URBAN COAST
Special Issue: State of the Bay

*Volume 5 Issue 1* *Article 2.1.2*

December 2015

# Habitat Conditions: Coastal Wetlands

Richard F. Ambrose[1], John H. Dorsey[2], Karina Johnston[3], and Eric D. Stein[4]

[1] University of California, Los Angeles
[2] Loyola Marymount University
[3] The Bay Foundation
[4] Southern California Coastal Water Research Project

The *Urban Coast* multidisciplinary scientific journal is a product of the Center for Santa Monica Bay Studies, a partnership of Loyola Marymount University's Seaver College of Science and Engineering and The Bay Foundation.

Recommended Citation:
Ambrose, R.F., J.H. Dorsey, K.K. Johnston, and E.D. Stein. (2015). State of the Bay Report. "Habitat Conditions: Coastal Wetlands." *Urban Coast* 5(1): 59-68.

Available online: http://urbancoast.org/

ISSN 2151-6111 (print)
ISSN 2151-612X (online)

## 2.1.2 Coastal Wetlands

*Contributors: Richard F. Ambrose[1], John H. Dorsey[2], Karina Johnston[3], and Eric D. Stein[4]*

### Habitat Description

Coastal wetlands are low-lying areas of land that are frequently and regularly inundated with fresh and/or ocean water. They are habitats that can be perennially open to the ocean (e.g., Ballona Creek) or function instead as bar-built lagoons that only have an intermittent connection to the ocean (e.g., Malibu Lagoon). Coastal wetlands often include habitats such as salt marsh wetlands and adjacent brackish and freshwater wetlands that do not necessarily have a direct connection to the ocean.

The largest set of coastal wetland habitats in the Santa Monica Bay watershed is within the approximately 600-acre Ballona Wetland Ecological Reserve ("Reserve"). The Reserve contains wetlands, adjacent salt flats, freshwater, and upland habitats that were primarily former salt marsh habitats. For the purposes of this report, the entire former Ballona Wetland Complex is evaluated for the area and loss assessment scores, but the current, existing delineated wetland habitats at the Reserve (approximately 150 acres) are used for the condition scores ("Ballona wetlands"). Located in the eastern portion of the Bay at the mouth of Ballona Creek and situated between Los Angeles International Airport and Marina del Rey, this area is part of a historic and large wetland complex of approximately 2,100 acres that included Lower Ballona Creek, Marina del Rey, Ballona Lagoon, Del Rey Lagoon, Oxford Flood Control Basin, portions of Venice Beach and the Venice Canal system, and other adjacent subtidal and freshwater marsh habitats. These remaining pieces of the former complex still exist as hydrologically distinct separate systems, and in some cases (e.g., Marina del Rey) have been completely converted to other habitat types (e.g., subtidal).

In the north region of the Bay, several smaller wetlands are present. Largest among these is Malibu Lagoon, followed by Zuma Lagoon, Lower Topanga Creek and Lagoon, and Lower Trancas Creek. All of these smaller systems are periodically or permanently closed to the ocean.

Coastal wetlands are among the most productive ecosystems, providing an essential habitat for a variety of species, including birds, fish, reptiles, invertebrates, mammals, and vegetation. In addition to the species common to most coastal wetlands in Southern California, the Bay's wetlands are home to several protected species, including, but not limited to, Belding's savannah sparrow (*Passerculus sandwichensis beldingi*, state

[1] University of California, Los Angeles
[2] Loyola Marymount University
[3] The Bay Foundation
[4] Southern California Coastal Water Research Project

endangered species), tidewater goby (*Eucyclogobius newberryi*, federal endangered species), and southern steelhead trout (*Oncorhynchus mykiss irideus*, federal endangered species).

Urban sprawl, oil and gas exploration, the development of Marina del Rey, channelization, dredging, filling, and other human activities have reduced wetland acreage in the Bay watershed. While federal and state policies are in place to minimize future loss, and while much of the remaining habitat is under public ownership, restoration efforts are critical to preserving the diversity found in these habitats.

## Status and Trends

### Extent: POOR but IMPROVING (HIGH confidence)

Measuring changes in the extent of specific habitat types within coastal wetlands (e.g., salt marsh, salt flat, and mudflat habitats), in addition to total habitat loss, is important. The assessment for this category is based on one indicator: the area of coastal wetland habitat by type. Since this category comprises only one indicator, the extent of coastal wetlands is POOR but IMPROVING with HIGH confidence, and is the same as the score for the area of habitat type indicator (Table 2.1.2).

#### *Area of Habitat Type*

This indicator tracks changes in the total area of coastal wetland habitats and changes in area within wetland habitat types. Coastal development or restoration processes could lead to incremental changes in total wetland area and will be particularly useful in tracking changes in the smaller systems that are not publically owned and are potentially more vulnerable to encroachment or other changes. More dramatically, the ratio of habitat types within a site may change over time in response to restoration or the lack thereof, which has significant impacts on habitat availability for wildlife.

A recent report on the historical ecology of coastal wetlands in Southern California allows comparisons to pre-industrial wetland extents. Between 1850 and 2005 in Los Angeles County (including the area around the Ports of Los Angeles and Long Beach), there have been significant declines in the areas of vegetated (96% loss) and unvegetated (98% loss) estuarine wetland habitats relative to historic conditions (Stein et al. 2014). Based on this, the total area of coastal wetlands in the entire Santa Monica Bay is POOR (i.e., little remains of the former historic extent). However, in the last five years, restoration at Malibu Lagoon provided a net gain of two acres (Abramson, pers. comm. 13 August 2015). Therefore, the condition is IMPROVING. Confidence in this assessment is HIGH, as quantitative data are readily available and the availability of historical data provides a threshold by which to judge current status (Table 2.1.2, Line 1.1).

### Vulnerability: NOT SCORED

No indicators have been identified for this category yet, and it has not been scored.

## Structure and Disturbance: FAIR and CONSTANT to IMPROVING (MODERATE Confidence)

This category monitors changes in the structural aspects of coastal wetlands. It also tracks changes to factors that can cause disturbance, such as an influx in anthropogenic nutrients. Indicators included in this category are (1) eutrophication, (2) sedimentation, and (3) buffer and landscape context index scores from the California Rapid Assessment Method (CRAM) for Wetlands and Riparian areas (California Wetlands Monitoring Workgroup 2012), (4) hydrology index scores from CRAM, (5) physical structure index scores from CRAM, and (6) biotic structure index scores from CRAM. Note that the CRAM index scores are grouped below for the sake of brevity.

For the north region, all six indicators contribute to the overall Structure and Disturbance status of FAIR and IMPROVING. Confidence in this assessment is MODERATE because all the indicators were scored with moderate confidence due to data gaps for the smaller lagoons in the region. For the east region, five of the six indicators were scored and contribute to the overall Structure and Disturbance status of POOR and CONSTANT. Confidence in this assessment is HIGH because a majority of the indicators that comprise this category were scored with high confidence.

### *Eutrophication*

Eutrophication, or the anthropogenic-induced over-fertilization of a habitat, can result in shifts in algae, plant, invertebrate, and wildlife communities. For our purposes, it will be tracked by measuring dissolved oxygen (DO), submerged aquatic vegetation (SAV), and nutrients (nitrogen and phosphorous).

Eutrophication data were collected at Zuma Lagoon, Topanga Lagoon, Ballona Lagoon, and the Ballona Reserve as part of the Southern California Bight 2008 Regional Monitoring Program (Bight '08). The Bight program evaluated eutrophication in 23 estuaries in Southern California (McLaughlin et al. 2012). The Santa Monica Bay National Estuary Program (SMBNEP) collected additional eutrophication monitoring data from Ballona Reserve from 2008 to 2015 and from Malibu Lagoon from 2013 to the present. The Bight '08 eutrophication study included surveys of cover of macroalgae, phytoplankton biomass, dissolved oxygen, nutrients, and other general water quality parameters (McLaughlin et al. 2012). A subset of those indicators (DO, macroalgae, and phytoplankton) were analyzed and compared to thresholds of an existing assessment framework, the European Union Water Framework.

The results of the Bight '08 study show that, while nutrients are not a major input to Ballona Creek and thus the Ballona Reserve and Lagoon, several of the eutrophication indicators scored in the lower ecological condition categories for both sites, indicating that they are affected by eutrophication, though not necessarily requiring management action. Additionally, the data should be interpreted with caution, as the sampling design was intended to provide conservative results. Although data may exist from other sources, Del Rey Lagoon and other sites within the Ballona complex were not included in the study, so it is not scored here.

Given these results, the status of eutrophication in the east part of the Bay is considered FAIR and CONSTANT. Because of the rigor with which the Bight '08 study was conducted, and years of supplemental data, confidence in the score for the east part of the Bay is MODERATE despite the fact that only two of the wetlands in the region were scored (Table 2.1.2).

For this reason, restoration of Malibu Lagoon was designed to better manage nutrient inputs by improving circulation even during periods when the lagoon is closed to the ocean, and thereby reducing the stratification and low DO associated with harm to wildlife caused by excess nutrients. While some sources of nutrients to Malibu Creek and Lagoon, such as the nearby septic leach fields, are being phased out, others, such as discharges from the Tapia Treatment Plant, are likely to continue unless alternative uses for this treated wastewater are developed (see Section 1.1 for more). Therefore, while the DO and SAV conditions have improved, nutrient loading has not been reduced yet, hence a score of FAIR but IMPROVING. Conditions at Lower Trancas Creek have not been studied and are not scored. Confidence in the scores for the north part of the Bay are MODERATE, reflecting the lack of information from Lower Trancas Creek and questions about how to apply the thresholds used in the Bight '08 study to the monitoring data collected at Malibu Lagoon using slightly different methods (Table 2.1.2).

### *Sedimentation*

Sedimentation, or the influx of excess sediment into an estuary, can cause changes in the physical structure of an estuary, alter water movement and chemistry, and restrict tidal influence. However, some sedimentation is necessary to keep pace with sea level rise. In fact, either too much or too little sediment input can result in changes in plant, invertebrate, and wildlife communities. Sedimentation is often estimated by measuring channel cross-sections or through sedimentation plates.

Cross-section data are collected annually at Malibu Lagoon, where one of the post-restoration goals was to achieve no change in sedimentation or increases in channel elevations. Limited sedimentation data have been collected for the main tidal channels in the Ballona Reserve (Johnston et al. 2015), but not for the other wetlands in the Bay. Acquiring these data from the other wetlands should be a priority in the future. While a lower threshold is established by permitting requirements for Malibu Lagoon, the upper threshold still needs to be developed to better characterize conditions. In addition, thresholds need to be established for all the other wetlands in the Bay.

Based on two years of post-restoration monitoring at Malibu Lagoon, sedimentation for lagoons in the north is thought to be GOOD (i.e., maintaining current channel depths) because water circulation has increased, preventing sediment from accreting in the channels. Due to the restoration, the condition has IMPROVED in the last five years.

### HABITAT CONDITIONS: Coastal Wetlands

Confidence in this assessment is MODERATE due to the high-quality monitoring data and one of two established thresholds, but lack of data for elsewhere in the region.

Channel cross-section measurements were made in the tide channels at the Ballona Reserve in 2007 and again in 2011, and the data overall indicate some erosion, scour, and overall widening of several of the tide channels, but little to no sedimentation deposition (Johnston et al. 2015 unpublished data). Additionally, sediment movement in and out of Ballona Creek is reasonably well-understood and being fully evaluated as part of an ongoing California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) analysis for the Reserve. Sediment input from the watershed is restricted due to the channelization of the Creek and from the ocean due to the distance between the current openings (through tide-gates) and the mouth of Ballona Creek. While these very limited inputs might not be enough to keep pace with sea level rise, this is not well-established. Since less is known about the other wetlands in the Ballona complex, the status and trends are based on what is known about the Ballona Reserve. Based on this, sedimentation of wetlands in the east region is GOOD and conditions are CONSTANT. Confidence in this assessment is MODERATE due to the reasonable amount of information known about the Ballona Reserve despite not including other wetlands in the region in the score (Table 2.1.2).

#### *CRAM index*

The CRAM for wetlands and riparian areas is a rigorous assessment method designed to evaluate the functional capacity of an estuary (California Wetlands Monitoring Workgroup 2012). Index scores comprise four attribute scores: buffer and landscape context, hydrology, physical structure, and biotic structure. Each attribute comprises scores from multiple metrics and sub-metrics. Attributes and final scores range from 25 to 100, where 100 is the best attainable condition (Sutula et al. 2008). Thresholds distinguish between the bottom 50% of scores (less than 63 is considered poor) and the top third of scores (greater than 82 is considered good) (Sutula et al. 2008). Assessments are conducted using appropriate modules (i.e., perennially open vs. bar-built estuaries) to avoid making inappropriate comparisons between different types of estuaries.

At this time, public CRAM data are only available for the Ballona Reserve and Malibu Lagoon. As such, the status and trends for the east region are based solely on the Ballona Reserve CRAM scores, and the status and trends for the north region are based solely on the Malibu Lagoon CRAM scores.

At the Ballona Reserve, CRAM was conducted in 2012 and 2014. Based on these two surveys, buffer and landscape context is FAIR and CONSTANT, hydrology is POOR and CONSTANT, physical structure is POOR and CONSTANT, and biotic structure is POOR and DECLINING (Table 2.1.2-1). Within the Ballona Reserve, Area A and small pockets of degraded marsh in the eastern portion of Area B are in the worst condition, while Area B-West is in the best condition (Figure 2.1.2). Confidence in these assessments is MODERATE. Although high-quality data are available, there is some uncertainty surrounding the thresholds, and this score is based on only one of the wetlands in the region.

At Malibu Lagoon, CRAM was conducted in 2012 (pre-restoration) and semi-annually following restoration, in February 2013, October 2013, May 2014, and December 2014. The lagoon was open to the ocean in all but the May 2014 dates; therefore, this survey is excluded from the assessment based on the assessment parameters. Based on the aforementioned pre- and post-restoration surveys, buffer and landscape context is POOR but IMPROVING, hydrology is POOR but IMPROVING, physical structure is GOOD and IMPROVING, and biotic structure is FAIR and IMPROVING. Final CRAM scores at the Lagoon confirm steady improvement from the pre-restoration state in 2012. Improvements in the physical structure, biotic structure, and buffer and landscape context attributes contribute most to the improved condition (Table 2.1.2-1). Confidence in the assessment is MODERATE, as high-quality data are available, but some uncertainty surrounding the appropriate thresholds still exists, and the score is based on only one of the wetlands in the region.

**Table 2.1.2-1. CRAM Scores for Ballona Reserve and Malibu Lagoon**

**Ballona Wetlands Ecological Reserve**

| | ATTRIBUTE | SCORE | ERROR | | | ATTRIBUTE | SCORE | ERROR |
|---|---|---|---|---|---|---|---|---|
| 2012 | Buffer and Landscape Context | 69.4 | 4.0 | | 2014 | Buffer and Landscape Context | 69.4 | 4.0 |
| | Physical Structure | 37 | 4.4 | | | Physical Structure | 37 | 4.4 |
| | Hydrology | 45.8 | 4.7 | | | Hydrology | 48.6 | 5.3 |
| | Biotic Structure | 64.2 | 3.0 | | | Biotic Structure | 59 | 2.6 |
| | Final Score | 54.1 | 3.4 | | | Final Score | 53.5 | 3.3 |

**Malibu Lagoon**

| | ATTRIBUTE | SCORE | | | ATTRIBUTE | SCORE |
|---|---|---|---|---|---|---|
| 2012 | Buffer and Landscape Context | 38 | | Feb 2013 | Buffer and Landscape Context | 38 |
| | Physical Structure | 50 | | | Physical Structure | 58 |
| | Hydrology | 50 | | | Hydrology | 88 |
| | Biotic Structure | 61 | | | Biotic Structure | 39 |
| | Final Score | 50 | | | Final Score | 56 |
| Oct 2013 | Buffer and Landscape Context | 38 | | Dec 2014 | Buffer and Landscape Context | 53 |
| | Physical Structure | 58 | | | Physical Structure | 58 |
| | Hydrology | 75 | | | Hydrology | 88 |
| | Biotic Structure | 56 | | | Biotic Structure | 64 |
| | Final Score | 57 | | | Final Score | 66 |

## Biological Response: NOT SCORED

This category measures responses to changing conditions by assemblages of organisms forming the lower levels of the community food web (e.g., aquatic or terrestrial invertebrates), and shifts in ecosystem functions provided to higher-trophic-level organisms, such as fish and birds. The indicators that comprise this category are (1) the benthic invertebrate community, (2) nursery function for fish, and (3) forage function for birds. These indicators have not been fully developed and were not scored. As a result, this category was also not scored (Table 2.1.2-2).

### *Benthic Invertebrate Community*

Benthic invertebrates play a crucial role in assessing ecosystem health and function in coastal wetlands (Pennings et al. 2002, Williams & Desmond 2001, Zedler & Nordby 1991) . Determining thresholds will be challenging for this indicator, particularly since biological condition indicators for the lagoons in the Santa Monica Bay watershed are not fully developed. One approach, used as a success criterion for the Malibu Lagoon restoration project, is based on measuring the proportion of pollution-tolerant species, which are well-established for freshwater species but not for estuarine species. Similarly, other indices have been developed to determine the quality of sediment habitats based on benthic infaunal assemblages (Ranasinghe et al. 2007), and could be adapted as a possible indicator. Before this indicator can be used in an assessment, more research needs to be conducted to define expected benthic community structures for both types of estuarine systems found in the Bay watershed, using one or several indices.

### *Nursery Function for Fish*

Estuaries are home to several species of fish; some are resident and provide a source of food for larger predators, while others are migrant. For these migrants, estuaries often play an important role in their life-cycle (Fodrie & Herzka 2008, Allen et al. 2006). An indicator needs to be developed to monitor this nursery function. Questions that still need to be answered range from what species to include (e.g., juveniles of migrant species only, or also those of resident species) to how to measure it given the types of fish data commonly collected in coastal wetland monitoring programs.

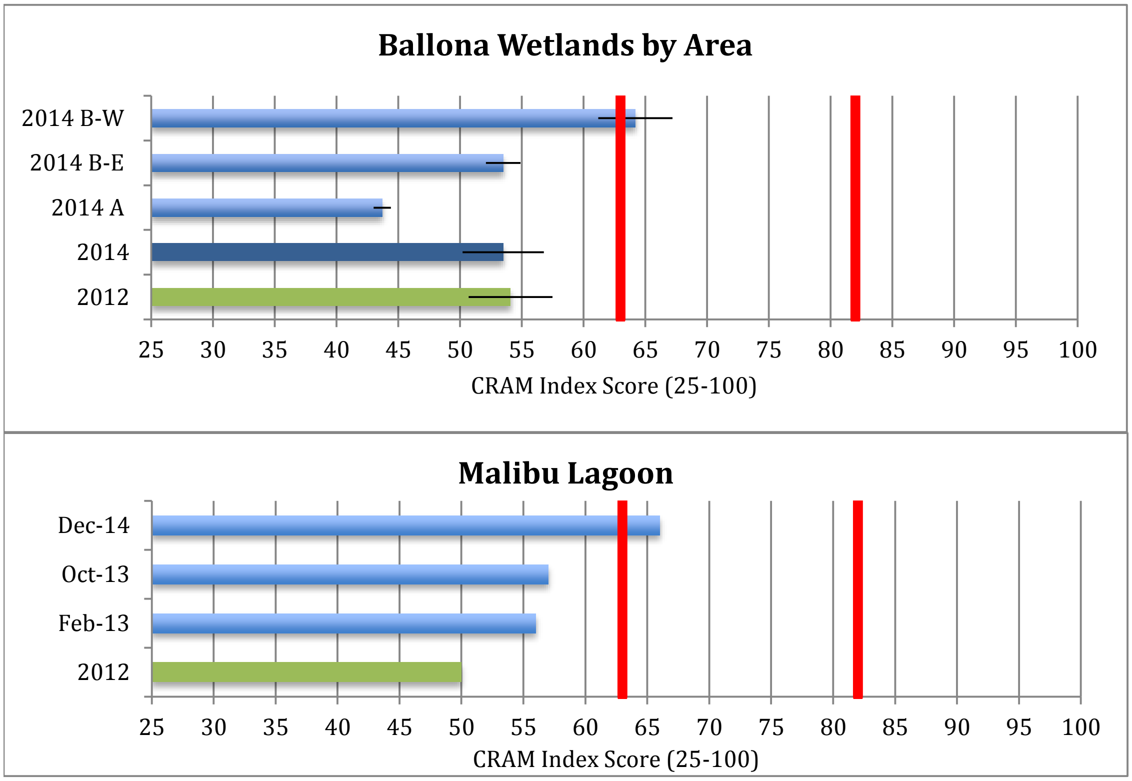
### *Forage Function for Birds*

Shorebirds and seabirds often forage on small fish and invertebrates found in the shallow waters of estuaries (Armitage et al. 2007). This can be measured by collecting data on the time individuals spend engaging in certain activities (Page, Schroeter, and Reed 2014). However, collecting these data is time-consuming, and none yet exist for wetlands in the Bay. Other metrics, such as shifts in bird guilds over time, could be explored as a proxy.

**Table 2.1.2-2. Indicators, Related Management Actions, and Status and Trends for Coastal Wetlands and Lagoons**

| *INDICATOR* | *METRIC* | *RELATED MANAGEMENT* | *SCORE* | | | *CONFIDENCE* |
|---|---|---|---|---|---|---|
| ***1 Habitat Extent*** *(Spatial Indicators related to extent, accessibility, availability, and temporal variability)* | | | SMB: | | | HIGH |
| ***1.1 Area of Habitat by Type*** | Acres of unvegetated subtidal, vegetated subtidal, unvegetated intertidal, and vegetated intertidal habitat. | SMBRC: BRP Objectives 7.1, 7.2, 7.5, 7.6, 7.7 & 7.8. | SMB: | STATUS: Poor | TREND: Improving | HIGH |
| ***2 Habitat Vulnerability*** *(Spatial Indicators related to disturbance potential)* *Indicators for this category have yet to be identified.* | | | | | | NOT SCORED |
| ***3 Structure & Ecological Disturbance*** *(Physical, chemical, and biological properties that impact the conditions of the habitat)* | | | North:<br>East: | | | MODERATE<br>HIGH |
| ***3.1 Eutrophication*** | DO, SAV, nitrogen, and phosphorous levels. Thresholds from McLaughlin et al. (2012). | Malibu Lagoon Restoration Plan | North:<br>East: | STATUS:<br>Fair<br>Good | TREND:<br>Improving<br>Constant | MODERATE<br>HIGH |
| ***3.2 Sedimentation*** | Channel cross-sections and flood-plain elevation. | Malibu Lagoon Restoration Plan | North:<br>East: | STATUS:<br>Good<br>Good | TREND:<br>Improving<br>Constant | MODERATE<br>MODERATE |
| ***3.3 CRAM – Buffer and Landscape Context*** | CRAM index values for the buffer and landscape context component. | | North:<br>East: | STATUS:<br>Poor<br>Fair | TREND:<br>Improving<br>Constant | MODERATE<br>HIGH |
| ***3.4 CRAM – Hydrology*** | CRAM index values for the hydrology component. | | North:<br>East | STATUS:<br>Poor<br>Poor | TREND:<br>Improving<br>Constant | MODERATE<br>HIGH |
| ***3.5 CRAM – Physical Structure*** | CRAM index values for the physical structure component. | | North:<br>East: | STATUS:<br>Good<br>Poor | TREND:<br>Improving<br>Constant | MODERATE<br>HIGH |
| ***3.6 CRAM – Biotic Structure*** | CRAM index values for the biotic structure component. | | North:<br>East: | STATUS:<br>Fair<br>Poor | TREND:<br>Improving<br>Declining | MODERATE<br>HIGH |
| ***4 Biological Response*** *(Changes to individuals, populations, communities, and ecosystems in response to changes in habitat quality)* | | | | | | NOT SCORED |
| ***4.1 Benthic Invertebrate Community*** | This indicator needs to be developed. | | | | | NOT SCORED |
| ***4.2 Nursery Function for Fish*** | This indicator needs to be developed. | | | | | NOT SCORED |
| ***4.3 Forage Function for Birds*** | This indicator needs to be developed. | | | | | NOT SCORED |

**Figure 2.1.2. Combined CRAM scores for the Ballona Reserve (top) and Malibu Lagoon (bottom).** The red vertical lines represent thresholds of possible scores (Sutula et al. 2008). Top: B-W means the western portion of Area B in the Ballona Wetlands, B-E means the eastern portion, and A means Area A. Bars labeled with just the year are averages for the entire site. Bottom: the green bar labeled 2012 is the pre-restoration score. The three blue bars are post-restoration. *Data Source: The Bay Foundation.*




## Conclusions and Next Steps

Despite significant historical losses of wetland habitats in the region, the recent restoration of Malibu Lagoon demonstrates that it is possible to increase the extent of coastal wetland habitats and improve conditions within them. The restoration of the Ballona Reserve and other remaining coastal wetlands in the Bay are the only way to further improve the overall conditions of these habitats, and should be considered a top priority. In addition, improvements need to be made in future assessments include identifying appropriate vulnerability indicators and developing the identified biological responses indicators. Finally, monitoring and evaluations of the smaller lagoon systems, in both the north and east regions, should be prioritized to obtain a higher level of confidence in the overall regional assessments.

## References

Allen, L. G., M. M. Yoklavich, G. M. Cailllet, and M. H. Horn (2006). “Bays and Estuaries.” REV&SCB. Soft Substrata and Associated Fishes. 119–48.

## HABITAT CONDITIONS: Coastal Wetlands

Armitage, A. R., S. M. Jensen, J. E. Yoon, and R. F. Ambrose (2007). “Wintering Shorebird Assemblages and Behavior in Restored Tidal Wetlands in Southern California.” MaL. Restoration Ecology 15 (1). Blackwell Publishing Inc: 139–48. DOI:10.1111/j.1526-100X.2006.00198.x.

California Wetlands Monitoring Workgroup (2012). “California Rapid Assessment Method for Wetlands and Riparian Areas, Version 6.0.” CA.

Fodrie, F. J., and S. Z. Herzka (2008). “Tracking Juvenile Fish Movement and Nursery Contribution within Arid Coastal Embayments via Otolith Microchemistry.” SDCo&Baja. Marine Ecology Progress Series 361: 253–65. DOI:10.3354/meps07390.

McLaughlin, K., M. Sutula, L. Busse, S. Anderson, J. Crooks, R. Dagit, D. Gibson, K. Johnston, N. Nezlin, and L. Stratton (2012). “SOUTHERN CALIFORNIA BIGHT 2008 REGIONAL MONITORING PROGRAM: VIII. Estuarine Eutrophication.” Vol. VIII. Costa Mesa, CA: Southern California Coastal Water Research Project.

Page, M., S. Schroeter, and D.Reed (2014). “Annual Report of the Status of Condition A: Wetland Mitigation.” Sacramento, CA: California Coastal Commission.

Pennings, S. C., V. D. Wall, D. J. Moore, M. Pattanayek, T. L. Buck, and J. J. Alberts (2002). “Assessing Salt Marsh Health: A Test of the Utility of Five Potential Indicators.” SC. Wetlands 22 (2): 405–14.

Stein, E. D., K. Cayce, M. Salomon, D. Liza Bram, R. Grossinger, and S. Dark (2014). “Wetlands of the Southern California Coast: Historical Extent and Change Over Time”. SCB.

Sutula, M., J. N. Collins, A. Wiskind, C. Roberts, C. Solek, S. Pearce, and R. Clark (2008). “Status of Perennial Estuarine Wetlands in the State of California Status of Perennial Estuarine Wetlands in the State of California Final Report to the Surface Water Ambient Monitoring Program State Water Resources Control Board.” Technical Report #571. Sacramento, CA: Surface Water Ambient Monitoring Program, State Water Resources Control Board.

Williams, G. D., and J. S. Desmond (2001). “Restoring Assemblages of Invertebrates and Fishes.” Handbook for Restoring Tidal Wetlands, edited by Joy B Zedler, 235–69. Marine Science Series. 2000 N.W. Corporate Blvd., Boca Raton, FL 33431: CRC Press.

Zedler, J. B., and C. S. Nordby (1991). “Responses of Fish and Macrobenthic in Disturbances Assemblages to Hydrologic Tijuana Estuary and Los Penasquitos Lagoon, California.” Estuaries 14 (1): 80–93.