Assessment of Select Estuaries of Marin County

Summary Data Report

Prepared for:
San Francisco Bay Regional Water Quality Control Board

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CCWG
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Background and Need

What are BBEs and Why are they Important

Bar-built Estuaries, also termed river mouth lagoons, bar-built lagoons, coastal river mouths and coastal confluences, are the terminus of creek and river mouths that flow to the coast, yet close to ocean influence periodically through the formation of a sand bar or barrier beach (Figure 1). These bar-built estuaries represent an important and unique subset (279 out of 576 of coastal confluences within California. The unique ecological services provided by these bar-built estuaries are influenced by the seasonal closures of their inlets.

Figure 1.Conceptual figure of a) open, b) partially open, and c) closed bar-built estuary.

The frequency and duration of inlet closure can be natural or managed. Many of these systems exhibit prolonged muted or non-tidal periods when ocean and river mixing is restricted leading to highly variable salinity regimes, ranging from fresh to hypersaline (Figure 2).

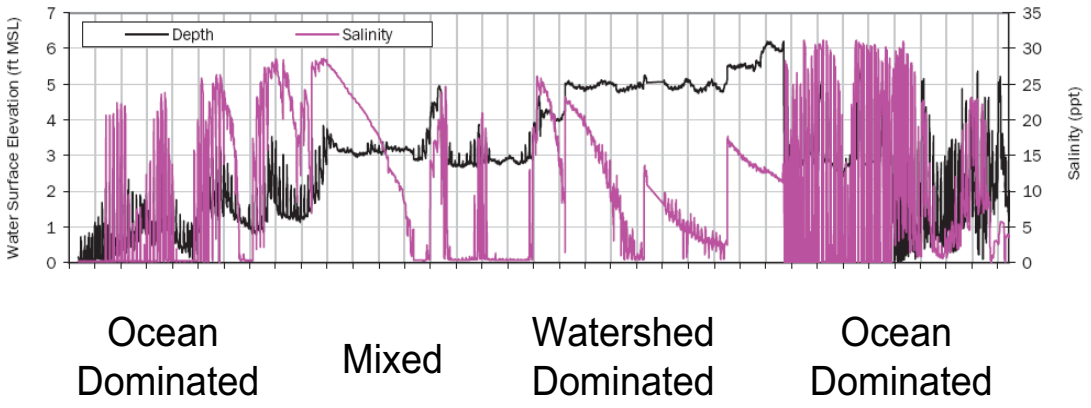


Figure 2.Hydrograph indicating variability in depth and salinity of a BBE over time.

California's Bar-built Estuaries are unique habitats that provide valuable services to important species. Water depths, salinity, and other physical characteristics within these systems can fluctuate wildly within and between years and seasons, creating a mosaic of habitats which support a unique set of rare and endangered species including steelhead trout and tidewater gobies. Adjacent land uses and alterations to natural closure and breaching dynamics have been shown to severely impact physical diversity and reducing ecological services for many of these species.

As urban development continues to expand along the California Coast, these systems often face varying degrees of alteration to accommodate development. Alterations to watershed and floodplain habitats, increasing demand for freshwater, and climate change and sea level rise all further threaten these habitats and the services they provide. Being at the bottom of watersheds bar-built estuaries accumulate impacts from upstream stressors creating both a management challenge and a monitoring opportunity.

As land uses change adjacent to and with the watershed of BBEs, some impacts and alterations (legal water diversions, flood protection for adjacent land uses and protection of coastal infrastructure including Highway 1) to these estuaries will be challenging to address, especially in the long-term. However, there are a number of lagoon characteristics that can be feasibly addressed with minimal or no impacts to adjacent land uses. For example, state regulatory agencies are routinely tasked with making management decisions through permitting of construction projects and breaching activities without a full understanding of the impact of these projects. Management strategies often focus on specific species, services or environmental objectives (i.e. water quality) sometimes in ignorance of or detriment to other services and species.

Estuarine resources on the coastline of RB2

To support restoration, enhancement and conservation of California's estuaries, the Central Coast Wetlands Group at Moss Landing Marine Labs (CCWG), with support from The Nature Conservancy and USEPA, completed an inventory and classification of all coastal confluences in California (Heady et al. 2014). Previous inventories, assessments and classifications of estuaries along the West Coast have occurred but were usually limited to a subset of larger estuaries.

We completed a comprehensive inventory of estuaries from California's 576 coastal confluences. Information from previous estuarine inventories were compiled and additional estuaries were identified using National Wetlands Inventory (NWI) maps and aerial imagery interpretation. Within this inventory and associated geodatabase, we generated a georeferenced polygon, and populated an excel database with other locational information, size, and noted all estuarine classifications of previous inventories and a project specific classification using the CCWG Classification system (Table 1). This effort provided the sample frame from which sites were selected for the verification and validation of the California Rapid Assessment Method for Wetlands (CRAM) for these systems.

Table 1.CCWG Coastal Confluence Classification system

Coastal Confluence Type	Description	Example system in RB2
Bar-Built Estuary	In systems with a strong fluvial influence, there is sign of estuary mouth closure by the formation of a sand bar at some point during the year. A pond forms behind the bar and connection with the marine environment is reduced or eliminated.	Redwood Creek

True Lagoon	Similar to bar-built estuaries, a sand bar forms across the mouth of the system creating a pond or lake with reduced or severed connection with the marine environment. However there is a very small watershed and little fluvial influence and the system opens infrequently.	Abbott's Lagoon
Bay/Open Estuary	Open bay with fringing estuarine wetlands or semi-enclosed estuary that is always open to tidal action.	Drakes Estero
Creek Mouth	A small coastal confluence that does not close off to the marine environment from the formation of a sand bar or form a ponded system. This may be due to natural reasons (steep gradient or large grain size on the beach), or anthropogenic in that it used to be a BBE but lost all habitat and ability to close.	Alamere Creek
Open River Mouth	A very large coastal confluence that does not close to the marine environment due to large freshwater flows or local geology, but shows some effect of a bar formation.	N/A
Coastal Depression	A ponded or Palustrine system adjacent to the coast with limited interaction with the marine environment	Laguna Salada
Urban Drain	A coastal confluence in an urban setting with no obvious watershed area or historical drainage feature.	N/A

The inventory effort recorded a total of 65 coastal confluences in the San Francisco Bay Regional Water Quality Control Board's outer coast, which includes Marin and most of San Mateo Counties. The SF Bay was not included in this inventory. Of that, 4 are open estuaries, 29 are bar-built estuaries, 29 are creek mouths, 1 is a coastal depression, and 1 is a true lagoon (Figure 3). There was a total of 5034.2 hectares of wetland habitat (Figure 4) mapped within the 65 systems. As calculated by number of systems and range of geographic distribution, bar-built estuaries make up the dominant coastal confluence type on the two counties, while by wetland area open estuaries are dominant. Figure 4 illustrates how the total area of

Figure 3. Locations of all coastal confluences in Marin and San Mateo Counties. (blue=BBE, green=creek mouth, red=true lagoon, pink=open estuary, yellow=coastal depression).

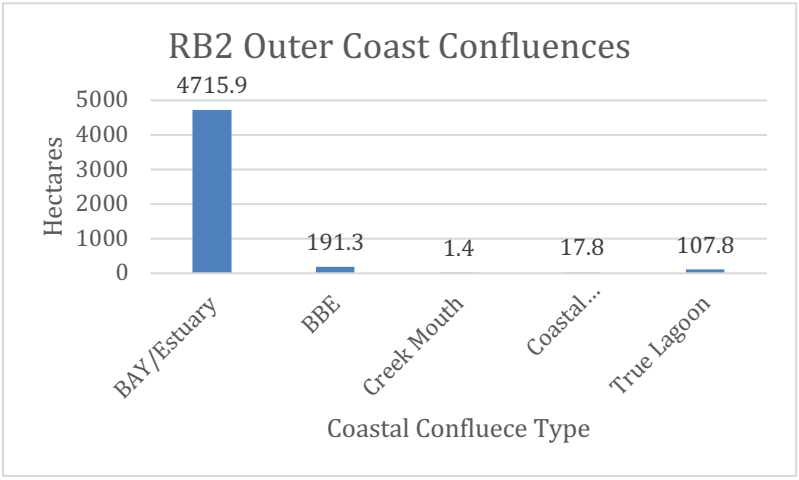


Figure 4.Coastal confluence area (hectares) by confluence classification type in Marin and San Mateo Counties

coastal confluence wetland habitat is distributed among the five confluence types.

Purpose


Horseshoe Pond

This project aims to add to our regional understanding of the current ecological services these systems provide to this coastal area. It builds off of an effort funded by the USFWS San Francisco Area Coastal Program in 2016, which assessed the condition of bar-built estuaries in San Mateo County. That project provided the USFWS San Francisco Area Coastal Program with several possible prioritization options to strategically allocate federal funding for on-the-ground efforts to improve habitat conditions of bar-built estuaries within the San Mateo coast focus area.

In addition, this document provides a summary of information available within the California Coastal Confluence database which describes the region's BBE condition, use by protected species, and anthropogenic stressors of the bar-built estuaries and their watersheds.

Methods

Site Selection

With input from RB2 staff, CCWG selected 5 of the 13 bar-built estuaries, along with 3 open estuaries and a creek on the Marin County coast to investigate (Figure 5). It's important to note that most of these estuaries, as well as their contributing watersheds, generally benefit from being located within protected public lands. Drake's Estero, Drake's Beach, and their watersheds are entirely within Point Reyes National Seashore, while Rodeo Lagoon, Redwood Creek (Big Lagoon), Tennessee Valley, and their watersheds are entirely within Golden Gate National Recreation Area. Bolinas Lagoon, Pine Gulch Creek, and Tomales Bay are surrounded by primarily public lands with limited adjacent private property.

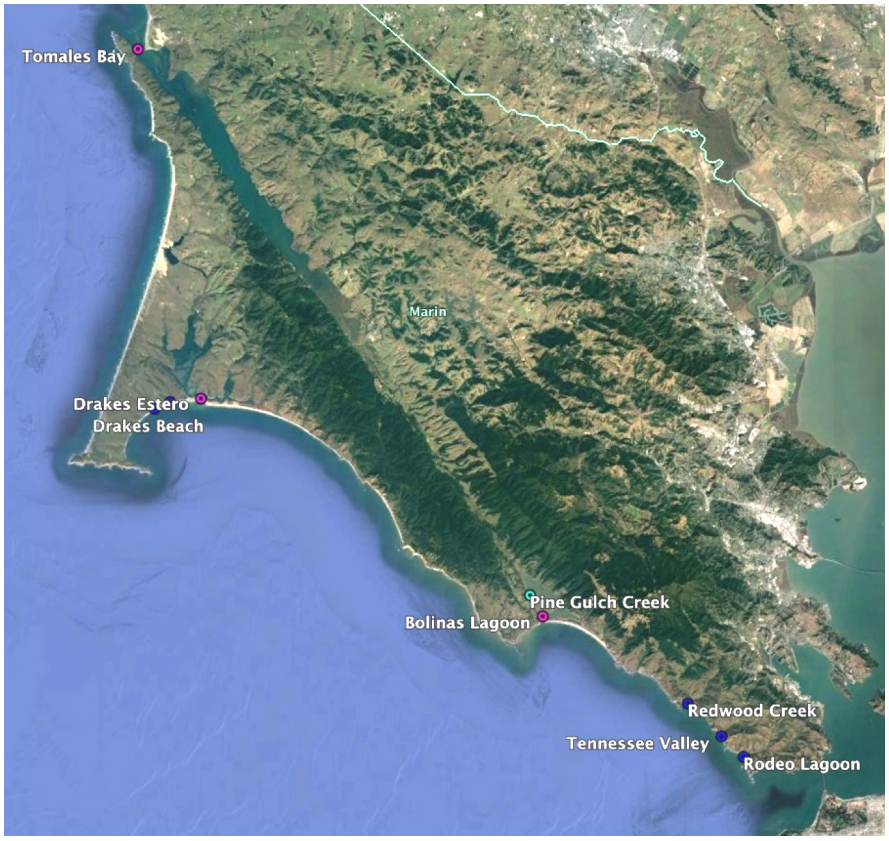


Figure 3. Selected sites in Marin County

Existing plans and reports

Management plans and biological reports exist for several of the estuaries and the watersheds within the project region, written by private consultants and government agencies. CCWG compiled existing plans and reports that reference the 8 estuaries and 1 creek within this study and their associated watersheds. These documents are listed in the results section.

Wetland Habitat Condition

The California Rapid Assessment Method (CRAM) is a cost-effective and scientifically defensible rapid assessment method for monitoring the conditions of wetlands throughout California. It is designed for assessing ambient conditions within watersheds, regions, and throughout the State. It can also be used to assess the performance of compensatory mitigation projects and restoration projects. More information on CRAM can be found at https://www.cramwetlands.org/about.

In 2013 CCWG produced a module for CRAM for BBEs throughout California. Spatially and temporally variable processes such as beach bar formation, seasonal flooding, and ocean overtopping create variability in surface water elevations and salinity gradients that are unique to these systems.

Using simple, repeatable field measurements and visual indicators of ecological condition, two trained practitioners working together can assess the overall condition of a BBE within hours. Seventeen assessment Metrics, each categorically estimating the relative condition of various wetland features are organized into four functional Attributes: Buffer and Landscape Context, Hydrology, Physical Structure, and Biotic Structure. Each Attribute score is derived by a mathematical combination of its associated metric scores. An average of all four Attribute scores calculates the overall "Index" or condition score for that assessment area. Index scores can range from 25 to 100, and are meant to encompass the entire range of possible condition within California. In addition to Metric, Attribute, and Index scores, CRAM compiles a list of anthropogenic stressors found at each site which can attribute to lower condition scores and be used to develop management strategies. Assessments of wetland habitat condition were conducted at all 5 BBE sites in 2017. For systems less than 2.25 hectares, the assessment area covered the entire system. For BBEs larger that 2.25 hectares, multiple assessments were completed to calculate an average condition score. CRAM assessment completed in prior years for the three open estuaries included in this study were compiled as well.

Watershed Stressors

Landscape level investigations of potential stressors were conducted for each BBE. The watersheds of each estuary were demarcated using Watershed Delineation Tools in ArcGIS. The predominance of different landform modifications and land cover types that can affect the condition of downstream wetland habitat were calculated for each bar-built estuary. The effects of watershed stressors on downstream BBE resources was studied at four different scales: 1) the entire watershed; 2) a 2 kilometer area surrounding the bar-built estuary; 3) within a 30 meter buffers of all watershed streams; and 4) within a 30 meter buffers of all streams within the 2 kilometer area surrounding the bar-built estuary. These four geographic scales test the significance of various landscape scale stresses on bar-built estuary habitat. Our previous research throughout California has shown these four landscape scales to be useful in highlighting the influence of different stressors on condition and in prioritizing management actions.

Wetland Habitat Change

For each bar-built estuary we compared the current relative cover of different wetland habitat types with estimates of historical cover (approximately 150 years ago) using U.S. Coastal Survey Topographic Sheets (T-sheets) created in the mid to late nineteenth century to estimate changes and loss of wetland acreage. We used 2012 aerial imagery available from the National Agriculture Imagery Program (NAIP) to delineate the distribution of various wetland types, using the same wetland classification system applied to the historical habitat composition analysis. It is important to note that in both cases (historical and current imagery) we are basing

the habitat change analysis on a snapshot picture of the estuary that reflect conditions at the time of mapping/photo documentation. This is important when considering the habitat quantities that are presented in this study, especially due to the variability of BBEs. All maps were geo-rectified and delineated using ArcGIS. Percent loss, percent change and absolute loss of each habitat type as well as total wetland acreage was calculated using R.

Special Status Species

For each bar-built estuary we searched through peer-reviewed literature, agency reports (e.g. USFWS, CDFWS, NMFS, USGS, County etc.) and CNDDB for the presence (or habitat provided for potential without documented occurrence) of a list of 7 special status species. Species presence was recorded for each system with source information references. The species, along with their protection status, include:

- Snowy Plover (ESA-threatened, CA species of special concern)
- Coho Salmon (ESA-endangered, CESA-endangered)
- Steelhead (ESA-threatened)
- Western Pond Turtle (CA species of special concern)
- Tidewater Goby (ESA-endangered, CA species of special concern)
- California Red-Legged Frog (ESA-threatened, CA species of special concern)
- Saltmarsh Common Yellowthroat (CA species of special concern)

Results

Redwood Creek

CRAM Survey Results

CRAM assessments were conducted at the estuaries included in this study over the following time periods:

- Tomales Bay: August 2007 (n=6)
- Drakes Estero: August 2007-November 2012 (n=11)
- Bolinas Lagoon: September 2007 and October 2011 (n=3)
- The CRAM data for the bar-built estuaries was collected in November 2017
    - Drakes Beach (n=1)
    - Horseshoe Pond (n=2)
    - Redwood Creek (n=1)
    - Tennessee Valley (n=1)
    - Rodeo Valley (n=2)

Index and Attribute Scores

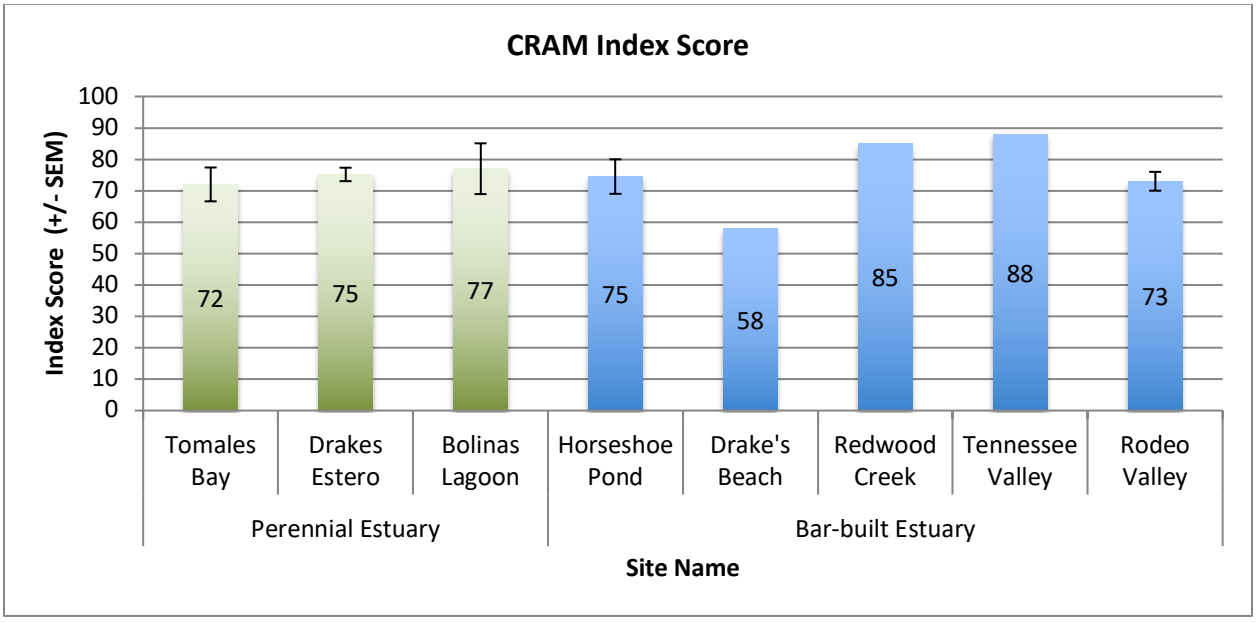


Figure 6. The index score is an overall assessment of a wetland comprised of all attributes. Error bars representing the standard error of the mean are present at sites when more than one CRAM assessment was performed for a particular system.

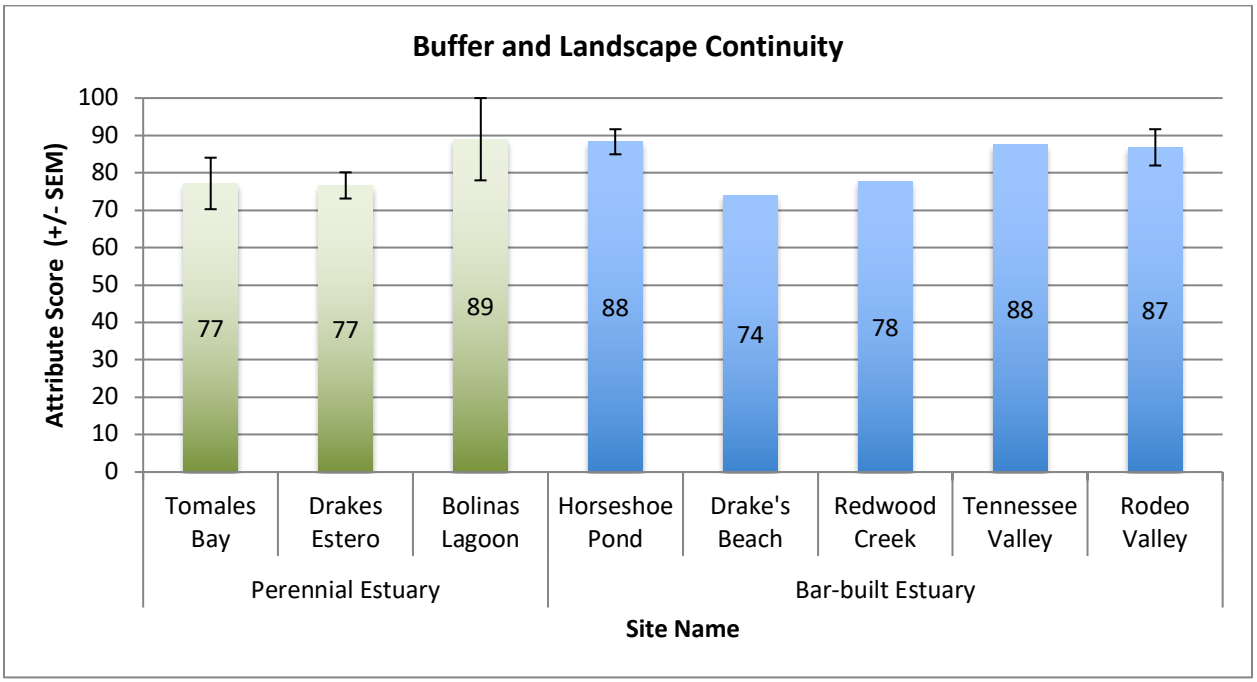


Figure 7. The Buffer Landscape Continuity Score addresses the presence and/or continuity of wetlands and riparian areas adjacent to the Assessment Area. Error bars representing the standard error of the mean are present at sites when more than one CRAM assessment was performed for a particular system.

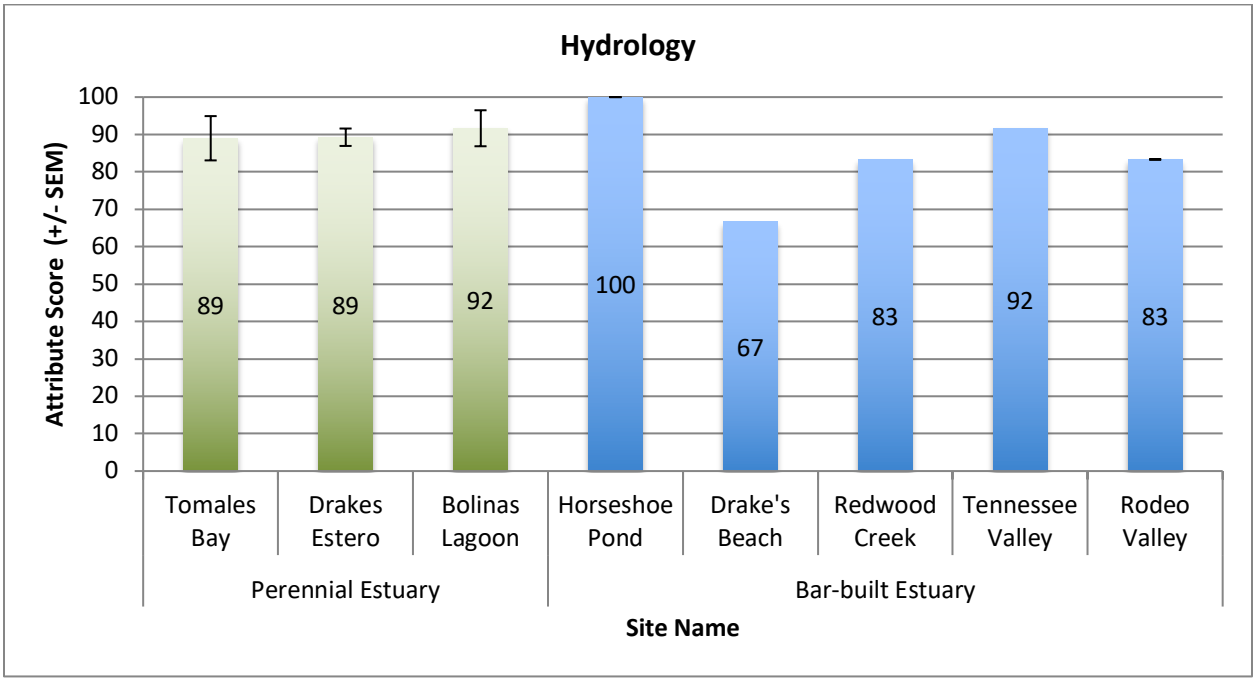


Figure 8. The Hydrology attribute measures the extent of departure of observed hydrological conditions from the "least-disturbed" state by evaluating water source, hydroperiod, and hydrologic connectivity of the assessed wetland. Error bars representing the standard error of the mean are present at sites when more than one CRAM assessment was performed for a particular system.

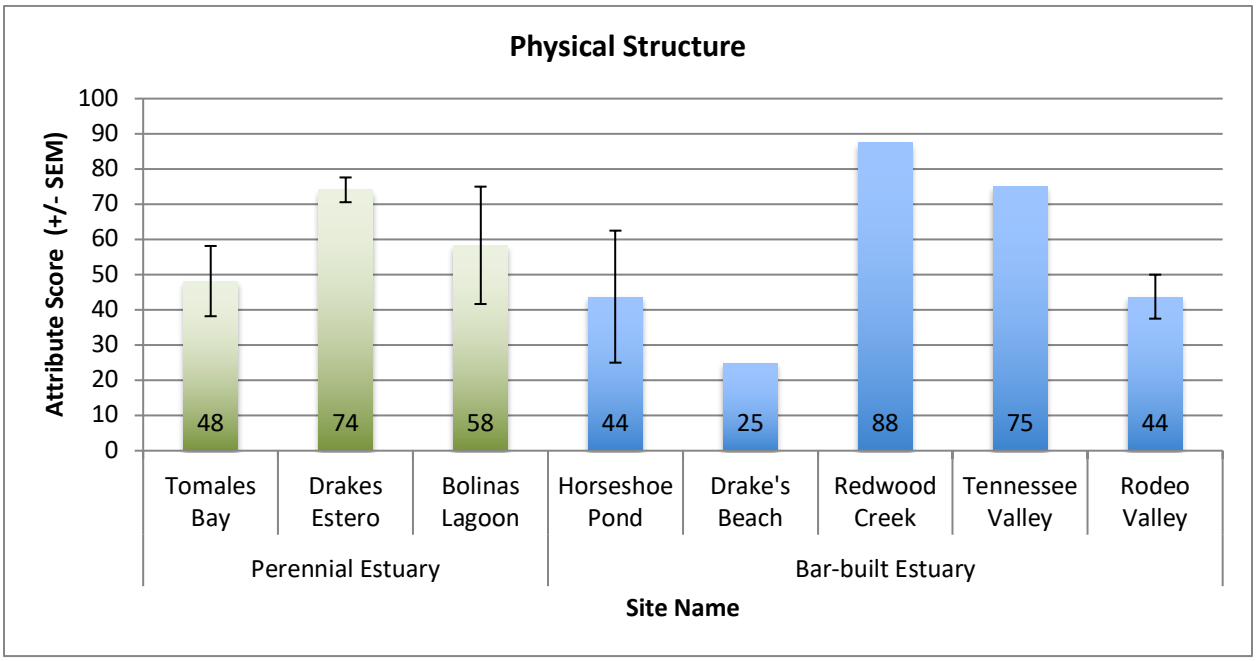


Figure 9. The physical structure attribute evaluates the complexity of form and structure affecting the biodiversity and other functions of a wetland by looking at structural patch richness and topographic complexity within the Assessment Area. Error bars representing the standard error of the mean are present at sites when more than one CRAM assessment was performed for a particular system.

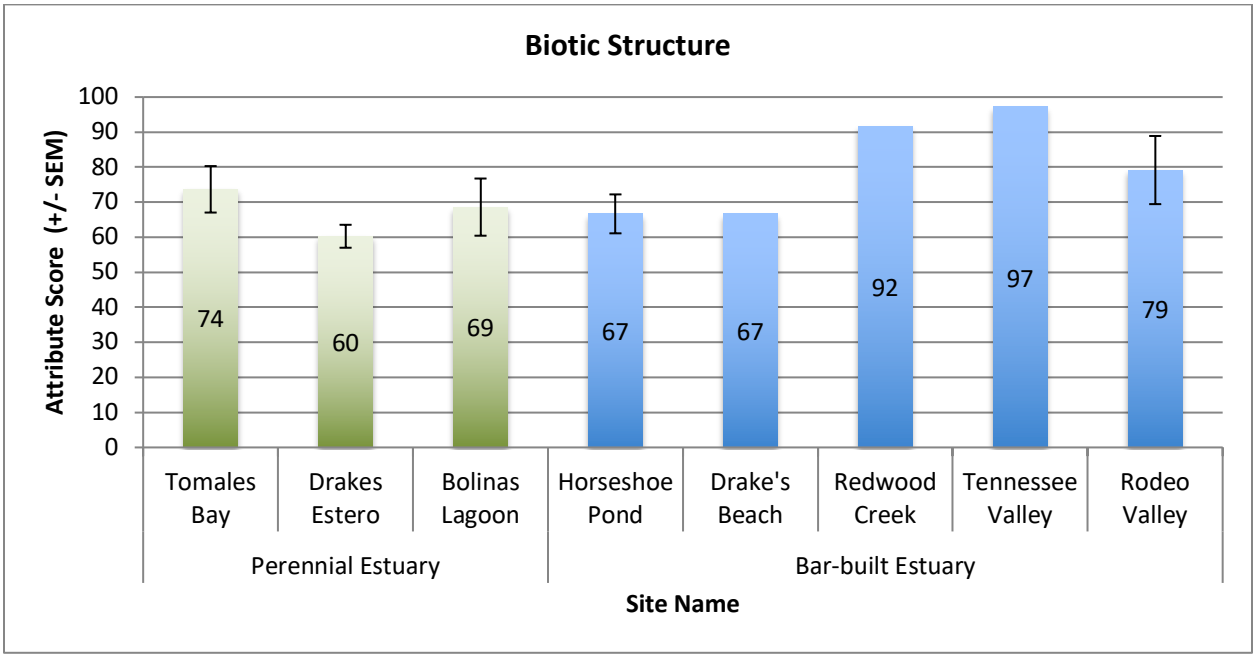


Figure 10. The biotic structure attribute addresses the complexity of a wetland by looking at plant species richness, horizontal zone complexity, and vegetation layering within the assessment area. Error bars representing the standard error of the mean are present at sites when more than one CRAM assessment was performed for a particular system.

CRAM Stressors

For the purposes of CRAM, a stressor is an anthropogenic perturbation within a wetland or its setting that is likely to negatively impact the functional capacity of a CRAM Assessment Area (AA). In contrast, disturbances are distinctly defined as natural phenomena, although they might have similar impacts as stressors.

The process to identify stressors is the same for all wetland types. For each CRAM attribute, a variety of possible stressors are listed. Their presence and likelihood of significantly affecting the AA are recorded in the Stressor Checklist Worksheet. The stressor is marked as having a significant negative effect (rather than just being present) if it can be directly linked to a decreased metric score in the assessment.

For the Hydrology, Physical Structure, and Biotic Structure attributes, the focus is on stressors operating within the AA or within 50 m of the AA. For the Buffer and Landscape Context attribute, the focus is on stressors operating within 500 m of the AA. More distant stressors that have obvious, direct, controlling influences on the AA can also be noted.

Tables 2 and 3 below list the habitat stressors observed in the perennial and bar-built estuary AAs during the CRAM assessments. They are in order of the number of times they were observed and then noted as having a significant effect or not. The significant negative effect could be present at a single or several Assessment Areas.

Table 2. Perennial Estuary Stressors (3 estuaries)

Stressor type	# estuaries with stressor	# of times noted	May have significant negative effect? Y/N
Passive Recreation (e.g. bird watching, hiking, etc)	3	17	N
Transportation corridor	3	8	Y
Active recreation (e.g., off-road vehicles, mountain biking, hunting, fishing)	3	5	Y
Urban Residential	3	4	Y
Non-point source discharges	2	6	N
Rangeland (including livestock rangeland also managed for native vegetation)	2	5	Y
Dams (e.g. reservoirs, detention basins, recharge basins)	2	3	N
Dikes/levees	2	5	Y
Mowing, grazing, excessive herbivory (within AA)	2	3	Y
Ranching (e.g. enclosed livestock grazing or horse paddock or feedlot)	2	5	Y
Dairies	2	2	N
Excessive human visitation	2	2	Y
Trash or refuse	1	2	N

Lack of treatment of invasive plants adjacent to AA or buffer	1	1	Y
Weir/drop structure	1	1	Y
Bacteria and pathogens impaired	1	6	N
Nutrient impaired (i.e. point source or nonpoint source pollution)	1	5	N
Industrial/commercial	1	4	N
Biological resource extraction or stocking (e.g. fisheries, aquaculture)	1	3	Y
Commercial feedlots	1	1	N
Intensive row-crop agriculture	1	1	N
Sports fields and urban parklands (e.g. golf courses, soccer fields, etc.)	1	1	N

Table 3. Bar-built Estuary Stressors (5 estuaries)

Stressor type	**# estuaries with stressor**	**# of times noted**	**May have significant negative effect? Y/N**
Active recreation (e.g. off-road vehicles, mountain biking, hunting, fishing)	5	6	N
Grading/compaction	5	5	Y
Passive Recreation (e.g. bird watching, hiking, etc)	4	5	N
Non-point source discharges	4	4	N
Excessive human visitation	4	5	Y
Lack of treatment of invasive plants adjacent to AA or buffer	4	4	Y
Industrial/commercial	3	3	N
Engineered channel (e.g. riprap, armored channel bank, bed)	3	3	N
Transportation corridor	2	3	N
Urban Residential	2	2	N
Rangeland (including livestock rangeland also managed for native vegetation)	2	4	Y
Mowing, grazing, excessive herbivory (within AA)	2	3	Y
Dams (e.g. reservoirs, detention basins, recharge basins)	2	2	Y
Trash or refuse	2	2	N
Bacteria and pathogens impaired	2	2	N
Intensive row-crop agriculture	1	1	N
Flow obstructions (e.g. culverts, paved stream crossings)	1	1	Y
Tree cutting/sapling removal	1	1	N
Excessive runoff from watershed	1	1	N
Pesticide application or vector control	1	1	N
Lack of vegetation management to conserve natural resources	1	1	N
Filling or dumping of sediment or soils	1	1	N

Co-Dominant Plant Species

The Plant Community Metric of CRAM is composed of three submetrics for each wetland type: Number of Plant Layers, Number of Co-dominant Plants and Percent Invasion. A thorough reconnaissance of an AA is required to assess its condition using these submetrics.

The second submetric, Number of Co-dominant Species, deals directly with dominant plant species richness in each plant layer and for the AA as a whole. For each plant layer in the AA, all species represented by living vegetation that comprises at least 10% relative cover within the layer are considered to be dominant. Only living vegetation in growth position is considered in this metric. Dead or senescent vegetation is disregarded.

For the third submetric, Percent Invasion, the number of invasive co-dominant species for all plant layers combined is assessed as a percentage of the total number of co-dominants, based on the results of the Number of Co-dominant Species sub-metric. The invasive status for many California wetland and riparian plant species is based on the Cal-IPC list.

Tables 4 and 5 list the co-dominant and invasive plant species observed in the perennial and bar-built estuary AAs.

Table 4. Co-Dominant plants observed in Perennial Estuaries

Common Name	Scientific Name	Number of Estuaries Present	Number of AAs present
Common pickleweed	Salicornia pacifica	3	19
Saltgrass	Distichlis spicata	3	16
California cordgrass	Spartina foliosa	3	10
Marsh jaumea/Salty susan	Jaumea carnosa	3	10
Sea lavender/Marsh rosemary	Limonium californicum	3	4
Rushes	Juncus spp.	2	3
Salt rush	Juncus lesueurii	2	2
Arrow-Grass	Triglochin concinna	1	2
Scirpus pungens	Scirpus pungens	1	2
Alkali bulrush	Scirpus maritimus	1	1
Annual beard grass/Rabbitfoot grass *	Polypogon monspeliensis *	1	1
Arroyo willow	Salix lasiolepis Benth.	1	1
Mulefat	Baccharris salicifolia	1	1
Baltic rush	Juncus balticus	1	1
Bulrush	Scirpus robustus	1	1
Coyote brush	Baccharis pilularis	1	1
Marsh gum-Plant	Grindelia stricta	1	1
Nutsedge	Cyperus involucratus	1	1
Saltbush	Atriplex triangularis	1	1
Seaside arrow-Grass	Triglochin maritima	1	1
Silverweed Cinquefoil	Potentilla anserina	1	1
Velvet grass *	Holcus lanatus *	1	1

*=invasive according to Cal IPC

Table 5. Co-Dominant plants observed in Bar-built Estuaries

Common Name	Scientific Name	Number of Estuaries Present	Number of AAs present
Arroyo willow	Salix lasiolepis	4	4
Salt grass	Distichlis spicata	3	5
Common three-Square bulrush	Schoenoplectus pungens var. longispicatus	3	4
Silverweed Cinquefoil	Potentilla anserina	3	4
Slough sedge	Carex obnupta	3	3
Marsh jaumea/Salty susan	Jaumea carnosa	2	3
California blackberry	Rubus ursinus	2	2
Coast or bog rush	Juncus hesperius	2	2
Red Alder	Alnus rubra	2	2
Salt rush	Juncus lesueurii	2	2
Water smartweed	Persicaria amphibia	2	2
Baltic rush	Juncus balticus	1	2
Common pickleweed	Salicornia virginica	1	2
Alkali bulrush	Scirpus maritimus	1	1
Alkali heath	Frankenia salina	1	1
Mulefat	Baccarris salicifolia	1	1
Creeping wild rye	Leymus triticoides	1	1
Bristly ox-Tongue *	Helminthotheca echioides *	1	1
Broad-Leaved cattail	Typha latifolia	1	1
Buck-horn's Plantain	Plantago coronopus	1	1
California coffee berry	Frangula californica	1	1
Cattail	Typha sp.	1	1
Coyote brush	Baccharis pilularis	1	1
Ice Plant/Sea Fig *	Carpobrotus chilensis *	1	1
Soft or lamp rush	Juncus effusus	1	1
Southern bulrush	Schoenoplectus californicus	1	1
Vetch	Vicia sp.	1	1

*=invasive according to Cal IPC

Wetland Habitat Change

Historical change analysis of estuaries provides evidence of how previous land form changes and current land use has affected the size and shape as well as the diversity of wetland features within the estuary. A GIS analyses of the historical (1850s T-Sheets) and current (NAIP aerial imagery) size and class of wetland habitat was estimated using the CCWG wetland classification system. While there has not been a significant loss of wetland habitat in the five BBEs that were assessed in Marin County, there has been a change in the type of wetland. At two of the BBEs (Drakes Beach and Tennessee Valley), much of the wetland habitat is now behind a levee, restricting interactions with the marine environment (Figures 11 and 12).

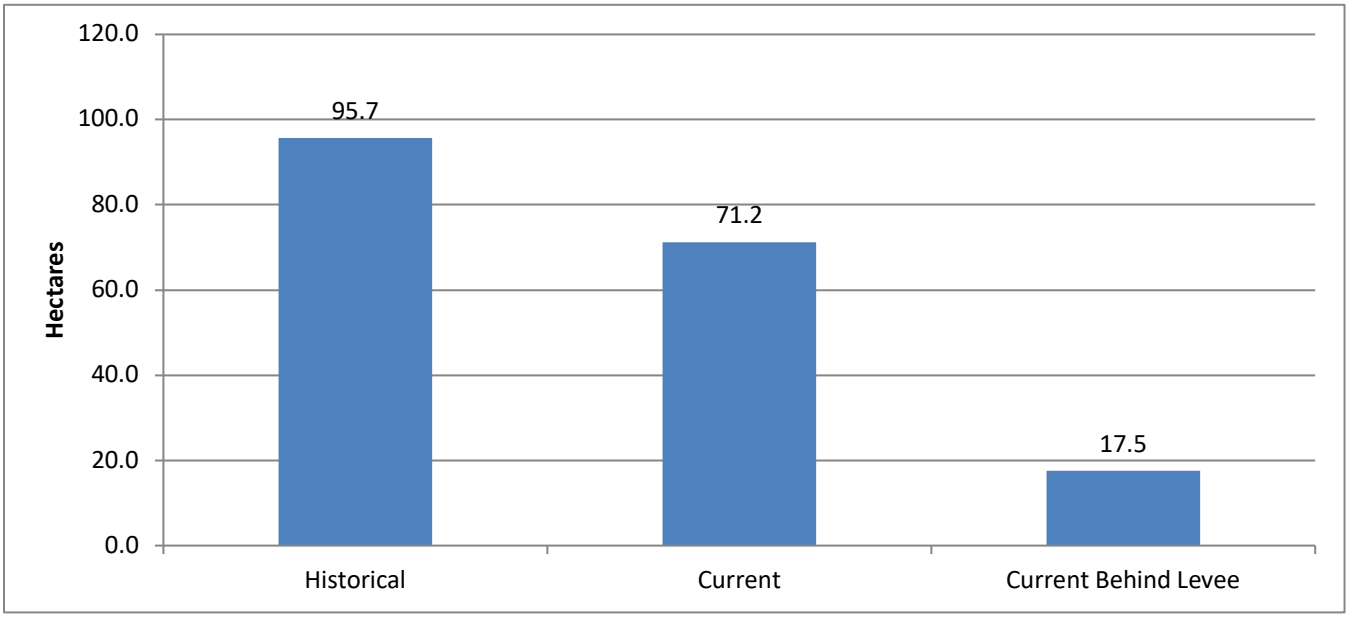


Figure 11. Total wetland area for the 5 bar-built estuaries for the historical (1850's) and current time periods.

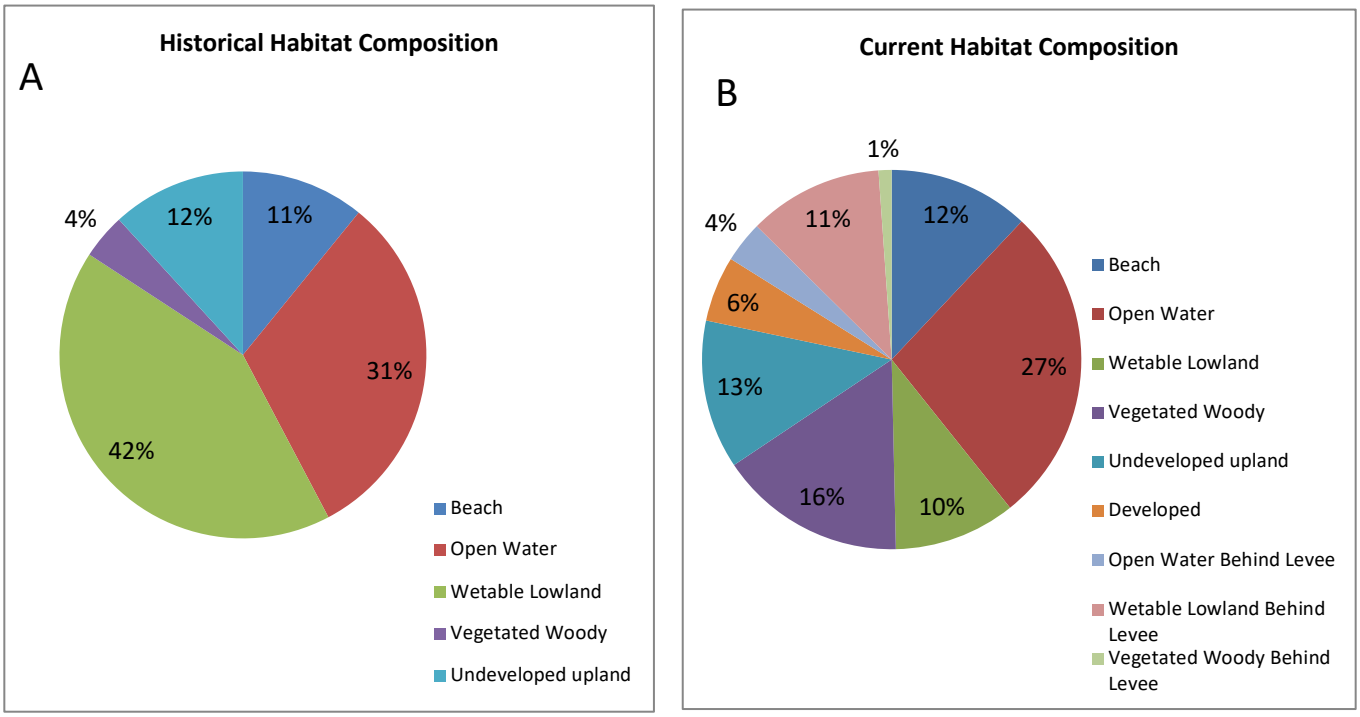


Figure 12. Historical (A) and current (B) Level 2 habitat composition for 5 Bar-built estuaries..

Special Status Species in BBEs

An investigation of the California Natural Diversity Data Base (CNDDB), local recovery plans, reports on locations of species status and input from local researchers documented (or assumed high probability) that six of the

seven special status species of interest were present within the studied estuaries. Redwood Creek and Rodeo Valley supported the greatest number of documented special status species (Table 6), but this may partially reflect the fact that restoration activities at Redwood Creek in the 2000s necessitated extensive protocol-level surveys for listed species. Drake's Beach Lagoon, Horseshoe Pond, and Tennessee Valley are not regularly surveyed by land managers for special-status species. For many of these species, the suitability of BBE habitats will vary within and between years based on habitat structure, inlet status, and other variables.

Table 6. Presence of seven special status species of interest at project sites

System Name	Snowy Plover	Coho	Steelhead	Western Pond Turtle	Tidewater Goby	Red-Legged Frog	saltmarsh common yellowthroat
Rodeo Lagoon			P		P	P	P
Tennessee Valley							P
Redwood Creek Muir Beach		P	P	P		P	
Drakes Beach Lagoon						P	
Horseshoe Pond						P	

General Site Information

Source: The Marin Watershed Program
Link: http://www.marinwatersheds.org/creeks-watersheds
Summary: This website provides information to understand how watersheds function, information about the creeks and habitats, flooding and flood protection, and what you can do to be a steward of your watershed, no matter where you are in Marin. It includes maps of land use, vegetation, and wildlife occurrence as well as quick links to some local projects.

Source: KRISWeb Bibliography
Links: http://www.krisweb.com/biblio/biblio_tomales.htm
http://www.krisweb.com/biblio/biblio_smarin.htm
http://www.krisweb.com/biblio/biblio_drakesbay.htm
Summary: These links lead to a bibliography of reports on projects done in Tomales Bay, Drakes bay and Southern Marin County. Most articles are from prior to 2000.

Source: KRISWeb West Marin-Sonoma
Links: http://www.krisweb.com/kris_wms/krisdb/html/krisweb/index.htm
Summary: This project was undertaken in large part to assemble information useful in State and federal Pacific salmon recovery planning pursuant to the State and federal endangered species acts. The contents of the KRIS West Marin-Sonoma project come from a wealth of sources and incorporate results of numerous previous studies, watershed plans and restoration projects.

Information: Bar-built Estuaries

Horseshoe Pond and Drakes Beach

Species of concern

California red-legged frog

Stressors

During CRAM surveys, 9 stressors were noted. Non-point discharges, Rangeland, Mowing/grazing, and Passive Recreation were noted most frequently. The stressors considered to have negative significant effect were non-point source discharges, Rangeland, Mowing/grazing, and lack of treatment of invasive plants.

References

Citation: *Environmental Assessment: Restoration of Horseshoe Pond to a Coastal Lagoon/Tidal Estuary*. Point Reyes National Seashore National Park Service, 21 Jun. 2004.
Link:https://www.nps.gov/pore/learn/management/upload/planning_horseshoepond_restoration_ea_final_040621.pdf
Summary: This environmental assessment evaluates the potential environmental consequences of three alternative strategies for implementing the restoration of natural hydrologic and shoreline process to the Horseshoe Pond area of the historic D-Ranch in Point Reyes National Seashore. Horseshoe Pond is a former 35-acre coastal lagoon situated on the north side of Drakes Beach between the Ken Patrick Visitor's Center and the mouth of Drakes Estero. For hundreds of years, the Horseshoe Pond area functioned as a lagoon, controlled by the sand-dominated outlet to the west side of the beach interface. The pond was part of the D-Ranch dairy operation acting as a water source and ultimate destination for much of the dairy waste. Constant maintenance of the dam facility was required as high seas constantly eroded and breached the dam facility. The pond breached in January 2002. The brackish waterbody is heavily influenced by tidal overwash into the pond area, as well as freshwater runoff. The objectives of the restoration project include restoring natural hydrologic and coastal beach processes to the site, accelerate improvements to water quality in Horseshoe Pond towards stabilizing dissolved oxygen levels to improve habitat for aquatic species, and to restore native dune function and habitat, among others.

Redwood Creek/Big Lagoon/Muir Beach

Species of concern

Coho salmon, Steelhead, Western pond turtle, California Red-legged frog

Stressors

In a CRAM survey, 13 stressors were noted at Redwood Creek. None of these stressors were considered to have significant negative effect on the assessment area.

References

Citation: Pacific Watershed Associates (PWA). 2002. Summary report: 2000 S.B. 271 Watershed assessment and erosion prevention planning project for the Redwood Creek Watershed, Marin County, California. Prepared for Muir Beach Community Services District, California Department of Fish and Game, Marin Municipal Water District, and National Park Service by PWA. Arcata, CA. 52 pp. [666kb]
Link: http://www.krisweb.com/biblio/southmarin_pwa_pwa_2002_erosion271.pdf
Summary: Redwood Creek is one of four main streams supporting Coho salmon and Steelhead trout in Marin County and dispels directly into the Pacific Ocean at Muir Beach. The highest priority goals for restoration are preventing sedimentation due to erosion within the watershed and loss of salmonid rearing habitat. PWA concluded in 2002 that road and trail maintenance and decommissioning are the best methods of reducing erosion risk.

Citation: Kimball, L. C. and G. M. Kondolf. 2002. Analysis of channel geomorphology and habitat forming processes for feasibility assessment of rip-rap removal, Muir Woods National Monument, Mill Valley, California. University of California, Berkeley, Department of Landscape Architecture. Prepared for the National Park Service, Muir Woods National Monument, and the Golden Gate National Recreation Area. 90 pp. [3.5Mb]
Link: http://www.krisweb.com/biblio/southmarin_ucb_kimballetal_2002_riprap.pdf
Summary: This pilot study aims to evaluate the success of riprap removal on a small scale within Redwood Creek to observe effects on salmonid habitat and to provide a basic understanding of geomorphic and ecological processes related to habitat maintenance. The final recommendation from this study is to remove riprap and also add large woody debris to encourage natural processes to take back over.

Source: Restoration of Redwood Creek at Muir Beach
Links:
https://www.nps.gov/goga/learn/nature/redwood-creek-restoration-progress-to-date.htm
https://www.nps.gov/goga/learn/nature/muir-beach.htm
https://www.nps.gov/muwo/learn/nature/restoration-mb.htm
http://www.sfbayjv.org/project-redwood-creek-restoration-at-muir-beach.php
Summary: These pages on the multiple websites describe the progress made in restoring Redwood Creek from 2009 to 2015. Phase 1 in 2009 focused on removing artificial fill and some of the existing parking lot to restore the tidal lagoon, and planted natives. Phases 2 and 4 in 2012 included 550 feet of new creek channel, and side channels to provide young coho and steelhead habitat as well as more native restoration and improvements to community engagement and visitor amenities. Phase 3 in 2011 included a 225 pedestrian bridge for beach access, removal of 1,000 feet of old levee road to reconnect the floodplain. Phase 5 in 2013 changed the orientation of the parking lot and added another 225 feet to the pedestrian bridge for beach access and continued plans of native restoration and invasive management.

Citation: Redwood Creek Restoration at Muir Beach: Project Examples for Climate Change Planning.
Link: http://www.sfnps.org/download_product/5009/0
Summary: This powerpoint features images spanning the Redwood Creek Restoration Project from 2009 to 2014. It highlights the change in the watershed to a connected floodplain and the function of the land as flood control. Ecosystem context was considered beyond the planning area footprint. Atmospheric rivers (vapor belts

from the ocean) are discussed as major contributors to flooding conditions. Secondary channels and sand dune formation occurred from 2012 to 2014 to maintain coastal function.

Citation: SFBRWQCB 2008. Water Quality Monitoring and Bioassessment in Selected San Francisco Bay Region Watersheds in 2004-2006. Surface Water Ambient Monitoring Program, San Francisco Bay Regional Water Quality Control Board, Oakland, CA.
Link:
https://www.waterboards.ca.gov/water_issues/programs/swamp/docs/reports/rb2_report_appnd122308.pdf
Summary: Redwood Creek supported a healthy diversity of benthic macroinvertebrates, including some pollution intolerant species, except near the Green Gulch drainage. All Redwood Creek sites tested within the accepted range for dissolved oxygen, pH, and metals. Only at the Green Gulch drainage was specific conductance above 500 us/cm. Only one Redwood Creek sampling site returned a coliform concentration exceeding objectives. The main stem of Redwood Creek has been selected as a reference for continued SWAMP studies.

Source: EcoAtlas
Link: https://www.ecoatlas.org/regions/adminregion/sfbjv/projects/5562
Summary: Redwood Creek Restoration at Muir Beach (Big Lagoon)

Rodeo Valley Lagoon

Species of concern

Steelhead trout, Tidewater goby, California Red-legged frog, Saltmarsh common yellowthroat

Stressors

During 2 CRAM surveys, 15 stressors were noted at Rodeo Valley. The stressors noted during both surveys were Excessive human visitation, Passive recreation, Active recreation, and Transportation corridor. None of the stressors were considered to have significant negative effects on the assessment area.

References

Citation: SFBRWQCB 2008. Water Quality Monitoring and Bioassessment in Selected San Francisco Bay Region Watersheds in 2004-2006. Surface Water Ambient Monitoring Program, San Francisco Bay Regional Water Quality Control Board, Oakland, CA.

Link:https://www.waterboards.ca.gov/water_issues/programs/swamp/docs/reports/rb2_report_appnd122308.pdf
Summary: Rodeo Creek runs primarily through open space. Most of the Rodeo Valley sites had lowered invertebrate diversity, especially lacking in pollution sensitive species. Dissolved oxygen levels were mostly within the normal range, except some spring and summer deployments that returned low values, probably due to sonde positioning during the deployment. Metals, coliform, pH, and specific conductance were not an issue at any sites in the watershed. Rodeo Creek exceeded the limit for phosphorus but Rodeo Lake and Rodeo Lagoon did not.

Citation: Striplen, C., R. Grossinger, and J. Collins, 2004. Wetland Habitat Changes in the Rodeo Lagoon Watershed, Marin County, CA. A Technical Report of the Historical Ecology and Wetlands Programs, SFEI Contribution 116, San Francisco Estuary Institute, Oakland CA.
Link: www.sfei.org/sites/default/files/biblio_files/RodeoLagoonHEFinalReport116_0.pdf
Summary: Rodeo Valley Lagoon Watershed is one of the better documented coastal watersheds due to its military history. This document aims to plan for improvement to public access to Rodeo Lagoon specifically and to identify areas suitable for restoration or habitat improvement. Researchers used mostly historical maps of the area for century old data and use them to discuss changes that have taken place from early farming to military use to present day NPS management. Pages 30 through 32 describe management limitations and opportunities regarding the lagoon and surrounding watershed.

Tennessee Valley Lagoon

Species of concern

Saltmarsh common yellowthroat

Stressors

In a CRAM survey, 7 stressors were found at Tennessee Valley. The only one noted as having significant negative effect on the assessment area was Dams (reservoirs, detention basins, recharge basins).

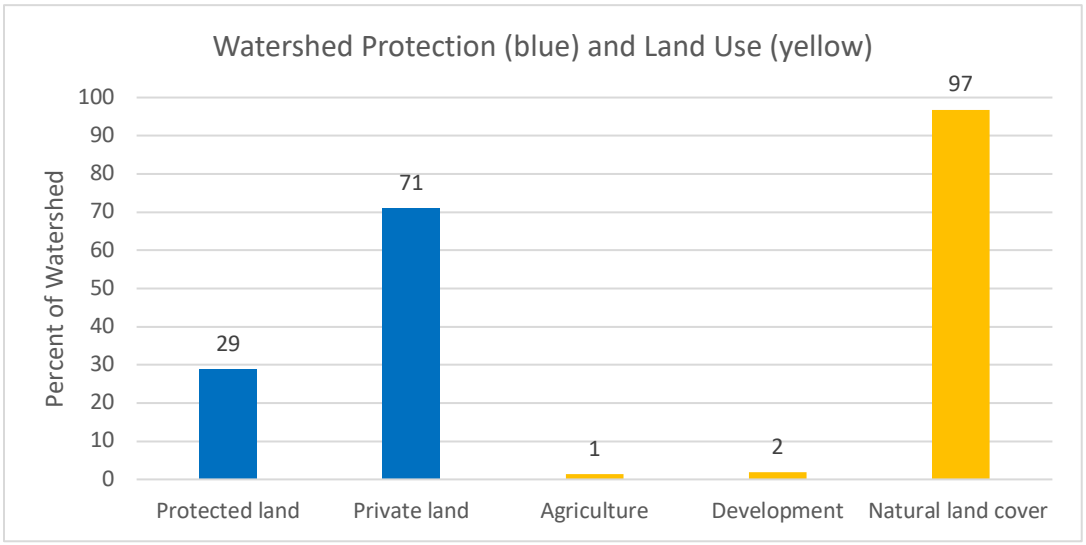
References

Citation: SFBRWQCB 2008. Water Quality Monitoring and Bioassessment in Selected San Francisco Bay Region Watersheds in 2004-2006. Surface Water Ambient Monitoring Program, San Francisco Bay Regional Water Quality Control Board, Oakland, CA.
Link:
https://www.waterboards.ca.gov/water_issues/programs/swamp/docs/reports/rb2_report_appnd122308.pdf
Summary: Tennessee Valley Creek tested above the minimum for dissolved oxygen, within the range for pH, below the upper limit for conductance, below coliform objectives, and below for metals. There was high phosphorus and nitrate recorded. Tennessee Valley Creek did have a lower benthic macroinvertebrate diversity, possibly due to a large amount of fine sediment on the creek bed with not a lot of interstitial space.

Information: Perennial Estuaries

Tomales Bay

California Coastal Records Project, Kenneth & Gabrielle Adelman



Date source: TNC Conservation Assessment of West Coast USA Estuaries

Stressors

During CRAM surveys, 15 stressors were noted in total, with Passive Recreation noted most frequently, followed by Non-point source discharges and Transportation corridor. The stressors found to have significant negative effect were Transportation corridor, Rangeland, Active Recreation, Dikes/levees, mowing/grazing/excessive herbivory, Ranching, Urban residential, excessive human visitation, lack of treatment of adjacent invasive plants, and weir/drop structure.

References

Citation: The Nature Conservancy. "The Aquaculture Opportunity." *Nature Conservancy Global Solutions*, global.nature.org/content/the-aquaculture-opportunity.
Link: https://global.nature.org/content/the-aquaculture-opportunity
Summary: This article discusses how a growing aquaculture business in Tomales Bay and elsewhere could have a positive impact on the environment and support economic development in at the same time.

Citation: "Tomales Bay Watershed Species of Local Interest." *HABITATS & SPECIES*, Tomales Bay Watershed Council, www.tomalesbaywatershed.org/habitats---species.html.
Link: http://www.tomalesbaywatershed.org/habitats---species.html
Summary: This page is an overview of the Species of Local Interest List, described further in the following link.

Citation: Gardali, T., J. P. Kelly, J. Evens. 2011. Tomales Bay Watershed Species of Local Interest: native and non-native species of conservation or management concern. A Report of the Tomales Bay Watershed Council, Box 447, Point Reyes Station, CA 94956.
Link: http://www.tomalesbaywatershed.org/assets/tbwc_speciesoflocalinterest_2011_final.pdf
Summary: "The Species of Local Interest list for the Tomales Bay watershed is created and managed by the Tomales Bay Watershed Council. The list provides a means for prioritizing and promoting efforts to protect and restore native species and habitat areas, through restoration, management, ecological monitoring, and guided research. The list is divided into two parts: Species of Local Concern and Local Ecological Pest Species. The species in each list are ranked to highlight "Priority" and "High Priority" Species of Local Interest, based on several scoring criteria, published papers, unpublished reports, and expert opinion. Species of Local Concern include 203 taxa, of which 119 are Priority species and 27 are High Priority species. Local Ecological Pest Species include 168 taxa, of which 50 are Priority pests and 55 are High Priority pests."

Citation: **National Park Service (NPS). 2001.** Final compliance report, Muddy Hollow Creek culvert removal. Prepared by the staff at the Coho Salmon and Steelhead Trout Restoration Project (CSRP). Point Reyes National Seashore. Point Reyes Station, CA. 7 pp. [1.2Mb]
Summary: Prior to National Park Service (NPS) acquisition of the land in the 1960's, an 80' culvert was installed to pass an access road over Muddy Hollow creek. Over time the culvert failed, creating fish impediments, elevating sediment load, and diminishing streambed stability. Removal of the culvert, or daylighting, was performed to restore hydrologic connectivity and to reduce the long-term maintenance requirements associated with culvert operation.
The National Marine Fisheries Service designed structure has allowed NPS staff to successfully restore a section of Muddy Hollow creek that would otherwise have remained impaired. Ongoing studies were planned to monitor the impacts of this removal.

Citation: **California Regional Water Quality Control Board (CRWQCB) . 2002.** Total maximum daily load for pathogens in Tomales Bay. Preliminary project report. November 15, 2002. CRWQCB, San Francisco Bay Region. San Francisco, CA. 88 pp. [2.7Mb]

Summary: Tomales Bay is listed as an impaired waterbody under the federal Clean Water Act, Section 303(d) for pathogens. The implementation plan describes existing regulatory programs and authorities that can assist with Total Maximum Daily Load (TMDL) implementation. The implementation plan also identifies specific management measures that are necessary to achieve TMDL targets, a time schedule for implementing source control actions and, monitoring to determine compliance with the objectives. The implementation plan includes interim targets of a 30% reduction in Bay pathogen concentrations by 2005 and 75% reduction in Bay pathogen concentrations by 2007.

Citation: Smith, EH. Tomales Bay Water Quality Status & Trends Report. EH Smith & Associates, 2003.
Link:http://www.bml.ucdavis.edu/peeir/manuscripts/Smith.Tomales.Bay.Water.Qual.Status.&.Trends.%20Rpt.pdf
Summary: Water quality narrative that summarizes existing literature from Tomales Bay and tributaries in order to understand the status and trends for contaminants found by these studies. Most of the report relies on existing data analysis and conclusions drawn by the responsible authors. Data was extracted from a number of studies that used bivalve to bioconcentrate contaminants from Tomales Bay. This data was compiled and plotted to indicate the status and possible trends over time.

Citation: Lewis, David, et al. "WATER QUALITY IN THE TOMALES BAY WATERSHED: Conflict and Response to On-Farm Water Quality Management." cesonoma.ucanr.edu/files/27411.pdf.
Link: http://cesonoma.ucanr.edu/files/27411.pdf
Summary: "The UCTBWQP conducted storm runoff sampling on cooperating Bay ranches during the 1999-2000, 2000-2001, and 2001-2002 winters. Results indicate that fecal coliform loading in control watersheds is less than loading in watersheds with active animal agriculture operations. Having generated results that illustrate the link between pollutant inputs to Tomales Bay and agriculture practices in the watershed, the project initiated an evaluation of animal waste management practices to reduce pollution to surface waters. This work started in 2001 and was completed in the 2003-2004 field season. Specifically, they investigated the effectiveness of vegetative buffers, dry lot and corral management, and improved pasture management to reduce pollutant loads."

Citation: Lewis, David, et al."LINKING ON-FARM DAIRY MANAGEMENT PRACTICES TO STORM-FLOW FECAL COLIFORM LOADING FOR CALIFORNIA COASTAL WATERSHEDS." *Rd.springer.com*, Environmental Monitoring and Assessment (2005) 107: 407–425 rd.springer.com/content/pdf/10.1007/s10661-005-3911-7.pdf.
Link: https://rd.springer.com/content/pdf/10.1007/s10661-005-3911-7.pdf
Summary: Water quality data was taken on a storm event basis from loading units related to agricultural operation at 10 coastal dairies and ranches to document fecal coliform concentration and loading to surface waters. In stream samples were also collected above and below the dairy facilities and from a control watershed. The results concluded that fecal coliform load from units of concentrated animals and manure were significantly more than units such as pastures, while storm flow amounts were significantly less. This data is useful for management decisions because it represents current management activities.

Citation: California Department of Fish and Wildlife, Office of Spill Prevention and Response, Marine Invasive Species Program. *Introduced Aquatic Species in California Bays and Harbors 2011 Survey*. Mar. 2014, https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=80969&inline.
Summary: Report of 2011 study done by California Department of Fish and Wildlife that collected information on the presence, distribution, and abundance of non-indigenous species in California bay and harbours, including Tomales Bay.

Citation: California Department of Fish and Wildlife, Office of Spill Prevention and Response, Marine Invasive Species Program. "2014 TRIENNIAL REPORT ON THE CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE'S MARINE INVASIVE SPECIES PROGRAM."*Data Portal*, California Department of Fish and Wildlife, Nov. 2014, nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=91995&inline.
Link: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=91995&inline
Summary: Report summarizes the activities and results of California Department of Fish and Wildlife's Marine Invasive Species Program from July 2011-July 2014. In 2011, the highest percentage of non-native aquatic species of the resolved taxa collected was found in Tomales Bay compared to other sites.

Citation: Ruiz, Gregory M, and Jonathan Geller. "Spatial and Temporal Analysis of Marine Invasions in California: Morphological and Molecular Comparisons across Habitats." *Data Portal*, California Department of Fish and Wildlife, 2015, nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=123887&inline.
Link: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=123887&inline
Summary: Program undertaken to analyze spatial and temporal patterns of nonindigenous species invasions in estuarine waters of California. Invertebrate communities in 10 different estuaries (including Tomales Bay) were sampled, some with commercial ports and some without. This is a long term program and the report presents results on approximately half of the initial phase of the program. The second phase of the program is now underway and will expand the geographic scope of the survey and continue synthesizing the current data with historical data. The overall goals of the program are to measure status and trends of biological invasions in coastal marine ecosystems of California.

Citation: Maloney, E., Fairey, R., Lyman, A., Walton,Z., Sigala, M. 2007. Introduced Aquatic Species in California's Bays and Harbors -2006. Final Report. California Department of Fish and Game, Sacramento, CA., 116pp.
Link: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=24275&inline
Summary: This report describes the non-indigenous species investigations conducted by California Department of Fish and Game's Office of Spill Prevention and Response to fulfill the Marine Invasive Species Act of 2003. The study was done in areas including a variety of man made and natural habitats. The focus of the study was bay, port and marina locations where introductions from ballast water are most likely to have occured.

Citation: Foss, Stephen F, et al. NON-INDIGENOUS AQUATIC ORGANISMS IN THE COASTAL WATERS OF CALIFORNIA. California Fish and Game Office of Spill Prevention and Response, *California Fish and Game 93* (3) :111-129. Summer 2007, https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=15521&inline
Link: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=15521&inline
Summary: Project investigating Invasive Species under California Ballast Water Management Act of 1999. Data from the study can be used as a baseline to assess the effectiveness of ballast water control measures on species introductions into California. The data generated by this investigation was anticipated to be used in future studies such as the determination of alternative ballast water discharge zones, delineation of environmentally sensitive areas to be avoided for uptake or discharge of ballast, and an assessment of potential risk zones where uptake must be prohibited. Over 70 non-indigenous taxa were identified in Tomales Bay.

Citation: Tomales Bay Biodiversity Inventory Reaches 2000 Species. National Park Service, 7 Dec. 2004
Link: https://www.nps.gov/pore/learn/news/newsreleases_20041207_tomalesbayatbi.htm
Summary: This article from National Park Service gives an overview of the work being done to account for all the species living in Tomales Bay. 2015 species were found in the bay. 477 of these species had not been previously documented in the bay, and one species was completely new to science. The purpose of this cataloging of species is to uncover management concerns, such as invasive species, and to display how many species rely on healthy habitats within Tomales Bay. At least 28 of the species documented were non-natives, with at least 5

"deemed to be a serious threat to ecosystem health and native species". Other projects are using this inventory as a reference to plan restoration projects and invasive species monitoring.

Citation: Kelly, John, and Jules Evans. "Tomales Bay Revival: The Ripple Effects of Restoration." *Bay Nature*, 21 June 2015.
Link: https://baynature.org/article/tomales-bay-revival/
Summary: This article recounts observations of the health of the bay post-restoration of its largest tidal wetland, Giacomini Wetlands, which reintroduced tidal action in 2008. The restoration effort has increased the habitat for migrating birds as well as provided space for tidal marsh to adjust in response to future sea level rise. Following the restoration of Giacomini Wetlands, Audubon Canyon Ranch's annual waterbird surveys showed a dramatic increase in shorebird abundance in that area. The article goes on to discuss the eelgrass habitat in Tomales Bay that has been restored, which is important for bird and fish species.

Citation: Carson, Rob 2013. Tomales Bay Wetlands Restoration and Monitoring Program 2007- 2012 Final Water Quality Technical Report and Program Summary. Tomales Bay Watershed Council Foundation prepared for California State Water Resources Control Board SRF Project No. C-06-6926-110.
Link:http://www.tomalesbaywatershed.org/assets/2011_12_tbwc_finalwqreport_complete_finalv4_sm.pdf
Summary: This is a water quality project with 3 main components: "1) The Trends Program which focuses on long-term monitoring at fixed sites throughout the watershed to monitor water quality trends; 2) the Source Area Program which focuses on identifying and characterizing existing water quality threats in target sub-watersheds selected annually; and 3) the Giacomini Wetlands Restoration Project which monitors the restoration project area and local reference areas before, during and after restoration to evaluate changes in water quality conditions. This report presents Trends Program and Source Area Program activities, particularly summary and analysis of water quality data collected from December 2007 through September 30, 2012." Results suggest that the monitored tributaries are not complying with bacteria objectives proposed in the pathogen TMDL for Tomales Bay. Observed nutrient levels in the watershed were relatively low.

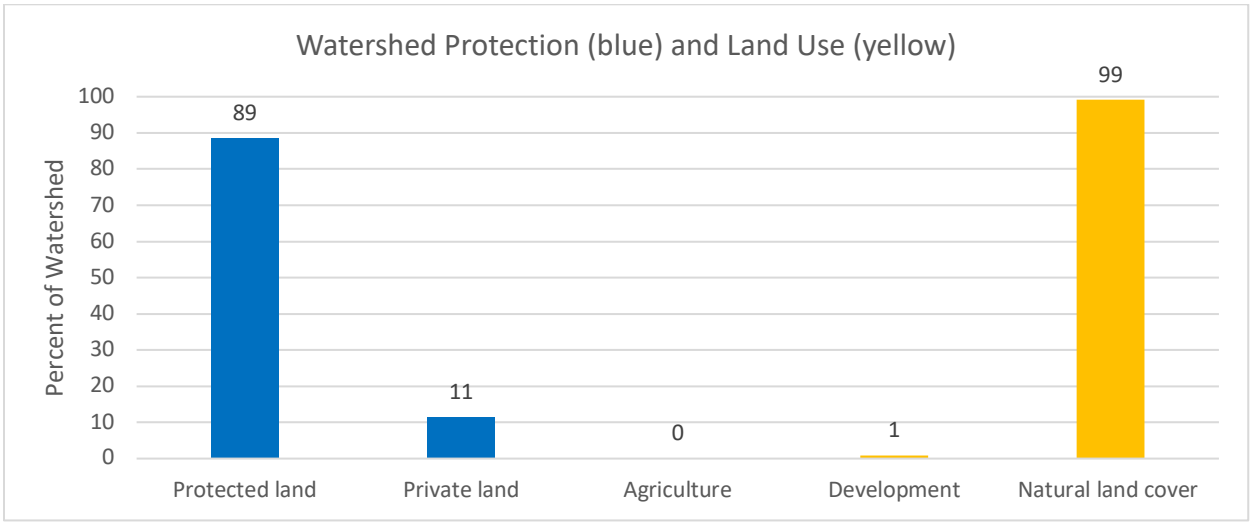
Data Source: Tomales Bay Watershed Council Library
Link: http://www.tomalesbaywatershed.org/library.html
Summary: A webpage documenting resources for Tomales Bay research.

Data Source: Southern California Coastal Water Research Project data
This is a link to a data search tool, where you can search for Southern California Coastal Water Research Project data by project or by geographic region. You may then refine the search by survey, parameter, or group of chemicals or nutrients.
Link: http://www.sccwrp.org/Data/SearchAndMapData.aspx

Data Source: Marine Invasive Species Program - List of reports, publications and studies:
https://www.wildlife.ca.gov/OSPR/Science/Marine-Invasive-Species-Program/Reports-and-Publications

Drakes Estero

California Coastal Records Project, Kenneth & Gabrielle Adelman



Date source: TNC Conservation Assessment of West Coast USA Estuaries

Stressors

During CRAM surveys, 17 stressors were noted in total, with Passive Recreation being noted most frequently, followed by Bacteria and pathogens impaired, Nutrient impaired, and industrial/commercial. The stressors found to have a negative effect were Biological resource extraction, and mowing or grazing.

References

Citation: *NLAA Detennination for the Drakes Estero Restoration Project, Point Reyes National Seashore*. National Park Service, 22 May 2015, https://www.nps.gov/pore/learn/management/upload/planning_drakesestero_restoration_background_noaa_application_for_nlaa_determination_150522.pdf

Link:
https://www.nps.gov/pore/learn/management/upload/planning_drakesestero_restoration_background_noaa_application_for_nlaa_determination_150522.pdf
Summary: This article describes a proposed restoration project located within the main body of Drake's Estero that would remove the remaining non-historic and non-essential facilities including more than 5 miles of oyster racks and aquacultural debris from the subtidal lands. The removal would affect Endangered Species Act listed species Central California Coast Coho Salmon and Central California Coast Steelhead positively by restoring natural conditions and improving wilderness character within the marine waters of Drakes Estero.

Citation: *Coastal Watershed Restoration Program: Drakes Estero Road Crossing Improvement Project*. National Park Service, www.nps.gov/pore/learn/management/planning_cwr_drakesestero_roadcrossingimprovements.htm.
Link:
https://www.nps.gov/pore/learn/management/planning_cwr_drakesestero_roadcrossingimprovements.htm
Summary: This link leads to 3 articles relating to the Drakes Estero Road Crossing Improvement project. "In 2004, Point Reyes National Seashore proposed replacement or improvements to culverted road crossings at 6 locations within the Drakes Estero Watershed. The need for the project was to repair or replace existing road-crossing facilities in a manner that is sustainable ecologically and hydrologically, with infrastructure that will require less maintenance for long-term park operations. This Environmental Assessment evaluates the potential environmental consequences of three alternative strategies for implementing the Coastal Watershed Restoration - Culvert Replacement Project."

Citation: *Coastal Watershed Restoration Program: Geomorphic Restoration Project*. National Park Service, www.nps.gov/pore/learn/management/planning_cwr_drakesestero_roadcrossingimprovements.htm.
Link: https://www.nps.gov/pore/learn/management/planning_cwr_geomorphic.htm
Summary: "The Coastal Watershed Restoration - Geomorphic Restoration Project Environmental Assessment examines alternative means to restore natural hydrologic function at these locations and assesses the potential environmental effects of the implementation of each strategy. This Environmental Assessment addresses two water impoundments and one road crossing site within the Drakes Estero Watershed. The project is intended to restore natural conditions and increase estuarine habitat at Point Reyes. The project is needed to reduce the maintenance demands at Point Reyes, to eliminate the risk of catastrophic failure of culverts and dams, and to increase sustainability, both operationally and ecologically within these small coastal watersheds. This Environmental Assessment evaluates the potential environmental consequences of three alternative strategies for implementing the Coastal Watershed Restoration – Geomorphic Restoration Project."

Citation: *Project: EMAP Western Pilot*. Southern California Coastal Water Research Project, www.sccwrp.org/ResearchAreas/RegionalMonitoring/EMAPWesternPilotInCalifornia.aspx.
Link: http://www.sccwrp.org/ResearchAreas/RegionalMonitoring/EMAPWesternPilotInCalifornia.aspx
Summary: This webpage describes the EMAP Western Pilot Project that was conducted from 1999 to 2006. "The project objectives were to develop consistency in sampling design, sampling methods, data storage and data interpretation among the west coast states." The indicators measured included Water Column chemistry, Fish and Invertebrate Trawls, and Sediments. The project was successful in establishing a framework could be adopted by state agencies for designing wetland monitoring programs.

Citation: Kiernan, Tom. *Protecting the Wilderness at Drakes Estero*. National Parks Conservation Association, 11 Dec. 2012, www.npca.org/articles/154-protecting-the-wilderness-at-drakes-estero.
Link: https://www.npca.org/articles/154-protecting-the-wilderness-at-drakes-estero

Summary: Article discussing the effort to protect Drakes Estero. A commercial shellfish company was trying to extend its lease and remain in operation in the estuary despite a 1976 law designating the estuary as a marine protected area until the commercial license ended in 2012. US Secretary Ken Salazar made decision to provide full wilderness designation to Drakes Bay as planned, but faced backlash by opponents.

Citation: *Research Regarding Drakes Estero Wilderness*. National Parks Conservation Association, 29 Nov. 2012, www.npca.org/resources/2608-research-regarding-drakes-estero-wilderness.
Link: https://www.npca.org/resources/2608-research-regarding-drakes-estero-wilderness
Summary: Provides download links to research related to the environmental impacts of oyster agriculture in Drakes Estero. Summary on webpage: "Those that are most significant are the preemption of space by culture racks that results in the loss of about 8 acres of eelgrass, the damage to eelgrass beds by boating (propeller scars and channel scour), the provision of suitable habitat for exotic fouling species by placing mariculture infrastructure in the estero, the placement of bottom culture bags on harbor seal haul-out areas, and disturbance to harbor seals and birds from pedestrians and boats. Some impacts are not mitigable, but the negative effects of others can be significantly reduced."

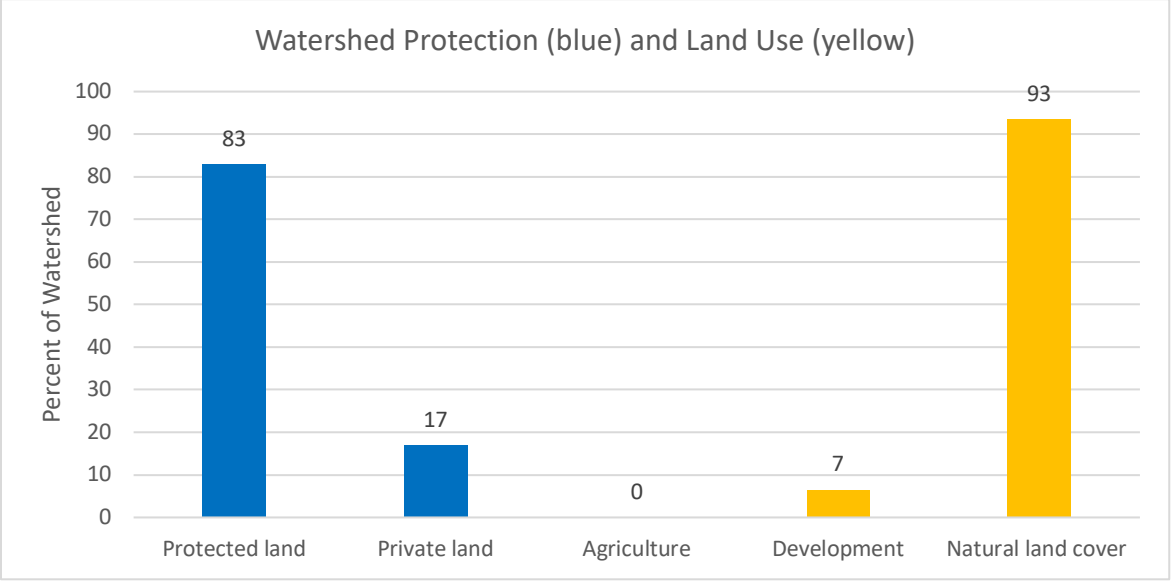
Citation: "Drakes Estero, A Sheltered Wilderness Estuary." *Park News*, 11 May 2011, www.sealwatch.org/resources/Drakes-Estero-Report-05112007red.pdf.
Link: http://www.sealwatch.org/resources/Drakes-Estero-Report-05112007red.pdf
Summary: Discusses the history of the designation of Drakes Estero as a wilderness area and the oyster company (Drakes Bay Oyster Company) that was trying to extend its lease beyond 2012. The report discusses the ecology of the estuary and the impacts of oyster farming on the ecological communities there.

Citation: *Celebrating Drakes Estero Marine Wilderness*. West Marin Environmental Action Committee, 2013, static1.squarespace.com/static/587d5638bebafb893ba15a0b/t/58c34bafd1758e424ee697a3/1489193904559/2013+%281%29.pdf.
Link:
https://static1.squarespace.com/static/587d5638bebafb893ba15a0b/t/58c34bafd1758e424ee697a3/1489193904559/2013+%281%29.pdf
Summary: Discusses Secretary Ken Salazar's decision not to issue a new permit to Drakes Bay Oyster Company, therefore honoring the 1976 Congressional intent of wilderness protection for Drakes Estero.

Source: EcoAtlas
Link: https://www.ecoatlas.org/regions/adminregion/sfbjv/projects/8951
Summary: Link to Drakes Estero restoration project info and project map.

Bolinas Lagoon

California Coastal Records Project, Kenneth & Gabrielle Adelman



Date source: TNC Conservation Assessment of West Coast USA Estuaries

Stressors

In reviewing CRAM surveys that have been completed in this estuary, 6 stressors in total were noted, with the most predominant being Passive Recreation and Transportation Corridor. Transportation corridor was the only stressor noted as having a significant negative effect.

References

Source: Marin County Parks-Bolinas Lagoon Ecosystem Restoration Project

Link: https://www.marincountyparks.org/depts/pk/our-work/os-main-projects/bolinas
Summary: One stop shop for information on the effort to do habitat restoration activities in Bolinas Lagoon

Citation: Gulf of the Farallones National Marine Sanctuary. Bolinas Lagoon Ecosystem Restoration Project Recommendations for Restoration and Management. August 2008.
Link: https://www.marincountyparks.org/~/media/files/departments/pk/projects/open-space/bolinas-lagoon/bolinas-lagoon-ecosystem-restoration-project---recommendations-fo-restoration-and-management.pdf
Summary: This document was a precursor to an EIS under NEPA and CEQA and provided a Locally Preferred Plan for review. This plan recommended protecting ecological functions by promoting Best Management Practices for farming, ranching, and summer water use, helping to educate the public via Easkoot Creek, and controlling invasive species during restoration, focusing on invasive cordgrass and invertebrates. An emergency protocol for the closure of the Bolinas inlet was recommended for the safety of the public, as well as a spill response plan for water quality. Identifying toxins and replacing toxic materials (docks, etc) within the lagoon were also recommended for water quality control.

Citation: Kerr, Drew. Aquatic Pesticide Application Plan for the San Francisco Estuary Invasive *Spartina* Project. March 2015.
Link: http://www.spartina.org/documents/2015_ISP_APAP_wAppendices.pdf
Summary: The hybridized offspring between non-native *Spartina alterniflora* and native *Spartina foliosa* has become a problem in tidally influenced marshes, brackish channels, and mudflats along the coast of California, eliminating natives and altering wildlife habitat. Chemical treatment of this aggressive invader has been the most effective method of control with the herbicide imazapyr preferred over glyphosate based herbicides. Between the Bolinas Lagoon Watershed, on the north end of the lagoon, and Pine Gulch, 183.5 m^2 of invasive *Spartina* area was treated in 2014.

Citation: Rohmer, Tobias, D. Kerr, and I. Hogle. 2014 ISP Monitoring and Treatment Report. San Francisco Estuary Invasive *Spartina* Project. August 2015.
Link: http://www.spartina.org/documents/2014ProgressReport_wCover.pdf
Summary: In 2011, two large *Spartina* clones were discovered on the mudflat of Bolinas Lagoon, North and had expanded between 2013 and 2014, controlled unsuccessfully via mowing to prevent accumulation of seed biomass (while causing an increase in vegetative biomass). Smaller instances sprung up during this time in addition to the larger coalesced stand. After lengthy review, imazapyr application was finally approved and conducted on October 21, 2014. Bolinas Lagoon, South remained *Spartina* free after three years of observation, achieving local eradication status. There was a net area of 72 m^2 and a treatment area of 181 m^2.

Citation: *Preserving a National Treasure: Uniting to Protect Bolinas Lagoon*. *Preserving a National Treasure: Uniting to Protect Bolinas Lagoon*. www.marincountyparks.org/~/media/files/departments/pk/about-us/agendas-minutes/2017/blac/12_1_2017_meeting/171201blacitem-4combrochure.pdf?la=en
Link: https://www.marincountyparks.org/~/media/files/departments/pk/about-us/agendas-minutes/2017/blac/12_1_2017_meeting/171201blacitem-4combrochure.pdf?la=en
Summary: Brochure gives overview of the nature found at Bolinas Lagoon, its “Legacy” in terms of changes made to it as well as its connection to the community, the impacts of human land-use changes, and a summary of the projects proposed to restore the lagoon.

Citation: Philip Williams & Associates, Ltd. , and Wetland Research Associates. *Bolinas Lagoon Ecosystem Restoration Feasibility Project: Final Public Reports* . Marin County Open Space District, July 2006, www.marincounty.org/~/media/files/departments/pk/projects/open-space/bolinas-lagoon/projecting-the-future-of-bolinas-lagoon.pdf.

Link: https://www.marincounty.org/~/media/files/departments/pk/projects/open-space/bolinas-lagoon/projecting-the-future-of-bolinas-lagoon.pdf
Summary: This is a report describes a 50-year projection of the evolution of Bolinas Lagoon and its habitats. The Marin County Open Space District contracted the authors of this report to conduct this study in order to develop a scientifically sound Ecosystem Restoration Plan with "greater support from the community and regulatory agencies". The report details past, current, and future predictions of ecological processes in the lagoon.

Citation: Draft Conceptual Design Report: Bolinas Lagoon North End Restoration Project. Marin County Park and Open Space District, August 2017
Link: https://www.marincountyparks.org/~/media/files/departments/pk/projects/open-space/north-end-project/draftconceptualdesign-report_08242017_full.pdf?la=en
Summary: This report details three project alternatives that offer different design solutions to meet the Bolinas Lagoon North End Restoration Project goals of habitat restoration and reconnection, road safety, and climate change / sea level rise adaptation. The report evaluates each alternative based on traffic safety, ecological benefit, hydrologic reconnection, and sea level rise resilience. The authors overall recommend Alternative 2, the hybrid of Alternatives 1 and 3 that "includes raising SR 1 onto two causeways, restoring Lewis Gulch Creek, and restoring the entire Wilkins Gulch Creek floodplain to the head of the alluvial fan (both downstream and upstream portions of the drainage)."

Citation: Draft Initial Study/Environmental Assessment: Kent Island Restoration at Bolinas Lagoon .Marin County Open Space District and US Army Corps of Engineers San Francisco District, August 2012
Link: https://nmsfarallones.blob.core.windows.net/farallones-prod/media/archive/eco/bolinas/pdf/kentislandisea.pdf
Summary: "This document serves as a joint National Environmental Policy Act (NEPA) Environmental Assessment (EA) and California Environmental Quality Act (CEQA) Initial Study (IS) of the proposed Kent Island Restoration at Bolinas Lagoon project. The project is intended to help ensure the long-term stability and viability of the Island through removal of non-native plant species and passive and active revegetation with appropriate native species."

Creek Mouth-Pine Gulch Creek

References

Citation: National Park Service. 2002. Documentation of Coho Salmon (*Oncorhynchus kisutch)* in Pine Gulch Creek, Marin County, CA. Coho Salmon and Steelhead Trout Restoration Project. PORE-NR-WR-02/02. 12pp. Plus appendices.
Link: http://www.krisweb.com/biblio/southmarin_nps_brownetal_2001_pinegulchcoho.pdf
Summary: Pine Gulch is a watershed in Marin County that dumps fresh water into Bolinas Lagoon and a home to some salmonid populations. Once thought to be extirpated from Pine Gulch in the 70's, biologists caught several juvenile Coho salmon during electrofishing surveys. A follow up Hankin Reeves survey resulted in the discovery of an estimated 538 (±349) juvenile coho that may have been born from more than one redd.

Citation: SFBRWQCB 2008. Water Quality Monitoring and Bioassessment in Selected San Francisco Bay Region Watersheds in 2004-2006. Surface Water Ambient Monitoring Program, San Francisco Bay Regional Water Quality Control Board, Oakland, CA.

Link:https://www.waterboards.ca.gov/water_issues/programs/swamp/docs/reports/rb2_report_appnd122308.pdf
Summary: SWAMP in the SF Bay Area monitors watersheds for water quality as well as fish contaminant levels where people regularly catch them. Benthic macroinvertebrates were observed to be in good health within both sites in Pine Gulch Watershed. The sites tested within the range considered good for dissolved oxygen, pH, and specific conductance. An elevated concentration of dissolved nickel was the only difference in metals in the watershed.

Citation: Charles, J. 2008. Bolinas Farms Cede Stream Rights to Coho. Point Reyes Light.
Link: http://www.marinrcd.org/wp/wp-content/uploads/2014/01/Charles-Jacoba-Pt.-Reyes-Light_Bolinas-Farms-Cede-Stream-Rights-to-Coho.pdf
Summary: In November 2007, three organic farms that drew their water from Pine Gulch Creek during the dry season agreed to instead source their water from several large constructed ponds. This aims to improve dry season conditions for endangered Coho salmon. These farmers committed to the change voluntarily, an unprecedented move by landowners.

Citation: Kimmey, Samantha. 2015. Bolinas farmers break ground. Point Reyes Light.
Link: https://www.ptreyeslight.com/article/bolinas-farmers-break-ground
Summary: This article reported on the beginning stages of the construction of the water storage ponds for the three Bolinas farms that drew their dry season water supply from Pine Gulch Creek. From the project's inception to 2015, CDFW decided that the farmers could draw no water during the dry season, instead of the original temporary withdrawal agreement, receiving the storage ponds to collect rainwater in exchange. Some amount of new wetland habitat was constructed as a result of altering the land for the storage ponds and several agencies will continue to monitor the biological resources related to the ponds. The project concluded in September of 2015.

Data Source: Calfish.org
Link:
http://www.calfish.org/ProgramsData/ConservationandManagement/MonitoredRivers/CentralCoast/PineGulchCreek.aspx
Summary: According to Calfish.org, Coho salmon are considered extirpated from Pine Gulch Creek as the last individuals were recorded in 2010, with no redds discovered past 2009. Genetic testing done in 2002 revealed that the fish sampled from were related to coho from the Redwood Creek population, meaning this population was experiencing a natural expansion from its home watershed.

Data Source: SF Waterboard 401 Certification
Water Quality Certification for Pine Gulch Watershed Enhancement Project, Marin County
Summary: The Pine Gulch Watershed Enhancement Project is located at three organic farms along Pine Gulch Creek with the purpose of eliminating commercial agricultural diversions of water for irrigation during the summer in order to improve coho salmon and steelhead trout habitat while maintaining commercial agricultural production. This is proposed to be accomplished by constructing five off-stream pools to meet the summer irrigation demand of the farmers, and allow the farmers to modify their water operations to enhance habitat for these species. The article goes on to discuss the possible impacts of this project and mitigation techniques for these impacts.