U.S. WEST COAST MAPPING OF RESTORED TIDAL AREAS: METHODOLOGY, RESULTS & RECOMMENDATIONS

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PMEP
PACIFIC MARINE & ESTUARINE FISH HABITAT PARTNERSHIP

Photo credit: Brent Lawrence

EXECUTIVE SUMMARY

The Pacific Marine & Estuarine Fish Habitat Partnership (PMEP) identified a need to update its recent assessment of tidal wetland loss (TWL) to include areas where tidal connectivity and inundation have been restored. PMEP mapped 127 tidal re-connection projects across the West Coast, identifying 8,085 hectares (19,978 acres) of restored tidal wetland habitat. This project focused on mapping restored areas that were shown as “lost” within the 55 estuaries included in its original (V1) TWL assessment (Brophy et al., 2019). Restored areas that were already classified as tidal in the NWI (due to an NWI update that occurred after restoration) were shown as “retained” in the TWL assessment, and therefore were generally not included in this new mapping effort. Therefore, restored tidal wetlands included in this effort are a subset of all tidal wetland restoration projects on the West Coast.

This mapping effort resulted in 2.3% of tidal wetlands that were previously classified as “lost” being reclassified as “restored,” while 82.7% of tidal wetlands remained classified as “lost.” The Salish Sea region had the highest change in classification, with 4.1% of tidal wetlands that were "lost" now classified as "restored." Losses remained highest for major river deltas, with over 94% of tidal wetlands classified as lost and <1% as restored. In the 5 estuary areas of the San Francisco Bay and Delta 5,340 ha of tidal wetlands have been restored, representing more than half of the total area restored on the West Coast. However, this large area of restoration represents only a small proportion of historical tidal wetlands for the Bay and Delta (2.4% restored). These results illustrate both the successes of restoring tidal connectivity and the potential for future efforts to re-connect important fish habitat across the West Coast.

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Acknowledgements

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INTRODUCTION

IIn 2018, the Pacific Marine & Estuarine Fish Habitat Partnership (PMEP) completed an Indirect Assessment of West Coast USA Tidal Wetland Loss (TWL) across 55 estuaries (Brophy et al., 2019). The assessment classified historical tidal wetlands as either “retained” or “lost,” and found that approximately 85% of vegetated tidal wetlands have been lost from West Coast estuaries. One limitation of the analysis was due to the dated inputs of the National Wetland Inventory (NWI) (U.S. Fish and Wildlife Service, 2014); some restored tidal wetlands were attributed as nontidal in the NWI, and were therefore categorized as “lost” in the analysis. Because of this limitation, PMEP recommended an update of the TWL assessment to map tidally restored areas along the West Coast, and to classify these as “restored areas”. Funding for this project came from NOAA’s Office of Habitat Protection.

Project deliverables include:

- Standardized spatial data including the locations (points) of restored tidal wetland projects and extents (polygons) of the restored areas (available on request to gis@psmfc.org);
- Updated TWL assessment spatial data (V2) to include “restored" areas (publicly available); and
- Summary of project and recommendations for future efforts.

METHODS

Using a variety of existing GIS data layers, in combination with professional review, PMEP's data steward identified locations of tidal wetland restoration projects and digitally mapped the location and extent (in ArcMap) of areas within estuaries along the West Coast where tidal connectivity was restored. Priority was given to projects within the 55 estuaries included in PMEP's TWL assessment (V1), with a focus on areas classified as "lost" in that assessment. See Figure 1. This work was completed under the guidance of PMEP's Science and Data Committee and the Pacific States Marine Fisheries Commission (PSMFC) GIS team.

The following publicly available GIS data layers were used to help determine locations and status of tidally restored areas along the West Coast:

- National Restoration Atlas, National Oceanic and Atmospheric Administration (NOAA)
- Washington Habitat Work Schedule (HWS)
- Washington Project Information System (PRISM) database, WA State Recreation and Conservation Office
- Watershed Restoration Inventory (OWRI), Oregon Watershed Enhancement Board (OWEB)
- Fisheries Restoration Grant Program Projects, California Department of Fish and Wildlife (CDFW)
- California EcoRestore Projects, California Natural Resources Agency

Each data layer was queried for keywords including "tide", "tidal", and "estuary" to identify potential tidal restoration projects. Results of the query were used to generate a list of restoration projects, which was then reviewed by PMEP's Science and Data Committee and PMEP's Steering Committee. The review process generated more projects, which were then added to the project list.

The following additional GIS data layers were obtained from organizations engaged in tidal restoration. These datasets are not currently publicly available, but were used to identify the extent of tidally restored areas.

- Lower Columbia Estuary Partnership Project Database
- Hood Canal Salmon Enhancement Board Restoration Projects
- Tulalip Tribes Restoration Projects
- Puget Sound Partnership Restoration Efforts
- Oregon Central Coast Estuary Collaborative (OCCEC) Implemented Projects
- Elkhorn Slough Restoration Projects

- Southern California Wetlands Recovery Project (SCWRP) Restoration Projects
- Coos Bay/South Slough NERR Restoration Inventory

See Appendix A for a full list of restoration data sources consulted during this effort. After the identification of restoration projects was completed using database searches and expert input, PMEP used the following base layers to consistently map the extent of tidally restored areas:

- PMEP West Coast USA Current and Historical Estuary Extent V1 (PMEP 2018)
- PMEP Tidal Wetland Loss Assessment detailed polygon layer V1 (2018)
- World Imagery aerial photos from ESRI Online (various years)
- Aerial photos from Google Maps and Google Earth (various years)

The PMEP data steward used the restoration datasets to identify the location, and when available, the extent of the tidally restored area. The above base layers were used as a reference to develop the final boundaries of the restored areas. Restored areas were clipped to the extent of the estuary (using PMEP's Estuary Extent data); areas that occurred outside of the estuary extent were not included. To provide consistency with other West Coast-wide data, polygons from the PMEP TWL assessment detailed layer (available upon request) were used to map the restored area boundaries. This detailed layer is a union of PMEP's estuary extent and all features attributed as "tidal" in NWI. When available, the restored area from the data source was used to identify the area restored, and polygons within the area were selected and split, if required. Aerial images from ESRI and Google were used as references when identifying the tidally restored areas. Figure 2 shows an example of data processing and results in the Nisqually River Estuary.

Specific types of restoration efforts within this mapping effort include: berm, dike, and levee removals, tide gate removals, channel creation, channel reconnection and modifications, and tidal wetland modification (fill or fill removal). Projects that were solely tide gate modifications or upgrades were not included, because data on the degree of tidal restoration produced by such projects are not generally available.

Restoration projects that remained disconnected from "retained" areas, channels or areas of open water classified as "N/A" in the TWL assessment were not included in this effort. In other words, a site needed to be clearly reconnected tidally to be included in this effort, even if the connection was muted.

More specific details on GIS data processing methods are available by request at gis@psmfc.org.

Figure 1. Locations and numbers of restoration projects mapped across PMEP Regions. Note that the map odes not include all tidal restoration project across the West Coast. See Appendix D for a list of projects mapped for this effort.

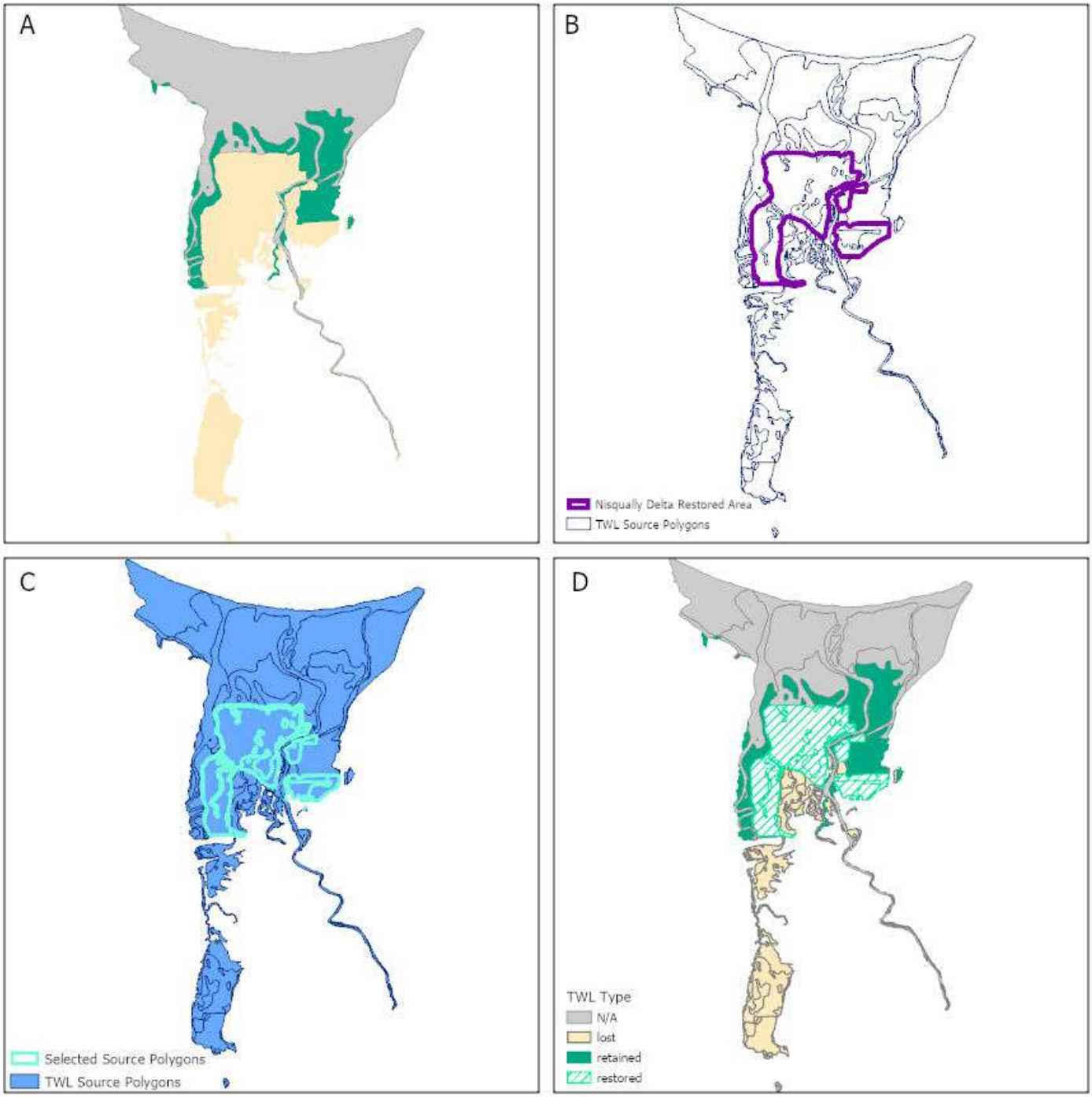

Figure 2. Example of data processing and results in the Nisqually River Estuary. (A) Original TWL assessment data showing Nisqually as "lost" tidal wetlands, (B) PMEP TWL assessment detailed layer data and the Nisqually Restoration Project boundary (Nisqually Indian Tribe, 2017), (C) PMEP TWL assessment detailed layer with specific polygons to be included as the restored area selected, (D) Updated TWL Assessment with Restored Areas.

RESULTS

This project updated 8,085 hectares of “lost” tidal wetlands to “restored” across 127 restoration projects within 35 estuaries. Overall, through this process, a total of 11,299 hectares (27,921 acres) of restored tidal wetlands were identified and mapped. In total, 2.3% of area that was classified as lost in the original TWL assessment has been restored. TWL results (V2) for 55 estuaries is illustrated in Figure 3a and 3b. See also Table 1.

The Salish Sea region had the highest change in classification; with 4.1% of tidal wetlands that were lost now classified as restored. Restoration efforts in the Salish Sea that had proportionally large restoration efforts in comparison to their estuary size include the Nisqually River (3,464 ha or 35.4% of the area), Skokomish River (127.4 ha or 32.3% of the area), Lynch Cove (18.6 ha or 10.9% of the area) and Quilcene Bay (12.5 ha or 9.9% of the area).

Despite restoration efforts in the Salish Sea, losses remained highest for major river deltas, with over 94% of tidal wetlands classified as lost and < 1% as restored. Samish Bay and Nooksack River still have high areas of tidal wetland loss.

In Central California, three of the regions of San Francisco Bay have restored large areas of tidal wetlands. However, when compared with the total historical area of tidal wetlands, the percentage that has been restored is quite low: in Suisun-Grizzly Bays (425.1 ha of restoration representing 1.1% of

historic tidal wetlands), San Pablo Bay (3,006 ha, 12%), and South San Francisco Bay (1,854.8 ha, 2.4%).

The restored areas dataset contains attributes describing the type of restoration, project contacts, degree of tidal connectivity, andother project details. See Appendix C for a list of attributes and descriptions included in this effort, and Figure 1 for locations of restoration projects

Table 1: Area and percent loss of tidal wetlands in emergent, scrub-shrub and forested classes as well as restored area for 55 estuaries on the Pacific Coast, by estuary type and marine ecoregion.

	# of estuaries	Tidal wetland loss (ha)	# tidal restoration projects	Restored (ha)	Historical tidal wetland area (ha)	% loss	% was lost, now restored
Ecoregion							
Salish Sea	13	24,680	32	1,251	30,448	81.1	**4.1**
WA, OR, N. CA	26	58,705	65	1,401	88,164	66.6	**1.6**
Central CA	9	208,542	28	5,341	233,271	89.4	**2.3**
S. CA Bight	7	1,874	2	92	3,347	56.0	**2.7**
Estuary type							
Embayment/Bay	20	67,361	42	5,504	88,870	75.8	**6.2**
Major river delta	9	170,382	28	1,280	180,856	94.2	**0.7**
Riverine estuary	26	56,058	61	1,300	85,505	65.6	**1.5**
Total	**55**	**293,801**	**131**	**8,085**	**355231**	**82.7**	**2.3**

Photo credit: John Bragg

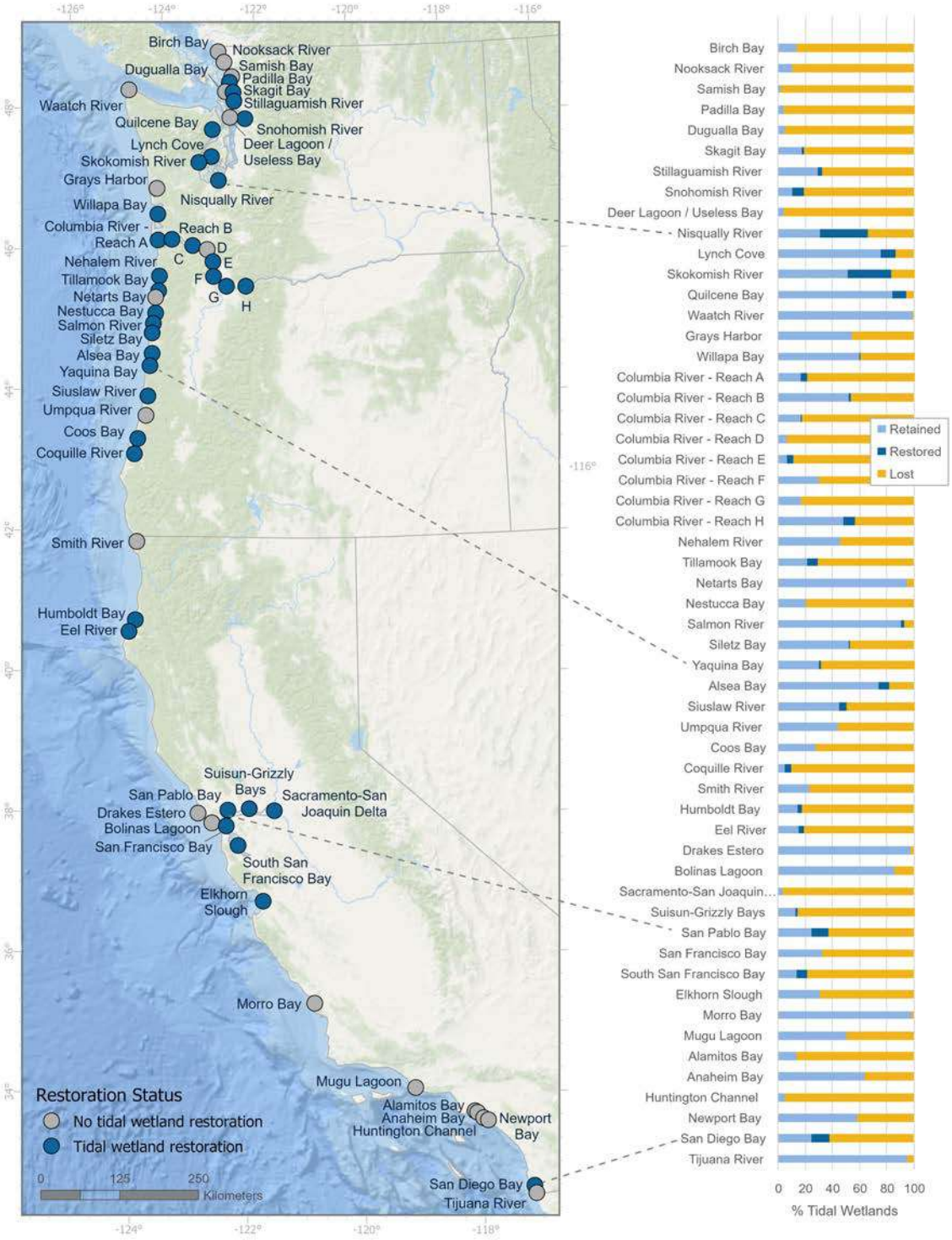

Figure 3a. Wetland loss and restored area in 55 estuary systems across the Pacific coast. The map above denotes all estuaries used in the wetland loss analysis (blue and gray dots), and which estuaries had tidal wetland restoration efforts (blue dots). The bar graph at right illustrates % tidal wetland loss, % restored area (i.e. area that was reclassified from "lost" to "restored" in V2 of the TWL assessment), and % retained area. It is important to note that the figures include only those tidal restoration projects completed after the most recent update to the National Wetlands Inventory used in the TWL assessment in each estuary. Appendix E provides summary attributes for each estuary.

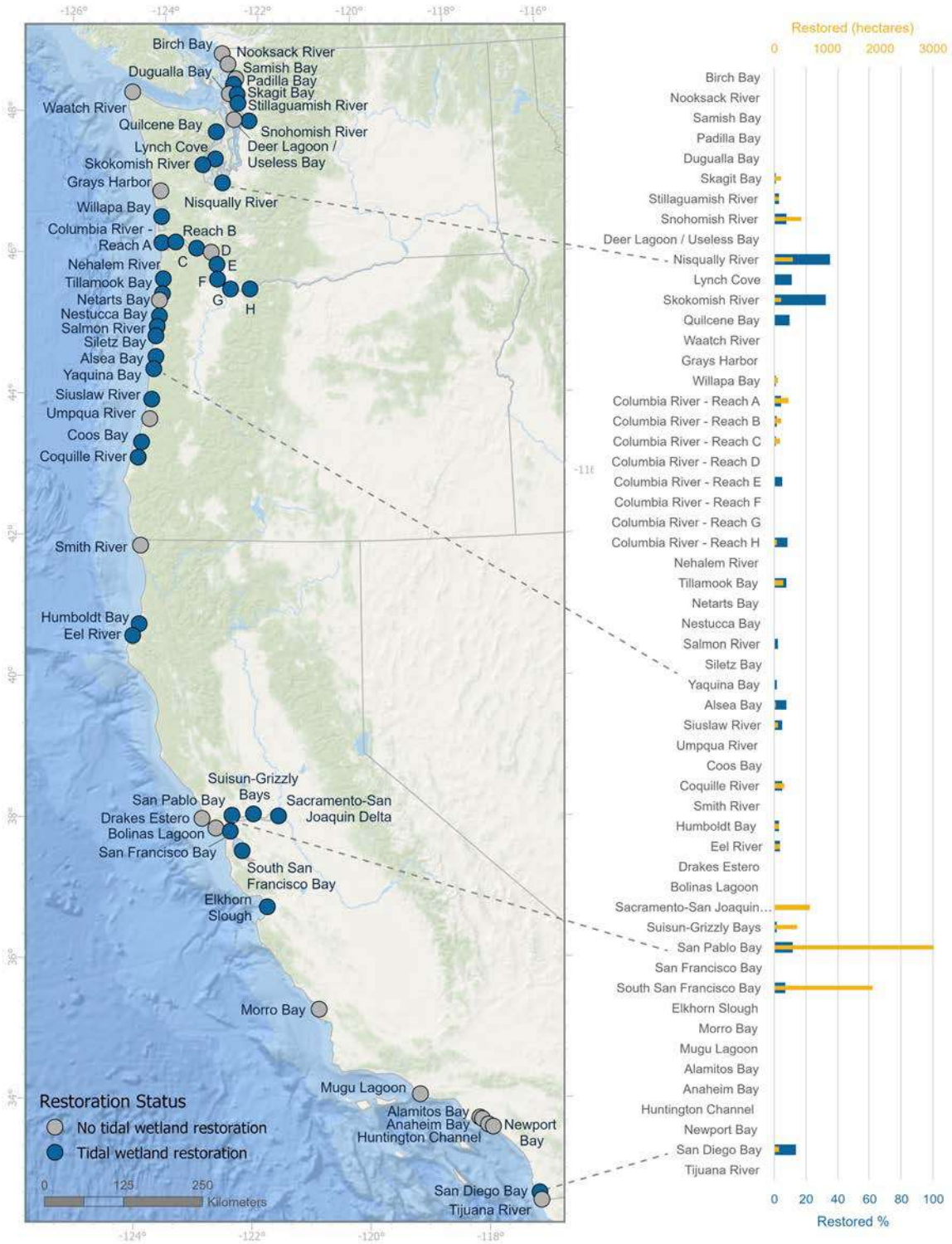

Figure 3b: Restored area in 55 estuary systems across the Pacific coast. The map above denotes all estuaries used in the analysis (gray and blue dots) and which estuaries had tidal wetland restoration efforts (blue dots), and the bar graph at right illustrates restored area (i.e. area that was reclassified from " lost" to "restored" in V2 of the TWL assessment) as a percentage of historical tidal wetland area and as total area (hectares). It is important to note that the figures do not include all tidal restoration projects across the West Coast. Appendix E provides summary attributes for each estuary.

Data Challenges and Limitations

Not all restored tidal wetlands are included in this mapping effort. This project focused on restored areas that were shown as “lost” in the 55 TWL estuaries. Other restored areas were already classified as tidal in the NWI, due to NWI updates that occurred post-restoration; these were shown as “retained” in the TWL assessment and therefore were generally not included in this effort.

To remain consistent across the West Coast and related TWL assessment data, restoration projects that remained disconnected from “retained” areas, channels or areas of open water classified as “N/A” in the TWL assessment were not included in this effort. In other words, a site needed to be clearly reconnected to tidal influence for the project to be classified as a tidal wetland restoration effort, even if the connection was muted. In addition, restoration projects that modified tidegates (as opposed to removing tidegates) were not included, since our understanding of tidal reconnection through tidegate modification is limited. One example of this is a project that was both geographically surrounded by “lost” areas in PMEP’s TWL assessment, and included the installation of a tidegate, therefore it was not included in our tidally restored areas mapping effort.

Many restoration datasets provide only point features for the locations of restoration projects. Outreach to restoration project leads was conducted when polygon data showing the extent of the tidally restored area were not available. When polygon data were available, the actual extent of the tidally restored area was not always well defined. In many cases, the polygon represented the full scope of the project, which was beyond the extent of tidal reconnection. To identify the tidally restored area, PMEP used a combination of the PMEP TWL assessment detailed layer (which was based on elevation data) and aerial imagery (see sources above), and included areas that were part of the restoration effort. The extent of restored areas is an estimate based on available data, aerial photo-interpretation, and in some cases professional expert input.

Results of restoration are not instantaneous; changes to habitat as a result of restoration take time, and in some areas, maintenance.

Restoration efforts included in this effort were conducted over different periods of time, therefore, restored areas may be at different stages of habitat recovery. For example, former salt ponds in San Francisco Bay which were tidally reconnected by removing dikes or levees will take time for adequate sediment to accumulate to re-establish vegetated tidal wetlands from mudflat or open water.Data for this effort came from a variety of disparate data sources which have different data fields (Appendix A), and not all attributes included in PMEP's dataset (see Appendix C) were available for each data source.

The data compiled and standardized represent a snapshot in time, and were developed to improve the TWL assessment. PMEP does not currently intend to be a long-term steward of restored tidal wetlands data; the best sources for data on restored areas are the regional restoration databases, and the organizations that engage in restoration.

RECOMMENDATIONS

The main goal of this effort was to update PMEP's TWL assessment to include restored areas. Currently, there is no comprehensive, quantitative source of tidal restoration efforts along the West Coast. The data in this effort can be updated and expanded by PMEP, or other entities interested in restoration, to identify all tidal restoration efforts that have occurred historically and the many tidal restoration projects that are currently underway.

Not all restoration projects have spatial data available on the extent of the tidally restored area. This information should be made available, because it is important for understanding where habitat improvements and re-connections occur, both for monitoring changes in habitats across the West Coast as well as for planning and prioritizing future restoration efforts. PMEP recommends that restoration practitioners and their data managers include the following fields in the GIS data showing the extent of tidal restoration:

- Project name
- Short project description (less than 250 words)
- Date completed
- Mapped spatial extent of tidally restored area
- Restoration action (dike removal, tide gate removal, etc.)
- Degree of tidal reconnection (muted tidal, fully tidal)
- Biotic classification of tidal wetland habitats restored, using CMECS classification system
- Project contact
- Link to project information/reports /data

PMEP's Estuary Extent is a consistent, West-Coast wide dataset showing the current and historical extent of estuaries and tidal wetlands, and is a good baseline dataset for mapping the extent of tidally restored areas. In the future, as restoration practitioners and resource agencies map tidally restored areas, we recommend the use of PMEP's estuary extent dataset as a consistent source for determining the extent of tidal restoration. This will place each project within a consistent spatial dataset, allowing analysis within the context of work being done across the West Coast. One example of this is the Puget Sound Partnership's Vital Signs monitoring and reporting, where PMEP's estuary extent data was chosen as the best data source to develop the "full potential estuary surface footprint" to track and assess river delta restoration efforts in Puget Sound (Ramirez 2019).

More information is needed on tide gate upgrades and modifications and the degree to which they restore tidal connectivity. Data showing the degree of tidal re-connection achieved through tide gate upgrades or modifications were not available with these projects. PMEP recommends that entities upgrading and modifying tide gates for the purpose of tidal wetland reconnection should document over time the degree and extent of tidal re-connection resulting from the upgrades and modifications, and monitor the effects of the re-connection on wetland ecosystems as well as species of concern.

As areas are restored for tidal connectivity, habitat and wetland types within these areas will change. Loss of tidal wetlands has resulted in not only a decrease in available estuarine habitat, but also a shift in the distribution of accessible habitat and reduction in diversity of wetland types (Beamer et al. 2005, Brophy 2019). Existing, standardized habitat data (such as PMEP's West Coast USA Biotic Habitat) are recommended for classifying habitat types within the identified restored areas. This would provide a baseline understanding of the suite of habitats being restored to be used by managers and organizations planning for restoration.

Future Data Updates

Tidal wetland restoration is an ongoing activity along the West Coast. PMEP is the steward of these data, and will update this dataset as needed, pending funding.

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Appendix A: List of Data Sources

Data Source	Dataset Name	Dataset Type	Public Data Link
National Oceanic and Atmospheric Administration (NOAA)	National Restoration Atlas	Regional	https://restoration.atlas.noaa.gov/src/html/index.html
WA State Recreation and Conservation Office	Washington Habitat Work Schedule	Regional (Washington)	http://hws.ekosystem.us/
WA State Recreation and Conservation Office	Washington Project Information System (PRISM) database	Regional (Washington)	https://rco.wa.gov/prism_app/about_prism.shtml
Oregon Watershed Enhancement Board (OWEB)	Watershed Restoration Inventory (OWRI)	Regional (Oregon)	https://oregonexplorer.info/content/oregon-watershed-restoration-inventory-owri
San Francisco Estuary Institute (SFEI)	EcoAtlas Project Tracker	Regional (California)	https://ecoatlas.org/
California Department of Fish and Wildlife (CDFW)	Fisheries Restoration Grant Program Projects	Regional (California)	https://www.wildlife.ca.gov/Grants/FRGP
California Eco Restore	EcoRestore Restoration Projects	Regional (San Francisco Bay Area)	http://resources.ca.gov/ecorestore/california-ecorestore-projects/
Southern California Wetlands Recovery Project	Restoration Project Database	Organizational restoration database	
Skagit River Systems Cooperative		Organizational restoration database	
Lower Columbia Estuary Partnership		Organizational restoration database	
Hood Canal Salmon Enhancement Board		Organizational restoration database	
Tulalip Tribes		Organizational restoration database	

Data Source	Dataset Name	Dataset Type	Public Data Link
Puget Sound Partnership		Organizational restoration database	
Oregon Central Coast Estuary Collaborative (OCCEC)		Organizational restoration database	
Elkhorn Slough National Estuarine Research Reserve		Organizational restoration database	
South Slough National Estuarine Research Reserve		Organizational restoration database	
U.S. Fish and Wildlife Service	Bear River Estuary	Site Specific	
City of Arcata	South Jacoby Creek	Site Specific	
Institute for Applied Ecology	Wilbur Mitigation Bank, Lower Drift Restoration Project, Alder Creek Farm, Millport Slough - Jackson & Gray Tracts, North Fork Restoration	Site Specific	
Nisqually Indian Tribe	Nisqually Delta Restoration	Site Specific	

Appendix B: Restored Areas Geodatabase

A final ArcGIS file geodatabase and metadata delineating the extent of restored tidal wetlands, and updated data on TWL assessment is available on the PMEP website:

http://www.pacificfishhabitat.org/data/tidal-wetlands-loss-assessment

Appendix C: Attribute Table Fields

Field	Field Description
Restoration Project Information	
ProjectTitle	Title of the restoration project, from data source
ProjectDescription	Brief description (250 words or less) of the project from the data source
Completion Year	Year restoration project was completed yyyy
Status	Status of the restoration project
Project Identification	
SourceDataID	Record ID from the data source
DataIDField	Field for the SourceDataID in the data source
DatasetName	Name of the dataset where the record was retrieved
SiteName	The site name or location of the restoration project, based on the source
DataContact	Contact for the data source
Organization	Lead organization for the restoration project
FunderName	Funding source for the restoration project
ProjectWebLink	URL for more information on the project
SourceDataNotes	Notes about the data source
Restoration Habitat Plan	
RestorationTechnique	Type of restoration activity
WaterRegime	The type of tidal inundation that was restored
HabAmount	Quantity of habitat restored from the source (note: this may differ than actually calculated areas)
HabAmountUnits	Units for the quanitity of habitat restored
HabitatType	Description of habitat restored by the source
PMEP Spatial Data System	
EstuaryName	PMEP Estuary Name
Link	PMEP Estuary LinkID
State	State where the restoration project was completed
Polygon	Is there a polygon associated with the restoration project
PMEP_UID	Unique ID created by PMEP for the resotration project
ActualHabAcres	Calculated acres

Appendix D: PMEP Inventory Restored Areas by Estuary

In some cases, NWI year of data collection is more recent than the completion date for the restoration effort. This is most likely due to the time it takes after restoration for tidal influence to have effect on the landscape.

EstuaryName	ProjectTitle	Reported Restored Area (Ha)	Reported Restored Area (Acres)	Completion Year	NWI Year
Padilla Bay	Swinomish Channel Fill Removal and Marsh Restoration	4	10	2014	1981
Skagit Bay	Wiley Slough Dike Removal	64	157	2010	1981
	Deepwater Slough Restoration	81	200	2000	1981
	Milltown Island	69	170	2014	1981
	Fisher Slough Floodgate, Levee, Marsh Construction	23	57	2011	1981
	SF Levee Setback	8	19	2007	1981
Stillaguamish River	Livingston Bay Pocket Estuary Restoration Phase III	4	10	2013	1981
	Port Susan Bay Estuary Restoration Implementation	63	156	2013	1981
	zis a ba Estuary Restoration	36	88	2019	1981
	Fir Island Farm Restoration Construction	53	131	2016	1981
Snohomish River	Spencer Island Estuary Restoration	162	400	2007	1981
	Qwuloolt Estuary Restoration Project	143	354	2015	1981
	Smith Island/Union Slough Estuarine Habitat Restoration	38	93	2013	1981
	Smith Island Estuary Restoration	153	378	2018	1981
	Port of Everett Union Slough	8	19	2001	1981
	Marysville Mitigation	1	3	Unknown	1981
Appletree Cove	Carpenter Creek Estuary Restoration	12	30	2013	1981
Nisqually River	Nisqually Refuge Estuary Restoration	308	760	2011	1981
	Nisqually Estuary/Red Salmon Slough Rest	40	100	2007	1981
Lynch Cove	Union River Estuary Restoration	12	29	2014	1980
	Klingel Estuarine Levee Removal	6	15	2011	1980
	Belfair State Park Estuary Restoration	3	8	2009	1980
Skokomish River	Skokomish Estuary Restoration Phase 1- Nalley Slough	47	115	2007	1980
	Skokomish Estuary Restoration Phase 2- Nalley Island	90	224	2011	1980
	Skokomish Estuary Restoration Phase 3 A,B - Skokomish Flats	14	34	2014	1980
Duckabush River	Duckabush Robinson Road Levee Removal	2	4	2008	1980

EstuaryName	ProjectTitle	Reported Restored Area (Ha)	Reported Restored Area (Acres)	Completion Year	NWI Year
Quilcene Bay	B. Little Quilcene Estuary Restoration	15	37	2009	1980
	C. Schinke Dike Removal and Channel Enhancement	10	24	2009	1980
	Little Quilcene River Delta Cone Removal	2	6	2015	1980
	WDFW Big Quilcene Estuarine Dike Removal	1	4	2008	1980
	Quilcene River Restoration - Muncie Avenue	8	19	2014	1980
Shine Creek	Shine Creek Estuary Tidal Exchange Restoration	10	25	2012	1981
Willapa Bay	Bear River Estuary Restoration	208	513	2013	2011
Columbia River - Reach A	Fort Clatsop - Colewart Creek	0	1	2013	2011
	Fort Columbia	5	12	2011	2011
	Haven Island	39	97	2010	2011
	Lewis & Clark River Dike Breaches	5	12	2006	2011
	Otter Point Dike Breach	13	33	2012	2011
	Wallacut River Acquisition & Restoration	46	113	2017	2011
	Walluski River North, Elliot property #1	10	24	2008	2011
	Sharnelle Fee Property	20	50	2014	2011
	Chinook River WDFW Conservation & Restoration	170	420	2014	2011
	Port of Astoria Warrenton Airport Dike Breach	12	30	2002	2011
	Walluski / Youngs Confluence	68	169	2017	2011
	Trestle Bay Jetty Breach	254	628	2016	2011
Columbia River - Reach B	Brownsmead/Blind Slough	8	20	2005	1981
	Grays Bay - Deep River. Svensen's Landing Acq. & Rest.	0	0	2005	1981
	Gnat Creek Tidal Wetlands Restoration	8	20	2012	1981
	Grays Bay - Kandoll Farm Conservation & Restoration	66	163	2013	1981
	South Tongue Point (Liberty Lane)	6	15	2012	1981
	Grays Bay - Mill Road Conservation & Restoration	22	55	2011	1981
	Gnat Creek North	24	60	2013	1981

EstuaryName	ProjectTitle	Reported Restored Area (Ha)	Reported Restored Area (Acres)	Completion Year	NWI Year
	Grays Bay - Devils Elbow Non-AA Acquisition & Rest - Johnson Farm	36	88	2004	1981
	Karlson Island Restoration	127	314	2014	1981
	Julia Butler Hansen NWR - Steamboat Slough	28	68	2014	1981
Columbia River - Reach C	Dibblee Point	7	18	2013	1981
	Louisiana Swamp Restoration Project	13	32	2013	1981
	Crims Island Acquisition & Restoration	77	190	2006	1981
	Kerry Island Acquisition & Restoration	40	100	2016	1981
	Westport Slough, USFWS	20	50	2016	1981
Columbia River - Reach E	Lewis River East Fork - Reach5A-B Side Channel	1	3	2017	1981
Columbia River - Reach F	Oaks Bottom Habitat Enhancement Project	30	75	2018	2009
	Ramsey Wetland Complex Off-Channel Habitat Design and Restoration	1	3	2005	2009
	Sauvie Island North Unit CREST/PC Trask	50	123	2015	2009
	Crane Slough - Domeyer Wetland Restoration	10	25	2016	2009
	Willow Bar Restoration	8	19	2016	2009
Columbia River - Reach G	Sandy River Dam Breach	21	51	2013	1981
Columbia River - Reach H	Horsetail Creek	39	96	2013	2011
Nehalem River	Alder Creek Farm	14	35	2005	2000
Tillamook Bay	Tillamook Bay Southern Flow Corridor Restoration	179	443	2017	2000
	Kilchis Wetlands Restoration Project	27	66	2017	2000
	Miami River Restoration Project	18	44	2011	2000
Nestucca Bay	Little Nestucca Tidal Marsh Restoration Project	33	82	2007	2014
Salmon River	Pixieland Restoration	20	50	2014	2014
	Tamara Quays Dike Removal and Fish Passage Culvert	5	13	2010	2014
	Crowley Creek Restoration	1	3	2014	2014
Siletz Bay	Millport Slough – Jackson & Gray Tracts	81	200	2003	2010

EstuaryName	ProjectTitle	Reported Restored Area (Ha)	Reported Restored Area (Acres)	Completion Year	NWI Year
Yaquina Bay	Yaquina Bay Estuary (35th street) Fish Passage	2	6	2010	2010
	Yaquina Estuarine Wetland Restoration	15	38	2002	2010
Alsea Bay	Lint Slough Restoration Project	53	130	2009	2010
	Lower Drift Restoration Project	33	82	2005	2010
Siuslaw River	Karnowsky Creek	0	1	2001	2000
	North Fork Restoration	3	7	2007	2000
	Wilbur Mitigation Bank	66	162	Unknown	2000
	North Fork Siuslaw Estuary Tide Channel Restoration Project	34	85	2001	2000
Coos Bay	Perrin Wetland Restoration	1	2	2003	2000
	Winchester Tidelands	13	33	1998	2000
Coquille River	Lowe Creek Channel and Wetlands Restoration at Boatman Grove	36	90	2007	2011
	Bandon Marsh NWR Ni-les'tun Restoration	169	418	2013	2011
Humboldt Bay	McDaniel Slough Tidal Restoration - ERA	94	232	2013	2010
	Wood Creek Tidal Marsh Enhancement Project	14	34	2009	2010
	Salmon Creek Delta, Phase 2 Implementation	6	14	2008	2010
	South Jacoby Creek Wetland Enhancement and Restoration Project	12	30	2018	2010
	Salmon Creek Delta, Phase 2 Implementation	6	14	2008	2010
Eel River	Riverside Ranch Salt River Restoration	134	330	2013	2010
Tomales Bay	Giacomini Wetlands	247	610	2008	1985
Sacramento-San Joaquin Delta	Decker Island Tidal Restoration	45	110	2017	2012
Suisun-Grizzly Bays	Biological Restoration and Monitoring in the Suisun Marsh/North San Francisco Bay Ecological Zone	Unknown	Unknown	2015	2009
	Blacklock Restoration Project	28	70	2006	2009

EstuaryName	ProjectTitle	Reported Restored Area (Ha)	Reported Restored Area (Acres)	Completion Year	NWI Year
	Hill Slough Tidal Restoration	304	750	2018	2009
	Tule Red Tidal Restoration	162	400	2018	2009
San Pablo Bay	Petaluma River Marsh (Carl's Marsh)	18	45	1994	2009
	Sonoma Baylands Restoration Project	123	305	2007	2009
	Sears Point Wetland and Watershed Restoration Project	59	146	2015	2009
	Tolay Creek	124	306	2002	2009
	Hamilton/Bel Marin Keys Wetlands Restoration	301	744	2014	2009
	Little Island Farms	123	305	2008	2009
	Cullinan Ranch	117	290	2015	2009
	Napa-Sonoma Marshes - Ponds 3, 4, and 5	1,253	3,095	2006	2009
	Green Island Unit (Napa Plant Site Restoration)	437	1,080	2010	2009
	Napa Plant Site	591	1,460	2010	2009
	Dotson Family Marsh Restoration & Public Access Project	61	150	2015	2009
San Francisco Bay	Crissy Field Phase 1	4	10	2001	2009
South San Francisco Bay	South Bay Salt Ponds: Eden Landing - Ponds E8A, E9, E8X	276	681	2011	2009
	South Bay Salt Ponds: Alviso - A8 Pond Cluster - Ponds A8, A8S, A5, A7	352	870	2011	2009
	Bair Island Restoration	969	2,394	2012	2009
	South Bay Salt Ponds: Alviso - Knapp Tract - Pond A6	134	332	2010	2009
	South Bay Salt Ponds: Alviso - Pond A16, A17	53	130	2013	2009
	Eden Landing Ecological Reserve - Baumberg Tract Restoration	314	775	2008	2009
	Oro Loma Marsh Restoration - Hayward Regional Shoreline	147	364	1997	2009
	Candlestick Point - Yosemite Slough Wetland Restoration	6	16	2017	2009
	South Bay Salt Ponds: Alviso - Island Ponds A19, A20, A21 (Initial Restoration Actions)	196	485	2006	2009

EstuaryName	ProjectTitle	Reported Restored Area (Ha)	Reported Restored Area (Acres)	Completion Year	NWI Year
Elkhorn Slough	Hester Marsh Restoration Phase I	25	61	2018	2005
	Whistlestop Lagoon	6	14	2014	2005
Bolsa Chica Lowlands	Bolsa Chica Wetlands Restoration	231	570	2008	2005
San Diego Bay	South San Diego Bay Restoration - Western Salt Ponds	104	257	2011	2005

Appendix E: PMEP Estuaries Table with % Tidal Wetland Loss and Restored Area by Estuary

Estuary Name	PMEP Region	CMECS Physiographic Setting	Historical Estuary Extent (ha)	Historical Extent - Vegetated (ha)	Current Extent - Vegetated (ha)	Restored Area Extent (ha)	Restored Area %	Vegetated Loss % (Pre Restoration)	Vegetated Loss % (After Restoration)
Birch Bay	Salish Sea	Embayment/ Bay	677.3	146.4	19.2	0.0	0.0%	86.9%	NA
Nooksack River	Salish Sea	Major River Delta	6,421.2	2,729.1	274.2	0.0	0.0%	90.0%	NA
Samish Bay	Salish Sea	Major River Delta	6,685.5	3,336.0	59.8	0.0	0.0%	98.2%	NA
Padilla Bay	Salish Sea	Embayment/ Bay	8,553.9	2,691.1	111.7	0.4	0.01%	95.9%	95.9%
Dugualla Bay	Salish Sea	Embayment/ Bay	653.7	245.5	11.4	0.0	0.0%	95.4%	NA
Skagit Bay	Salish Sea	Major River Delta	17,144.6	9,803.0	1,705.3	134.6	1.4%	82.6%	81.2%
Stillaguamish River	Salish Sea	Major River Delta	9,954.3	3,124.1	911.2	97.8	3.1%	70.8%	67.7%
Snohomish River	Salish Sea	Major River Delta	9,438.1	6,330.9	672.9	513.5	8.1%	89.4%	81.3%
Deer Lagoon / Useless Bay	Salish Sea	Embayment/ Bay	664.8	371.0	14.8	0.0	0.0%	96.0%	NA
Nisqually River	Salish Sea	Major River Delta	1,968.6	979.2	298.9	346.4	35.4%	69.5%	34.1%
Lynch Cove	Salish Sea	Embayment/ Bay	678.0	170.9	129.4	18.6	10.9%	24.3%	13.4%
Skokomish River	Salish Sea	Major River Delta	1,035.2	394.8	202.0	127.4	32.3%	48.8%	16.6%
Quilcene Bay	Salish Sea	Major River Delta	446.8	126.0	106.1	12.5	9.9%	15.8%	5.9%
Waatch River	WA, OR, Northern CA Coast	Riverine Estuary	162.4	122.0	120.8	0.0	0.0%	1.0%	NA
Grays Harbor	WA, OR, Northern CA Coast	Riverine Estuary	33,583.2	8,711.9	4,753.8	0.0	0.0%	45.4%	NA
Willapa Bay	WA, OR, Northern CA Coast	Riverine Estuary	43,264.3	8,040.0	4,780.6	79.4	1.0%	40.5%	39.6%
Columbia River - Reach A	WA, OR, Northern CA Coast	Riverine Estuary	20,903.9	6,291.0	1,063.0	271.7	4.5%	83.1%	78.8%
Columbia River - Reach B	WA, OR, Northern CA Coast	Riverine Estuary	34,094.7	9,252.3	4,782.1	137.0	1.5%	48.3%	46.8%
Columbia River - Reach C	WA, OR, Northern CA Coast	Riverine Estuary	17,294.4	10,403.0	1,695.7	119.1	1.1%	83.7%	82.6%

Estuary Name	PMEP Region	CMECS Physiographic Setting	Historical Estuary Extent (ha)	Historical Extent - Vegetated (ha)	Current Extent - Vegetated (ha)	Restored Area Extent (ha)	Restored Area %	Vegetated Loss % (Pre Restoration)	Vegetated Loss % (After Restoration)
Columbia River - Reach D	WA, OR, Northern CA Coast	Riverine Estuary	4,354.3	2,338.8	156.2	0.0	0.0%	93.3%	93.3%
Columbia River - Reach E	WA, OR, Northern CA Coast	Riverine Estuary	5,951.9	3,413.1	211.0	1.1	5.3%	93.8%	93.8%
Columbia River - Reach F	WA, OR, Northern CA Coast	Riverine Estuary	21,127.6	12,184.8	3,686.9	3.7	0.03%	69.7%	69.7%
Columbia River - Reach G	WA, OR, Northern CA Coast	Riverine Estuary	8,976.0	3,319.2	544.6	4.3	0.3%	83.6%	83.5%
Columbia River - Reach H	WA, OR, Northern CA Coast	Riverine Estuary	3,639.1	541.9	259.6	45.4	8.4%	52.1%	43.7%
Nehalem River	WA, OR, Northern CA Coast	Riverine Estuary	2,126.0	1,196.4	546.5	3.1	0.3%	54.3%	54.1%
Tillamook Bay	WA, OR, Northern CA Coast	Riverine Estuary	5,677.1	2,292.1	494.2	181.6	7.9%	78.4%	70.5%
Netarts Bay	WA, OR, Northern CA Coast	Embayment/ Bay	1,065.9	126.0	119.8	0.0	0.0%	4.9%	4.9%
Nestucca Bay	WA, OR, Northern CA Coast	Riverine Estuary	1,119.4	660.3	134.7	0.5	0.1%	79.6%	79.5%
Salmon River	WA, OR, Northern CA Coast	Riverine Estuary	356.8	254.6	229.9	6.0	2.4%	9.7%	7.3%
Siletz Bay	WA, OR, Northern CA Coast	Riverine Estuary	1,097.2	467.1	242.8	2.7	0.6%	48.0%	47.4%
Yaquina Bay	WA, OR, Northern CA Coast	Riverine Estuary	2,690.9	983.2	295.3	15.8	1.6%	70.0%	68.4%
Alsea Bay	WA, OR, Northern CA Coast	Riverine Estuary	1,441.6	496.0	367.0	38.7	7.8%	26.0%	18.2%
Siuslaw River	WA, OR, Northern CA Coast	Riverine Estuary	2,557.7	1,445.0	648.0	76.1	5.3%	55.2%	49.9%
Umpqua River	WA, OR, Northern CA Coast	Riverine Estuary	5,025.6	1,942.9	861.9	0.0	0.0%	55.6%	NA
Coos Bay	WA, OR, Northern CA Coast	Riverine Estuary	8,322.8	3,286.5	896.0	7.7	0.2%	72.7%	72.5%
Coquille River	WA, OR, Northern CA Coast	Riverine Estuary	4,378.5	3,497.0	157.1	187.3	5.4%	95.5%	90.2%

Estuary Name	PMEP Region	CMECS Physiographic Setting	Historical Estuary Extent (ha)	Historical Extent - Vegetated (ha)	Current Extent - Vegetated (ha)	Restored Area Extent (ha)	Restored Area %	Vegetated Loss % (Pre Restoration)	Vegetated Loss % (After Restoration)
Smith River	WA, OR, Northern CA Coast	Riverine Estuary	481.3	130.7	29.8	0.0	0.0%	77.2%	NA
Humboldt Bay	WA, OR, Northern CA Coast	Embayment/ Bay	10,683.3	3,777.1	532.3	108.3	2.9%	85.9%	83.2%
Eel River	WA, OR, Northern CA Coast	Riverine Estuary	4,275.5	2,991.2	447.8	119.1	4.0%	85.0%	81.0%
Drakes Estero	Central California	Embayment/ Bay	1,118.3	282.0	274.5	0.0	0.0%	2.7%	NA
Bolinas Lagoon	Central California	Embayment/ Bay	510.4	136.2	117.0	0.0	0.0%	14.1%	NA
Sacramento-San Joaquin Delta	Central California	Major River Delta	174,212.0	154,033.0	4,964.3	48.0	0.03%	96.8%	96.7%
Suisun-Grizzly Bays	Central California	Embayment/ Bay	37,832.8	25,539.7	3,262.5	425.1	1.7%	87.2%	85.6%
San Pablo Bay	Central California	Embayment/ Bay	57,510.4	25,016.2	6,185.0	3,006.3	12.0%	75.3%	63.3%
San Francisco Bay	Central California	Embayment/ Bay	24,164.1	1,207.2	385.4	6.9	0.6%	68.1%	67.5%
South San Francisco Bay	Central California	Embayment/ Bay	74,972.1	25,182.4	3,480.9	1,854.7	7.4%	86.2%	78.8%
Elkhorn Slough	Central California	Embayment/ Bay	2,398.0	1,662.6	511.7	0.0	0.001%	69.2%	69.2%
Morro Bay	Central California	Embayment/ Bay	1,046.4	211.3	207.2	0.0	0.0%	2.0%	NA
Mugu Lagoon	Southern California Bight	Riverine Estuary	1,321.7	980.2	491.1	0.0	0.0%	49.9%	NA
Alamitos Bay	Southern California Bight	Embayment/ Bay	343.1	144.4	19.2	0.0	0.0%	86.7%	NA
Anaheim Bay	Southern California Bight	Embayment/ Bay	763.0	418.6	265.9	0.0	0.0%	36.5%	NA
Huntington Channel	Southern California Bight	Embayment/ Bay	625.4	582.3	27.6	0.0	0.0%	95.3%	NA
Newport Bay	Southern California Bight	Embayment/ Bay	808.8	279.4	162.3	0.0	0.0%	41.9%	NA
San Diego Bay	Southern California Bight	Embayment/ Bay	5,195.9	679.2	166.2	91.6	13.5%	75.5%	62.0%
Tijuana River	Southern California Bight	Riverine Estuary	332.4	263.3	249.8	0.0	0.0%	5.1%	NA