxiliary door within the main door that is permanently open (currently open 1x1 ft); 2) improved adult passage by eliminating potential for dikes to breach and flood the pasture in winter, and creating a defined channel with adequate widths and depths for upstream migration; 3) significant protection of the pasture by: (1) reducing or eliminating flooding onto it, (2) reducing or eliminating salt water intrusion onto it, (3) providing watering access for cattle at erosion-resistant hardened streambeds, (4) improving access to the pasture along Old Arcata Road via new bridge crossing; 3) a defined floodway within reconstructed dikes that will contain floods of approximately Q5 to Q10 year recurrence and a muted tidal prism; 4) greatly improved rearing habitat in the freshwater/tidal "ecotone" for high quality summer and winter rearing, and down into the brackish estuarine slough channels; 5) maintenance of pre-existing salt marsh sustained by the muted tidal prism from the tidegate; 6) long-term protection of utility infrastructure; 7) increased riparian vegetation along Old Arcata Road, existing mature conifer cover that was preserved, and improved plant species diversity; 8) better drainage of tributaries along Old Arcata Road (Halvorsen Gulch, Stevens Gulch, others) to flow directly into Rocky Gulch, improving overall drainage of rainfall runoff.	
System Effects:	
Lessons Learned: Side hinged door caused scour on opposing bank, requiring additional rock armoring. The tidegate fails to swing fully open, deflecting flow towards the opposite bank. This led to substantial bank erosion, which was later mitigated by placing riprap along the bank. The fabricator [Nehalem Marine?] reasoned that placing the auxiliary door in the gate reduced the forces on the gate, resulting in it not fully opening. By working successfully with the private landowners to implement the project, clearly demonstrated the mutual benefits to both the landowners and the fishery resources. This success may encourage future cooperation with other landowners for restoration projects around Humboldt Bay. Additionally, despite a 1-year delay to the original implementation schedule, we were able to design, permit, and implement this project in a little over 2 years from completion of the CDFG Agreement .	
Funders:	
Partners: Contributed Funds or Services: California State Water Resources Control Board; County of Humboldt; City of Ferndale; State Coastal Conservancy; California Department of Fish and Game; U.S. Army Corps of Engineers; NOAA/National Marine Fisheries Service; USDA Natural Resources Conservation Service. Project Contributors: McBain & Trush; Nehalem Marine; Jeff Anderson & Associates	
Project Documentation: Mierau, D. 2005. Rocky Gulch Salmonid Access and Habitat Restoration Project: Phase I Restoration Final Report. Prepared for California Dept. of Fish and Game and US Fish & Wildlife Service. 25p. http://coastalwatersheds.ca.gov/portals/0/humboldtbay/monitor/docs/Hydro_McBTrush_rocky_4.pdf NOTE: Includes a good air photo-based diagram of major project elements, including location of tide	

gate work.

Mierau, D. 2002. Rocky Gulch Stream Assessment Project. California Dept. of Fish and Game Project Number 0010372. Prepared for California Dept. of Fish and Game.

McBain & Trush, Inc. 2005. Rocky Gulch Tidegate Completion: Final Report. Rocky Gulch Salmonid Access and Habitat Restoration Project (Contract No. AWIP-N-1). 9p.

NOTE: Detailed description of tide gate replacement, with a site map and several pictures.

Case Study: Rocky Gulch Tide Gate Retrofit. USFS National Stream & Aquatic Ecology Center. https://www.fs.fed.us/biology/nsaec/fishxing/case/RockyGulch/index.html

NOTE: Includes technical information on hydrologic characteristics, etc.

Szlosek, E. 2007. Rocky Gulch Habitat Restoration Project: Restoring Coastal Stream on Private Land (US Fish & Wildlife Service Field Note): https://www.fws.gov/fieldnotes/regmap.cfm?arskey=22831

Contacts:

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Mike Wallace, CDFW (mike.wallace@wildlife.ca.gov)

Scott Flaherty, USFWS Scott_Flaherty@fws.gov

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Humbolt Bay	**Name**: California Department of Fish and Wildlife Natural Stocks Assessment Project (Humboldt Bay Tributary Monitoring)
Type: Replacement	**Total Cost**:

Summary: This monitoring effort focused mainly on juvenile salmonid use of estuary habitats in several small tributaries to Humboldt Bay, including restored habitats, primarily newly-constructed off-channel ponds. Some restoration projects included tide gate work, but the focus of this monitoring was not on tide gates.

[2007-2009] CDFG's Natural Stocks Assessment Project (NSA) continued sampling tidal portions of Freshwater Creek Slough, Elk River Slough, and Salmon Creek estuary to document use by juvenile salmonids. In 2007 began sampling smaller Humboldt Bay tribs- Jacoby Creek/Gannon Slough, Martin Slough, Rocky Gulch, and Wood Creek to determine if juvenile salmonids use these very small tidal streams as year round or over winter rearing habitat during high stream flow events.

[2009-2011] NSA continued sampling tidal portions of upper Freshwater Creek Slough, Wood Creek, and Salmon Creek estuary. Completed sampling in lower Freshwater Creek Slough, Elk River Slough, Hookton Slough, Jacoby Creek/Gannon Slough, Martin Slough, Rocky Gulch. Initiated sampling in Ryan Creek Slough to determine how juvenile salmonids use the Freshwater-Ryan stream-estuary ecotone as a rearing area. Installed PIT tag antennas in Wood Creek to assess performance of a newly constructed off-channel pond as over winter habitat for juvenile coho. By describing life history traits and habitat needs of juvenile coho, Chinook, steelhead, and sea-run coastal cutthroat this project provides data to help restoration planning- "snapshots" of juvenile salmonid use of these areas before and after restoration projects.

Aerial Image (Rocky Gulch, 5/26/2016):

Restoration Metrics: Presence and spawning by coho, Chinook, steelhead, and anadromous cutthroat	
Monitoring Focus: Biological	**Study Design**: Sampled fish using seine nets and minnow traps baited with frozen salmon roe
Parameters: Fish	**Species Monitored**: coho, Chinook, steelhead, cutthroat (all species caught were recorded)
Project Findings: New populations of coho salmon moved into Rocky Gulch and Gannon Slough after impassable tidegates were replaced by fish friendly tidegates. Juvenile salmonids sought out freshwater rather than brackish water habitat while rearing in the ecotone. Juvenile salmonids, especially coho, utilized newly constructed off channel ponds as soon as they were completed and fall/winter rains increased stream flows and converted the ponds to primarily fresh water habitat. The stream-estuary ecotone provides productive rearing habitat for juvenile salmonids, especially over winter habitat for juvenile coho.	
System Effects:	
Lessons Learned:	
Funders:	
Partners: Contributed Funds or Services: California State Water Resources Control Board; County of Humboldt; City of Ferndale; State Coastal Conservancy; California Department of Fish and Game; U.S. Army Corps of Engineers; NOAA/National Marine Fisheries Service; USDA Natural Resources Conservation Service.	
Project Documentation: Wallace, M. and S. Allen. 2009. Juvenile salmonid use of tidal portions of selected tributaries to Humboldt Bay, California 2007-2009. State of California Dept of Fish and Game, Pacific States Marine Fisheries Commission. Final Report for Contract P0610522. Wallace, M. and S. Allen. 2012. Juvenile salmonid use of tidal portions of selected tributaries to Humboldt Bay, California 2009-2011. State of California Dept of Fish and Wildlife, Pacific States Marine Fisheries Commission. Final Report for Grant P0810517. Wallace, M., S. Ricker, J. 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, 4,: 241-266. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwjW96_79OPVAhUJxmMKHRVGBToQFggmMAA&url=https%3A%2F%2Fnrm.dfg.ca.gov%2FFileHandler.ashx%3FDocumentID%3D113245&usg=AFQjCNEWp7oD1D7GvTVymocz46Tu1qA61Q NOTE: Data from Rocky Gulch and several other sites used for this paper.	

Estuary: Humbolt Bay	**Name**: Salmon Creek Restoration Project
Type: One tide gate replaced, one new tide gate installed.	**Total Cost**:

Summary: Salmon Creek is Humboldt Bay's third largest tributary, draining about 5060 hectares and entering the ocean at the extreme southern end of Humboldt Bay via Hookton Slough. Historically, the Salmon Creek delta was a tidal salt marsh with a mosaic of slough channels and the drainage supported significant runs of coho, steelhead, coastal cutthroat, chinook and pacific lamprey. In the early 1900's the area was converted for grazing by construction of dikes and levees, marsh draining, straightening or relocation of stream channels, and installation of tide gates. Humboldt Bay NWR acquired the lands in 1988 and identified Salmon Creek as needing work to reestablish estuarine and off-channel habitat- sloughs, ponds and oxbows adjacent to the main channel needed by salmonids to transition to saltwater. Compared to pre-1900 conditions, almost all such rearing habitat in lower Salmon Creek had been lost.

In the early 1990's, a small "fish door" was added to a tide gate flap, slightly improving fish passage and allowing minor tidal exchange upstream of the tide gate. In 1993, the refuge dug a new channel, re-establishing channel sinuosity and complexity. This improved habitat, but further restoration was needed to increase tidal circulation, and improve hydrology, fish access, and habitat for estuarine dependent species. In 2006-2007, an existing tide gate structure was replaced and two new gates at the mouths of Salmon Creek and adjacent Cattail Creek where they enter Hookton Slough, increasing tidal connectivity and tidal influence (Phase 1). The new tidegates have two side-hinged doors which provide better fish passage by reducing flow velocities and staying open longer through tide cycles. The middle door on the new tidegates is top-hinged but has a 2' x 4' slide door which can be kept open for constant movement of bay water into the upstream reaches of Salmon Creek, creating muted tidal conditions which improve ecosystem function.

Phase 2 (2010-2011) focused on construction of 4,000' of new tidal slough channel with more capacity and sinuosity, mostly aligned with historic slough channels, but also maintaining connection to the former ditched channel so it could serve as backwater habitat. Four off-channel ponds totaling 2 acres were constructed and a connecting channel between Salmon Creek and Cattail Creek was excavated to provide winter freshwater rearing habitat for salmonids and improve fish movement between the two systems. Over 100 logs and rootwads, and 20 complex wood structures were added to provide cover for fish and add stream hydrology complexity. Also, twelve species of native trees and shrubs were planted adjacent to the channel and ponds. The Phase 2 design process included extensive modeling of both tidal and streamflow conditions using unsteady state hydraulic models, tidal channel geometry relationships, sediment transport analysis, and evaluation of soil properties and salinity data to predict rates of channel adjustment in response to the increased tidal prism.

M. Wallace: "Here are the two subsequent reports describing our work on Salmon Creek, where an old tide gate was replaced by a newer fish friendly one (2009), and on Wood Creek where the old top hinged tide gate flap was removed. In both instances other habitat restoration measures- e.g. constructing off-channel ponds and enlarging/relocating the stream channel occurred so changes can't be attributed solely to the change in tide gates."

Salmon Creek Project Description: (2006-07) Replace old tide gate with fish friendly tide gate to re-establish muted tidal prism coupled with channel habitat restoration (enlarging stream/tidal channel, creating off channel ponds, riparian planting) in the stream-estuary ecotone upstream of tide gate.

Aerial Image: Salmon Creek restoration projects and locations (5/26/2016).

Restoration Metrics:	
Monitoring Focus: Biological (salmonids) Limited water quality data	**Study Design**: Pre-replacement monitoring, post-replacement 2009>. Beach seine or minnow trap to collect fish. Fish ID'd to spp, life stage, counted; salmonids examined for tags/marks, measured mm), weighed (0.1g), scale removed. Salmonids PIT tagged if size allowed. Monitoring: Pre and post project monitoring for salmonids in Salmon Creek and limited water quality (WQ) data. Likely other physical and biological monitoring upstream of new tide gate by project proponents. 2011-2012: Pre-restoration sampling was conducted in the old stream channel. Post-project (after fall 2011) this became a dead end tidal channel so most sampling shifted to the new off-channel ponds. In Dec. 2011 a paired PIT tag antenna array was installed at the opening of the second-most upstream pond in Salmon Creek. Water quality (temp, salinity, conductivity, DO) sampled in the newly constructed ponds and adjacent slough habitat. 2013-2015: Bi-weekly sampling for juvenile salmonids in Salmon Creek, monthly sampling in Cattail Creek. A 9.1 m X 1.2 m seine net was used at two sites in Cattail

	Creek; a 30.5 m X 1.5 m seine net was used at the off channel ponds on Salmon Creek. In heavily vegetated areas where effective seining was not possible, minnow traps baited with frozen salmon roe were used at four sites in Cattail Creek and two sites in each of the constructed off-channel ponds in Salmon Creek. PIT tag detections from previously installed antenna array were stored on a data logger, downloaded every 1-2 weeks. Water quality (temp, salinity, DO) was sampled bi-weekly at the off-channel ponds in Salmon Creek. Due to stratification between fresh and brackish water, samples were collected at surface, mid, and bottom elevations when water depths > 0.91 m, surface and bottom when water depth was 0.46 m to 0.91 m, and bottom when depths were < 0.46 m (same as 2011-2012).
Parameters: Salmonids Water quality: temp, salinity, DO	**Species Monitored**: salmonids
Project Findings: Generally, stream-estuary ecotone (SEE) habitat restoration (off-channel pond construction; tide gate replacement/modification) in Salmon Creek appears successful at providing overwinter habitat for juvenile salmonids. Juvenile coho moved into the off-channel ponds in Salmon Creek immediately after they were built. More juvenile coho were captured in the ponds the first year post-construction than the previous 7 pre-project years combined. Most years the off-channel ponds were occupied by juvenile salmonids from December-May, but due to high water temperature and salinities and often low DO they were unsuitable for salmonids from June-November. Fish growth could be quite high in the ponds, especially in spring. In the Salmon Creek ponds we recaptured one yearling-plus coho tagged in the ponds during each of the three years of our study with growth rates of 0.79-0.87 mm/day.	
System Effects: Summary Project Results (2003-2012). NOTE: Compiled results from several Humboldt Bay drainages, including but not limited to Salmon Creek. Juvenile salmonids, especially coho, utilize cool, freshwater tidal portion of stream-estuary ecotone (SEE). Sub yearling coho rear in the stream-ecotone up to eight months. Some may emigrate to salt water as sub yearlings while others rear in the SEE over the winter and emigrate to salt water in early spring. Yearling coho move into the SEE during fall and winter and rear there until the following spring (up to five months). By summer end, sub yearling coho rearing in the SEE are typically 15-20 mm FL longer than coho rearing in stream habitat. Coho rearing in the SEE are larger at every life stage compared to their cohorts rearing in stream habitat. The largest juvenile coho were found in tidal freshwater pond habitat. Growth rates in ponds are higher than in sloughs.	
Lessons Learned:	
Funders:	
Partners: Project engineers: Michael Love & Associates (MLA); Partners: US Fish & Wildlife Service, Pacific Coast Fish, Wildlife, and Wetlands Restoration Association, California Department of Fish and	

Wildlife.
Project Documentation: Wallace, M. and S. Allen. 2015. Juvenile salmonid use and restoration assessment of the tidal portions of selected tributaries to Humboldt Bay, California, 2011-2012. California Dept. of Fish and Wildlife and Pacific States Marine Fisheries Commission, Fisheries Administrative Report No. 2015-02. Prepared as part of the Federal Aid in Sport Fish Restoration Act Program (California Project F-137-R) and Fisheries Restoration Grant Program Project P1010516. 50pp. Wallace, M. and S. Allen. 2013. Juvenile salmonid use of the tidal portions of selected tributaries to Humboldt Bay, California, 2011-2012. California Dept. of Fish and Wildlife and Pacific States Marine Fisheries Commission Northern Region, Fisheries Restoration Grant Final Report No. P1010516. 45pp. Allen, S., E. Ojerholm and M. Wallace. 2016. Juvenile salmonid use and restoration assessment of the tidal portions of selected tributaries to Humboldt Bay, California 2013-2015. https://www.fws.gov/FieldNotes/regmap.cfm?arskey=31208 NOTE: USFWS Field Note with project history and details. https://www.fws.gov/refuge/Humboldt_Bay/wildlife_and_habitat/SalmonCreekRestoration.html NOTE: This USFWS webpage has maps and pictures in addition to a project description. Salmon Creek Estuary Expansion (Michael Love & Associates) http://h2odesigns.com/salmon-creek-estuary-expansion/ NOTE: This web page includes about 20 photos of the project being constructed. Michael Love & Associates. 2013. Post-Implementation Monitoring for Phase 2 of the Salmon Creek Habitat Enhancement Project. California Department of Fish and Wildlife Grant Agreement No. P1010524. NOTE: Geomorphologic-topographic monitoring of constructed ponds. Contacts: Eric Nelson, USFWS, Manager Humboldt Bay Wildlife Refuge (Eric_T_Nelson@fws.gov) Mike Love, Mike Love and Associates (mlove@h2odesigns.com) Mitch Farro, Pacific Coast Fish, Wildlife, and Wetlands Association (mitch@pcfwwra.org) Conor Shea, USFWS (Conor_Shea@fws.gov) Bob Pagliuco, NOAA (bob.pagliuco@noaa.gov) Mike Wallace, CDFW (mike.wallace@wildlife.ca.gov)

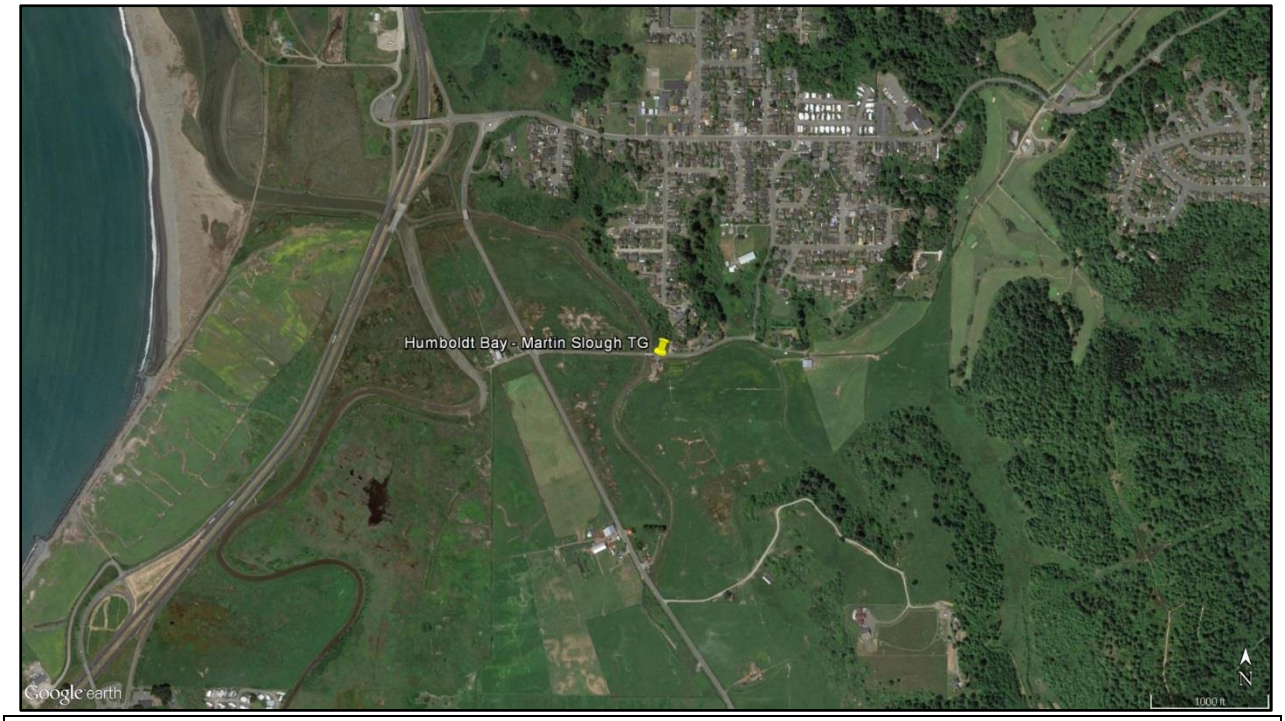
Estuary: Humbolt Bay	**Name**: Martin Slough Restoration Project
Type: Replacement	**Total Cost**:

Summary: Martin Slough, a tributary of Elk River Slough, is an important fish-bearing tributary of Humboldt Bay near Eureka, CA. In 2011, a 43-acre parcel of riparian bottomlands along the slough was purchased by North Coast Regional Land Trust (NRLT) with goals of restoring riparian and wetlands habitats, improving fish access, reducing upstream flooding, maintaining traditional agricultural production and protecting the land from further development. The Redwood Community Action Agency (RCAA) plan to address these goals includes installation of a state-of-the-art replacement tide gate, excavation of the historic Martin Slough stream channel, reinforcement of a failing levee along Swain Slough, construction of a 4-acre tidal pond complex, improvement of agricultural infrastructure and productivity on 35 acres of pastureland, installation of riparian fencing and planting of native riparian and wetland plants in restored areas. The tide gate was replaced in 2014, but due to budgeting, permitting and infrastructure issues (e.g. lowering of a gas line that crosses the property in 3 places) no further work had been completed as of January 2017. In June 2017, funds were authorized for the habitat restoration work.

From 2007-2010 California Dept of Fish and Wildlife (CDFW) conducted monthly fish and water quality sampling in the tidal portion of Martin Slough, primarily on Eureka Municipal Golf Course property, to gather pre-restoration data on water quality (WQ) and salmonid use of the slough. After replacement of the old, failing tide gate in 2014, CDFW reinitiated monthly fish and WQ sampling to document effects of replacing the gate on juvenile salmonid use of the slough.

Monitoring: Pre and post project monitoring for salmonids in Martin Slough and limited water quality (WQ) data. Likely other physical and biological monitoring upstream of new tide gate by project proponents.

Aerial Image (5/26/2016).



Restoration Metrics: Number of juvenile salmonids, with a focus on coho.

Monitoring Focus: Biological (salmonids); Water quality: temp, salinity, DO	**Study Design** Sampled before & after TG replacement. 2013-2015: Monthly sampling at two sites in Martin slough using a 9.1 m X 1.2 m seine net, and a 30.5 m X 1.5 m seine to sample in the off-channel pond. In heavily vegetated areas where effective seining was not possible, minnow traps baited with frozen salmon roe were used at three sites in Martin Slough. Field crews anaesthetized, counted, and examined all juvenile salmonids for marks or tags, and documented the life stage of each. Coho were designated “sub-yearling” or “yearling-plus” based on size differences. Yearling-plus coho, steelhead and cutthroat were also designated by development stage: parr (heavy parr marks present), presmolt (faded parr marks; silvery color), smolt (no parr marks visible; black fin edges), or adult. Fork lengths (FL) were measured to the nearest millimeter, weights to nearest 0.1 gram, and scales were collected from the left side of all juvenile salmonids >50 mm. All healthy juvenile salmonids were PIT tagged to gather residency, movement, and growth data while they were in the SEE. Fish already containing tags or marks were measured for FL, weighed, scale sampled on their

	right side, and their mark or tag number recorded.
Parameters: Salmonids	**Species Monitored**: coho, steelhead, cutthroat

Project Findings: During 2007-2010 (pre-restoration) large numbers of juvenile coho reared in Martin Slough, especially in winter-spring. In East Tributary they reared almost exclusively in the winter-spring. Juvenile coho were also captured in Martin Slough and East Tributary during 2011-2014 sampling for invasive Sacramento pikeminnow, along with cutthroat trout, tidewater goby, and a few juvenile steelhead and Chinook. After tide gate replacement, few juvenile salmonids were captured June-Dec 2015 followed by increased catches Jan-May 2016, and few were captured June-Nov 2016 followed by higher numbers in Dec. These patterns are similar to pre-restoration. Higher catches would have been likely in Nov 2016 if not for poor WQ conditions in Martin Slough and the 17th hole pond, probably at least partially caused by the new tide gate being left in a summer low flow setting, allowing little tidal exchange between Martin and Swain sloughs. WQ in Martin Slough improved shortly after the tide gate was adjusted to allow greater tidal exchange, illustrating the need actively monitor WQ and tide gate operation, and respond quickly with appropriate tide gate adjustments to maintain WQ conditions favorable for salmonids.

Growth rates of recaptured PIT tagged juvenile salmonids were quite high in 2015 (0.29-0.61 mm/day) and in 2016 (0.49-0.77 mm/day). Also, based on the increase of monthly mean FL of coho, it appears rearing conditions in Martin Slough were good for salmonids in the winter and spring of 2016, and late Nov 2016-Jan 2017. WQ conditions throughout Martin Slough were much improved Dec 2015-May 2016 over conditions found July to November 2015, and are generally much better for juvenile salmonids from late fall-spring than summer-early fall, similar to pre-restoration. Tide gate replacment has not appreciably improved conditions in Martin Slough over pre-restoration conditions, but has probably prevented them from declining- the new tide gate has preserved pre-restoration conditions that would have radically changed when the old tide gate failed completely. The new tide gate can be operated to precisely control the amount of tidal influence into Martin Slough, allowing managers to provide more stable freshwater habitat for juvenile salmonids.

System Effects:

Lessons Learned: "Lesson from 2016-2017 sampling: Abundant October rain increased freshwater flow and juvenile salmonid rearing conditions began to improve throughout Martin Slough. But in November, WQ became poor in mainstem Martin Slough, 17th hole pond, and North Fork while conditions were good to adequate in the East Tributary and Fairway Drive sites. With abundant Oct-Nov rain, better DO conditions were expected in the mainstem and pond. Salinity was <2 ppt at all golf course locations, indicating that the low DO was not the result of remnant trapped brackish water. CDFW noted large numbers of juvenile coho moving into the stream-estuary ecotone (SEE) of nearby Wood and Jacoby creeks, but during Nov 10 sampling of Martin Slough only 14 juvenile coho were captured, all in the East Tributary and Fairway Drive sites and none in the mainstem or 17th hole pond. These results did not fit WQ or fish capture patterns from past years, so on Nov 17 CDFW initiated a meeting with project partners and determined the new Martin Slough tide gate was likely still set for low flow (summer) operation to keep saltwater from reaching the Eureka Municipal Golf Course irrigation pond and may have been limiting water circulation in mainstem Martin Slough and 17th hole pond. The group decided to adjust the tide gate to allow greater tidal exchange between Martin and Swain sloughs. On Nov 18 CDFW collected WQ data and found modest improvement from Nov 10, likely due to continued rain and increased freshwater runoff. On Nov 21 RCAA adjusted the tide gate to increase tidal circulation and on Nov 22 CDFW found further WQ improvement. By the next regularly scheduled WQ surveys on Dec 6 (2016) and January 17 (2017), WQ conditions in Martin Slough were again similar to past years. Also, during CDFW fish sampling on Dec 6 field crews captured ~120 juvenile coho, about 50% of these in the

17th hole pond. It is likely that improved WQ in Martin Slough after tide gate adjustments resulted in large numbers of juvenile coho again using Martin Slough as non-natal rearing habitat. This lesson illustrates the need actively monitor WQ and tide gate operation, and respond quickly with appropriate tide gate adjustments to maintain WQ conditions favorable for salmonids."

From Jan-2017 Eureka Times-Standard article: “Much of our work since 1993 has been grant funded but as the decades click on there’s more competition for these grants so we’ve had to tweak our proposals to meet the needs of the projects and missions of donor agencies.”

Funders: Design work (Michael Love & Associates) funded by: California Department of Fish and Wildlife Fisheries Restoration Grant Program, Agreement #P1110309; California Department of Water Resources Urban Streams Restoration Program, Agreement #4600009869

Partners: Project Partners include the North Coast Regional Land Trust, State Coastal Conservancy, the Natural Resource Conservation Service, the City of Eureka, the Redwood Community Action Agency, and the Eureka Municipal Golf Course.

Project Documentation: http://www.naturalresourcesservices.org/projects/martin-slough-enhancement-project-65-designs

NOTE: Redwood Community Action Agency web page has PDFs of project design plans developed by Michael Love & Associates:

Martin Slough Enhancement Project, Eureka, CA: Basis of Design Report (198pp)

NOTE: This report contains a detailed site and project description, and several photos and site maps. See p. 7-10 for a detailed description of the new tide gate and it's operation.

Martin Slough Enhancement Project July 2015: Structural Details (35pp)

NOTE: Detailed maps and blueprints of each project component

http://ncrlt.org/restoration

NOTE: North Coast Regional Land Trust web page; includes a project description and site map

Allen, S., E. Ojerholm and M. Wallace. 2016. Juvenile salmonid use and restoration assessment of the tidal portions of selected tributaries to Humboldt Bay, California 2013-2015.

NOTE: This report contains a description and air photo of the site.

http://scc.ca.gov/webmaster/ftp/pdf/sccbb/2017/1706/20170615Board05_Martin_Slough_Enhancement.pdf

NOTE: Describes authorization of extensive habitat restoration project to complement the tide gate work. $1,730,000.

Martin Slough Field Note July 2015 to May 2016

Martin Slough Field Note June 2016 to Jan 2017

http://www.times-standard.com/article/NJ/20170111/NEWS/170119940

NOTE: Jan 2017 article, iincludes history of project, photo of new TG, next phase of funding and restoration and some lessons learned.

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Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Humbolt Bay	**Name**: McDaniel Slough (Janes Creek) Tidal Restoration
Type: Removal (four TGs)	**Total Cost**: "Million dollar plus"

Summary: The McDaniel Slough project removes 4 tide gates, deepens historic slough channels and removes failing or obsolete levees to restore 222 acres of former tidelands and 24.5 acres of freshwater wetlands. The project area was diked and drained in the early 1900's and most of the salt and brackish marsh habitats were converted to other uses. Project objectives: 1) restore a large area of tidal marsh habitat dominated by native vegetation; 2) provide unimpeded access for anadromous fish migration between Humboldt Bay, McDaniel Slough and Janes Creek; 3) create a tidal channel system maximizing estuarine fisheries habitat in large, high-order, sub-tidal channels; 4) provide connectivity of habitats using "eco-levees" with 10-to-1 slopes on bayward side to create gradation between salt marsh/mudflat habitats and uplands; 5) provide connectivity with existing habitats which also include palustrine freshwater, riparian, and brackish wetlands at Arcata Marsh and Wildlife Sanctuary and CDFW's Mad River Slough Wildlife Area; 6) alleviate rural and urban flooding due to tide gate restrictions and chronic channel aggradation; and 7) provide opportunities for public access, recreation and education.

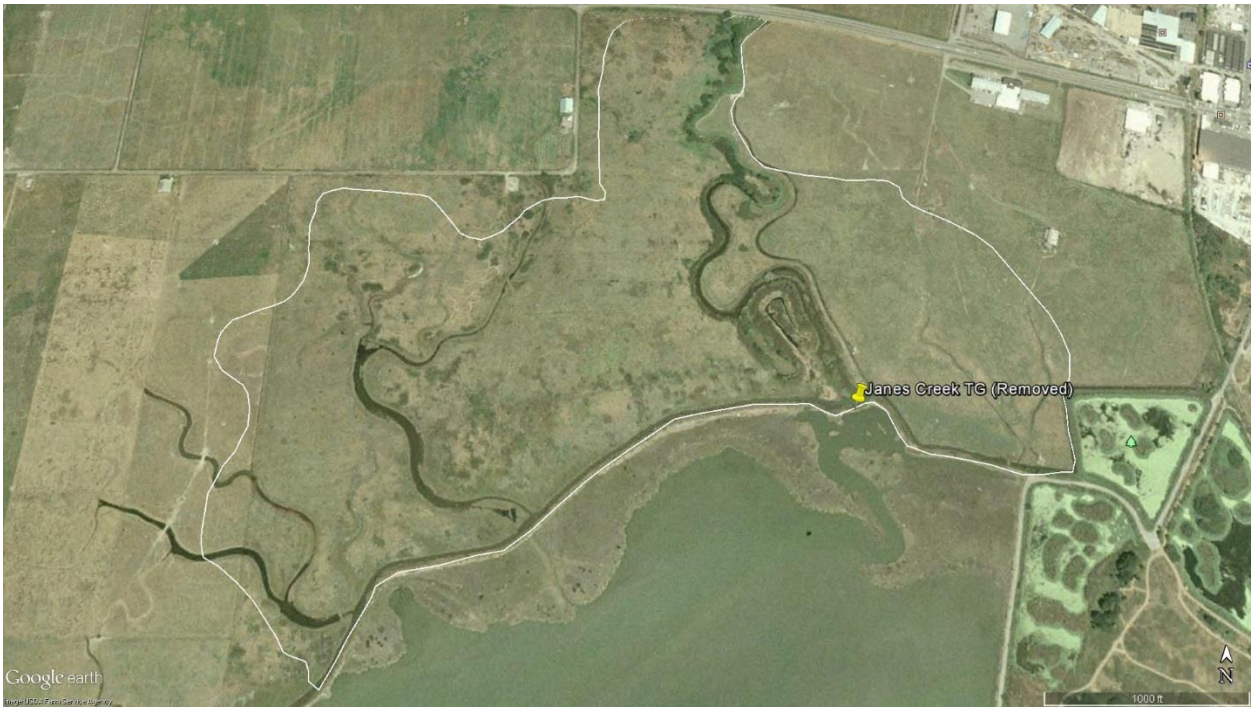
The 2013 McDaniel Slough project created a self-sustaining estuarine tidal marsh system through restoration of natural geomorphic and biologic processes. The project removed tide gates on McDaniel slough to provide access for anadromous fish between Humboldt Bay and Janes Creek. Design features included salt marsh, mudflat, tidal channels, brackish and freshwater habitats and uplands. Excavation to create or enhance brackish and freshwater habitats provided the fill for the levees that were constructed to protect adjacent non-project lands.

Project Description: Complete tide gate removal and levee setback to re-establish estuarine marsh habitat and allow fish passage into Janes Creek.

Monitoring: Pre and post project monitoring for salmonids in Janes Creek. Likely other physical and biological monitoring in newly established marsh by project proponents.

Aerial Images: Janes Creek tide gate removal – after project (5/26/2016)

Janes Creek before project (6/30/2004):



Restoration Metrics: Restore lost hydrologic function and estuarine habitat to 197 acres of Humboldt Bay's former tidelands, improve habitat for 57 acres of adjacent brackish and freshwater wetlands, restore fish passage to coho stream, improve instream habitat, improve water quality	
Monitoring Focus: Biological (salmonids)	**Study Design**: As part of the post-project

	monitoring efforts, biologists continue [as of spring 2015] to sample for fish species monthly, and monitor vegetation annually for five years. Pre and post project monitoring for salmonids in Janes Creek. Likely other physical and biological monitoring in newly established marsh by project proponents.
Parameters: Salmonids	**Species Monitored**:
Project Findings: A performance standard for project success included utilization by one or more of the following species: steelhead, coho salmon, coastal cutthroat trout, and/or tidewater goby. Based on 2010-2016 monitoring, the project has met this performance standard. Monitoring resulted in frequent detections of coho, coastal cutthroat trout and tidewater goby.	
System Effects: "Tidal inundation pushing water upstream during winter storms and high tide events has also helped to kill the invasive reed canary grass, which chokes the stream channel, causes poor water quality, impedes water flow causing flooding, and overall negatively impacts conditions for fish. Golightly said the City of Arcata and the Coastal Program have been at the forefront of battling the invasive plant for years and many who worked on the McDaniel's Slough Restoration project are hopeful that some of the salt water intrusion will benefit the eradication effort. Hydraulic modeling was used to show that the project, in addition to restoring tidal exchange to over 200 hundred acres of former tide lands and anadromy to the system, would also help improve flood flows on the creek." [https://www.fws.gov/FieldNotes/regmap.cfm?arskey=35901] Mad River Union newspaper article quote: "'McDaniel slough fits into the sea level rise adaptation picture,' Andre said. 'The future salt marsh there will be a huge benefit in terms of buffering.' [Arcata Env. Serv. Director Mark] Andre explained that as sea level rise impacts Arcata, McDaniel slough marsh and the new taller and wider internal levees will help buffer Arcata. The salt marsh plain will slowly add elevation as silt is deposited and plants anchor the material in place. Further, Andre said, salt marshes sequester a tremendous amount of CO2 over time. HSU students are calculating the carbon-binding potential for the project."	
Lessons Learned: https://www.fws.gov/FieldNotes/regmap.cfm?arskey=35901 NOTE: This USFWS "Field Note", which appears intended to educate and inform general audiences, includes an interview with two key project members who share their experiences from the 13-years it took to complete the project. The main lesson seems to be the importance of patience and cooperation among project partners and stakeholders.	
Funders: Coastal Conservancy, CDFW, Natural Resources Conservation Service, US Fish and Wildlife Service, Caltrans, Wildlife Conservation Board NOAA, Natural Resource Conservation Service, , Pacific Coast Joint Venture, Ducks Unlimited, Redwood Community Action Agency, Humboldt Area Foundation, and many local non-profits and businesses.	
Partners: Nahalem Marine Manufacturing	
Project Documentation: Neander, J. 2015. McDaniel Slough Tidal Restoration in Janes Creek Watershed, Humboldt Bay, CA. California Society for Ecological Restoration Quarterly Newsletter, Volume 25, Issue 2 (Summer 2015). https://static1.squarespace.com/static/558d9dd9e4b097e27b791a1f/t/56a977740e4c114ebc853566/1453946746128/15ii-ecesis.pdf	

NOTE: Two-page summary of this project, with several pictures.

http://www.appropedia.org/File:Arcataslough.jpg

NOTE: Good project map.

http://scc.ca.gov/webmaster/ftp/pdf/sccbb/2012/1210/20121018Board07_McDaniel_Slough.pdf

NOTE: This California Coastal Conservancy web page includes links to additional PDFs, including a project map, and images of project area, including new tide gate

http://slideplayer.com/slide/10251354/

NOTE: This PP presentation has a good project map.

https://www.fws.gov/fieldNotes/print/print_report.cfm?arskey=35901

NOTE: Includes interview with project staff. Discusses post-project monitoring.

Ojerholm, E. 2014. Field note: Janes Creek, McDaniel Slough, Thence Humboldt Bay, City of Arcata Property, October 2013-March 2014. Pacific States Fisheries Management Commission, California Dept. of Fish and Wildlife.

NOTE: Fish sampling and water quality data only.

https://www.cacities.org/Member-Engagement/Helen-Putnam-Awards/California-City-Solutions/2014/McDnaiel-Slough-Wetland-Restoration-Enhancement

http://www.madriverunion.com/give-em-the-business/

NOTE: Article with quotes from people familiar with project. One mentions climate and sea-level rise implications.

Contacts:

Julie Neander, City of Arcata (jneander@cityofarcata.org)

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Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

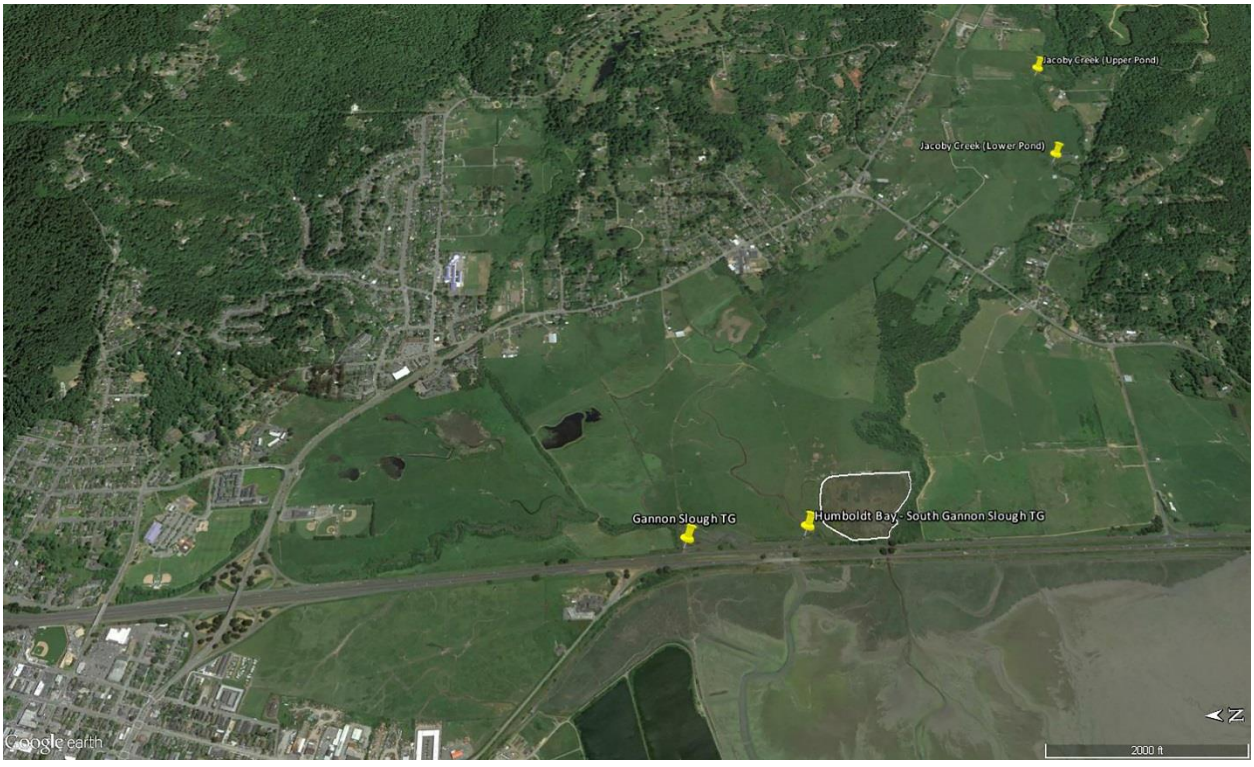
Estuary: Humbolt Bay	**Name**: Arcata Baylands/Lower Jacoby Creek Enhancement Project (Gannon Slough)
Type: Addition of fish friendly TG (old gate left in place)	**Total Cost**:

Summary: Project Description: Addition of fish friendly tide gate (old tide gate left in place) coupled with marsh channel enhancement to re-establish muted tidal prism and allow fish passage into Gannon Slough and small tributaries entering the slough. A total of 17.1 acres of estuarine function of estuarine channels associated with Gannon Slough was restored. 15.9 acres of historical connectivity between fringe tidal and non-tidal lands channels was restored. 15.3 acres of tidal habitat and channels associated with Jacoby Creek was restored through construction of a new setback levee.

Monitoring: Pre and post project monitoring for salmonids and tidewater goby in Gannon Slough and Jacoby Estuary and limited water quality (WQ) data. Likely other physical and biological monitoring upstream of new tide gate by project proponents.

[City of Arcata completed projects] Habitat enhancement and restoration activities were completed on the Jacoby Creek/Gannon Slough Wildlife Area between Old Arcata Road and Highway 101. Arcata City staff worked on a 3-acre waterfowl pond. Heavy construction began on September 6, 2011. GR Sundberg, Inc. constructed a habitat levee totaling 1,915 linear feat; modified 300' of existing levee; excavated 2,150' of new tidal channel; and installed tide gates, culverts and other related habitat enhancement work.

Aerial Image (5/26/2016):



Restoration Metrics:

Monitoring Focus: Biological (salmonids) Limited water quality data	**Study Design**: Pre and post project monitoring for salmonids in Gannon Slough and limited water quality (WQ) data. Fish monitoring was conducted using minnow traps baited with frozen salmon roe and with beach seine hauls. Seine hauls included the main channel and two side channels. Water quality samples were collected at three locations within the main channel using a Yellow Springs Instrument Model 85 meter to monitor for conductivity, salinity, DO, water temperature, and depth.
Parameters: Salmonids	**Species Monitored**:
Project Findings: The final monitoring report has not yet been completed.	
System Effects:	
Lessons Learned:	
Funders: U.S. Fish and Wildlife National Coastal Wetlands Conservation Program, the State Coastal Conservancy and the U.S. Fish and Wildlife Partners for Wildlife Program.	
Partners:	
Project Documentation: Wallace, M. 2010. Field note: Gannon Slough/Jacoby Creek, Thence Humboldt Bay, City of Arcata Property. California Fish and Wildlife Department. NOTE: Pre-restoration monitoring data. Includes Includes air photo diagrams of project area, including tide gate locations. http://scc.ca.gov/webmaster/ftp/pdf/sccbb/2006/0606/0606Board05_Arcata_Baylands_Ex3.pdf NOTE: Air photo showing project area Jacoby Creek Off-Channel Habitat Restoration: Basis of Design Report http://h2odesigns.com/wp-content/uploads/2014/12/Jacoby_C_Off_Channel_Habitat_Design_2014.pdf NOTE: This document discusses work to reconnect ponds, not tide gate work, but has some good background info and context. http://www.cityofarcata.org/219/Arcata-Baylands-Restoration-Enhancement- NOTE: Detailed description of project, including background, funders and goals http://www.cityofarcata.org/421/Completed-Projects NOTE: Description of completed project. Contacts: Julie Neander, City of Arcata (jneander@cityofarcata.org) Bob Pagliuco, NOAA (bob.pagliuco@noaa.gov) Mike Wallace, CDFW (mike.wallace@wildlife.ca.gov) Arcata Environmental Services Department 707-822-8184.	

Appendix C. Summaries of Non-OWEB tide gate projects, 2006 – 2016.

Estuary: Humbolt Bay	**Name**: Wood Creek Tidal Marsh Enhancement Project, Freshwater Farms Reserve
Type: Remove TG flap from concrete tide gate structure	**Total Cost**:

Summary: Wood Creek drains about 150 hectares and is a tributary to Freshwater Creek Slough, itself a tributary to Humboldt Bay. In 2005, the Northcoast Regional Land Trust (NRLT) purchased 54 acres of bottomland pasture along Wood Creek from neighboring Freshwater Farms Nursery to facilitate a wetland restoration and enhancement project and to maintain agricultural uses. Located in an area historically dominated by tidal wetlands, the land was converted to pasture in the early 1900's. The project site itself was cut off from the greater Freshwater Slough system by a wooden flap tide gate and a levee, preventing tidal influence. Stream and slough habitat was simplified into a single linear channel. Eventually the tide gate fell into disrepair, a muted tidal cycle returned and juvenile salmonids were eventually able to pass through the tide gate and move in and out of Wood Creek. Surveys showed that endangered and threatened fish species- coho, steelhead and coastal cutthroat trout- were still using the area for rearing prior to migrating to the ocean. The endangered tidewater goby was also discovered on the site. In 2006, recognizing the need to reclaim this wetland habitat, NRLT and the Redwood Community Action Agency initiated restoration planning, working with numerous public and private groups to design and implement the project.

The primary objective of the Wood Creek Tidal Marsh Enhancement Project was to restore about 35 acres to its original tidal hydrology and create estuarine conditions on about 15 acres. Project elements included: removal of a wooden-flap tide gate; construction of 3,200' of slough channels; removal of a 300' dike/berm on the north bank of Wood Creek; excavation of three seasonal ponds to provide year-round habitat; replacement of an old, crushed culvert with a modified flatbed trailer bridge; construction of tidal hummocks (shallow hills subject to tidal inundation) using the soil excavated onsite; and placement of redwood root wads in the slough channel banks, one of the ponds, and on the marsh plain for raptor and wetland bird perches. This work was completed in 2009. Revegetation of the constructed tidal hummocks and slough channel margins occurred in March-April 2010 [another source says March-June] with 46,000 native wetland-associated plants [another source says 38,000]. The revegetation plan was developed to mirror natural conditions at neighboring Fay Slough. Two hummocks were left as unvegetated controls to help the project team determine the extent and profile of passive wetland plant colonization over time. The test hummocks will be surveyed annually; invasive plant species will be manually removed when observed.

NRLT has engaged the local community in these restoration efforts through their education and outreach program "Building Community for Conservation." This program includes interpretive hikes, K-12 education programs, canoe trips, and restoration activity days at the site.

Project Description: Remove tide gate flap from concrete tide gate structure to re-establish muted tidal prism coupled with estuarine habitat restoration (addition of tidal channels and off-channel pond, removing undersized culvert, riparian planting, cattle exclusion) in the stream-estuary ecotone upstream of tide gate.

Monitoring: Pre and post project monitoring for salmonids in Wood Creek and limited water quality (WQ) data. Likely other physical and biological monitoring upstream of new tide gate by project proponents.

Aerial Image (5/26/2016):

Restoration Metrics: Over winter habitat for juv coho Rearing habitat for juv coho	
Monitoring Focus: Biological (salmonids) Limited water quality data	**Study Design**: Pre and post project monitoring for salmonids in Wood Creek and limited water quality (WQ) data. Sampled fish and water quality intensively in 2010-15. Sampling appears to have started in 2007. Starting mid-Oct. 2016 sampled 3 sites in Wood Cr with baited minnow traps and the off-channel pond with minnow traps and beach seine in the Phase 1 area and 5 sites in the Phase 2 restoration area with minnow traps and beach seine. We operated one pair of PIT tag antennas at the tide gate structure at the mouth of Wood Cr and installed 2 sets of paired antennas in the Phase 2 area to detect PIT tagged fish. Collected WQ data during highest daytime tides of the month (~ every 2 weeks) and during fish sampling effort with a YSI Professional Plus handheld WQ meter to describe juvenile salmonid rearing conditions. [Paraphrased from Ricker et al. 2014.] The CA Dept of Fish and Wildlife (CDFW) and NOAA Fisheries cooperatively developed the draft

	Coastal California Salmonid Monitoring Plan (CMP). Two complimentary tasks are considered high priority in the northern monitoring area and form the foundation of the CMP approach: 1) probabilistic sampling of stream reaches within a defined region using spawning ground surveys (SGS) to establish the regional status and trends of adult salmonid abundance, and 2) develop intensively monitored Life Cycle monitoring Stations (LCS) nested within the regional sample frame of the SGS. LCS studies have 4 primary objectives: 1) define the relationship between SGS observations and adult escapement; 2) estimate juvenile and adult abundance, and freshwater and marine survival rates; 3) provide a study framework to investigate habitat-productivity relationships; 4) characterize the diversity of life history patterns. The Freshwater Creek Salmonid Monitoring Project is designed to be a LCS with these principal objectives.
Parameters: Salmonids	**Species Monitored**:
Project Findings: [2010 case study] In winter and early spring juvenile coho likely sought out low velocity habitat in Wood Creek when water velocities in mainstem Freshwater Creek Slough were too fast to support many yearling coho. Restoration appears to have met a project goal to increase tidal prism (by removing the tide gate flap) without net loss of over winter freshwater rearing habitat for coho salmon by constructing the pond. The pond appears to replace freshwater habitat lost by the increased presence of brackish water in Wood Creek between Sites 1 and 4. Allen, S., E. Ojerholm and M. Wallace. 2016. Juvenile salmonid use and restoration assessment of the tidal portions of selected tributaries to Humboldt Bay, California 2013-2015. NOTE: This report has extensive fish and water quality monitoring data for Wood Creek (and several other Humboldt Bay tributaries) but little in the way of interpretation specific to Wood Creek. Some clips: "Typically there is a fall redistribution of coho salmon moving from stream habitat downstream to the SEE. This year's [2013/14, a drought year] observations at...Wood Creek [i.e. few salmonid detections prior to 1st significant rainfall in Feb 2014] illustrate that a large redistribution of juvenile coho salmon occurs with the first large rain and stream flow events of the season regardless of whether they occur in the fall or later in the winter." "This and earlier studies by NSA [CDFW Natural Stock Assessment Program] (Wallace 2006; Wallace and Allen 2007, 2009, 2012, 2015; Wallace et al. 2015) showed that sub-yearling and yearling-plus coho salmon, as well as a wide size range of juvenile steelhead trout routinely reared in the stream-estuary ecotone for months." "Fish growth could be quite high in the ponds, especially in spring. In Wood Creek from Feb-April 2013 we found yearling-plus coho that were tagged and recaptured in the pond had a mean growth rate of 0.40 mm/day while those tagged and recaptured in the main channel of Wood Creek had a mean growth rate of 0.22 mm/day."	
System Effects: [From 2010 Climate Adaptation and Knowledge Exchange (CAKE) write-up] "The Wood Creek Tidal Marsh Enhancement Project's primary climate change benefit is flood mitigation for the lower Wood Creek/Freshwater Creek area. Anticipated increases in winter precipitation will likely bring increased flooding to local watersheds. Reconnection of Wood Creek to Freshwater Creek	

through removal of the tide gate and creation of a more complex wetland channel system will expand the flow capacity of the project area, thereby reducing the velocity and shear potential of flood flows."

Lessons Learned:

Funders: Private and public partners who granted funding and in-kind assistance:

US Fish & Wildlife Service; The Nature Conservancy; NOAA Fisheries; CA Department of Fish and Game; National Fish & Wildlife Foundation; North American Wetlands Conservation Act; Natural Resources Conservation Service.

Partners: Restoration work was completed by Northcoast Regional Land Trust and Redwood Community Action Agency.

Project Documentation: http://ncrlt.org/node/36

NOTE: Northcoast Regional Land Trust (NCRLT) web page, circa 2015. Summary of Freshwater Farms Reserve project- Woods Creek tide gate removal and habitat restoration.

https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=85569

Ricker, S.J. , D. Ward, M. Reneski and C. W. Anderson. 2014. Results of Freshwater Creek Salmonid Life Cycle Monitoring Station 2010-2013. Prepared by California Dept. of Fish and Game, Anadromous Fisheries Resource Assessment and Monitoring Program, in partial fulfillment of Fisheries Restoration Grant No. P0910513. 50 Ericson Ct., Arcata, CA 95521.

NOTE: Summarizes results of yearly abundance and survival monitoring efforts from March 2010-July 2013; integrates all years of project data to make inference on population trend and limiting factors for coho salmon in Freshwater Creek.

http://ncrlt.org/sites/ncrlt.org/files/FWFR%20Estuary%20Rehab%20Project%20Map.jpg

NOTE: Detailed site map.

http://ncrlt.org/sites/ncrlt.org/files/land-conservation/FWFR%20Story%20doc.pdf

NOTE: Another project summary, circa 2010, with additional details.

http://ncrlt.org/sites/ncrlt.org/files/land-conservation/FWFcontruction.jpg

Graphic showing several phases of project construction

http://www.cakex.org/case-studies/northcoast-regional-land-trust-wood-creek-tidal-marsh-enhancement-project

NOTE: Project summary from 2010 on Climate Adaptation and Knowledge Exchange (CAKE) website. Focuses on climate change adaptation benefits of the project.

CA Dept. of Fish and Game. 2010(?). Wood Creek Restoration Project Case Study. California Department of Fish and Game Fisheries Restoration Grant Program-P0810517: Response of Juvenile Salmonids and Water Quality to Habitat Restoration in Humboldt Bay Estuaries.

NOTE: Contains detailed information about the project and first-year post-project monitoring, including several photos.

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Estuary: Eel River	**Name**: Salt River Restoration, Lower Eel River Watershed
Type: Removal /replacement. 1 TG removed from mouth of Salt River at confluence with Eel River, 3 new ones installed in setback berm	**Total Cost**: $2,001,150

Summary: The Eel River is the third largest watershed entirely within California and has a drainage area of about 3,700 sq. mi. The Salt River is a tidally influenced slough tributary to the Eel River estuary located in Humboldt County near Ferndale, CA. In the late 1800's the Salt River was a functioning river, large enough to accommodate small ocean steamers. At Port Kenyon, the Salt was approximately 200' wide and 15' deep. Now [2010] a person can almost jump over it. Over time fine sediments eroded from the surrounding Wildcat Hills into tributaries and deposited in the Salt River channel. Vegetation colonized the channel; trapping more sediment, blocking fish passage and increasing flooding on surrounding agricultural lands, roads, and residences.

The Salt River Ecosystem Restoration Project is a watershed scale approach to address the range of complex land management and ecological issues that have led to reduced agricultural productivity and ecological decline. The project is a large public-private partnership as most restoration activities will occur on private, actively managed agricultural land. Multiple public and private agencies have committed substantial financial and professional support to restore hydrologic processes and functions to the Salt River watershed. Main project components: 1) restoration of the river channel and riparian floodplain, 2) tidal marsh restoration at Riverside Ranch, 3) sediment management in the channel and riparian floodplain, and 4) upslope sediment reduction.

Near the Salt River mouth, the 420-acre [another source says 446-acre] Riverside Ranch was purchased with a 2007 National Coastal Wetland Conservation grant; title is now held by CA Dept of Fish and Wildlife (CDFW). Phase 1 of restoration focused on Riverside Ranch. In 2013, the levee and tide gate at the Salt River's confluence with the Eel River were removed and upstream slough channels were excavated to: 1) increase hydrologic function to the lower 2.5 miles of the Salt River; 2) provide access for re-colonization of the lower Salt River by native fish; and 3) improve habitat for waterfowl and other birds. Interchange of flow between the Eel River estuary and the lower Salt River was restored in October 2013 following completion of Phase 1 excavation and other construction activities. Purchase of the Riverside Ranch allowed re-opening of two main sloughs and numerous secondary channels. Phase 2 was completed during summer and fall 2014, with another 1.8 miles of Salt River channel restored up to the Dillon Road Bridge. Phases 3 and 4 will eventually reconnect Francis and Williams creeks to the Salt River channel, for 7 total miles of restored channel.

Salt River – Lower Eel post-restoration (5/26/2016):

Salt River – Lower Eel pre-restoration (8/23/2012):

Restoration Metrics: Miles of restored channel; Presence of coho; Overwinter use by coho; Coho growth	
Monitoring Focus:	**Study Design**: In spring-summer 2014, low tide fish sampling was conducted in lower Salt R by CDFW, Humboldt County Resource Conservation District, and Humboldt State U. Seine nets and minnow traps at 11 sites throughout main channel and slough networks. Documented numerous fish species - coho, tidewater goby and Chinook. At request of NOAA Fisheries, sampled at low and high tide at the same sites w/ same methods in fall/winter 2014-2015. 17 fish species caught, incl 1st documentation of longfin smelt. Also confirmed over-wintering use by coho with rapid growth and good condition factors. Avian surveys documented >100 species using the restored habitat.
Parameters: Fish presence and growth	**Species Monitored**: Coho, Chinook, tidewater goby Birds
Project Findings:	
System Effects:	

Lessons Learned:
Funders:
Partners: Contributed Funds or Services: California State Water Resources Control Board; County of Humboldt; City of Ferndale; State Coastal Conservancy; California Department of Fish and Game; U.S. Army Corps of Engineers; NOAA/National Marine Fisheries Service; USDA Natural Resources Conservation Service; U.S. Fish and Wildlife Service; Ducks Unlimited; Wildlife Conservation Board; Western Rivers Conservancy; Humboldt County Resource Conservation District. Community Volunteers: Salt River Watershed Council; Salt River Advisory Group. Consultants: Winzler and Kelly; Kamman Hydrology and Engineering; H.T. Harvey and Associates; Northern Hydrology and Engineering; Timberland Resource Consultants; Grassetti Environmental Consulting; LACO & Associates; Freshwater Environmental Services; Roscoe & Associates; Pacific Watershed Associates.
Project Documentation: Taylor, R. 2015. Salt River Restoration in the Lower Eel River Watershed. California Society for Ecological Restoration Quarterly Newsletter, Volume 25, Issue 2 (Summer 2015). https://static1.squarespace.com/static/558d9dd9e4b097e27b791a1f/t/56a977740e4c114ebc853566/1453946746128/15ii-ecesis.pdf http://www.humboldtrcd.org/saltriverupdates.pdf NOTE: Documents installation of 3 tidegates in setback berm by Nehalem Marine in Sept. 2013. Salt River Ecosystem Restoration Program http://humboldtrcd.org/index_files/salt_river_ecosystem_restoration_project.htm NOTE: Humboldt County Resource Conservation District web page, with links to several project documents: -Salt River Ecosystem Restoration Project Short History -2008 Project Summary -2009 Project Summary -2010 Project Summary -Salt River Adaptive Management Plan -Salt River Rare Plant Plan -Salt River Final Environmental Impact Report -Salt River Ecosystem Restoration Project Notice of Determination -Salt River Ecosystem HMMP Report -Notice of Preparation of Environment Impact Report Salt River Phase I Design (pdf)

Estuary: Various, New South Wales, Australia	**Name**: Bringing Back the Fish
Type: Replacement/Modification	**Total Cost**: $7,792,058 Floodgate sites only: $2,565,965

Summary: 32 of the 55 native freshwater species in NSW are considered migratory – moving between habitat types. In stream structures act as barriers to fish migration and, therefore, are considered Key Threatening Processes under the Fisheries Management Act 1994 and the Threatened Species Conservation Act 1995. Australian fish are generally poor swimmers and jumpers, making the barrier effect of instream structures even greater. New structures are now required to incorporate fish passage. However, there are many older structures that remain deleterious to fish populations by severely limiting migratory movements. As in many places, floodgates are used to reduce inundation and increase drainage to support agriculture. In this region, however, there is a high prevalence of acid sulphate soils. When these soils are exposed to the air they oxidize and acid is released. The runoff causes acidification (lower pH) in the drainage and downstream waters.

In the 1990's I&I NSW began auditing fish passage barriers in coastal NSW and prioritized the structures for remediation (modification, removal, or fishway installation). The Bringing Back the Fish Project aimed to 'enhance aquatic ecosystems across the five NSW coastal Catchment Management Authority regions by restoring stream connectivity and rehabilitating key aquatic habitats' to improve fish passage and habitat quality. Over a three year period the project removed, improved, or bypassed weirs and floodgates, redesigned or removed road crossings, and restored habitat through inundation and revegetation.

Throughout the process I&I NSW engaged the commercial and recreational fisheries, local governments, State agencies, community organizations, and landowners. Steering committees were formed in each region that included members of these groups. The committees provided regional perspective, identified overlooked barriers, and assisted in project prioritization and approval. Projects could only move forward with sufficient funding and the support of landowners. A total of 80 sites were expected to be restored over the course of the project. However the project was able to complete restoration actions at 94 sites (10 weirs, 22 road crossings, 54 floodgates, and 8 habitat sites) improving access to 1,235 km of coastal waterways.

Catchment Management Authorities and local government councils gained greater understanding of fish passage and habitat requirements and the informational and skill requirements of successful projects on waterway crossings. CMAs have continued to fund restoration projects including fish passage after the Bringing Back the Fish project was completed. Local groups have organized to recommend additional barriers be removed and recreational fishing groups have been party to grant applications for aquatic habitat rehabilitation.

Restoration Metrics:	
Monitoring Focus: The monitoring aimed to determine of ecosystem processes related to native stock integrity, primarily fish passage, had been restored.	**Study Design**: Rapid evaluation of three priority sites (1 weir, 1 double box culvert, and 1 auto-tidal floodgate). Monitoring was described in a stand-alone report, which I have not been able to locate.

Parameters:	**Species Monitored**:
Project Findings: Ten (10) weirs were improved: 4 - removed, 4 - fishway installed, 2 – structural design changes, 611 kms opened. Twenty (22) road crossings were improved: 9 – removed, 8 – fishway installed, 5 – low-flow box culverts installed, 453 kms opened, 50 ha habitat improved. Fifty-four (54) floodgates improved: 54 traditional flap gates were replaced or modified with structures allowing controlled upstream flow, 123 kms opened, 1,694 ha habitat improved. Eight (8) habitat sites were restored, resulting in 48 kms opened, 163 ha habitat improved. Restoration actions included culvert installation, bank stabilization to assist mangrove recruitment, and installation of seagrass friendly moorings. Projects were completed in 5 regions but 65% of the sites were in one region. The size of the region and the land use regulations within the area determined the number of floodgates requiring remediation. The average cost per project was: weir - $85,000, road crossing - $100,000, floodgate - $35,000.	
System Effects:	
Lessons Learned: Most of the projects completed were in the NRCMA region. This region has more than twice the number of floodgates than the other regions. However, the disparity in projects completed is likely due to the existence of prior road crossing and floodgate programs in that area, which meant that partnerships with structural stakeholders (i.e. landowners) were already developed. Aquatic restoration requires specialized contractors. Rock-ramp fishways require specific construction expertise and many contractors are not qualified to install them. Despite the large number of projects completed, there are more than 300 high priority barriers remaining in coastal NSW. The impact of remaining barriers is a continuing threat to migratory fish populations.	
Funders: Bringing Back the Fish funding accounted for 30% of the project cost. The Australian government provided approximately 25% of the funds. The remaining balance was comprised of in-kind (cash and non-cash) contributions from local councils, water authorities, landholders, and State government sources.	
Partners: Catchment Management Authorities; Regional Steering Committees; 34 local governments; private land owners, Office of Water; Land Property Management Agency; Department of Environment, Climate Change, and Water; National Parks and Wildlife Service; Soil Conservation Services; State Water Corporation, Fishway Consulting Services; Manly Hydraulics Lab; Department of Commerce; MidCoast Water; Streamline River Restoration; Local Aboriginal Land Councils; Landcare / RiverCare; Recreational Fishermen; Council of Freshwater Anglers; Commercial Fishermen; Wetland Care Australia; NSW Recreational Fishing Trust; and the NSW Environmental Trust, and the Federal government of Australia.	
Project Documentation: Industry and Investment NSW (2009). Bringing back the fish – Improving Passage and Aquatic Habitat in Coastal NSW. Final Report to the Southern Rivers Catchment Management Authority. Industry and Investment NSW, Cronulla, NSW.	