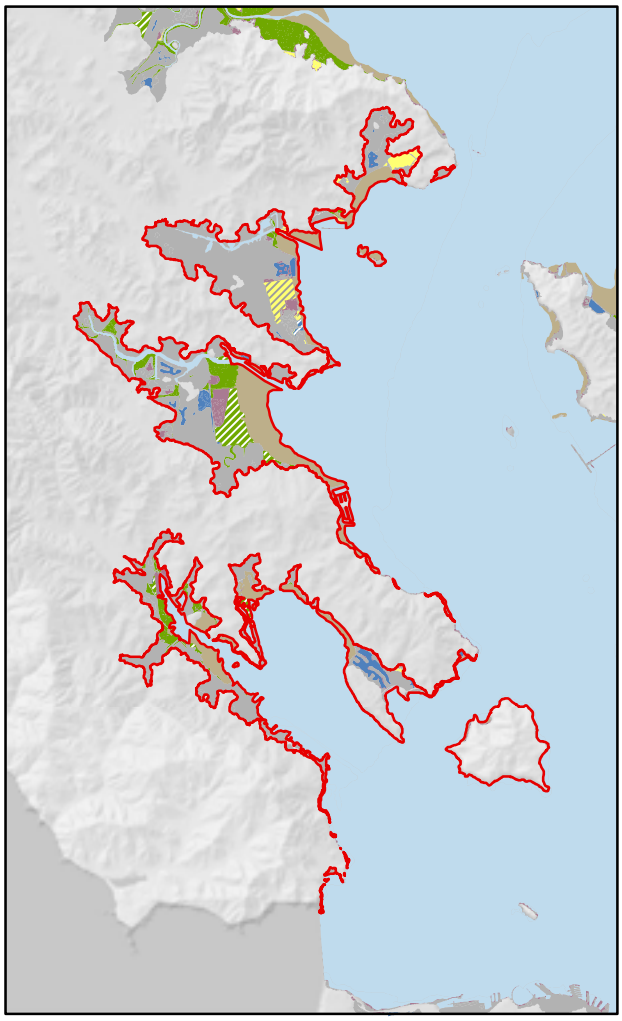

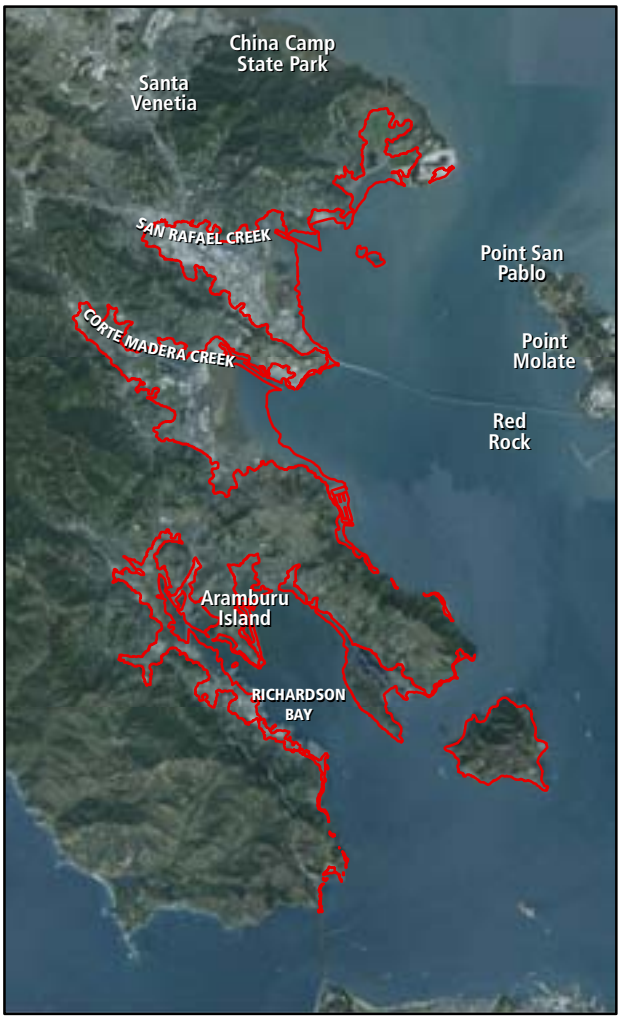

SOUTH MARIN

Western edge of central San Francisco Bay extending from Point San Pedro to the Golden Gate

Baylands 2009

- Bay/Channel
- Diked Wetland
- Salt Pond
- Managed Pond
- Tidal Flat
- Tidal Marsh
- Agriculture and Other Undeveloped Areas
- Developed Areas

Red line shows the boundaries of Segment I.

Hatching indicates areas where restoration activities had occurred as of 2009. For managed ponds this included habitat enhancement.

By: San Francisco Estuary Institute

Data: Wetland data from SFEI includes BAARI (v1, 2009) Baylands and Wetlands, NLCD 2006, and wetland tracker data.

Imagery: ESRI World Imagery (updated 2015)

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Unique Opportunities

Segment I has low-lying urbanized lands that are not protected by large flood-control levees, and areas already subject to flooding. Thus, this segment can serve as a laboratory for testing ecological design concepts for sea-level rise adaptations that integrate flood control and habitat benefits. In particular, marshes can be used for wave attenuation, and coarse-grained beaches can buffer the impacts of wind–wave erosion. This segment is highly visible to the public. Demonstration projects could educate residents and raise awareness about the impacts of climate change and gain support for solutions to address these impacts. There are several opportunities to provide important wide transition zones and migration space for tidal salt marshes to migrate landward in response to sea-level rise. Nearshore eelgrass and oyster beds can be expanded at multiple locations as well.

Segment Features and Setting

Historically, the relatively steep bayshore topography of this segment limited large areas of tidal marsh to the lower reaches of San Rafael and Corte Madera Creeks and to the western part of Richardson Bay. In addition, there were many historic pocket and barrier beaches along sections of the Richardson Bay shoreline. The steep watersheds of Mount Tamalpais with their high sediment yields contributed fluvial sediment to the baylands.

Today, much of the baylands within this segment has been filled and developed for urban, transportation, and residential uses. Only a few remnants of the original tidal marshes remain (e.g., Heerdt Marsh and the Corte Madera Ecological Reserve). However, mature wide salt marsh habitat has regenerated near the mouth of Coyote Creek, supporting regionally rare plant populations, including some of the largest colonies of northern salt marsh bird's-beak in San Francisco Bay). The Corte Madera Ecological Reserve supports one of the densest populations of Ridgway's rails in northern San Francisco Bay; it also supports a black rail population. Important tidal mudflats remain in Corte Madera Bay (the Corte Madera Ecological Reserve), Richardson Bay (the Richardson Bay Audubon Sanctuary), and Mill Valley marshes. Eelgrass and oyster habitats occur along the length of this segment, from McNears Beach to Fort Baker.

Harbor seals formerly used the Corte Madera Marsh and Strawberry Spit areas for resting and pupping. Aramburu Island (on the north end of Strawberry Spit) has been rehabilitated with beaches next to both deep water and tidal flats to accommodate reoccupation by seals, terns, and shorebirds, but alternative seal haul-out and pupping habitats are limited in this segment.

Implications of Drivers of Change

High-tide inundation is already affecting the eastern Marin shoreline. During high-tide events the urbanized bay edge is subjected to direct flooding and roadway closures. Sea-level rise can be expected to significantly worsen these conditions as well as threaten critical infrastructure such as Highway 101. Subsidence due to development on bay mud exacerbates flooding; low-lying areas have elaborate systems of

pump stations and detention ponds that are not necessarily sized to accommodate future conditions. The flood-control requirement to protect existing infrastructure and both residential and commercial areas will be a large driver of change, and the way that flood control integrates with habitat goals will be a challenge. Outboard levees, trails, and roadways in particular will be subject to greater wave action as water depths increase, allowing larger waves to propagate inshore. Increasing wave action will also accelerate the ongoing erosion of marsh edges, resulting in the narrowing of marshes and a loss of habitat. A reduced sediment supply also threatens the ability of the natural marshes to keep pace with sea-level rise.

Considerations for Implementing the Actions

NEAR TERM (NOW TO MIDCENTURY, PRIOR TO SLR CURVE ACCELERATION)

The near term presents significant opportunities to build on studies completed at the mouth of Corte Madera Creek as well as in Richardson Bay (Aramburu Island). Pilot projects could demonstrate ecological design concepts for the fringing marshes and pocket beaches.

Sediments dredged from creeks for flood control could be recycled for marsh and mudflat nourishment within the sub-embayments of Richardson and Corte Madera Bays, following the natural deposition patterns that established the existing marsh landscape positions. Sediment could be placed directly as hydraulic thin-layer deposits, or placed on adjacent mudflats to be resuspended and then dispersed by tidal action through creek networks into the interior marsh plains.

LONG TERM (LATTER HALF OF THE CENTURY, AFTER SLR CURVE ACCELERATION)

In the longer term, if sea-level rise accelerates and sediment supply falls as projected, providing flood protection for the highly urbanized edge will become increasingly important. Existing tidal marshes will be subject to greater erosion, further narrowing the fringing marshes. Tidal marshes may be unable to keep up with sea-level rise, resulting in more inundation of the marsh surface. This will likely lead to a habitat conversion to low marsh, mudflat, and ultimately subtidal areas. Landward migration of the marsh should be undertaken where there is room for managed retreat. Construction of a gently sloping transition zone bayward of the levee would facilitate such migration. Coarse-grained beach will need to be strengthened and perhaps augmented with larger-grained sediments as wave energy increases with rising sea levels.

Harbor seals

At some point, the amount of sea-level rise will make protection of residential and commercial developments and infrastructure from both direct bay coastal flooding and fluvial flooding (from backwater storm-drain flooding from a higher bay level) a preeminent public safety goal. Other approaches

such as muting high tides with engineered barriers may be required to maintain public safety during flooding events. Working with local governments to explore managed retreats and changes to building and planning codes should be considered in long-term planning.

Recommended Actions

FOR HABITATS AND THE LANDSCAPE IN GENERAL

- Design and restore complete tidal wetland systems, even at a small scale, that include tidal marshes, beaches, lagoons, and broad transition zones. Develop techniques for implementing active revegetation, high-tide-refuge islands, and subtidal habitat restoration.
- Tidal restoration should stress wide platforms for high salt marsh and local native terrestrial transition zone (wet meadow) vegetation tolerant of infrequent tidal flooding, rather than an expanded intertidal marsh plain that is subject to drowning as the sea-level rise accelerates.
- Incorporate seasonal and perennial wetland features in the transition zone by using freshwater discharges (subsurface or diffuse sheetflow) from treated stormwater.
- Create transition zone habitats on gentle slopes in conjunction with flood-risk-management features (or other high-ground areas). Consider preparing transition zones with dredged material and treated wastewater to encourage tidal-channel formation and pan development, resulting in topographic complexity (high-tide refugia).
- Protect fringe marshes throughout the segment.
- Protect subtidal habitat including mudflats, native oyster beds, and eelgrass beds.
- Consider ways to increase sediment supply to the tidal baylands. For example, dredged sediments could be placed directly on local marshes or adjacent mudflats to be reworked by wave and tidal action to build up local suspended-sediment concentrations and marsh-accretion rates.
- Reduce the horizontal erosion of marshes by creating coarse beaches in front of marsh scarps.
- Evaluate the construction of a steep transition zone using strategically placed fill in areas of the bay to decrease wave attenuation and reduce costs for levee protection.

FOR PARTICULAR WILDLIFE POPULATIONS

- Provide additional harbor seal haul-out and pupping sites in Corte Madera Marsh and at Richardson Bay.
- Protect and enhance Pacific herring spawning areas.

- Incorporate the management of rare and uncommon estuarine plant populations (augmenting their population, giving additional colonies wider distribution) in tidal marsh restoration and management projects, including sediment nourishment.
- Preserve existing populations of rare high-marsh and transition zone plants as seed sources for future reintroduction and population management as long as feasible.
- Control the spread of pepperweed in rare high-marsh plant associations and control and prevent the reemergence of invasive *Spartina* at all locations.

Restoration Benefits

Constructing wide terrestrial transition zones landward of existing major salt marsh habitats of the Corte Madera Ecological Reserve would significantly improve the resilience of existing Ridgway's rail and black rail populations, improve wildlife buffers along trails, and offset tidal marsh submergence and the loss of high-tide cover as existing marsh plains submerge. Implementing the recommendations for this segment would improve habitat support for harbor seals, salt marsh harvest mice, and other mammals.

Enhancing seasonal wetlands would provide improved high-tide roosting habitat for shorebirds. Enhancing riparian and instream habitats would benefit migratory songbirds and steelhead. Restoration of coarse-grained gravel beach habitat at various locations would provide high-tide roosting habitat for shorebirds and terns. Isolated (islandlike) marsh-fringing beaches may provide additional nesting sites for terns. Restoration of native oyster and eelgrass beds offshore would provide habitat for birds and fish, and might enhance food and nursery resources for species that use both wetlands and offshore shallow subtidal habitats. Living-shorelines designs may provide wave attenuation, sediment stabilization, and some flood protection in the near term for tidal marsh habitats on the shoreline.

Challenges

Challenges in this segment include Highway 101, an urbanized edge with roadways and infrastructure that currently flood (e.g., Miller Avenue, Manzanita parking areas, the Mill Valley sewer plant), Northwestern Pacific railroad tracks, flood-control considerations, erosion from the Larkspur Ferry, and exotic predators (e.g., rats and red fox), invasive *Spartina*, and on-site contaminants.