URBAN COAST

Special Issue: State of the Bay

Volume 5 Issue 1

December 2015

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List of Acronyms

BMP	Best Management Practice
BPJ	Best Professional Judgment
BRP	Bay Restoration Plan
BWER	Ballona Wetlands Ecological Reserve
CalCOFI	California Cooperative Oceanic Fisheries Investigation
CalTrans	California Department of Transportation
CCMP	Comprehensive Conservation Management Plan
CDFW	California Department of Fish and Wildlife
CDS	Continuous deflective separation unit
CEC	Contaminants of emerging concern
CenCOOS	Northern California Coastal Ocean Observing System
CEQA	California Environmental Quality Act
CIAWH	Integrated Assessment of Watershed Health for California
CLA-EMD	City of Los Angeles Environmental Monitoring Division
CMP	Comprehensive Monitoring Program
CPUE	Catch per unit effort
CRAM	California Rapid Assessment Method
CSCI	California Stream Condition Index
DDT	Dichloro-diphenyl-trichloroethane
ddPCR	Digital droplet polymerase chain reaction
DO	Dissolved oxygen
DPR	Department of Pesticide Regulation
DTSC	Department of Toxic Substances Control

DWP	Department of Water and Power
EPA	U.S. Environmental Protection Agency
FIB	Fecal indicator bacteria
HAB	Harmful algal bloom
JWPCP	Joint Water Pollution Control Plant
LACSD	Sanitation Districts of Los Angeles County
LARWQCB	Los Angeles Regional Water Quality Control Board
LCP	Local Coastal Program
LFD	Low flow diversion
LID	Low impact development
MARINe	Multi-Agency Rocky Intertidal Network
MPA	Marine Protected Area
MTBE	Methyl tert-butyl ether
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
RCD	Resource Conservation District of the Santa Monica Mountains
PBDE	Polybrominated diphenyl ether
PCB	Polychlorinated biphenyl
PCE	Perchloroethylene
POTW	Publicly owned treatment work
PPCP	Personal care products
qPCR	Quantitative polymerase chain reaction
SAV	Submerged aquatic vegetation
SCB	Southern California Bight
SCCOOS	Southern California Coastal Ocean Observing System

SCCWRP	Southern California Coastal Water Research Project
SMB	Santa Monica Bay
SMBNEP	Santa Monica Bay National Estuary Program
SMBRA	Santa Monica Bay Restoration Authority
SMBRC	Santa Monica Bay Restoration Commission
SMBRF	Santa Monica Bay Restoration Foundation
SMC	Stormwater Monitoring Coalition
SMCRMP	Southern California Stormwater Monitoring Coalition Regional Monitoring Program
SMURRF	Santa Monica Urban Runoff Recycling Facility
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
TBF	The Bay Foundation
TCE	Trichloroethylene
TMDL	Total Maximum Daily Load

URBAN COAST

Special Issue: State of the Bay

Volume 5 Issue 1 *Executive Summary*

December 2015

Executive Summary: At a Glance

Guangyu Wang[1] and Lia Protopapadakis[2]

[1] Santa Monica Bay Restoration Commission
[2] The Bay Foundation

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.

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AT A GLANCE

Authors: Guangyu Wang[1] and Lia Protopapadakis[2]

The 2015 State of the Bay Report is a science-based comprehensive assessment of the environmental conditions of the Santa Monica Bay. The Santa Monica Bay National Estuary Program (SMBNEP) periodically conducts and reports this assessment with the goal of measuring progress in restoring the Bay's natural habitats and resources, educating the public about the Bay's valuable natural resources, and identifying and helping scientists and managers to address remaining and emerging challenges. More specifically, this report provides information that can be used to both gauge the progress in implementing the Bay Restoration Plan (BRP) and inform updates of the BRP to meet ongoing and new challenges.

This report covers all major Bay habitats and a broad range of issues, which follow closely the three priority issues addressed by the BRP: water quality, natural resources, and benefits and values to humans. The habitat assessments provide an overview of the habitats in the Bay and the Bay watershed, and an assessment of the ecological health of these habitats using the refined rating system applied to available data on indicators recommended by our panels of experts.

Additionally, the report identifies and discusses in more detail issues that affect the health of the Bay's beneficial uses, with feature articles and sidebars written by members of the SMBNEP Technical Advisory Committee (TAC) and invited experts. The topics of these articles were selected to represent the most current and pressing issues in the Bay and the Bay watershed. Many of the stories also provide good examples of how various issues have been addressed, including areas of progress, current status, information gaps, major obstacles, causes of the remaining problems, and ways to ameliorate them. Finally, the Report looks ahead at emerging issues that will need to be addressed in the coming years.

The SMBNEP TAC is made up of scientific and technical professionals from universities, research institutions, and governmental agencies, representing a wide range of expertise and disciplines. The role of the TAC is to ensure that the SMBNEP has the necessary scientific and technical information upon which to base its decision-making. Over the years, the TAC has assisted the SMBNEP in developing research agendas, monitoring programs, and overseeing the implementation of key research projects. The TAC led the development of the State of the Bay report by providing content guidelines, developing assessment framework, and participating in writing feature articles.

WATER RESOURCES

This chapter of the report features five articles that present major ongoing and new programs and projects that increase the region's water

[1] Santa Monica Bay Restoration Commission

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supply and improve water quality in the Bay watershed. These articles discuss, in detail, both the progress made over the last five years (2010–2015) and remaining or emerging challenges to our local water resources. One noteworthy trend of the past five years is a more incorporated consideration of water resources with increased levels of coordination in and among agencies. Careful consideration has been given to the inputs and outputs of traditional water management, with an understanding that drought, climate change, and water pollution need to be considered collectively as we look to improve water security and a healthy environment in Los Angeles and in Santa Monica Bay.

FEATURES AND KEY MESSAGES

Water Supply and Use. Four years of drought have put increased focus on water supply. The State's Recycled Water Policy will increase water supply, while assisting with the implementation of water quality regulations. Examples of such measures that are already underway include conservation, rainwater harvesting, stormwater harvesting, groundwater treatment, greywater reuse, and water reclamation (Section 1.1).

Water Quality. Four new Total Maximum Daily Loads (TMDLs) were enacted in the last five years to address the impacts of marine debris, dichloro-diphenyl-trichloroethane (DDT), and Polychlorinated biphenyl (PCB) on Santa Monica Bay, sediment and invasive exotic vegetation in the Ballona Wetland Ecological Reserve, and sedimentation and nutrients affecting the benthic community (animals and other organisms that live on or in the bottom) of Malibu Creek and Malibu Lagoon. The beach bacteria TMDL, designed to reduce bacterial levels along the beaches of Santa Monica Bay, has been successful. Bacteria levels at the beaches have been in decline, showing a measurable improvement in beach water quality. These improvements are attributable to sewer system and low-flow diversion upgrades, as well as the implementation of Low Impact Development (LID) stormwater management strategies and lower rainfall. Additionally, toxics in Santa Monica Bay sediments are no longer having adverse impacts on aquatic life, although seafood contamination is still an issue (Section 1.2.2). Monitoring data from Ballona Creek indicate that dry weather metal loading now rarely exceeds the TMDL targets, lessening impacts on wildlife in the creek and on the sediments in the Bay (Section 1.2.2). Finally, compliance with the Ballona Creek Zero Trash TMDL has reached 96.7% as of the 2013/2014 reporting year (Section 1.2.3), and trash found on Santa Monica Bay beaches has declined since 2008 (Section 1.2.3). However, a regional survey of trash in streams found that streams in the Santa Monica Mountains contain more cigarette butts, sports balls, and plastic bottles than elsewhere in Southern California (Section 1.2.3).

New Water Quality Issues. More knowledge has been gained in the last five years about contaminants of emerging concern (CECs; e.g., current use pesticides, pharmaceuticals, and flame retardants). For example, 12% of streams in the Santa Monica Bay watershed contain potentially toxic concentrations of two common use pesticides (cyhalothrin and bifenthrin) in the pyrethroids group. As a result, new strategies are being developed to manage and regulate the CECs (Section 1.3), including pilot studies testing a new monitoring framework that targets 16 of these CECs (Section 1.3).

HABITAT

This chapter of the report provides an assessment of the conditions of the seven major habitat types found in the Bay and its watershed, as well as three articles highlighting conditions and efforts designed to improve several habitats in the Bay. The assessment was conducted under a new framework developed by the SMBNEP's TAC for identifying indicators and assessing habitat health that can be applied to all major types of habitats in the Bay in a consistent manner. Four categories of indicators were applied that relate to habitat health: extent, vulnerability, structure and disturbance, and biological response. Due to limited data availability and the high level of uncertainty, the scores for the four categories were not combined into one overall score for each habitat. Overall, the assessment finds that most habitats in most areas are degraded to some degree due to human disturbances. There are areas of improvement because of restoration efforts at Malibu Lagoon and in kelp forests in the Bay. There are also concerns that the conditions of some habitats are still in decline, such as rocky intertidal habitats, due to intensive human trampling and collecting activities.

FEATURES AND KEY MESSAGES

Stream Health in the Santa Monica Mountains. A report by the Stormwater Monitoring Coalition found that 43% of stream miles in the Santa Monica Mountains are in near reference condition, while 20% are severely degraded. Sites in Malibu Creek generally have the lowest condition based on benthic invertebrates (Section 2.2.1).

Wetland Restoration. Restoration of Malibu Lagoon was completed in October of 2012. Post-restoration monitoring describes increased levels of dissolved oxygen, with patterns of dissolved oxygen that are typical of similar estuarine systems. Additionally, plants and animals are repopulating the restored area, and the benthic invertebrate community has shifted from pollutant-tolerant species to one that contains more sensitive species (Section 2.2.2).

Marine Protected Areas. Four Marine Protected Areas (MPAs) took effect in January 2012. Implementation efforts focus on outreach, education, and enforcement. Successes include the creation of the Los Angeles MPA Collaborative, the formation of several community-based monitoring programs, and an expansion of the state's violation reporting system. Initial monitoring results indicate that commercial fishermen tend to be complying, recreational fishermen in the Santa Monica Bay demonstrate better compliance than fishermen further south, and fishing vessels are not currently displaying compaction as they shift away from now-closed fishing grounds (Section 2.2.3).

BIODIVERSITY

The articles in this chapter focus on several issues of biodiversity, such as restoring endangered populations and their genetic diversity (Section 3.1), population decline and what that may mean for coastal ecosystems (Section 3.2, Section 3.3), and managing populations to maintain diversity while allowing extraction (Section 3.4). More discussion on the issues surrounding ecosystem diversity can be found in Chapter 2 of this report.

FEATURES AND KEY MESSAGES

Endangered Species. Forty-one species were listed as federally or state endangered or threatened species in the Santa Monica Bay watershed. Another 29 are considered critically imperiled or imperiled by outside entities. The majority of these are plants, mosses, and arthropods. The habitat most affected is the chaparral and oak woodlands (Section 3). One specific project to improve the survivability of the threatened red-legged frogs in the Santa Monica Mountains is underway. Biologists have been reintroducing these frogs to streams where they once occurred that have good water quality and surrounding habitats (Section 3.1).

Beach and Intertidal Organisms. Grunion runs have declined in the Bay and throughout their range. This decline is likely due to a combination of several issues, including disrupted runs due to fishing activities, loss of spawning habitat due to “coastal squeeze,” and changes in ocean chemistry. On a positive note, beach managers have altered their grooming practices to leave the area below the high tide line undisturbed during the grunion nesting season, in an effort to help these fish continue to survive (Section 3.2). Also, in June 2013, at least 20 different species of sea stars along the entire west coast of North America experienced a mass mortality event. In some parts of the Santa Monica Bay, local populations have completely disappeared. While recovery, fueled by unusually high recruitment, has begun elsewhere, there is no evidence of this as yet in Santa Monica Bay (Section 3.3).

Fisheries. Recreational and commercial fishing in Los Angeles County contributes $53.5 million in wages and 1,550 jobs to the local economy. While many types of commercial fishing gear are not allowed inshore of a line drawn from Malibu Point to Rocky Point, significant fishing activity occurs north of Point Dume, around Palos Verdes, and at Short Bank. Commercial fishing in the Santa Monica Bay primarily targets market squid, pacific sardine, red sea urchin, spiny lobster, hagfish, and thornyheads (related to rockfish).

AT A GLANCE

Improved fishery management plans, data collection, and stock assessments for these species are critical and needed to ensure that these important fisheries are sustainable over time (Section 3.4).

LOOKING AHEAD

After briefly recapping major success stories of the last five years, this chapter discusses in detail major challenges that threaten the Bay and its watershed's environmental health in the coming years. These challenges include climate change, human development in remaining natural areas, sediment management, the development of new monitoring tools, ocean acidification, nutrient loading, and harmful algal blooms.

FEATURES AND KEY MESSAGES

Climate Change Impacts. Local impacts of climate change are expected to include more extreme weather patterns; severe drought; increased extreme heat waves; more frequent Santa Ana wind events; sea level rise; increased frequency, intensity, and reach of storm surge; and increased acidity in coastal waters. In order to respond, local municipalities and agencies have initiated independent and collaborative adaptation planning. In addition, the SMBNEP plans to conduct a broad, risk-based climate change vulnerability assessment of all goals and objectives in the Bay Restoration Plan in 2015–2016 (Section 4).

Natural Habitat Protection in the Santa Monica Mountains. In 2014, a local coastal program (LCP) was adopted for the unincorporated areas of the Santa Monica Mountains, which puts limits on development; requires stormwater BMPs, improved on-site wastewater treatment, erosion prevention, slope stabilization, and ridgeline protection; and adopts a strong biological resource protection approach (Section 4.1). However, more efforts are needed to ensure effective implementation of the LCP and to address other challenges, such as pollution from septic systems, coastal lagoon restoration, removal of Rindge Dam and other fish migration barriers, and control of invasive species.

Sediment Management. Increasingly, management agencies in the Santa Monica Bay watershed recognize that our coastline is starved of new sediment input as reservoirs, debris basins, and dams trap these sediments upstream. In other areas, our urban landscapes and channelized creeks limit erosion and sediment transport. With expected sea level rise and increased storm surge, the need for sediment along our coast is apparent. The current problems of artificially managing sediment transport from our watersheds to the coast leave management agencies challenged to keep reservoirs and debris basins clear of sediment in order to maintain the flood protection these basins provide, while others attempt to find sources of sediment to add to beaches in order to reduce the effects of erosion and protect infrastructure. Now, more than ever, a holistic, watershed-based approach is required to restore the natural sediment transport process, which is considered the best long-term solution to both problems (Section 4.2).

New Monitoring Tool Development. Two new, faster methods for measuring beach bacteria contamination are now being tested. Both are molecular methods. The first is called quantitative polymerase chain reaction (qPCR). It is performed in the lab, can give results within two hours, and can also distinguish between human and animal sources of fecal bacteria. The second is automated digital droplet PCR (ddPCR), which is similar to qPCR but has the advantage of allowing lifeguards to perform the test and obtain results while in the field. Both of these methods would allow for more accurate and quicker results than the techniques currently in use, creating better protection for public health. Further testing and financing will be needed to determine if these methods can be implemented to ensure the safety of swimmers, surfers, and others along the beaches of Santa Monica Bay (Section 4.3).

Ocean Acidification. Recent models predict that, within the next 30 years, much of the near-shore California Current System will experience "corrosive" waters all summer long in the upper 60 meters (top 180 feet) of the ocean due to ocean acidification. Locally, ocean discharges containing elevated nutrient levels can exasperate this process. These conditions are believed to reduce the fitness or prevent the development of marine organisms that produce calcium carbonate shells, such as snails, clams, and sea urchins. Such organisms include the commercially important red sea urchin and all seven species of abalone (Section 4.4). It is critically important to monitor for ocean acidification in our coastal waters to understand how intensely and where ocean acidification is likely to impact living organisms in Santa Monica Bay. The SMBNEP and partners are deploying a sensor array in 2015–2016 to begin tracking these changes to our local environment.

Nutrient Loading and Harmful Algal Blooms. Results from several recent studies provide multiple lines of evidence that human-derived nutrients are influencing ecological conditions in Santa Monica Bay and the rest of the Southern California Bight (Section 4.5). Increased focus in the coming years on determining the sources and impacts of nutrient loading will be needed to understand how intensely it influences hypoxia, eutrophication, harmful algal blooms, cyanotoxin, domoic acid, and ocean acidification. In response to increasing frequency and severity of harmful algal blooms in Southern California, monitoring of these events has increased along the coast of California, and more vigilant monitoring for the presence of these algae and their toxins needs to be carried out in the future. Furthermore, studies have found that cyanotoxins are widespread throughout the state, which means that they should be included in all watershed monitoring programs. A better understanding of what causes cyanotoxin production and the potential for effects of cyanotoxins on aquatic life (both upstream and down) will be critical for developing informed management approaches.

URBAN COAST

Special Issue: State of the Bay

Volume 5 Issue 1 *Introduction*

December 2015

Introduction

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[1] Santa Monica Bay Restoration Commission

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.

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Introduction

Author: Guangyu Wang[1]

The 2015 State of the Bay Report is a science-based comprehensive assessment of the Bay's environmental condition. The Santa Monica Bay National Estuary Program (SMBNEP) periodically conducts and makes a report on this assessment, with the goal of measuring progress in restoring the Bay's natural habitats and resources, educating the public about the Bay's valuable natural resources, and identifying and helping scientists and managers to address remaining and emerging challenges. More specifically, this report provides information that can be used both to gauge the progress in implementing the Bay Restoration Plan (BRP) and to guide updates of the BRP to meet new and existing challenges.

This report covers a broad range of issues across all major Bay habitats, closely following the three priority issues addressed by the BRP: water quality, natural resources, and benefits and values to humans. It represents the multi-year collaborative effort of the SMBNEP's Technical Advisory Committee (TAC), with participation of outside experts and several partner agencies and organizations. The report includes an assessment of the ecological health of all major habitats in the Bay and the Bay watershed, using a refined rating system and available data on the indicators recommended by panels of experts. Professional judgments by the TAC and expert panels were also considered and applied to the assessments for indicators with no available data.

Planning for the 2015 State of the Bay Report began shortly after the publication of the last State of the Bay Report, in 2010. The 2010 report marked the first time that a new standard scale was used to rate the condition and characterize the overall status and trends of all major habitats in the Bay. The method used in 2010 has now been improved upon for the 2015 report by developing and applying a standardized assessment framework that encompasses all major types of habitats in the Bay. The new framework uses a set of comparable indicators of habitat health (quality of habitat, quantity of habitats, etc.) in the same categories across habitat types. Additionally, this approach focuses on indicators that directly relate to BRP goals. These goals often related to numeric values associated with acres of habitat restored or protected, pollutant reductions, and other management actions, like the establishment of marine protected areas.

Additionally, the report identifies and discusses issues that affect the health of the Bay's beneficial uses in more detail, with feature articles and sidebars written by TAC members and invited experts. The topics of these articles were selected to represent the most current and pressing issues in the Bay and the Bay watershed. Many of the articles also provide good examples of how various issues have been addressed, including areas of progress, current status, information gaps, major obstacles, and causes of remaining problems. In some cases,

[1] Santa Monica Bay Restoration Commission

solutions to these issues are suggested by the contributing authors. Finally, the report looks ahead at emerging issues that will need to be addressed in the coming years.

Information included in the report was gathered from a variety of sources, including many years of monitoring data collected in the Bay, research findings published in scientific journals, and technical reports developed by agencies and other organizations.

About the SMBNEP

The Santa Monica Bay National Estuary Program (SMBNEP) is one of 28 similar programs established under Section 320 of the 1987 *Clean Water Act* and administered by the U.S. Environmental Protection Agency (EPA). The SMBNEP's comprehensive plan of action for protecting and restoring Santa Monica Bay, known as the Bay Restoration Plan (BRP), was approved by the State of California and the EPA in 1995 and updated in 2008 and 2013. The BRP includes goals, objectives, and milestones that guide the SMBNEP's programs and projects in three priority areas: water quality, natural resources, and benefits and values to humans. The BRP also identifies responsible lead and partner entities, as well as the roles of the SMBNEP in supporting, promoting, and implementing restoration work.

The SMBNEP comprises a partnership of three entities. The Santa Monica Bay Restoration Commission (SMBRC) is a non-regulatory, locally based state entity established by an act of the California Legislature in 2002. It is charged with overseeing and promoting the BRP by securing and leveraging funding to put solutions into action, building public–private partnerships, promoting cutting-edge research and technology, facilitating stakeholder-driven consensus processes, and raising public awareness. The Santa Monica Bay Restoration Authority (SMBRA) was created by a joint exercise of powers agreement between the SMBRC and the Los Angeles County Flood Control District, and operates as a local public agency within the Santa Monica Bay Watershed and the jurisdictional boundaries of the SMBRC and the District. The purpose of the SMBRA is to broaden funding opportunities for projects within the Santa Monica Bay Watershed; it provides an efficient method by which state agencies can fund important programs of the SMBNEP. The Bay Foundation (TBF), also known as the Santa Monica Bay Restoration Foundation (SMBRF), is an independent, non-profit 501(c)(3) organization founded in 1990. It serves as the fiscal partner for the SMBNEP and provides administrative, management, and program services to the SMBNEP.

To learn more about the SMBRC, go to www.smbrc.ca.gov.
To learn more about TBF, go to www.santamonicabay.org.

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Special Issue: State of the Bay

Volume 5 Issue 1 *Article 1.1.0*

December 2015

Water Resources: Water Supply and Use from a Water Quality Perspective

Hubertus Cox[1], Eric D. Stein[2], Lia Protopapadakis[3], and Mas Dojiri[4]

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1.1.0 Water Supply and Use from a Water Quality Perspective

Authors: Hubertus Cox[1], Eric D. Stein[2], Lia Protopapadakis[3], Mas Dojir[4]

In our urbanized watershed, water can come from a variety of sources. It can come from rainfall and snowmelt that is captured, imported, and stored for use in our drinking water systems. It can be runoff captured for irrigation, mostly lost to the ocean via storm drains. It can be potable water discharged to the ocean as effluent from wastewater treatment plants after being used in our homes and industry, or as runoff after being used outdoors for landscaping. Each of these sources of water in the Santa Monica Bay Watershed is managed separately by different agencies. For example, in the City of Los Angeles, the Los Angeles Department of Water and Power (DWP) manages potable water, the Department of Public Works is responsible for managing runoff, wastewater treatment, and flood control, and the state's Los Angeles Regional Water Quality Control Board regulates the water quality of discharge to the receiving waters.

Despite this separation, one agency's management action can be affected by the decisions of a different agency. For example, reclaiming wastewater can reduce demand for potable water and decrease the amount discharged into receiving waters. Reducing outdoor water use can decrease runoff, and capturing runoff and using it onsite can also decrease demand for potable water. Conversely, one agency's activities can also create challenges for other agencies, such as when development and flood control efforts convert pervious surfaces into impervious ones, preventing rainwater from recharging underground aquifers, or when conservation efforts successfully reduce the volume of water disposed into the sewer system, but simultaneously increase the concentration of said wastewater, making it more challenging and expensive to treat.

Four years of drought in California have increased the focus on water supply and the urgency for agencies to work together to forge solutions that meet all of their collective mandates. Pressure to solve water shortages with traditional, single-minded solutions is still high. A better approach, however, would be to coordinate efforts across the different agencies. Australia provides an example of such collaboration. During the Millennium Drought in southeastern Australia, the city of Melbourne succeeded in reducing water consumption and rebuilding its water reserves, due in part to having one water management agency that oversees all aspects of water supply, use, and disposal (Grant et al. 2013).

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[1] City of Los Angeles, Bureau of Sanitation
[2] Southern California Coastal Water Research Project
[3] The Bay Foundation
[4] City of Los Angeles, Environmental Monitoring Division

Where We Have Come From and Where We Are Going

Following the Australian example, the State Recycled Water Policy calls for increases in local water reuse through irrigation, groundwater infiltration, surface water augmentation (primarily in Northern California), and exploration of the feasibility of direct potable reuse. The state's goals are to increase the capture and use of stormwater by 500,000 acre-feet by 2020 and 1 million acre-feet by 2030 (relative to 2007 levels); increase use of recycled water by 1 million acre-feet by 2020 and 2 million acre feet by 2030 (relative to 2002 levels); and increase the amount of water conserved by 20% by 2020 (relative to 2007 levels) (SWRCB 2013).

Accomplishing this vision will require increased use of comprehensive water budgeting, which can help fulfill the current demand for water through a combination of traditional sources, wastewater reclamation, desalination, stormwater harvesting, and conservation. Moving forward, local groundwater and water reuse will likely be added to the conversation.

Traditional Sources

Traditional sources of water in the Santa Monica Bay Watershed come from local groundwater, imported snowmelt, and surface water from the Sacramento-San Joaquin Bay-Delta, the Colorado River, and to a lesser extent the Owens Valley. However, meeting water demands in southern California with traditional sources will be increasingly challenging due to projected longer and more severe droughts combined with less reliable imported water sources from the Colorado River and the Bay-Delta (California Natural Resources Agency et al. 2014).

Conservation

Municipalities have focused a lot of effort on public outreach to encourage water conservation and rainwater harvesting. The DWP and local municipal water districts have created a variety of programs that offer rebates and other incentives to encourage residential, commercial, and industrial users to reduce their indoor and outdoor water use, such as turf removal programs and rebates for installing water-efficient appliances (see Sidebar 1.1 for more).

1.1 Turf Removal: This practice requires replacing existing turfgrass with California drought-tolerant or permeable materials. The Metropolitan Water District is offering up to $2 per square foot, while the DWP is offering up to $3.75 per square foot. For availability of these residential and commercial rebates, check: www.socalwatersmart.com and www.ladwp.com/cf

These efforts appear to have been successful, as individual consumer water use has declined and potable water use in the region has remained relatively constant since the 1970s despite a growing population (LADWP 2011). Furthermore, many of these programs not only reduce water consumption for irrigation, but also wastewater discharge and dry-weather runoff caused in part by over-irrigation. This has reduced one source of contaminated discharge to the ocean and other surface waters such as rivers and creeks (Figure 1.1-1).

Low Impact Development and Rainwater Harvesting

Low Impact Development (LID) provides best management practices (BMPs) for many categories of residential, commercial, and industrial development and redevelopment projects with the goal of capturing and retaining on-site stormwater from a 0.75-inch 24-hour rain event, or an 85th percentile 24-hour rain event, whichever is greater. Typical BMPs used for rainwater harvesting and onsite infiltration are rainwater barrels, porous pavement, rain gardens, and vegetated swales (see Sidebar 1.2 for more). Well designed and constructed LID-based BMPs capture, infiltrate, or provide stored water for future use while simultaneously lowering the need for irrigation, reducing the demand on traditional water sources. In the best cases these landscape options can provide habitats for enhanced urban ecology benefiting native wildlife.

Although the primary goal is management of urban runoff, these types of BMPs also often provide esthetic enhancements and water conservation benefits, and can be implemented throughout an entire watershed. In the Bay's watershed, LID ordinances were first put in place in Los Angeles, Santa Monica, and unincorporated areas of Los Angeles County. Most other cities in the watershed have followed suit, partly driven by the need to meet the requirements of the recently renewed NPDES permit for the municipal separate storm sewer system which mandates all cities in the County of Los Angeles to have a LID ordinance or equivalent regulation by the end of 2014. These programs have the added benefit of reducing use of potable water for irrigation.

1.2 Rain Barrels and Cisterns: This stormwater practice is used to divert water flow from rooftops into a storage unit, such as a 50-gallon barrel or cistern, for saving and reuse. *Rebates available through LADWP and www.socalwatersmart.com.*

Permeable Pavements: Permeable pavements are materials or techniques that allow water to infiltrate through the surface while capturing solids and filtering pollutants. *For more information regarding Permeable Pavements visit this LA City Stormwater page.*

Rain Gardens and Bioretention: Rain gardens and bioretention basins are used to increase infiltration by diverting stormwater flow into shallow landscape depressions that may include annual or perennial plants for onsite pollutant removal. *For more information on Rain gardens/bioretention go to this EPA site. For information about designing a residential rain garden go to this Surfrider site.* ***For information on rain gardens constructed by the SMBNEP, go to The Bay Foundation site rain garden page***

Berms and swales: Berms and swales are designed with the contour of the land diverting the flow of water to desired locations like a vegetated area. A swale is a parabolic depression which holds the water, while a berm is the result of the walls of the swales. *For more information regarding Berms and Swales visit this EPA site.* ***For information on projects implemented by the SMBNEP, go to this TBF site.***

Stormwater Harvesting

Many cities along Santa Monica Bay and elsewhere in the County of Los Angeles are in the process of developing and implementing Watershed Management Programs or Enhanced Watershed Management Programs (EWMPs) to satisfy new permit requirements and to ensure compliance with Total Maximum Daily Load water quality regulations. The focus of the EWMPs is to identify and implement regional water quality improvement projects that capture and retain stormwater from 85th percentile storm events for infiltration, storage for irrigation, or other beneficial uses. These programs, including several run by the City of Los Angeles in collaboration with Los Angeles County and other cities in the watershed, plan to use a combination of large-scale, centralized stormwater capture facilities and smaller scale, distributed stormwater capture projects, such as green streets (bioswales), rain gardens, and rain barrels (for more see Sidebar 1.2 or visit LA's Stormwater Capture page). These multi-benefit projects will not only improve Santa Monica Bay's water quality, but will also aid in recharging our local groundwater supplies while conserving water.

Groundwater Treatment

Three groundwater basins exist within the Santa Monica Bay watershed. These are the West Coast Basin, Santa Monica Basin, and Hollywood Basin, of which the West Coast Basin is the largest. Water quality in these basins can be affected by seawater intrusion and contaminants from industrial, agricultural, and residential activities (Reed, DWP, pers. comm., 23 July 2015).

Of over 400 wells in operation in the West Coast Basin, 20 have been identified as high priority remediation sites due to chemical contamination. Contaminants of concern are primarily Volatile Organic Compounds (VOCs), although other pollutants including DDT, metals, and petroleum hydrocarbons are also present. Responsible parties have implemented fourteen groundwater remediation projects in the West Coast Basin, including three United States Environmental Protection Agency (EPA) Superfund sites, and plans for two more sites are underway (TODD Groundwater et al. 2015). Saltwater intrusion into the West Coast Basin is managed by the operation of two barrier systems where imported and recycled water are injected into the aquifers to maintain hydraulic pressure and prevent the intrusion of ocean water into the basin. Future efforts are focused on using 100% reclaimed water at the two barrier systems. In addition, two desalter projects have been implemented to help remove brackish groundwater from the basin (Reed, DWP, pers. comm., 23 July 2015).

Although Methyl tert-butyl ether (MTBE) and trichloroethylene (TCE) are no longer used, they are still concerns in the Santa Monica Basin. The City of Santa Monica installed new treatment facilities to remove MTBE contamination from local wells, and in 2011, began to meet 50% of its water use with local groundwater. Additional groundwater treatment facilities for treatment of TCE and perchloroethylene (PCE) are currently being pilot tested, with full-scale facilities anticipated to be in place by 2020. Santa Monica is hoping to reach self-sufficiency by 2020 by fully utilizing its local groundwater supply and aggressive conservation actions (Cardenas, Pers. Comm., 3 August 2015). The Hollywood Basin contains four sites contaminated with Total Dissolved Solids and one site contaminated with arsenic. The City of Beverly Hills pumps from this basin, but shuts down the well when water being pumped out of it reaches levels of concern for arsenic (SA Associates 2011). The City also has a treatment plant that removes Total Dissolved Solids using reverse osmosis.

Greywater Reuse

Wastewater from showers and tubs, bathroom sinks, and washing machines are classified as greywater in California, and wastewater from kitchen sinks, dishwashers and toilets are classified as blackwater and must be disposed of through the sanitary sewer. While greywater is thought to be higher quality than blackwater, it can still pose public health and environmental risks if not reused wisely (Friedler 2004). Regulations are often complicated, and installing greywater systems can be technically challenging. As a result, public attention only drifts to greywater during extreme drought.

The current drought is no exception. Revisions to the state plumbing code in 2010 made it possible to reuse wastewater from washing machines on landscapes without a permit, as long as the water is released below at least 2” of mulch and a means of switching the flow back to the sewer is in place. Beyond that, city and county construction permits are required (2010 California Plumbing Code, Ch 16A). The City of Los Angeles has begun to make reusing greywater easier by providing “over-the-counter” permits for pre-approved systems, primarily from showers and tubs. In addition, DWP has been asked by the City Council to provide additional recommendations for promoting greywater reuse (LACity Clerk Connect Website, 2015).

Water Reclamation

In 2014, the City of Los Angeles’ four wastewater treatment facilities recycled 76.2 million gallons per day (MGD) of wastewater that would otherwise have been discharged into the ocean and local rivers. While most of these facilities reclaim wastewater on their premises, the City of Los Angeles’ Hyperion Treatment Plant (Hyperion) sends nearly 35 MGD of treated wastewater to the nearby Edward C. Little Recycling Facility, operated by the West Basin Municipal Water District, to be recycled. This represents an increase of 60% over the last ten years (Figure 1.1-1). The West Basin anticipates this volume to increase even more to 54 MGD in the next 2-5 years. This water is used primarily in industrial processes and for irrigation through “the purple pipes”, which are colored to identify reclaimed water.

From 2013-2014, Los Angeles County’s eleven wastewater treatment facilities produced approximately 155 MGD of recycled water (Figure 1.1-1). At the county level, nearly 60% of this reclaimed water is used for irrigation, industrial processes, recreational impoundments, and habitat maintenance. The rest is used for groundwater replenishment, primarily to prevent saltwater intrusion into coastal aquifers.

Not only does reclaimed wastewater supplement the water supply, but it also reduces discharges of wastewater to Santa Monica Bay, Los Angeles Harbor, and the Los Angeles River. As shown in Figure 1.1-1, the total amount of wastewater discharged by Hyperion and by the County’s Joint Water Pollution Control Plant has declined by approximately 28% and 18% over the past ten years, respectively. At the same time, the amount of wastewater Hyperion has been sending to West Basin for recycling has increased 60%, which has further reduced effluent discharges from the Hyperion Treatment Plant to the ocean.

One obstacle for future expansion of reclaimed water is the state's "Service Duplication Act", or anti-paralleling statute (Pub. Util. Code § 1501-1507). It was adopted to protect the infrastructure investments made by water purveyors by discouraging one purveyor from installing competing water distribution lines in the certified service area of another purveyor. However, it can also prevent producers of reclaimed water from distributing reclaimed water unless the water purveyor in the area builds the distribution systems (purple pipes).

Desalination

Desalination has also regained attention as the drought condition worsens in the state. However, there is still on-going debate on whether desalination is a viable and cost-effective source of water supply. There is also great concern regarding the environmental impacts of ocean water intake and brine disposal. Between 2002 and 2007, the West Basin Municipal Water District conducted a demonstration project that included a 40 gallon per minute pilot facility to identify optimal performance conditions and test for water quality, and evaluate environmental impacts of ocean water intake and brine disposal methodologies. The West Basin's ultimate goal is to supplement its water-reliability portfolio with a full-scale desalination facility capable of producing at least 20 million gallons per day (MGD).

Unintended Challenges

Many of the above activities, such as water conservation measures, stormwater harvesting, and onsite infiltration may alter flows and change discharge and pollutant loading patterns in ways that have not yet been fully evaluated. These include:

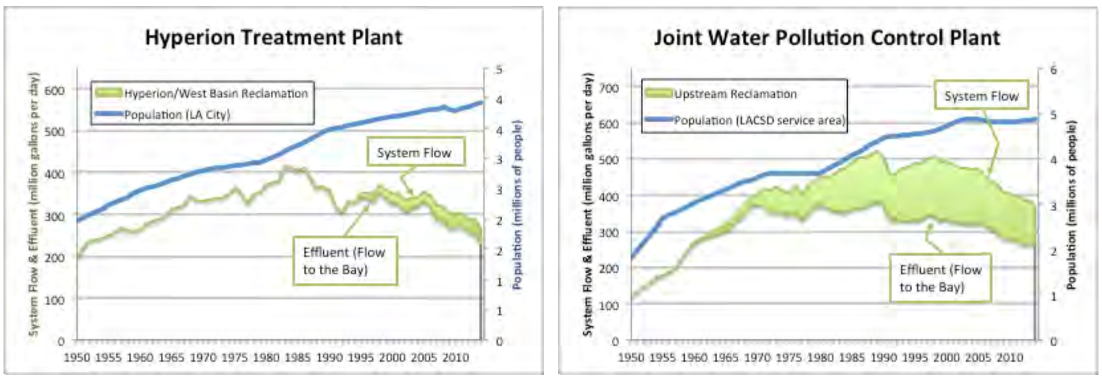
1) Increased concentrations of salts and chemicals of concern in ocean discharges (due to reduced volumes). These increased concentrations may affect behavior of the effluent plume and may have impacts on marine organisms.
2) Changes in stream flow patterns. These may affect habitat suitability for in-stream invertebrates or fish.
3) Changes in the timing and volume of freshwater discharge to coastal estuaries and lagoons. This could alter salinity patterns and mouth opening/closing dynamics.
4) Reduced pollutant loading and freshwater flows. This could aid in TMDL and NPDES compliance.

Such potential changes and their impacts should be monitored and assessed in the future.

Conclusions and Next Steps

As the state prepares to distribute Proposition 1 funds to projects that will improve water quality, supply, and infrastructure in order to alleviate the drought, consideration should be given to long-term and multi-benefit solutions. The best way forward will be to develop projects that benefit both water supply and water quality objectives through coordination across multiple agencies. LID strategies have proven effective at meeting these goals, and in many cases provide direct benefits to public health through increased green space and recreational opportunities. In many cases LID strategies incorporate native vegetation, which is drought-tolerant in southern California and provides food and structure for wildlife. Cleaning up polluted water, reducing impacts to the Bay and rivers, and securing a more diverse portfolio of water supply options are attainable through these approaches and specified in newly formed precedent-setting policies being developed and implemented throughout Los Angeles County.

Figure 1.1-1. Sanitation sewer system flows, outflows to the Bay, and population growth from 1950-2014 for the City of LA's Hyperion Treatment Plant and Los Angeles County's Joint Water Pollution Control Plant. Plant effluent discharges in both systems have been declining as a result of water conservation, recycled water use, and other factors. The volume of Hyperion's wastewater reclamation shown here does not reflect the total volume of wastewater reclaimed by the City of Los Angeles. ***(Data Sources: LA City-EMD, JWPCP, and U.S. Census Bureau)***



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December 2015

Water Resources: Existing Water Quality Programs

Guangyu Wang[1]

[1] Santa Monica Bay Restoration Commission

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1.2.0 Existing Water Quality Programs

Author: Guangyu Wang[1]

Santa Monica Bay is markedly cleaner today than it was 30 years ago, demonstrated most prominently by the steady decrease of pollutant loadings to the Bay from the two major publicly owned treatment works (POTWs), and by the recovery of marine life and habitat around the outfalls of these POTWs in the Bay (see Section 2.1 for more detail). Improvements have continued over the last five years, although progress has slowed as the remaining sources of pollutant loading are more difficult to control. Population growth in an already highly urbanized coastal plain—one of the most populous areas in the nation—continues to generate different kinds of pollutants in large quantities. The pollutants of greatest concern include pathogens, trash, nutrients, and chemical contaminants that discharge through the region's thousands of miles of storm drains, most of which flow directly into the Bay without effective source control or treatment. Other ongoing contributors of contaminants to the Bay come from nonpoint sources such as septic systems and boating activities. Legacy pollutants remain in the Bay's sediments from historical discharges such as dichloro-diphenyl-trichloroethanes (DDTs) and polychlorinated biphenyls (PCBs). Relatively new, but growing in recent years, are the recognition and the need to address contaminants of emerging concern (CEC), such as pharmaceuticals and personal care products (PPCPs), and perfluorinated compounds, among others. CECs are such because they are widely distributed, persistent in the environment, potentially detrimental to the health of aquatic organisms and humans, and difficult to remove through wastewater treatment processes.

The primary, and one of the most effective, mechanisms to control pollutant loading from various sources are the pollutant reduction targets in the form of the Total Maximum Daily Loads (TMDLs). These were developed and issued by the federal and state water quality regulatory agencies. Since 2003, 12 TMDLs have been developed and adopted by the Los Angeles Regional Water Quality Control Board (Los Angeles Regional Water Board) to regulate the amount of trash, bacteria, metals, and other toxins in the Bay and three major water bodies in the Bay watershed: Marina del Rey, Ballona Creek and its estuary, and Malibu Creek and Lagoon (Table 1.2-1). Two additional TMDLs were developed and enacted by the United States Environmental Protection Agency (EPA), one for sedimentation and nutrients to address benthic community impairments in the Malibu Creek and Lagoon (see Sidebar 1.2 for more), and one for sediment and invasive exotic vegetation in the Ballona Creek Wetlands (Table 1.2-1). The TMDLs are being implemented mostly through new control measures incorporated into existing National Pollution Discharge Elimination System (NPDES) permits.

[1] Santa Monica Bay Restoration Commission

Successful development and implementation of TMDLs is achieved through an adaptive process that matches management capabilities with scientific understanding. It requires cultivation of a good understanding of all relevant watershed issues, including knowledge of the sources of pollutants, and the link between specific pollutants and other stressors to water quality impairments. It also relies on engaging all stakeholders to develop, evaluate, and adopt cost-effective and innovative pollutant control strategies. This collaboration may result in broad implementation achieving integrated water resource management within a given geography. Finally, extensive and long-term monitoring is needed for tracking the progress of water quality improvements moving towards the TMDL goals, and for collecting information on specific watershed elements needed for possible mid-course correction.

Articles presented in this chapter provide several case studies that demonstrate how the TMDL development and implementation processes have been carried out in the Bay watershed, with emphasis on the application of scientific understanding and implementation through collaborative source control and sustainable solutions.

Sidebar 1.2: Biology-based TMDL for Malibu Creek and Lagoon

Authors: Cindy Lin[2], Eric D. Stein[3]

Malibu Creek and Lagoon were identified as impaired water bodies under Section 303(d) of the Federal Clean Water Act for sedimentation and nutrients to address benthic community impairments. These listings are different from most others in the country because there was no specific pollutant associated with or identified as causing negative benthic community effects. Instead the listing was based on biological endpoints, which is consistent with the Clean Water Act's goal of protecting the biological integrity of state and federal waters. Since pollution impacts have become so complex, California increasingly relies on biological endpoints as measures of condition, as they reflect cumulative stress on the aquatic environment and integrate the effects of various stressors over time.

The challenge of developing biologically-based TMDLs is that they require multiple lines of evidence and assessments to determine the cause(s) of impairment that are critically affecting the benthic community condition. Potential causes of impairment for the Malibu Creek Watershed and Lagoon were investigated using the EPA Causal Analysis/Diagnosis Decision Information System (CADDIS) approach. CADDIS provides a systematic evaluation of all potential stressors based on the best available comprehensive data sets, and produces a list of "likely" and "unlikely" causes of stress on the biological communities. In conjunction with CADDIS and other statistical analyses, nutrients and sediment were identified as the pollutants most strongly associated with biological impairment and negative stream condition. The TMDL implementation plan focused on these pollutants as priorities for restoration management.

The biologically-driven approach used in the Malibu Creek watershed provided a more comprehensive and unbiased approach to identifying key stressors than the traditional approach, where stressors are assumed to produce adverse or undesirable biological effects at the start of the process. This approach is also consistent with California's stated objective to focus more directly on biological endpoints in regulatory and management programs.

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[2] United States Environmental Protection Agency, Region 9

[3] Southern California Coastal Water Research Project

Table 1.2-1. TMDLs developed for Santa Monica Bay and their implementation status. *EPA-established TMDLs; **Amended in Feb. 2014 to include load allocations for discharge of dissolved copper, etc.

Pollutant	Water Body	Date in Effect
Bacteria	Santa Monica Bay, dry weather	JUL 2003
	Santa Monica Bay, wet weather	JUL 2003
	Marina del Rey Harbor, Mother's Beach and Back Basin	MAR 2004
	Malibu Creek	JAN 2006
	Ballona Creek, Estuary, Sepulveda Channel	APR 2007
Trash	Ballona Creek	AUG 2002
	Malibu Creek	JUL 2009
Marine Debris	Santa Monica Bay	MAR 2012
Toxics	Ballona Creek Estuary	JAN 2006
	Marina del Rey Harbor**	MAR 2006
Metals	Ballona Creek, Ballona Creek Estuary	OCT 2008
DDTs and PCBs*	Santa Monica Bay	MAR 2012
Sedimentation and Nutrients to Address Benthic Community Impairments*	Malibu Creek and Lagoon	JUL 2013
Sediment and Invasive Exotic Vegetation*	Ballona Creek Wetlands	MAR 2012

URBAN COAST

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December 2015

Water Resources: Reducing Bacteria along Santa Monica Bay Beaches

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[1] Loyola Marymount University
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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.

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1.2.1 Reducing Bacteria along Santa Monica Bay Beaches

Authors: John H. Dorsey[1], Amber Kuhn[2], Mas Dojiri[2]

Santa Monica Bay Bacterial TMDL

For cities along Santa Monica Bay, having clean water for swimming, surfing, and other beach activities is a top priority. Unfortunately, beach water quality along Santa Monica Bay beaches has not always met the standards established by the United States Environmental Protection Agency (EPA). As a result, bacterial TMDLs have been established for all Santa Monica Bay beaches: Marina del Rey Harbor, Mother's Beach, and Back Basin; Malibu Creek; Ballona Creek and Estuary; and the Sepulveda Channel (SWRCB 2015). These TMDLs focus on reducing coliform bacteria, mainly through stormwater programs, and compliance is based on monitoring fecal indicator bacteria (FIB) in runoff and along beaches (for more on why FIB are a human health risk see Sidebar 1.2.1a).

Beach Contamination by Fecal Indicator Bacteria (FIB)

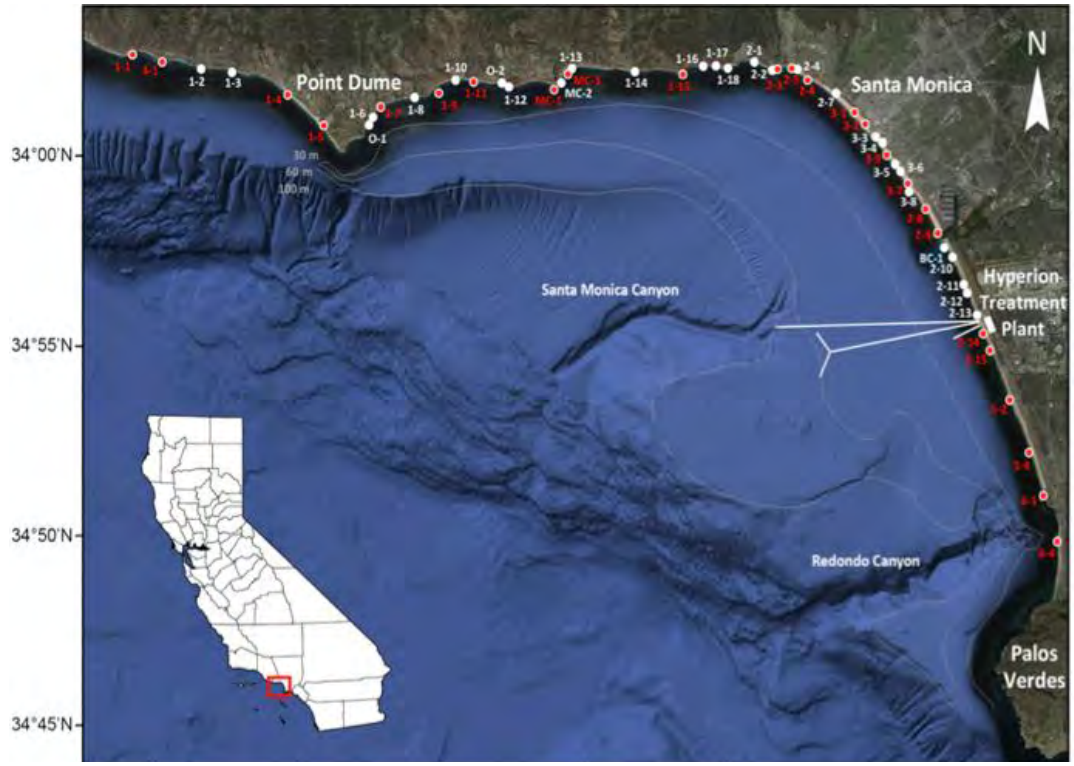
FIB serve as proxies for disease-causing microorganisms as the latter are difficult to measure and quantify. Elevated levels of FIB do not mean that pathogens are present; rather, a high FIB count implies that there is a greater chance of the presence of pathogens, and thus an increased risk to people swimming or surfing in the water (for more on advances in measuring FIB see Section 5.1).

The cleanliness of a beach is determined through routine monitoring of FIB along a beach's shoreline, with results compared to water quality standards adopted by the EPA and individual states. In Santa Monica Bay, several agencies are responsible for collecting FIB samples daily or weekly. FIB are monitored daily by the City of Los Angeles' Environmental Monitoring Division, and weekly by the Los Angeles County Department of Health Services (Figure 1.2.1-1). The South Bay beach cities, Los Angeles County Sanitation District, and others monitor additional sites (City and County of Los Angeles 2004).

[1] Loyola Marymount University

[2] City of Los Angeles, Environmental Monitoring Division

Figure 1.2.1-1. Shoreline sampling of beach water quality. Shows locations sampled by the City of Los Angeles (white) and Los Angeles County Department of Health Services (red). *Data source: City of Los Angeles Environmental Monitoring Division.*



The main source of contamination by FIB in Santa Monica Bay is from polluted runoff occurring during both dry and wet weather. Runoff impacts beaches directly from storm drains discharging directly into the surf zone, or forming ponds in back-beach areas that eventually flow to the ocean. The largest source of runoff comes from Ballona Creek, where about 16 million gallons per day (MGD) of runoff flows into the Bay during dry weather, and 10 times higher or more during larger storms (LA Stormwater, n.d.). Runoff itself is contaminated by FIB from a variety of terrestrial sources, including rotting vegetation, sewer overflows, trash, and feces from domestic pets, wildlife, and humans. Illegal sewage discharges from boats also contribute to the contamination of water in marinas and the ocean. In addition, the feces of sea birds, bacteria associated with decomposing beach wrack, and populations living in damp beach sands can directly elevate FIB densities in the adjacent water.

Reducing Bacterial Loads

Watershed-wide, a variety of actions have been implemented to reduce coliform bacteria in runoff, ranging from individual efforts by people and businesses to large-scale engineering projects. Most of the actions taken have focused on either preventing bacteria associated with fecal and other organic matter from coming into contact with runoff, or reducing the amount of runoff entering the storm drain system or surf zones. The following are some of the main measures being taken:

Municipal Operations: The County and City of Los Angeles, along with various local environmental organizations, wage campaigns educating the public on cleaning up after pets, capturing rain with rain barrels, and not placing organic matter, like lawn clippings, into the storm drains. The City of Los Angeles (Bureau of Sanitation) has improved its sewer collection system, implemented grease collection regulations for restaurants, and increased its response time to reported sewage blocks, all resulting in over 80% reduction in sewage spills from July 2000 to June 2014.

Clean Bay Restaurant Certification: Restaurants in many parts of the Bay's watershed are certified through The Bay Foundation (TBF) program by practicing good housekeeping to prevent storm drain contamination. More than 300 restaurants now are certified. Learn More.

Boater Education and Outreach: TBF staff work with the boating community in reducing ocean pollution vessel operations, with

Sidebar 1.2.1a: Epidemiology Studies at Malibu's Surfrider Beach

Author: Ken Schiff, Southern California Coastal Water Research Project

Epidemiology studies quantify patterns of disease and illness in order to better understand risk factors. These studies have been used to link swimming in contaminated water to illnesses in swimmers, and are a key underpinning of federal and state regulations for beach water quality. More of these epidemiology studies have occurred in Southern California than anywhere else in the country. Five epidemiology studies have been conducted over the last two decades, two of which were conducted at Malibu's Surfrider Beach. The first was in the summer of 1995 and the second in the summer of 2009.

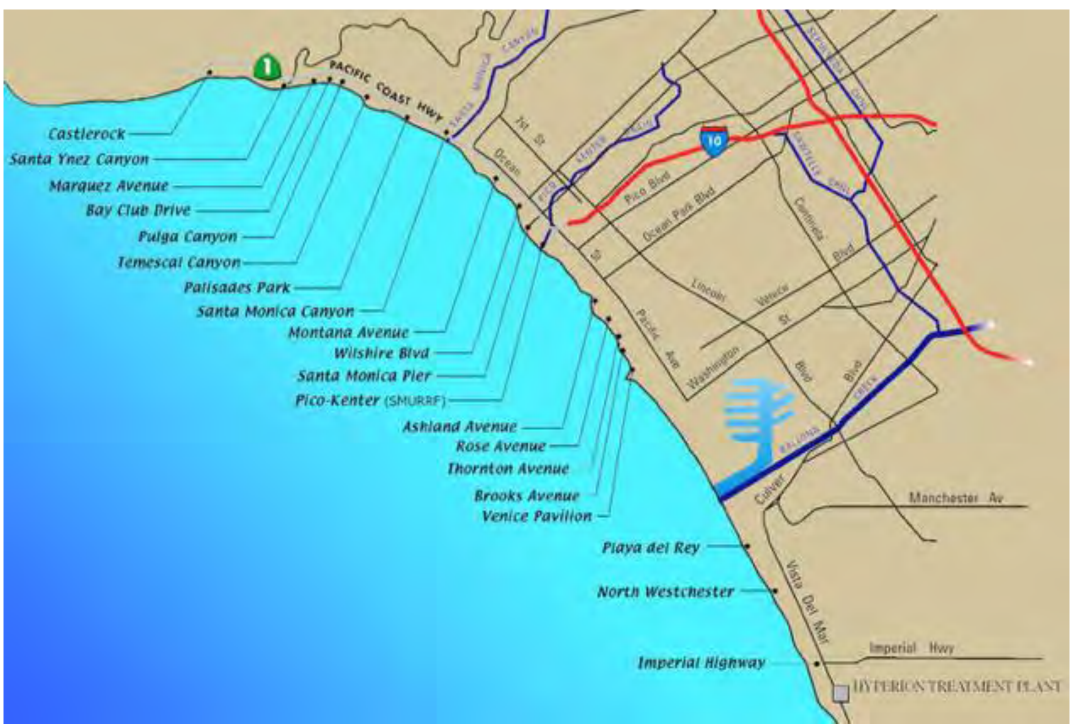
In 1995, highly credible gastrointestinal illnesses (i.e., combinations of cramps, diarrhea, nausea, or vomiting that are likely related to water contaminated with pathogenic viruses or bacteria) correlated with fecal indicator bacterial concentrations (such as *Enterococcus*), which also correlated with distance to the outflow from Malibu Creek and Lagoon, a large source of fecal indicator bacteria contamination (Haile et al. 1999). In 2009, gastrointestinal illnesses also correlated with swimming and the rates of illness rose with increased swimming exposure. However, overall incidence of illness was lower (857 swimmers were exposed to beach water quality exceeding state standards in 1995 compared with 30 swimmers in 2009) and there was little to no correlation with indicator bacterial contamination (Arnold et al. 2013).

The reason for this lies with changes in behavior. The results of the 1995 study provided the basis for issuing warnings not to swim within 100 yards of a flowing drain and helped form the California's present beach water quality standards. As a result, lifeguards prevent swimming near the Malibu Creek outlet to the beach. While this reduced the number of people exposed, it appears the underlying problem of contaminated water has not disappeared. The relative risk of contracting highly credible gastrointestinal illness for swimmers that immersed their heads was nearly double that of non-swimmers that went to Surfrider Beach during the summer of 2009 (Odds Ratio = 1.91, 95% confidence intervals 1.17-3.14). The City of Malibu has taken significant steps towards cleaning up some of the bacterial contamination at Surfrider Beach, including building a stormwater treatment facility at Legacy Park that opened in 2010, and planning for the construction of a sewage treatment facility (now in the permitting phase) to treat wastewater from properties in the low-lying areas in and around the civic center currently using septic systems.

particular focus on establishing sewage pump-out facilities for boaters. See Sidebar 1.2.1b for more.

Low-Flow Diversions (LFDs): Low-flow diversions are large underground structures that prevent contaminated runoff from ponding or flowing across beaches to the ocean waters. These structures intercept runoff in the storm drain, pass it through a screen to separate the trash from the water, and pump the runoff into the adjacent sewer system, where it mixes with raw sewage for treatment at a wastewater treatment facility. 29 LFDs are located along the coast of Santa Monica Bay: 17 are operated by the City and County of Los Angeles, and four by the City of Santa Monica (Figure 1.2.1-2). Those operated by the City of Los Angeles flow throughout the year, but are automatically shut down during rain events to prevent flooding of the sewers. Once the storm has passed and flows in the sewers are back to normal, the diversions are reactivated. This system helps provide good shoreline water quality for swimmers and surfers year around, except during and right after rain events.

Figure 1.2.1-2. Location of 21 low-flow diversions (LFDs) operated by the City and County of Los Angeles, and the City of Santa Monica. Two LFDs are located at Imperial Highway. Not shown on the map are two LFDs in Marina Del Rey, operated by the County of Los Angeles, as well as nine others in the Cities of El Segundo, Manhattan Beach and Redondo Beach. *Data Source: Wing Tam, City of Los Angeles Stormwater Program.*



Santa Monica Urban Runoff Recycling Facility (SMURRF): The SMURRF, owned and operated by the City of Santa Monica, is located close to the foot of Santa Monica Pier, intercepting 500,000 gal/day of highly contaminated runoff from the Pico-Kenter catchment area. Runoff is cleaned to the level where it can be recycled for landscape irrigation and other uses.

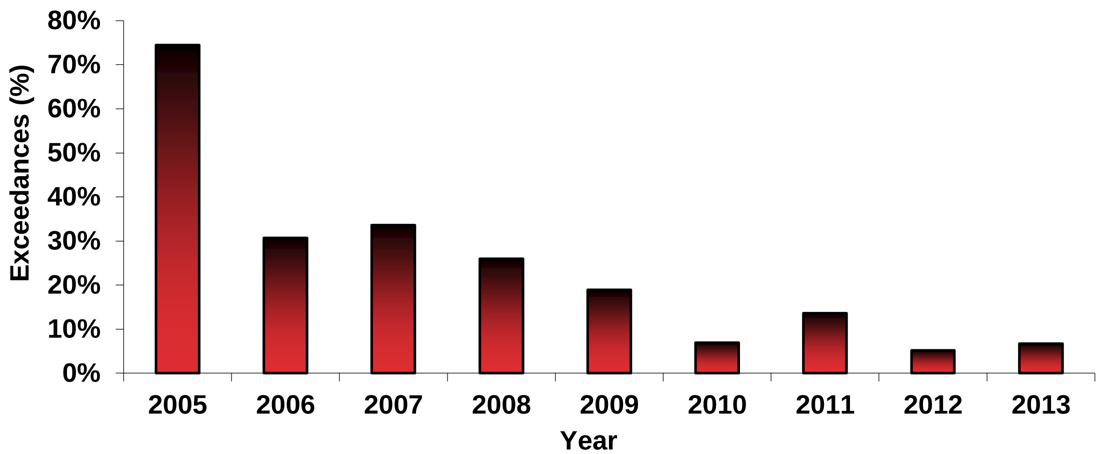
Biofiltration systems: Stormwater biofiltration systems capture urban runoff and allow it to percolate into the ground. Through this process, plants take up nutrients, soil microorganisms decontaminate pollutants, and groundwater supplies are enhanced. Using native vegetation enhances biodiversity, boosts aesthetics, and provides other ecosystem services needed in urban settings. These decentralized systems, including rain gardens, bioswales, and retention basins (Figure 1.2.1-3), can significantly reduce runoff entering receiving waters, thus improving water quality, water supply, and extending the life of the existing storm drain infrastructure (Ambrose and Winfrey 2015). Because of their multiple benefits, biofilters form the backbone of the Low-Impact Development (LID) stormwater management strategy now being implemented throughout the Bay's watersheds. To learn more about LID go to Section 1.1.

Figure 1.2.1-3. The newly planted Culver City rain garden located along the Ballona Creek. This 1000-ft rain garden intercepts runoff from commercial buildings and parking lots located along Jefferson Blvd. *Photo: Ivan Medel, The Bay Foundation*

Natural Wetlands: The Ballona Wetlands Ecological Reserve (BWER), degraded by decades of human activities and development, still provides valuable water purification services for contaminated runoff from Ballona Creek that enters this salt marsh system via the adjacent estuary. Of its 577 acres, only approximately 15 (> 3%)

receive tidal water. Studies have shown that as water flows into the wetlands from flood tides occurring during daylight hours, densities of FIB are significantly reduced by up to two orders of magnitude (Dorsey et al. 2010), especially in the uppermost layers of the water (Johnston et al. 2015). Although some FIB load is released back into the estuary during the lowest ebb flows, overall loads are diminished, thus improving the quality of water that flows past adjacent beaches. Enabling more water to enter the wetlands will provide additional natural water cleansing services, boost other ecosystem services that provide enhanced biodiversity and cleaner water, and create recreational, educational, and spiritual opportunities for the residents of the region and its visitors. Various restoration scenarios that would increase tidal flows into the Ballona Wetlands are being considered by the California Department of Fish and Wildlife and the Army Corps of Engineers (www.ballonarestoration.org).

Figure 1.2.1-4. Dry-weather exceedances of state water quality standards at the Santa Monica Canyon station SMB 2-7 during the period 2005-2013. Starting November 1, 2009 the LFDs were in operation year-round during dry weather (LAC-EMD 2014). Percent exceedances were significantly lower from 2010-2013 relative to 2006-2009 (Mann-Whitney U-Test, p=0.008); data from 2005 were not included in the analysis as the total rainfall for that year was 27.32”, or 180% of normal. *Data source: City of Los Angeles-Environmental Monitoring Division.*



All of the strategies mentioned above have led to cleaner beaches along the Bay’s shoreline. This achievement is best demonstrated by the decline in the percentage of samples that exceeded state water quality standards during dry weather at what was one of the more polluted beach sites in the Bay, Will Rogers State Beach at Santa Monica Canyon. Here, exceedances were significantly reduced after year-round operation of a LFD began in 2009 (Figure 1.2.1-4). Throughout the Bay, improved beach water quality most likely resulted from the automated LFDs, but certainly reflects the combined effects of water conservation efforts from local residents, and natural treatments from vegetation, wetlands, bioswales and infiltration areas. Continued work by municipalities and the public to implement these strategies will further reduce the volume of runoff reaching the Bay, and begin to tackle the next big challenge: reducing bacteria and other pollutants in wet weather runoff.

Sidebar 1.2.1b. Preventing Boat Sewage Discharges
Author: Victoria Gambale, The Bay Foundation

In Southern California, over half of all boaters have a toilet or port-a-potty on their boat (Godard & Browning 2011). With over 5,000 boaters based in Marina del Rey and a total of 6,000 boaters who call Santa Monica Bay home, the collective water quality impacts associated with boating activities pose a considerable risk to coastal waters if these waste disposal systems are not properly used or maintained.

A variety of services are available for boaters to properly dispose of sewage: public pump-outs, private pump-outs, in-slip pump-out systems, and mobile pump-out services. Using Clean Vessel Act Grant funding from the California State Parks Division of Boating and Waterways, The Bay Foundation has conducted a Boater Education Program since 1996, which provides several tools and resources to promote environmental boating practices throughout Santa Monica Bay. Efforts include:

- **Honey Pot Day**- This program educates boaters about the adverse effects of sewage and offers them a free mobile sewage pump-out to demonstrate the ease of proper disposal. This program has reached approximately 800 boaters and properly disposed of 20,000 gallons of sewage.
- **Dockwalker Volunteers**- This program educates boaters on how to conduct outreach to their peers about environmental boating practices, including the prevention of sewage discharges. Statewide, it reaches 7,000 boaters annually.
- **Southern California Boater's Guide**- Available as an interactive e-book since February 2014, it conveniently features environmental boating practices. The Boater's Guide has reached approximately 8,000 people and is used by marina operators, yacht brokers, marina industry representatives, and boaters throughout Southern California.
- **Southern California Tidebook**- This free resource features environmental boating services and the locations of all public sewage pump-out stations in southern California. This resource reaches over 4,000 boaters annually.

The operability and location of these pump-outs are an important part of preventing waste from entering the Bay. Boater program monitoring in Marina del Rey indicates a decline in public pump-out usage. This could be due to a number of factors, such as malfunctioning or difficult to use pump-outs, increasing use of private pump-outs, declining boat usage, and increasing utilization of landside facilities, but data on such factors in Santa Monica Bay are limited. However, statewide boater surveys indicate that while mobile pump-out services are declining, pump-out use at facilities where boats are berthed or stored is increasing. In addition, awareness of environmental issues seems to be on the rise. According to boater surveys, recognition of the sewage pump-out logo has increased from 2007/2008 to 2009 (Godard & Browning 2011). Due to the overall increased awareness of environmental issues and the installation of new in-slip pump-outs in Marina del Rey, it is reasonable to believe boaters in Marina del Rey are also exchanging one type of pump-out for another.

Staff monitoring a public pump-out unit to ensure it works properly and at peak efficiency. *Photo: Michelle Staffield, The Bay Foundation*

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URBAN COAST

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Volume 5 Issue 1 *Article 1.2.2*

December 2015

Water Resources: Toxics TMDLs

Steve Bay[1]

[1] 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.

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1.2.2 Toxics TMDLs

Author: Steve Bay[1]

The Clean Water Act (CWA) requires that each state "shall identify those waters within its boundaries for which the effluent limitations are not stringent enough to implement any water quality objective applicable to such waters." The CWA also requires states to establish a priority ranking and TMDLs (Total Maximum Daily Loads) for these impaired waters. Multiple water bodies within Santa Monica Bay and its watershed are listed as impaired due to various constituents such as trash, bacteria, nutrients, and toxic pollutants in water or sediment. Recent monitoring data and analyses have been conducted that provide an update on the impacts from toxics on Santa Monica Bay seafood contamination and aquatic life. As a result of this information, TMDLs for toxics and metals in sediment and/or water have been established or updated for four water bodies: Santa Monica Bay (offshore), Ballona Creek, Ballona Creek Estuary, and Marina del Rey Harbor. These activities provide an opportunity to evaluate the current impact from toxics and assess recent progress towards improving water and sediment quality.

Santa Monica Bay

Previous assessments of Santa Monica Bay have identified multiple types of impairments due to toxics in sediment. The United States Environmental Protection Agency (EPA) updated its assessment of Santa Monica Bay water quality in the course of establishing a TMDL for Santa Monica Bay in 2012. While the sediments in the Bay contain elevated concentrations of many contaminants as the result of decades of input from urban runoff, wastewater discharge and other sources, recent monitoring data indicates that these toxics are no longer having adverse impacts on aquatic life. This is indicated by healthy benthic communities and a lack of sediment toxicity in most areas. However, contamination of seafood in Santa Monica Bay and other portions of the Southern California Bight continues to be prevalent and a potential health risk to humans.

Fish consumption advisories for multiple species of fish are in effect in most part of Santa Monica Bay. The first ever regional survey of sportfish contamination was conducted by the State Water Resources Control Board (SWRCB) in 2009 and provides perspective on relative contamination levels in Santa Monica Bay (Davis et al. 2010). Contamination of popular sportfish such as kelp bass, mackerel, and white croaker by mercury, PCBs, and DDTs is prevalent throughout southern California, with the greatest potential health risk associated with mercury and PCBs (Figure 1.2.2-1). Mercury contamination is mostly due to large-scale contamination patterns and not related to specific sources in Santa Monica Bay.

The EPA's TMDL for Santa Monica Bay is focused on PCB and DDT contamination of fish, and establishes concentration targets for both tissue and sediment that are intended to minimize the health risk of consuming seafood. Ongoing inputs of these legacy contaminants are very

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small; most fish contamination is due to existing sediment contamination, a result of legacy discharges of contamination from wastewater outfalls and other sources. Reduction in fish contamination is therefore dependent on natural processes of contaminant degradation and burial by sedimentation, which are predicted to take more than 30 years to achieve TMDL targets (Figure 1.2.2-2).

Figure 1.2.2-1. Average concentration of contaminants measured in parts per billion (ppb) in kelp bass fillets in 2009 by fishing zone in Southern California. Vertical lines indicate OEHHA fish consumption advisory thresholds. *Data Source: Davis et al. 2010.*

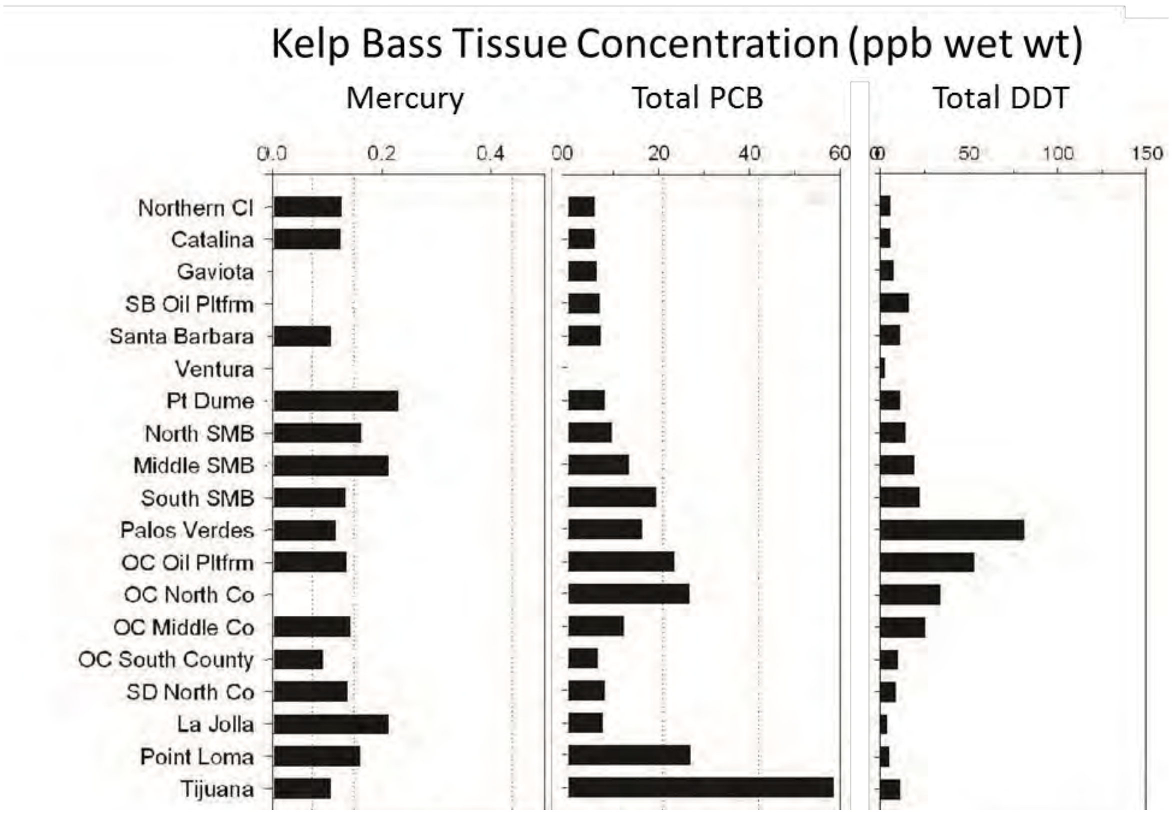
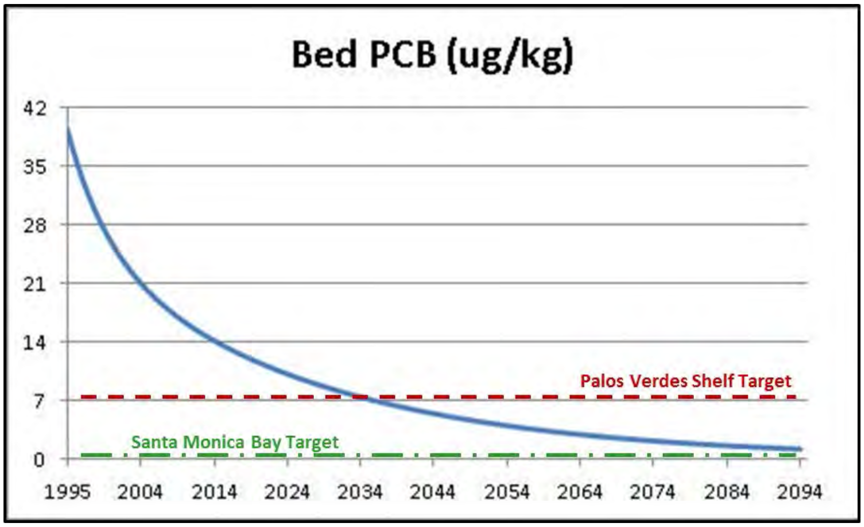


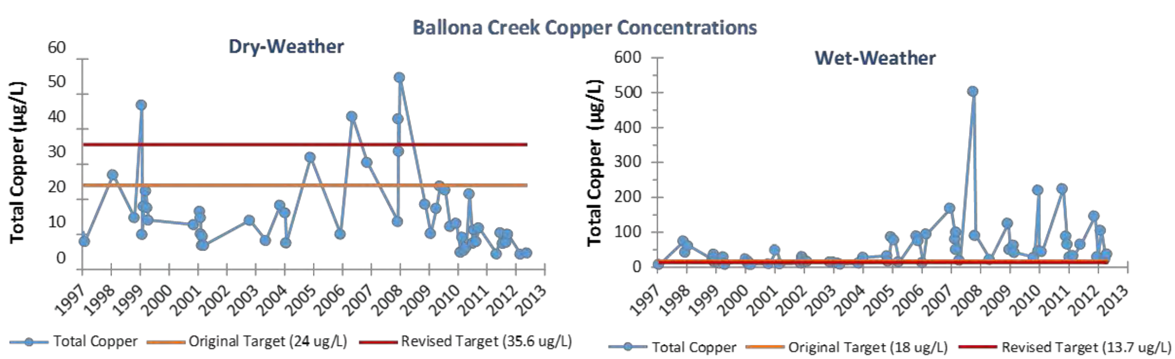
Figure 1.2.2-2. Projected change in sediment PCB concentrations in Santa Monica Bay due to natural processes measured in micrograms per kilogram (µg/kg). Reference lines indicate TMDL sediment targets for the Palos Verdes Shelf and other portions of Santa Monica Bay. *Data Source: EPA 2012.*



Ballona Creek

The TMDL for metals in the Ballona Creek water column was updated in 2013 to include revised compliance targets and load allocations for copper, lead, and zinc. The revised targets and allocations took improved data on flows, water hardness, and partitioning between total and dissolved metals into account. Monitoring data indicates reductions in dry weather metal loadings have occurred since 2009, and concentrations now rarely exceed the TMDL targets (Figure 1.2.2-3). This progress is likely due to a combination of factors, including lower runoff volumes due to weather patterns and the effectiveness of BMPs installed in the watershed. Ballona Creek wet weather metal loads have not shown similar declines, and achieving water quality standards in wet weather will continue to be a challenge.

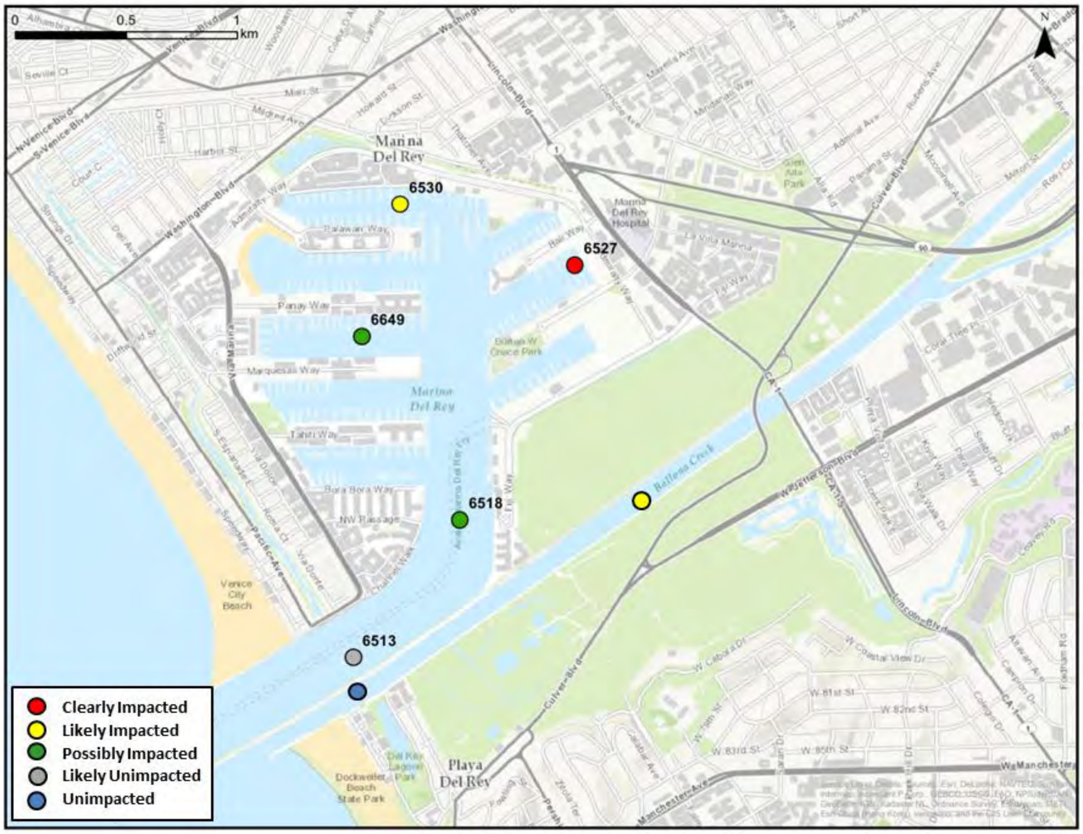
Figure 1.2.2-3. TMDL monitoring results for Ballona Creek water column copper measured in micrograms per liter (µg/L). Reference lines indicate TMDL compliance targets. *Data Source: SWRCB 2014***.**



Ballona Creek Estuary

The Ballona Estuary TMDL was established in 2006 to address impairments due to toxins in the sediment. This TMDL was revised in 2014 to incorporate new information pertaining to sediment quality objectives, monitoring results and special studies. The state's Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality (EB&E Plan) was adopted in 2009 and established narrative sediment quality objectives (SQOs) to protect aquatic life (benthic communities) and human consumers of seafood. This plan also established a new method for assessing toxic impacts on sediment quality based on multiple lines of evidence. The Ballona Creek Estuary TMDL was revised to include fish tissue and bioaccumulation-based sediment targets for PCBs, DDTs, and Chlordane, as well as alternative compliance targets for sediment condition based on SQO assessment categories (LARWQCB 2013a). Sediment quality in the Ballona Creek Estuary and other bays and estuaries are now being assessed using the new SQO framework, and the results show evidence of continuing impairment in both the estuary and adjacent Marina del Rey Harbor (Figure 1.2.2-4). The dominant cause of sediment quality impacts in the estuary has been shown to be pyrethroid pesticides discharged in urban runoff, with minor contributions from the other toxins listed in the TMDL (Greenstein et al. 2014). TMDL monitoring of sediment quality using the SQO framework is continuing, and additional data are needed in order to determine whether or not conditions are improving over time.

Figure 1.2.2-4. Sediment quality monitoring results for Marina del Rey Harbor and Ballona Creek Estuary in 2008 using the SQO assessment framework.

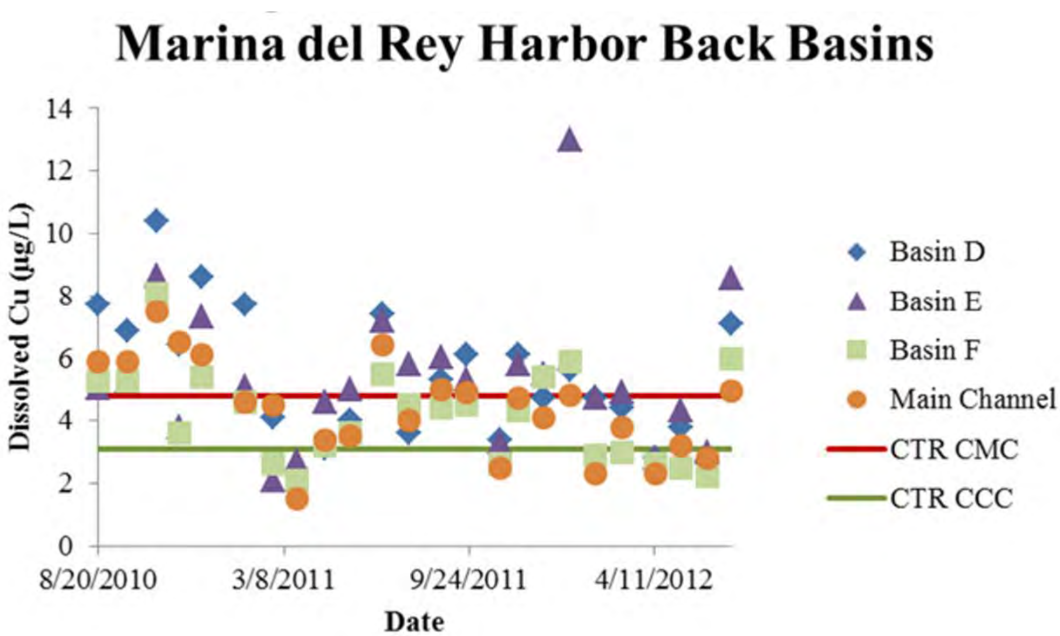


Marina del Rey Harbor

Similar to the Ballona Creek Estuary, the sediments of Marina del Rey Harbor are impacted due to sediment toxins. The original TMDL identified impairments in the back basins of the harbor from multiple metals and trace organics. Results from recent TMDL monitoring and special studies were used as a basis for several significant TMDL revisions in 2014. First, the extent of the TMDL was expanded to include the entire harbor, as the studies identified widespread sediment impairments based on SQO assessments. Second, additional impairments and TMDL targets were added for PCBs, DDTs, and Chlordane associated with fish tissue contamination. Finally, special studies and monitoring identified frequent and widespread exceedances of the water quality objective (California Toxics Rule) for water column copper (Figure 1.2.2-5; LARWQCB 2013b). Attaining the current TMDL targets for the sediment and water column in Marina del Rey Harbor is likely to have substantial economic and recreational impacts. Much of the water column copper contamination is from antifouling paints on the 4,700 boats in the harbor; most of these boats will need to be repainted with alternative coatings in order to achieve the TMDL-required load reductions, an expensive task that may be beyond the existing capability of harbor boatyards.

Restoring the sediment quality of the harbor is also a major challenge that could require extensive dredging of sediments. Two special studies are planned in the coming years that will help regulatory agencies and responsible parties develop the most effective management plans to improve conditions in Marina del Rey Harbor. First, an extensive study of copper toxicity and bioavailability in harbor waters will be conducted. This study will determine whether there is a scientific basis for developing a more accurate site-specific copper water quality objective for the harbor, potentially resulting in a revised objective that will protect aquatic life while requiring less drastic reductions in copper loads. The second special study will conduct toxicity identification evaluations in order to identify the specific contaminants responsible for sediment quality impacts. The results of this study are expected to produce a more accurate determination of the sediment contamination targets needed to support good sediment quality in the harbor, which in turn will help determine the most effective and technically feasible sediment management alternatives for Marina del Rey Harbor.

Figure 1.2.2-5. Water column monitoring results for copper in Marina del Rey Harbor. Most samples exceed the TMDL target, which is based on the California Toxics Rule chronic toxicity water quality objective. *Data Source: CTR CCC.*



These recent TMDL revisions and planned special studies illustrate a substantial evolution of the approaches for dealing with toxins in Santa Monica Bay over the last decade. Initial listings of impairments and TMDLs were relatively broad in scope, a reflection of data gaps and limited scientific understanding of toxicological relationships. The revised TMDLs use improved monitoring data and technological advances to develop programs with a better focus and greater potential for success. Of course, continued efforts are needed to implement these best management practices in order to reduce the impact of toxins on Santa Monica Bay habitats.

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Water Resources: Trash and Debris

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1.2.3 Trash and Debris

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Marine debris has become one of the most recognized pollution problems in the world's oceans and watersheds today (Lippiatt et al. 2013). About 80% of debris found in marine environments is generated from land-based sources of trash (SCCWRP 2013). Therefore, reduction of trash sources from watersheds is an important management action to reduce marine debris. To address marine debris, the Los Angeles Regional Water Quality Control Board (LARWQCB) established a Total Maximum Daily Load (TMDL) for trash for the Ballona Creek in 2002, for Malibu Creek in 2009, and for marine debris for Santa Monica Bay in 2012. Land-based trash also affects the condition of stream ecosystems, but in general there has been much less management focus on the impacts of trash on stream habitats in comparison to beaches and coastal environments.

The implementation schedule for the Ballona Creek TMDLs requires a 10% progressive reduction from the baseline waste load allocation each year. It aimed to achieve a 50% reduction by 2009, followed by a target of zero trash by 2015 (LARWQCB 2004). For Malibu Creek, the target of zero trash must be met by 2017 (LARWQCB 2008). For Santa Monica Bay, the target of zero trash must be met by 2020, except for cities that pass ordinances banning plastic bags, smoking in public places, and single-use expanded polystyrene food packaging (Styrofoam), which have until 2023 (LARWQCB 2011).

Compliance is derived from the number and type of best management practices (BMPs) employed to prevent trash from entering the storm drain system: full-capture devices, partial-capture devices, and/or institutional controls. Achieving compliance means the capture of 100% of the baseline amount of trash as estimated by the stated effectiveness of the implemented BMPs. Using this metric, the cities in the Ballona Creek Watershed achieved an estimated 96.7% reduction in the 2013/2014 reporting year, one year ahead of schedule, and appear to be on track for meeting the 2015 target (LARWQCB 2015). In April of 2015, the Los Angeles Regional Water Quality Control Board began considering an amendment to the Ballona Creek Trash TMDL that would require municipal separate storm sewer system (MS4) permittees to monitor the receiving waters for trash. According to this amendment, compliance would still be determined based on BMPs, but monitoring of receiving water would help refine assessments about the effectiveness of these BMPs (LARWQCB 2015).

Full-capture devices, such as catch basin covers and inserts, keep trash out of storm drains, and in-channel trash capture devices, such as continuous deflective separation (CDS) units and trash

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nets, collect trash within the channel before it reaches the Bay. Weekly or twice-weekly street sweeping, installation of trashcans on public streets, and public education campaigns are other strategies that have been employed. Several cities in the Santa Monica Bay Watershed have also passed ordinances banning plastic bags, smoking on the beach, and single use Styrofoam food packaging. However, additional strategies will be required to address the trash generated within state and national parklands, both by non-point sources (such as beachgoers), and from non-land based activities (such as boaters). Furthermore, the many creeks and streams in the Santa Monica Bay Watershed that do not have trash TMDLs are likely to continue serving as transport corridors for conveying land-based sources of trash to coastal ecosystems and Santa Monica Bay beaches. Ultimately, measureable trash reductions in the receiving bodies will determine whether these strategies are successful.

Data Sources

Without mandatory receiving water monitoring, few other sources of data on trash loading in the Bay exist. Data are limited, as trash removed from full or partial capture devices, the trash booms placed at the mouths of major rivers, or trash collected at beaches after grooming are not consistently weighed, measured, or categorized with standard methodology. Beach cleanups can occur annually, monthly, or sporadically. Data typically consist of counts of the different types of trash collected. Some also include information about the amount of effort expended during the cleanup (number of people, number of hours, etc.). However, beach cleanup data is typically recorded and reported by volunteers with few quality control measures in place. In addition, the trash categorization used varies widely between groups.

SMCRMP member agency staff conducting a stream trash assessment during the 2012 surveys. Photo Credit: M. Mathis, Weston Solutions, Inc.).

One of the most robust sources of beach trash data is the Ocean Conservancy's data from Coastal Cleanup Day. While the cleanup occurs one day every year, making the data sensitive to random occurrences, and the data are collected by volunteers, making them sensitive to year-to-year differences in volunteer effort, it is a consistent long-term data set that reports itemized numbers of trash by site from thousands of sites around the world. In addition, the trash categories are more detailed than most, and can be readily compared with trash data from other efforts and future receiving water monitoring programs. Another robust source of beach trash data comes from Heal the Bay's monthly beach cleanups. Like the Ocean Conservancy's data, these beach cleanups report itemized numbers of trash by site from most beaches in Santa Monica Bay. They also report the number of man-hours expended during

Heal the Bay operates an online database for their beach trash data. View their beach trash data here.

each beach cleanup, which gives an approximation of effort, although the reported amount of trash collected and effort were relatively rough estimates due to the difficulty in controlling the number of participating volunteers, among other factors.

Until recently, very few efforts have been made to measure the trash in streams. However, beginning in 2009 and ending in 2013, the Southern California Stormwater Monitoring Coalition Regional Monitoring Program (SMCRMP) conducted a regional scale pilot survey of debris in stream ecosystems. The goal was to test a standardized, relatively rapid (less than 20 minutes to complete per site) tool for assessing trash in streams in conjunction with the SMCRMP's existing stream assessment program. The program uses a probability-based sampling design to assess the ambient condition of the region's 15 major watersheds. In 2011, SMCRMP added trash to its list of indicators used to identify key stressors to stream health throughout the region. These data will improve our understanding of the spatial distribution and magnitude of the trash problem at both the regional and local levels and to examine the sources of trash and pathways into streams.

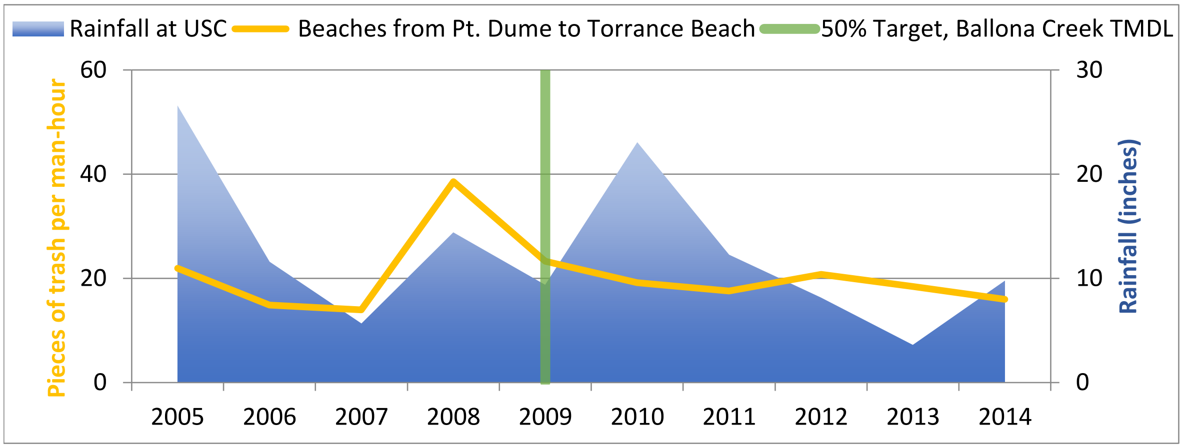
Learn more about the SMCRMP here: http://www.socalsmc.org

Outcomes

In general, trash found on beaches along the Bay has declined since 2008, a decline which roughly coincides with the implementation of the Ballona Creek Trash TMDL. In addition, the relationship between rainfall and trash present on beaches prior to 2009 has diminished (Figure 1.2.3-1). Although there are some differences within regions of the Bay, plastic items continue to be the most numerous items collected, followed by smoking-related items and Styrofoam (Figure 1.2.3-2). Based on annual coastal cleanup data, plastic bags and cigarette butts have declined since 2009 as well, presumably related to management actions taken by local jurisdictions, such as bans on smoking on the beach and the use of single-use plastic bags.

Results of the regional stream survey indicated that, in general, a few types of trash represent most of the quantities of trash found, and that the same types of trash are found at nearly one-half of all the sites surveyed (Figure 1.2.3-2). The distribution of trash in the creeks and streams that drain into Santa Monica Bay reflect that of the streams in the region as a whole, with a few exceptions: substantially larger proportions of cigarette butts, sports balls, and plastic bottles were observed. Furthermore, when comparing common items found in streams and on beaches, some items (plastic bags, cigarette butts, and plastic wrappers/containers) are prevalent in beaches and streams, others (plastic bottles and sports balls) appear to remain in streams, and still others (caps/lids, plastic utensils, straws, and paper bags) appear to originate on beaches (Figure 1.2.3-2).

Figure 1.2.3-1. Annual averages of total pieces of trash per man-hour collected during monthly beach cleanups from 2005-2014. Twenty-two sites from Point Dume to Torrance Beach were sampled during the time range. Data from these sites were summed by month. Monthly totals were averaged by year. Rainfall and the year in which 50% trash reduction was targeted for the Ballona Creek watershed are also shown. Trash collected on area beaches appear to be sensitive to rainfall prior to implementation of the Ballona Creek Trash TMDL. The slight rise in trash collected since 2011 is due to an increase in trash collected per unit effort along the Malibu coastline. *(Data source: Heal the Bay, Western Region Climate Center, and Los Angeles Regional Water Quality Control Board)*

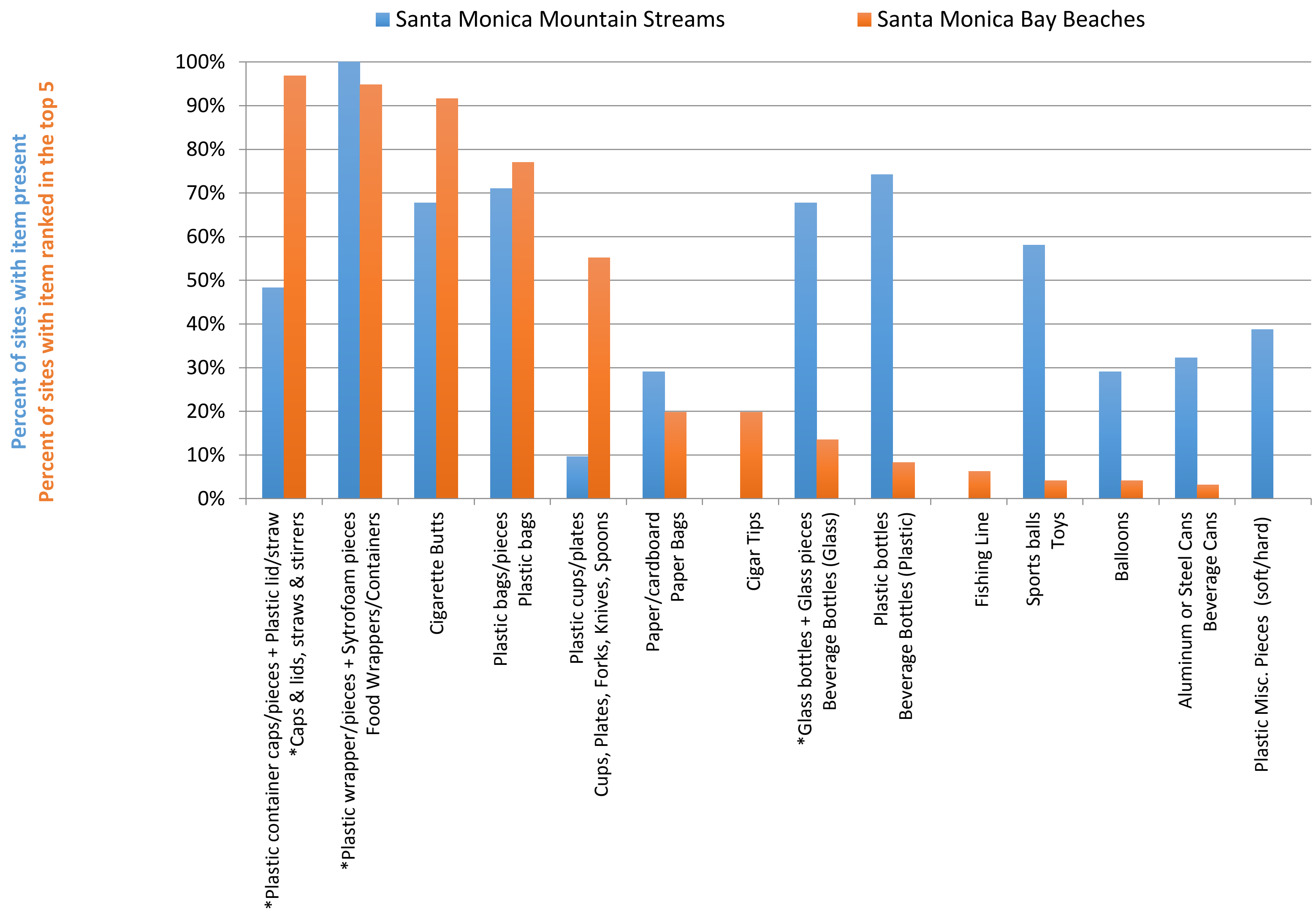


Conclusions and Next Steps

Credit and acknowledgement should go to the thousands of beach clean-up volunteers and beach management agencies' maintenance activities. Their efforts keep the Bay's beaches clean and have helped to demonstrate that management actions, such as implementing BMPs to reduce the amount of trash entering storm drains, and banning activities or products that tend to generate high amounts of trash, seem to have had a positive impact on the amount of trash collected on Santa Monica Bay beaches. In addition, new efforts to monitor trash in streams are providing insight into the sources of different types of trash and marine debris.

Another key benefit of the SMCRMP project is that for the first time, managers have been provided an unbiased analysis of the types and quantities of trash found throughout stream ecosystems across Southern California. Because of the probabilistic design, the types and quantities of trash found throughout the stream ecosystems can be extrapolated to the stream ecosystems within the Santa Monica Bay Watershed. Developing similar sampling strategies for beach cleanups and attempting to standardize trash categories across different data collection efforts would make these data more useful. Assessing the effectiveness of the many measures taken to reduce the presence of trash on beaches, in streams, and in the storm drains of the Santa Monica Bay Watershed will become a higher priority if the proposed amendments to the Ballona Creek Trash TMDL are approved. Collaboration between municipalities and existing trash monitoring efforts, like the SMCRMP and Heal the Bay, could help reduce the cost of required receiving water monitoring. Furthermore, more accurate data on the common categories of trash and where they tend to accumulate can help prioritize areas of greatest management concern and track the progress of management actions over time.

Figure 1.2.3-2. Comparison between the most common trash items found in streams and those found on beaches from 2009-2012. Stream data represent the proportion of sites with trash present, while beach data represent the proportion of sites where a trash item ranked in the top 5. Categories are labeled as they are on the data sheets. An * indicates categories that have been combined to make them more comparable. Items such as food wrappers and containers, cigarette butts, and plastic bags are prevalent at beaches and streams. Others, such as glass and plastic bottles and sports balls, appear to remain in streams. Still others, such as plastic utensils and fishing line, appear to originate on beaches. *(Stream Data Source: Southern California Stormwater Monitoring Coalition Regional Monitoring Program; Beach Data Source: Ocean Conservancy Coastal Cleanup Day).*



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Water Resources: Contaminants of Emerging Concern

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[2] Delta Stewardship Council

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1.3.0 Contaminants of Emerging Concern

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Overview

Contaminants of emerging concern (CECs) encompass a vast number of compounds that are largely unregulated in the U.S. and abroad, and have limited or no monitoring data available for environmental media (e.g., air, water, sediment, and biota). A wide variety of pharmaceuticals, flame retardants, contemporary use pesticides, and even food additives are considered CECs. Many of these compounds have likely been present in aquatic ecosystems for decades, but were not previously detectable using available chemical methods. However, recent advances in analysis have allowed for the detection of many CECs in coastal habitats around the world. Previous studies of CEC occurrence and fate in Santa Monica Bay and other coastal areas, summarized in the 2010 State of the Bay Report, identified the widespread occurrence of some CECs and the potential for exposure of coastal fish and manifestation of adverse effects. However, these studies also identified many knowledge gaps that limit our ability to make decisions on managing CECs that are based on sound science. In the last 5 years, steps have been taken by California agencies to fill these knowledge gaps and develop new strategies for CEC management and regulation.

Several recent regional and statewide studies have been conducted that add significantly to our understanding of CEC contamination in southern California and suggest directions for future management efforts. The 2008 Southern California Bight Regional Monitoring Program analyzed sediments from bays and estuaries for polybrominated diphenyl ether (PBDE) flame retardants and pyrethroid pesticides. In 2009-10, the Mussel Watch California Pilot Study was conducted to determine the extent and magnitude of more than 150 CECs in mussels (*Mytilus* spp.), low trophic level sentinels for contaminant exposure, at 68 sites along the California coast. Water column concentrations of CECs were also measured at selected sites using **passive sampling technology**. The Stormwater Monitoring Coalition (SMC) has also conducted chemical analyses of water from perennial streams in southern California coastal watersheds.

Passive sampling devices (PSDs) are simple, low cost alternatives to conventional methods for the extraction and chemical analysis of water or sediment that rely on diffusive mass transport and/or preferential sorption to concentrate chemicals of interest.

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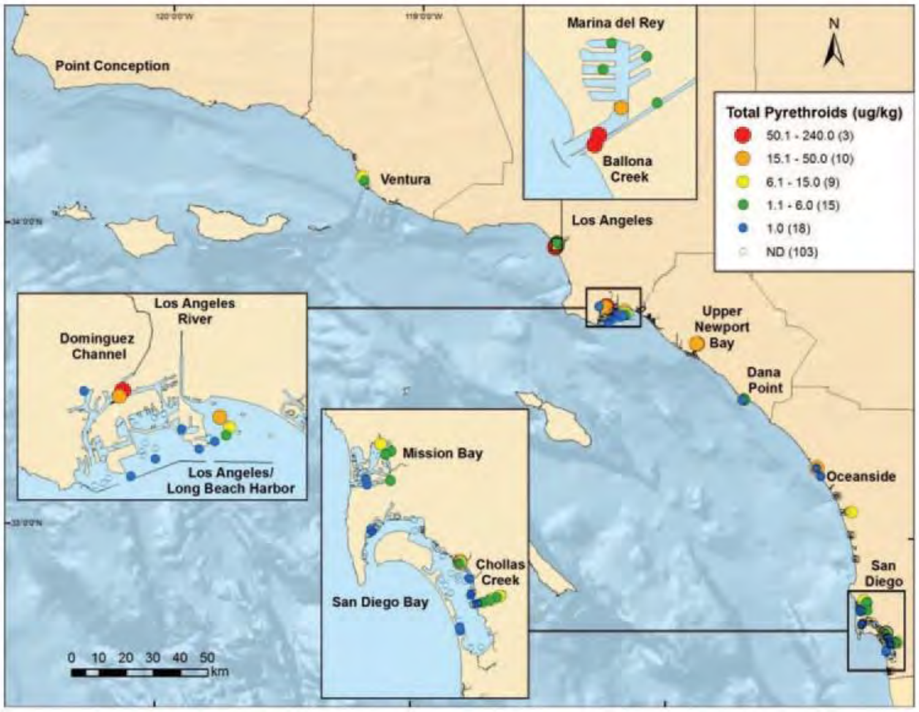
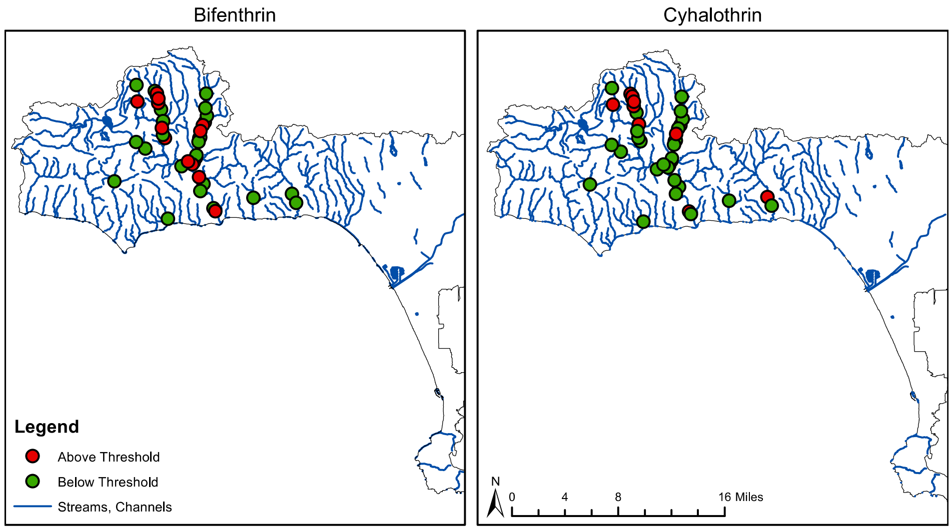
[2] Delta Stewardship Council

Figure 1.3 -1. Geographical distribution of pyrethroid pesticide concentrations in sediments from embayments of the Southern California Bight in 2008. Concentrations shown are the sum of 8 individual pyrethroids. *Source: Lao et al. 2012.*



Results from these studies confirm that a wide variety of CECs are present in the water, sediments, and biota of the Bight, including Santa Monica Bay. Pyrethroids, a group of current-use pesticides with high toxicity to some aquatic life, were detected in 34% of southern California embayments (Lao et al. 2012), with the highest concentrations present at the mouth of Ballona Creek Estuary (Figure 1.3-1). They make up the dominant cause of sediment toxicity in that body of water (Greenstein et al. 2014). Pyrethroids are also present in streams throughout our coastal watersheds; therefore, streams are a likely source of these insecticides in embayments. Monitoring by the SMC found 12% of streams in the Santa Monica Bay watershed contained potentially toxic concentrations of the pyrethroid, cyhalothrin, while 27% of streams in the Los Angeles River Watershed contained elevated concentrations of bifenthrin (Figure 1.3-2). Residues of CECs in mussel tissue indicated that marine life are exposed to a wide variety of CECs along the coast of California, with the greatest exposure occurring near urban centers and especially near areas receiving stormwater input (Dodder et al. 2013). Of the different CECs detected, pharmaceuticals and personal care products (PPCPs) were most prevalent (30 compounds detected). Other types of CECs present in mussels included alkylphenol surfactants, flame retardants (PBDEs), current-use pesticides, and perfluorinated compounds. Water column measurements also detected the presence of CECs (e.g., chlorinated phosphate flame retardants) that did not accumulate in mussels. Most CECs found in these studies were at relatively low concentrations compared to legacy contaminants such as DDTs and PCBs (Figure 1.3-3).

Figure 1.3-2. Occurrence of the pyrethroid insecticides bifenthrin and cyhalothrin in streams throughout southern California coastal watersheds in 2008-13. *Data Source: The Stormwater Monitoring Coalition.*



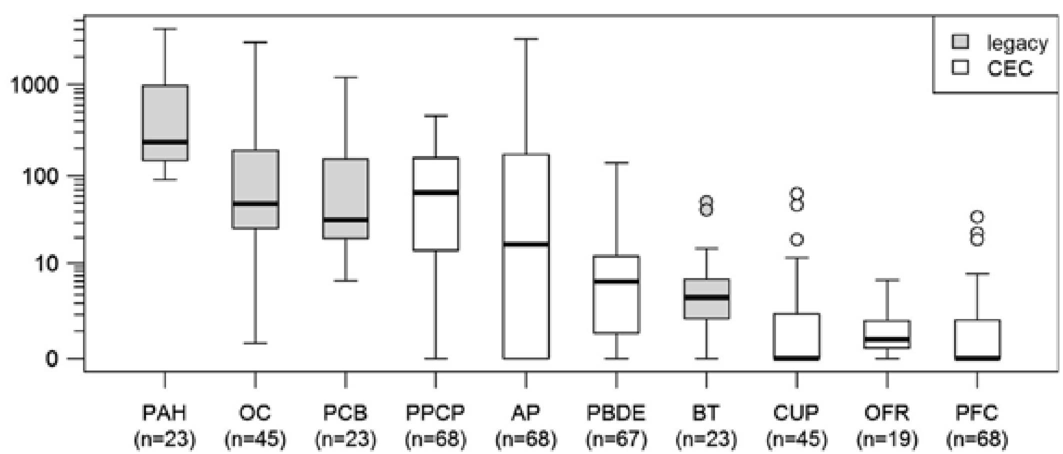
The large number of CECs discharged into aquatic systems, combined with the limited information on thresholds of concern, presents a challenge for monitoring and regulating these compounds. California has begun to take action to address the issue. An expert panel convened by the State Water Resources Control Board (SWRCB) reviewed the potential sources, fate and effects of CECs, and provided guidance for monitoring the State's receiving waters (Anderson et al. 2012). The panel identified 16 CECs for initial monitoring in wastewater effluents, freshwater, estuarine, and marine habitats based on existing occurrence and toxicity data (Table 1.3-1). The panel also determined that the monitoring and regulatory paradigm based on chemical-specific water quality criteria is not feasible for CECs (see Sidebar 1.3 for more on how CECs are monitored). Instead, the panel recommended the use of a comprehensive monitoring framework that integrates biological testing and chemical analysis in a tiered approach (Figure 1.3-4). Routine monitoring (Tier I) would include the use of cell-based (*in vitro*) bioassays in addition to

Sidebar 1.3: Monitoring Wastewater for CECs

One of the key data gaps in assessing the environmental risk of CECs to coastal ecosystems is the lack of information on the types and amounts of chemicals being discharged. The Los Angeles Regional Water Quality Control Board has begun requiring monitoring for selected CECs in the NPDES discharge permits for the major municipal wastewater discharges into Santa Monica Bay, and is sponsoring studies on the occurrence of CECs in local watersheds. The City of Los Angeles' Hyperion Treatment Plant began monitoring its effluent in 2012. Once a year, a 24-hour composite sample of the final effluent discharged into the Bay through Hyperion's 5-mile outfall is analyzed for over 30 CECs, including most of those recommended by the SWRCB Expert Panel. In addition to the SWRCB recommended compounds, the effluent samples are being analyzed for a wide variety of other pharmaceuticals and personal care products, including antibiotics, pain relievers, sedatives, and cholesterol-lowering agents. Annual CEC monitoring is also underway for effluent from the Sanitation Districts of Los Angeles County's Joint Water Pollution Control Plant (JWPCP), which is discharged into waters offshore of the Palos Verdes Peninsula. The results from these monitoring efforts will improve our understanding of the sources and loads of CECs into Santa Monica Bay and provide a foundation for improving monitoring programs in the future.

targeted chemical analyses to screen for CECs in aquatic environments. The cell assays would complement the chemical analyses by accounting for the joint effects (including synergism and antagonism) of contaminant mixtures. These tests will provide the necessary sensitivity without the need to analyze for every CEC of potential concern. Follow-up studies (Tier II) that include more detailed biological testing and additional chemical analyses (e.g., additional compounds, non-targeted analysis) would be used to determine the level of concern and need for management actions when screening thresholds are exceeded. Elements of the CEC monitoring framework are currently being tested in pilot studies conducted by local sanitation districts, the SMC, and the Bight Regional Monitoring Program. Screening thresholds will be determined in subsequent phases of the program, utilizing data from previous studies and ecological risk models.

Figure 1.3-3. Mussel (Mytilus spp.) tissue concentration box plots for multiple contaminant classes of samples collected at 68 sites along the California coast in 2009-10. Rectangle, horizontal bar and error bars represent the interquartile range (IQR), median, minimum and 1.5 times the IQR, respectively. Concentrations greater than 1.5 times the IQR are shown as individual circles. PAH-polycyclic aromatic hydrocarbons; OC-organochlorine pesticides; PCB-polychlorinated biphenyls; BT-butyltins; PPCP-pharmaceuticals and personal care products; AP-alkylphenols/alkylphenol ethoxylates; PBDE-polybrominated diphenyl ethers; CUP-current-use pesticides; OFR-other non-PBDE flame retardants; PFC-perfluorinated chemicals. *From Dodder et al. 2013*



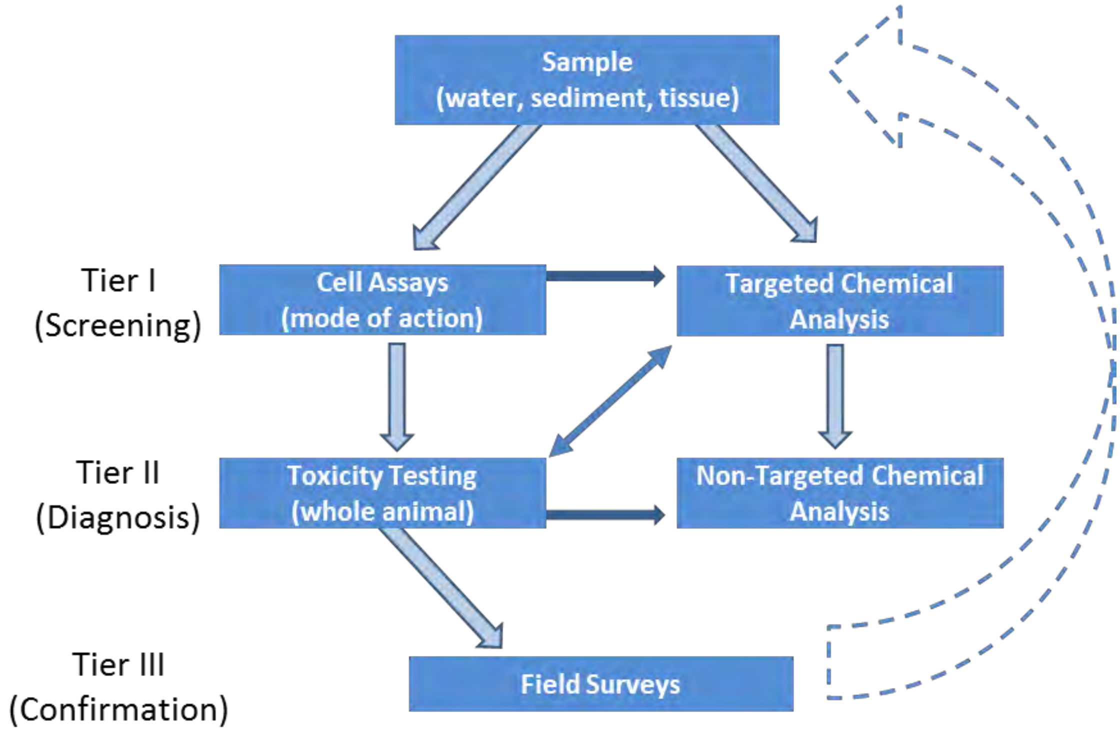
In addition to the SWRCB, other state agencies are developing regulations to reduce sources and inputs of CECs to the environment. The Department of Pesticide Regulation (DPR) promulgated regulations in 2012 to prevent surface water contamination by pesticides used in outdoor urban settings. The Department of Toxic Substances Control (DTSC) has developed Safer Consumer Products Regulations that will require product manufacturers to ask: "Is it necessary?" So far, DTSC has identified three products for which alternatives will be investigated: children's sleep products containing the flame retardant known as chlorinated tris (TDCPP), cleaning fluids with methylene chloride, and polyurethane foam containing unreacted diisocyanates.

The DTSC process includes four steps:

1. Identify candidate CEC based on hazard traits and evidence of exposure.

2. Identify consumer products containing candidate CECs for which there is a potential exposure that may contribute to or cause significant or widespread adverse impacts.
3. Identify possible alternative product designs or formulations.
4. Implement regulatory responses, including restrictions or prohibitions on sales and end-of-product life stewardship.

Figure 1.3-4. Proposed integrated monitoring framework for CECs in aquatic environments. *Source: SCCWRP*



The intended outcome of the DTSC process is to send a signal to the marketplace before restrictions or prohibitions need to be initiated.

There has been substantial progress in recent years in cataloging the occurrence of CECs in coastal waters, and in developing bioanalytical methods with the high levels of sensitivity needed for environmental monitoring. Future research will focus on developing new technologies for biological effect testing and using these tests to determine CEC thresholds that are protective of water quality. Pilot studies to test the application of California's CEC monitoring strategy are in progress, and are expected to further develop this strategy into monitoring programs that will likely be implemented in discharge permits and new product evaluations. The control and treatment of CECs in waste discharges is a daunting task due to the diversity of CEC types and sources. The challenge facing California's water quality agencies is how to identify and limit the use of problematic CECs before they become a source of environmental degradation and diminish the invaluable benefits provided by the coastal ecosystem.

Table 1.3-1. Contaminants of emerging concern (CECs) recommended for pilot monitoring in wastewater treatment plant effluents and environmental samples (depending on exposure type). *Data Source: Adapted from Anderson et al., 2012.*

Compound	Primary Use	Aqueous Exposure Potential Risk	Sediment Exposure Potential Risk	Bio-accumulation Potential Risk
Bis (2-ethylhexyl) phthalate	Plasticizer for PVC		X	
Bisphenol A	Monomer or epoxy/polycarbonate	X		
Bifenthrin	Pyrethroid insecticide	X	X	
Butylbenzyl phthalate	Plasticizer for PVC		X	
Permethrin	Pyrethroid insecticide	X	X	
Chlorpyrifos	Organophosphate insecticide	X		
Estrone	Steroid hormone	X		
Ibuprofen	Pain reliever	X		
Fipronil	Insecticide	X	X	
17-beta estradiol	Steroid hormone	X		
Galaxolide (HHCB)	Synthetic fragrance	X		
Diclofenac	Non-steroidal anti-inflammatory drug	X		
p-Nonylphenol	Alkylphenol surfactant degradant		X	
PBDE 47 and 99	Brominated flame retardant		X	X
PFOS	Perfluorinated organic chemical		X	X
Triclosan	Antimicrobial	X		

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URBAN COAST

Special Issue: State of the Bay

Volume 5 Issue 1 *Article 2.1.0*

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Habitat Conditions: Overview

Lia Protopapadakis[1]

[1] The Bay Foundation

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2.1.0 Habitat Conditions Overview

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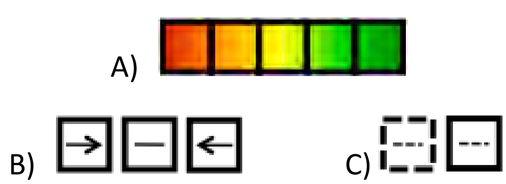
Santa Monica Bay and its watershed encompass many types of habitats. These habitats deliver essential ecosystem services, such as nutrient cycling, water purification, and flood control, as well as life's basic necessities for the species that inhabit them. It is important to periodically assess the health of these habitats so that resource managers can track changes over time, attribute causes to these changes, evaluate the effectiveness of current resource protection policies, and ultimately provide policy-makers with the information they need to plan for the future.

The assessments that follow are conducted under a framework developed by the Santa Monica Bay National Estuary Program Technical Advisory Committee (TAC) for identifying indicators and assessing habitat health that can be applied consistently to all major types of habitats in the Bay. A variety of quantitative and qualitative information and data are used for the assessment. The "how to" guide below provides general reading instruction for the habitat-specific assessment sections that follow (Sections 2.1.1–2.1.7). Appendix A provides more technical details regarding the indicator development process, categorization, identification, and scoring criteria.

How to Read the Assessments

The assessments contain two types of information: the habitat description and the status and trends. The habitat description explains where the habitat is found, its historic context, what it looks like in its undisturbed state, the organisms that live there, reasons for any degradation that exists, and challenges in restoring or managing it. The status and trends section describes how the assessment category is interpreted for the habitat, the indicators used in the assessment, why they were chosen, how they relate to management goals, any data gaps that exist, a summary of the status and trend findings using the data available, and a discussion of the confidence in the assessment.

Figure 2.1-1. Graphic interpretation of the habitat assessment scores. A) The color bar with boxes surrounding each of the possible condition scores (see Figure 2.1-2 for a description of each condition). B) Interpretation of a trend (from left to right: improving, constant, and declining). C) Interpretation of low confidence in status and trend (left) and in trend only (right).



It should be noticed that these assessments were based on the non-human components of the ecosystem only. The effects of the current condition of the habitats in the Bay and

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its watershed on human health and enjoyment of these resources are important and are discussed in other sections of the Report.

The status and trend scores are also represented graphically for each habitat (Figure 2.1-1). The graphic includes a color bar reflecting the range of possible conditions (Figure 2.1-2), a box outlining the condition score for the habitat, and a directional (or non-directional) arrow indicating the trend. Instances of low confidence are graphically represented using dashed lines and can be applied to the status component (the box), trend component (the arrow), or both.

Figure 2.1-2. Interpreting the habitat status color bar.

Status:		POOR	FAIR	GOOD	EXCELLENT
Characteristics:	Habitat does not support key ecosystem functions.	The number of ecosystem functions present is significantly reduced and those present are at a reduced level.	All major ecosystem functions are present, but may be at reduced level.	Ecosystem functions may not be equivalent to pristine habitat, but significance of differences is uncertain. Changes may be due to natural variations.	Ecosystem function is equivalent to the best expected for the region.

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Freshwater Aquatic

Rosi Dagit, Resource Conservation District of the Santa Monica Mountains
Felicia Federico, UCLA Institute of the Environment
Lee Kats, Pepperdine University
Eric D. Stein, Southern California Coastal Water Research Project

Coastal Wetlands

Richard F. Ambrose, University of California Los Angeles
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Rocky Intertidal Habitat

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HABITAT CONDITIONS: Overview

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Appendix A Habitat Assessment Development

In 2010, the State of the Bay Report included, for the first time, a standardized assessment of habitat condition for all habitats in Santa Monica Bay and its watershed. This assessment was a big step forward, but for many habitats, the assessment relied heavily on qualitative data and best professional judgment. In an effort to improve upon the assessment for the 2015 Report, the Santa Monica Bay National Estuary Program (SMBNEP) worked with its Technical Advisory Committee (TAC) to develop more quantitative, comprehensive, and objective assessments for each habitat type.

For this purpose, the TAC developed a framework for identifying indicators and assessing habitat health that can be applied to all major types of habitats in the Bay and ensures that the assessment includes comparable characteristics of habitat health. The framework builds off the assessments developed in the 2010 report. It identifies four categories of indicators that relate to specific expectations of habitat health: extent, vulnerability, structure and disturbance, and biological response.

Indicator Categorization

The Habitat Extent category encompasses spatial indicators that cover issues such as habitat loss, fragmentation, access, and temporal variability. The Habitat Vulnerability category covers indicators that relate to risk and potential disturbance, such as fishing pressure, exposure to water quality discharges, or interference with natural coastal processes. The Structure and Disturbance category includes indicators that describe physical, chemical, and biological properties that impact the conditions of habitats. Examples of structure-type indicators include nutrient and chlorophyll concentrations in coastal pelagic waters, channel morphology of tidal wetlands, and wrack presence on beaches. Examples of disturbance-type indicators include the diversity and abundance of invasive species, eutrophication, and the intensity of collection or harvesting activities. Lastly, the Biological Response category encompasses indicators that measure changes to individuals, populations, communities, and ecosystems in response to changes in habitat quality. Examples include the presence/absence of amphibian species from streams, the reproductive success of nesting shorebirds, and the index of fish diversity.

These categories are broad and inclusive so as to be applicable in the context of the seven habitats assessed. For example, a strict interpretation of habitat extent makes sense for coastal wetlands, but not for coastal pelagic habitat. Also, in many cases, extent indicators, vulnerability indicators, and disturbance indicators can be hard to differentiate. In general, the type of metric used determines the distinction between extent and structure indicators. For example, the area covered by a biogenic habitat (i.e., surfgrass or kelp) is included in the extent category because they are spatial metrics, whereas the presence and diversity of native vegetation is included in the structure category. In the case of the vulnerability vs. disturbance category, it relates to whether or not the indicator directly or indirectly measures impacts. For example, past fishing behavior is categorized as a vulnerability indicator because it indicates the risk of fishing pressure on rocky reefs, whereas time-activity budgets of people collecting organisms from rocky intertidal sites is a disturbance indicator.

Identifying Indicators

The SMBNEP identified working groups for each of the seven habitats included in the assessment. With the exception of the rocky reef habitat, each working group consisted of at least one member of the TAC and at least one outside expert. The rocky reef habitat assessment was solely the work of one TAC member and the SMBNEP staff. For the other habitats, working group size ranged from three to seven members.

The SMBNEP staff developed a list of possible indicators for each habitat that drew from the Comprehensive Monitoring Program (CMP, SMBRC, 2007), prior State of the Bay Reports, and other report card and habitat assessment efforts. For the three habitats that relied most heavily on best professional judgment in the 2010 Report—beaches and dunes, the rocky intertidal habitat, and the coastal pelagic (open water) habitat—the SMBNEP hosted workshops to identify additional indicators and data sources. Participants also gave recommendations on prioritizing indicators and identifying the best ones to use for the assessment at the workshops. For the other four habitats, conference calls were held to do the same.

Recommended indicators were evaluated for data availability and quality, and a database was created that includes information about data availability, coverage (geographic and temporal), source, and format, among other things. The experts then reviewed this list and made final recommendations on which should be included in the 2015 assessment based on the following criteria: sensitivity to changing conditions locally, responsiveness in a time-frame that can be measured in 5–10 years, connection to current or future management actions, relationship to the framework (which category does it fit into and how many other indicators are already in that category), and data quality and coverage. A target of three indicators per category was identified, but not always followed. For some habitats, only one indicator represents the entire category, while for others, four indicators were included in one category.

It is important to note that, while the availability of data was considered, it is not the most important factor for inclusion. Instances where an indicator was strongly recommended for inclusion but no data exist did occur. In these cases, these indicators were still included in the framework and this assessment without being scored. It is expected that these gaps will serve as a reminder of the need to find a way to procure these data. Indicators identified through this process that were not included in the Comprehensive Conservation and Management Plan of the Santa Monica Bay National Estuary Program, known colloquially as the Bay Restoration Plan, may be added when it is updated.

Assessing Habitat Health

Data for selected indicators were gathered, analyzed, and presented to the respective working groups as part of a best professional judgment (BPJ) exercise. Using a three-level system, experts were asked to score the indicator status (good, fair, or poor) and trend (improving, constant, or declining) based on the presented data. In instances where data were not available, experts had the option of scoring by relying on their experience. Experts were also asked to rate their level of confidence in the status and trend scores, also using a three-level system (high, moderate, or low). During the conference calls, scores were discussed and agreed upon unanimously. However, some indicators were not scored during the conference calls or when agreement could not be reached. In these cases, experts were asked to provide their scores individually. These scores were later combined using rules laid out in Table 2.1-1. The confidence scores assessed by the experts and a factor relating to the agreement between reviewers determine the combined indicator confidence score.

Scores for each category were then combined using a different set of rules to convert three-level scores to the system used in the 2010 report: a five-level status score, three-level trend score, and three-level confidence score (Table 2.1-2). Confidence in the score for each category is based on the confidence in the score for each indicator within the category and a factor relating to the completeness of the category (the percentage of indicators scored within the category). A high completeness factor results in the combined indicator confidence score being reported. A moderate completeness factor results in a high combined indicator confidence score being lowered to moderate, but does not change a moderate or low combined indicator confidence score. A low completeness factor results in the combined indicator confidence score being lowered by one (i.e., high becomes moderate, or moderate becomes low).

For some habitats, obvious differences within areas of the Bay resulted in separate regional scores rather than one score for the entire Bay. Typically, the break was between the northern and southern portions of the Bay, but in some cases, was more related to the system differences and data availability (i.e., there were three regions used for coastal wetlands, one for the Ballona Reserve, one for Malibu Lagoon, and one for the other smaller systems that are far less studied).

Table 2.1-1. Rules for combining scores from different experts or different sites. From top to bottom: rules for combining status scores, trend scores, and confidence scores, and rules for assessing agreement.

SCORE	RULES FOR COMBINING STATUS SCORES
GOOD	All experts scored indicator good or all sites were scored good
FAIR	All scores good or fair
FAIR	Majority of scores fair
FAIR	50% of scores good, 50% of scores poor
POOR	Majority of scores fair or poor (when less than a majority are fair)
POOR	Majority of scores poor
* When something is not scored, it is ignored.	

SCORE	RULES FOR COMBINING TREND SCORES
IMPROVING	Majority of experts scored indicator as improving or majority of sites were scored as improving
IMPROVING	50% of scores improving, 50% of scores constant
CONSTANT	Majority of scores constant
CONSTANT	50% of scores improving, 50% of scores declining
DECLINING	50% of scores constant, 50% of scores declining
DECLINING	Majority of scores declining
* When something is not scored, it is ignored.	

SCORE	RULES FOR COMBINING CONFIDENCE SCORES
HIGH	Majority of experts scored confidence for indicator as high
MODERATE	All scores high or moderate
MODERATE	Majority of scores moderate
MODERATE	50% of scores high, 50% of scores low
LOW	50% of scores moderate, 50% of scores low
LOW	Majority of scores moderate or low (when less than a majority are moderate)
LOW	Majority of scores low
* When something is not scored, it is ignored.	

SCORE	RULES FOR SCORING AGREEMENT
HIGH	All experts agree
MODERATE	50% or more of experts agree or have similar scores
LOW	Majority of experts disagree (i.e., good/poor)
* When something is not scored, it is ignored.	

In cases where some indicators in the category were scored for the entire Bay and some for the regions, scores for the Bay were extrapolated to the regions. However, when assessing the completeness factor for the category confidence score, this extrapolation counts as half rather than a whole (i.e., if two of four indicators were scored in a category, but one of those two indicators was scored for the Bay rather than the region, the completeness factor is 1.5/4 not 2/4).

In future assessments, these category scores will also be combined into one overall score for the habitat. This was not done for this report, due to the nature of the data available now and the high level of uncertainties. It is the intention of the SMBNEP to continue building on these assessments in future reports, including revising the CCMP to better meet the needs of these assessments and working with researchers and agencies to further implement it.

Table 2.1-2. Rules for combining indicator scores into category scores. From top to bottom: combining status and confidence scores, and scoring completeness. Trend scores are combined as described in Table 2.1-1.

SCORE	RULES FOR COMBINING STATUS SCORES
EXCELLENT	All experts scored indicator good
GOOD	Majority of scores are good
FAIR	All scores are good or fair (when less than a majority are good)
FAIR	Majority of scores are fair
FAIR	50% of scores are good, 50% of scores are poor
POOR	Majority of scores are fair or poor (when less than a majority are fair)
POOR	Majority of scores are poor
CRITICAL	All scores are poor
* When something is not scored, it is ignored.	

SCORE	RULES FOR COMBINING CONFIDENCE SCORES
HIGH	Majority of experts scored confidence for indicator as high
MODERATE	All scores high or moderate
MODERATE	Majority of scores moderate
MODERATE	50% of scores high, 50% of scores low
LOW	50% of scores moderate, 50% of scores low
LOW	Majority of scores moderate or low (when less than a majority are moderate)
LOW	Majority of scores low
* When something is not scored, it is ignored.	

SCORE	RULES FOR SCORING COMPLETENESS
HIGH	66% or more indicators are scored
MODERATE	Less than 66% but more than 50% of indicators are scored
LOW	Majority of indicators are not scored

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URBAN COAST

Special Issue: State of the Bay

Volume 5 Issue 1 *Article 2.1.1*

December 2015

Habitat Conditions: Freshwater Aquatic and Riparian Habitats

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2.1.1 Freshwater Aquatic and Riparian Habitats

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Habitat Description

There are 28 distinct drainage basins in the Santa Monica Bay watershed, with more located in the north part of the Bay watershed than the south. In the north, Malibu Creek is the largest un-channelized creek in the Bay watershed. Smaller drainage basins are present throughout the Santa Monica Mountains. Many in the eastern Santa Monica Mountains are confined to concrete channels for at least parts of their lengths.

In the south, the Ballona Creek drainage basin dominates. At 130 square miles, it is the largest sub-watershed draining into Santa Monica Bay. Ballona Creek drains portions of west central Los Angeles and several other cities, as well as the southeastern portion of the Santa Monica Mountains. Most of Ballona Creek was channelized in the 1930s for flood control purposes, and consequently, little riparian habitat remains. Smaller drainage basins can be found throughout the South Bay and the Palos Verdes Peninsula. Most of these have been buried or replaced with storm drains (LA Creek Freak 2012).

At one time, the Santa Monica Bay watershed was covered with a web of creeks, streams, and depressional freshwater wetlands that were fed by seasonal rains and natural springs. Many of the natural streams in the watershed were intermittent, with greatest flows occurring in the wet season during winter. The streams from the eastern Santa Monica Mountains and northern part of the Palos Verdes Peninsula would flow out of the hills and onto the coastal plain, where they would meander or braid before gradually making their way to the ocean through the once-expansive Ballona Wetlands.

These freshwater aquatic areas and the surrounding riparian zone provide important habitats for many plants, invertebrates, fish, amphibians, reptiles, and birds. In a natural state, these habitats comprise the stream or river and the stream or river banks that the water flows through or over at higher water levels. These banks are part of the flood plain, where sediment is held in place by the roots of the many types of vegetation found naturally in these areas, e.g., grasses, sedges, shrubs, and trees. When considered together, these zones slow water flows, allow for water to soak into the ground, and capture sediment and pollutants from the watershed around them, while supporting many species of animals, as listed above. In turn, healthy riparian zones supply downstream areas with water and sediments needed to maintain beaches and rocky reefs via natural patterns of erosion and transport.

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HABITAT CONDITIONS: Freshwater Aquatic and Riparian Habitats

Coastal sprawl and urban development in the Los Angeles region has left little natural habitat in the riparian zone and surrounding areas of the Santa Monica Bay watershed. In addition, efforts to prevent flooding and tame the intermittent but potentially massive flows of the creeks in the area resulted in the channelization of Ballona Creek and most of its tributaries. In the Santa Monica Mountains, a few streams, such as Arroyo Sequit, Cold Creek, and Solstice Creek, remain in relatively natural states.

When it does rain, the replacement of open space with impervious surfaces in the watershed and in creek channels prevents rainwater from soaking into the ground, resulting in more freshwater flushing out to the sea and less freshwater recharging aquifers. However, California's severe drought poses different problems. Many of the normally perennial streams in the Santa Monica Mountains are dry, eliminating a freshwater habitat for many organisms. The summer of 2015 was the first time this has happened in 25 years (Lee Katz pers. comm. 21 August 2015).

While the drought is a mostly natural phenomenon, it makes the difference between the heavily undeveloped areas and less developed ones even starker. Excessive outdoor water use in developed parts of the upper watershed leads to runoff, which causes many historically intermittent streams to flow year-round today and changes their character, and while efforts are being made to curb this due to the drought, it is still occurring. Furthermore, this runoff often contains pollutants, such as fertilizers, and picks up others from surrounding development, which puts wildlife and public health at risk.

All this development, plus the erection of dams, road crossings, and other man-made barriers in streams, has resulted in the loss of riparian and aquatic habitats for many species. For example, more than 80% of southern steelhead trout (*Oncorhynchus mykiss irideus*) spawning habitat and 60% of their rearing habitat is inaccessible in Malibu Creek as a result of these barriers (California Trout 2006). In fact, more species were listed as threatened or endangered in these habitats than any other habitat in the Bay and its watershed, except for terrestrial habitats (see Section 3 for more). Other threatened and endangered species found in freshwater aquatic and riparian habitat of the Santa Monica Bay watershed include the Pacific lamprey (*Entosphenus tridentatus*), California red-legged frog (see Section 3.1), least Bell's vireo (*Vireo bellii pusillus*), Riverside fairy shrimp (*Streptocephalus woottoni*), and California orcutt grass (*Orcuttia californica*).

Riparian and freshwater aquatic habitats have also become home to spreading invasive species, such as the New Zealand mudsnail (*Potamopyrgus antipodarum*), Louisiana red swamp crayfish (*Procambarus clarkii*), American bullfrog (*Lithobates catesbeianus*), aquarium fish, mosquito fish (*Gambusia affinis*), largemouth bass (*Micropterus salmoides*), and others. Year-round flows in once-intermittent streams are partly responsible.

While there are many challenges facing this habitat, there is also great potential for improvement. Efforts to protect and restore streams in the watershed have gained momentum and achieved some success in recent years. Several projects to remove small barriers blocking fish passage and to control invasive species have been completed successfully, and further improvements are expected from similar, upcoming projects. Stream protection ordinances are also being discussed. Finally, the development and implementation of trash, metals, and nutrient Total Maximum Daily Loads (TMDLs) can help to reduce the adverse impacts of pollution on wildlife and habitat quality.

Status and Trends

In 2013, the U.S. Environmental Protection Agency (EPA) Healthy Watershed Initiative supported the development of an integrated assessment of watershed health for California (CIAWH). The CIAWH combines a variety of existing statewide datasets into several indices that describe the health of freshwater aquatic systems, such as the health of the catchment area, vulnerability to risk, and stream health (Cadmus Group 2013). The CIAWH framework aligns closely with the framework developed by the Santa Monica Bay National Estuary Program Technical Advisory Committee (TAC), allowing us to import this assessment, with minor adjustments and additions, into our own. The indices developed for the CIAWH are scaled relative to the best condition observed in the state, which makes development of thresholds much easier. In addition, they have developed a robust way of combining index scores into category scores. However, the CIAWH does not evaluate trends, and so trends were not evaluated for this report. In addition, the CIAWH indices may overlap to some degree, and future refinement of the indices may be warranted. The sections below are a description, and Table 2.2.2 is a summary of how the CIAWH fits into our framework. Time did not permit us to report the scores for the Santa Monica Bay Watershed here.

Extent

More than any other habitat, freshwater aquatic systems are directly influenced by conditions in their catchment areas. The CIAWH's Relative Watershed Condition Index measures the capacity of the watershed to support healthy streams using spatial indicators. This fits into our Extent category because it includes spatial indicators that measure the extent and quality of the catchment area, the extent and quality of the stream habitat, and the connectivity of the stream to the ocean.

The CIAWH's Relative Watershed Condition Index incorporates two indices: (1) natural watershed condition and (2) anthropogenic watershed condition. The CIAWH provides scores for each of these indicators and combines them into the Relative Watershed Condition Index. Rather than using the rules described in Section 2.1 to combine scores, we will use CIAWH's Relative Watershed Vulnerability Index score for our Extent category score, in addition to describing and reporting the scores for the four indicators below.

Natural Watershed Condition Index

This index measures the extent to which key characteristics of the watershed are in their natural state. It is derived from three metrics: percentage of natural land cover, percentage of intact active river area, and sedimentation risk. The report by the Cadmus Group (2013) provides more detail on why these indicators were chosen and on the underlying data.

Anthropogenic Watershed Condition Index

This index measures the extent to which streams and their catchment areas are affected by human activities. It is derived from three metrics: percentage of artificial drainage area, dam storage ratio, and road crossing density. The report by the Cadmus Group (2013) provides more detail on why these indicators were chosen and on the underlying data.

Vulnerability

The CIAWH's Relative Watershed Vulnerability Index measures the potential for future degradation of watershed processes. It incorporates four indicators: (1) climate change, (2) land cover change, (3) water use, and (4) fire. The CIAWH provides scores for each of these indicators and combines them into the Relative Watershed Vulnerability Index. Instead of using the rules described in Section 2.1 to combine scores, we will use the CIAWH's Relative Watershed Vulnerability Index score for our Vulnerability category score, in addition to describing and reporting the scores for the four indicators below.

Climate Change Index

This index measures the potential for impacts on freshwater aquatic ecosystem health from climate-driven changes. It is derived from seven projections of future climate and hydrology. These projections are based on models of hydrologic response to projected climate change in California (Cadmus Group 2013, CEC 2013). They are projected changes in precipitation, minimum temperature, mean temperature, maximum temperature, snowpack, baseflow, and surface runoff. The report by the Cadmus Group (2013) provides more detail on why these metrics were chosen and on the underlying data.

Land Cover Change

This indicator measures the potential for additional pressure on hydrologic processes and aquatic ecosystems caused by future development. This indicator is based on impervious cover change projections from the EPA's Integrated Climate and Land Use Scenarios project (Cadmus Group 2013, EPA 2010). The report by the Cadmus Group (2013) provides more detail on why this metric was chosen and on the underlying data.

Water Use

This indicator measures the potential for future surface and groundwater withdrawals to alter the natural flow regime in aquatic ecosystems. In the CIAWH, this indicator is based on current water demand because projections of future water use were not available statewide at the geographic scale they use. Since these projections are available for Santa Monica Bay, we will use the actual projections (distributed to the catchment units as done in the CIAWH) in future reports. The report by the Cadmus Group (2013) provides more detail on why this metric was chosen and on the underlying data.

HABITAT CONDITIONS: Freshwater Aquatic and Riparian Habitats

Fire Index

This index measures the potential for changes in wildfire regimes to affect stream health. This index comprises two metrics: projected change in wildfire severity and fire regime condition class. Projected change in wildfire severity captures the influence of future climate on wildfire risk. The fire regime condition class captures the existing potential for wildfire due to current fuel loads, observed fire frequency, and weather conditions (FRAP 2010, Cadmus Group 2013). The report by the Cadmus Group (2013) provides more detail on why this metric was chosen and on the underlying data.

Structure and Disturbance

The CIAWH's third index, the Stream Health Index, fits into our Structure and Disturbance category, but also overlaps with our Biological Response category. Here, we import two of the three indices that comprise the CIAWH's Stream Health Index: (1) physical and biological habitat condition and (2) water quality. Together, these two indices measure physical, structural, and disturbance-related components of freshwater aquatic ecosystems.

Since we are not using all three indices in the Stream Health Index, we cannot use the Stream Health Index score for our Structure and Disturbance category score. In future reports, we will need to apply the method used in the CIAWH to combine the indices into the larger index to these two indices.

Physical and Biological Habitat Condition Index

This index measures the physical, chemical, and biological conditions that support aquatic life. It encompasses two metrics: the California Rapid Assessment Method (CRAM) Wetland Habitat Assessment scores and physical habitat (PHAB) scores. CRAM measures a variety of physical and biological variables, such as buffer condition, water source, number of plant layers present, and percent invasion (Cadmus Group 2013, Collins et al. 2008). PHAB measures physical habitat variables such as the percentage of macroalgae cover, percentage of stable banks, and percentage of sands and fines (Cadmus Group 2013, Ode et al. 2011). The report by the Cadmus Group (2013) provides more detail on why this metric was chosen and on the underlying data.

The actual CRAM and PHAB scores were not available to characterize all catchments statewide, so the CIAWH created a model based on the scores they did have and landscape variables that predicts scores for all catchments. Since CRAM and PHAB scores are available for the Santa Monica Mountains watershed, we will use the actual scores in future reports. Until CRAM and PHAB assessments are done for the Ballona Watershed and the Palos Verdes drainages, the modeled scores can be used. The report by the Cadmus Group (2013) provides more detail on why this metric was chosen and on the underlying data.

Water Quality

This index measures stream water chemistry parameters that support aquatic life. In the CIAWH, it encompasses three metrics: the median summer conductivity, nitrate concentration, and turbidity. Like the metrics used in the Physical and Biological Habitat Condition Index, the CIAWH used a model based on the stream water chemistry data and landscape variables that predicts water chemistry scores for a catchment. Since water chemistry data are available for the Santa Monica Mountains watershed, we will use the actual data in future reports. Until these parameters are also measured for the Ballona Watershed and for the Palos Verdes drainages, the modeled scores can be used. The report by the Cadmus Group (2013) provides more detail on why this metric was chosen and on the underlying data.

Biological Response

This category measures biological responses to changes in physical, structural, and chemical stressors. It comprises the following indicators: (1) algae, (2) benthic macroinvertebrates, (3) amphibians, and (4) anadromous fish. Of these, only benthic macroinvertebrates is included in the CIAWH. Because of this, a method for relating all four indicators and combining them into a single category score needs to be developed before the category can be scored.

Algae

This indicator measures the response of algal communities to excess nutrients. The metric used is the hybrid algae index of biotic integrity (SCCWRP 2014a). This indicator is not part of the CIAWH. A method of scoring this indicator in a way that it can be related to the other indicators in the CIAWH needs to be developed before this indicator can be scored.

Benthic Macroinvertebrates

This indicator measures the health of the benthic macroinvertebrate community. The metric used to measure this is the California Stream Condition Index (CSCI) score. The CSCI uses the taxonomic completeness and community structure of the benthic macroinvertebrate community to assess biological condition of freshwater aquatic habitats (SCCWRP 2014b, Cadmus Group 2013). It is also the third indicator in the CIAWH's Stream Health Index. Like the other two indicators that comprise the Stream Health Index, the CIAWH used a model based on the available CSCI scores and landscape variables that predicts CSCI scores for any catchment. Since CSCI scores are available for the Santa Monica Mountains watershed, we will use the actual data in future reports. Until these parameters are also measured for the Ballona Watershed and the Palos Verdes drainages, the modeled scores can be used. The report by the Cadmus Group (2013) provides more detail on why this metric was chosen and on the underlying data.

While we did not score this indicator here, these data were reported on in Section 2.2.1 of this report. Approximately 43% of stream miles in the Santa Monica Mountains Watershed are in reference or near reference condition, while only 20% demonstrated substantially degradation of the macroinvertebrate community. The Malibu Creek sites tend to be in the worst condition, scoring in the lowest 10% relative to regional criteria. See Section 2.2.1 for more.

HABITAT CONDITIONS: Freshwater Aquatic and Riparian Habitats

Amphibians

This indicator measures the diversity of the amphibians of the Santa Monica Bay watershed. Amphibians are considered sentinel species because of their sensitivity to pollution and changing environmental conditions. Two metrics are used: the percentage of monitored streams with different amphibian species present and amphibian species' diversity. These data are collected by the National Park Service (NPS), the Resource Conservation District of the Santa Monica Mountains (RCD), and other local research groups at 10 fixed and 20 randomly selected sites throughout the Santa Monica Mountains every three years. However, data are not currently collected in the Ballona Watershed and the Palos Verdes drainages. This indicator is not part of the CIAWH. A method of scoring this indicator in a way that it can be related to the other indicators in the CIAWH needs to be developed before this indicator can be scored.

Anadromous Fish

This indicator measures the presence of now-rare anadromous fish in Santa Monica Bay watershed streams. These fish are extremely sensitive to lost connectivity between the ocean and stream headwaters. The metric used is the percentage of monitored streams with steelhead trout and Pacific lamprey present. These data are collected monthly by the RCD at eight of the nine streams in which the Santa Monica Mountains are capable of supporting anadromous fish. The Ballona Creek is the stream that is not monitored. This indicator is not part of the CIAWH. A method of scoring this indicator in a way that it can be related to the other indicators in the CIAWH needs to be developed before this indicator can be scored.

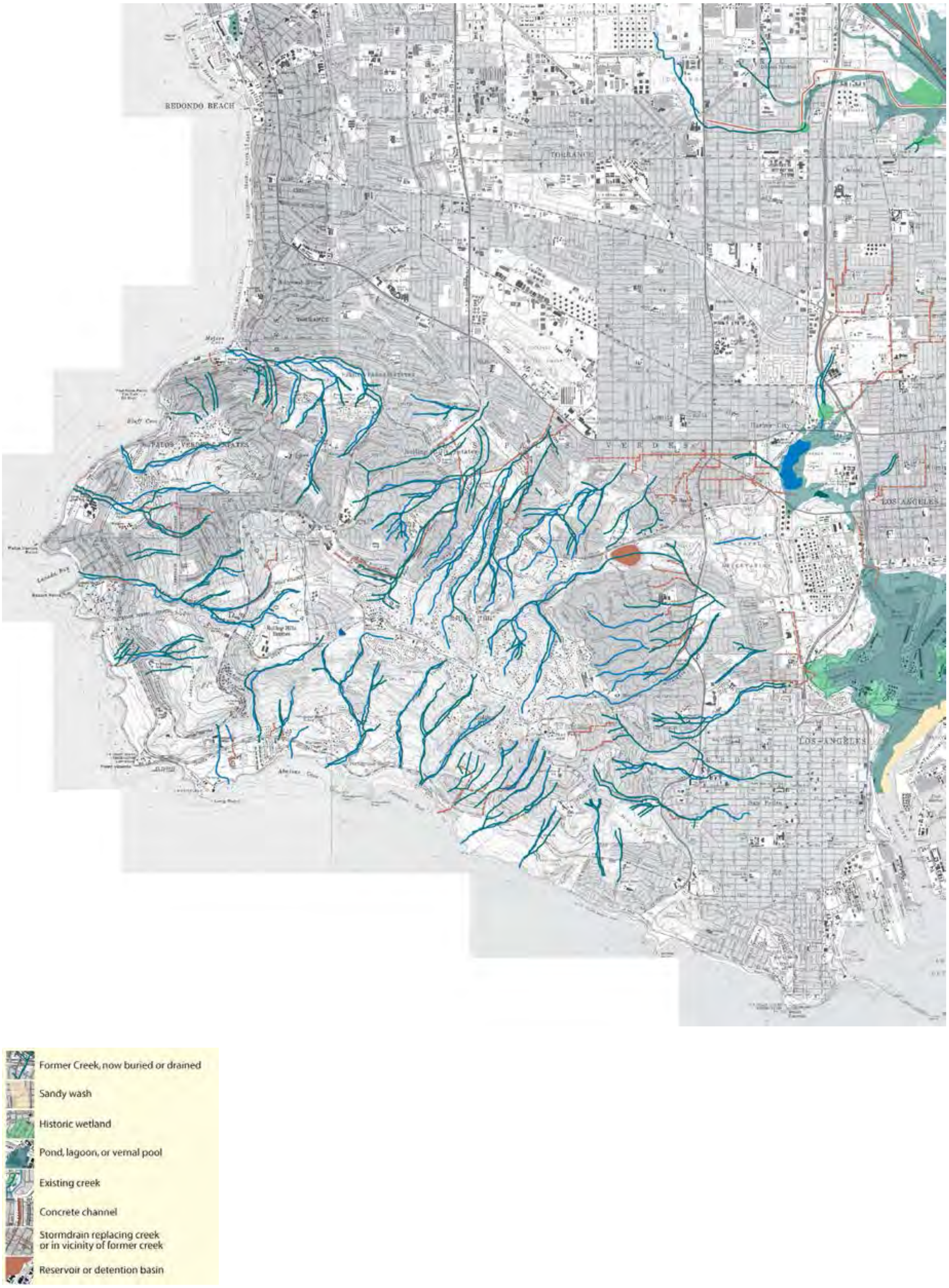
HABITAT CONDITIONS: Freshwater Aquatic and Riparian Habitats

Table 2.1.1. Indicators, Related Management Actions, and Status and Trends for Freshwater Aquatic and Riparian Habitat

INDICATOR	*METRIC*	*RELATED MANAGEMENT*
1 Habitat Extent: Relative Watershed Condition Index		
1.1 Natural Watershed Condition Index	% natural land cover, % intact active river area, and sedimentation risk	BRP 1.2, 2.1, 4.1, 5.2, 12.1, 12.2
1.2 Anthropogenic Watershed Condition Index	% artificial drainage area, dam storage ratio, and longitudinal connectivity	BRP 4.1, 7.3, 7.4
2 Habitat Vulnerability: Relative Watershed Vulnerability Index		
2.1 Climate Change Index	Projected change in precipitation, min. temperature, mean temperature, max temperature, snowpack, baseflow, and surface runoff	
2.2 Land Cover Change Index	Projected land cover change	BRP 2.1, 5.2
2.3 Water Use Index	Predicted future water demand	BRP 1.6
2.4 Fire Index	Projected change in wildfire severity and fire regime condition class	
3 Structure and Ecological Disturbance *(Physical, chemical, and biological properties that impact condition of habitat)*		
3.1 Physical and Biological Habitat Condition Index	CRAM Wetland Habitat Assessment Score, PHAB Stream Habitat Assessment Score	BRP 4.1, 6.2a
3.2 Water Quality Index	Median stream summer conductivity, nitrate concentrations, turbidity, water temperature, and pH	BRP 1.1, 1.2, 3.2
4 Biological Response *(Changes to individuals, populations, communities, and ecosystems in response to changes in habitat quality)*		
4.1 Algal Index	Hybrid Algae IBI	
4.2 Benthic Macroinvertebrate index	CSCI Stream Biological Assessment Score	
4.3 Amphibians	% of monitored streams with species present, species diversity	
4.4 Anadromous Fish	% of monitored streams with species present, species diversity	BRP 7.3

HABITAT CONDITIONS: Freshwater Aquatic and Riparian Habitats

Figure 2.1.1. Historic and Current Freshwater Aquatic Habitat on the Palos Verdes Peninsula. *Source: Jessica Hall, LACreekFreak.wordpress.com*



Conclusions and Next Steps

Although quantitative monitoring data were not evaluated for trends in habitat conditions, anecdotal information suggests that efforts to protect and restore streams in the watershed have gained momentum. Several projects to remove small barriers blocking fish passage and to control invasive species have been completed successfully, and further improvements are expected from similar, upcoming projects. Stream protection ordinances are also being promoted to prevent damage to remaining natural streams in the watersheds. Finally, the development and implementation of trash, metals, and nutrient TMDLs is expected to help to reduce the adverse impacts of pollution on wildlife and the quality of the riparian habitats.

Priorities for future health assessments of freshwater aquatic and riparian habitat include encouraging more spatially complete data collection in freshwater and aquatic habitats, updating the data used in the CIAWH report with more recent data, and developing a method for relating additional biological response indicators in our framework to those in the CIAWH.

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Habitat Conditions: Coastal Wetlands

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2.1.2 Coastal Wetlands

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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

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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.

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

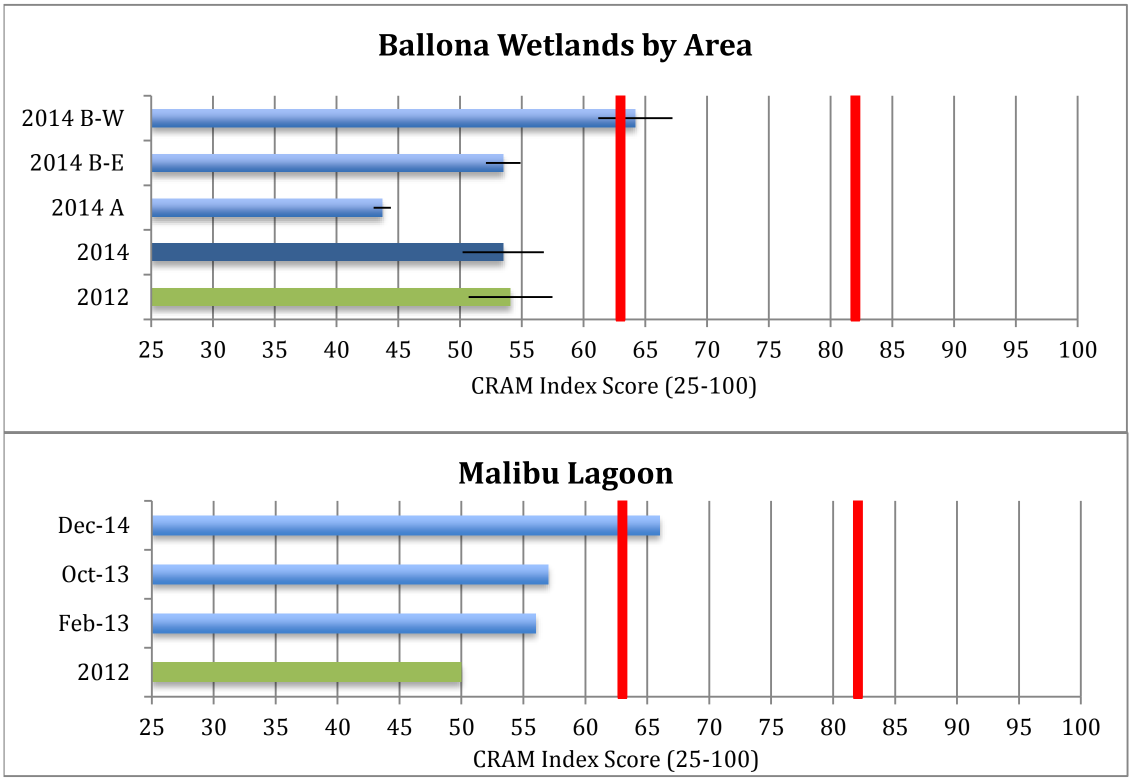
Shorebirds and seabirds often forage on small fish and invertebrates found in the shallow waters of estuaries (Armitage et al. 2007). This can be measured by collecting data on the time individuals spend engaging in certain activities (Page, Schroeter, and Reed 2014). However, collecting these data is 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.

HABITAT CONDITIONS: Coastal Wetlands

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: East:			MODERATE HIGH
3.1 Eutrophication	DO, SAV, nitrogen, and phosphorous levels. Thresholds from McLaughlin et al. (2012).	Malibu Lagoon Restoration Plan	North: East:	STATUS: Fair Good	TREND: Improving Constant	MODERATE HIGH
3.2 Sedimentation	Channel cross-sections and flood-plain elevation.	Malibu Lagoon Restoration Plan	North: East:	STATUS: Good Good	TREND: Improving Constant	MODERATE MODERATE
3.3 CRAM – Buffer and Landscape Context	CRAM index values for the buffer and landscape context component.		North: East:	STATUS: Poor Fair	TREND: Improving Constant	MODERATE HIGH
3.4 CRAM – Hydrology	CRAM index values for the hydrology component.		North: East	STATUS: Poor Poor	TREND: Improving Constant	MODERATE HIGH
3.5 CRAM – Physical Structure	CRAM index values for the physical structure component.		North: East:	STATUS: Good Poor	TREND: Improving Constant	MODERATE HIGH
3.6 CRAM – Biotic Structure	CRAM index values for the biotic structure component.		North: East:	STATUS: Fair Poor	TREND: Improving Declining	MODERATE 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.

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Habitat Conditions: Rocky Intertidal

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2.1.4 Rocky Intertidal

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Habitat Description

Rocky intertidal habitats are found at the interface between the ocean and land, and, in Southern California, can support as many as 500 species of macroinvertebrates and macrophytes (Littler 1980), including the iconic ochre seastar (*Pisaster ochraceus*), ever-present acorn barnacles (*Chthamalus* spp. and *Balanus glandula*), and endangered black abalone (*Haliotis cracherodii*).

Physical conditions in rocky intertidal habitats are highly variable. Primary environmental factors that drive differences in species composition and biodiversity at the site level are geomorphology (e.g., bedrock, cobble/boulder, or mixed sand-rock), wave regime (e.g., exposed or protected), sand exposure, slope, substratum relief, water temperature, and adjacent coastal habitat. Some of these factors, such as temperature and wave & sand exposure, vary seasonally as well as geographically. Site-to-site differences in these physical features result in expected differences in community composition (e.g., a site that has more wave exposure will have different species abundance patterns than a site that is protected). This makes it important when comparing sites to select those that have similar physical characteristics.

Much of the rocky intertidal habitat in the south end of Santa Monica Bay (off Palos Verdes) is characterized by warmer water and tends to be composed of bedrock that is not strongly influenced by sand. This contrasts with the rocky intertidal habitat in the north end of Santa Monica Bay (off the Malibu coastline), where water temperatures are mostly cooler and the substratum is composed mostly of cobble/boulder outcrops surrounded and influenced by sand. Recognizing these differences, analyses of biota performed by the Marine Life Protection Act-Science Advisory Team (MLPA-SAT) placed the northern Bay into a northerly, cooler water biogeographic subregion and habitats along the Palos Verdes Peninsula in a southerly, warmer subregion.

In addition to natural environmental disturbance, rocky intertidal habitats are vulnerable to a range of human impacts. Tide-poolers can relocate organisms from the intertidal to less hospitable habitats and can inadvertently trample invertebrates and vulnerable algal species; fishermen and collectors remove select species; and, where there are storm drains, urban runoff can alter salinity, nutrient levels, and water quality and clarity. All of

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these disturbances can impact species diversity, community composition, and ecosystem functions. Larger-scale processes (e.g., rising sea level, increasing temperature, ocean acidification) are also of regional concern, but cannot be addressed solely by local management actions.

Some management actions have been taken to address collection and other human-caused impacts on local rocky intertidal sites. Various marine protected areas (MPAs) were established over the past several decades in Santa Monica Bay, prohibiting the collection of most intertidal organisms within their boundaries. These MPAs were realigned in 2012 as part of the *South Coast Marine Life Protection Act* (MLPA) process. Now, four MPAs are present in the region, encompassing 55% of rocky intertidal habitat found in the Bay, and provide protection for the Bay's intertidal resources (data source: NOAA Environmental Sensitivity Index 2010 maps). For more on MPAs, see Section 2.2.3. Additional management measures to reduce the impacts of trampling and other tide-pooling-related impacts have been proposed, including installing educational signs and displays, developing an educator program whereby trained docents are on site during low tides, increasing enforcement of MPA regulations through the use of park rangers and lifeguards, and restricting certain activities in rocky intertidal areas. None have been implemented in Santa Monica Bay to date.

Status and Trends

Extent: GOOD and CONSTANT (MODERATE confidence)

The extent of intertidal rocky substrata in Santa Monica Bay is fairly stable over time. However, the extent of sub-habitats or zones within rocky intertidal areas can change on seasonal and annual scales due to land-based erosion, storms, and sand and rock movement. This category comprises two indicators: (1) rocky intertidal habitat extent and (2) extent of surfgrasses. Due to data limitations, only the extent of rocky intertidal habitat was included in this assessment.

Based on the scores for the rocky intertidal habitat extent indicator, the overall Extent category is judged to be GOOD, while the trend is CONSTANT. Confidence in the assessment is MODERATE due to moderate confidence in the scored indicator and the reliance on only one of two of the indicators that comprise this category (Table 2.1.4).

Rocky Intertidal Habitat Extent

This indicator evaluates how the area of rocky intertidal habitat has changed over time. While the length of rocky intertidal sites along the shoreline is relatively constant, factors such as landslides, coastal erosion, and armoring could reduce the area. In addition, as sea level rises, site width may narrow. Thresholds have not yet been developed, but will likely be based on historic habitat extent. Quantitative data were not evaluated for this assessment. However, based on the experience and knowledge of experts, the extent of rocky intertidal habitat is GOOD and trends are CONSTANT. Confidence is MODERATE, reflecting the familiarity with the sites, but also the lack of quantitative data and thresholds used in the scoring (Table 2.1.4).

HABITAT CONDITIONS: Rocky Intertidal

Extent of Surfgrasses

Surfgrasses (*Phyllospadix spp.*) are found on rocky shores in depths that overlap with the upper subtidal and lower intertidal. As a result, their true abundances are difficult to quantify during typical rocky intertidal or subtidal surveys. These and additional data sources, such as remote sensing data, need to be explored further before an accurate and consistent measure of seagrass abundance, as indicated by surface area of surfgrasses in the Bay, can be determined (Table 2.1.4).

Vulnerability: FAIR and DECLINING (LOW confidence)

The vulnerability indicators reflect the susceptibility of rocky intertidal habitats to human impacts. Note that vulnerability, while clearly related, is not the same as the actual magnitude of human impact, which is assessed in the Structure and Disturbance category, described below. The two indicators comprising this category assess the potential for (1) direct human disturbance and (2) landslides and sedimentation. Long-term monitoring data are not currently available for any of these indicators. In their place, data from publications and reports are used for this assessment. Developing a long-term monitoring program to track these indicators should be a priority for future assessments.

Overall, the vulnerability of rocky intertidal sites in both regions is thought to be FAIR, and this condition is DECLINING (i.e., vulnerability is increasing). While both indicators for this category were scored, confidence in the overall assessment is LOW due to the low confidence in one indicator and moderate confidence in the other (Table 2.1.4).

Potential for Direct Human Disturbance

People visiting rocky intertidal sites can intentionally and unintentionally impact the organisms that live there. While the number of visitors to a site does not signify that a site is impacted, it has been linked to shifts in community composition and is considered a reasonable predictor of potential disturbance (Ambrose and Smith 2005). This indicator is measured by instantaneous counts per unit of area. Thresholds need to be developed that incorporate data from sites exhibiting the full range of conditions.

In the absence of the desired data, alternative measures of visitor use are used here. For this report, data from two publications were used to assess status. Ambrose and Smith (2005) reported estimated annual visitors per 100m of shoreline for sites in Malibu and Palos Verdes, while Garcia and Smith (2013) reported numbers of people in instantaneous counts for sites from Palos Verdes to La Jolla. Separate thresholds were established to score the data from these two sources. Thresholds for the annual number of visitors per 100m of shoreline were the 33rd and 66th percentiles of the sites visited in the Santa Monica Bay. Thresholds for the number of people in instantaneous counts were the 33rd and 50th percentiles of sites visited in Palos Verdes. Five sites in the Malibu area (North Bay) and nine in the Palos Verdes area (South Bay) were scored individually. Then, scores from sites in each region were combined using the rules described in Section 2.1 to give overall scores for the region. Agreement between the scores for overlapping sites using the two different sets of data was high.

Trends in rocky intertidal habitat use over time were extrapolated from data in which sites from Orange County exhibited an approximate doubling in use intensity from 1995–1996 to 2013–2014 (Lucas 2015). This information was corroborated with data showing increasing population growth in the Santa Monica Bay watershed.

Based on these data, the potential for direct human disturbance at rocky intertidal sites in the North and South Bay is FAIR. However, conditions in both areas are believed to be in DECLINE. Despite the reliance on imperfect data and thresholds, confidence in the status scores for both regions are MODERATE in light of the moderate confidence expressed by experts in making their judgments. However, confidence in the trend is LOW due to the time span covered by the available data (Table 2.1.4).

Potential for Landslides and Sedimentation

This indicator is intended to measure the risk of landslides and other large sediment deposition events that can bury and scour rocky intertidal habitat. Of particular concern are sites where sand does not move in and out of the intertidal habitats regularly. A specific metric to measure this indicator has not yet been identified, but the metric is expected to measure proximity to areas with high landslide potential and/or frequency. Thresholds still need to be developed.

In the absence of these quantitative data, knowledge of the sites in both regions was used to score this indicator. In the North Bay, sites are exposed to small but chronic sediment inputs, such as erosion and small slides during winter rainfalls. However, these sites are surrounded by sandy beaches and naturally have significant sand influence. In addition, sand moves in and out of these intertidal habitats more readily. For these reasons, the potential for negative impacts related to sedimentation events in the North Bay is FAIR and CONSTANT.

In contrast, sites in the South Bay are exposed to large, infrequent landslides. While these events are a natural phenomenon in this area, they appear to have been exasperated by increased landscape irrigation and impervious surfaces related to the development of the Palos Verdes Peninsula. Furthermore, sites in this region are surrounded by cobble beaches and rocky reef habitat and therefore have less continual sand influence. In addition, sand does not move in an out of these habitats as readily. For these reasons, the potential for negative impacts related to sedimentation events in the South Bay is FAIR. However, the trend in the South Bay appears to be one of DECLINE, because a 2011 landslide between White Point and Point Fermin buried a large amount of habitat. Confidence in the scores for both regions is LOW due to the lack of high-quality quantitative data and thresholds, and lack of agreement between experts as to whether a score should be given or not based on limited information (Table 2.1.4).

HABITAT CONDITIONS: Rocky Intertidal

Structure and Disturbance: POOR and DECLINING (MODERATE confidence)

This category measures exposure to different types of anthropogenic disturbance in rocky intertidal habitats. Four indicators comprise this category: (1) collecting and handling disturbance, (2) elevated nutrient levels, (3) invasive species, and (4) disease. Long-term monitoring data are not available for any of these indicators. In the absence of such long-term information, data from publications and reports are used for this report. Developing a long-term monitoring program should be a priority for future assessments.

Overall, the level of anthropogenic disturbance at rocky intertidal sites in the North Bay is GOOD, and conditions are CONSTANT. In the South Bay, the level of anthropogenic disturbance is FAIR, and conditions are DECLINING. Confidence in the assessments for both regions is MODERATE due to mostly moderate confidence in the scores of the indicators that comprise this category (Table 2.1.4).

Collecting and Handling Disturbance

Collection (and to a lesser extent, handling) of intertidal organisms is correlated with changes in rocky intertidal community structure, species abundance, and population density (Murray et al. 1999). Handling is also the second most common activity people engage in when visiting Santa Monica Bay rocky intertidal sites (Ambrose and Smith 2005). This indicator is measured by the number of people per unit of time and area performing activities or behaviors known to cause negative impacts to rocky intertidal organisms, such as handling, collecting, and fishing (fishermen are often observed collecting rocky intertidal invertebrates for use as bait). Thresholds have not been developed yet.

For this report, data from Ambrose and Smith (2004) on the number of people per 10 minutes performing these activities were assessed. However, no thresholds were used. Five sites each in the North Bay and South Bay were scored, and then scores from each region were combined using the rules described in Section 2.1 to give overall scores for these regions. Because the sites selected in this study were specifically targeting low- and high-use areas, the results are skewed toward the middle. To account for this effect, expert knowledge about collection, handling, and fishing at other sites was incorporated into the assessment. While more sites in the North Bay are accessible and lower-use sites tend to have more visitors, sites in the South Bay, even those where access is difficult, experience much heavier levels of collection than in the North Bay.

Based on these data and expert knowledge, disturbance related to collecting activities were assessed as FAIR in the North Bay and POOR in the South Bay. Data were not available to assess trends. Confidence in this assessment is MODERATE due to the availability of moderate-quality data and the lack of thresholds (Table 2.1.4).

Exposure to Elevated Levels of Nutrients

When exposed to chronically elevated levels of nutrients, rocky intertidal sites can become dominated by fast-growing algal species. Exposure to elevated levels of nutrients is measured by tracking nutrient levels discharged in or near rocky intertidal sites.

Thresholds and a definition of *elevated* have yet to be developed. In the absence of quantitative data, information from the California Integrated Assessment of Watershed Health (CIAWH, Cadmus Group 2013) and knowledge about the location of storm-drain outfalls in relation to rocky intertidal sites in the Bay were used as a proxy. No thresholds were established, and scores were assessed based on expert knowledge.

The CIAWH assessed watershed and stream health throughout Southern California using a standardized scale pegged to the worst and best condition observed in the state. While it does not include data about water quality on rocky intertidal sites, it does include an indicator for nitrate concentrations in streams. This provides a basis for making estimates about the nutrient concentrations that could be entering rocky intertidal sites in the north and south parts of the Bay. Their analysis shows that nitrate concentrations for streams in the North Bay range from low to moderate, while nitrate concentrations for streams in the South Bay range from moderate to high (Cadmus Group 2013).

Storm-drain outfalls in the North Bay tend to discharge on beaches, rather than on rocky intertidal habitat. This, in conjunction with the low to moderate nitrate concentrations observed in streams in the region, leads to a conclusion that the risk of exposure to elevated nutrient levels in the North Bay is GOOD (i.e., low risk). In contrast, storm-drain outfalls in the South Bay tend to discharge directly onto rocky habitat (D. Pondella, pers. comm., 26 June 2015). Because of this and the moderate to high nitrate concentrations observed in streams in the region, the risk of exposure to elevated nutrient levels in the South Bay is assessed as FAIR (i.e., moderate risk). The trends were not assessed due to data limitations. Confidence in the assessments for both regions is LOW due to the low confidence expressed by experts in making their judgments and the lack of high-quality data and accepted thresholds for nutrient inputs. In addition, experts debated on whether there were sufficient data to arrive at a score (Table 2.1.4).

Invasive Species

Invasive species can outcompete native species, altering community composition and disrupting food webs. This indicator measures the diversity and percentage of intertidal area covered by invasive, non-native species (*Sargassum muticum*, *S. horneri*, *Caulacanthus okamurae*, *Lomentaria hakodatensis*, and *Monocorophium insidiosum*). Thresholds have not been developed.

Data from biodiversity surveys conducted by the Multi-Agency Rocky Intertidal Network (MARINe) from 2001 to 2013 were used in this assessment. One drawback to relying solely on this data stream is that the survey method tends to avoid the tide-pool habitat (more common in the South Bay), where some invasive species are more prevalent, thus undersampling these species. In addition, a modified protocol was used to survey several sites in the North Bay, resulting in potentially lower cover estimates. This means that any comparison between the North and the South must be done cautiously. To compensate for these shortcomings, expert knowledge was also incorporated into this assessment.

Individual sites were scored, and scores for sites in the North Bay and South Bay were combined using the rules described in Section 2.1 to give scores for each region.

Only one non-native species (*C. okamurae*) was observed at one of the four North Bay sites (Paradise Cove) in the last five years. *Sargassum muticum* is also known to be present (though not common) at sites in this region, even though the survey method did not capture it. The percentage of cover of *C. okamurae* at Paradise Cove was 0.25% in 2001, 0.5% in 2006, not observed in 2010, and 0.08% in 2013 (Figure 2.1.4).

In the South Bay, *C. okamurae* was observed at all three sites surveyed in the last five years. Two additional species (*L. hakodatensis* and *S. muticum*) were observed at two of the three sites. The percentage of cover of *C. okamurae* in 2012 ranged from 1.37% at Point Vicente to 6.24% at Point Fermin and increased over time at the two sites where longitudinal data were available (from 5.11% cover in 2001 to 6.24% in 2012 at Point Fermin and from 2.92% in 2001 to 4.38% in 2008 at White Point). While likely undersampled, *S. muticum* was observed at the two sites surveyed in 2001 (Point Fermin, 0.51% cover; White Point, 0.73%), was not observed in 2008 (one site surveyed), and was observed at one site in 2012 (Point Fermin, 0.4%). *Lomentaria hakodatensis* was observed at sites surveyed in the region in 2012 at Abalone Cove (0.1% cover). While the percentage of cover could be slightly higher in the South due to the survey method used, this result is in keeping with expert observations in the two regions (Figure 2.1.4).

Based on these data, disturbance due to invasive species in the North Bay is scored GOOD (i.e., low disturbance), and conditions are CONSTANT. In the South Bay, disturbance due to invasive species is FAIR but conditions are DECLINING (i.e., increasing number of species observed, and increasing percentage of cover). Confidence is MODERATE due to the availability of high-quality data but the lack of established thresholds (Table 2.1.4).

Presence of Disease

This indicator is intended to measure the percentage of diseased individuals per species per site. Thresholds have yet to be developed. At this time, the only data available are for diseased sea stars. To avoid skewing the assessment, experts assessed this indicator using their knowledge of the sites and best professional judgment. In addition, scores were assessed for Santa Monica Bay as a whole.

With the exception of sea star wasting disease (see Section 3.3 for more), which might be a natural phenomenon, disease among the large number of rocky intertidal organisms is infrequent. Given this, the status of disease presence in Santa Monica Bay is considered GOOD (i.e., low levels of disease) with a CONSTANT trend. Confidence in the score is MODERATE because, despite the lack of quantitative data, the sites are well-studied and the experts feel confident in their judgment (Table 2.1.4).

Biological Response: FAIR and CONSTANT (LOW Confidence)

Three indicators comprise this category, measuring the biological response to some common stressors in this habitat. These are response to (1) direct human disturbance, (2) collecting activities, and (3) elevated levels of nutrients.

Overall, the biological response in both regions is estimated to be FAIR, and conditions are CONSTANT. Confidence in this estimate is LOW due to low confidence in one of the indicator's scores, moderate confidence in another, and no score being given for the third (Table 2.1.4).

Response to Direct Human Disturbance

Trampling, handling, and rocky turning can lead to indirect mortality (Ambrose and Smith 2005), reduced reproductive potential (Denis 2003), and decreased diversity of organisms living in rocky intertidal habitats (Brown & Taylor 1999). This indicator measures changes known to occur in response to direct human disturbance, such as reduced percentage cover of upper-shore rockweeds (*Hesperophycus* and *Silvetia*), sessile invertebrates (*Anthopleura spp*. and *Mytilus spp.*), and sandcastle worms (*Phragmatopoma californica*); turf height of articulated coralline algae; and density of certain motile invertebrates (Ambrose & Smith 2004, Brown & Taylor 1999, Zedler 1978). However, research to further quantify the relationship between direct human disturbance and predicted responses of the biological communities is needed before this indicator can be assessed (Table 2.1.4).

Response to Collecting Activities

Large, conspicuous invertebrates such as owl limpets (*Lottia gigantea*), sea stars (*Pisaster spp.*), and sea urchins (*Strongylocentrotus purpuratus*) are common targets for collectors (Ambrose & Smith 2005). In addition to these more common species, the federally endangered black abalone (*Haliotis cracherodii*) could also become a target for collectors as it recovers, despite its protected status. This indicator measures the density and size frequency of the owl limpet. Sea stars, sea urchins, and other susceptible species were not included because they are more prone to population changes caused by other factors, such as disease and natural predation. Similarly, black abalone were not included because, at the moment, their population densities relate to recovery potential, not to human collection. If black abalone populations recover to levels for which human collection impacts could be separated from population recovery, they will be added. Thresholds have not been established yet, except that a minimum threshold for owl limpet size of 46cm was selected to distinguish between fair and good condition because collectors are known to target animals above this size (Sagarin et al. 2007).

Data from long-term monitoring surveys conducted by the Multi-Agency Rocky Intertidal Network (MARINe) were used in this assessment. Data from one site (Paradise Cove) were used to represent the North Bay, while data from two sites (Point Fermin and White Point) were used to represent the South Bay. These data go back to 1995 for Paradise Cove and to 2000 for the two South Bay sites. Expert knowledge was combined with scores for individual sites to give scores for each region. In the future, additional data sets, such as those from monitoring of the South Coast Marine Protected Areas, need to be included to access more sites within each region.

In the North Bay, owl limpet size at Paradise Cove in the last five years ranged from 14 to 70cm. However, the median size is 36cm. At Point Fermin in the South Bay, owl limpet size ranges from 14 to 63cm, and the median size is 38cm. In contrast, the size range at White Point is 14–52cm, with a median size of 31cm. All three sites are relatively high-use and are not representative of either region as a whole. Based on these data and expert knowledge of other sites in the Bay, the biological response to collecting was assessed as FAIR for both regions. No trends were evident in the data, so the condition is considered CONSTANT. Confidence in the assessment is MODERATE due to the availability of high-quality, long-term data, but from a limited number of sites. (Table 2.1.4).

Response to Elevated Nutrient Levels

To measure the biological response to elevated nutrient levels, the percentage of cover of small, fast-growing opportunistic algae (*Ceramium* spp., *Cladophora* spp., *Ulva* (including *Enteromorpha*) spp., *Polysiphonia* spp., blue-green algae, and diatoms) will be examined because these species respond positively to elevated levels of nutrients. However, these species can also respond to sand scour and other types of disturbance that vacate space on rocky surfaces. Because of this, research is needed to further quantify the relationship between nutrient levels at rocky intertidal sites and the predicted response of the biological communities. These issues will also have to be considered when establishing thresholds.

Data from biodiversity surveys conducted by the MARINe from 2001 to 2013 were used in this assessment. Individual sites were scored, and scores for sites in the North Bay and South Bay were combined using the rules described in Section 2.1 to give preliminary scores for each region. These scores were then evaluated based on expert knowledge of the sites in the two regions and modified as necessary to arrive at final scores.

In both regions, the percentage of cover of the indicator algal species is fairly low (less than 3%), with exceptions at Point Dume in 2013 (5%) and at White Point in 2008 (16%). In the North Bay, several of these species are consistently present (*Chaetomorpha linum*, *Chaetomorpha spiralis*, *Cladophora columbiana, Ulva* spp., blue-green algae, and diatoms), whereas in the South Bay, fewer species are observed (primarily *Ulva* spp. blue-green algae, and benthic diatoms). Therefore, the response to elevated nutrient levels in both regions was estimated to be FAIR with a CONSTANT trend. Confidence in these scores is LOW due to the limited data and lack of thresholds (Table 2.1.4).

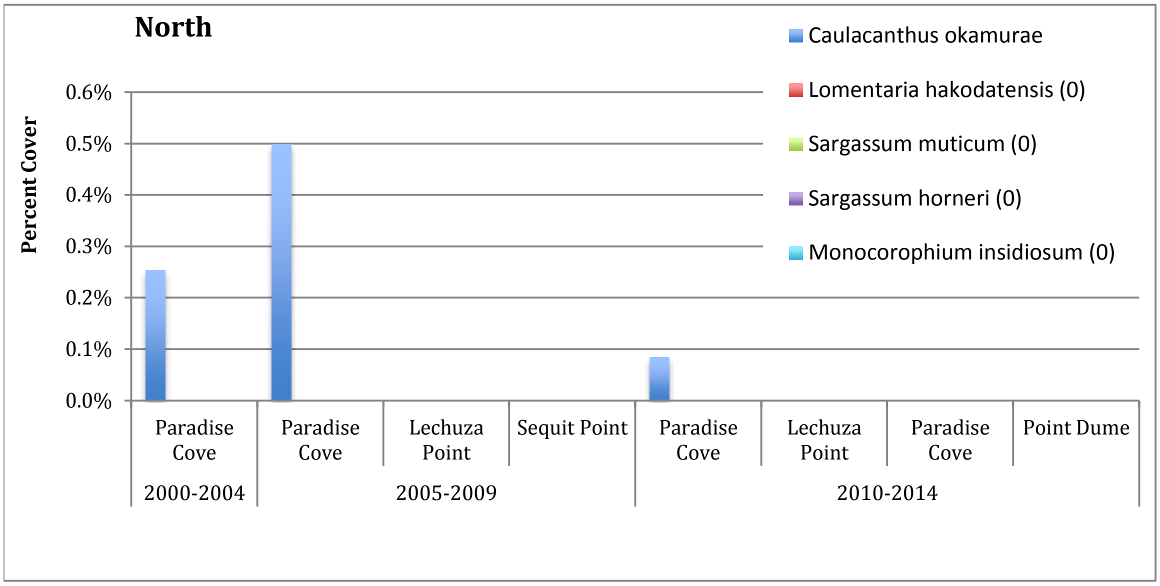
HABITAT CONDITIONS: Rocky Intertidal

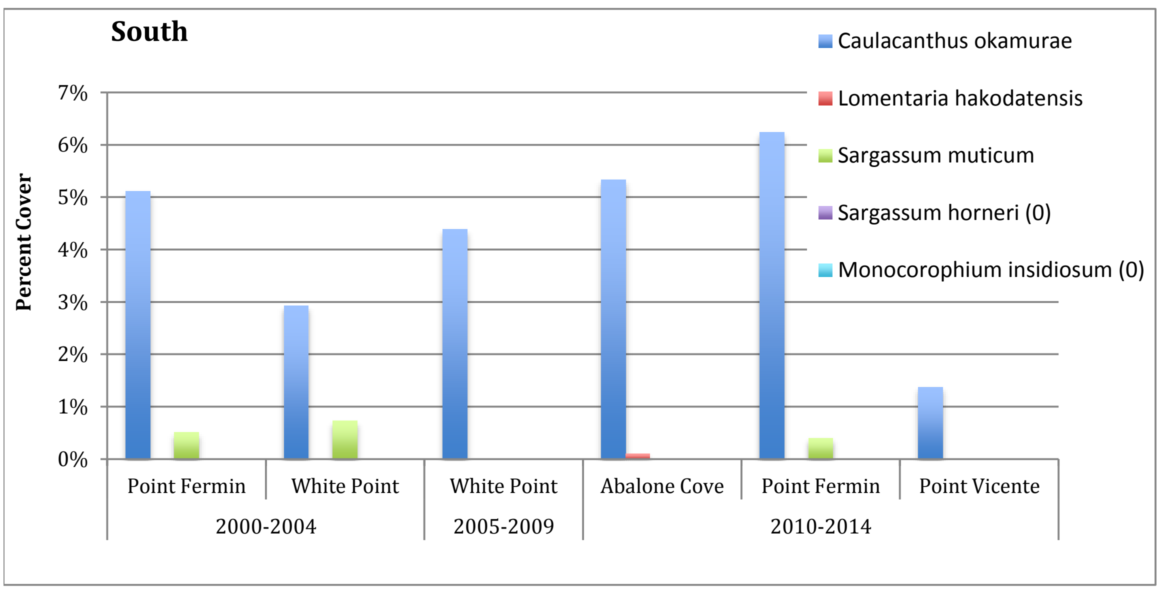
Table 2.1.4. Indicators, Related Management Actions, and Status and Trends for Rocky Intertidal Habitat

INDICATOR	*METRIC*	*MANAGEMENT ACTIONS*	*SCORE*			*CONFIDENCE*
1 Habitat Extent *(Spatial indicators related to extent, accessibility, availability, and temporal variability)*			SMB:			MODERATE
1.1 Extent of rocky intertidal habitat	Area of rocky intertidal habitat.		SMB:	STATUS: Good	TREND: Constant	MODERATE
1.2 Extent of surfgrass	Surface area of surfgrass. *This metric needs to be developed further.* It is related to SMBRC BRP Objective 9.4.					NOT SCORED
2 Habitat Vulnerability *(Spatial Indicators related to disturbance potential)*			N Bay: S Bay:	 		LOW LOW
2.1 Potential for direct human disturbance	Intensity of use measured by the # of people in instantaneous count per unit area.	SMBRC: BRP Objective 9.2.	N Bay: S Bay:	STATUS: Fair Fair	TREND: Declining Declining	MODERATE MODERATE (LOW for trends)
2.2 Potential for sediment deposition events	Proximity to areas with high landslide potential or frequency.		N Bay: S Bay:	STATUS: Fair Fair	TREND: Constant Declining	LOW LOW
3 Structure and Ecological Disturbance *(Physical, chemical, and biological properties that impact condition of habitat)*			N Bay: S Bay:	 		MODERATE MODERATE
3.1 Collecting disturbance	Visitor-hours spent collecting within rocky intertidal sites	SMBRC: BRP Objective 9.2; CDFW: MPA Regulations.	N Bay: S Bay:	STATUS: Fair Poor	TREND: No Data No Data	MODERATE MODERATE
3.2 Exposure to elevated nutrients levels	Nutrient levels in discharges onto rocky intertidal sites	SMBRC: BRP Objective 1.1; SWRCB: MS4 permits; EPA: Malibu TMDL	N Bay: S Bay:	STATUS: Good Fair	TREND: Constant Declining	LOW LOW
3.3 Invasive species	Diversity and percentage of intertidal area covered by non-native species.		N Bay: S Bay:	STATUS: Good Fair	TREND: Constant Declining	MODERATE MODERATE
3.4 Presence of disease	% of diseased individuals per species per site.		SMB:	STATUS: Good	TREND: Constant	MODERATE
4 Biological Response *(Changes to individuals, populations, communities, and ecosystems in response to changes in habitat quality)*			N Bay: S Bay:	 		LOW LOW
4.1 Response to direct human disturbance	Abundance of upper shore rockweeds.	SMBRC: BRP Objective 9.2.				NOT SCORED
4.2 Response to collection	Size frequencies of black abalone and owl limpets.	SMBRC: BRP Objective 9.2; CDFW: MPA Regulations.	N Bay: S Bay:	STATUS: Fair Fair	TREND: Constant Constant	MODERATE MODERATE
4.3 Response to nutrients	Percent cover of small, fast-growing opportunistic algae.		N Bay: S Bay:	STATUS: Fair Fair	TREND: Constant Constant	LOW LOW

HABITAT CONDITIONS: Rocky Intertidal

Figure 2.1.4. Invasive Species. The charts below show the percentage of cover of invasive species over time in the two regions of the Bay. Zero percent cover indicates that no invasive species were found at that site during that survey. Note the different scale for percentage of cover in the north and the south, and that different methods were used to survey the two regions, as described in the description of this indicator. *Data Source: MARINe biodiversity surveys.*





Conclusions and Next Steps

Bay rocky intertidal habitats are vulnerable to direct human disturbance, and that exposure to human activities is the foremost indicator affecting the biological populations and communities inhabiting rocky shores in the Bay. Measures to reduce the impacts of trampling and other tide-pooling-related human impacts have been proposed, including installing educational signs and displays, developing an educator program whereby trained docents are on site during low tides, increasing enforcement of MPA regulations through the use of park rangers and lifeguards, and limiting or reducing certain activities in rocky intertidal areas. However, none have been implemented in Santa Monica Bay to date. More resources should be devoted to support efforts by agencies and the local community to implement these measures.

Surfgrasses are an important habitat but have been neglected because they are found on rocky shores in depths that overlap with the upper subtidal and lower intertidal, and as a result are not fully captured on either typical rocky intertidal or subtidal surveys. Efforts to survey surfgrass, whether by traditional, remote sensing, or other another technique, should be prioritized in the future.

While data were available for the development of this report, much of it came from published research as opposed to being generated by long-term monitoring programs. In particular, long-term monitoring of human uses in rocky intertidal habitats needs to be implemented. In addition, the timing and spatial distribution of existing long-term biological monitoring sites should be better coordinated to meet the spatial and temporal needs of the assessment for this report in the future. Finally, more work needs to be done to develop defensible thresholds for the indicators used in this assessment.

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Habitat Conditions: Rocky Reefs

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2.1.5 Rocky Reefs

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Habitat Description

In Santa Monica Bay, hard bottom, rocky reefs, and outcrops are primarily located in the shallow subtidal zone off Malibu (from the Ventura County line to Sunset Blvd., north hereafter) and Palos Verdes (from Malaga Cove to Point Fermin, south hereafter). These rocky reefs are composed of sedimentary strata, marked by shale boulders and shelves separated by reaches of sand and cobble.

Although the area of rocky reef habitat is relatively small compared to other habitats in the Bay, they support some of the Bay's most diverse and productive biological communities. The abundance and diversity of marine life are especially apparent in the giant kelp forests (*Macrocystis pyrifera*) that cover some rocky reefs. The kelp beds provide protection and habitat for more than eight hundred species of fish and invertebrates, including a few protected species, such as the green abalone (*Haliotis fulgens*) and the giant sea bass (*Stereolepis gigas*). Because of the diverse and abundant assemblage of organisms, rocky reefs in the Bay are important sites for recreational diving and fishing. The key commercial and recreational species in this habitat are California spiny lobsters (*Panulirus interruptus*), kelp bass (*Paralabrax clathratus*), and white seabass (*Atractoscion nobilis*).

Giant kelp tends to grow and die along with changing oceanographic conditions (it grows better in colder water, with plenty of upwelled nutrients) and the frequency and intensity of storm events (heavy surf can rip entire kelp plants from the rocky substrate) that are a part of the natural cycle of kelp. However, it is also susceptible to poor water quality in the form of suspended solids and shifts toward purple sea urchin (*Strongylocentrotus purpuratus*)-dominated systems. Rocky reefs in the south are susceptible to landslides that have the potential to bury rocky substrate for decades and are a source of habitat loss along this stretch of Santa Monica Bay.

Status and Trends

Extent: FAIR and CONSTANT or IMPROVING (MODERATE confidence)

Typically, the extent of subtidal rocky substrata is fairly stable over the five-year time horizon used to measure trends in the State of the Bay Report. However, over decades, changes are possible. In addition, the extent of sub-habitats within rocky reefs, especially kelp canopy, can change in five-year timeframes and are worthwhile to measure here. The assessment for this category is based on two indicators: (1) the spatial extent of rocky substrata at different depth categories and (2) the spatial extent of kelp canopy coverage in the Bay. Only the kelp canopy indicator was used for this assessment.

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Since this assessment is based solely on the kelp canopy indicator, the score for this category is the same as for the kelp canopy indicator: the extent of rocky reef habitat in the Bay is FAIR and CONSTANT. Confidence in this assessment is MODERATE due to the moderate level of confidence in the indicator used to score it and the reliance on only one of the two indicators that comprise this category (Table 2.1.5).

Area of Hard Substrata
While this indicator is not yet used, it is expected to track changes in the availability of hard substrata at different depths that might occur due to lack of new inputs (such as boulders and cobbles entering rocky habitats through creeks and streams during significant rain events) or burial following sedimentation events. Quantitative data for this indicator exist; however, the availability of these historic and future data is uncertain, and thresholds for evaluating this indicator have not yet been established. Due to these limitations, this indicator was not scored for this report. However, it is known that the area of hard substrate has decreased since the last report due to the landslide at White Point.

Kelp Canopy
This indicator tracks changes in the extent of kelp canopy (km^2) relative to the area of suitable habitat. Kelp canopy is an important sub-habitat to track because it is a biogenic habitat and supports its own unique ecosystem. Quantitative data are collected by the Central Region Kelp Survey Consortium quarterly and have been since 2003. However, thresholds for evaluating this indicator have not yet been established. Due to this limitation, this indicator is scored using best professional judgment (BPJ).

Kelp canopy has recovered somewhat from the historic lows of the 1970s, but has not yet reached the extent covered in the early 1900s. In the north part of the Bay, three acres were restored off Escondido Beach from 1997 to 2006. Kelp canopy in this region declined from 2.06 km^2 in 2009 to 1.22 km^2 in 2011, but increased to 2.88 km^2 in 2014 (Figure 2.1.5). The 2014 kelp canopy represents a 40% increase since 2009. In the south part of the Bay, kelp canopy has only increased 4% from 2009 to 2014 (Figure 2.1.5; note that the area off Rocky Point was covered in clouds during the winter 2014 survey (Shelly Walther, pers. comm., 31 July 2015) and that kelp canopy in this area was excluded from the above calculation to prevent dramatic underestimation of the 2014 kelp canopy cover in the region). Ongoing kelp restoration efforts restored 0.13 km^2 off Palos Verdes from 2013 through July 2015 (Heather Burdick, pers. comm., 27 July 2015) and account for approximately 60% of the increase in that stretch of coast. However, a 2011 landslide just east of White Point buried high-quality kelp habitat and accounts for some of the decline in that stretch of coast. In addition, warmer water may have contributed to poorer kelp growth throughout the region (Dan Pondella, pers. comm., 26 June 2015). As a result, the condition of kelp canopy in the north and south is rated as FAIR. Conditions are IMPROVING in the north and CONSTANT in the south, due to the fact that we are both gaining and losing kelp canopy in different parts of the Bay. Confidence in this assessment is MODERATE because the loss at White Point has not been studied (Table 2.1.5).

HABITAT CONDITIONS: Rocky Reefs

Vulnerability: CRITICAL to FAIR and DECLINING (MODERATE confidence)

There are three principal factors that can significantly alter the balance in rocky reef ecosystems: water quality, fishing pressure, and sediment deposition. Excess nutrients favor fast-growing algal species, which may crowd out sessile invertebrates. Turbidity can lead to the loss of giant kelp. Selective fishing on key species can alter the food web. Extreme sediment deposition events can bury reefs and effectively reduce the availability of habitats. The assessment for this category is based on three indicators: (1) exposure to anthropogenic discharges, (2) vulnerability to fishing pressure, and (3) the risk of extreme sedimentation events (e.g., landslides).

Overall, the vulnerability of rocky reefs in the north part of the Bay is assessed as FAIR and CONSTANT, while vulnerability in the south part of the Bay is assessed as POOR and DECLINING (i.e., vulnerability is increasing). Confidence in the overall vulnerability assessment is MODERATE for both regions due to the range of confidence levels in the assessment of the three indicators (Table 2.1.5).

Exposure to Anthropogenic Discharges

Exposure to poor water quality, such as high nutrient levels, poor water clarity, or altered salinities and temperatures, has been shown to alter the community composition on reefs, particularly the understory algal and sessile invertebrate communities. While the discharge of these contaminants is regulated, other contaminants, such as pharmaceuticals, pesticides, or yet-to-be-identified pollutants, may be present in anthropogenic discharges and also harm marine life. Sources of anthropogenic discharges can include urban runoff and wastewater discharges, both of which are regulated for concentrations of known harmful pollutants and associated biological impacts. Wastewater discharges in particular have been consistently meeting all established water quality standards aimed at preventing harm to biological communities in the ocean.

This indicator measures the exposure to urban runoff and wastewater discharges and accounts for the possibility of exposure to as yet unknown or unregulated pollutants. It is assessed using the plume probability maps found in Schaffner, Steinberg, and Schiff (2015). The plume probability maps use 10-year average plume frequency data for rivers and publically owned treatment works (POTW) outfalls to estimate risk associated with magnitude and duration of exposure to anthropogenic discharges throughout the Southern California Bight (SCB). Probabilities range from 0 to 100%. The plume probability maps do not include proximity to stormwater outfalls. For future assessments, this metric will need to be expanded to include the proximity of smaller stormwater outfalls to rocky reefs and links between biologically harmful levels of pollutant loading and plume exposures from storm drains, creeks, and POTW discharges. In this report, proximity to storm drains was considered using best BPJ, but pollutant loading at levels that cause biological harm was not.

The results of the plume probability maps for the 2000–2010 time period show that, in the north, rocky reefs are not exposed to POTW discharge plumes. Reefs north of Latigo

Point are also not exposed to significant riverine discharge plumes. However, the reefs between Malibu Point and Topanga Point are exposed to 100% plume probabilities, while the rest of the reefs in the region have plume probabilities ranging from 21 to 80%, with the probability getting higher the closer they are to Malibu Creek and Santa Monica Canyon Creek (the two rivers included in the plume mapping) (Schaffner, Steinberg, & Schiff, 2015). While other creeks in the region (Topanga, Arroyo Sequit, Solstice, etc.) have mouths near rocky habitat, the stormwater outfalls in the north generally drain less developed areas and empty out onto sandy beaches, rather than rocky areas.

In the south, plume probabilities from POTW discharges range from 21 to 60%, with higher probabilities at reefs between Point Vicente and Point Fermin (Schaffner, Steinberg, & Schiff, 2015). While the plume probability maps did not include any riverine inputs in the south region of the Bay, stormwater outfalls here generally drain developed areas and empty out directly onto rocky intertidal habitat with adjacent rocky reefs, making them at risk for exposure to unregulated pollutants, such as pesticides and fertilizers.

Given the above, the vulnerability of rocky reefs to anthropogenic discharges in the north is GOOD, while the vulnerability of rocky reefs in the south is FAIR. The trend, assessed using BPJ, is CONSTANT for both regions. Confidence in this assessment is MODERATE because, although the plume probability maps are high-quality data products with established thresholds, the plumes affecting reefs from storm drains are not currently being evaluated, nor are biologically significant pollutant loads (Table 2.1.5).

Vulnerability to Fishing Pressure

Commercial and recreational fishing occurs in Santa Monica Bay for a variety of species and at varying levels of intensity (for more on fishing and fishery management, see Section 3.4). Intense, localized fishing can directly alter kelp and rocky reef communities, through direct removal and the subsequent shifts as predators, prey, and competitors adjust. This indicator measures intensity of fishing pressure as a risk factor for rocky reefs. It is estimated as the average annual biomass (in metric tons, MT) of reef-related species (fish and invertebrates; red sea urchins were excluded because they overshadow trends for other species) harvested by commercial and recreational (commercial passenger fishing vessels, CPFVs) fishermen per unit of natural reef habitat (km^2) in depths less than 30m per fishing block ($MT/yr/km^2$) (Zellmer et al., In review).

Fishing blocks are a 10-mile by 10-mile grid system used by the California Department of Fish and Wildlife (CDFW) to monitor landing data.

Five-year averages are used to describe risk and assess trends. Data from 2005–2009 were used for this assessment, and trends are not assessed. Thresholds are based on data for the SCB during the same time period. The median of the data (2.4 $MT/yr/km^2$) was used to distinguish between good (low risk) and fair (moderate risk), while a natural break in the data at 150.0 $MT/yr/km^2$ was used to distinguish between poor (high risk) and fair. In future assessments, these thresholds should be refined and the area of natural reef habitat should be reviewed.

The eastern part of the Bay receives some the highest fishing pressure per unit of reef area in the SCB (305.2 MT/yr/km^2), and is considered to be in POOR condition (high risk). However, this fishing effort is likely occurring on the artificial structures near the Venice Pier, Marina Del Rey, and King Harbor. Of these fished areas, only the artificial structures around King Harbor were included in the reef area calculation, possibly skewing the index of fishing pressure to be higher than it really is.

Of the areas in the Bay with natural rocky reefs, the north experienced approximately three times the fishing pressure per unit reef area than the south. However, fishing index values in both regions are in FAIR condition (moderate risk). Four fishing blocks encompass the reefs in the north. These have fishing pressure index values of 1.8 MT/yr/km^2 (reefs west of Lechuza Point), 5.3 MT/yr/km^2 (shallow reefs offshore of Point Dume and Little Dume), and 36.6 MT/yr/km^2 (reefs between Point Dume and Malibu Point). The reef area east of Malibu Point was not included in this assessment. Two fishing blocks encompass the reefs in the south. These have fishing pressure index values of 3.6 MT/yr/km^2 (reefs between White Point and Point Fermin, also includes the breakwaters off the Ports of Los Angeles and Long Beach) and 5.5 MT/yr/km^2 (reefs from Malaga Cove to White Point). It will be interesting to see how warming waters, other oceanographic changes, and the creation of Marine Protected Areas (MPAs) in both the north and the south alter these fishing index values for data after 2012 (see Section 2.2.3 for more on MPAs).

While trends were not assessed due to a lack of recent data, over the years 2005–2009, fishing pressure remained constant in the south and increased in the north. Confidence in this assessment is HIGH because of the high-quality data and comparability to the rest of the SCB (Table 2.1.5).

Landslides and Sedimentation Risk

Large-scale sedimentation events can have significant impacts on rocky reefs and their associated communities. A landslide in 1999 at Bunker Point, Palos Verdes, resulted in 250 acres of buried reef that remains buried to this day (MSRP 2015). Smaller-scale but chronic sedimentation events, such as those that occur regularly along stretches of the Malibu coastline after a rain, can have similar impacts. This indicator estimates the risk of these sedimentation events impacting exposed rocky reefs in Santa Monica Bay. The indicator will be measured by a reef's proximity to slide hazard areas and the area impacted by recent slide events. Quantitative data for this indicator are not uniformly available, and thresholds have not been established. As a result, this assessment is based on BPJ.

Reefs in the north part of the Bay are vulnerable to small-scale slides that occur every few years somewhere in the area. These slides often occur land-side of the Pacific Coast Highway (PCH), but work to remove the debris can result in sedimentation of the nearby reefs. In the last five years, two slides occurred in the northern part of the Bay (Google

News search results, 28 July 2015). In both instances, debris ended up on the PCH and was removed by Cal Trans. In contrast, reefs in the south part of the Bay are vulnerable to large-scale, less frequent events that typically impact rocky reefs directly. Areas that are particularly active are near Bluff Cove and the stretch of coastline between Portuguese Bend and Point Fermin. In the last five years, one slide occurred in this part of the Bay (Google News search results, 28 July 2015), which buried a large amount of (the area covered has not yet been estimated) high relief and very productive fish and kelp habitat (Google News search results, 28 July 2015). Given these factors, the vulnerability of reefs in the north is assessed as FAIR and CONSTANT, while vulnerability in the south is assessed as POOR and DECLINING. Confidence in these estimates is MODERATE, as these ongoing issues are well-documented (Table 2.1.5).

Structure and Disturbance: POOR to FAIR and IMPROVING (MODERATE confidence)

Whereas fishing pressure, water quality, and the risk of sedimentation events create vulnerabilities for rocky reefs, the primary factor causing disturbance in rocky reef habitat in Santa Monica Bay is the overabundance of sea urchins, particularly purple sea urchins (*Strongylocentrotus purpuratus*). At the moment, the assessment for this category is based on one indicator: the extent of urchin barrens on rocky reefs in the Bay. In the future, additional indicators relating to deeper rocky reef habitat may be added.

Since this assessment is based solely on the urchin barren indicator, the score for this category is the same as for the urchin barren indicator: FAIR and CONSTANT in the north and POOR but IMPROVING (urchin barrens are declining) in the south. Confidence in this assessment is MODERATE, based on the confidence level in the urchin barren assessment (Table 2.1.5).

Urchin Barrens

Sea urchins are an important component of the rocky reef ecosystem. However, under certain circumstances (e.g., release from predation or competition), urchins can become overpopulated, reaching densities of $70m^{-2}$ or more, and forming urchin barrens: areas that are devoid of kelp and most other kelp-dwelling organisms. Once formed, barrens will often self-perpetuate until their densities are reduced back to levels that allow kelp to grow and persist (approximately $2m^{-2}$).

This indicator tracks the extent of urchin barrens in the Santa Monica Bay over time. It is measured as the percentage of rocky reef habitat suitable for kelp growth, covered by urchins at densities greater than $2m^{-2}$. Quantitative data for this indicator are not uniformly available, and thresholds have not been established. As a result, this assessment is based on BPJ.

In the last five years, there have been no additional restoration efforts in the north part of the Bay. However, long-term monitoring suggests that the areas previously restored there remain stable. In the south part of the Bay, a large-scale restoration project on the Palos Verdes Peninsula to remove urchin barrens in the area is currently in place. In the last five years, this restoration effort has converted 28 acres of urchin barrens into viable kelp habitat (Heather Burdick, pers. comm., 27 July 2015).

Based on this information, disturbance caused by urchin barrens in the northern part of the Bay is assessed as FAIR and CONSTANT, while urchin-related disturbance in the southern part of the Bay is assessed as POOR but IMPROVING (i.e., the urchin barrens are declining). Confidence in this assessment is MODERATE because barrens are well-studied in the Bay, but these data have not been compared to other areas, and thresholds have not been developed (Table 2.1.5).

Biological Response: Not Scored

This category measures the response of higher trophic levels to changes in rocky reef habitats. The assessment for this category is based on two indicators: (1) the abundance of California spiny lobster and (2) the index of rocky reef fish guilds. Neither indicator was scored for this assessment due to a lack of time needed to analyze the available data (Table 2.1.5).

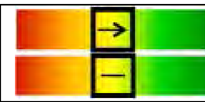
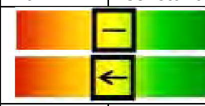
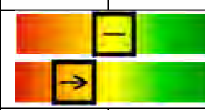
Spiny lobster abundance

California spiny lobster are a known sea urchin predator and a target species for commercial and recreational fishermen (Lafferty 2004, Tegner & Dayton 2000). This indicator will track changes in lobster abundance on rocky reefs, as measured by the number per square meter observed during standardized scuba surveys (Tenera Environmental 2006). Thresholds have not been established yet, but quantitative data are available. However, analysis of this data was not possible in time for the publication of this report. As a result, this indicator is not assessed (Table 2.1.5).

Rocky Reef Fish Guild Index

This indicator tracks the health of the rocky reef fish community, which is an important indicator of habitat quality. This indicator is measured by the rocky reef fish guild index, which evaluates density, fidelity, and mean size in fish guilds found on reefs (Bond et al. 1999). Fish guilds are based on community, feeding technique, activity period, and refuge location. In this index, higher scores are given to sites that reliably have greater abundances and more guilds represented. Thresholds have not been established yet, but quantitative data are available. However, analysis of this data was not possible in time for the publication of this report. As a result, this indicator is not assessed but likely unchanged from the 2010 report, which showed fair to poor condition in the north (the reefs around Point Dume were in the worst condition) and good to poor condition in the south (the reefs north of Flat Rock and east of Bunker Point were in the worst condition, while the reefs off Rocky Point and Point Vicente were in the best condition) (Table 2.1.5).

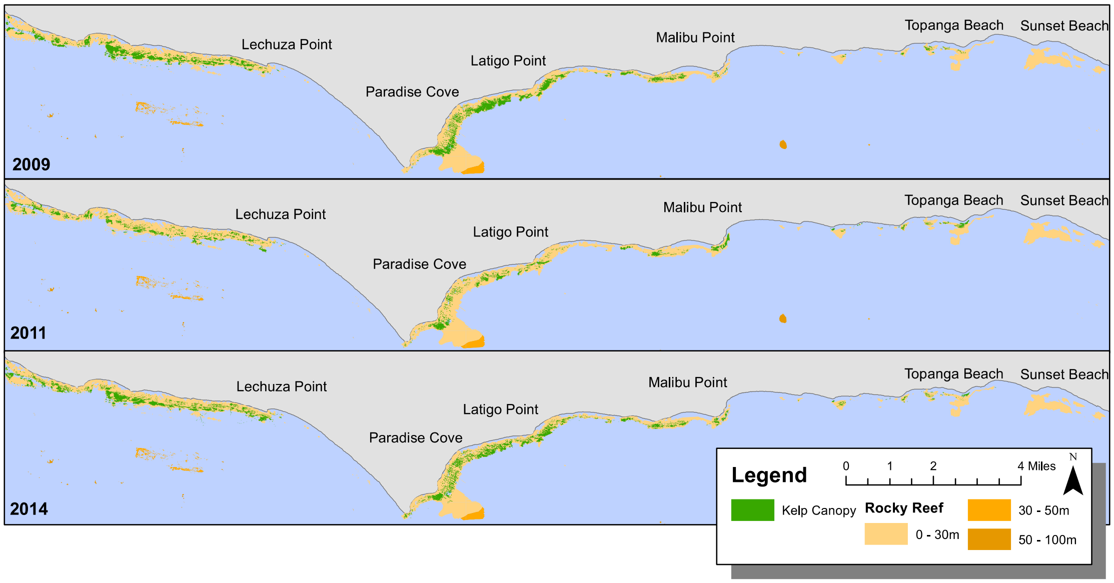
HABITAT CONDITIONS: Rocky Reefs

Table 2.1.5. Indicators, Related Management Actions, and Status and Trends for Rocky Reefs						
INDICATOR	***METRIC***	***RELATED MANAGEMENT***	***SCORE***			***CONFIDENCE***
1 Habitat Extent *(Spatial indicators related to extent, accessibility, availability, and temporal variability)*			North South			MODERATE
1.1 Rocky Reef Habitat	Area of hard substrata by depth category					NOT SCORED
1.2 Kelp Canopy	% of suitable rocky reefs covered by kelp	SMBRC: Objective 9.1	North South	STATUS: Fair Fair	TREND: Improving Constant	MODERATE
2 Habitat Vulnerability *(Spatial Indicators related to disturbance potential)*			North South			MODERATE MODERATE
2.1 Exposure to Anthropogenic Discharges	Plume probability mapping		North South	STATUS: Good Fair	TREND: Constant Constant	MODERATE MODERATE
2.2 Fishing Pressure	Index of fishing pressure		North South	STATUS: Fair Fair	TREND: N/A N/A	HIGH HIGH
2.3 Landslides and Sedimentation	Proximity to land vulnerable to sliding and recent landslide events		North South	STATUS: Fair Poor	TREND: Constant Declining	MODERATE MODERATE
3 Structure & Ecological Disturbance *(Physical, chemical, and biological properties that impact the conditions of the habitat)*			North South			MODERATE MODERATE
3.1 Purple urchin barrens	% of rocky reef habitat covered by purple urchins by density category. Threshold between Good and Fair is 2 per m^2.	SMBRC: Objective 9.1	North South	STATUS: Fair Poor	TREND: Constant Improving	MODERATE MODERATE
4 Biological Response *(Changes to individuals, populations, communities, and ecosystems in response to changes in habitat quality)*			SMB			NOT SCORED
4.1 Invertebrate Indicator species	Spiny lobster density. This indicator needs to be developed further.					NOT SCORED
4.2 Rocky Reef Fish Guild Index	Fish guild index score (Bond et al. 1999)					NOT SCORED

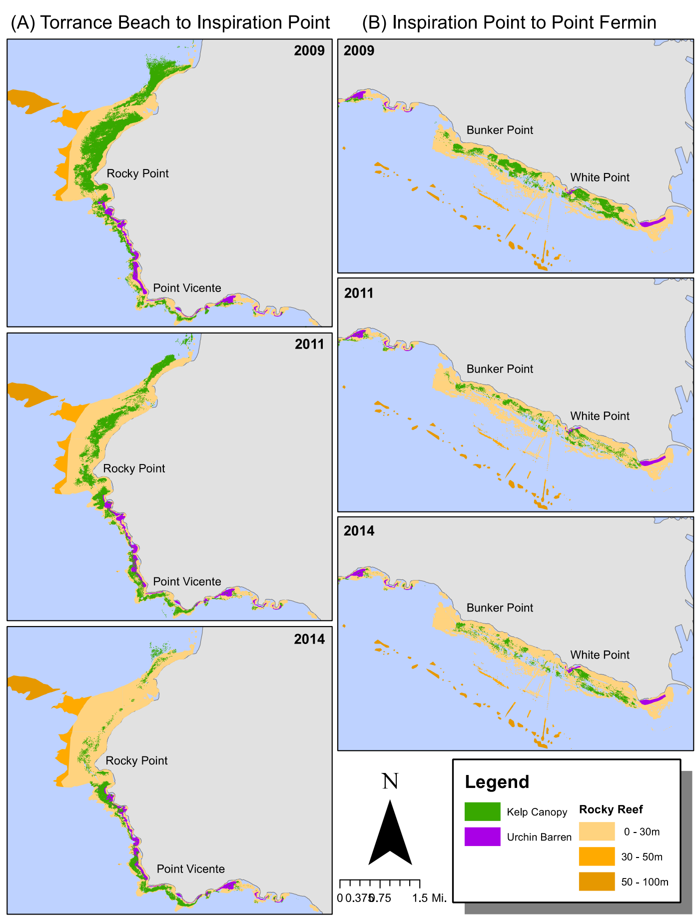
HABITAT CONDITIONS: Rocky Reefs

Figure 2.1.5. Map depicting changes in kelp canopy over time in (1) the north part of the Bay and (2) the south part of the Bay (source: Central Region Kelp Survey Consortium).

(1) Ventura County line to Sunset Blvd.



(2) Malaga Cove to Point Fermin



Conclusions and Next Steps

Kelp restoration through sea urchin removal should be continued and expanded, as it is the only proven effective mechanism to convert urchin barrens into viable kelp habitat. Long-term monitoring suggests that the previously restored areas remain stable. Moreover, monitoring and research are needed to determine the potential occurrence and impacts of risk factors, such as landslides and stormwater discharges, in order to plan and implement necessary preventive and remedial measures. Finally, more resources should be allocated to collect and analyze data to assess biological responses, such as the abundance of California spiny lobster and the index of rocky reef fish guilds.

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URBAN COAST

Special Issue: State of the Bay

Volume 5 Issue 1 *Article 2.1.6*

December 2015

Habitat Conditions: Soft-Bottom Benthos

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2.1.6 Soft-Bottom Benthos

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Habitat Description

Soft sediments composed of sand, silt, and clay make up the majority of the bottom habitat in the Bay. These are found throughout the Bay, with exceptions in the deep-water canyon off Point Dume; on Short Bank in the middle of the Bay; on the shelf off Rocky Point; and along the coast from the county line to Lechuza Point, from Point Dume to Malibu Point, and off the Palos Verdes Peninsula.

Soft sediments provide both shelter and foraging grounds for thousands of benthic invertebrate species, ranging from tiny worms, shrimps, and crabs to sea stars, clams, and sea slugs. These bottom organisms are near the base of the food web that supports an abundant and diverse assemblage of bottom-dwelling fishes. Soft-bottom fish found in the Bay include flatfishes, rockfishes, sculpins, combfishes, and eelpouts. Some of these fish, such as California halibut (*Paralichthys californicus*), California scorpionfish (*Scorpaena guttata*), barred sand bass (*Paralabrax nebulifer*), and white croaker (*Genyonemus lineatus*), also account for a significant percentage of recreational fish catches from piers and boats.

Soft sediments are also a major reservoir of chemical contaminants in the Bay. Many chemical contaminants bind to organic material on sediment particles, where they can accumulate to high levels and provide an ongoing source of exposure to marine life. Chemical contaminants have been introduced to this habitat primarily through historical wastewater discharges at outfalls offshore from Hyperion Treatment Plant (Hyperion) near Los Angeles International Airport and the Joint Water Pollution Control Plant (JWPCP) near White Point on the Palos Verdes Peninsula. Other significant contributors are dry and wet weather runoff from rivers and creeks and industrial discharges to the Bay.

Status and Trends

Extent: EXCELLENT and CONSTANT

Two indicators are needed to describe the extent of soft-bottom habitat in the Bay: (1) the spatial extent (surface area) of the bottom habitat and (2) the depth range (vertical distribution) of near-bottom water quality conditions indicative of high-quality habitat.

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[2] City of Los Angeles, Environmental Monitoring Division
[3] Sanitation Districts of Los Angeles County

HABITAT CONDITIONS: Soft-Bottom Benthos

The overall score for extent in this assessment is based solely on the available surface area of soft-bottom habitat, as the vertical distribution indicator is still under development. The extent of the soft-bottom habitat is considered to be in EXCELLENT condition with no change in the last five years. Confidence in this overall score is MODERATE, due to the use of only one of the two indicators in the category (Table 2.1.6, Line 1).

Surface Area

This indicator tracks changes in the availability of the soft-bottom habitat due to activities, such as the creation of artificial reefs that convert part of this habitat to other purposes. Quantitative data for this indicator exist; however, the availability of historic and future data is uncertain, and thresholds for evaluating this indicator have not yet been established. Despite the limitations, this indicator is considered to be in EXCELLENT condition due to the ample amount of habitat available. Its condition is CONSTANT due to the lack of substantial changes in area in the last five years. For this report, best professional judgment (BPJ) was used to score this indicator. Despite the lack of quantitative data and thresholds, which limit full evaluation of trends, the extent of this habitat is well known. As a result, confidence in the current assessment is HIGH (Table 2.1.6).

Vertical Distribution

While this indicator is not fully developed, it is intended to describe changes in the distribution of water quality conditions near the sediment surface needed to support healthy benthic communities (e.g., depth range of temperature, pH, and dissolved oxygen). While near-bottom water quality data are available, the development of thresholds for data interpretation is incomplete. As a result, this indicator is not scored at this time. However, ongoing research into this topic, including ways to relate changes in near-bottom water quality data to changes in benthic infauna species distribution, will help inform the development of this indicator for use in future assessments (Table 2.1.6).

Vulnerability: Not Scored

The indicators for this category have not been developed yet. However, the intention is to identify and track changes in how exposed the soft-bottom habitat is to activities that have the potential to negatively impact it (i.e., certain types of bottom trawling, sea floor drilling, and the installation and maintenance of equipment on the seafloor) (Table 2.1.6).

Structure and Ecological Disturbance: FAIR and IMPROVING

The assessment for this category is based on the sediment concentrations of three chemicals that bioaccumulate through the food web and have the potential to pose risks to humans and wildlife through the consumption of contaminated fish and shellfish. The chemicals are dichlorodiphenyltrichloroethane (DDT), polychlorinated biphenyls (PCBs), and mercury (Hg). Trends in this category are evaluated in approximately 10-year time-steps for this report. In future reports, this will be revised down to five-year time-steps that are aligned with the State of the Bay reporting periods.

Based on the scores for all three indicators in this category, the overall score for structure and ecological disturbance is FAIR. The condition is IMPROVING. Confidence is HIGH due to the high confidence in two of the three indicators scored and moderate confidence in the third (Table 2.1.6).

DDT

Sediment contamination from DDT is pervasive throughout Santa Monica Bay, with most of the contamination related to inputs to the Palos Verdes Shelf. From the late 1950s to the early 1970s, an estimated 1,700 tons of DDT were deposited on the shelf through the JWPCP wastewater outfall at White Point (Environmental Protection Agency 2015). This chemical is believed to be the cause of reproductive failure in several bird species in the 1970s, including the California brown pelican (*Pelecanus occidentalis californicus*), and is subject to Total Maximum Daily Load (TMDL) regulations in Santa Monica Bay. DDT in surface sediments is closely monitored by both the Sanitation Districts of Los Angeles County (LACSD) going back to 1972 and the City of Los Angeles Environmental Monitoring Division (CLA-EMD) going back to 1974. The target for Santa Monica Bay sediment DDT concentration established in the TMDL is used here to define the threshold for interpreting this indicator.

The indicator is scored by evaluating the percentage of surface area exceeding the DDT TMDL-based threshold. The condition of DDT in the Bay is FAIR due to 30% of Bay sediments exceeding the threshold. The condition is IMPROVING, although the pace of this improvement has slowed. Confidence in this assessment is HIGH given the availability of an established threshold and high-quality, long-term monitoring data (Table 2.1.6).

PCBs

PCB contamination of Santa Monica Bay sediment is primarily associated with historical wastewater outfall discharges from JWPCP and Hyperion. There is also a TMDL in place for sediment PCBs, and this contaminant has been monitored by both LACSD and CLA-EMD since 1984 and 1974, respectively. The sediment target for PCB concentration established in the TMDL is used here as the threshold to evaluate conditions. This indicator is scored by evaluating the percentage of the surface area exceeding the PCB threshold.

The condition of PCBs in the Bay is FAIR due to 25% of Bay sediments exceeding the threshold. The condition is IMPROVING, although the pace of this improvement has slowed. Confidence in this assessment is HIGH given the availability of an established threshold and high-quality, long-term monitoring data (Table 2.1.6).

HABITAT CONDITIONS: Soft-Bottom Benthos

Mercury

There are multiple sources of anthropogenic mercury in Santa Monica Bay sediments, including wastewater discharge, industrial effluents, urban runoff, and atmospheric fallout. While there is no TMDL or preexisting sediment threshold for mercury in Santa Monica Bay, some species of local fish contain elevated levels of this contaminant and pose a potential health risk to humans. Sediment mercury concentrations have been monitored by both LACSD and CLA-EMD since 1972. Thresholds for this assessment are defined as the 50th, 90th, and 99th percentiles of sediment mercury concentration in the 2008 Southern California Bight Regional Survey (Schiff et al. 2011). This indicator was scored by evaluating the percentage of the surface area exceeding each mercury threshold.

Mercury levels in the Bay are in FAIR condition because 89% of Bay sediments have concentrations that exceed those measured in 50% of samples from the rest of the Bight (the 50th percentile). However, the condition is IMPROVING. Confidence in this assessment is MODERATE because the thresholds used are not based on biological responses. However, high-quality, long-term monitoring data are available, and the consensus among the expert panel conducting the assessment was high (Table 2.1.6).

Biological Response: EXCELLENT and CONSTANT

Two indicators comprise the biological response category: a measure of benthic community condition (Benthic Response Index, BRI) and the community structure of sediment-associated fish species. For this report, trends are evaluated in approximately 10-year time-steps. In future reports, this will be revised down to five-year time-steps that are aligned with the State of the Bay reporting periods.

The overall score for extent in this assessment is based solely on the BRI, as further development of a fish community structure indicator is needed. Biological response is considered to be in EXCELLENT condition and a CONSTANT state. Confidence in this overall score is MODERATE, due to the reliance on only one of the two indicators in the category for the score (Table 2.1.6).

Benthic Community Condition

The BRI describes the level of disturbance in the benthic community, based on the presence, abundance, and pollution tolerance level of species occurring at the site. The index values are interpreted using four thresholds that define five response categories that reflect changes in key community attributes (Smith et al. 1999). The BRI thresholds are used as thresholds for this assessment, creating a five-level scoring system, instead of the three-level system used elsewhere in this report. This indicator is scored by evaluating the percentage of surface area in each response category.

The benthic community of the Bay is in EXCELLENT condition because BRI index values are at reference condition or within the uncertainty inherent in the index (marginal deviation) in over 99% of the area (Figure 2.1.6). This condition has also been relatively

CONSTANT over the last 10 years, following substantial improvements between the 1980s and the early 2000s. Within this time period, incremental improvements may have occurred, but are not statistically significant. Confidence in this assessment is HIGH due to the established and accepted e thresholds and the availability of high-quality, long-term monitoring data (Table 2.1.6).

Fish Community Condition

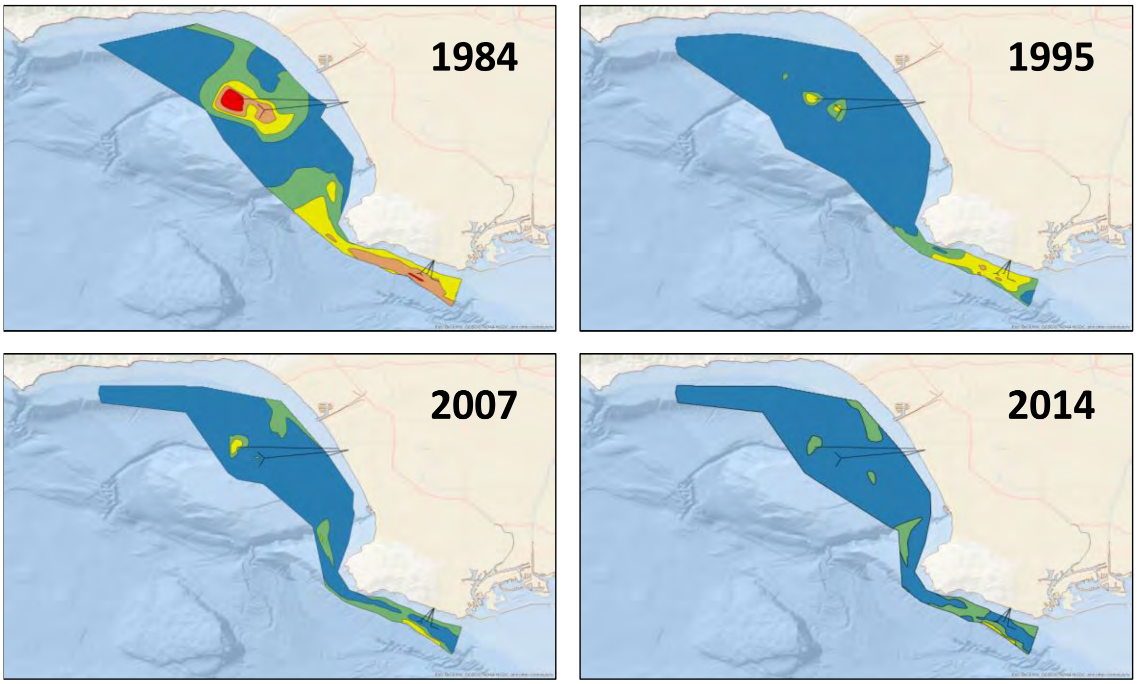
This indicator will allow us to track changes in the diversity and abundance of bottom-dwelling fish. An existing index, the Fish Response Index (FRI), is no longer considered to be an accurate measure of fish community condition. Unlike the BRI, the FRI was not based upon statistically determined pollution tolerances of the fish, but was derived through correlation with existing BRI scores at the time. Since then, some of these correlations have disappeared as oceanographic conditions and other factors unrelated to sediment contamination have changed. The development of a new index that more accurately measures the health of fish communities under changing habitat conditions is needed (Table 2.1.6).

HABITAT CONDITIONS: Soft-Bottom Benthos

Table 2.1.6. Indicators, Related Management Actions, and Status and Trends for the Soft-Bottom Benthic Habitat

INDICATOR	*METRIC*	*RELATED MANAGEMENT*	*SCORE*	*CONFIDENCE*
1. Habitat Extent *(Spatial Indicators related to extent, accessibility, availability, and temporal variability)*				MODERATE
1.1 Spatial extent	Surface area of the soft-bottom habitat. This indicator will be developed further in the future.	State Lands Commission and Coastal Commission permitting of artificial reefs, and other projects	STATUS: Excellent TREND: Constant	HIGH
1.2 Vertical habitat availability	This indicator needs to be developed.			NOT SCORED
2. Habitat Vulnerability *(Spatial Indicators related to disturbance potential)* *The indicators for this category still need to be developed.*				NOT SCORED
3. Structure & Ecological Disturbance *(Physical, chemical, and biological properties that impact condition of habitat)*				HIGH
3.1 DDT	% of surface area in each class of DDT concentration (ug/g %OC dw) as defined by TMDL targets for Santa Monica Bay	SMBRC: BRP Goal 1.1; EPA TMDL for DDT in the Bay; EPA Superfund Site goals	STATUS: Fair TREND: Improving	HIGH
3.2 PCBs	% of surface area in each class of PCB concentration (ug/g %OC dw) as defined by TMDL targets for Santa Monica Bay	SMBRC: BRP Goal 1.1; EPA TMDL for PCBs in the Bay	STATUS: Fair TREND: Improving	HIGH
3.3 Mercury	% of surface area in each class of mercury concentration (mg/kg dw) based on regional results from the Bight '08 study.		STATUS: Fair TREND: Improving	MODERATE
4. Biological Response *(Changes to individuals, populations, communities, and ecosystems in response to changes in habitat quality)*				MODERATE
4.1 Benthic Community Condition	% of surface area in each class of values for the benthic response index (Figure 2.1.6)		STATUS: Excellent TREND: Constant	HIGH
4.1 Fish Community Condition	This indicator needs to be developed.			NOT SCORED

Figure 2.1.6. Map (top) showing Benthic Response Index (BRI) values at various time points as monitored and table (bottom) showing the percentage of area in each class defined by BRI threshold values. Advanced primary treatment of wastewater was used from 1970 to 1983. Partial secondary treatment was used from 1984 to 2002 for JWPCP and from 1997 to 1998 for Hyperion. Full secondary treatment was used from 2002 to the present for JWPCP and from 1998 to the present for Hyperion. The extent of the area monitored has declined over the years, and is responsible for the small decline in the percentage of area in reference condition since 1995. *Data Source: CLA-EMD and LACSD, analysis and map done by LACSD.*



Area coverage in percentage				Benthic Response Index (BRI) Threshold Intervals	
1984	1995	2007	2014		
1.6%	0.0%	0.0%	0.0%	>=72	Defaunation
7.9%	0.2%	0.0%	0.0%	44-71	Loss of community function
13.7%	5.1%	1.5%	0.4%	34-43	Loss of biodiversity
26.0%	6.1%	13.4%	12.1%	26-33	Marginal deviation from reference
50.7%	88.7%	85.1%	87.2%	<=25	Reference conditions

Conclusions and Next Steps

The physical, chemical, and biological properties of the soft-bottom habitat have continued to improve, primarily due to the continuous shrinking of surface areas with high DDT, PCB, and mercury concentrations, even though they are still higher compared to the rest of the Southern California Bight.

Priorities for this habitat include additional research to develop a new index of biological response in soft-bottom fish and invertebrates, in addition to thresholds to interpret near-sediment surface water column parameters that support marine life, such as dissolved oxygen levels and ocean acidity.

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URBAN COAST

Special Issue: State of the Bay

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December 2015

Habitat Conditions: Coastal Pelagic

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2.1.7 Coastal Pelagic

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Habitat Description

The oceanic water column between the surf zone and the continental shelf break represents the coastal pelagic habitat. Within Santa Monica Bay, the coastal pelagic habitat extends north to the Ventura-Los Angeles county line and south to Point Fermin. This is the most extensive habitat in the Bay and includes waters to depths of 1,600 feet.

The coastal contour and bathymetry of Santa Monica Bay influence ocean currents, upwelling, and other oceanographic processes that in turn dictate the physical and chemical properties of this habitat. The Bay generally features a clockwise circulating current. In addition, two eddies—one near Malibu Point, the other near the southern end of the Palos Verdes Peninsula—create upwelling that bring nutrients and less oxygenated and lower-pH water from depth, where they become available to upper water column (or pelagic) marine organisms. Upwelling also occurs when the Santa Ana winds blow offshore. The Bay is also located at a minor transition between warmer and colder biogeographies within the Southern California Bight. This means that a wider variety of species can be found here than elsewhere. The abundance of these species fluctuates as ocean current and temperature regimes undergo change. During El Niño periods, warmer water species (including popular migratory sport fish) increase in abundance, while colder water species likely move north and deeper. Marine organisms found in this habitat include microbes, phytoplankton, zooplankton, small schooling fish, larger predatory fish (e.g., California Barracuda, *Sphyraena argentea*), sea birds, sharks, sea lions, seals, dolphins, and whales.

This habitat is exposed to natural shifts in oceanographic and climatic conditions that occur at scales ranging from local to global. Bight-wide and local impacts related to human activities include point and nonpoint source discharges, ocean intakes, and shipping. The City of Los Angeles and the Sanitation Districts of Los Angeles County discharge treated wastewater into the Bay off of El Segundo and Whites Point, Palos Verdes, respectively, and an oil terminal is located in the southern portion of the Bay, offshore from Los Angeles International Airport (LAX). Shipping lanes for the nation's busiest port complex, the Ports

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of Los Angeles and Long Beach, pass the mouth of the Bay just off the continental shelf, and two ocean water intakes currently operate to support power generation off LAX and Redondo Beach. While a third intake at El Segundo was recently shut down, water suppliers are considering the possibility of desalination, which would likely reopen or create new intakes and discharges (for more on desalination, see Section 1.1). However, many of these activities are heavily regulated to reduce or mitigate their impact on the environment. For example, point and nonpoint source discharges are subject to strict water quality standards, and ocean intakes for once-through cooling power generation facilities are scheduled to be phased out by 2020. In addition, the coastal pelagic habitat and the species found here support a variety of other human activities, ranging from whale watching to sport and commercial fishing.

The conditions in Santa Monica Bay reflect what is occurring in the rest of the Bight on the grand scale (e.g., El Niño). This can provide context for interpreting the indicators below. However, the Bay has unique characteristics that may result in differences in conditions from the rest of the Bight.

Status and Trends

Extent: GOOD and IMPROVING (MODERATE confidence)

This category assesses the extent of the water column that is capable of supporting the organisms commonly found there. One indicator comprises this category. It is Extent of Hypoxic Conditions in the Bay. Based on this indicator, the extent of life-supporting coastal pelagic habitat in the Bay is in GOOD and IMPROVING condition. There is MODERATE confidence in this assessment due to the lack of reference conditions by which to judge an upper threshold (Table 2.1.7) and only quarterly monitoring within the Bay.

Extent of Hypoxic Conditions

Hypoxia is a condition in which levels of dissolved oxygen (DO) are lower than what can support most marine life, such as fish, which utilize oxygen to respire. Hypoxia is typically caused when phytoplankton assemblages grow, sink, and decay, consuming much of the available oxygen in the water. Hypoxic conditions are more common deeper in the water column, where sinking organic matter accumulates and oxygen levels are not quickly replenished by mixing with air at the surface (see Section 4.5 for more). This indicator is measured by the area exhibiting excursions into low DO levels near the seafloor (or at 100m in areas where the bottom is deeper than 100m) and the frequency of those low levels. Low DO is defined as less than 30% oxygen saturation (also 0.5ml/L or 62.5μM depending on the units of measurement). However, an upper threshold (to distinguish fair from good conditions) has not been established, in part because that level varies among different taxa.

Data come from quarterly monitoring conducted by the Sanitation District of Los Angeles County (LACSD) and the City of Los Angeles Environmental Monitoring Division (CLA-EMD). Temperature, salinity, and density from these samples are used to help interpret the data for this assessment. In the future, the upwelling index produced by the National Oceanic and Atmospheric Administration (NOAA) will be used instead.

In 2010–2014, 1.1% of the deep water in the Bay experienced water levels with less than 30% oxygen. This is down from the 2005–2009 time period, in which 8.6% of the deep water in the Bay experienced the same conditions. However, strong upwelling indicated by water temperatures below 10°C, salinities above 34psu (practical salinity units), and densities greater than 26.2σ_t (kg/m^3 at a given temperature) during this same period are the likely cause of the low DO. The areas that exhibit low DO tend to be in places were upwelling occurs, such as along the Palos Verdes Shelf and near the Point Dume, Santa Monica, and Redondo submarine canyons (Figure 2.1.7).

The extent of deep water in the Bay experiencing hypoxia is considered to be in GOOD condition (i.e., little hypoxia is observed); however, the experts emphasize that, without an upper threshold to distinguish fair from good, this score mostly reflects the fact that the Bay is not in poor condition with respect to hypoxia. The trend appears to be IMPROVING, although this is not necessarily meaningful, as the trend has only been present for one five-year time step and is likely more indicative of changes in upwelling patterns. Because of the lack of an upper threshold and only quarterly monitoring within the Bay, confidence in this assessment is MODERATE (Table 2.1.7).

Vulnerability: GOOD and CONSTANT (MODERATE Confidence)

This category assesses the extent to which indicators of changing ocean chemistry due to global climate change are present in the Bay. This category consists of one indicator: ocean acidification. Based on this indicator, the ocean chemistry in the Bay is in GOOD and CONSTANT condition. Confidence in this assessment is MODERATE due to uncertainty about how to interpret the thresholds (Table 2.1.7) and only quarterly monitoring within the Bay.

Ocean Acidification

Increasing levels of carbon dioxide (CO_2) in the atmosphere causes more CO_2 to diffuse into the ocean and leads to a decrease in ocean pH and carbonate ions through spontaneous chemical reactions. This process is termed *ocean acidification*. Many organisms in the ocean, from microscopic coccolithophorids to commercially harvested shellfish, need carbonate ions to form their calcium carbonate shells. Less-available carbonate and increased acidity (lower pH) can hamper the growth of these organisms (Orr et al. 2005). However, the extent of the impact, especially for species common in Santa Monica Bay, is not fully understood (for more, see Section 4.4). This indicator is measured by the area exhibiting excursions into lower pH levels and the frequency of excursions. The global average for ocean pH is 8.2. Levels measured in the Southern California Bight typically range from 7.6 to 8.2 (Alin et al. 2012). For this

Coccolithophorids are microscopic phytoplankton that create calcium carbonate plates on their exteriors. They are an important base of the marine food web.

assessment, low pH was defined as 7.4. An additional value of 7.8 was used as an upper threshold (between fair and good). Data come from quarterly monitoring conducted by LACSD and CLA-EMD. Oxygen, temperature, and salinity from the same samples are used to help interpret the data for this assessment.

In the last 17 years, only the time period from 2000 to 2004 saw a drop in pH below 7.4, and the frequency of this occurrence in that time period was 0.1%. Excursions below 7.8 occurred in all four 5-year time steps in the last 20 years. The frequency of these occurrences range from 22.9% in the years 1989–1999 to 34.5% in the 2005–2009 time period. In the 2010–2014 time period, the frequency of excursions into pH levels between 7.4 and 7.8 was 24.7%. Interestingly, oxygen levels and pH levels do not correlate in time. However, the areas in which low DO and low pH are concerns are similar and coincide with areas of upwelling. The ocean acidification is considered to be in GOOD condition (i.e., little evidence of it). Due to the variation observed over the years, the trend is considered to be CONSTANT. Confidence in this assessment is MODERATE due to limited information on how to interpret the thresholds (i.e., what percentage below or between thresholds is significant) (Table 2.1.7) and only quarterly monitoring within the Bay.

Structure and Disturbance: FAIR and CONSTANT (MODERATE confidence)

The basis of the coastal pelagic food web consists of nutrients and phytoplankton. However, specific types of phytoplankton, at high concentrations and under certain circumstances, can significantly disrupt the top of the coastal pelagic food web. This category measures the status of these building blocks in the form of (1) dissolved inorganic nitrogen (DIN) and phosphorus (DIP), (2) chlorophyll *a* (Chl *a*), and (3) harmful algal blooms (HABs). Based on these indicators, the structure of the coastal pelagic ecosystem in Santa Monica Bay is in FAIR and CONSTANT condition. However, confidence in this assessment is LOW due to low confidence in the assessment of all of the three indicators in this category.

DIN and DIP

Nutrients enter the coastal pelagic zone through three primary pathways: coastal upwelling; effluent discharges, including treated wastewater and coastal runoff; and aerial deposition. Nitrogen is a principal ingredient for phytoplankton when building protein and nucleic acids, and phosphorus is critical for nucleic acids and other cellular constituents. In much of the world's ocean, marine algal growth is generally nitrogen-limited, meaning that phytoplankton populations run out of nitrogen before they run out of phosphorus or other elements. These and other nutrients tend to stratify by depth, where concentrations are near zero at the surface due to utilization by phytoplankton and increase with increasing depth. This indicator is measured by five-year averages of DIN and DIP concentrations at a depth of 30m. Data come from quarterly monitoring of the Southern California Bight by the California Cooperative Oceanic Fisheries Investigation (CalCOFI). Data from Santa Monica Bay are compared with data from a site 100km south of the Santa Monica Bay, off Del Mar, San Diego. However, an objective assessment is difficult because thresholds have not been established.

Nutrient levels at both sites (Santa Monica Bay and Del Mar) have steadily increased from approximately 2uM/L DIN and 0.4uM/L DIP in 1980–1984 to approximately 8uM/L DIN and 0.8uM/L DIP in 2010–2014. These substantial and significant increases are also consistent with observations along the coast of California and appear to be caused by a change in source water that is being brought into the region by large-scale ocean currents (Bograd et al., 2015). Nutrient levels in Santa Monica Bay are in FAIR condition. There is a clear increasing trend, but experts were not comfortable interpreting this trend. Confidence in this estimate is MODERATE due to the reliance on high-quality data but a lack of comprehensive sampling coverage and accepted thresholds (Table 2.1.7).

Chl a

Chlorophyll *a* is a pigment used by plants to capture light during photosynthesis. It is a commonly used measurement of the concentration of phytoplankton in oceanography. This indicator is measured by five-year averages of Chl *a* concentrations, integrated to a depth of 60m, and the frequency of reoccurrence of samples with high concentrations. High concentrations were defined as 20μg/L and are based on long-term coastal datasets from the region (Seubert et al. 2013; Kim et al. 2009). Data are available through quarterly monitoring in Santa Monica Bay by LACSD, CLA-EMD, and CalCOFI. CalCOFI data from Santa Monica Bay are compared with data from a CalCOFI site off Del Mar (San Diego, CA). In future assessments, comparisons will be made to data from additional stations in the Southern California Bight.

The frequency of occurrence of Chl *a* samples above the five-year average (20μg/L) in the 2010–2014 time period is 0.9%. There has been considerable variability in this metric since 1999, but this is less frequent than in the 2005–2009 time period (1.6%) and down from a high of 2.3% in the 1998–1999 time period. The five-year averages for each time period from 1999 (a two-year average) to 2014 remain relatively constant. However, the variability of samples within time periods and the maximum Chl *a* concentrations observed are increasing. Based on this, algal populations (biomass) as measured by Chl *a* concentrations appear to be in GOOD and CONSTANT condition. Confidence in this assessment is MODERATE due to high-quality data, as well as the lack of a good reference for an upper threshold (Table 2.1.7).

HABs

Certain phytoplankton species are capable of producing high concentrations of neurotoxins and other toxic or noxious compounds. The neurotoxins accumulate through the food web and have resulted in the illness and death of marine life (Gulland et al. 2002, Kudela et al. 2005). However, not all blooms of potentially toxic species result in the production of these toxins, complicating the prediction and monitoring of toxic events (for more, see Section 4.6). This indicator is measured by evaluating the concentration of toxin-producing species of diatoms in the genus *Pseudo-nitzschia* and other toxin-producing species (*Alexandria* spp., *Dinophysis* spp.), and in other harmful or noxious species (*Lingulodinium polyedrum*, *Akashiwo sanguinea*, *Cochlodinium* spp., *Phaeocystis* spp., and *Prorocentrum* spp.). Data on toxins are also considered. Data are from the

HABITAT CONDITIONS: Coastal Pelagic

Southern California Coastal Ocean Observing System (SCCOOS) harmful algae and red tides monitoring program (http://www.sccoos.org/data/habs/). Data from the Santa Monica Pier station are compared with average values from the rest of the Bight (San Diego, Newport Beach, Santa Barbara, and Goleta). However, established thresholds do not exist. If additional toxins are added to this program, they will also be included in our assessment.

While blooms in Santa Monica Bay do not always coincide with blooms in the rest of the region, there is no apparent difference between the Bay and the rest of the Bight from the period 2008 to 2014 across all metrics. The condition of HABs in the Bay is considered FAIR and CONSTANT. Confidence in this assessment is LOW due to the lack of established thresholds and some uncertainty in the way the data are tabulated (Table 2.1.7).

Biological Response: FAIR and DECLINING (low confidence)

This category measures the response of marine life to conditions in the Bay at various levels of the ecosystem. The indicators that comprise this category are: (1) forage fish, (2) coastal sharks, (3) marine mammals, and (4) seabirds. Only the forage fish and coastal sharks indicators were used in this assessment. Based on these two indicators, the condition of the biology of the coastal pelagic habitat in the Bay is in FAIR and DECLINING condition. Confidence in this assessment is LOW due to incomplete data, a lack of thresholds, and the reliance on only two of the four indicators for this category (Table 2.1.7).

Forage Fish

Schooling fish and invertebrates, such as sardines, anchovies, and market squid, are prey for larger piscivorous fish, marine mammals, and sea birds. They are also commonly used as bait in recreational and commercial fisheries. Market squid also supports one of the largest commercial fisheries in California (for more on fishing, see Section 3.4). While changes in this indicator may be due to coast-wide factors, such as fishing pressure or oceanographic conditions, the presence or absence of these fish in the Bay can indicate how much food may be locally available for piscivorous species residing in the Bay. Due to the lack of robust fishery-independent population data, this indicator is measured by the species-specific landed weight of forage fish commercially caught in the Bay. Data come from the California Department of Fish and Wildlife Marine Region Statistical Unit. These data are subject to changes in commercial fishing efforts that might not reflect changes in the number of forage fish in the Bay. In the future, fishery-independent sources of data for this indicator should be considered.

Total landings of forage fish in the Bay have varied considerably in the last 10 years. While no trend is present over the entire period, landings have declined over the last five years, from 24,079 MT (metric tons) to 8,860 MT. Furthermore, declines in Pacific sardine landings since 2007 (15,633 MT to 103 MT) were replaced by an increase in landings of market squid (1,268 MT in 2008 to 16,039 MT in 2010). Market squid, however, have a lower caloric content per gram of body weight in comparison to sardines and anchovies. Therefore, this transition indicates a reduction in forage fish quality. Based on this, forage fish in the Bay are in FAIR but DECLINING condition. Confidence in this assessment is LOW due to the use of low-quality data, as these data are not normalized for effort; the lack of thresholds; and some disagreement between experts on the use of these data (Table 2.1.7).

Predatory Fish

Piscivorous fish, as the name implies, eat other fish, but they are also preyed on by larger predators. As such, they are a mid-level in the coastal pelagic food web. Juvenile thresher sharks (*Alopias vulpinus*) were selected as an indicator of predatory fish because they reside in the near-shore coastal pelagic zone during this phase of their life (Cartamil et al. 2010); primarily consume forage fish, such as anchovies (Preti, Smith & Ramon 2001); and high-quality, fishery-independent data are collected about them. Thresher shark presence in the Bay is measured as catch per unit effort (CPUE) by size class (0–49cm, 50–99cm, 100–149cm, and 150–199cm) during annual targeted research surveys. These data are compared to similar data collected in the rest of the Southern California Bight. Data come from the National Marine Fisheries Service Southwest Fisheries Science Center.

Data from 2006 to 2014 reveals that cohorts of juvenile thresher shark remain in the shallower waters of the Bay until they are ready to migrate to their adult habitat, as evidenced by distinct recruitment peaks that travel through the distribution of size classes over time. This is not apparent in the data from the rest of the Bight. In addition, nearly all size classes of juvenile thresher shark in the Bay exhibit comparable CPUEs during this time, whereas in the rest of the Bight, only the smallest and largest size classes do. Furthermore, CPUE for all size classes has been variable, ranging from 0.013 sharks per 100 hooks per hour to 0.038, but exhibits no trend. However, the CPUE of the smallest size class, indicative of new recruitment, has been zero in the Bay since 2008. In contrast, the CPUE of this same size class has been on the rise in the rest of the Bight since 2010. Finally, the CPUE of the largest size class has been declining in the Bay and Bight-wide since 2006. This could be due to a variety of reasons, including earlier migration into adult habitats. Based on this, the condition of predatory fish in the Bay is GOOD but DECLINING. The confidence in this estimate is MODERATE due to the limitation on the sample frequency and sample size of the data, the lack of any kind of threshold, and some disagreement among experts on the use of these data (Table 2.1.7). One disagreement comes from the recent anecdotal observations and limited tagging that the abundance of other predatory fish in the Bay, such as white shark, has been increasing since 2005.

Marine Mammals

The presence of marine mammals of all types indicates the availability of food and other features that may attract them. Some, such as harbor seals (*Phoca vitulina*) and female California sea lions (*Zalophus californianus*), tend to be resident. Others, such as the large whales, common dolphin (*Delphinus spp.*), and bottlenose dolphin (*Tursiops truncatus*), are not resident, but use this area as a foraging hotspot, therefore spending a large amount of time inside the Bay (Bearzi & Saylan 2011). The distribution, frequency of occurrence, seasonality, and behavior of these animals will be used as an indicator of this feature of the coastal pelagic ecosystem in future reports. The Ocean Conservation

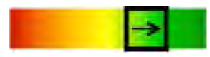
Society, National Marine Fisheries Service, and Southern California Cascadia Research Collective collect data on these animals. However, we were not able to obtain these data in time for this report and so this indicator was not scored.

Sea Birds

Sea birds, such as pelicans, terns, cormorants, and storm petrels, forage in the coastal pelagic zone, most commonly for fish. Because they are not targeted directly by human activities and are relatively easy to survey, they are good indicators of coastal pelagic health. Densities of seabirds will be used to measure this indicator. Data were collected during CalCOFI and SCCOOS research surveys. However, we were not able to obtain these data in time for this report and so this indicator was not scored.

HABITAT CONDITIONS: Coastal Pelagic

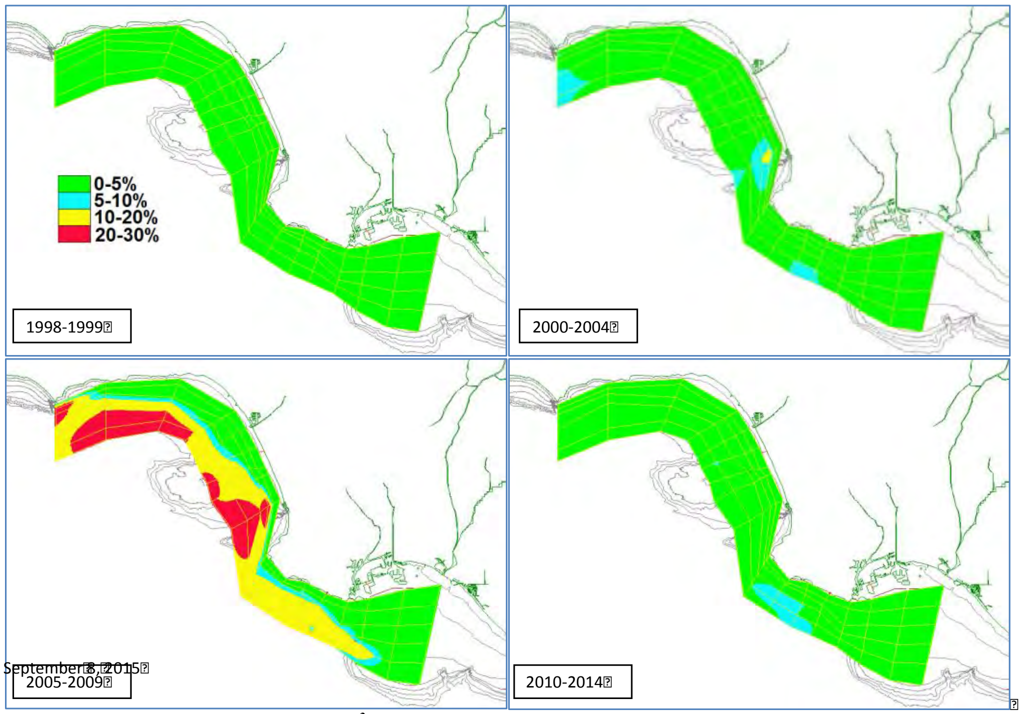
Table 2.1.7. Indicators, Related Management Actions, and Status and Trends for Coastal Pelagic Habitat.

INDICATOR	*METRIC*	*RELATED MANAGEMENT*	*SCORE*	*CONFIDENCE*
1 Habitat Extent *(Spatial Indicators related to extent, accessibility, availability, and temporal variability)*				MODERATE
1.1 Hypoxia	Area with and frequency of excursions into low DO in the bottom 5m of casts (or 100m)	SMBRC: Objective 10.2	STATUS: Good TREND: Improving	MODERATE
2 Habitat Vulnerability *(Spatial Indicators related to disturbance potential)* *The indicators for this category still need to be developed.*				MODERATE
2.1 Ocean Acidification	Area with and frequency of excursions into low pH in the bottom 5m of casts (at bottom or 100m)	SMBRC: Milestone 4.7e	STATUS: Good TREND: Constant	MODERATE
3 Structure & Ecological Disturbance *(Physical, chemical, and biological properties that impact condition of habitat)*				MODERATE
3.1 Nitrogen and Phosphorous	Five-year averages of DIN and DIP concentrations at 30m.		STATUS: Fair TREND: Increasing*	MODERATE
3.2 Chlorophyll	Five-year averages of Chl *a* concentrations integrated across all depths.		STATUS: Good TREND: Constant	MODERATE
3.3 Harmful Algal Blooms (HABs)	Seasonal averages of domoic acid concentrations and concentrations of P-N, toxic species, and all other HAB species (cells/Liter) in the Bay.	SMBRC: Objective 10.2	STATUS: Fair TREND: Constant	LOW
4 Biological Response *(Changes to individuals, populations, communities, and ecosystems in response to changes in habitat quality)*				LOW
4.1 Forage Fish	Landings by weight of forage fish caught (commercial) in the Bay by species.	CDFW: Management of market squid. NMFS/PFMC: Coastal Pelagic Fishery Management Plan.	STATUS: Fair TREND: Declining	LOW
4.2 Predatory Fish	CPUE of young thresher shark by size category.	NMFS: Highly Migratory Species Fishery Management Plan.	STATUS: Good TREND: Declining	MODERATE
4.3 Marine Mammals	Data for this indicator were not available.			NOT SCORED
4.4 Sea Birds	Data for this indicator were not available.			NOT SCORED

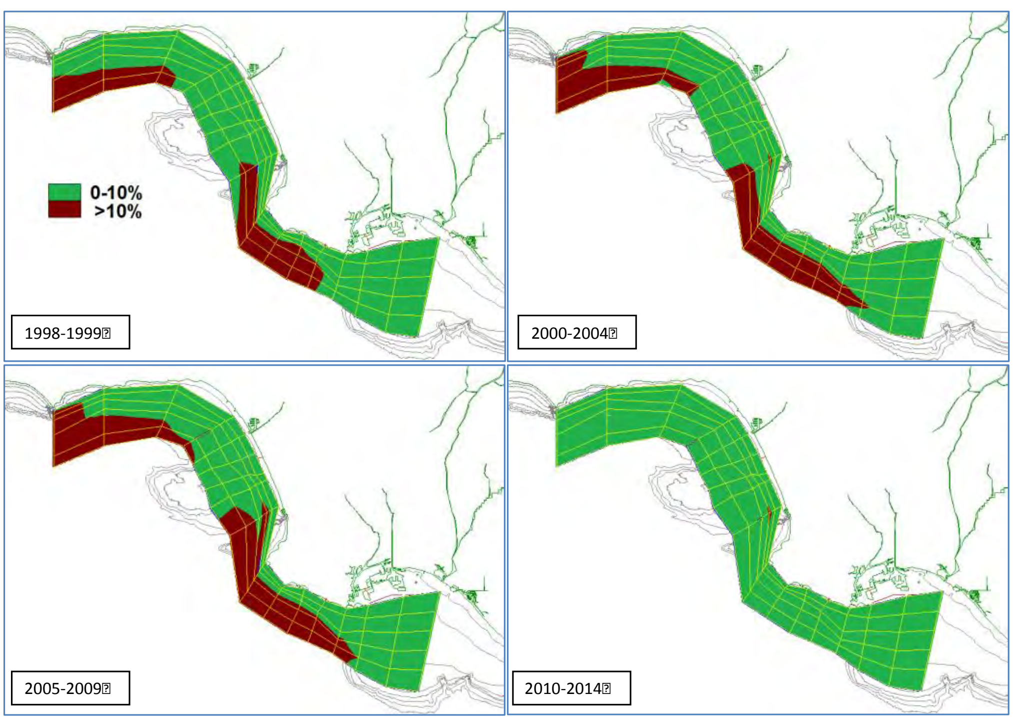
*While the values are increasing, it is not clear whether this indicates an improving or declining trend.

Figure 2.1.7. Maps depicting the frequency of low oxygen (top) and corresponding high-density water (bottom) in the bottom 5m of the water column in Santa Monica Bay. The oxygen saturation panel (top) shows the frequency that low levels of oxygen (<30% saturation) occur spatially in the Bay. The density panel (bottom) shows the frequency that high-density seawater associated with incursions of deeper water with lower levels of oxygen (>26.2 kg/m[3]) occur spatially in the Bay. *Data Source: LACSD and CLA-EMD.*

Oxygen saturation – Frequency of saturation < 30% in bottom 5m



Density – Frequency of density > 26.2 kg/m^3 in bottom 5m (Red areas are >10%)



Conclusions and Next Steps

Overall, the condition of coastal pelagic habitat in the Bay ranges from FAIR to GOOD with mixed trends. In addition to encouraging the collection of better data to be used in this assessment, present baselines against which to measure future changes for nearly all indicators and action levels for some indicators need to be developed in order to better interpret the data for effective management decisions. Developing these baselines and action levels through increased monitoring and research will be difficult but should be a priority. In addition, high-precision, high-frequency pH measurement or some other metric, such as saturation of the carbonate mineral aragonite, is needed to fully understand the trend in ocean acidification.

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Habitat Highlights: Regional Stream Monitoring in Southern California

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[1] Southern California Coastal Water Research Project

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2.2.1 Regional Stream Monitoring in Southern California

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There are over 4,200 stream-miles in the coastal watersheds[2] of Southern California. These streams are important resources for wildlife, as well as drinking water, recreation, agriculture, and many other uses. Despite the beneficial uses of these streams, Southern California's burgeoning population may stress coastal watersheds because of habitat alteration, flood control, water augmentation and diversion, discharge of treated and industrial wastewaters, and urban or agricultural runoff. In 2008, the Stormwater Monitoring Coalition (SMC), a partnership of stormwater agencies, State and Regional Water Quality Control Boards, United States Environmental Protection Agency, CalTrans, and SCCWRP initiated a regional monitoring program to address the following three questions:

1) What is the condition of Southern California streams?
2) What stressors affect stream condition?
3) Is stream condition changing over time?

The SMC program uses a probability-based approach whereby overall condition in the region can be inferred from samples collected at a relatively modest (i.e. around 500) randomly selected locations. Condition assessment is based on three indicators: benthic invertebrates, algae, and the California Rapid Assessment Method (CRAM). In addition, a variety of "stressors" related to water chemistry, toxicity, and physical habitat are also measured to help explain potential causes of poor condition, where it exists.

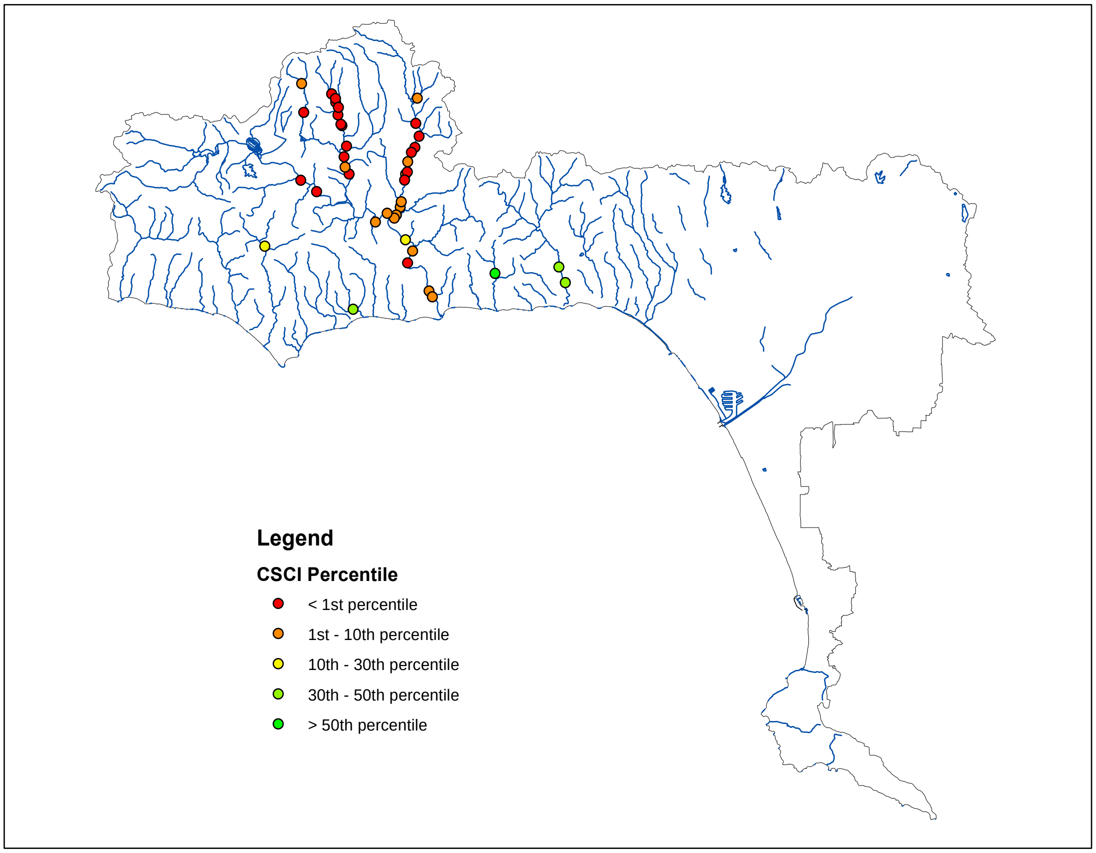
The first five years of monitoring show that approximately 25-30% of the stream miles in Southern California coastal watersheds are in reference or near-reference condition, while another 25-40% are substantially degraded depending on the indicator. The stressors that are most associated with poor biological condition are physical degradation (such as erosion, sedimentation, and physical alteration of the stream channel) and nutrients (Mazor 2015).

For the streams in the Santa Monica Mountains watersheds, approximately 43% of stream miles were in reference or near reference condition, while only 20% were substantially degraded (Figure 2.2.1-1). Sites in the Malibu Creek watershed were generally within the lowest 10% of condition relative to regional reference criteria based on the benthic invertebrate index. Sites in other locations in the Santa Monica Mountains were generally healthier. Similar to the region as whole, the primary stressors associated with poor condition are nutrients, sediments, and high primary productivity (as indicated by chlorophyll concentrations).

[1] Southern California Coastal Water Research Project

[2] All watersheds in Southern California that drain to the ocean

Figure 2.2.1-1. California Stream Condition Index (CSCI) scores for condition based benthic macroinvertebrates for sites within the Santa Monica Bay watersheds. Percentile scores are relative to the distribution of scores at reference sites. Green dots correspond to a CSCI score of 1.0, which is the mean of the reference distribution. Other dots represent CSCI score cutoffs of 0.92 (30%ile), 0.79 (10%ile), and 0.63 (1%ile) of the reference distribution. *Data Source: Stormwater Monitoring Coalition and Southern California Coastal Water Research Project.*



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URBAN COAST

Special Issue: State of the Bay

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December 2015

Habitat Highlights: Malibu Lagoon Restoration and Enhancement Project

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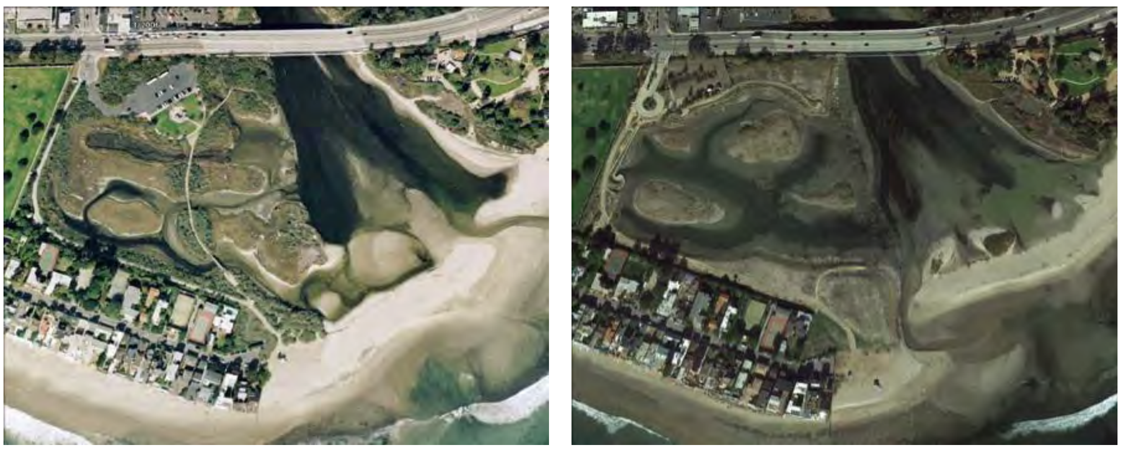
2.2.2 Malibu Lagoon Restoration & Enhancement Project

Author: John H. Dorsey[1]

On October 29, 2012, water flowed back into the newly restored area in the western portion of Malibu Lagoon, marking the completion of a major component of the restoration project that began in 2010. Water was able to freely circulate through this portion of the lagoon for the first time in decades (Figure 2.2.2-1).

Figure 2.2.2-1. Malibu Lagoon prior to (A) and just after (B) restoration. Before the project (A), channels in the western portion of the lagoon were narrow and filled with accreted fine sediments rich in organic matter. After restoration (B), channels were wider, reconfigured to promote water circulation, and excessive sediments and old construction debris removed. *Photo Source: Google Earth.*

A. Pre-Project, March 15, 2006 **B. Post-Project, December 10, 2013**



Historically, the environment of the lagoon was profoundly altered by development projects in the lower Malibu Creek watershed and around Malibu Lagoon. Chief among these actions impacting the lagoon were the construction of Rindge Dam and Malibu Canyon Road, which altered sediment flows; construction of the Pacific Coast Highway, which crossed the lagoon and dumped construction debris into the lagoon; and development of the Malibu Colony and Malibu Civic Center, which increased flows of contaminated runoff and altered habitats (Ambrose & Orme 2000).

In 1983, California State Parks restored habitats in the western arm of the lagoon by removing two baseball fields and a landfill, and by creating three tidal channels bisected by a boardwalk, which connected a parking lot to the beach (Manion & Dillingham 1989). Since this design did not promote adequate water circulation, organic-laden sediments accumulated in the dead-end channels, and levels of dissolved oxygen (DO) in bottom water often were hypoxic, where DO was below 2–3 mg/L, levels below limits needed by

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most aquatic organisms. For example, during baseline surveys from September 2006 through November 2009, levels of DO were hypoxic on 66 occasions in the western arm of the lagoon (2NDNATURE, 2010). These periods of low DO occurred most often with warmer water temperatures when the lagoon was closed from ocean circulation by the barrier sandbar. Because of this poor circulation, the system was more vulnerable to periods of low DO.

After nearly 20 years of planning, extensive stakeholder meetings, and producing environmental documentation, a second major restoration project began in 2012 with three goals:

- enhance the salt marsh/lagoon function,
- improve water quality, and
- improve ecological sustainability.

Restoration staff and volunteers trapped and relocated fish (Figure 2.2.2-2), mammals, and reptiles from the project site to adjacent habitats, and ensured that nesting birds were protected prior to construction activities. Around 5,000 cubic yards of entrained sediments were removed from the 12-acre area, where channels were reshaped to promote better water circulation and the banks were made shallower to promote more extensive wetland habitat. A considerable amount of debris was removed, including fill dirt, pipes, trash, and concrete from illegal dumping or discarded during the construction of the Pacific Coast Highway in 1949.

A vegetated swale was constructed along the western border of the site to capture and infiltrate runoff from the adjacent homes, thus eliminating a source of pollution to the lagoon. At the conclusion of the project, the site was vegetated with over 70,000 plants representing 80 species, of which about 70% were wetland and 30% upland species.

Figure 2.2.2-2. Project staff removing any fish trapped behind an exclusion barrier prior to pumping water from the channel. *Photo: Abramson et al. 2013.*

HABITAT HIGHLIGHTS: Malibu Lagoon

A significant measure of success for the project would be for levels of DO to be greater in the restored channels relative to pre-restoration conditions when hypoxic conditions often occurred, and anoxic dead-zones were forming in some of the back channels. The new channel configuration was designed to enhance water circulation, thus reducing periods of stagnation, especially during periods when the lagoon is closed to the ocean.

Post-restoration monitoring was performed between May 2013 and December 2014 with *in situ* continuous recording water quality sensors that measured a suite of water quality parameters (e.g., salinity, temperature, pH, and DO). Sensors were positioned at the lagoon's main channel and two back-channel sites (Stations 5 and 8), and programmed to collect a set of measurements every 30 minutes (Abramson et al. 2015).

During the most critical periods for DO, when the lagoon was closed to the ocean, DO in these two sites were above 1.0 mg/L for 97% of the measurements (Figure 2.2.2-3). These results indicate that periods of hypoxia due to stagnation were greatly diminished relative to pre-restoration conditions.

Figure 2.2.2-3. Percentage of DO readings above four thresholds at Stations 5 and 8, Malibu Lagoon.
Source: Modified from Table 4 in Abramson et al. 2015.

STATION 8:

DO Threshold (mg/L)	% Measurements Above Threshold
1.0	95.8
1.5	94.3
3.0	88.2
5.0	75.3

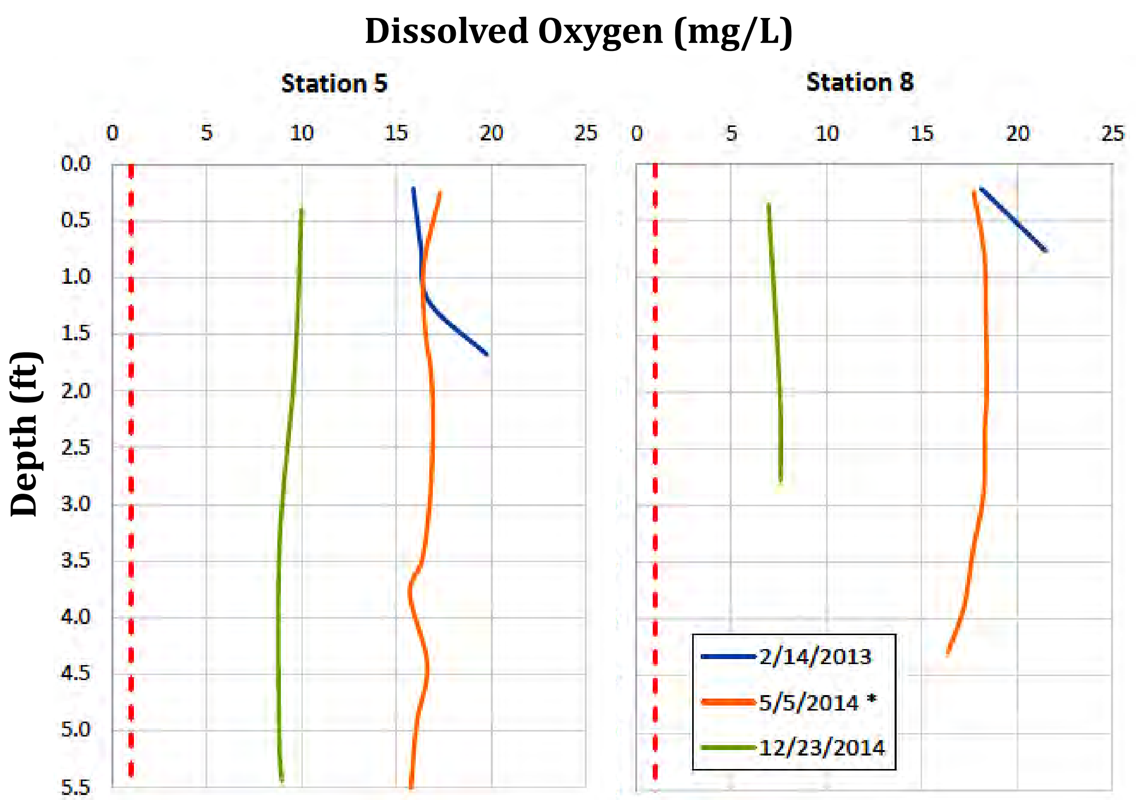
STATION 5:

DO Threshold (mg/L)	% Measurements Above Threshold
1.0	97
1.5	94.7
3.0	85.2
5.0	66.6

A second line of evidence for improved water quality came from a series of post-restoration vertical profiles of various water quality parameters (temperature, salinity, DO, and pH) collected on three occasions from 2013 to 2014 with similar electronic sensors used for the continuous measurements (Abramson et al. 2015). Readings were measured through the water column at six-inch increments from surface to bottom at each of eight stations sited throughout the restored channels.

Profiles of DO all were well above the 1.0 mg/L threshold, even during the May 2014 survey when the lagoon was closed to the ocean (Figure 2.2.2-4). Concentrations were similar throughout the water column, or even increased with depth, as found at both stations during the survey in February 2013. During the pre-restoration monitoring, severe oxyclines occurred where DO concentration rapidly diminished to hypoxic, or even anoxic, conditions in the bottom water (2NDNATURE 2010). Post-restoration profiles have demonstrated that bottom water retained good levels of DO, so stagnate conditions were absent.

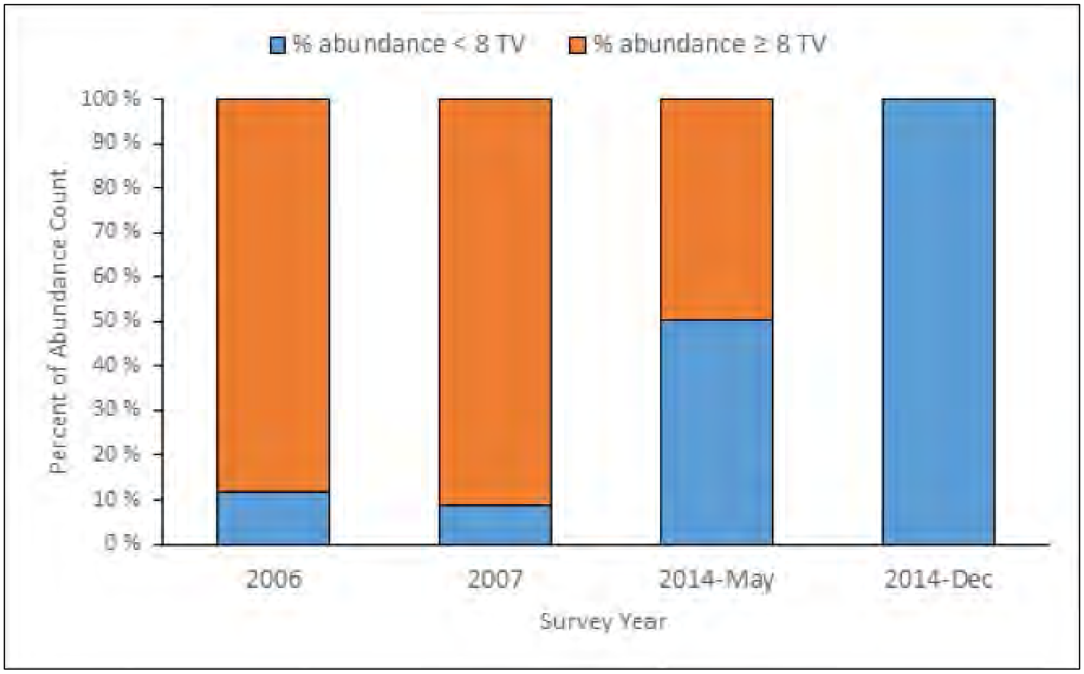
Figure 2.2.2-4. Post-restoration DO profiles at Stations 5 and 8, Malibu Lagoon. Figure 2.2.2-3 shows the location of these sites in the lagoon. The orange profile denoted with an asterisk indicates a closed lagoon condition, and the vertical red dashed line is along the 1.0 mg/L threshold. *Source: Modified from Abramson et al. 2015.*



Based on post-restoration monitoring, plants and animals are quickly repopulating the restored area. Benthic invertebrates—animals living in the lagoon's sediment—shifted from a pollution-tolerant assemblage to one having a greater number of sensitive individuals, as demonstrated by a freshwater bioassessment metric (SAFIT, 2003). The pollution tolerance values (TVs) of the metric range from 0, where the community comprises only pollution-sensitive species, to 10, where pollution-tolerant species prevail. During the pre-restoration surveys in 2006 and 2007, the benthic community was dominated by pollution-insensitive species like ostracods and various fly larvae, reflecting index values usually greater than 8 (Figure 2.2.2-5). During post-restoration surveys in

2014, the assemblage shifted to more pollution-sensitive species with TV values of 4, 5, and 6, indicating that bottom conditions had improved.

Figure 2.2.2-5. The percent pollution tolerance values (TVs) of individuals collected during benthic core surveys in the restoration project area of Malibu Lagoon. TV values of 8–10 reflect an assemblage of organisms tolerant to polluted conditions, while values less than 8 reflect species more sensitive to polluted conditions in the sediments. The lagoon was closed to the ocean during surveys done in September 2007 and May 2014. *Source: Abramson et al. 2015.*



Initial surveys recorded several species of fish in the new channels, including the endangered tidewater goby (*Eucyclogobius newberryi*) and large numbers of staghorn sculpin (*Leptocottus armatus*). Most excitingly, a southern steelhead trout (*Oncorhynchus mykiss irideus*) was observed during the May 2014 fish survey. This is the first sighting of a steelhead in the lagoon in decades, suggesting that levels of DO are sufficient for this species. Juvenile fish and larvae were also collected in the post-restoration surveys (e.g., juvenile diamond turbot, *Hypsopsetta guttulata*), indicating the increasing value of the lagoon as a fish nursery.

During the February 2013 survey, 53 species of birds representing 1,304 individuals (not counting roosting gulls on the beach) were observed in the area. Bird diversity may continue to increase as replanted vegetation continues to develop horizontally and vertically.

During two post-restoration surveys in February 2013 and December 2014, submerged aquatic vegetation (SAV) was represented mainly by the green alga *Cladophora* (Abramson et al. 2013, Abramson et al. 2015). This turf alga was found throughout the area, but in low density where the average percent cover ranged from 0.0 to 4.4 among three 50-m transects. The sea grass *Phyllospadix* was recorded in the 2014 survey, representing a longer-lived SAV species. Various species of floating algae and sea grass, termed *wrack*, accumulated along the transects, ranging in cover from 0.0 to 9.9%. These post-restoration results for SAV reflect a healthier condition since masses of benthic algae have not formed.

During pre-restoration studies, large masses of the green alga *Ulva intestinalis* were noted along the lagoon banks (Dagit 1989), and the percent cover of SAV, floating, and matted algae averaged 10% in the western channels of the lagoon (2NDNATURE 2010). Decomposition of these algal masses often led to eutrophic and hypoxic or anoxic conditions in the western channels. With the increased water circulation in the restored channels, accumulations of benthic algae were much less, so the occurrence of eutrophic conditions should be greatly reduced or eliminated.

During the restoration, around 67,000 plants representing over 70 species were planted. Since planting, the percent cover of native plants in the newly vegetated areas has increased based on three post-restoration transect surveys conducted in 2013 and 2014, with coverage ranging from 25.3 to 84.3% (Abramson et al. 2015). As expected, the percent bare ground fell as the plant community developed (Figure 2.2.2-6). As the community matures, vegetation cover is expected to increase, and possibly diversity as new species are recruited into the area.

The pre- and post-restoration condition of the wetland habitat was assessed using the California Rapid Assessment Method (CRAM 2014) during June 2012 just prior to construction, and after restoration in 2013 and 2014 (Table 2.2.2-2). After the project was completed, the overall condition of the wetland habitat increased over time and as compared to pre-restoration conditions (Abramson et al. 2015). Indicator 4 (biotic structure) was initially low following restoration, but as the plant community developed and matured, this attribute increased significantly, and should continue to do so. The biotic structure indicator was the only one to decrease immediately post-restoration since it takes time for a complex and well-defined vegetation community to develop. The overall condition will continue to increase as the vegetation structure continues spreading and becoming denser, thus providing more habitats for the many species of invertebrates, birds, mammals, reptiles, and other animals living in this system.

Overall, these results indicate that the project has been a success. Average levels of DO have increased over pre-restoration concentrations based on monitoring data collected to date, indicating that water flow within the restored channels has improved. Birds and fish have repopulated the area, including the endangered tidewater goby. The assemblage of native plants associated with wetland habitats has become established and should continue to mature, based on CRAM surveys. Biodiversity in the restored area should continue to increase as the newly vegetated areas continue to develop, and better water circulation and quality promote a greater diversity of aquatic and marine species.

HABITAT HIGHLIGHTS: Malibu Lagoon

The Bay Foundation staff will continue monitoring biota and water quality in the restoration area to further document how the estuarine, wetland, and upland habitats progress into a thriving ecosystem.

Figure 2.2.2-6. Comparison of the vegetated area soon after restoration planting (A) and about 27 months later (B). View is from the parking lot looking SSE. *Photo Credit: (A) from Abramson et al. 2013, (B) John Dorsey.*

A. March 15, 2013

B. June 4, 2015

Table 2.2.2-1. Attribute scores for the CRAM surveys conducted in 2014-2014. The overall AA score is the average of the four scores for each survey.

Attribute	Pre-Restoration	2/14/13	10/4/13	12/23/14
1: Buffer and landscape context	38	38	38	53
2: Hydrology attribute	50	58	58	58
3: Physical structure attribute	50	88	75	88
4: Biotic structure attribute	61	39	56	64
Overall AA Score	50	56	57	66

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URBAN COAST

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Volume 5 Issue 1 *Article 2.2.3*

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Habitat Highlights: Marine Protected Areas and Santa Monica Bay

Dana R. Murray[1] and Lia Protopapadakis[2]

[1] Heal the Bay

[2] The Bay Foundation

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2.2.3 Marine Protected Areas and Santa Monica Bay

Authors: Dana R. Murray[1], Lia Protopapadakis[2]

Marine Protected Areas (MPAs) are a valuable tool for both ecosystem protection and fishery management, and have been shown to be effective in replenishing depleted fish populations in other parts of California, the Florida Keys, New Zealand, and in close to 50 other countries around the world (Aburto-Oropeza et al. 2011, McClanahan and Mangi 2000, Kelly et al. 2002, Lester et al. 2009, Roberts et al. 2001, Gell and Roberts 2003).

California's state legislature enacted the Marine Life Protection Act (MLPA) in 1999, directing the California Department of Fish and Wildlife (CDFW, formerly California Department of Fish and Game) to design and manage a statewide network of MPAs to protect marine life and habitats, marine ecosystems, and marine natural heritage. Through the phased "MLPA Initiative" process, various interests ranging from fishing groups to conservationists designed 119 MPAs, which were implemented along California's Central Coast in 2007, the North Central Coast in 2010, and the North Coast in December 2012. The MPAs off Southern California's coast took effect on Jan. 1, 2012. Local organizations like The Bay Foundation and Heal the Bay were extremely active in the MLPA process, representing the conservation community in stakeholders groups and providing a science-based perspective, respectively.

Establishing these MPAs marks a historic moment to be celebrated: this is the first statewide network of underwater parks in the U.S. The statewide network of 119 MPAs lines our 1,100 miles of coast, protecting habitats, ocean ecosystems, and marine natural heritage. The final Southern California portion includes 50 MPAs encompassing 356 square miles of state waters and about 15% of the Southern California coastline.

Along the Los Angeles mainland coast, this network (Figure 2.2.3-1) includes:

- A marine reserve encompassing Point Dume in Malibu
- A partial take marine conservation area stretching from Zuma Beach through El Matador State Beach
- A no-take conservation area at Point Vicente in Palos Verdes
- A partial take marine conservation area at Abalone Cove

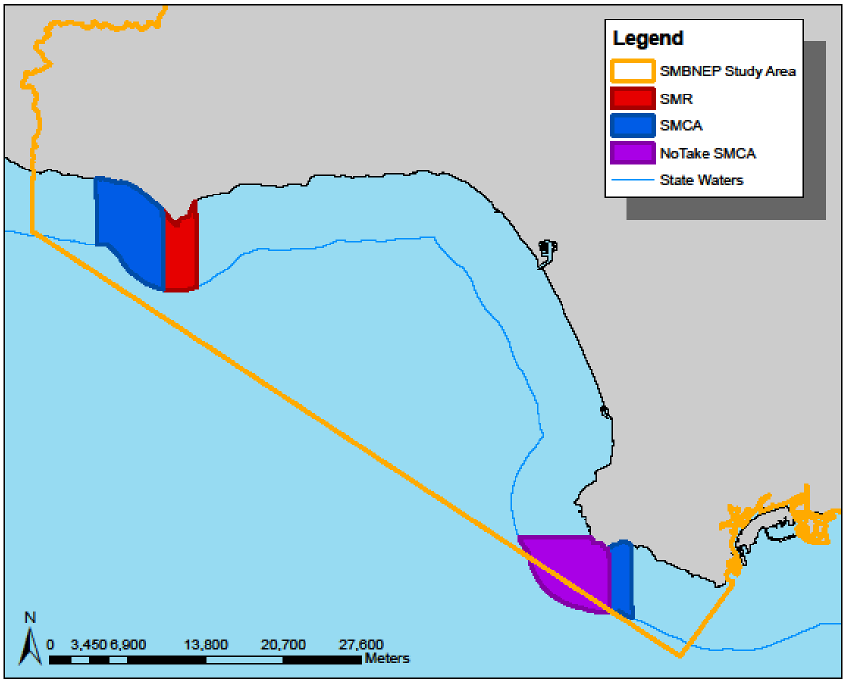
Maps of the entire network and more information about regulations within MPAs and the MLPA planning process can be found online at **http://www.dfg.ca.gov/marine/mpa/**

[1] Heal the Bay

[2] The Bay Foundation

HABITAT HIGHLIGHTS: Marine Protected Areas

Figure 2.2.3-1. Map of MPAs in Santa Monica Bay (courtesy: CDFW).



Despite the consensus-building efforts the state made during the MLPA Initiative process, balancing the various interests while meeting scientific guidelines proved challenging, and the MPA designation and adoption process was contentious. However, after the MPAs took effect, some unlikely partnerships have formed and efforts are being made to engage the community (both consumptive and non-consumptive users) in outreach, education, monitoring, and enforcement efforts. Below are some examples.

Los Angeles MPA Collaborative

The Los Angeles MPA Collaborative is a part of the California MPA Collaborative Implementation Project, a statewide group of county-based councils dedicated to inter-agency communication and localized, more effective implementation of MPAs in California. The Los Angeles MPA Collaborative formed in 2013 and is composed of local municipalities, non-profit organizations, academic institutions, businesses, aquaria, and local, state, and federal government agencies involved with different aspects of MPA implementation. The Collaborative is dedicated to sharing existing resources and building bridges between the Los Angeles area community and CDFW regarding the unique needs and goals of MPAs in the Los Angeles region. The Collaborative has hosted local enforcement training and designed and installed initial MPA signage along the coast. Within several sub-committees, Collaborative members have been working on collaborative projects such as MPA boundary marker signs, fishing guides, a diversity outreach survey, MPA Watch monitoring, and MPA interpretive signage. One next step will be to engage members of the fishing community in the collaborative.

Community-based Monitoring and Outreach

Recognizing the connection between citizen science and stewardship, and the need for more monitoring to fill data gaps, a broad range of local groups have initiated community-based MPA monitoring programs to conduct research. Some examples include: trained volunteer SCUBA divers surveying marine life with Reef Check; fishermen working with marine ecologists to assess the impact of MPAs on California spiny lobsters (*Panulirus interruptus*); high school students monitoring tide pools through the LiMPETS program; aerial monitoring of boating activity by The Bay Foundation; boat-based monitoring of boating activity by Los Angeles Waterkeeper's MPA Watch program; and volunteers monitoring consumptive and non-consumptive human uses onshore and offshore in MPAs through Heal the Bay's MPA Watch program. These community-based scientific monitoring programs offer many benefits beyond data collection—they are cost-effective, build awareness, create community trust and transparency in the research, and promote stewardship among participants.

Get Involved or Learn More. Here are links to most of these community-based programs:
Reef Check
LiMPETS
Heal the Bay's MPA Watch
LA Waterkeeper's MPA Watch

Enforcement

Cal-TIP, a confidential call-in line for the public to report illegal activities of poaching and polluting is a long-standing state effort to help protect California's biological resources. In 2015, the state expanded the Cal-TIP program to other platforms including a smart phone application, tip to text program, and online web form. In the 2012, the first year of MPAs in Southern California, 259 calls came in from the public reporting violations in California's MPAs. Public reporting is a form of community stewardship of our oceans, as it helps both our natural resources and CDFW's enforcement efforts. Although education efforts are key to the success of MPAs, reporting violations to CDFW is imperative as well, as CDFW has stated, "poaching activity directly affects the recovery and rebuilding rates of an area."

The Cal-TIP number is 1-888-DFG-CALTIP (888-334-2258). Click here to learn more.

Initial MPA Monitoring Results

California's network of MPAs is being monitored by state and federal agencies, academics, citizen science groups, and others. Baseline monitoring of Southern California's MPAs took place in the initial three years following implementation. A second round of monitoring is planned for years 5-8 with the first status and trends report being released ten years after implementation. In addition to state-sanctioned monitoring efforts, a program to monitor boating activity, initiated by the Los Angeles Waterkeeper and now run by The Bay Foundation, began during the MPA Implementation process and can draw some initial before and after conclusions about behavior changes and compliance (Ford et al. 2013). Below are some of the findings specific to the Southern California mainland (Point Conception to the U.S. Mexican Border) Marine Protected Areas:

Baseline monitoring reports can be found here: http://oceanspaces.org/home

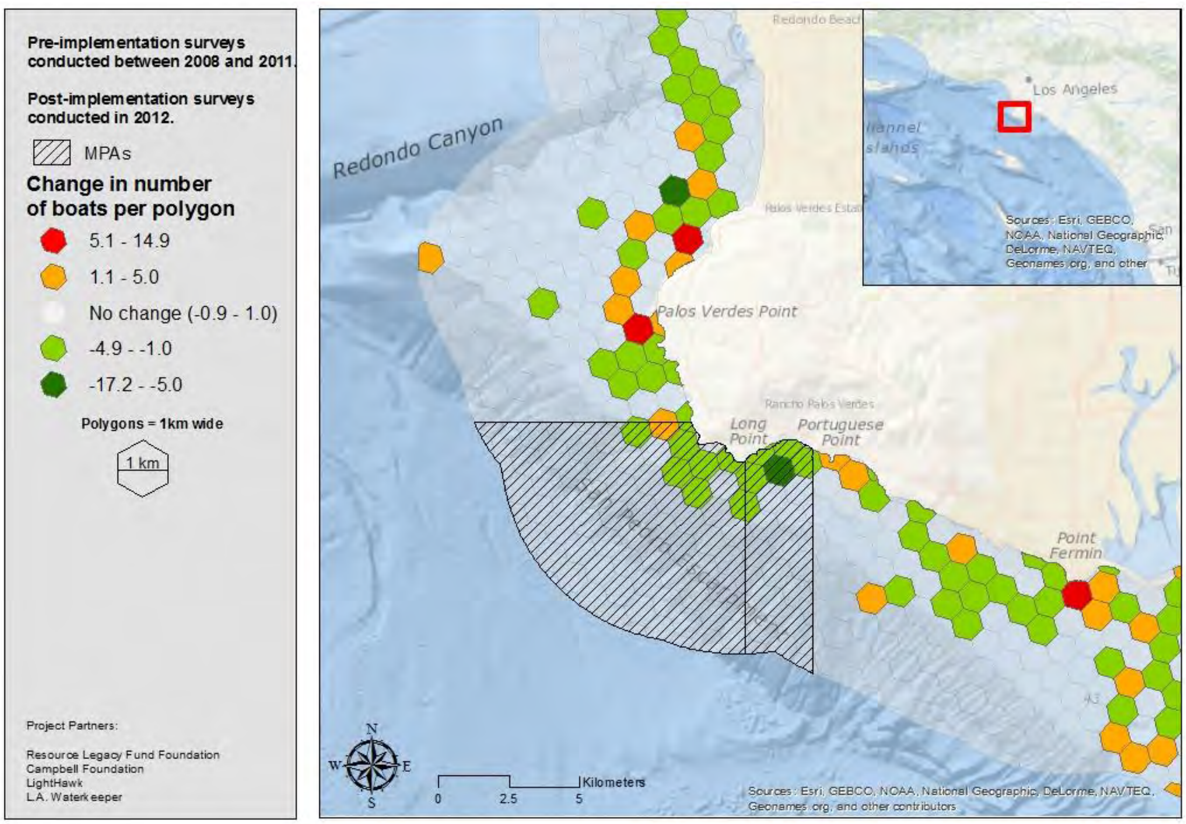
- The commercial fishing sectors that were observed displayed compliance with the MPA regulations with very few exceptions.

- Recreational fishing sectors that were observed displayed greater non-compliance than commercial sectors, however this non-compliance is greater in San Diego and Orange Counties.
- While fishing vessels have shifted to areas outside the MPAs (Figure 2.2.3-2), these vessels are not displaying compaction due to displacement from MPAs.
- Commercial fishing vessels are not **fishing the line**. The data suggest that the opposite is the case; commercial fishing has shifted away from the borders of the MPAs within the study area.

Fishing the Line refers to a fishing strategy in which fishermen place their gear on the borders of MPAs in hopes of catching marine life that may spill over from the MPA.

- The majority of fishing effort in Southern California occurs on rocky reefs (75% pre-MPA and 73.1% post-MPA) and is concentrated on three reef complexes: Point Loma, La Jolla and Palos Verdes. These reef complexes represent 31% of the rocky reef along the mainland coast.

Figure 2.2.3-2. Difference in boats fishing around Palos Verdes before and after MPA implementation (normalized for number of surveys flown). Green hexagons indicate a decrease in the number of boats; Red/Orange hexagons indicate an increase in the number of boats. A shift from inside the MPAs to outside the MPAs is observed here. *Source: Ford et al. 2013.*



Conclusions

Residents of Santa Monica Bay care about the health of local marine life, regardless of whether they are fishermen, divers, or photographers. Communities are working together in creative ways to build stewardship for MPAs. Through long-term, concerted education, enforcement, and monitoring efforts, it is hoped that California's new MPAs will show long-lasting benefits for the coastal environment and California's ocean users.

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Biodiversity in Santa Monica Bay and its Watershed

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3.0 Biodiversity in Santa Monica Bay and its Watershed

Author: Lia Protopapadakis[1]

The concept of biodiversity covers genetic, species, and ecosystem diversity. These types of diversity are important for ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic reasons (Convention on Biological Diversity 1993). Genetic diversity gives populations the ability to adapt to changing environmental conditions and is the source of plant varieties and pet breeds. Species diversity supports increased ecosystem function and services (Zedler, Callaway, and Sullivan 2001). Finally, ecosystem diversity creates the variety of land and waterscapes that we are familiar with.

Santa Monica Bay and its watershed were historically diverse. A wide range of ecosystems, including a variety of upland, riparian, coastal wetland, and marine habitats, supported thousands of species of native plants, insects, reptiles, fish, mammals, and birds. This high diversity is what brings us amazing natural phenomena such as the famous grunion run or the giant kelp, known as an "underwater rain forest" for its high diversity and productivity. These are also among what make the area adjacent to the Bay attractive to humans for activities ranging from commercial and recreational fishing to diving, tidepooling, hiking, and bird-watching.

Special Regulatory Status means species that are listed by the federal or state governments as threatened, endangered, or at risk of becoming extinct due to dwindling populations.

However, rapid population growth and urbanization during the last century have resulted in severe damage to biological resources and the subsequent loss of biodiversity in the Bay and its watershed. This rapid development cleared vast areas of natural habitats and altered or fragmented the native landscape. Pollution, disease, hunting, and industrialized fishing have also contributed to the decline in population or even expiration of several plant and animal species. Climate change now threatens to further alter the native habitats of the surviving species.

One measure of the severity in the loss of diversity is the kind and number of species attaining special regulatory status. Of the species whose ranges encompass Santa Monica Bay and its watershed, 128 are being tracked by the state because of their rarity (Table 3.3-1). Plants and mosses are particularly affected (Figure 3.3-1), as are terrestrial habitats in the area (Figure 3.3-2). Some of the best known species, including the red-legged frog (*Rana draytonii*, discussed in Article 3.1), the El Segundo blue butterfly (*Euphilotes battoides allyni*), and the coastal California gnatcatcher (*Polioptila californica californica*) attained special regulatory status in the 1970s, 80s, and 90s. Fishing, disease, pollution, and continued disturbance of habitats have brought about more recent decline of other species, including the giant sea bass (*Stereolepis gigas*) white and black abalone (*Haliotis*

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[1] The Bay Foundation

sorensenii and *H. cracherodii*, respectively) and southern steelhead trout (*Oncorhynchus mykiss irideus*).

Table 3.3-1. Number of species in Santa Monica Bay and its watershed that are in the California Natural Diversity Database of Rare Plants and Animals. Rare marine species were added. "Informal" means the species status is ranked by the state or a non-profit organization [International Union for Conservation of Nature (IUCN Red List), American Fisheries Society, or the Western Bat Working Group], but not protected by law. *Data source: California Department of Fish and Wildlife's California Natural Diversity Database of Rare Plants and Animals.*

Status	Formal (Legal)	"Informal"
Extirpated / Possibly Extirpated	0	4
Endangered / Critically Imperiled / Full Legal Protection	27	14
Threatened / Rare / Imperiled / Vulnerable	14	15
Sensitive / of Concern / Vulnerable / Near Threatened	38	7
Watched / State Tracked Seed Bank	1	3
Protected under Marine Mammal Protection Act	5	0

Figure 3.3-1. Number of special status species by class. The categories shown here are the same as in Table 3.3-1. *Data source: California Department of Fish and Wildlife's California Natural Diversity Database of Rare Plants and Animals.*

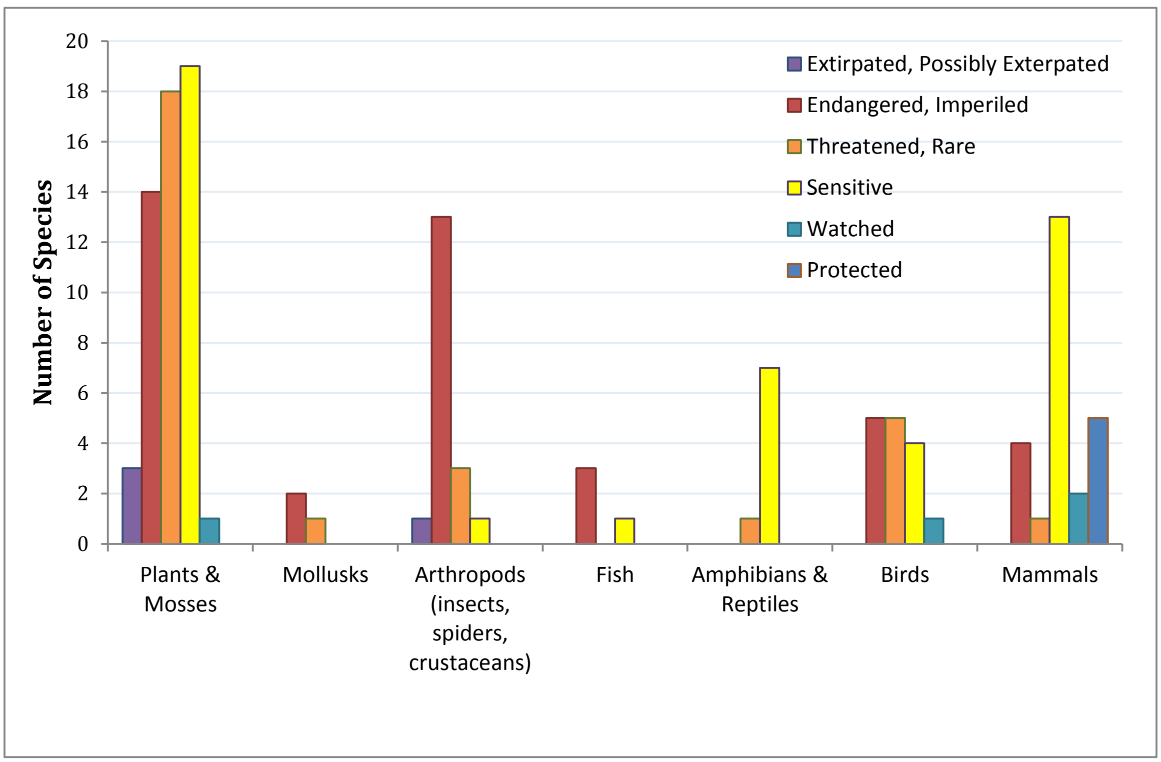
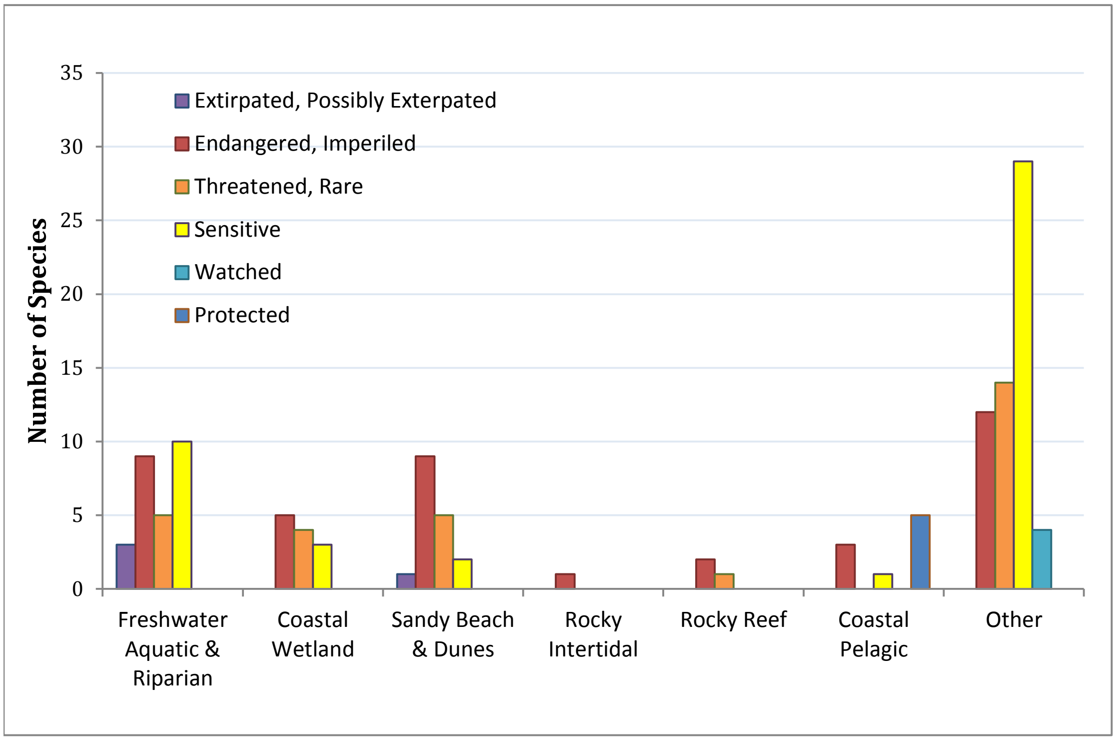


Figure 3.3-2. Number of special status species by habitat type. "Other" refers to terrestrial habitats in the Santa Monica Bay Watershed not incorporated in the habitat categories listed. It includes coastal scrub, chaparral, oak savannah, valley and foothill grassland, cismontane woodland, and closed-cone coniferous forest. *Data source: California Department of Fish and Wildlife's California Natural Diversity Database of Rare Plants and Animals.*



The articles in this section focus on several issues of biodiversity, such as restoring endangered populations and their genetic diversity (Section 3.1), population decline and what that may mean for coastal ecosystems (Section 3.2, Section 3.3), and managing populations to maintain diversity while allowing extraction (Section 3.4). More discussion on the issues surrounding ecosystem diversity can be found in Chapter 2 of this report.

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URBAN COAST

Special Issue: State of the Bay

Volume 5 Issue 1 *Article 3.1*

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Biodiversity: Red-Legged Frog Recovery

Jack Topel[1]

[1] Santa Monica Bay Restoration Commission

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3.1 Red-Legged Frog Recovery

Author: Jack Topel[1]

Amphibians (frogs, toads, newts, salamanders) are important indicators of ecosystem health. Most amphibians spend a portion of their lives in water, to breed and reproduce, and a portion on land. Amphibians absorb gases and liquids directly through their porous skin. This property makes amphibians extremely sensitive to changes in the environment, as along with absorbing oxygen and water, their skin also absorbs air- and water-born pollutants.

Globally, amphibian populations are in steep decline. Almost one-third of amphibians (more than 1,800 species) are threatened. Many factors have played a role in the worldwide decline of amphibians, including: fragmentation and loss of habitat through urban and agricultural development, diseases, climate change, widespread use of pesticides, pollution, and the introduction of non-native species (AmphibiaWeb 2015). In California, fourteen amphibians are listed as threatened or endangered. One of these species, the California red-legged frog (*Rana draytonii*, red-legged frog hereafter), is of particular concern to biologists working in the Santa Monica Mountains.

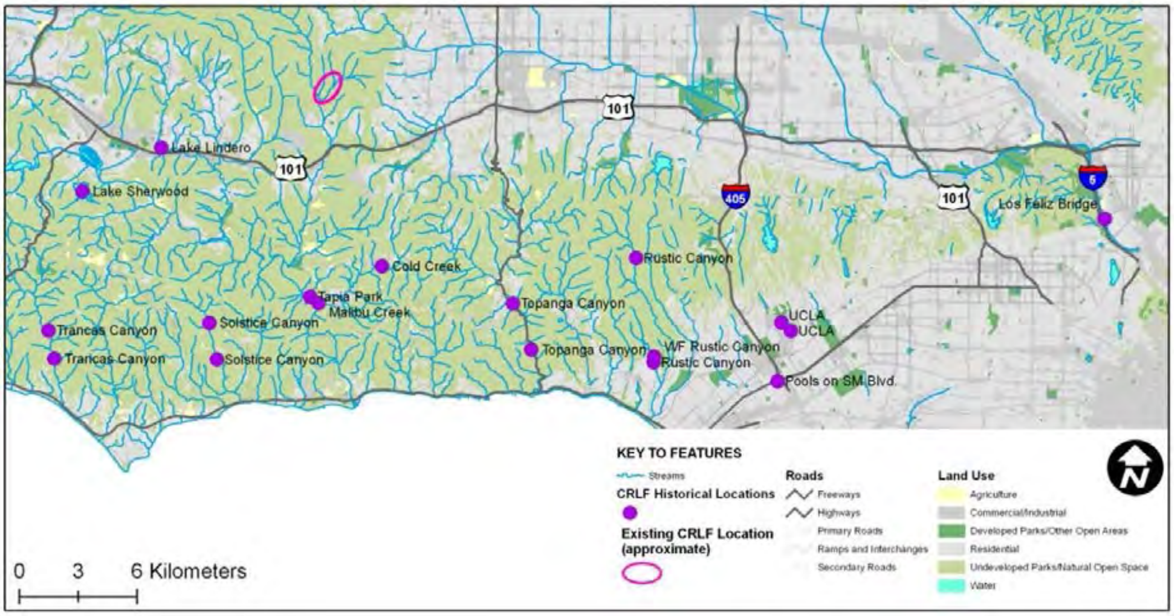
Photograph of a California red-legged frog. *Photo Credit: Katy Delany, National Park Service.*

The red-legged frog is the largest native frog in the western United States. Once widespread and abundant in almost all central and Southern California coastal watersheds and the Central Valley, the red-legged frog has been extirpated from more than 70% of its historic range. Statewide, the U.S. Fish and Wildlife Service has determined that the red-legged frog is currently found in only 238 streams in 31 California counties. The U.S. Fish and Wildlife Service listed the red-legged frog as Federally Threatened in 1996. In the Santa Monica Mountains, historical records indicate that the red-legged frog was abundant in most of the watershed's major streams, including Malibu, Topanga, Solstice, Cold, and Trancas Creeks (See Figure 3.1-1). Until biologists discovered a small population in the Simi Hills in the late 1990s, the last known red-legged frog recorded in the Santa Monica Bay watershed was in Cold Creek in 1975. The Simi Hills population is

[1] Santa Monica Bay Restoration Commission

the only population of red-legged frog known to exist in the Santa Monica Bay watershed.

Figure 3.1-1. Map of the historical distribution of the California red-legged frog. *Credit: National Park Service*



Most of the factors impacting global amphibian populations have played a role in the decline of the red-legged frog in the Santa Monica Mountains, with loss of habitat and the introduction of invasive species such as Louisiana red swamp crayfish (*Procambarus clarkii),* and particularly bullfrogs (*Rana catesbeiana*), likely playing major roles. Bullfrogs were introduced in California during California's gold rush and into the early 1900s, likely to replace the over-harvested red-legged frogs as a source of food. According to researchers, tens of thousands of red-legged frogs were harvested yearly during that period (Jennings and Hayes 1985). To supply the demand for frog legs, bullfrogs were eventually imported from the east coast. The much larger bullfrog is the largest frog in North America and is a "gape-limited" predator, eating just about anything that will fit in its mouth, including mammals, birds, reptiles, and other amphibians. Moyle (1973) proposed that the decline in the red-legged frog population was due "largely to the competition and predation of introduction of bullfrogs."

In an effort to stave off the local extinction of the red-legged frog, in 2010 the Santa Monica Bay National Estuary Program (SMBNEP) funded the National Park Service (NPS) and the State Department of Parks and Recreation to conduct surveys in the northern Santa Monica Bay watershed to identify and assess suitable habitat for reintroduction of the red-legged frog in the Santa Monica Mountains.

Led by NPS Wildlife Ecologist Katy Delaney, experts surveyed more than 30 streams in the Santa Monica Mountains; seven streams were identified as meeting the requirements for successful reintroduction. Sites were evaluated on a number of criteria, including: available cover, water persistence, depth, temperature, available upland habitat, historical presence, and the absence of invasive predators, especially bullfrogs and crayfish. Additionally, SMBNEP staff conducted monitoring at all seven potential relocation sites to ensure that water quality was adequate to support the red-legged frog. By late 2013, two streams were selected for the initial relocation, and all necessary permits had been secured.

Geographic proximity, and a hydrologic connection between the Simi Hills and the Santa Monica Mountains, led Delaney's team to conclude that the Simi Hills population was likely genetically similar to the original Santa Monica Mountains population of the early 20th century. This population was chosen as the source for the relocation project.

In early 2014, NPS personnel built mesh fabric pens to protect the frog eggs from predators, and then pre-placed them at the selected relocation sites. This allowed time for algae to grow on the mesh and provide a food source for any newly hatched tadpoles. United States Geological Survey and NPS biologists collected clusters of eggs from the Simi Hills site and transported them to the two selected streams.

Biologists from National Park Service and United States Geological Survey collecting egg masses for translocation. *Photo Credit: National Park Service*

At the relocation sites, eggs were placed in small mesh bags and attached to the tops of the pens. This configuration mimicked the natural position of red-legged frog egg masses in the wild. In addition to the algae growing on the pens, NPS biologists provided organic greens for supplemental nutrition as necessary. Within 10 days after relocation, all the egg masses had hatched and newly hatched tadpoles could move in and out of the mesh bags freely. After about a week, the bags were opened to release any tadpoles that were too large to escape the smaller bags into the larger enclosures. Additional pens were added to prevent overcrowding as the eggs hatched and tadpoles grew.

By late August of 2014, Delaney had counted 24 metamorphs (the transformation from tadpole to true frog) during a single visit to one of the sites. At the second site, biologists noted that many tadpoles had developed front feet and long tails, with many showing well developed back legs. Since mid-February 2015, Delaney’s team has been finding juvenile red-legged frogs at both sites during twice-weekly visits. NPS will continue to monitor the sites and Delaney hopes that soon there will be adult, breeding-age frogs at both the relocation sites.

Future plans include relocating the red-legged frog to two new sites, and relocating additional eggs to the current sites. NPS will also continue monitoring the Simi Hills population to assure the sustainability of the site as a source of future relocations. Additionally, a local group, Mountains Restoration Trust, is working to manage crayfish in the area through trapping.

Although the red-legged frog still faces many threats such as drought, climate change, urban encroachment, invasive predators, and environmental contaminants, for now, after four decades, the recently named State Amphibian, the "Celebrated Jumping Frog of Calaveras County" has returned to the Santa Monica Mountains.

Acknowledgements

Thanks to the project leader, National Park Service Wildlife Ecologist Katy Delaney for her valuable feedback on this story and her dedication to the recovery of the California red-legged frog.

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URBAN COAST

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Biodiversity: California Grunion

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3.2 California Grunion

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Beaches are important nursery areas for many species of birds, mammals, and even marine fishes (McLachlan et al. 2006, Martin 2015). The California Grunion, an iconic beach-spawning fish species, has been appearing on the shores of Santa Monica Bay for thousands of years. During spring and summer, when tides are high, these silversides dash onto sandy beaches to lay their eggs (Walker 1952). The adults are vulnerable while out of water, so they are protected by a unique set of rules. No take is permitted during the closed season in April and May, and no gear is ever permitted during open season (CDFW 2015). People can catch the grunion only with bare hands, and those over the age of 16 must have a fishing license. Closed season allows the fish a chance to reproduce undisturbed, and is usually the best time to observe the runs without human interference (Spratt 1986).

Grunion eggs are buried under a few inches of warm sand to incubate above the water line, developing at warmer temperatures than the surrounding ocean (Martin et al. 2009). They are ready to hatch within two weeks, when the waves from the next high tide reach them and wash them out to sea (Martin & Carter 2013). Regulations to protect the adults during the spawning runs do not protect the eggs and nests on shore, but other steps are being taken to protect them.

Many of the Southern California beaches that experience high human visitation are also nursery beaches for grunion. Management for high human use includes many types of activities to maintain access and assure human safety, which may include construction of buildings, piers, and parking lots. Lifeguards drive vehicles on beaches, as do public safety officers and vendors. Operators perform mechanized maintenance by raking and grading the sand to remove trash and other debris. This beach grooming creates a smooth, clean-looking surface, but it disturbs the upper levels of the sand, and this can destroy the incubating eggs (Martin et al. 2006). As a result, managers have decided to curtail maintenance activities on Southern California's urban beaches during grunion spawning season, from March to August. The area below, or seaward, of the highest high tide line is left natural and ungroomed to prevent disturbance of any hidden grunion nests (Martin et al. 2011).

This policy often results in the accumulation of a line of seaweed, or wrack, that washes in from nearby kelp forests on the beaches. Leaving this wrack to decompose on the beach may cause consternation in some beachgoers, but it has many beneficial effects for the ecosystem. When the wrack remains, nutrients are recycled back to the ocean and a nutrient subsidy is provided for the food chain on the beach, which supports many species

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of burrowing invertebrate herbivores and the shorebirds that feed on them (Llewellyn & Shackley 1996, Dugan et al. 2003).

California grunion nests may also be disturbed or destroyed by construction activities or sand replenishment operations (Martin 2015). Such activity on a beach is regulated by resource agencies, including the California Department of Fish and Wildlife (CDFW), California Coastal Commission, and National Marine Fisheries Service. These agencies place conditions on permits that are intended to protect these spawning fish and their nests from harm.

Since 2002, a group of citizen scientist volunteers has followed the spawning runs of the California grunion (Martin et al. 2006). Teams of Grunion Greeters go out to sandy beaches at specific times on designated nights to observe and report on the presence and extent of the runs. Each year reports from over 50 beaches throughout the habitat range are submitted, including many beaches in Santa Monica Bay, the home of this program. In addition to their unusual spawning behavior, California grunion are atypical in their activities off shore. They are very difficult to monitor using traditional fishery methods, as they avoid nets and cannot be caught by fishing. Therefore the Grunion Greeters provide the best long-term data available for this species (Martin et al. 2011).

All evidence indicates that California grunion are not, and never have been, present in large numbers (Gregory 2001, Sandrozinski 2011). On some nights, there may be no or only a few fish showing up. Even when the waves and tides seem conducive, no spawning runs may occur (Martin & Raim 2014). Through the years, the largest runs occur in less than 2% of the observations. On these rare nights, many thousands of fish show up on shore, surfing onto shore and back into the water for over an hour, a living river of silver along the wave wash. Considering this behavior, this species may need to aggregate to a certain minimum density in order for a spawning run to happen. This may concentrate a large portion of the population in a few local areas.

Grunion during a spawning run. *Photo Credit: Chris Lindeman.*

California's human population is over 38 million, and many millions of tourists visit the beaches in summer. About one million California residents buy ocean sport fishing licenses in a given year, along with about 25,000 tourists. During open season, any of them may be hunting for grunion. On the beaches in Santa Monica Bay, many thousands of people line the shore in hopes of capturing these elusive fish during their runs. The number of people on the beach may far exceed the number of fish attempting to come on shore, and in many cases every fish that appears is taken into a bucket (Spratt 1986). Informal surveys indicate that many of those hunting for grunion do not have a fishing license. Behavior of those hunting the grunion is very different from typical angler's fishing behavior, with shouting, grabbing, running and chasing after the fish. This traditional wild chase may be exciting but results in disruption of the runs, broken backs of animals that are carelessly trampled, failure of reproduction during the run, and needless waste of fish.

In the previous decade, the median run reported was a few hundred to a thousand fish on shore, for approximately half an hour. Within the last few years, the median run has dropped to below 100 fish, with very little spawning. This means that about half the time or more, even on nights when spawning runs are expected, few fish appear and no reproduction occurs (Figure 3.2-1). Even though large runs still occur, they are increasingly rare. The loss of the moderately sized runs has potentially negative consequences for the population as a whole.

Figure 3.2-1. Spawning runs of California grunion in Santa Monica Bay for the last decade. Medians are indicated by the red line. From 2004-09, the median run was a W2 on the Walker Scale. Since 2010, the median run has been W1. About 55% of runs were a W2 or above in the previous decade, but in the current decade, only about 37% of runs are in this grouping. This is a significant drop in run strength ($X^2 = 18.01$, df = 5, p = 0.003). These figures are based on 857 observations from Grunion Greeters at more than 27 beaches, ranging from Cabrillo Beach Park to County Line. On the Walker Scale, W-0 means zero or only a few fish were seen for only a few minutes; W1 means up to 100 fish scattered about, with some spawning that lasts several minutes; W2 means between 100-500 fish spawning at different times for up to 1 hour; W3 means 500-1000 fish spawning at once for up to 1 hour; W4 means thousands of fish together with little sand visible between fish for 1 hour or more; and W5 means fish covering the beach several individuals deep, creating a silver lining in the surf for over 1 hour. *Data Source: Karen L. Martin.*

Increased protection for many species has taken the form of "No Take" reserves in Marine Protected Areas. In California, MPAs typically extend from the ocean to the mean high tide line on shore, but this is an artificial boundary that owes more to real estate law than to ecosystem integrity. Because the grunion place their eggs out of water at the highest monthly tides, the spawning runs are actually above the mean high tide line (Smyder &

Martin 2002, Moravek & Martin 2011), technically out of the MPA. However, this is the only place where reproduction of this species occurs, and the only part of the life cycle when this endemic species requires protection from fishing. Wardens became frustrated because the reserves were "No Take" for all fish species except the grunion because they jumped out of the reserve when spawning, which is the only time they actually needed protection from fishing. In 2015, marine biologists at CDFW determined to enforce "No Take" reserves for California grunion adults and eggs in the MPAs, both above and below the mean high tide line, throughout the season. This new protection is the first "No Take" reserve for California grunion, an important step forward.

California grunion are vulnerable to the impact of changes in water chemistry and temperature. Increased salinity from waste brine created by desalination plants can deform or kill embryos (Matsumoto & Martin 2008). California grunion are also affected by activities on shore, including coastal construction and seawalls that armor approximately a third of the shoreline in Southern California (Martin 2015), as these activities increase erosion of sand (Griggs et al. 2005, McLachlan & Brown 2006) and result in habitat loss for grunion nesting areas. The fixed back of the beach and erosion from waves and sea level rise create a "coastal squeeze" that shrinks the beach width over time, particularly in the upper beach where grunion nests occur (Defeo et al. 2009). The natural supply of sand in Southern California has also been altered by coastal development, such as beach armoring, jetties, seawalls and loss of wetlands. Other activities away from the beaches, including urbanization, channelization of creeks and rivers, and dams, prevent or trap sediment from moving though the coastal landscape to the beaches. These changes exacerbate the erosion of beaches due to the loss of natural supply of sand, gravel and cobbles to the coast, making replacement of these erosional losses more difficult (Flick & Ewing 2009). See Sidebar 3.2 for more on the effects of climate change for this species.

Sidebar 3.2. Climate change and grunion habitat loss
Author: K.L. Martin[1]

California grunion are an endemic marine fish species found only in the waters of coastal California and northern Baja California. Over 95% of the population resides between Pt. Conception and the Mexican border. These fish spawn out of water during high tides on sandy beaches in the intertidal zone (Martin et al. 2004), a unique behavior that makes them particularly vulnerable to habitat loss during climate change. Spawning takes place above the mean high tide line in an area with a dry surface during much of the tidal cycle. The upper dry beach is most vulnerable to habitat loss through sea level rise and coastal armoring (Griggs et al. 2005, Feagin et al. 2005, Defeo et al. 2008), and this loss can be seen in many places already (Fletcher et al. 1997, Dugan et al. 2008, 2011).

Habitat shifts are one response to changing ocean temperatures for marine fishes. Occasionally, California grunion are seen north of Pt. Conception in the central coast as far as Monterey Bay. Within the last decade, spawning grunion were seen for the first time in San Francisco Bay and Tomales Bay (Roberts et al. 2007, Johnson et al. 2009). In these northern areas the spawning season was very short, and spawning started so late the closed season did not provide significant protection to the runs. In both bays, the adult fish were smaller, produced smaller, fewer eggs in their clutches, and had shorter breeding seasons (Martin et al. 2013). These northern bay populations of California grunion were very small and disappeared after only a few years, although new colonization was seen in Tomalas Bay and San Francisco Bay during the summer of 2015.

As climate changes, both air and water temperatures increase. Changing temperature regimes may shift the spawning season so that the protections provided by the fixed times of the closed season will not protect the most significant runs. In addition, California grunion and other beach-spawning fishes, such as surf smelt and capelin, may be affected earlier than fully marine fishes as a result of their terrestrial reproduction (Martin 2015). Because their embryos develop on shore, temperatures may become inhospitable during early life long before the adults are impacted (Martin et al. 2004). Unfortunately, California grunion that move northward will also encounter more rugged, rocky coastal cliffs than soft, sandy beaches, complicating their poleward shift. On moving north, this species may find itself locally concentrated in disconnected embayments rather than colonizing the entire coast (Martin et al. 2013).

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URBAN COAST

Special Issue: State of the Bay

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Biodiversity: Sea Star Wasting Disease in Santa Monica Bay

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3.3. Sea Star Wasting Disease in Santa Monica Bay

Author: Richard F. Ambrose[1]

Sea stars (commonly called starfish) are conspicuous members of the rocky intertidal community. Their bright colors (often orange or purple), large size and slow movement make them favorites of many visitors to rocky intertidal habitats along the Pacific Coast. They are also critically important predators whose activities can strongly influence the nature of intertidal communities. In fact, studies of sea stars off the coast of Washington formed the basis for the important ecological concept of keystone predator. By consuming mussels, sea stars prevent mussels from outcompeting other species and dominating the area, thereby maintaining a high diversity of intertidal organisms (Paine 1966).

Sea stars, like other echinoderms such as sea urchins, have periodically experienced disease outbreaks in Southern California and elsewhere (Dungan et al. 1982). Over the past few decades in Southern California, these disease outbreaks were typically associated with warm water occurring during El Niño conditions. Most times, one or two sea star species were affected in a limited geographic area. Typically, diseased sea stars develop lesions (Figure 3.3-1) and appear to "dissolve" in a pile of white goo.

Starting in June 2013, however, sea stars along the west coast of North America have been affected by an unprecedented disease epidemic that has led to the death of millions of sea stars. Like previous epidemics, sea stars affected by the disease disintegrate, often over a period of only a few days. Unlike previous epidemics, the current outbreak has affected at least 20 different sea star species in subtidal and intertidal habitats along the entire coastline, from Baja California to Alaska. The effects on local populations are also more severe than during some past outbreaks, with all sea stars in some areas disappearing in a matter of weeks after the first diseased individual is discovered.

Information about the sea star wasting disease has come from many sources, but critical data has come from the Multi-Agency Rocky Intertidal Network (MARINe), which established a network of long-term monitoring sites throughout California and the entire west coast of North America. Repeated sampling at MARINe sites and elsewhere has enabled researchers to follow the occurrence of the disease over time. MARINe data have been used to track the development of another disease epidemic, the withering syndrome affecting black abalone, which showed a clear progression northward along the California coastline from its first occurrence on the mainland near Point Conception (Altstatt et al. 1996, Raimondi et al. 2002). In contrast, the current epidemic of sea star wasting disease spread quickly across the entire west coast but did not affect every population; over the next year or so, however, the disease spread more evenly through each local area. MARINe maintains a website, www.pacificrockyintertidal.org, with a

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compilation of data on the sea star disease, a map of locations that have been sampled, and a way for individuals to submit their own observations.

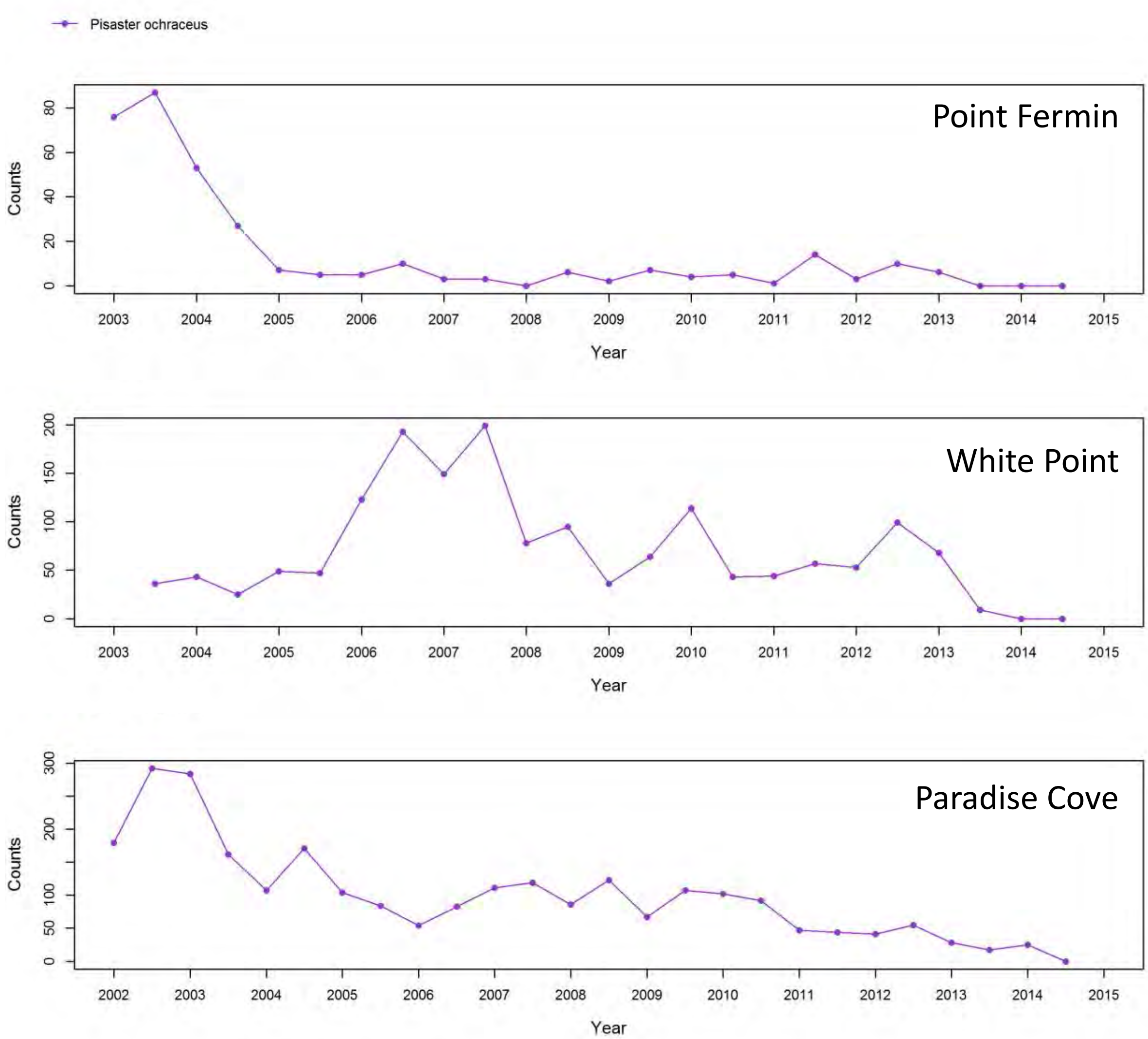
The cause of the sea star wasting disease is not fully understood. A recent paper combined field samples with laboratory experiments to identify a type of virus, specifically a densovirus, as the organism that is most likely causing the disease (Hewson et al. 2014). However, the authors also sampled preserved sea stars in museum collections and determined that the densovirus has been present along the west coast of North America for at least 72 years. It is not known why the outbreak is occurring now rather than at other times. While there are many possible triggers for the disease, including a variety of natural and anthropogenic stressors, at this point there is no evidence indicating which factor(s) may be responsible.

Figure 3.3-1. Diseased ochre sea star (*Pisaster ochraceus*) from White Point from November 2013. *Photo Credit: R.F. Ambrose.*

The sea stars of Santa Monica Bay have been hard-hit by the wasting disease. The disease has been reported from both intertidal and subtidal habitats. There are no quantitative subtidal data available to assess the impacts of the disease there, but there are three long-term MARINe rocky intertidal monitoring sites in the Bay, at Point Fermin and White Point on the Palos Verdes Peninsula, and Paradise Cove in Malibu. Although sea star abundances vary naturally at all sites, sea stars were absent from both Palos Verdes sites by 2014 (Figure 3.3-2). Once sea star abundances became very low, the entire site (not just the fixed plots) was searched thoroughly, and no sea stars were found at either site through fall 2014. Sea stars had low abundance at Paradise Cove in 2013, and had disappeared completely from the site by the fall 2014 survey.

At this point, there is little sign of recovery at the Santa Monica Bay sites. In the spring 2015 survey, two sea stars were found outside of the fixed plots at Point Fermin, two were found outside the fixed plots at White Point, and no sea stars were found at Paradise Cove. At some other sites in California, unusually high recruitment of sea stars has been reported, with many very small juvenile sea stars, but there is no evidence of that in Santa Monica Bay. Sites in Ventura and Santa Barbara Counties had increasing numbers of sea stars during the spring 2015 survey with significant recruitment at some sites, but that has not been seen in Santa Monica Bay.

Figure 3.3-2. Sea star abundances in plots at long-term monitoring sites in Santa Monica Bay. Sea stars are counted in



BIODIVERSITY: Sea Star Wasting Disease

The future prospects for sea stars and the rocky intertidal communities in Santa Monica Bay are uncertain. In some previous disease outbreaks, the population declines were less severe and widespread, so ecological impacts were not noted. In other past outbreaks, one species of sea star was severely impacted, and recovery of that species took years to a decade or more. The presence of young sea stars could lead to faster recovery of a population, though even the sites with high recruitment might not benefit if the young sea stars also become infected and die. In Santa Monica Bay, however, researchers have not recorded any young sea stars, so it could be many years before sea star populations recover. Because sea stars play such an important role in rocky reef habitats, especially in the intertidal zones, there may be significant changes in intertidal communities. Scientists will continue monitoring these habitats to determine any changes to intertidal communities as well as recovery of sea star populations.

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December 2015

Biodiversity: Fishery Management

Lia Protopapadakis[1]

[1] The Bay Foundation

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3.4 Fishery Management

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Since 1950, California's commercial fisheries have produced in the top ten by value and in the top five by weight of all coastal states (NMFS 2014). The Port of Los Angeles, the primary fishing port for Santa Monica Bay, is consistently the top producing port in California by weight and value (NOEP 2012). The Bay also supports a thriving recreational fishing industry. Los Angeles County is home to approximately 70,000 sport fishermen and generates approximately 7% of all sport-fishing related GDP for the state (CDFW 2015). Overall fishing (recreational and commercial) contributes approximately $53.5 million in wages and $122 million in GDP, generates 1,550 jobs, and supports approximately 150 businesses (National Ocean Economics Program 2012). It is therefore important to ensure that the fish populations that support these activities are healthy and well managed.

Inside Santa Monica Bay, top commercially caught species (by weight) include important prey species such as market squid and pacific sardine, kelp forest inhabitants such as red sea urchin and spiny lobster, and deep-water species such as hagfish and thornyheads (Table 3.4-1). In addition, California halibut (*Paralichthys californicus*) and sea hares (*Aplysia* spp.; see photo) are in the top ten by value, but not by weight. Commercial fishing activity is heaviest off the northern Malibu coast, around Palos Verdes, and in the middle of the Bay at Short Bank (Figure 3.4-1).

The most lucrative of these fisheries (those that command the highest price per pound based on 2013 data) are California spiny lobster ($19/lb) and sea hare ($11/lb). Spiny lobster are sold live and mostly shipped to Asia; sea hares are not consumed but are instead sold for use in neurobiological research.

On the other end of the spectrum are the coastal pelagic species (CPS): market squid, Pacific sardine, northern anchovy, Pacific mackerel, and jack mackerel. These species command a relatively low price per pound ($0.9 - $0.32) but are caught in extremely high volume (nearly 35 million pounds annually). Fishermen are paid by the ton for these particular fish. Despite their low price per pound, this fishery is the most valuable in the state. Market squid alone is the second most valuable statewide (behind the Dungeness crab, *Cancer magister*) and is the largest by weight. Pacific sardine is the 8th most valuable fishery statewide and is the 2nd largest by weight. Los Angeles area fishing ports are the top producers of CPS in the state, with landings coming from nearby fishing grounds north of Point Dume and offshore of the Redondo Canyon. Market squid is typically exported to Asia and Europe, although some of it also remains in the US (Porzio and Brady 2006). Pacific sardine is typically canned, but is also turned into fish meal and fish oil products (Protasio 2011). California barracuda also command a relatively low price per pound at market, fetching around $0.70/lb. As it is a warmer water species, it is surprising to find

[1] The Bay Foundation

that California barracuda are in the top 10 of fish caught in Santa Monica Bay during a predominately cold water cycle[2].

Table 3.4-1. Top 10 commercial fisheries by weight in Santa Monica Bay from 2008-2013. Santa Monica Bay includes fishing blocks 678, 679, 680, 681, 701, 702, 703, 704 (no data from 2008-2011), 719, 720, and 721 (see Figure 3.4-1 for more details). *Data Source: California Department of Fish and Wildlife Commercial Fisheries Information System, accessed July 2014.*

Common Name	Scientific Name	Annual Avg (lbs)
Market squid	*Doryteuthis opalescens**	24,589,215
Pacific sardine	*Sardinops sagax*	9,256,444
Other coastal pelagic species	†	960,882
Red sea urchin	*Mesocentrotus franciscanus*‡	833,338
California spiny lobster	*Panulirus interruptus*	107,253
Rock crab (brown, red, and yellow)	§	99,489
Thornyheads (long and short spine)	*Sebastolobus alascanus* and *S. altivelis*	54,843
Hagfish (slime eel)	*Eptatretus stoutii*	30,364
California barracuda	*Sphyraena argentea*	23,875
Sea cucumbers	*Parastichopus spp.*	22,822
All other species	----	120,492
Total	-----	36,099,017

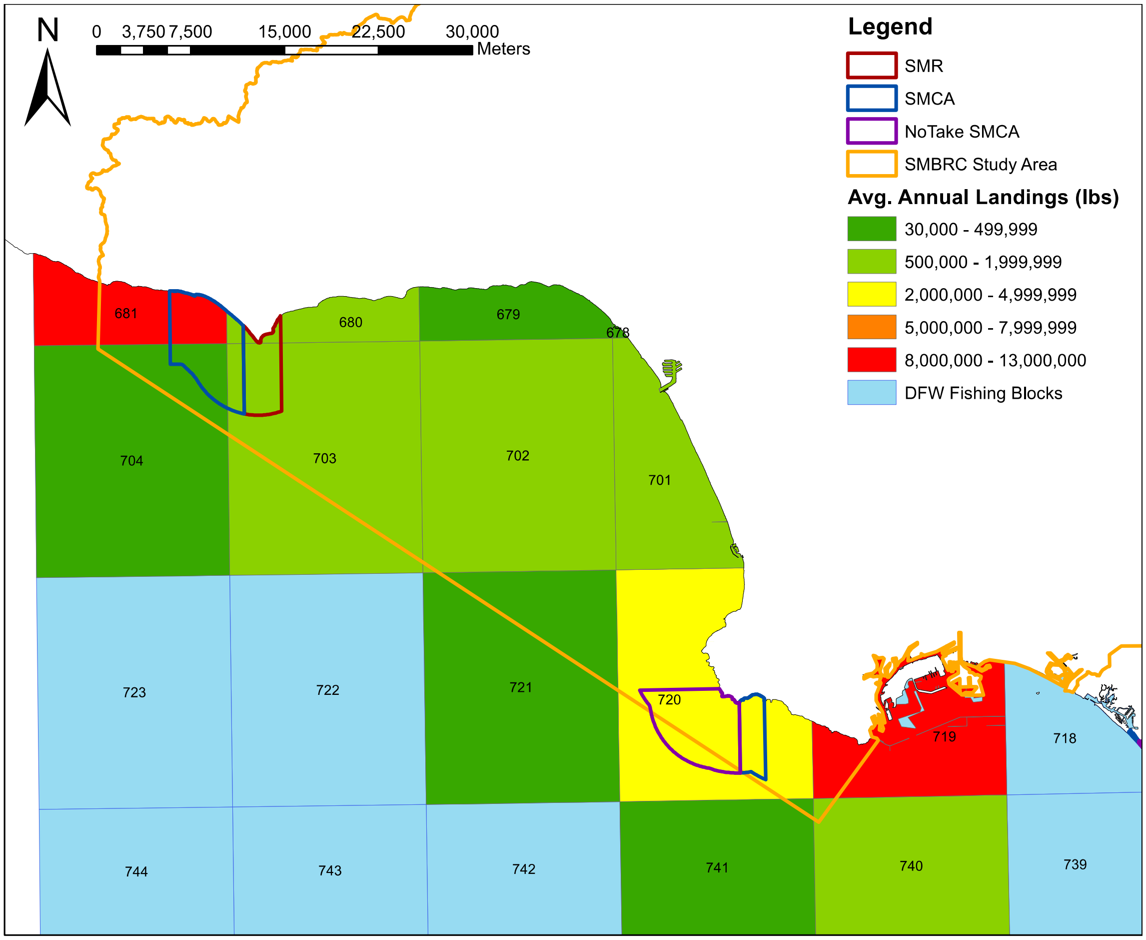
* Syn. *Loligo opalescens*
† Northern anchovy (*Engraulis mordax*), Pacific mackerel (*Scomber japonicus*), and jack mackerel (*Trachurus symmetricus*).
‡ Syn. *Strongylocentrotus franciscanus* (Kober and Bernardi, 2013).
§ Brown rock crab (*Romaleon antennarium*, syn. *Cancer antennarius, C. antennarium*), red rock crab (*C. productus*), yellow rock crab (*Metacarcinus anthonyi, syn. C. anthonyi*)

Other Santa Monica Bay seafood exports are sea cucumbers and hagfish. Sea cucumbers are primarily shipped to Asia for consumption, although a small portion is sold in local Asian markets (Rogers-Bennett and Ono 2007). Hagfish are predominantly sold to Korean buyers for their skins and for human consumption (Tanaka 2008).

The remaining seafood products are primarily sold locally. Rock crab are typically sold live in local fresh fish markets (Parker 2002). Red sea urchins are processed and sold to sushi restaurants locally and abroad as *uni*. California halibut are sold to local fish markets and restaurants; live halibut fetch a higher price than when they are sold whole or filleted (Tanaka 2011). Thornyheads can be found in local grocery stores and restaurants under the name 'channel rockfish' (Roberts and Stevens 2009).

[2] Data Source: NOAA Pacific Decadal Oscillation index.

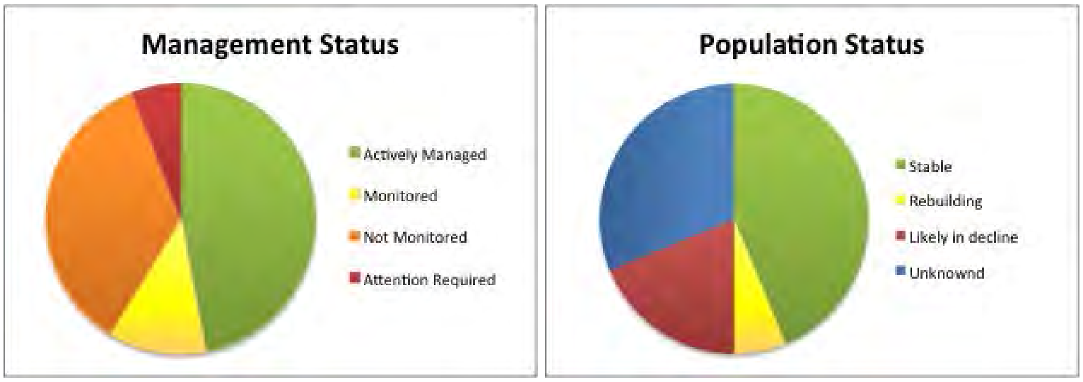
Figure 3.4-1. Average annual commercial landings by weight from 2008 to 2013 in Santa Monica Bay. MPAs took effect January 1, 2012. Santa Monica Bay includes fishing blocks 678, 679, 680, 681, 701, 702, 703, 704 (no data from 2008-2011), 719, 720, and 721. *Data Source: California Department of Fish and Wildlife Commercial Fisheries Information System, accessed July 2014.*



Interestingly, most of the top fisheries in Santa Monica Bay are managed by the State of California. These are market squid, spiny lobster, red sea urchins, rock crab (three species), sea cucumbers, California halibut, sea hares, and hagfish. The federal government manages thornyheads, pacific sardine, and the other coastal pelagic species. Market squid is part of the federal Coastal Pelagic Species fishery management plan, however the entire fishery occurs in California so the state manages this species.

Of these top fisheries, 16 species in total, eight have had recent stock assessments and are managed according to a fishery management plan (FMP) or have an FMP in process; two are monitored without a stock assessment (i.e. CPUE and length-weight composition of landings, all fishery-dependent data) and managed either according to a management plan or standalone management measures (i.e. size, gear, and season restrictions); six are managed in some way without any significant data collection (i.e. using seasons and gear restrictions); and one species requires attention in that despite restricting take to scientific collection, substantial numbers are caught commercially (Figure 3.4-2).

Figure 3.4-2. The status of management (left) and populations (right) for the top commercial fisheries in Santa Monica Bay from 2008-2013. Actively Managed means management is informed by regular stock assessments. Monitored means management occurs, but without the aid of a stock assessment. Not Monitored means some management measures are in place, but data about the stock is not collected or analyzed. Action Required means that management and fishing activity are out of sync. *Data Sources: Ally, Miller & Wertz 2001; Hill et al. 2014; Kalvass et al. 2002; Lopuch 2008; Maunder et al. 2011; Neilson 2011; PFMC 2011; Parker 2002; Porzio & Brady 2006; Rogers-Bennett & Ono 2007; Stephens & Taylor 2013.*



All four of the federally managed species have had recent stock assessments and have FMPs. As a result, the stocks tend to be managed in a way so as to prevent overfishing on a collapsed stock and to encourage rebuilding. The recent management action in 2015, undertaken for the sardine fishery, provides an excellent example. Sardine populations are known to vary dramatically with environmental conditions; the annual stock assessment in advance of the 2015 season showed poorer recruitment than anticipated, so the fishery was closed to prevent overfishing.

Unfortunately, the state does not have the same resources to spend on fishery management that the federal government does. As a result, very few of the state-managed species have had stock assessments. Spiny lobster and California halibut are the only two that have, and while a spiny lobster management plan is under development, one for California halibut has not yet begun. A few more species are monitored, but many of the other important fisheries in Santa Monica Bay are not, and some, like sea hare, have very little data collected about them at all. Because of the lack of data, the state-managed fisheries are more prone to decline. In fact, all three of the top species in the Bay are likely in decline; moreover, all five of the species whose status are unknown, and three of the seven species identified as stable, are managed by the state (Figure 3.4-2).

Data used to make fishery management decisions are either fishery dependent or fishery independent. Fishery dependent data are acquired through fishing activities and speak to what is being caught by different sectors of the fishery. These data include the weight and species of fish caught and catch per unit effort, and can be used to determine the impact the fishery has on the population. Fishery independent data are data acquired from research activities, such as SCUBA surveys, research traps, and research trawl programs. These data can be used to determine the status of the fish population. Both types are needed for fishery management. However, because fishery independent data is more expensive to collect, it is not always available. In California, the California Department of Fish and Wildlife (CDFW) collects fishery dependent data from commercial fishermen, commercial passenger fishing vessels, and recreational fishermen. Most of these data are self-reported. While many reports are accurate, some are subject to human introduced error, such as lazily reporting the same fishing location regardless of where fishing was occurring, purposefully misreporting, or low response rates when responding is voluntary. In the case of the California Recreational Fishing Survey, this also includes mistrust of the surveyor, which can result in refusal to participate. Recreational data is particularly limited in that whole groups of fishermen (such as free divers) are frequently missed, and extrapolation of the small sample size can lead to misleading conclusions.

CDFW has been making progress on developing FMPs for priority stocks statewide, and the network of MPAs established on January 1, 2012 may help buffer against errors in fishery management (see Section 3.3.3 for more on MPAs). However, without reliable data on the life history of these species and the fisheries that target them, efforts to manage these populations will be frustrating at best. To this end, the Santa Monica Bay National Estuary Program supported an effort by the Marina del Rey Anglers to develop a citizen science tool for collecting and reporting "Essential Fishery Information" about California halibut in order to inform a planned revision the stock assessment for this species. More efforts like this are needed to ensure reliable streams of data to support effective fishery management.

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Conclusions and Looking Ahead

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[1] Santa Monica Bay Restoration Commission

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4.0 Conclusions and Looking Ahead

Author: Guangyu Wang[1]

Five years is a short timeframe to detect and report changes in status and trends in environmental conditions. Many natural processes that affect status and trends occur in much longer time spans, and many restoration projects, especially large regional ones, take years to implement and even longer before results are measurable. Despite these limitations, we are pleased to present this report that describes ongoing improvement to the water quality and health of the habitats in the Bay. A few highlights of the past years include the restoration of Malibu Lagoon in 2013, following more than a decade of planning and construction (Section 2.2.2). Elsewhere in the Santa Monica Mountains, we have removed small dams and culverts in our streams, making miles of habitat available for steelhead trout and other wildlife to inhabit. Starting in 2013, we've spent 6,000 hours underwater to restore more than 30 acres of kelp forest off of Palos Verdes. New policies have also changed our land and sea; Santa Monica Bay National Estuary Program (SMBNEP) staff worked with hundreds of other stakeholders to establish a network of Marine Protected Areas throughout Southern California. On January 1, 2012, that network gave us a new way to protect Santa Monica Bay. There are MPAs off of Point Dume in Malibu and Point Vicente in Palos Verdes, where fish and invertebrates are protected from most types of fishing.

Improving water quality along our world-famous coast is a very high priority, and there is clear evidence that our beaches are cleaner, with less trash and bacterial contamination. This is largely due to the diversion of dry weather runoff, zero-trash TMDL implementation, and decreased rainfall. Much of this work is in response to the adoption and implementation of 14 Total Maximum Daily Loads (TMDLs), which limit pollutant loading and toxicity to surface waters in the Santa Monica Bay watershed (Section 1.2). Ongoing efforts to improve the water quality from sewage outfalls is resulting in less contamination on the Bay's soft-bottom habitat, improving the health of local fish and protecting public health.

The drought has brought due attention to water resource management. We see a new paradigm unfolding where water is considered a resource rather than a liability or a byproduct of our former single-use approach. To secure a sustainable water supply for Los Angeles and Southern California, water supply is diversifying to include stormwater, recycled wastewater, and gray water. This dynamic has encouraged new legislation, regulation, and funding, creating unprecedented coordination amongst the agencies that provide or treat our water. In essence, these projects, worth billions of dollars, will reduce pollution in our streams and creeks and reduce discharges and pollutants to the ocean. Meanwhile, these "captured and infiltrated" waters will increase our local drinking water supplies via recharge of our local aquifers. The SMBNEP continues to promote cutting-edge research, technologies, and projects to construct

[1] Santa Monica Bay Restoration Commission

these water-saving, pollution-reducing projects. A greener Los Angeles that makes the most of its water supplies is clearly our future for a healthier and sustainable Los Angeles.

In addition to the drought, the localized effects of climate change will impact virtually every aspect of our Bay Restoration Plan, as well as every habitat in the Bay and on land. We expect a number of changes, namely hotter and drier periods, increased intensity of rain events, ocean acidification, and greater storm surge associated with bigger waves and sea level rise. Accordingly, we have received additional support from the U.S. Environmental Protection Agency to assess our entire plan to prioritize and alter our goals to ensure that our work addresses the stressors of climate change in Los Angeles. We are fortunate to have many partners to draw from at the federal and state levels, and for the research produced by our world-class colleges and universities. Specific examples of this work include the City of Los Angeles's AdaptLA vulnerability assessment, which is now expanded to include all coastal jurisdictions in LA County (http://dornsife.usc.edu/uscseagrant/adaptla/), and the City of Los Angeles' "One Water LA 2040" initiative (http://lacitysan.org/irp/OneWater.htm).

Our mission directs us to restore and enhance Santa Monica Bay through actions and partnerships that improve water quality, conserve and rehabilitate natural resources, and protect the Bay's benefits and values. To accomplish this mission, our work must be contextual and incorporate the stressors associated with pollution, drought, and climate change. Over the years, the SMBNEP has continually found ways to restore and protect habitats, often with great success, and those efforts will continue in the future. With the consideration of Los Angeles in 2000 and 2100, we are looking at our beaches as a place to hold back rising waters, while supporting wildlife and sequestering carbon. Los Angeles' iconic beaches are a great resource for us to rehabilitate and protect, and if we're successful, those beaches will protect us in turn, while allowing us to recreate and surf into the next century.

Our oceans are changing physically and chemically. Helping wildlife cope with these changes by providing large and stable habitats will be key to their survival. Accordingly, our work to restore coastal wetlands and reestablish seagrass meadows off our coast will be prominent actions that we will undertake to enhance flood protection and provide habitat for wildlife. While work to restore coastal habitats will continue and expand, there has also been, and will continue to be, more attention on preservation and restoration of inland habitats, especially more push for protection of natural ecosystems in the Santa Monica Mountains and other headwater areas of the Bay watershed (Section 4.1). Our rivers and streams in these areas in particular will need our assistance as they change in nature, becoming drier and conversely more prone to flooding. Finding a way to reconnect the flow of water and sediment from our mountains through our communities and to the coast may prove to be one of the region's largest challenges, a challenge that warrants a holistic, regional approach in water and sediment management (Section 4.2).

The changing watershed and ocean conditions, as well as management priorities, also pose new challenges to the scientific community. The vast scale and associated potential cost in addressing water quality issues will facilitate research and development of faster and more accurate pollution source identification tools, methods, and technology (Section 4.3). There will also be a new focus on determining the sources and impacts of nutrient loading, especially the role of nutrient loading as it relates to eutrophication, harmful algal blooms, and ocean acidification (Section 4.4, 4.5, & 4.6).

Finally, let's remember that all these works will be supported as they have been in the past by a diverse and dedicated partnership whose interrelated interests and obligations to the people and wildlife of Los Angeles have served our communities well. With the ongoing support of this partnership, the SMBNEP has great expectations for our future and for the continued improvement of the Bay and its people.

URBAN COAST

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Looking Ahead: Protection of Natural Habitats in the Santa Monica Mountains

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4.1 Protection of Natural Habitats in the Santa Monica Mountains

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The coastal watersheds in the northern portion of Santa Monica Bay mainly encompass the Santa Monica Mountains, including more than a dozen streams and cutting through deep canyons and coastal lagoons. Most of these streams and canyons are small except for Malibu Creek, which extends well inland to the Simi Hills and drains approximately 67,000 acres of watershed into Malibu Lagoon. The complex topographic and geologic features of the region provide a backdrop to a diverse and increasingly rare complex of natural ecosystems adapted to the Southern California Mediterranean-type climate of wet winters and warm, dry summers. Vegetation types in the region include a variety of woodlands, valley oak savannas, grasslands, coastal sage scrub, southern willow scrub, several types of chaparral, wetlands, and coastal marshes (Figure 4.1-1). These highly diverse plant assemblages provide habitat for abundant wildlife including fifty species of mammals, nearly 400 species of birds, and over 35 species of reptiles and amphibians (Cooper and Hamilton 2012).

The recent history of the Santa Monica Mountains has continuously been marked by the tug of war between conservationists and private development interests. Thanks to the efforts of early and present-day visionaries, large areas of intact habitat still remain in the Santa Monica Mountains, especially in the upper reaches of the streams, an extraordinary fact given the dense urban development that surrounds the area. By the latest account in 2014, more than half of the 52,000-acre area in the County's unincorporated coast zone is now publicly owned parkland under various levels of protection.

While there are still management issues involving levels of public access and recreational use on the protected public lands, the number one challenge comes from the impacts of new and existing developments in the unprotected areas. The unprotected areas comprise more than 90 percent rural-residential lots and a small percentage of parcels allowing limited small-scale commercial development (Figure 4.1-2). The parcels range in size from less than 0.2 acres (10,000 square feet) to parcels of 80 acres or more. According to a California Coastal Commission report, a typical single-family residence in the area will disturb an average of 4-5 acres of land, inherently degrading habitat; this includes a mandatory 200-foot brush-clearance zone around the structure to meet fire code (CCC 2014). The impacts of developing in these areas include loss and fragmentation of the native habitat, introduction of invasive species, erosion and sedimentation, and impairment of water quality. Native vegetation is often replaced with exotic plants. Construction of new residences, and associated infrastructure if done improperly, will contribute to increased runoff and sediment loading. Impacts on habitats and water quality can be far worse if the developments are close or adjacent to riparian corridors or wetlands. Furthermore, because

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most of the areas are not feasible for sewer hookup, septic systems are usually installed and may cause bacterial and nutrient contamination if not maintained properly.

In 2014, a local coastal program (LCP) for the unincorporated area of the Santa Monica Mountains was adopted by the California Coastal Commission and certified by the Los Angeles County Board of Supervisors (LACDRP 2014). It is hailed as a great victory for people advocating for habitat conservation and is also historically significant, as it is the first time a state-certified plan has been put in place that regulated future development and land use in the area. The new LCP sets more stringent standards for new development through many new policy provisions, limiting the number of subdivisions and the increase of minimum lot size ("downzoning"), and limiting the maximum building site (disturbed area) not to exceed 10,000 sq. ft./parcel, or 25 percent of the parcel size, whichever is less. The LCP also includes new, stronger requirements for stormwater BMPs, positioning of on-site wastewater treatment systems, erosion prevention, slope stabilization, and ridgeline protection.

More significantly, the LCP adopts a strong biological resource protection approach under the principle that protection of habitats is critical to the ecological vitality, and the preservation of ecological diversity takes priority over other development policies or standards (LACDRP 2014). Under this approach, all habitats are mapped and designated into three habitat categories (H1-H3) for the Santa Monica Mountains segment of the county's coastal zone. A new policy was established prohibiting new development, with the exception of a few limited uses, on habitats of highest biological significance and sensitivity (H1), covering almost all woodlands, streams, wetlands, and many other native habitat types. Strict development regulations are also enacted to avoid, or minimize and fully mitigate, impacts to the habitat by new development and to protect the habitat in other categories from significant disruption of habitat values. In addition, the LCP establishes requirements for a buffer zone between development sites and riparian habitats, disallowing fencing around private properties to protect wildlife corridors.

Besides single-family residential development, vineyard and equestrian facilities are the next two major issues. The Santa Monica Mountains have a long history of equestrian uses, including equestrian trail riding and the keeping of equines for personal and recreational use. There are existing confined animal facilities for equestrian use scattered throughout the area, either as a primary use or accessory to residential development. The keeping of horses and other equines is an important part of the rural character of the area and is recognized as such in the LCP. The management approach is not to eliminate equestrian facilities but to ensure the corrals, barns, riding rings, etc. are properly placed and maintained to prevent runoff and other types of damage to streams. The new LCP now requires owners to obtain a permit to ensure their facilities meet the newly established and very stringent criteria, including setback requirements from streams, sloping criteria (no facility on a slope more than 3 to 1) and other BMPs. The county has adopted a phased approach to get facilities permitted first through outreach and encouragement. For facilities still failing to comply under this approach, the operation will have a forced sunset at a maximum of 24 years.

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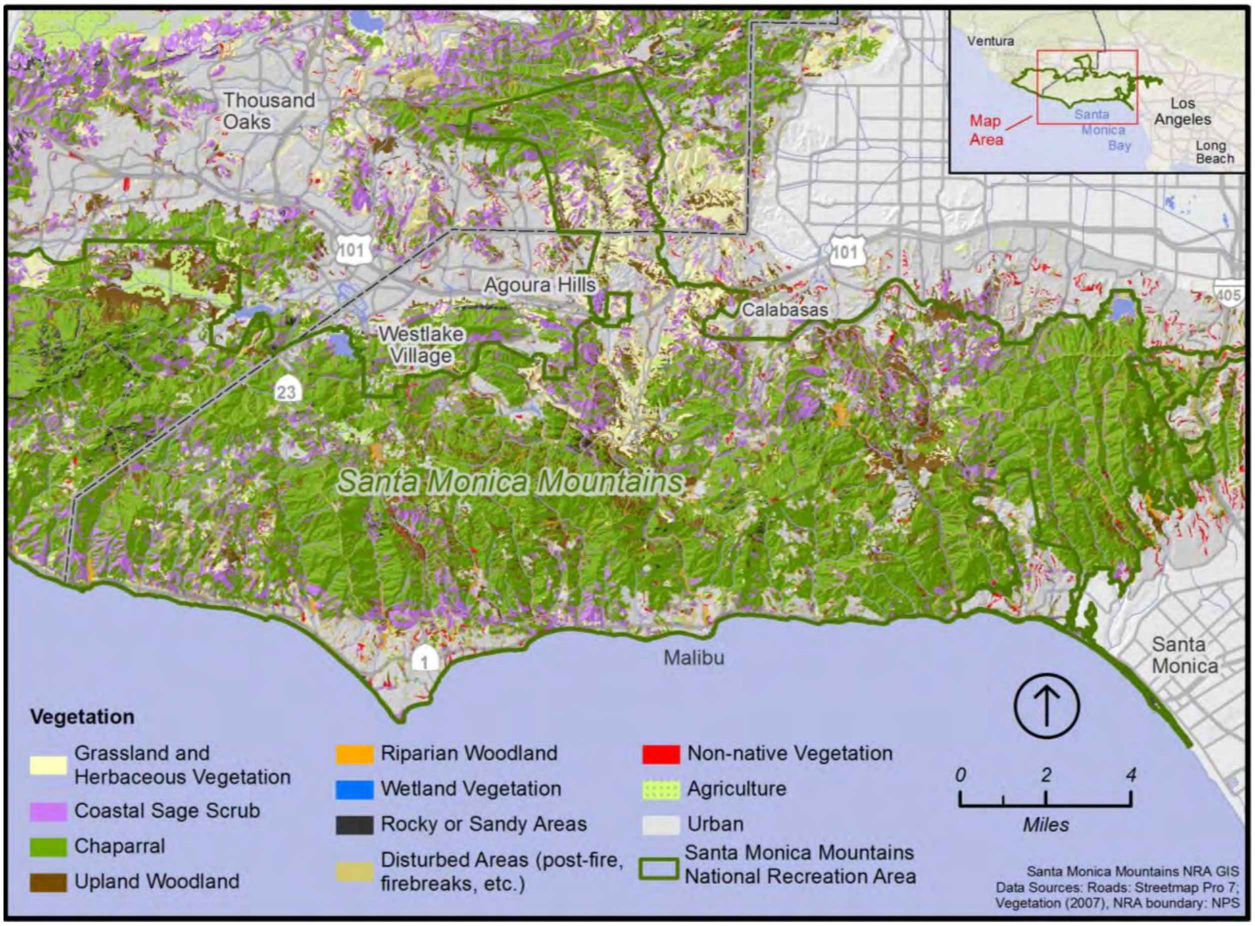
In contrast to equestrian facilities, development of vineyards is a more recent phenomenon. In the past, the planting of grapevines was sporadic, and done partially due to encouragement from fire departments as a fire-safe method of fuel modification. The number of vineyards started to sprout in 2006-2008, as some cash-strapped residents looked for alterative means to make a living, and as the popularity of small, craft-produced wines began to grow. However, if uncontrolled, the impacts of sprawling grape production are not limited to the consumption of water supply; such monoculture also results in the loss of ecological diversity, disruption of native habitats, and potential water quality impairment due to erosion and pollutant runoff. The new LCP has a prohibition on new vineyards. Only a small number of grapevines are allowed if planted in backyard gardens within fuel modification zones that allow irrigation.

Looking ahead, the prospect for stronger and better protection of natural habitats and wildlife in the Santa Monica Mountains looks promising, assuming the county will follow through in implementing the new LCP and provide effective enforcement. Of course, the county is not the only responsible agency in the area. National Parks, California State Parks, Santa Monica Mountains Conservancy, City of Malibu and City of Los Angeles all have jurisdictions over land in the area. In addition, state regulatory agencies including the California Coastal Commission and the Los Angeles Regional Water Quality Control Board play a major role in protecting the natural resources and water quality in the region. Efforts by these jurisdictions and regulatory agencies, many in partnership with the Santa Monica Bay National Estuary Program (SMBNEP), have resulted in significant progress over the last five years. Major accomplishments include full restoration of the Malibu Lagoon, protection of more than 1,000 acres of natural habitats through land acquisition, and septic prohibition enacted for the Malibu Civic Center area.

Despite these accomplishments there remain many challenges, including: continued water quality impairments resulting from storm water runoff and septic discharge; restoration of lost wetland habitats such as Topanga Lagoon; removal of remaining fish migration barriers, especially Rindge Dam for steelhead trout (*Oncorhynchus mykiss*); recovery of the California red legged frog (*Rana draytonii*), eradication of invasive species such as giant cane (*Arundo donax*), red swamp crayfish (*Procambarus clarkii*), and New Zealand mudsnail (*Potamopyrgus antipodarum)*; and adaptation to the impacts of climate change. These challenges must all be addressed through concerted efforts by the county, cities, and state resource management and water quality regulatory agencies.

Figure 4.1-1. Vegetation distribution in the Santa Monica Mountains. *Map Credit: National Park Service.*



Acknowledgements

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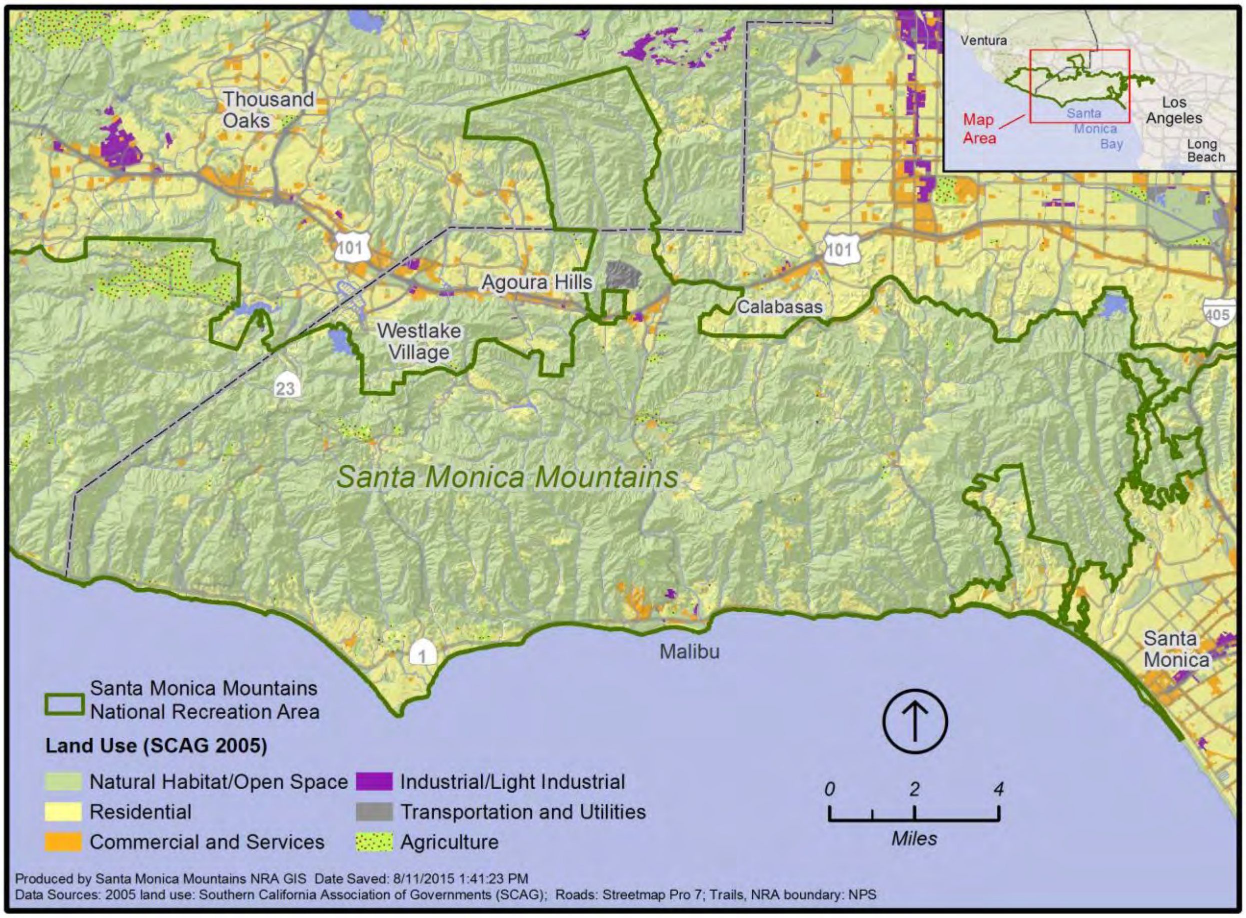
Figure 4.1-2. Land uses in the Santa Monica Mountains. *Map Credit: National Park Service.*



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Looking Ahead: Sediment Management

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4.2 Sediment Management

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There has been growing recognition that the health of the Bay's coastal and upland habitats depends on sediment transport processes in the watershed, and the transport of sediments up and down the coast (Yates et al. 2009). Addressing these issues is becoming increasingly urgent as predictions related to climate change indicate that sea level rise and more intense storm surges will likely cause additional beach erosion (Bird 2000, Zhang et al. 2004, Griggs et al. 2005, McLachlan and Brown 2006). Furthermore, warmer temperatures and altered rainfall patterns may increase the range and frequency of wildfires, potentially leading to more erosion and changing sediment loading in affected upper watershed areas.

The Bay's sandy beaches provide a great example of what might be to come. Several large erosion events with intense waves and storm surges have removed sand from many beaches (Orme et al. 2011). Coastal construction of houses and roads have been followed by installation of seawalls and rock revetments that protect structures, but increase the reflection of waves, and contribute to a higher erosion rate (Runyan and Griggs 2005, Griggs 2005). Beach widths in areas with armoring and coastal construction tend to shrink over time, a classic example of "Coastal Squeeze" (Feagin et al. 2005, Defeo et al. 2008, Dugan and Hubbard 2006, Dugan et al. 2008).

One response to sand erosion is to bring in new sand and replenish the beach, either from an offshore location or a distant source inland. The ecological impacts of these methods are now recognized as more significant than previously believed (Lawrenz-Miller 1991, Moiser and Witherington 2002, Manning et al. 2013, Manning et al. 2014). If offshore subtidal sand is used, its removal disturbs the dwellers of the soft sediments at the source. Placing the sand in a coastal location may bury or smother existing beach life, and recovery may take months or years for some species, particularly if sand grading and raking continue after the initial placement (Martin et al. 2005, Peterson et al. 2000, Peterson et al. 2014). Sediment plumes from the project site can also impact nearby ecosystems, such as rocky intertidal areas or kelp forests (Peterson et al. 2006).

The carbon footprint of moving sand between locations is also extensive. For offshore sand, it means a barge and dredge operate around the clock for months, travelling between the borrow site and the project. Use of an inland sand source requires many trips by dump trucks; at 10 cubic yards per truck, a 100,000 cubic yard project requires 10,000 round trips between the sand source and the drop location. Some proposed projects are 4 times that size, or more.

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LOOKING AHEAD: Sediment Management

An unexpected concern has developed in the past few years regarding the source of sand for beach replenishment projects. In the past it was assumed that sand would be available in sufficient quantities, and of sufficient quality, for any project that could afford to obtain it (Griggs et al. 2005, Flick and Ewing 2009). However, as municipalities begin assessing future needs for sand, this sand will become harder to come by, as a private project proposal to protect homes at Broad Beach recently discovered. To date, no offshore sand sites have been made available for purchase for this project. Municipalities and the county of Los Angeles stressed the importance of those sand reserves for potential future projects on public beaches, making them unobtainable for private projects (Orme et al. 2011, Pilkey and Cooper 2014).

While beach communities desperately try to hold onto the limited sand supplies, the region's flood control agencies constantly worry about how to get rid of the vast amount of sediments accumulated behind the huge network of dams and debris basins along the foothills of the region's mountain range. They run into strong opposition against upland disposal due to the negative impacts from trucking activities and the loss of natural habitat at the disposal sites. Meanwhile, transporting sediments from upper watersheds to beaches via either the existing flood control channel or through mechanical transportation such as trucking have been deemed unfeasible technically and economically.

Sediment accumulated behind dilapidated dams such as Rindge Dam on Malibu Creek is another potential source of material for beach replenishment (Sherman et al. 2002). However, there are still many challenges to address, including environmental impact review and funding, before removal of the dam and the transport of the sediments trapped behind it can flow, or be taken to the coast via trucking or conveyor belt.

It will take a paradigm shift in sediment management to effectively address these challenges and concerns. A holistic, watershed-based approach is required to restore the natural sediment transport process, which is considered the best long-term solution to the problem. This means a shift from dealing with sediment solely as a flooding risk to considering sediment as a resource for our waterways, floodplains, beaches and reefs. It also means changing the management principles that emphasize disposing sediments as waste to places such as landfills, moving toward keeping the sediments within the natural system where they are needed to maintain a balanced sediment budget and the ecological functions of riparian, wetland and beach habitats.

No doubt this shift will be highly controversial and challenging, due to the difficulty in modifying the existing flood control system, institutional barriers, and potential socio-economic impacts. Still, public agencies with sediment management responsibilities should be encouraged to think out of the box and consider taking an integrated and resource-focused approach to sediment management. An important step toward this approach is the incorporation of additional environmental impacts and values into cost-benefit analyses for various sediment management alternatives. One example is the transport and placement of sediment accumulated in upper watershed for beach nourishment. While the cost of this alternative compared to trucking to a landfill may be high from the Flood Control District's standpoint, the cost-benefit equation could shift if the economic benefits of replenishing beaches with natural material are taken into account. Benefits may also include: protection of coastal areas from erosion, flooding, and future sea-level rise scenarios; ecological and recreational benefits of replenished beaches; reduction of carbon footprints; and nutrient cycling. Another important step is to encourage more collaboration among county departments and other agencies to reduce and break regulatory and operational barriers. In addition, more studies and pilot projects should be carried out to promote flow-assisted sediment transport (FAST), or other kinds of sluicing as a mechanism for restoring some natural sediment transport through the system.

Figure 4.2-1. Los Angeles County Department of Beaches and Harbors using bulldozers to protect infrastructure on Dockweiler Beach in preparation for a storm in September 2011. *Photo Credit: Lia Protopapadakis, The Bay Foundation.*

Figure 4.2-2. Sandbags protecting property and contributing to beach erosion on Broad Beach, circa 2008. *Photo Credit: Lia Protopapadakis, The Bay Foundation*

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Looking Ahead: New Development in Beach Water Quality Monitoring and Bacterial Source Identification

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[1] Southern California Coastal Water Research Project

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4.3 New Development in Beach Water Quality Monitoring and Bacterial Source Identification

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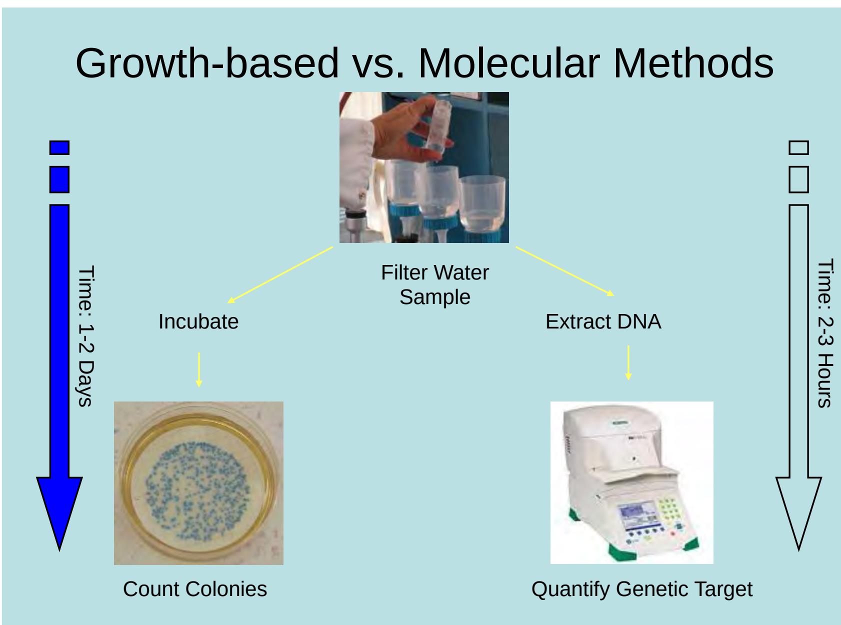
California has the most comprehensive beach water quality monitoring program in the nation. Water quality at California beaches is typically assessed using growth-based measurements of fecal indicator bacteria (FIB) including total coliform, fecal coliform and enterococci. Despite their wide use, growth-based methods are too slow to protect beachgoers from exposure to contaminated water because they require an 18-24 hour incubation period to produce an answer, and most contamination events last less than one day. Thus, swimmers are exposed to contaminated water during the incubation period and oftentimes warned to stay out of the water after the risk has abated.

New faster methods for measuring FIB are now available. In 2012, the United States Environmental Protection Agency (EPA) published new rapid molecular methods for measuring Enterococcus using quantitative polymerase chain reaction (qPCR). These methods do not rely on growth and can be performed in the laboratory in about 2 hours. Known as EPA Method 1609 and 1611, the methods detect and quantify specific gene sequences in bacteria, acceptable levels of which were determined through epidemiology studies (Figure 4.3-1).

Figure 4.3-1. Comparison of growth-based vs. molecular measurement methods for enumerating bacteria in beach water. *Data Source: SCCWRP.*



[1] Southern California Coastal Water Research Project

Despite the increased speed of measurement using qPCR, agencies that conduct beach water quality monitoring have been slow to adopt the new methodology. To date, only three Southern California counties (Los Angeles, Orange and San Diego) have conducted exploratory studies, and only one of these (Orange) has actually used qPCR results to make beach management decisions (Griffith and Weisberg 2011).

There are three types of impediments to agencies adopting qPCR, though none are technical. The first is regulatory. The California Department of Public Health has not yet approved qPCR for beach water quality monitoring and there is no laboratory training or certification program yet in place. Although the State Water Resources Control Board (SWRCB) is moving to revamp the Environmental Laboratory Certification Program, they are at the beginning of this process and it is unclear when and how laboratories will become certified to perform qPCR. There is as yet no estimate for when the Department of Public Health may approve qPCR. The next type of impediment is financial. Funding for beach water quality monitoring was cut drastically during the recession years. Many agencies reduced staffing or instituted hiring freezes during this time. The result was a commensurate decline in beach water quality monitoring efforts and many programs have not yet recovered. Thus, agencies that once tested beach water multiple days per week have cut their monitoring effort to once per week, and some agencies have stopped monitoring water quality altogether during the winter months. An additional disincentive to adopting a new methodology is created by training costs and the fact that setting up a new lab to conduct qPCR can require up to $100K in capital expenditures for equipment and laboratory modifications. There is also the cost of implementation. In order to gain approval to use qPCR at a particular beach, monitoring agencies must run qPCR side-by-side with a growth-based method for an entire season to demonstrate that the methods produce similar results. This requirement means an additional cost, as labs would have to add staff to maintain the old method on top of the increase in training and capital costs. The last impediment is practical. It makes little sense for agencies to adopt a more rapid measurement method if the results are to be used to extrapolate water quality for an entire week. Together, these impediments have stalled adoption of qPCR for beach water quality monitoring in California for the time being.

Despite the obstacles to adoption of qPCR, one agency, the Southern California Coastal Water Research Project (SCCWRP), was able to demonstrate its possibilities. Using funding from a State of California Clean Beaches Initiative Grant, SCCWRP trained and equipped three water quality monitoring labs with varying levels of experience to conduct qPCR at nine beaches five days per week. After an initial training and evaluation period, the labs were able to routinely produce consistent qPCR results and, working with public health officials in Orange County, notify the public of poor water quality before noon of the same day (Griffith and Weisberg 2011) (Figure 4.3-2). This was important because a task force consisting of stakeholders from the monitoring, regulatory, public health, business, and environmental communities asserted that there was little benefit to producing a rapid water quality result if the public could not be notified before they entered the water. During the summer in Southern California, a majority of swimmers do not enter the water before noon and are often heading home by late afternoon. Thus, noon is the critical cutoff for imparting water quality information.

Figure 4.3-2. Electronic sign at Huntington State Beach providing near real-time water quality information to beachgoers. *Photo Credit: John Griffith.*

One outstanding technical question about qPCR is how it will perform across the different beach types found in Southern California. To date, studies have been conducted at only a handful of beaches across the region, and there is not enough data to help predict if the method will perform as expected at any given beach type (embayment, open coast, etc.). For example, one of the important technical issues surrounding the qPCR method is termed 'inhibition'. Inhibition occurs when constituents such as humic or fulvic acids found in environmental water samples interfere with the chemistry of the PCR reaction, which can lead to underestimation of the target. However, it is unclear if this occurs more often at a particular type of beach. To help answer this question, the Microbiology Group from the Bight '13 Regional Monitoring Study organized by SCCWRP is collecting water samples at a variety of beach types from Ventura to San Diego. SCCWRP has trained these agencies in conducting qPCR, and the results are expected to shed light on the performance of the qPCR method across the different beach types in the region. When the current impediments to adoption ease, agencies will already have information about where they are likely to be most successful employing the method.

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In addition to the use of qPCR for beach monitoring, this same technology can be used with only minor modifications to identify sources of fecal contamination in beaches from land-based sources, an application where the impediments delaying implementation of qPCR for beach water quality monitoring do not apply. A recent evaluative study identified sensitive and specific bacterial markers for fecal contamination from humans, cattle, dogs, and waterfowl, and agencies are eager to use them to solve bacterial pollution problems (Boehm et al. 2013). To this end, the SWRCB funded SCCWRP to produce the *California Microbial Source Identification Manual*, which describes a tiered approach to microbial source identification (Griffith et al. 2013). Thus, as more agencies become proficient in the use of qPCR for beach water quality monitoring, beach managers will be able to leverage this expertise to identify and mitigate sources of bacteria to beaches.

Although qPCR was only recently approved by the U.S. EPA for beach monitoring, improved PCR technology is already on the horizon. Digital droplet PCR (ddPCR) is similar to qPCR in that it can detect and quantify the same set of targets. However, unlike qPCR, ddPCR does not require the user to produce a standard curve from reference material for quantification, and is much more resistant to inhibition than is qPCR. Recent studies have shown that ddPCR is able to produce similar but more precise results than qPCR when run in parallel on the same samples, especially when concentrations of the target organism are low (Cao et al. 2014).

While ddPCR improves on the quantification and precision of results compared to qPCR, it does not solve the problem of getting samples from the beach to the lab in time to issue water quality warnings by noon. Further, it is not financially feasible to send individual water samplers to each beach site to speed up data production as was done in SCCWRP's demonstration project. To address this time issue, SCCWRP and its partners at Monterey Bay Aquarium Research Institute and Arizona State University, are developing automated ddPCR technology designed for use in the field. About the size of a small suitcase, the automated ddPCR device would enable beach water quality measurements to be initiated by lifeguards or analyzed while a beach sampler is driving from site to site (Figure 4.3-3). Results would then be telemetered to the lab or public health officials where they could be acted upon in real time. Equally as exciting, the automated ddPCR device could be used by investigators in the field to follow the trails of fecal bacteria directly back to their source.

Figure 4.3-3. Conceptual rendering of a ddPCR device. A) Portable brief-case format digital PCR device with external power outlet; B) The tablet PC with control and data analysis; C) The sample injection port; D) The rapid-replace consumable reagent bay; and E) The target primer library. *Photo Credit: Cody Youngbull, Arizona State University.*

There is now broad consensus in the research community that PCR-based methodologies and tools represent the future of bacterial monitoring and source identification. The newest of these technologies have been demonstrated to be at least as quantifiable and precise as traditional growth-based measurement, and much faster in producing results. Although the initial transition and set-up cost may be high, use of the new methodology will also be more cost-effective in the long-term. Suffice it to say that wide adoption of the new methodology will only be a matter of time. Hopefully, more federal, state, and local support will help to accelerate the process.

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December 2015

Looking Ahead: Ocean Acidification

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[1] City of Los Angeles, Environmental Monitoring Division

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4.4 Ocean Acidification

Authors: Ashley Booth[1], Mas Dojiri[1]

Ocean acidification is often referred to as 'the other CO_2 problem' after global climate change (Doney et al. 2009). Since the beginning of the industrial revolution in the early 1800s, the burning of fossil fuels and changing land use has released billions of tons of carbon dioxide (CO_2) and other greenhouse gases into the atmosphere. Prior to industrialization, the concentration of CO_2 in the atmosphere was ~280 parts per million (ppm). Now, that number is approaching 400 ppm and the increase is accelerating. Scientists now know that about half of this anthropogenic, or man-made, CO_2 has been absorbed over time by the oceans (Sabine et al. 2004). When molecules of CO_2 interact with water (H_2O) they create carbonic acid (H_2CO_3), which lowers the pH of the ocean. By the end of this century, the sea surface is predicted to decrease by 0.3 to 0.5 pH units. This may not seem like a high amount, but pH units are measured on a logarithmic scale, and this rate of change is faster than any time in the past 300 million years (Bijma et al. 2013).

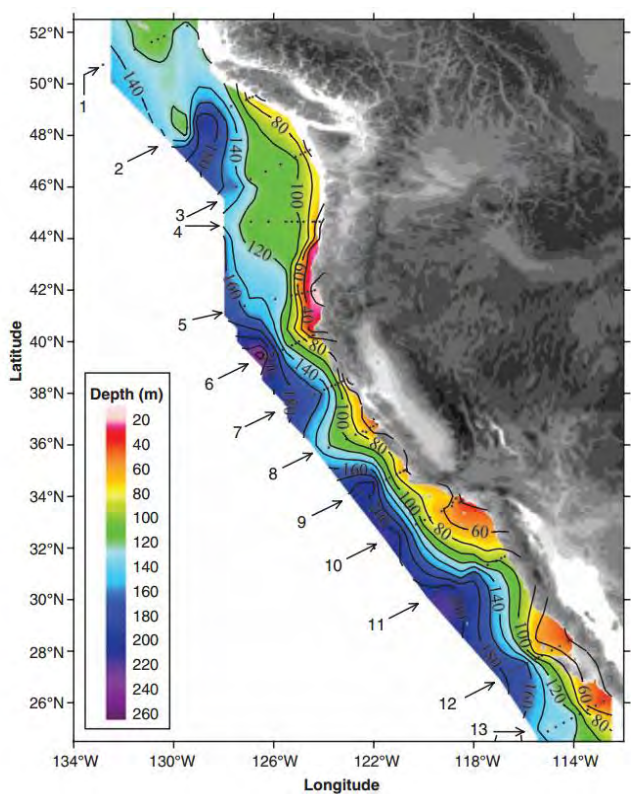

Figure 4.4-1. Depth of "corrosive" water (pH < 7.75) along the U.S. Pacific Coast. The depth of this layer is an estimated 50m shallower due to human generated CO_2 in the atmosphere. On transect line 5, the corrosive water reaches all the way to the surface in the inshore waters near the coast. The black dots represent station locations. *Source: Feely et al. 2008.*

Upwelling zones, like off the Pacific coast of the United States, are particularly susceptible to impacts from increased CO_2 in the atmosphere. In addition to direct acidification, increased temperatures on land could lead to greater winds due to higher coastal pressure gradients, which in turn may intensify upwelling of deep, low pH water (Snyder et al. 2003). An increasing number of studies are documenting the progression of ocean acidification and already observing the effects (Figure 4.4-1). Models predict that much of the nearshore California Current System will experience 'corrosive' waters all summer long in the upper 60 meters within the next 30 years (Gruber et al. 2012). Localized impacts can also have an additive effect, as human inputs of nutrients into coastal waters can lead to the excessive production of algae, a process known as eutrophication.

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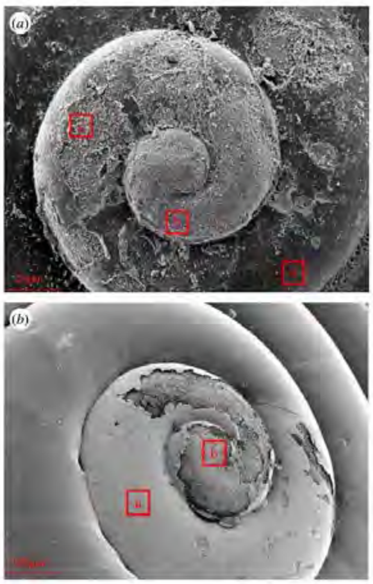
Microbial consumption of this organic matter lowers oxygen, as carbon dioxide production increases through respiration, which lowers pH (Cai et al. 2011).

Figure 4.4-2. Images of sea butterfly (pteropod) shells from a nearshore station showing severe shell dissolution (a), and an offshore station with minor shell dissolution (b). *Source: Bednaršek et al. 2014.*



Ocean acidification can affect many marine organisms, but especially "marine calcifiers" that build their shells and skeletons from calcium carbonate, such as corals, clams, oysters, snails, mussels, urchins, and many phytoplankton and zooplankton, the tiny plants and animals that form the base of the marine food web. Changes to the primary producer community, from phytoplankton to giant kelp, could lead to cascading effects up the food web, influencing marine herbivores and detritivores, and delaying access to recycled trace nutrients (Swanson and Fox 2007).

Marine calcifiers face potential challenges, both from their carbonate shells and skeletons dissolving in the corrosive water and also during the formation of their shells, as the chemical building blocks they need (calcium carbonate) are less biologically available (Orr et al. 2005). The ability of many marine animals, most importantly pteropods, foraminifera, and some benthic invertebrates, to produce calcareous skeletal structures is directly affected by seawater CO_2 chemistry (Fabry et al. 2008). Pteropods (see image) are a type of pelagic marine snail often called sea butterflies and an important prey group for ecologically and economically important fishes (such as salmon), birds, and whales (Armstrong et al. 2005). Significant decalcification of pteropod shells in recently acidified waters off the United States Pacific Coast has been documented (Bednaršek et al. 2014, Figure 4.4-2).

Many local taxa such as sea urchins, corals, mussels, coralline algae, and calcareous planktons have shown signs of vulnerability (Hauri et al. 2009). Larvae of marine calcifying organisms are particularly at risk, especially in upwelling regions. This includes the commercially important red sea urchin (*Mesocentrotus franciscanus*, formerly *Strongylocentrotus franciscanus*) and all seven species of wild abalone, whose populations are already severely depleted due to a combination of fishing pressure, disease, and severe El Niños. Though the physiological research is limited, a few studies have shown some responses to changing pH levels, ranging from abnormal larval shell development under mild ocean acidification conditions (Byrne et al. 2011; Crim, Sunday, and Harley 2011), and some shell decalcification but no decrease in weight gain (White 2011), to no effect on gene expression (Zippay and Hofmann 2010). More research, both *in situ* and in the laboratory, are necessary to determine the long-term impact on these sensitive species.

California's seven abalone species are: black (*Haliotis cracherodii*, endangered), white (*H. sorenseni*, endangered), pink (*H. corrugata, species of concern*), green (*H. fulgens, ,species of concern*), red (*H. rufescens*), pinto (*H. kamtschatkana, species of conern*), and flat (*H. walallensis*).

Economic Impact of Ocean Acidification

Beginning in 2005, production at some Pacific Northwest oyster hatcheries began declining at an alarming rate, posing a severe economic threat. Oyster production represents $84 million of the West Coast shellfish industry (60% of the total revenue), which supports more than 3,000 jobs (NOAA). Marine researchers have definitively linked the collapse of oyster seed production at a commercial oyster hatchery in Oregon to an increase in OA (Barton et al. 2012).

While acidification is persistent, its impact in these areas is seasonal, being exacerbated in the spring with the onset of upwelling of cold, deep, acidic water. As waters acidify, however, the survival of many calcifying coastal species may depend on the timing and duration of low pH events. For example, if major spawning events occur at the same time as sustained periods of upwelling, some animals may see a reduction in their numbers or size. The acidity of the water being upwelled is slowly intensifying as the ocean absorbs more CO_2 in naturally cold subduction zones. This water is then transported by deep ocean currents to coastal upwelling regions where it resurfaces, a process that can take decades. We are just starting to feel the effects of high atmospheric CO_2 from 50 years ago, and higher levels are "in the pipeline" (Feely et al. 2008).

Currently, the science is limited by the precision of the available sensors. Given that ocean acidification occurs in small increments over long periods of time, it will be critical to have precise instruments to detect when important biological thresholds are breached. The California Current Acidification Network (C-CAN), is an interdisciplinary collaboration dedicated to advancing the understanding of ocean acidification and its effects on biological resources along the U.S. West Coast. C-CAN is currently working to standardize ocean acidification monitoring and data management practices to ensure data comparability and quick public access. One of C-CAN's partners, the Southern California Coastal Water Research Project (SCCWRP), is also collaborating with the Wendy Schmidt Ocean Health XPRIZE to develop accurate, affordable, and robust ocean pH sensors. The cooperative of Southern California publically-owned treatment works marine monitoring programs will be the test bed for the newly designed sensors.

Live sea butterfly, pteropod. *Image from Russ Hopcroft, UAF (http://funwithkrill.blogspot.com/2011/08/pity-pteropods.html)*

Not all species are susceptible to ocean acidification; some species even seem to grow better in these conditions (Ries, Cohen, and McCorkle 2009). It is difficult to predict who will be the winners or losers, but what is clear is that the impact of ocean acidification is already being felt and food web changes are accelerating. It is critically important to monitor coastal waters, ecosystems, and economically important fisheries as ocean acidification intensifies, while putting pressure on governments and industries to reduce carbon dioxide pollution.

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URBAN COAST

Special Issue: State of the Bay

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Looking Ahead: Nutrients and Hypoxia

Ashley Booth[1]

[1] City of Los Angeles, Environmental Monitoring Division

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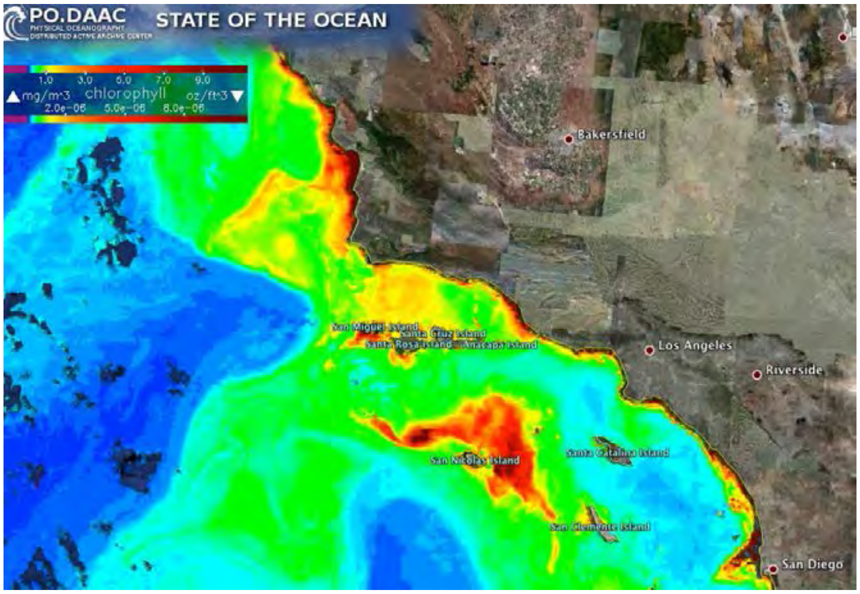
4.5 Nutrients and Hypoxia

Author: Ashley Booth[1]

Human, or 'anthropogenic', activities have accelerated the rate and extent of **eutrophication** through both point-source discharges and non-point loadings of limiting nutrients, such as nitrogen, iron, and phosphorus, into aquatic ecosystems through urban stormwater runoff, agricultural fertilizers, livestock operations, aquaculture, atmospheric deposition, wastewater treatment plants, and septic systems. Eutrophication can lead to intense algal blooms (Figure 4.5-1) including harmful algal blooms (HABs) that result in wildlife mortality and the contamination of shellfish (Sidebar 4.5). In upwelling-dominated ecosystems like Santa Monica Bay, untangling the relative influence of natural (i.e., upwelling) versus anthropogenic nutrient sources in coastal waters has proven to be complex. For these ecosystems, there has been a perception that nutrient inputs from anthropogenic sources are small relative to upwelling, and thus can have little effect on important coastal biogeochemical processes (nearshore productivity, hypoxia, and coastal acidification). However, the results from several recent studies (described below) cast doubt on this assumption and provide multiple lines of evidence that human-derived nutrients are influencing ecological conditions in Santa Monica Bay and the rest of the Southern California Bight (SCB).

Eutrophication is characterized by excessive plant and algal growth due to the increased availability of one or more limiting growth factors needed for photosynthesis, such as sunlight, carbon dioxide, and nutrient fertilizers.

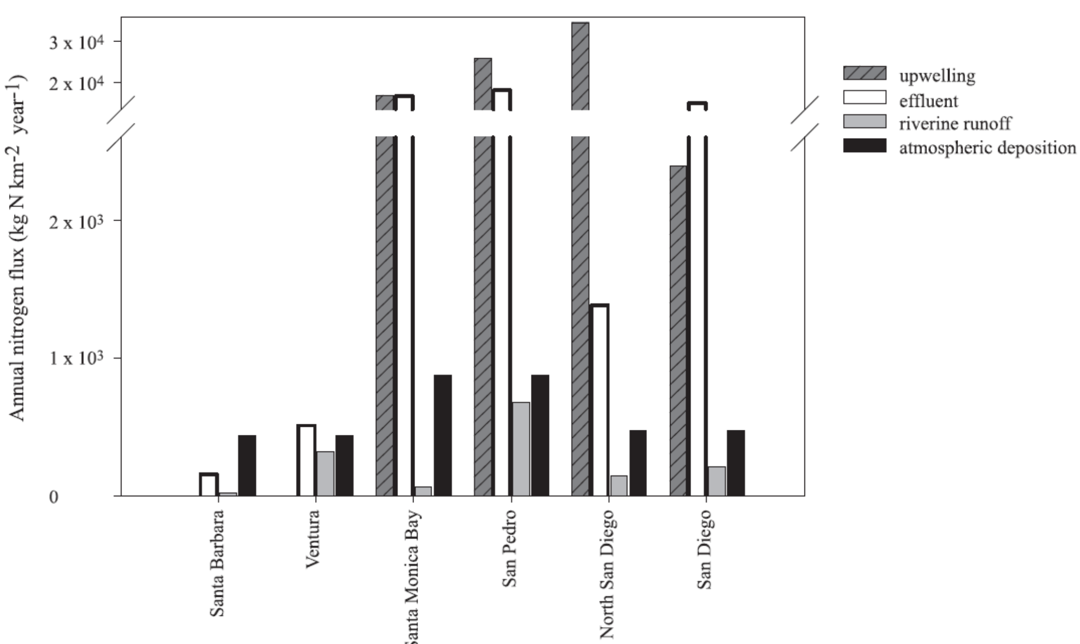
Figure 4.5-1. Example of intense algal bloom in Southern California. The yellow to red colors indicate high levels of chlorophyll (indication of phytoplankton biomass), extending well offshore as well as in narrow bands next to the coastline. In this image, the northern portion of Santa Monica Bay is impacted. *Image from Physical Oceanography Distribution Active Archive Center et al. 2011.*



[1] City of Los Angeles, Environmental Monitoring Division

Municipal coastal wastewater dischargers, along with Southern California Coastal Water Research Project (SCCWRP), have conducted several joint special studies as part of the Southern California Bight Regional Monitoring Program (Bight) to understand the impacts of anthropogenic nutrient inputs into the SCB, including Santa Monica Bay. The Bight '03 study determined that *Pseudo-nitzschia*, a potentially harmful alga that can produce the neurotoxin domoic acid, was significantly more abundant than previously reported throughout the SCB (Nezlin et al. 2007). The Bight '08 study observed high rates of nitrification (the biological transformation of ammonia, the dominant nitrogen form in effluent, to nitrate, a more biologically usable form of nitrogen), which indicated that a significant source of nitrate came from effluent ammonia (Howard et al. 2012). Additionally, there was evidence of effluent nutrients in two trophic levels of the food web (primary producers and zooplankton), indicating that primary producers are utilizing wastewater effluent for growth. Model results also showed that on small spatial scales (~75-100 km of coastline and ~15-25 km offshore), relevant to the development of algal blooms, available nitrogen derived from effluent was comparable or greater than that from upwelling near large wastewater outfalls, whereas riverine runoff and atmospheric deposition were determined to be 1-3 orders of magnitude smaller (Howard et al. 2014, Figure 4.5-2). However, a pilot isotope study conducted in the spring of 2008, during peak upwelling, indicated that effluent nitrate comprised less than 10% of the available nitrate, suggesting that the effects of effluent nitrogen on the nearshore environment may have strong seasonality. Upcoming analysis from Bight '13 will use isotopic markers to distinguish between nitrogen sources and validate model results.

Figure 4.5-2. Total annual nitrogen inputs into each of the six subregions in the southern California Bight, attributed to different sources. Effluent and upwelling are the two most important contributions of nitrogen in Santa Monica Bay. *Figure from Howard et al., 2014.*



Algal blooms can rapidly deplete the available oxygen in surface waters. Recent historical analyses of dissolved oxygen concentrations in the Bay and elsewhere in the SCB compared data collected in the nearshore by the municipal coastal wastewater dischargers with those collected offshore by the California Cooperative Oceanic Fisheries Investigations (CalCOFI). This analysis revealed that dissolved oxygen concentrations have declined throughout the Southern California Bight. However, the rates of decline in the nearshore areas were observed to be up to four times faster than offshore waters, which were concomitant with increased phytoplankton biomass (Booth et al. 2014).

Eutrophication can stimulate hypoxic conditions *and* acidification (see Section 4.4) for more on ocean acidification) in the nearshore when aerobic bacteria break down phytoplankton after a bloom (Zhang et al. 2010, Cai et al. 2011). This process draws down oxygen and generates CO_2, lowering pH in deeper waters where aeration does not occur. However, because the increased atmospheric CO_2 is also driving decreases in pH that are observed in upwelled waters, it is unclear at this time whether the nearshore declines that have been documented are a result of upwelled or anthropogenic nutrient inputs.

The Hyperion Water Reclamation Plant (Hyperion hereafter, discharging in the middle of Santa Monica Bay) and the Joint Water Pollution Control Plant (JWPCP, discharging off Palos Verdes Shelf) recently conducted a special study in Santa Monica Bay. The study assessed existing effluent and receiving water nutrient data to quantify any direct effects of effluent nutrients on the dissolved oxygen (DO), pH, and percent light transmission (LT) of receiving waters (SDLAC and LAC-EMD 2014). A localized effluent effect was detectable, but was within regulatory compliance. It is important to emphasize that the existing dataset cannot answer questions about indirect effects of wastewater nutrient inputs into the coastal environment, which was the impetus for the focus of the Bight projects. While overall nutrient emissions have steadily declined over the last several decades, which would suggest that any recent declines in regional DO, pH, and LT are not being driven by effluent discharges, nitrogen in the form of ammonia did not decrease with the implementation of full-secondary treatment and could be a factor in the declining DO and pH.

The California Ocean Plan (SWRCB 2015) identifies regulatory limits for declines in DO, pH, light transmission, and increases in ammonia around an outfall.

In summary, these studies have provided multiple lines of evidence that anthropogenic nutrients are altering the ecological conditions in the SCB, including the Bay. However, the exact magnitude of the impact of anthropogenic nutrients, and the relative role of different sources, or forms (i.e. ammonia, nitrate, nitrite) has yet to be determined. The Southern California POTWs, including Hyperion and the JWPCP, are in the process of purchasing several ocean moorings, equipped with water quality sensors, to allow staff researchers to have their fingers on the pulse of the Southern California Bight. To insure compliance with California Ocean Plan standards, the relative influence of anthropogenic nutrients on primary production and nutrient cycling must be resolved, and is therefore the focus for the Bight ’13 Nutrients Study. The Program will assess the reliability of the existing pH time series data and collecting precise discrete pH and carbonate chemistry samples in collaboration with researchers at Scripps Institution of Oceanography, as well as working with coastal modelers across the Pacific Coast to estimate secondary effects of anthropogenic nutrient sources. This information will help inform whether further management actions are warranted.

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Looking Ahead: Harmful Algal Blooms in Southern California Waters

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4.6 Harmful Algal Blooms in Southern California Waters

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A great variety of microalgae occur commonly and constantly in the waters off the coast of California. These species range in size from cells just larger than a typical bacterium (0.001 mm) to cells or colonies that are visible to the naked eye. Microalgae are an essential component of marine environments, and constitute a large proportion of the food consumed in the food webs of coastal and open-ocean ecosystems.

While the vast majority of these species are harmless, and even beneficial as the base of marine food webs, a few are capable of producing substances that are noxious or toxic, resulting in illness and even death of marine life and occasionally humans who consume contaminated seafood. When microalgae create these conditions, we refer to them as *harmful algal blooms* (HABs). An older term often used to describe some of these phenomena is *red tide* because of the visible discoloration (usually reddish, greenish, or brownish) that sometimes, but not always, accompanies these events.

The waters off Southern California contain a number of species of algae that can cause harmful events ranging from anoxia (loss of oxygen from the water due to over-proliferation of algae and subsequent decomposition of that biomass) to the production of powerful neurotoxins that can poison thousands of marine animals (Gulland et al. 2002, Kudela et al. 2005). Human illness resulting from these events can occur through the consumption of certain seafood, particularly filter-feeding marine bivalves (clams, mussels, and other shellfish) that strain large amounts of the algal cells from the water, giving rise to such colloquial terms as *paralytic shellfish poisoning* or *amnesic shellfish poisoning*. Two algal species responsible for these latter conditions (the dinoflagellate species *Alexandrium catenatum* and several species of the diatom genus *Pseudo-nitzschia*, respectively) occur commonly in the waters off Southern California and in Santa Monica Bay, as well as other locations throughout the world (Glibert et al. 2005).

Scientific research involving HABs is currently focusing on the environmental factors that lead to outbreaks of these harmful algae and the toxins that they produce. An essential component of that research is vigilant monitoring of coastal waters for the presence of these algae and their toxins (Seubert et al. 2013). Documenting where and when harmful algal blooms arise allows correlation of these outbreaks with local water conditions, enhancing overall understanding of their causes, as well as facilitating human response to these harmful events.

Increased HAB monitoring is the goal of a group of scientists supported by the Southern California Coastal Ocean Observing System (SCCOOS) and the Central and Northern California Coastal Ocean Observing System (CenCOOS). Scientists sample at piers located throughout Central and Southern California, including a station at the Santa Monica Pier operated by the University of

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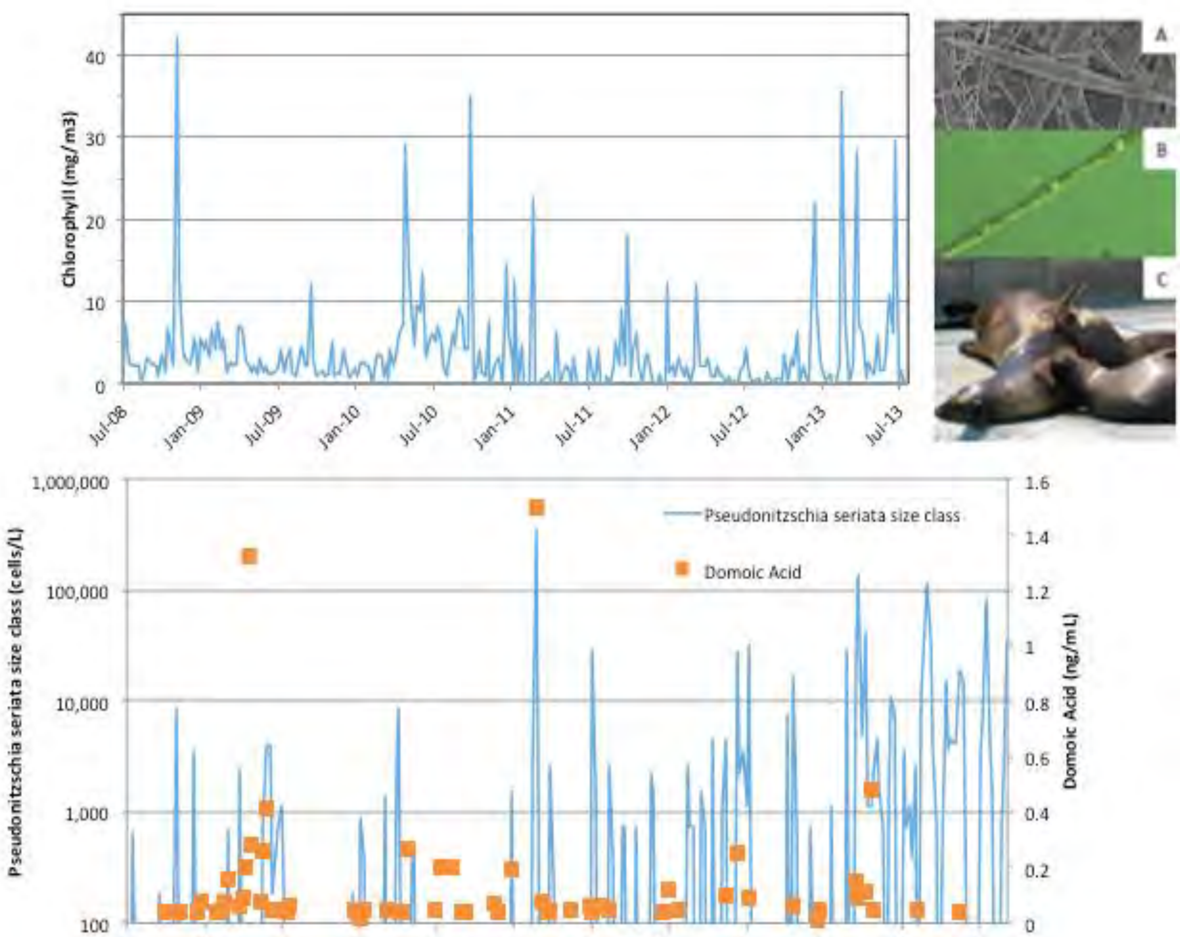
California, Los Angeles. Investigators from each group collect a standard suite of measurements weekly at each sampling location (including data on the absolute and relative abundances of harmful algal species, and nutrient and algal toxin concentrations). These simple measurements provide vital information on the presence or absence of potentially toxic algae and their toxins, and expand an ever-increasing database that is enabling an assessment of long-term changes in the occurrence of HABs in the region and their relationship to environmental conditions. Data collected weekly at each pier since mid-2008 are freely available to the public through the SCCOOS HABs website (http://www.sccoos.org/data/habs/).

Several conclusions have been drawn from the findings of this collaborative effort. Analyses of the data have identified springtime as the dominant season for the appearance of *Pseudo-nitzschia* and domoic acid, the neurotoxin it produces, in coastal waters of Southern California (Schnetzer et al. 2007, Schnetzer et al. 2013). The timing and magnitude of outbreaks of this neurotoxin in the plankton are still difficult to predict, but the trend over the last decade has been one of increasing frequency and severity in our region. Toxic blooms of these algae along the California coast have been linked to mass mortality events of marine animals in Central California since the late 1990s (Scholin et al. 2000), while blooms during 2006 and 2007 along the coast near San Pedro and Long Beach resulted in hundreds of marine mammal and bird deaths. The highest concentrations to date of toxic plankton in our region were measured during a short-lived bloom in surface waters of San Pedro Basin during the spring of 2011. Thus far, *Alexandrium catenatum*, the primary cause of paralytic shellfish poisoning in the region, has been less dominant along the coast of Southern California relative to the major environmental and human health threats it poses in the northeastern and northwestern United States. Aside from these broad generalities, the timing and magnitude of HABs in Southern California waters appears to be a consequence of a complex mixture of hydrology and local conditions rather than any single environmental factor (Figure 4.6-1). Continued study will provide greater insight into the causes, prediction, and (possibly) prevention of these unwanted events.

LOOKING AHEAD: Harmful Algal Blooms

Figure 4.6-1. Data from a weekly time series of samples collected off the Santa Monica pier beginning in 2008. The pattern of chlorophyll concentration in the plankton is shown in the top graph (a proxy for total algal biomass), while abundances of *Pseudo-nitzschia* cells of the *P. seriata* size class are shown in the bottom graph (a group of closely related species that are the most prevalent producers of domoic acid in our coastal region). Orange squares on the lower graph show the occurrence of measurable quantities of domoic acid in the plankton. Note that peaks in chlorophyll (total algal biomass) are not necessarily a good predictor of peaks in the abundances of *Pseudo-nitzschia* cells. Peaks in chlorophyll concentration appear where *Pseudo-nitzschia* cells do not, and vice-versa. Similarly, high abundances of *Pseudo-nitzschia* cells in the water are not necessarily indicative of toxin accumulation in the plankton (red dots). Only some of the peaks in the abundances of *Pseudo-nitzschia* correspond to significant occurrences of domoic acid. This reflects the fact that toxin production by the algae is not constituitive (constant and continuous), but rather is stimulated by specific environmental conditions that are only partly understood. A scanning electron micrograph (A) and photomicrograph (B) of *Pseudo-nitzschia* that caused toxic blooms on the San Pedro shelf during 2007 and 2008 are pictured. Marine mammals (C) and seabirds can suffer domoic acid poisoning by the introduction of toxic algae into their food chain. *Data Source: SCCOOS HABs website.*



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Looking Ahead: Preliminary Examination of Stream Cyanotoxins in Santa Monica Bay and California Watersheds

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4.7 Preliminary Examination of Stream Cyanotoxins in Santa Monica Bay and California Watersheds

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Cyanobacteria ("blue-green algae") are photosynthetic prokaryotes that are nearly ubiquitous in freshwater and brackish habitats. Nuisance cyanobacterial blooms occur commonly (Chorus & Bartram 1999), and are problematic because they can impede the recreational use of water bodies, reduce aesthetics, lower dissolved-oxygen concentrations, cause drinking water taste and odor problems, and sometimes produce toxins (cyanotoxins), the most common of which are microcystins (Butler et al. 2009). Microcystins are powerful hepatotoxins associated with wildlife mortality and liver tumors/cancer in humans (Codd et al. 2005). They have also been implicated in impairment of benthic macroinvertebrate communities, as they can depress bioassessment scores (Aboal et al. 2002). Freshwater harmful algal blooms (HABs, blooms of cyanotoxin-producing cyanobacteria) have been increasing in geographic range, frequency, duration, and severity as a result of various anthropogenic factors, including nutrient enrichment and changes in temperature (Paerl & Huisman 2008, Paerl & Paul 2012, Paerl et al. 2011). Although little data are available on cyanotoxins in the Santa Monica Bay Watershed, based on what data exist, there is currently no indication of a persistent cyanotoxin problem in SMB streams. Nonetheless, toxic cyanobacterial blooms are an emerging issue throughout California, and merit our attention.

Exposure of estuarine and marine biota to high concentrations of microcystins in outflows from impaired freshwater systems has been implicated in the injury or death of marine fish, shellfish, and mammals. The most notable impact in California has been the recent mortality of over 30 federally threatened southern sea otters in and around the Monterey Bay National Marine Sanctuary (Miller et al. 2010, M. Miller pers. comm.). Pinto Lake, a eutrophic lake that experiences frequent cyanobacterial blooms, has been identified as a source of the toxin. Pinto Lake is drained by the Pajaro River, which periodically transports the toxin to Monterey Bay, where it can bioaccumulate in bivalves and ultimately be consumed by the otters (Miller et al. 2010). Microcystins have been shown to be a persistent issue in the major coastal watersheds that flow into the Monterey Bay National Marine Sanctuary (Gibble & Kudela 2014). This phenomenon has been the basis for increasing interest in the transport of cyanotoxins from their source to distant areas via waterways. These toxins can be persistent in the environment, with half-lives spanning weeks to months. Thus, it is important to pay attention to receiving waters downstream from cyanobacterial hotspots, as the experience in Monterey suggests.

Despite the potential importance of cyanotoxin-containing HABs to a wide range of agencies (e.g., those dealing with human and wildlife adverse health effects, or with recreational resources or water supply), the prevalence of cyanobacterial blooms and associated concentrations of

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cyanotoxins are not routinely quantified or monitored in California, hindering the informed development of effective management responses. In an effort to address this data gap, a group of scientists from the Southern California Coastal Water Research Project (SCCWRP), the San Diego Regional Water Quality Control Board, UC Santa Cruz, and CSU San Marcos have begun examining the prevalence of cyanobacteria and cyanotoxins throughout the state. This work has revealed that cyanotoxins (and in particular, microcystins) are widespread throughout Southern California, in every fresh or brackish water body type that has been tested to date (i.e., wadeable streams, depressional wetlands, lakes, lagoons, and estuaries).

In contrast to the region as a whole, only limited cyanotoxin production has been documented within the Santa Monica Bay Watershed, and this is limited to select streams in the Santa Monica Mountains. Although this finding is based on sparse sampling, and few conclusions can be drawn at this time, the low frequency of cyanotoxin production observed in the watershed suggests that future work to examine drivers of toxin production in streams may be able to use the Bay's watershed as a control.

Due to the episodic and ephemeral nature of toxic blooms, in general, the fact that cyanotoxins are widespread throughout the state means that they should be "on the radar" for any watershed monitoring program, as their presence might help explain unexpectedly low bioassessment scores (e.g., the California Stream Condition Index, CSCI, based on benthic macroinvertebrates, see Section 2.2.1 for more on bioassessments) and/or unexplained wildlife mortality (as exemplified by the Monterey Bay sea otter story). Better understanding of what causes toxin production and the potential for effects of cyanotoxins on aquatic life (both upstream and down) will be critical for developing informed management approaches, if and when they are needed.

For more information on cyanotoxin research, contact Dr. Meredith Howard (mhoward@sccwrp.org).

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