



Tidal marsh, Corte Madera • UAS imagey by Pete Kauhanen, SFEI

ALIGNING PLANNED INDICATORS OF THE WETLANDS REGIONAL MONITORING PROGRAM WITH OTHER SAN FRANCISCO ESTUARY EFFORTS

PHASE 2 VERSION

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The WRMP is co-managed by the San Francisco Estuary Partnership
(Estuary Partnership) and San Francisco Estuary Institute (SFEI)

SFEI San Francisco
Estuary Institute



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Tidal marsh, Corte Madera • UAS imagery by Pete Kauhanen, SFEI

INTRODUCTION

Aligning the Wetlands Regional Monitoring Program with Estuary-wide Efforts

[The Wetlands Regional Monitoring Program \(WRMP\)](#) has planned for a suite of indicators and metrics to address management questions that inform five Guiding Questions about the status and management of the San Francisco Bay tidal wetlands. The WRMP's indicator metrics can be quantified and tracked through time to monitor the changing ecological conditions, and to inform science-based decision-making for wetland restoration and adaptive management.

There are several similar ongoing regional indicator efforts across the entire San Francisco Estuary (Estuary) that—despite having differences in geographic scope, focus, or definitions—join the WRMP in ultimately asking, “How is the Estuary doing; how can we protect and improve ecological conditions and functions and human benefits; and are our protections and improvements working?”

For this document, we define Regional Indicator Effort as an Estuary entity that has developed multiple conceptual indicators informed by quantitative metrics, to track progress in Estuary health as part of the effort's stated goals and objectives. We elaborate on this in the section: [Regional Indicator Efforts](#)

Geographic Scope

The geographic scope for the WRMP indicator alignment is the Estuary, which includes the geographic scope of the Bay (defined here as San Francisco Bay, San Pablo Bay, Suisun Bay and their watersheds, and the Sacramento-San Joaquin Delta; Figure 1).



Figure 1. Geographic scope of the San Francisco Estuary indicator alignment study area (map from the State of the Estuary Report, developed by the Estuary Partnership).

Regional Indicator Efforts

In addition to the WRMP, several ongoing initiatives are dedicated to evaluating the health of the Estuary. Each effort has a distinct focus, whether it pertains to ecosystem type or function, geographic extent (Figure 2), or taxonomic group. Nonetheless, these efforts share common objectives, indicators or metrics, and communication strategies, and all would benefit from coordination among them.

The Regional Indicator Efforts in this and the [Summary of Indicators](#) section of this document were included based on the following criteria:

- **The indicator effort must be published and accessible** by publication date of this version of the report
- **The effort has developed conceptual indicators**—informed by quantitative metrics—for evaluating and communicating its goals and objectives related to the health of the San Francisco Bay, Delta, or Estuary as a whole
- **An effort’s metrics may rely on data collected by another entity** and collaboratively compiled to address the goals and objectives of the individual effort, or may be collected in-house.

If a monitoring program or strategy does not meet these criteria, but broadly informs and interacts with WRMP’s indicator alignment efforts, or would benefit from aligning with the WRMP, they are included at the end of this subsection and/or where topically relevant in the [Roadmap for Alignment](#) section. Numerous individual monitoring projects, teams, and strategies inform these regional indicator efforts—for example, the South Bay Salt Pond Restoration Project (SBSP) and Nutrient Management Strategy (NMS)—but do not meet the criteria for inclusion as a Regional Indicator Effort. It is also important to note that for indicators and metrics involving a federally listed species, the U. S. Fish and Wildlife Service recovery plan for that species, and its associated targets and roadmap for recovery would take precedence.

The following Regional Indicator Efforts make use of indicators and associated quantitative metrics to measure and communicate their goals and objectives.

- **Wetland Regional Monitoring Program (WRMP).** Co-administered by SFEI and the Estuary Partnership, the WRMP is coordinated regional monitoring of the San Francisco Estuary’s wetlands to inform science-based decision-making for wetland restoration and adaptive management and to increase the cost-effectiveness of permit-driven monitoring associated with wetland restoration projects (WRMP 2022).
- **San Francisco Bay Restoration Authority (Restoration Authority).** Staffed by the State Coastal Conservancy (SCC) and the Estuary Partnership.
- **State of the Estuary Report (SOTER).** A product of the Estuary Partnership and the Delta Stewardship Council (DSC), it reviews a broad range of indicators, depicting the health of the Estuary using status scores and trends (e.g., Estuary Partnership 2015, 2019). This report shares several indicators with the WRMP, State of the Birds and San Francisco Bay Joint Venture, and the Bay RMP.
- **Regional Monitoring Program for Water Quality in San Francisco Bay (Bay RMP).** Collaborative effort between the SFEI, the Regional Water Quality Control Board, and the regulated discharger community. Comprehensively assesses water quality across the Bay, producing The Pulse of the

WRMP

How are tidal marsh wetlands doing and are they supporting the functions and services we want?



SOTER

What is the health of the Estuary and how well is the Estuary supporting people and wildlife?



DELTA PM

Are we meeting the coequal goals of a reliable water supply for CA and a healthy Delta ecosystem?



SFBJV

Are we protecting, restoring, increasing, and enhancing habitats throughout the Bay for the benefit of birds, other wildlife, and people?



Restoration Authority

How successful is restoration and what benefits are Measure AA funded projects providing?



Figure 2 - Geographic scope and key questions of several efforts in need of alignment.

Bay (SFEI 2022) and RMP Update reports (SFEI 2023a). Most water quality indicators used by WRMP and SOTER rely on RMP data.

- **San Francisco Bay Joint Venture (SFBJV) State of the Birds San Francisco Bay (SOTB).** In partnership with Point Blue Conservation Science, SOTB summarizes monitoring data to report the current status of bird populations and their recent trends across multiple habitat types of the Bay (Point Blue and SFBJV 2011). Several indicators are common to the WRMP and SOTER.
- **Delta Plan: Ecosystem Amendment Performance Measures (Delta PM).** Developed by the DSC, the Delta Plan is California's comprehensive long-term plan for managing water and environmental resources in the Delta and Suisun Marsh. The Ecosystem Amendment Performance Measures (Delta PM) track achievement of goals and objectives defined in the Delta Plan (DSC 2023). Though the WRMP covers only the Suisun Bay portion of the Delta PM study area, the Estuary Partnership and SOTER efforts cover the Delta. Alignment between WRMP indicators and the Delta PM will improve efficiency and communication across the Estuary.
- **The Delta Regional Monitoring Program (Delta RMP) is implemented by a non-profit organization also called the Delta Regional Monitoring Program (DRMP).** It tracks and documents the effectiveness of beneficial use protection and restoration efforts through water quality monitoring the Delta region. Most indicators are common to the Delta Plan PM.

RELATED PROGRAMS AND PRODUCTS

While not explicitly incorporating stand alone indicators, the following additional efforts broadly inform and interact with WRMP's indicator alignment efforts.

- **The Baylands Ecosystem Habitat Goals Science Update (BEHGU).** Produced by 21 management agencies and over 100 scientists, it synthesizes the state of the science and updates to generate strategies to sustain a healthy SF Baylands ecosystem (Goals Project 2015; an update to the 1999 Bayland Ecosystem Habitat Goals). Includes case studies for 32 species or species groups from which common patterns are gleaned to inform specific management actions for enhancing population resilience that is expected to maintain or restore populations. Several case study species or species groups align with indicators selected for SOTER and SFBJV SOTB.
- **The San Francisco Estuary Blueprint (Blueprint).** A product of the Estuary Partnership, a comprehensive conservation and management plan and collaborative agreement and roadmap for how to protect and restore the Estuary. The SFEB identifies consensus-based regional priorities, asks participating entities to commit to identified actions, and tracks achievement progress on publicly available sources (Estuary Partnership 2022).
- **Baylands Resilience Framework for the San Francisco Bay (BRF).** Developed by SFEI, this is a framework for increasing Bay shoreline resilience through management of natural shoreline elements to sustain desired ecosystem functions. The BRF identifies a suite of shoreline resilience elements, many of which are being considered as WRMP indicators (SFEI 2023b).
- **Bay Conservation and Development Commission (BCDC).** The BCDC's Bay Adapt Joint Platform established nine goals to achieve adaptation to San Francisco Bay's rising waters. The Bay Adapt Metrics—an online dashboard to track and report progress and guide future actions of the BCDC—is expected to be released in 2024.

Definitions

INDICATORS, METRICS, AND WHAT'S BEING INDICATED

Some of the difficulty in coordinating across multiple efforts is the use of different terminology or definitions for commonly used terms (Heink and Kowarik 2010). To better align indicators, we need to understand the intent of each effort: how does an initiative define an indicator versus a metric, and what component of the Estuary is being indicated? This report adopts the WRMP’s definition of indicator and metric. Table 1 provides this definition in comparison to other effort definitions.

Table 1: A comparison of how each effort defines “indicator” and “metric” and what is broadly being indicated. Examples are provided. “Not explicitly defined” means we were unable to find an explicit definition in the effort’s documentation, but the definition is implied.

EFFORT	INDICATING WHAT?	INDICATOR	METRIC
WRMP	Tidal wetland condition, function and status of factors driving persistence	Factors or processes to monitor in order to answer monitoring questions. <i>Example: map of complete marshes</i>	How indicators are quantified. <i>Example: acres and mapped locations of complete marshes</i>
Restoration Authority	Benefits provided by shoreline restoration projects	Not explicitly defined; uses Performance Measures. <i>Example: Habitat restoration and enhancement</i>	Not explicitly defined; uses Performance Measures. <i>Example: Number of acres of tidal marsh restored</i>
SOTER	Estuary health	Not explicitly defined. Internal definition: Components measured to represent the conditions and attributes of natural and socioeconomic systems, with a defined approach for measuring status and trends over times. <i>Example: Fish</i>	Not explicitly defined. Specific quantitative measure. <i>Example: Bay Fish Index comprised of 10 different metrics (e.g., fish species composition)</i>
Bay RMP	SF Bay water quality	Not explicitly defined. <i>Example: Bay contamination</i>	Not explicitly defined. <i>Example: Mercury concentration in SF Bay fish species</i>
SFBJV SOTB	Bay habitats and ecosystem conditions, via bird population health of select birds in that habitat	Not explicitly defined. <i>Example: Tidal marsh birds</i>	Not explicitly defined. <i>Example: Index of abundance of Song Sparrow, Saltmarsh Common Yellowthroat, California Black Rail</i>
Delta PM	Achievement of Delta Plan goals & objectives	Performance Measure to track how well goals and objectives are being achieved. <i>Example: Urban water use</i>	Quantitative measure to assess the Performance Measure. <i>Example: Gallons per capita per day of urban water use.</i>
Delta RMP	Effectiveness of restoration and beneficial use protection	Not explicitly defined. <i>Example: Delta water quality</i>	Not explicitly defined. <i>Example: PFOS concentration in environmental water samples</i>

What is “Indicator Alignment”?

Indicator alignment is the process of summarizing and coordinating the selection and use of specific indicators, metrics, or criteria across different programs or initiatives. It aims to create efficiency, consistency, and better decision-making among them. In general, alignment aims to:

- Adopt standardized indicators and metrics across efforts where possible and appropriate.
- Understand which groups and individuals are collecting and analyzing data for which indicators.
- Identify instances where the same dataset is used across efforts with different approaches or selected indicators or metrics.
- Understand differences in approaches to easily establish coherent messaging across efforts.

The ideal outcomes of **indicator alignment** are:

- Fewer, clearer messages communicating the health of the Estuary, while maintaining the identity and branding of individual efforts
- A more efficient use of resources
- Fewer data gaps or improved ability to manage resources within the region

Scope and Intended Use of This Report

This report lays out the plan for indicator coordination over the next 2-3 years and possibly beyond. We expect that components of what is included here will change over time and that this document will become outdated as alignment progresses. The 2023 Phase 1 version of this report was used as a tool to encourage discussion and solicit feedback; this 2024 Phase 2 version incorporates that feedback. Future Phases will represent substantial updates, including a proposed web-based tracker of alignment partners. Our intended audience is the WRMP, the other Regional Indicator Efforts highlighted in this report, permitting and regulatory agencies, and associated monitoring efforts and initiatives.



Oro Loma tidal marsh • Photo by Shira Bezalel, SFEI

SUMMARY OF INDICATORS

The WRMP Monitoring Matrix organizes each of the WRMP monitoring questions, indicators, and metrics by one or more of the WRMP Guiding Questions. Because individual WRMP indicators can align with multiple Guiding Questions, because other efforts organize their indicators in different ways, and because an aim of this report is to identify and summarize indicators from disparate efforts in an accessible way to assist alignment with the WRMP, we group indicators under the following 5 categories:

- *Habitat Extent and Configuration*
- *Water Quality and Quantity*
- *Resilience Processes*
- *Wildlife*
- *People*



Within each category, we group similar indicators across efforts into Indicator Groups. All 23 WRMP indicators included in the program plan (WRMP 2020) are summarized in this table. A larger suite of indicators and more details on specific metrics have been developed since 2020; these will be incorporated into future phases of this report. For SOTER indicators, we include only full indicators published in the 2015 report and the 2019 report and indicators currently being updated to full indicators for the 2025 report (e.g., soft shorelines, subsidence, and sediment); we do not report current or past emerging indicators. An effort listed here is not necessarily the entity responsible for the collection of the data for its indicator (e.g., SOTER compiles water quality data from the Bay RMP and Delta RMP for its water quality-related indicators), and efforts may use the same dataset and metric for their selected indicator.

Note that for indicators and metrics involving a federally listed species, the U. S. Fish and Wildlife Service recovery plan for that species—including population, distribution, habitat extent and configuration targets—would take precedence.

Table Summaries of Indicators & Metrics

HABITAT EXTENT AND CONFIGURATION

Indicator Group	Effort	Indicator	Metric
Tidal marsh extent and configuration	WRMP	4. Complete marsh	Acres and mapped location of "complete marshes".
	WRMP	5. Tidal wetland special-status species habitat	Acres and mapped location of habitat types that could support special-status species.
	WRMP	11. Overall condition of tidal wetlands	CRAM site scores and regional Cumulative Distribution Functions.
	SOTER	Tidal marsh	Patch size distribution; % of marshes > 500 acres; acreage of tidal marsh.
Other estuarine habitats	WRMP	1. Baylands habitat types and elements	Acres and mapped locations of habitat types and elements differentiated by hydrology, salinity, vegetation cover, and elevation capital.
	WRMP	7. Dominant vegetation communities; 8. Rate of change of dominant vegetation communities	Acres and mapped location of dominant tidal wetland vegetation alliances; Remote sensed measures of % cover, height and patch characteristics.
	WRMP	9. Expansion of unvegetated areas	Remote sensed measures of 2nd-order and larger channels, mosquito control and other ditches, size-frequency of pannes.
	SOTER	Open water	Index of hydrodynamics and occurrence of reverse flow conditions in the Delta, occurrence of low salinity conditions in Suisun Bay.
	SOTER	Eelgrass	Acreage of eelgrass beds.
Restoration	Restoration Authority	Habitat restoration and enhancement	# authorized restoration and enhancement projects; # of restoration plans to be completed; Acres total and by 10 Baylands habitat types.
	Delta PM	Natural communities restored	Acres of natural vegCAMP communities restored.

WATER QUALITY AND QUANTITY

Indicator Group	Effort	Indicator	Metric
Spatial and Temporal Fluctuation	WRMP	14. Tidal inundation of marsh plains	Tidal inundation regime (tidal stage, height, and site topography relative to local MHHW).
	SOTER	Freshwater inflow	Freshwater flow index consists of ten sub-metrics of amount, timing, and variability of freshwater flow.
	Delta PM	Natural functional flows	Yolo Bypass inundation: Area and duration; Peak and Recession Flow: At Bend Bridge Sac River, frequency of two-year return interval peak flows (Nov 1 - Apr 30), hydrograph rate of change on the receding limb (spring high flows to summer low flows); In-Delta Flow: 10-year rolling average slope of Delta outflow- inflow ratio, disaggregated by seasonal, annual, and 10-year periods, outflow-inflow ratio in dry and critically dry years.
Projects	Restoration Authority	Clean water	# clean water projects authorized by the governing board.
Bacteria	SOTER	Safe for swimming	Fecal Indicator Bacteria concentrations.
	Bay RMP	Bacteria	Beach Report Cards for >400 California beaches for fecal indicator bacteria.
Contaminants	WRMP	17. Mercury concentrations	Hg concentrations in blood/ tissue of bio-sentinel species.
	SOTER	Safe for aquatic life	Hg PPB small fish; % samples non-toxic to invertebrates.
	SOTER	Fish safe for eating	PCB (PPB) and Hg (PPM) concentrations in fish.
	Bay RMP	Bay water quality	Hg, PCBs, selenium, PFOS, and dioxin concentrations in Bay fish, PBDE concentrations in cormorant eggs. Dissolved copper, bisphenols, organophosphate esters, and microplastics in Bay water.
	Delta RMP	Delta water quality	Concentrations of 174 pesticides; copper; total nitrogen, particulate carbon, organic carbon, and dissolved organic carbon; HG concentrations in black bass; Methylmercury in water; Constituents of Emerging Concern in water, sediment, fish, and clams.
	Delta RMP	Delta water quality	The number of Delta watershed "waterbody-contaminant" and "waterbody-pesticide" combinations on the 303(d) list; concentrations or loads of inorganic nutrients (ammonium, nitrate, and phosphate); toxicity in sediment invertebrates.

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WATER QUALITY AND QUANTITY (CONTINUED)

Indicator Group	Effort	Indicator	Metric
Dissolved Oxygen	WRMP	Do in tidal marsh channels	DO concentration
	Bay RMP	Delta rmp	DO concentrations
	Delta RMP	Delta water quality	DO concentrations (mg/L) - continuous, real-time.
Nutrients/ Harmful Algal Blooms	Bay RMP	Nutrients	Dissolved inorganic nitrogen loads, chlorophyll concentrations in Bay water; algal toxins in mussels; phytoplankton populations.
	Delta RMP	Nutrients and harmful algal blooms	Microcystis, Cyanotoxins.
	Delta PM	Harmful algal blooms	Microcystis sp. cell concentration equivalents (cells/ml) in large water bodies.



Liberty Island 2017 • Photo by Steve Martarano, USFWS, courtesy of CC BY 2.0


RESILIENCE PROCESSES

Indicator Group	Effort	Indicator	Metric
Sea Level Rise	WRMP	15. Rate of sea level rise	Annual mean sea level rise, spatially distributed.
	Delta PM	Sea level rise planning	Number of proposed actions covered by the Delta Plan policy to require flood protection for residential development in rural areas.
Migration Space	WRMP	2. Tidal wetland elevation and elevation capital	Mapped elevations (ft NAVD) and elevation capital (Z*) relative to local MHHW.
	WRMP	3. Transition zones and migration space	Mapped elevations (ft NAVD) and elevation capital (Z*) relative to local MHHW.
	SOTER	Migration space	% area undeveloped for 2 and 5 ft sea level rise; % protected undeveloped for 2 and 5 ft sea level rise.
Shorelines	WRMP	6. Extent of natural foreshores	Map shoreline location change.
	SOTER	Soft shorelines	Land-water interface defined and mapped.
Accretion & Sediment	WRMP	12. Accretion rate	Marsh plain and tidal flat accretion rates relative to local tidal datums and NGVD.
	WRMP	13. Suspended sediment	Suspended sediment concentrations.
Salinity	WRMP	16. Salinity	Aqueous (in-channel) and porewater salinity measures.
	Delta PM	Salinity	Monthly electrical conductivity, water temperature, and X2 in the Delta and Suisun Marsh.
Inundation	WRMP	14. Tidal inundation	Tidal stage, height, and topography relative to local MHHW; Frequency, duration, and depth of tidal inundation of marsh plains
	Delta PM	Seasonal inundation	Delta/Suisun acres hydrologically connected to fluvial and tidally influenced waterways; Acres nontidal floodplain that inundates at least once every two years.

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RESILIENCE PROCESSES (CONTINUED)

Indicator Group	Effort	Indicator	Metric
Subsidence	SOTER	Subsided lands	Acres of land below MHHW that is diked off from tidal action, by land use category.
	Delta PM	Subsidence reversal	# subsidence reversal projects; Acres of Delta and Suisun Marsh with subsidence reversal activity (on islands with large areas at shallow subtidal elevations); Average elevation accretion at each project site (cm/year).
Beneficial flows	Delta PM	Natural functional flows	Yolo Bypass inundation (Area and duration); Peak & Recession Flow (At Bend Bridge Sac River, frequency of two-yr return interval peak flows Nov 1 - Apr 30, hydrograph rate of change on the receding limb - spring high flows to summer low flows); In-Delta Flow (slope of Delta outflow-inflow ratio, disaggregated by seasonal, annual, and 10-year periods, outflow-inflow ratio in dry and critically dry yrs).
	SOTER	Beneficial floods	Index of seasonal inflows to the Delta from the Yolo Bypass and high volume freshwater flows to the Bay.
Other	Delta PM	Funding for restoring ecosystem function	Project funding of covered actions that file Disclose Contributions to Restoring Ecosystem Function, excluding those without protection, enhancement, or restoration of the Delta ecosystem.
	Delta PM	Carbon sequestration	# of carbon sequestration projects.



Flooding at Yolo Bypass, 2017 • USFWS, courtesy of CC BY 2.0

WILDLIFE

Indicator Group	Effort	Indicator	Metric
Tidal Marsh Birds	WRMP*	19. Tidal marsh indicator bird species	Distribution and abundance (California Ridgway's Rail, California Black Rail, Tidal Marsh Song Sparrow, Saltmarsh Common Yellowthroat)
	SOTER	Tidal marsh birds	Index of 3-species breeding season abundance (California black rail, Song Sparrow, Common Yellowthroat)
	SFBJV SOTB	Tidal marsh birds	Index of abundance (Song Sparrow, Salt Marsh Common Yellowthroat, California Black Rail)
	SOTER	Ridgway's rail	Density (# birds/ha)
	SFBJV SOTB	Endangered clapper rail	# individuals
Waterfowl	SOTER	Wintering waterfowl	Index of 6-species winter dabbling duck abundance (American wigeon, gadwall, green-winged teal, mallard, Northern pintail, and Northern shoveler); Index of 10-species winter diving duck abundance (bufflehead, canvasback, Barrow's goldeneye, common goldeneye, ruddy duck, black scoter, white-winged scoter, surf scoter, lesser and greater scaup)
	SOTER	Breeding waterfowl	Index of 5-species breeding season waterfowl abundance (mallard, gadwall, green-winged teal, northern pintail, and northern shoveler)
	SFBJV SOTB	Managed ponds waterfowl	Peak winter counts (dabbling ducks)
	SFBJV SOTB	Subtidal: submerged aquatic vegetation birds	# winter sea ducks and diving ducks

*These are examples of possible indicators and metrics, based on the 2020 version of the monitoring matrix, and have not yet been formally adopted by the WRMP (WRMP 2020).

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WILDLIFE (CONTINUED)

Indicator Group	Effort	Indicator	Metric
Shorebirds	SOTER	Shorebirds	Combined winter abundance for size groups: Large shorebirds (American avocet, willet, marbled godwit), medium shorebirds (black-bellied plover, and short- and long- billed dowitcher), and small shorebirds (dunlin, Western and least sandpiper)
	SFBJV SOTB	Tidal flats birds	High tide roost shorebird counts
	SFBJV SOTB	Endangered snowy plover	# individuals
	SFBJV SOTB	Managed ponds shorebirds	Peak spring migration counts (small and medium-sized shorebirds); # breeding birds (American Avocets, Black-necked Stilts)
Herons and Egrets	SOTER	Herons and egrets	Index of 2-species (Great-blue Heron, Great Egret) nest density; nest survival
	SFBJV SOTB	Tidal marsh herons and egrets	# nests (Great Blue Herons, Great Egret, Snowy Egret, Black-crowned Night Heron)
	SOTER	Feeding chicks	# young fledged per successful nest (Great -blue Heron, Great Egret);
Other bird and habitat types	SOTER	Feeding chicks	# young fledged per breeding pair (Alcatraz Island Brandt's cormorants)
	SFBJV SOTB	Human-created habitat birds	# breeding pairs, peak nest counts (Brandt's Cormorants, Double-crested Cormorants)
	SFBJV SOTB	Managed ponds terns and gulls	# breeding Forster's Tern, Caspian Tern, California Gulls
	SFBJV SOTB	Endangered california least tern	# breeding pairs Alameda Colony of California Least Tern
Invertebrates	SOTER	Bottom dwellers	% native benthic invertebrates
	SOTER	Zooplankton as food	Biomass and abundance

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WILDLIFE (CONTINUED)

Indicator Group	Effort	Indicator	Metric
Fish	WRMP*	21. Tidal marsh indicator fish species	Abundance (Longjaw Mudsucker); Community composition, abundance, and distribution of estuarine fish (pelagic/larval and marshplain) and anadromous fish (Chinook salmon and steelhead trout).
	SOTER	Sf bay fish species	Bay Fish Index of 10 measures (abundance, diversity, species composition, distribution), native fish abundance, % native fish, % native species.
	SOTER	Fish as food	Abundance of marsh-, pelagic-, open water-, and beach-dwelling native and introduced fish (total fish caught/unit effort).
	Delta PM	Salmon doubling goal	Annual average natural production of all Central Valley Chinook salmon runs: fall, late fall, spring, and winter.
	Delta PM	Fish passage	# priority fish passage barriers and select large rim dams in the Sac-San Joaquin River watershed; # unscreened diversions along native, anadromous fish migration corridors in Delta and Suisun Marsh.
	Delta PM	Managing non-native fish	% fish biomass that are native fish spp; % total relative abundance that are native species in Delta and Suisun Marsh.
Mammals	WRMP*	20. Tidal marsh indicator small mammal species	Distribution and abundance (Salt marsh harvest mouse, possibly California Vole).
	SOTER	Harbor seal	Abundance index

*These are examples of possible indicators and metrics, based on the 2020 version of the monitoring matrix, and have not yet been formally adopted by the WRMP (WRMP 2020).

PEOPLE

Indicator Group	Effort	Indicator	Metric
Risk reduction to people and property	WRMP	22. Mosquito breeding areas	Total area, patch size of known and potential mosquito production areas.
	WRMP	23. Mosquito production	# of mosquito adults and larvae by species.
	Restoration Authority	Flood protection	Number of projects that implement one or more flood protection components.
	Restoration Authority	Levee construction	Miles of levee to be constructed.
	Delta PM	Multi-hazard coordination task force	% of recommendations implemented.
	Delta PM	Flood casualties and damages	Expected Annual Fatalities and Damages in the Delta.
	Delta PM	Delta levees	% urban communities and % urban areas in Delta protected by levees meeting DWR's urban level of flood protection criteria, as of completion of the Delta Levees Investment Strategy.
	Delta PM	Flood insurance community ratings	Community Rating System credit points of Delta communities participating in the National Flood Insurance Program.

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Repairing the Yolo Bypass, August 2011 • Photo by Todd Plain, USACOE, courtesy of CC BY 2.0

PEOPLE (CONTINUED)

Indicator Group	Effort	Indicator	Metric
Water use	SOTER	Recycled water use	Surface and groundwater supply usable for drinking water (TAF); Total amount of water recycled, treated and distributed from water treatment plants to provide a beneficial use (TAF).
	SOTER	Urban water use	Bay Area: Total and residential portion of water use measured as total gallons per year & total gallons per capita; Delta: total gallons and gallons per capita urban water use.
	Delta PM	Urban water use	Gallons per capita per day of urban water use; Percentage change in urban per capita water use from SB X7-7 baseline years.
	Delta PM	Alternative water supply	% of urban water suppliers meeting their recycled water projections, storm water-use projections; and desalination projections.
	Delta PM	Water supply reliability	% of urban water suppliers that are within/relying on water from Delta watershed, projecting reliability during a single dry year, and reliability for multiple dry years.
	Delta PM	Delivery interruption	# water-delivery interruptions and acre-feet of water not delivered caused by floods or earthquakes in the Delta.
	Delta PM	Sustainable groundwater	Completion of actions required by SGMA.
	Delta PM	Water exports	Total water exported each critically dry yr, each wet yr, and fifteen-yr average of all types, by the SWP and the CWP through the Harvey O. Banks and C.W. Bill Jones Pumping Plants in the southern Delta.
	Delta PM	Protect groundwater	# groundwater wells used for drinking water supply exceeding arsenic and/or nitrate drinking water limits.
Public Access	Restoration Authority	Public access	# public access projects authorized by the governing board; Miles of trail to be designed and constructed; Number of water trail sites to be designed and constructed; Number of public access facilities.
	SOTER	Trail access	Rate of trail mileage increase in the Bay Area and Delta over time.
	SOTER	Urban green space	Area of park accessible within a ten-minute walk (half mile) of one's home; Number of people sharing that park area.
	Delta PM	Recreation opportunities	# regional Recreation Proposal recommendations and outcomes implemented within the Delta and Suisun Marsh.
Involvement	Restoration Authority	Youth involvement	% projects with significant youth involvement component; Number of youth to be engaged.
	Restoration Authority	Volunteer involvement	Time in hours; Number of unique volunteers expected to participate.

PEOPLE (CONTINUED)

Indicator Group	Effort	Indicator	Metric
Benefits to Disadvantaged Communities	Restoration Authority	Benefits to economically disadvantaged communities	% of projects providing benefits to EDCs.
Agriculture	Delta PM	Agricultural water planning	% of AWMPs submitted to DWR on time and that include a quantification of water use efficiency.
	Delta PM	Farmland loss	Conversion of farmland acres to urban development; Annual conversion of land designated for agricultural use to urban land use under GP land designations.
Cultural	Delta PM	Legacy communities	# of annual community action plans adopted and initiated to achieve legacy community Delta Plan objectives.
Economy	Delta PM	Delta tourism	Acres of State and federal land accessible to the public for recreation and tourism; Length (in linear feet) of shoreline accessible for public recreation; # fishing licenses bought per year by county; # first-time visitors, off-season visitors, website views and social media traffic, and existing and new visitor engagement.
	Delta PM	Delta economy	Regional Opportunity Index for People and Place (score), in the Primary Zone and Secondary Zone.

Agricultural fields • Photo by Shira Bezalel, SFEI



San Francisquito Creek • Imagery courtesy of Google Earth

ROADMAP FOR ALIGNMENT

Building on our understanding of where there is indicator overlap between efforts (Summary of Indicators tables), we are beginning to develop a roadmap summarizing current and future opportunities for alignment across efforts. Because of the large number of planned WRMP indicators in need of alignment, for this roadmap we have highlighted five indicators or indicator groups with specific near-term opportunities to assist alignment. For each we provide a brief summary and a timeline linking current status with proposed timelines for future opportunities of related efforts. The roadmap follows the intent of the report as a whole and focuses on regional efforts that use indicator trends and benchmarks for evaluating the Bay, Delta, or Estuary as a whole. Thus, the many monitoring projects and teams that inform and complement these efforts (e.g., SBSP and NMS monitoring) are included in this section only when directly relevant to aligning these regional efforts.

Tidal Marsh Extent

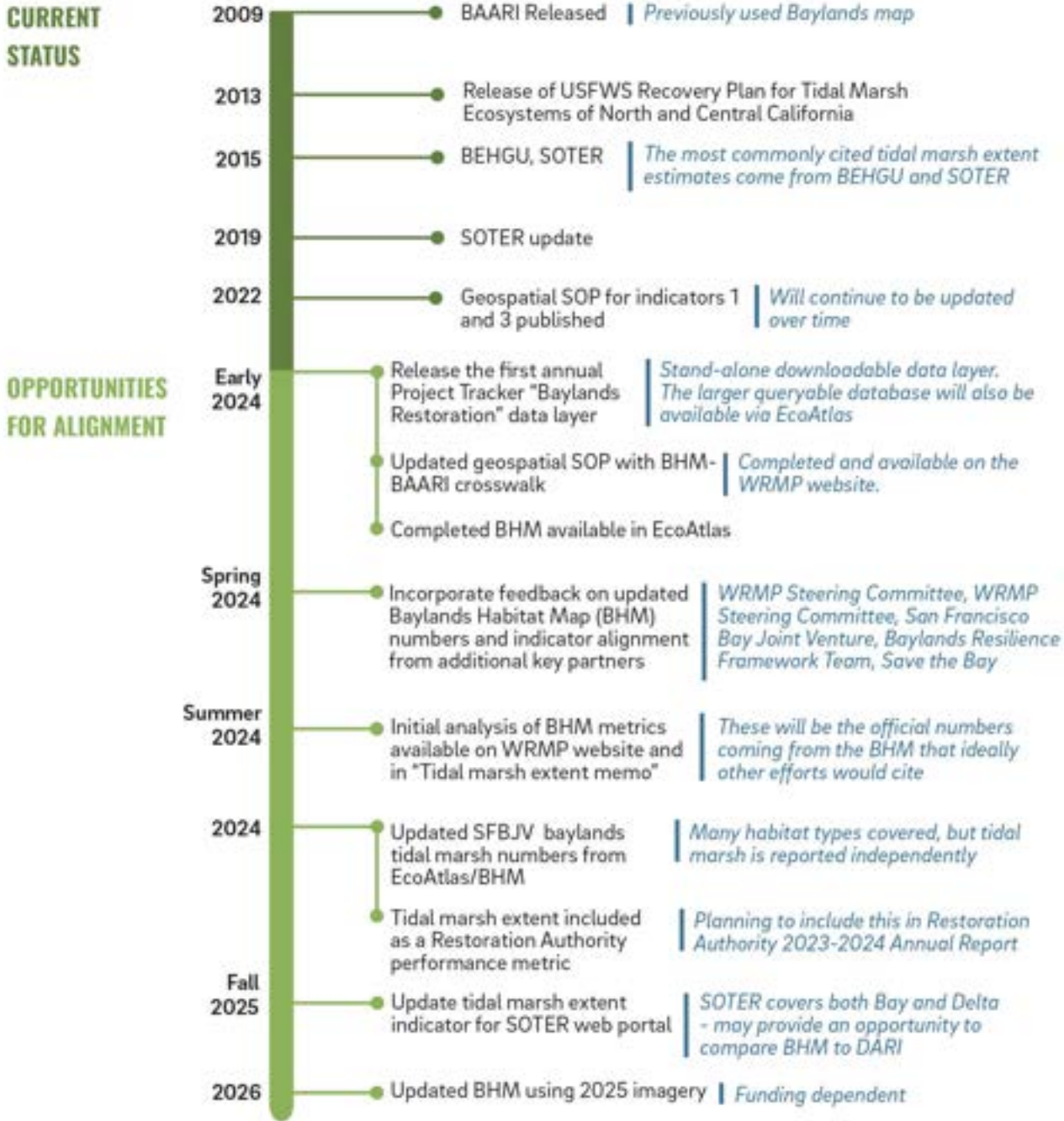
Tidal marsh acreage is a key metric of restoration success, used to track progress toward both project level targets and regional goals. Updated wetland mapping offers the opportunity to assess progress toward these goals. The Baylands Habitat Map 2020 (BHM), released in the spring of 2024, provides the first Baywide update to wetlands mapping since the Baylands Area Aquatic Resource Inventory (BAARI) was completed in 2009 (with minor updates in 2011). The BHM provides a snapshot of wetland extent using 2020 aerial imagery and supporting datasets including elevation.

Estimating wetland extent with infrequent regional wetland mapping is challenging, and has led to confusion in the past about which numbers are most up to date. If frequent updates to the BHM occur as planned, this will lead to more regional agreement about the numbers reported and how they should be interpreted. One key point of previous confusion has been how restoration projects were counted so it is important to consider how Project Tracker restoration data will be used in combination with the BHM to assess tidal marsh extent. More details on the past confusion and how BHM and Project Tracker can be used together are included in the forthcoming report on tidal marsh extent.



Palo Alto Baylands, 2014 • Photo by Don DeBold, courtesy of CC BY 2.0

TIDAL MARSH EXTENT ALIGNMENT ROADMAP



KEY QUESTIONS FOR ALIGNMENT ON TIDAL MARSH EXTENT

- Should SOTER change its approach to align with WRMP marsh extent numbers?
- Will there be an attempt to update the restoration extent numbers in BEHGU, which includes non-tidal restoration of baylands?
- How can we move toward more comparable mapping between the Bay and the Delta?
- What additional analysis could tell a more specific story of marsh extent gains (through restoration, shoreline progradation, etc.) versus loss (marsh drowning, panne expansion, etc)?

Marsh Patch Configuration

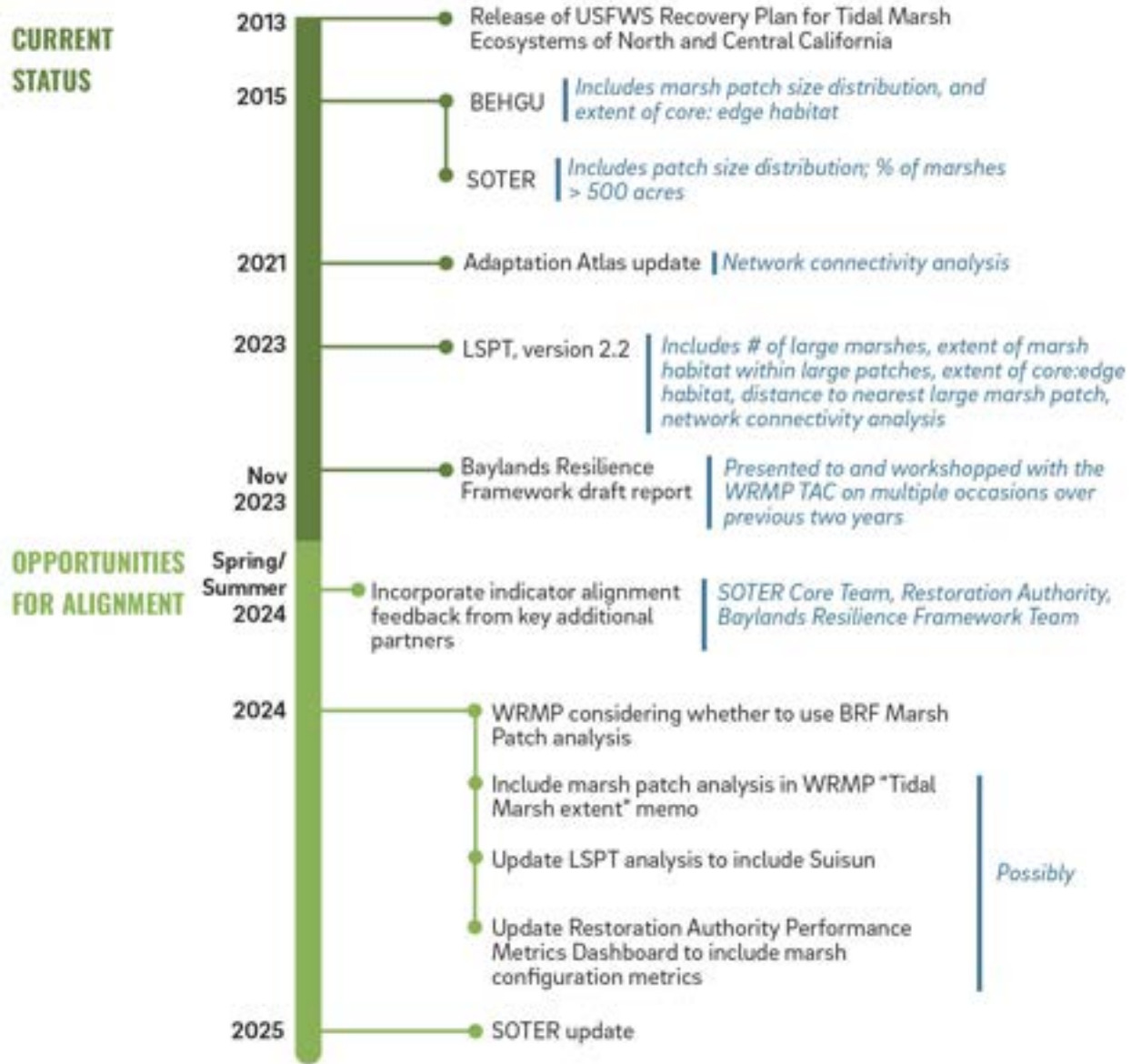
Marsh patch configuration analysis offers a way to assess wildlife support and presumed functioning of marshes via remote sensing. The size, shape, and connectivity of marsh patches are highly correlated with their ability to support robust wildlife populations. Marsh configuration metrics have been used previously in efforts such as Goals Project (2015), Landscape Scenario Planning Tool (LSPT), SOTER (patch size only), and the Adaptation Atlas (SFEI 2021), as a way to show patterns and progress in marsh wildlife support.

The Baylands Resilience Framework (BRF) is analyzing marsh patch configuration metrics using the BHM in the near-term. The WRMP will consider adopting these or other metrics once the analysis is complete. As an indicator that speaks to marsh function that can be fairly easily derived from wetland mapping, these marsh configuration metrics are being considered as Restoration Authority performance metrics as well. There are many potential metrics and analysis decisions wrapped up in marsh patch configuration. Using similar metrics and definitions, as appropriate, can help us leverage work between efforts (e.g., re-use code, report the same results). However, the different focus among efforts may lead to different decisions and priorities (e.g., considering different species for Bay vs Delta; complex connectivity metrics may not always be necessary or appropriate).

Point Isabel tidal marsh • Photo by Shira Bezalel, SFEI



TIDAL MARSH PATCH CONFIGURATION ALIGNMENT ROADMAP



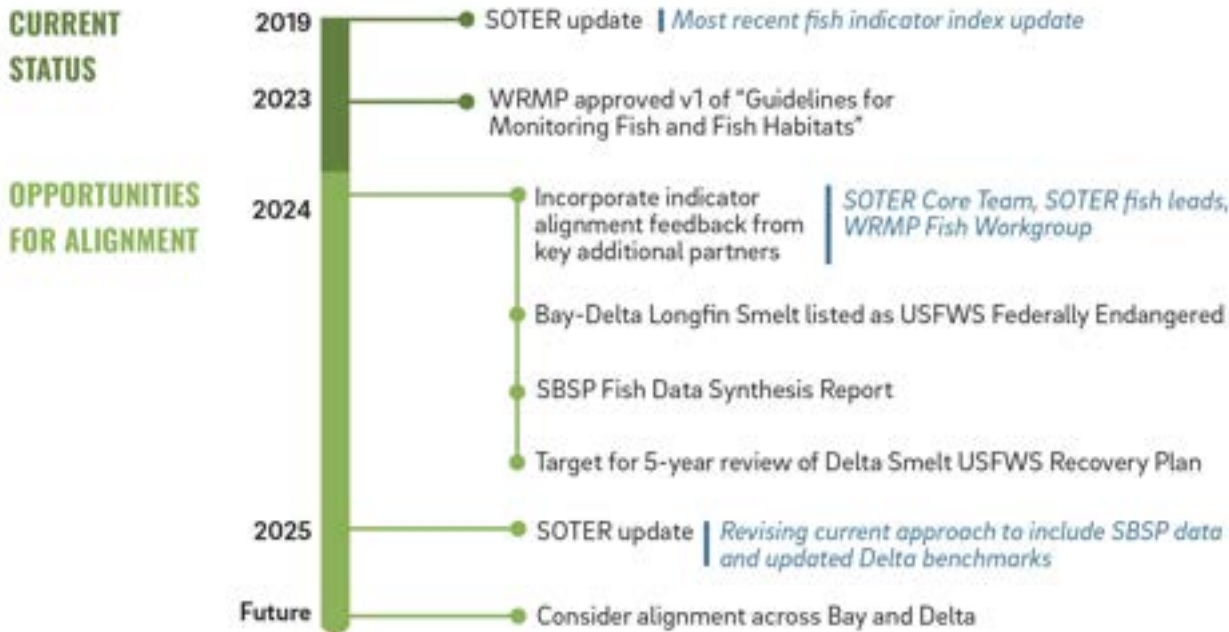
KEY QUESTIONS FOR ALIGNMENT ON MARSH PATCH CONFIGURATION

- Because the ability to quantify wildlife movement has improved with the development of smaller, cheaper, and more automated tracking devices, should we update how we define marsh patches? To date a fairly similar ruleset, based loosely on expected movement of tidal marsh birds, has been used for LSPT, SOTER, BEHGU, and Adaptation Atlas analysis.
- Which metrics are best for capturing marsh patch size? Options include distribution of patch sizes, number of large patches (previously defined as >100ha or >500ha), extent of marsh within large patches.
- Which metrics are best for capturing marsh shape? Options include: comparison to a circle, core-to-edge ratios, extent of core and edge habitat.
- Which metrics and models are best for capturing marsh connectivity?

Fish

The establishment of the WRMP Fish Workgroup and the rethinking of fish indicators for SOTER 2025 offer opportunities for alignment across efforts. Plans for updating SOTER fish indicators in 2025 include getting input from members of the WRMP workgroup, incorporating SBSP data, and identifying better benchmarks for interpreting Delta fish data. The synthesis of SBSP fish data, planned for 2024, will help inform this effort. The WRMP and SOTER efforts do have different aims and scopes, so standardized and identical methodologies between them is unlikely. Nonetheless, ongoing communication between the WRMP Fish Workgroup and SOTER team can move regional communication and alignment forward. It might also be possible for these disparate efforts to agree on a few shared metrics and analyses to allow for increased efficiency.

FISH ALIGNMENT ROADMAP

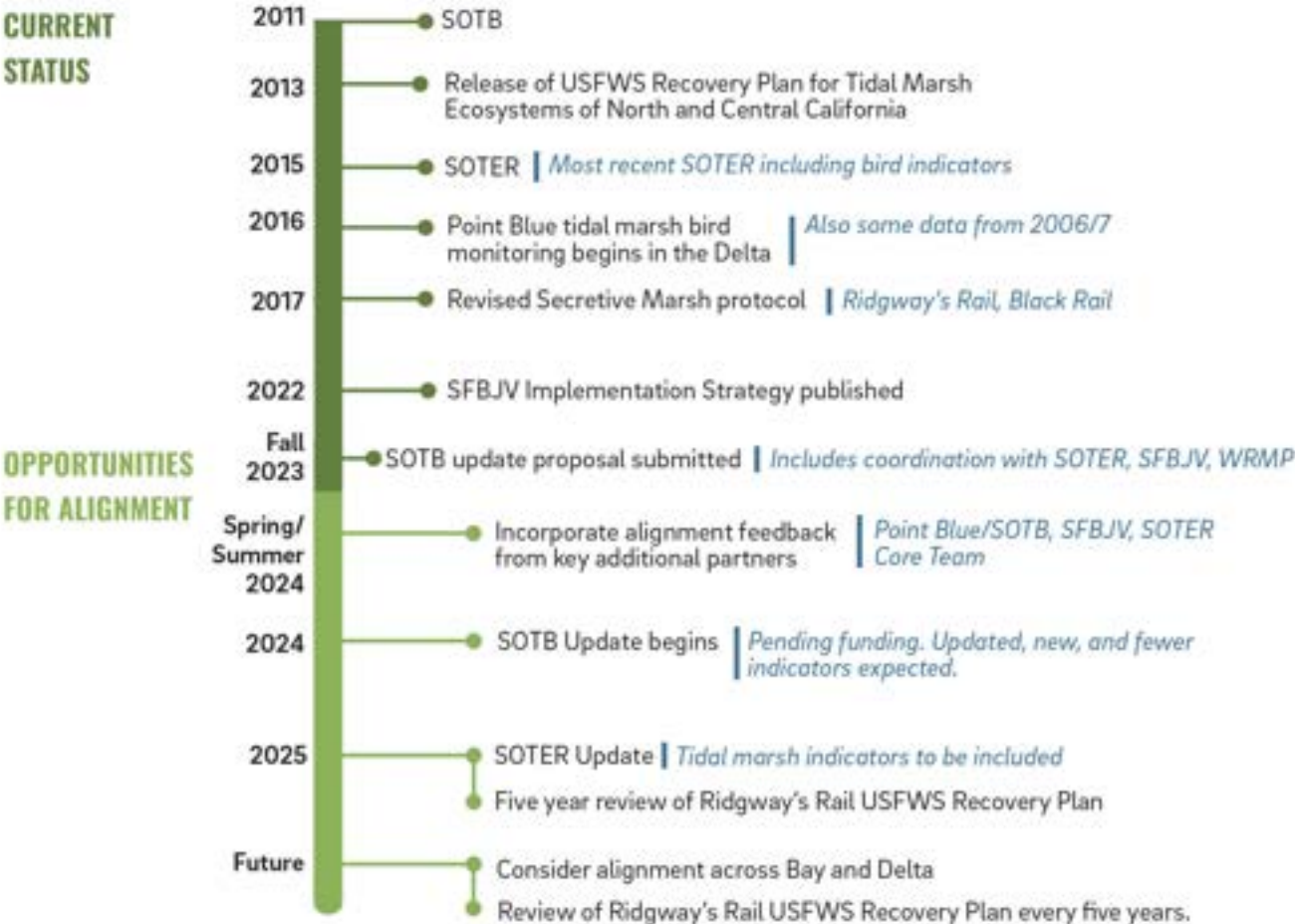


Chinook salmon • Photo by USEFWS, courtesy of CC BY 2.0

Tidal Marsh Birds

A common goal among estuarine protection and restoration projects is to provide habitat for tidal marsh dependent bird species and to increase their resilience to sea level rise and increased storm frequency and intensity. In turn, population trends of birds that occupy tidal marsh are considered good indicators of the marsh health. Long-term standardized bird monitoring across a network of tidal marsh sites track changes in the abundance and distribution of tidal marsh birds in the Estuary across space and time, while also allowing managers and researchers to zoom in to measure how successful individual tidal marsh restoration projects are at protecting and restoring bird communities. Indicators for SOTB, SBJV, SOTER and WRMP rely on the same standardized data collected by Point Blue, the Invasive Spartina Project, and regional, state, and federal agencies throughout the Bay and Delta, though specific metrics informed by these data vary among efforts.

TIDAL MARSH BIRDS ALIGNMENT ROADMAP



KEY QUESTIONS FOR ALIGNMENT ON TIDAL MARSH BIRDS

- Are there plans for regular SOTB updates?

People and Wetlands Indicators

A key consideration for the WRMP and other regional efforts is how people are using and benefiting from wetlands, and how equitable the access to and benefits from those wetlands are. The WRMP People and Wetlands Workgroup (PWW) was established to inform the indicators, metrics, and monitoring that can address those questions. The workgroup will emphasize community and Tribal values, align with information needs of decision-makers, enable evaluation of equity questions, and incorporate diverse ways of understanding wetland health. Other regional efforts outside of WRMP, such as SOTER and Restoration Authority performance metrics, are looking to the PWW for guidance.

TIMELINE FOR PEOPLE AND WETLANDS INDICATORS

CURRENT STATUS

- 2018 ● Restoration Authority performance metrics identified include metrics related to number of volunteers and youth engaged in projects | *Metric enhancements being considered by the PWW to better inform equity questions*
- Fall 2019 ● SOTER develops an emerging indicator related to urban green space | *Metric enhancements being considered by the PWW to better address quality of green spaces*
- Fall 2022 ● WRMP PWW established
- Winter 2023 ● Baylands Resilience Framework floodplain attenuation metrics developed | *Metrics being considered by the PWW*

OPPORTUNITIES FOR ALIGNMENT

- Spring/Summer 2024 ● Incorporate alignment feedback from key additional partners | *WRMP TAC and Steering Committee, SOTER Core Team and SRT*
- WRMP identifies People & Wetlands metrics that could be used as Restoration Authority performance metrics | *Followed by Restoration Authority review (staff, Advisory Committee and/or Governing Board)*
- 2024 ● Bayland Resilience Framework flood attenuation metrics analysis done
- 2025 ● Analysis of people and wetland metrics for Restoration Authority FY 2024-2025 Annual Report
- 2026 ● SOTER update | *People and Wetlands metrics and an updated "Urban Green Space" indicator included*



Ridgway's Rail during King Tide, December 2018 • Photo by Becky Matsubara, courtesy of CC BY 2.0

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