Urban Coast

The Journal of the Center for Santa Monica Bay Studies

Urban Greening | Public Access | Sustainable Seafood | Coastal Opinion Poll | Beach Water Quality
Historical Ecology | Ballona Wetlands Assessment | Diversifying Environmental Education
Preserving Habitat | Colorado Lagoon Restoration | Sustainable Infrastructure

Volume 3, Issue 1, March 2012

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LMU | LA

The Center for Santa Monica Bay Studies

a program of the Seaver College of Science and Engineering at Loyola Marymount University and the Santa Monica Bay Restoration Foundation

Diver Collects Sea Urchins as Part of Kelp Restoration Project

PHOTO: MICHAEL QUILL

PHOTO: JOHN HOLLENBECK

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PHOTO: GERICK BERGSMA 2010 / MARINE PHOTOBANK

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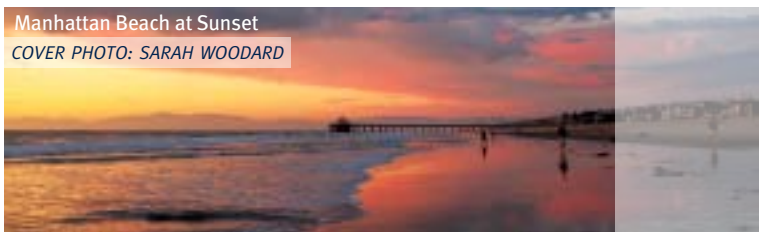
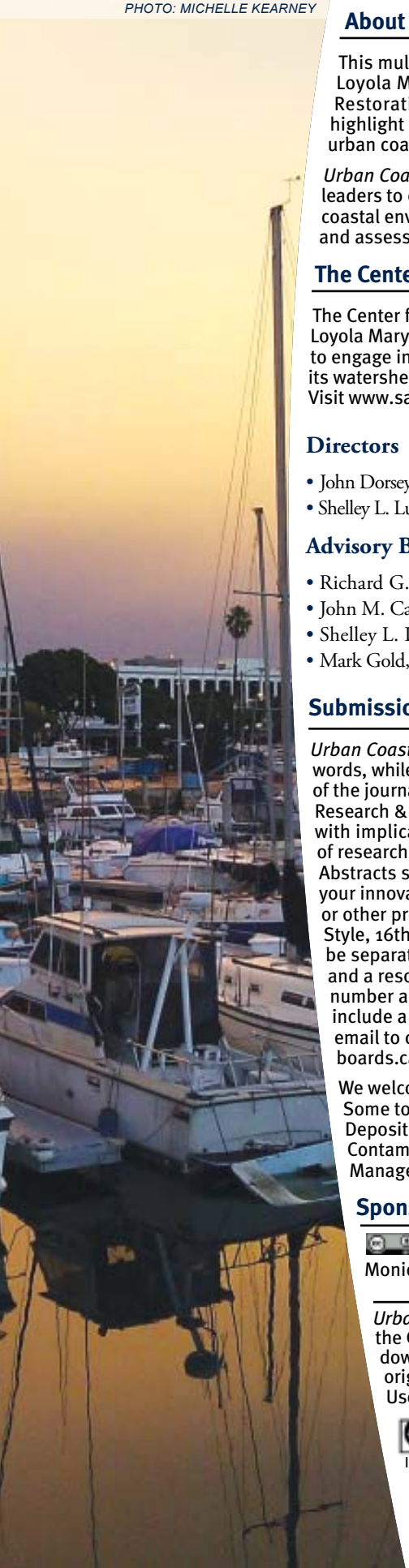


About Urban Coast



Boats in Marina del Rey

PHOTO: MICHELLE KEARNEY

About Urban Coast

This multidisciplinary 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 Santa Monica Bay Restoration Foundation. *Urban Coast* fulfills the Center's goal of providing a much-needed forum to highlight research that informs the most pressing issues of our day and policies that affect the condition of urban coastal resources.

Urban Coast is the ideal forum for researchers, agencies, advocacy groups, and other science and policy leaders to engage in constructive discussion and information exchange on issues that are pertinent to our coastal environments. In this way, we can find common ground and highlight the robust science, analysis, and assessment needed to catalyze good policy, design, and management measures.

The Center for Santa Monica Bay Studies

The Center for Santa Monica Bay Studies is a program of the Seaver College of Science and Engineering at Loyola Marymount University and the Santa Monica Bay Restoration Foundation. The mission of the Center is to engage in multidisciplinary research on environmental and social issues affecting Santa Monica Bay and its watershed, and to contribute to policies and actions that improve the environmental condition of the Bay. Visit www.santamonicabay.org.

Submissions

Urban Coast is a peer-reviewed publication. Feature articles are generally between 4,000 and 6,000 words, while short submissions are between 1,000 and 3,000. Submissions are accepted for all four sections of the journal, including Perspectives with essays and editorials that review current conditions or policies; Research & Policy features articles on scientific or policy studies; Case Studies are detailed project reports with implications for the urban coastal environment; and Notes & Abstracts include short descriptions of research, policy, and events relevant to our urban coastal environment. Submissions for the Notes & Abstracts section are between 250 and 500 words, and should be an abstract or a short summary about your innovative environmental research, technical study, restoration project, BMP or LID implementation, or other projects. All submissions should be written according to the standards of the Chicago Manual of Style, 16th Edition. References should be placed at the end of the document. Tables and images should be separated from the text. Images should be provided in .tif format, not exceeding a width of five inches and a resolution of 600 dpi (a width of 3,000 pixels). Include the article's title; the author's name, phone number and email address; and a two-sentence biographical statement. Article submissions should include a 250-word abstract. Submissions will be accepted on a rolling basis. Feel free to contact us by email to discuss your ideas. Please send manuscripts as .doc attachments via email to: swoodard@waterboards.ca.gov.

We welcome submissions for science and policy topics pertinent to the urban coastal environment. Some topics for consideration include: Habitat Preservation and Restoration, Stormwater Issues, Aerial Deposition, Water Conservation/Independence/Quality, Rapid Indicators, BMP Effectiveness, Emerging Contaminants, Low Impact Development, Climate Change, Sustainability, Invasive Species, Resource Management, Environmental Justice, and other pertinent coastal science and policy topics.

Sponsors

Publication of *Urban Coast* is made possible in part by the generous sponsorship of Santa Monica Seafood Company, Tidal Influence, Great Ecology, Inc., and Ballona Wetlands Conservancy.

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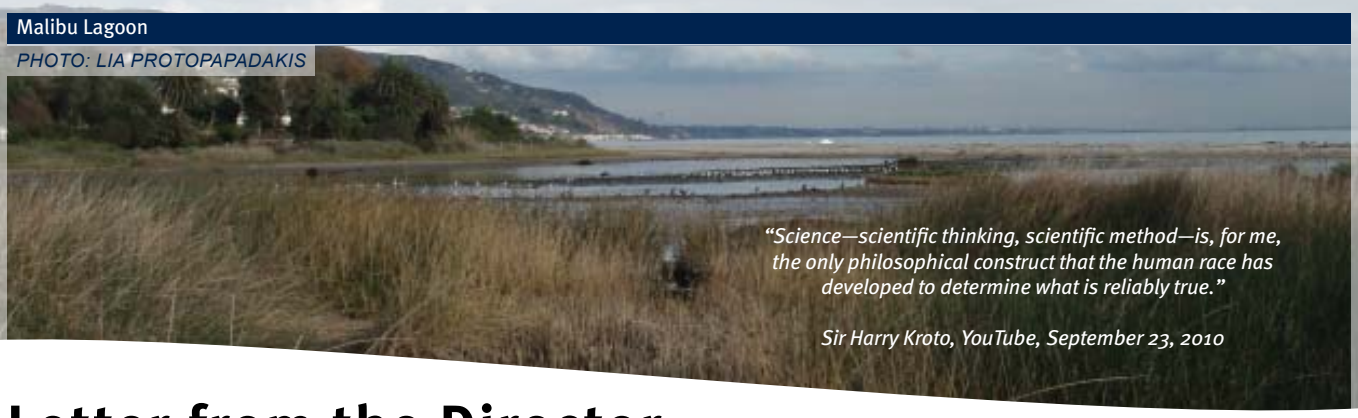
ISSN 2151-6111

Welcome



Malibu Lagoon

PHOTO: LIA PROTOPAPADAKIS

"Science—scientific thinking, scientific method—is, for me, the only philosophical construct that the human race has developed to determine what is reliably true."

Sir Harry Kroto, YouTube, September 23, 2010

Letter from the Director

In Science We Trust... Maybe

Science can be defined as the tested, systemized, and accepted knowledge of general truths or laws. As John Ruskin (1960) said, "The work of science is to substitute facts for appearances, and demonstrations for impressions." However, when it comes time to apply science, the tested and accepted knowledge may not fit with strongly held impressions or opinions, and then we find ourselves in conflict. We have seen this writ large in the politicized debate over climate change, and in recent work that the Santa Monica Bay Restoration Commission and others are doing to repair and enhance coastal wetlands in Los Angeles County.

It is no surprise. After all, there are many variables, interests, new pieces of information, and lessons learned from past applications to consider. While science strives to be black-and-white, the application of science is gray by comparison. Politics, passions, and opinions can easily cloud issues and sometimes outweigh reason and impede progress.

When addressing controversial issues, a scientist's role is to explain the facts and avoid subjective interpretation. Scientists are sometimes pitted against each other, when they are not actually in disagreement on the science, just its application. However, although some may choose to distort science through misrepresentation or selective use, these actions do not change the facts. The oceans are overfished, the climate is changing, and urban wetlands are endangered—regardless of how you and I feel about it.

Science is often ignored or distorted because of the inconvenience of facts when making decisions that also affect the environment. Applying science along our urban coasts requires tough decisions about balancing the restoration or preservation needs of the environment against other human interests and priorities. At Malibu Lagoon, for example, scientists agree the water is unhealthy and action must be taken to repair historic damage to the lagoon so it can support a thriving and diverse community of species and be resilient to future insults. This restoration project is supported by the most respected environmental groups in the region, including Audubon, Surfrider, Sierra Club, Heal the Bay, and Santa Monica BayKeeper. However, the project has suffered delays from a small but vocal group whose opposition is based on opinion and impressions, and not justified by science. The result is delayed action, continued damage to lagoon plants and animals, and escalating costs. Thankfully, the most recent court ruling affirms the robust science behind the restoration plan and allows the project to proceed in the summer of 2012.

It seems to be human nature to reject facts that get in the way of our opinions, but then our opinions get in the way of good projects and good science. It is the duty of scientists, including me, to communicate science in accessible ways, to promote better understanding of ecological principles, and to encourage the public to embrace change and create a more sustainable urban system. For our own survival, and that of the ecosystems we depend on, coastal communities must move forward with good projects based on good science. After all, allowing a few people's personal opinions to bog down restoration projects equates to doing nothing, and doing nothing will never solve our environmental problems.

Shelley L. Luce, Executive Director
Santa Monica Bay Restoration Foundation

References

Kroto, Sir Harry. 2010. "Ask a Nobel Laureate." (YouTube). NobelPrize.org.

Ruskin, John. 1960. The Stones of Venice. Vol. III. Edited by J. G. Links. New York: Farrar, Straus & Giroux.

Surfing in the South Bay

PHOTO: SARAH WOODARD

Urban Coast

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Urban Coast Volume 3, Number 1

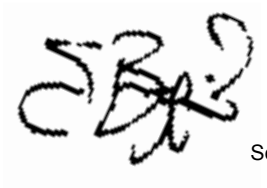
Editor's Note

Ballona Open House

PHOTO: SMBRF

I would like to take this opportunity to thank all those involved with Urban Coast: Dr. Shelley Luce for the guidance and support to produce a much-needed forum to discuss the many and diverse issues of coastal environments; Sarah Woodard for the drive and persistence to create a high quality journal; Dr. John Dorsey, the advisory boards of Urban Coast and the Center for Santa Monica Bay Studies, as well as the Staff and Technical Advisory Committee of the Santa Monica Bay Restoration Commission, whose input I have greatly valued; and, the authors. Thank you.

Dr. Guangyu Wang will be taking the reins of Urban Coast for the next issue. I am now working with Great Ecology, Inc., an ecological consulting firm focused on the restoration, planning, and design of both natural and urban environments through sustainable solutions.



Sean Bergquist, M.E.M. Principal Ecologist
Great Ecology, Inc.

Ballona Wetlands
PHOTO: SMBRF

Letter from the Editor

An Ecosystem-Based Approach to Mitigation

In this issue of Urban Coast, we consider the many impacts to our coastal areas as well as the health and access implications, community understanding, and restorative actions. In Southern California, the greatest impacts have been to our coastal wetlands, where we have lost over 90% of the historic extent (See page 61). Unique landforms, mountains plunging into the sea, and intermittent stream flows have placed these rare habitats in direct conflict with development. Coastal wetlands were initially filled for agricultural production, but as the population grew, urban development, ports, and harbors further consumed these habitats. The good news is that each of the remaining wetlands has some form of action plan in place, either in the conceptual design or the implementation phase. However, the results of these plans may not provide the ecological functions comparable to those that historically existed. The costs associated with restoring coastal habitat are extreme. Real estate and construction costs put restoration out of reach of all but the largest agencies (e.g., ports) or businesses (e.g., power facilities), none of which are practiced in the field of restoration.

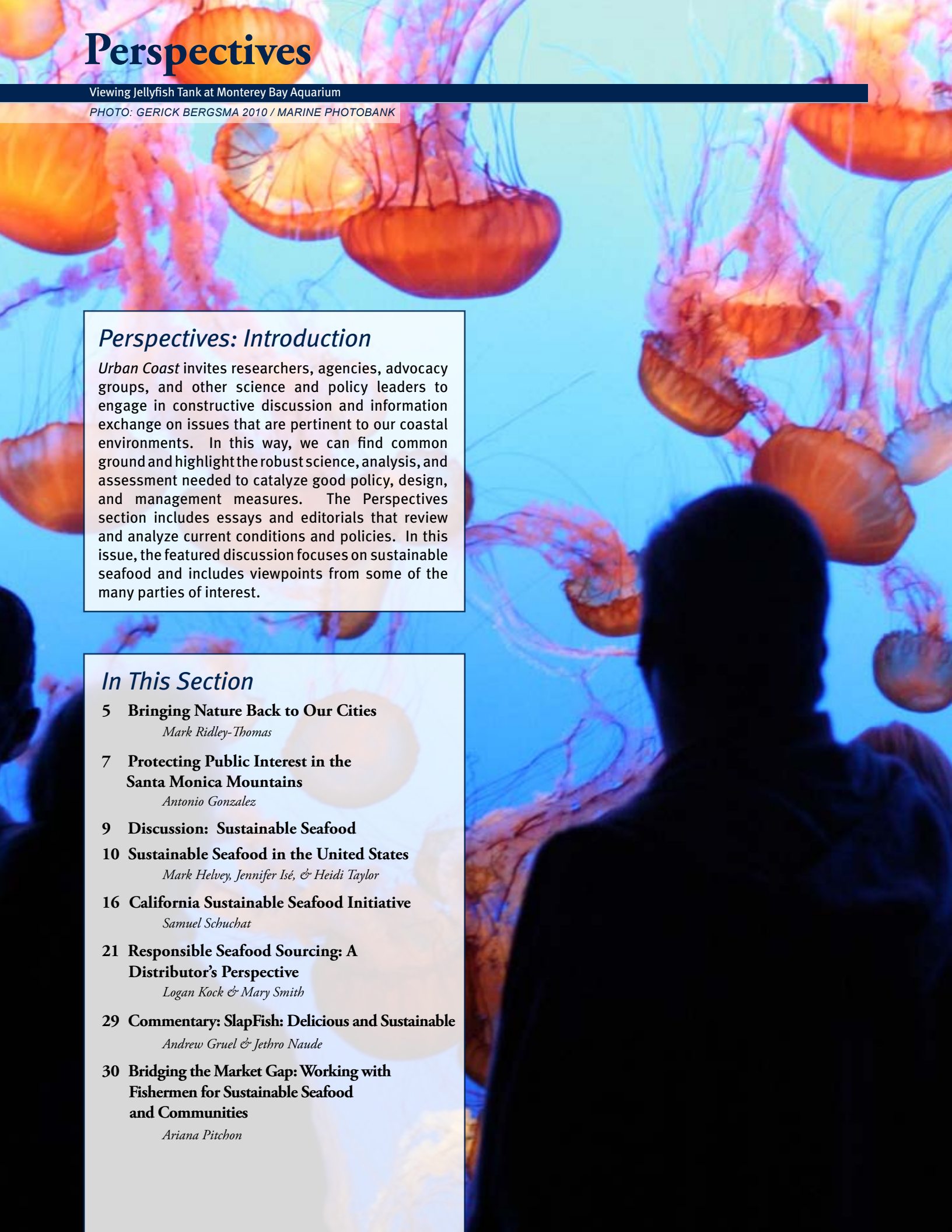
Today, the driving force compelling large organizations (ports, power facilities, etc.) to get involved in, and spend dollars on, the restoration of coastal wetlands is their need to mitigate for recent impacts. As we look back in the historical record, we see wetlands dominated by salt marsh and mudflat habitats (See page 54) dotting the Southern California coast. With few of these habitats remaining, impacts are now concentrated in near-shore, open-water habitats such as harbors, ports, and power facilities, followed by increased desalination efforts. This is creating conflict. Resource agencies and regulators are setting standards for mitigation that directly conflict with ecologically sound restoration practices. Agencies are often hamstrung by strict laws requiring mitigation of similar habitats at or near the existing impacts and narrowly focused agency mandates for high value ecosystem services – such as commercial fish production – rather than ecosystem functions.

The result is that large, well-funded organizations are leading restoration projects in need of their funding. These organizations are directed by no-net-loss mandates and are forcing habitats that achieve their mitigation needs into the few remaining spaces that persist on the coast. While coastal California is achieving significant gains in fish production and protected open-water habitats, we are missing critical opportunities to restore lost ecological functions—opportunities that we may never regain. As remaining impacted and degraded lands are restored to compensate for impacts to open-water habitats, opportunities to restore salt marsh, mudflats, and other associated habitats are permanently lost.

The solution requires a more holistic approach by agencies that control mitigation dollars, with greater flexibility to look further back in time, to habitats lost when our urban coast was first developed, rather than just their current impacts (See page 85). Resource agencies and regulators should focus on improving regional ecosystems and the rarest, most impacted, or most ecologically valuable habitats. This may require allowing restoration that is not in-kind. The extremely rare and impacted habitats of coastal wetlands should be highly valued, and restoration of ecosystem functions should be encouraged. Without this regional ecosystem-based approach we will continue to lose valuable habitats in the name of mitigation, instead of development.

Sean Bergquist, M.E.M. Principal Ecologist
Great Ecology, Inc.

Perspectives



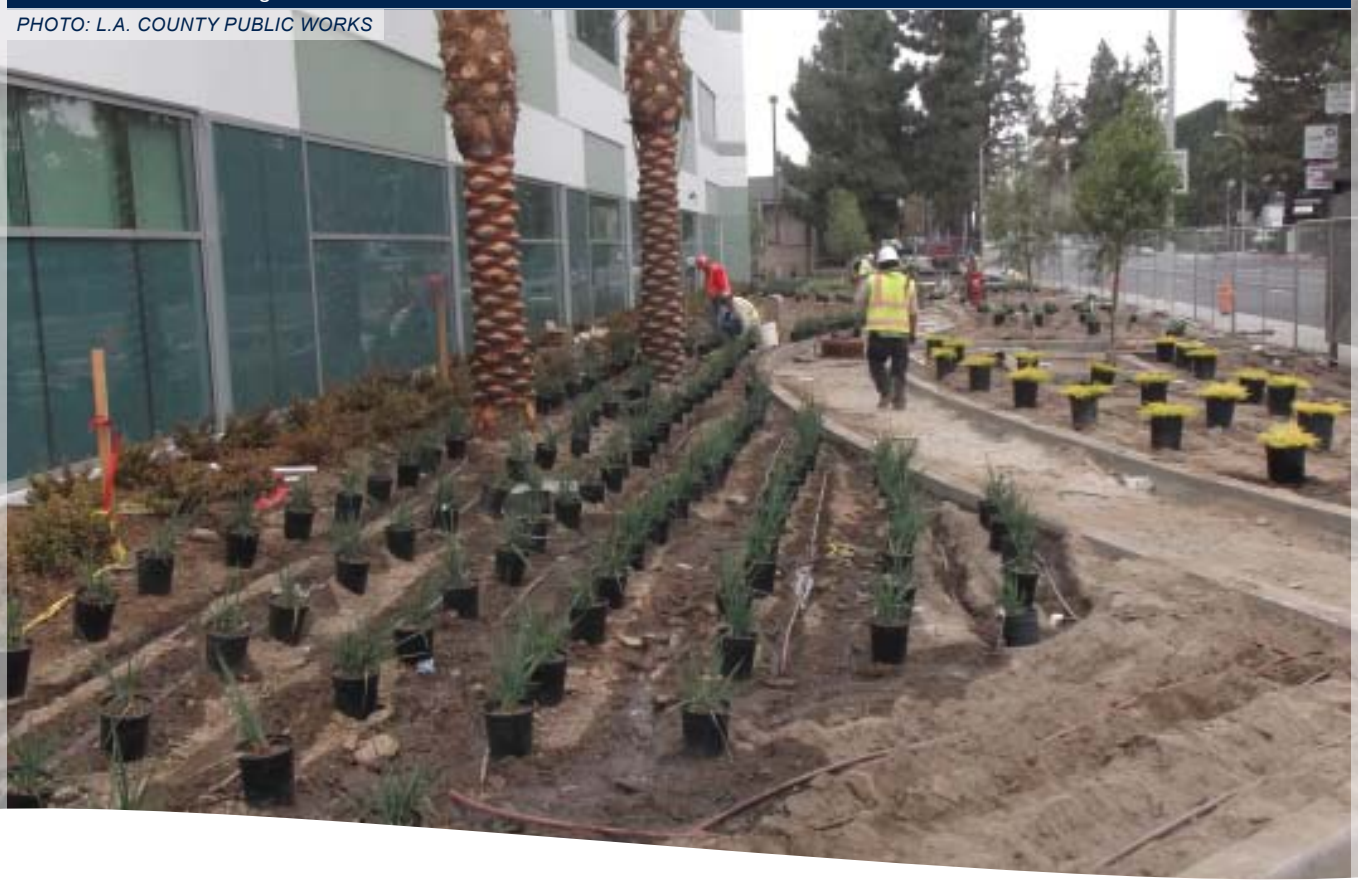
Viewing Jellyfish Tank at Monterey Bay Aquarium

PHOTO: GERICK BERGSMA 2010 / MARINE PHOTOBANK

Perspectives: Introduction

Urban Coast invites researchers, agencies, advocacy groups, and other science and policy leaders to engage in constructive discussion and information exchange on issues that are pertinent to our coastal environments. In this way, we can find common ground and highlight the robust science, analysis, and assessment needed to catalyze good policy, design, and management measures. The Perspectives section includes essays and editorials that review and analyze current conditions and policies. In this issue, the featured discussion focuses on sustainable seafood and includes viewpoints from some of the many parties of interest.

In This Section



MLK Fitness Garden Planting

PHOTO: L.A. COUNTY PUBLIC WORKS

Bringing Nature Back to Our Cities

MARK RIDLEY-THOMAS

The landscape of Los Angeles in 2012 strikes a dramatic contrast compared to that of the century prior, when orange groves dotted the southland, streams flowed naturally, and open space abounded.

The rapid urban development of Los Angeles County, which grew from just over 500,000 to almost 10 million over the past 100 years, is a profound accomplishment. Modernization has brought many benefits; an accessible public transit system, award-winning architectural designs, and tourist amenities galore, but even these cannot overshadow some of our mistakes.

We have paved our river channels, built freeways that bisected communities, and allowed for development on precious land that was once home to sensitive and unique habitat. The ecological consequences of unfettered development have not been without drawbacks; there is insufficient water to feed our lawns, our climate is changing, and we must adapt. Our destruction of the natural habitat has had consequences beyond the aesthetic; the built environment now accounts for approximately 40% of all of our carbon emissions . Also, we have jeopardized our ability to provide sufficient open space and parks for our children and families.

Park to Playa Trail Map

IMAGE: ALTA PLANNING

Garden Installation

PHOTO: L.A. COUNTY PUBLIC WORKS

Before & Proposed: Dominguez Channel Greenway

PHOTO / IMAGE: L.A. COUNTY PUBLIC WORKS ARCHITECTURAL ENGINEERING DIVISION

Existing Multi-Use Trail

Multi-Use Trail with Proposed Improvements

We can look at our dams, aqueducts, freeways, bridges, and buildings with pride, but the future health and prosperity of our county will significantly depend upon a systematic effort to restore and revitalize the natural ecosystems we once rushed to pave over.

In the Second District, we are rebuilding our communities and re-envisioning our natural spaces, one project at a time. Exciting developments include the 13.2 mile Park to Playa Trail, which promises to be the first urban trail that will connect bikers, hikers, and bicyclists from the beach to the communities of Ladera Crest, View Park, Baldwin Hills, and beyond.

With our residential communities almost completely built out, we are exploring unconventional opportunities for creating open space—this means linear parks in Wiseburn, a fitness garden by the new MLK Hospital Campus, and intimate community gardens under utility lines in Florence-Firestone and on the Caltrans right-of-way in Lennox to transform communities as well as their eating habits.

We are investing in multi-benefit projects, such as the Dominguez Channel, where the County Flood Control District will soon begin work on major pedestrian and bike improvements, along with educational signage, because our creeks can and should do much more than provide flood protection.

We have engaged academia, environmental advocates, and other public agencies in developing a Regional Climate Action Plan that will inventory our emissions and develop practical strategies for reducing our carbon footprint. The Board of Supervisors now requires developers of new residential and commercial buildings to abide by green building standards and low-impact design features, and we require it of ourselves as we build new libraries, community centers, and other public spaces.

This era of new challenges calls for new strategies. If we want to bring nature back into our cities we need everyone's input: scientists, policy makers, engineers, builders, financiers, and visionary politicians. In Los Angeles County, we have everything that we need to rebuild and un-pave our urban coastal region in order to create functioning ecosystems and healthy communities; we just need the collective will to do it.

[1] US Census

[2] US Green Building Council

MARK RIDLEY-THOMAS *is a member of the Los Angeles County Board of Supervisors and represents the Second District, which includes the cities of Culver City, Compton, Lynwood, Hawthorne, Inglewood, and a portion of Los Angeles in addition to numerous unincorporated areas such as Lennox, Florence-Firestone, Willowbrook, and Athens.*

Upper Las Virgenes Open Space (formerly Ahmanson Ranch)

PHOTO: SANTA MONICA MOUNTAINS CONSERVANCY (SMMC)

Protecting Public Interest in the Santa Monica Mountains

ANTONIO GONZALEZ

I grew up in Los Angeles and the San Gabriel Valley and saw development sprout up all around me. I often heard talk about the population of California swelling to such a degree that there would be one continuous city from San Diego to San Francisco.

In this nightmare scenario, only wealthy landowners would have access to open spaces and the coastline. Fortunately, the people of California fought back. They established public agencies like the California Coastal Commission and the Santa Monica Mountains Conservancy—of which I am the Chairperson—to champion the public interest in protecting the state's natural and scenic resources for the well-being of present and future residents of the state.

The Santa Monica Mountains Conservancy's mission is to strategically buy back, preserve, protect, restore, and enhance treasured pieces of Southern California to form an interlinking system of urban, rural, and river parks, open space, trails, and wildlife habitats that are easily accessible to the general public.

The Conservancy has helped to preserve more than 60,000 acres of parkland in both wilderness and urban settings, including Corral Canyon Park in Malibu, Upper Las Virgenes Open Space (formerly Ahmanson Ranch) on the border between Los Angeles and Ventura Counties, the Santa Clarita Woodlands, and Vista Hermosa Natural Park near downtown Los Angeles.

Acquiring land for the public is only the first step toward meeting the Conservancy's mission. Major challenges arise in the actual opening of public land for public use by providing the restrooms, parking, trails, and other facilities that make open-space parks truly accessible. In the densely populated coastal region of Los Angeles, some private landowners strongly oppose plans and projects that would encourage greater use of public spaces. They make arguments based on fears of increased traffic, pollution, crime rates, and fire risk—all factors that can be mitigated by careful planning and adequate monitoring of our parks.

In one example of local opposition to public parks, legal challenges by residents and the City of Malibu have

Coastal Slope Trail

PHOTOS: SMMC

Ahmanson Ranch

Corral Canyon Park

Corral Canyon Park

Upper Las Virgenes Open Space

temporarily stalled implementation of the Malibu Parks Public Access Enhancement Plan—Public Works Plan by the Santa Monica Mountains Conservancy and Mountains Recreation and Conservation Authority. It took 17 years of collaborative efforts by the Conservancy, other public agencies, environmentalists, and park advocates to develop this plan to improve and increase public use of five open-space parks in Malibu. The Plan creates seven new miles of the regionally significant Coastal Slope Trail and will provide two new trailheads, day-use picnic areas, 17.5 additional miles of new or improved recreational trails, restrooms, and the first public camping ever in Malibu.

The Coastal Slope Trail will one day provide an over 35-mile-long recreation corridor with commanding Pacific Ocean views that historically were only available to the wealthy. The trail will connect dozens of public parks from Topanga State Park, up the coast, to Leo Carrillo State Park and will fulfill the Conservancy's mandate to provide low cost, low impact recreation that provides essential relief from the urban environment.

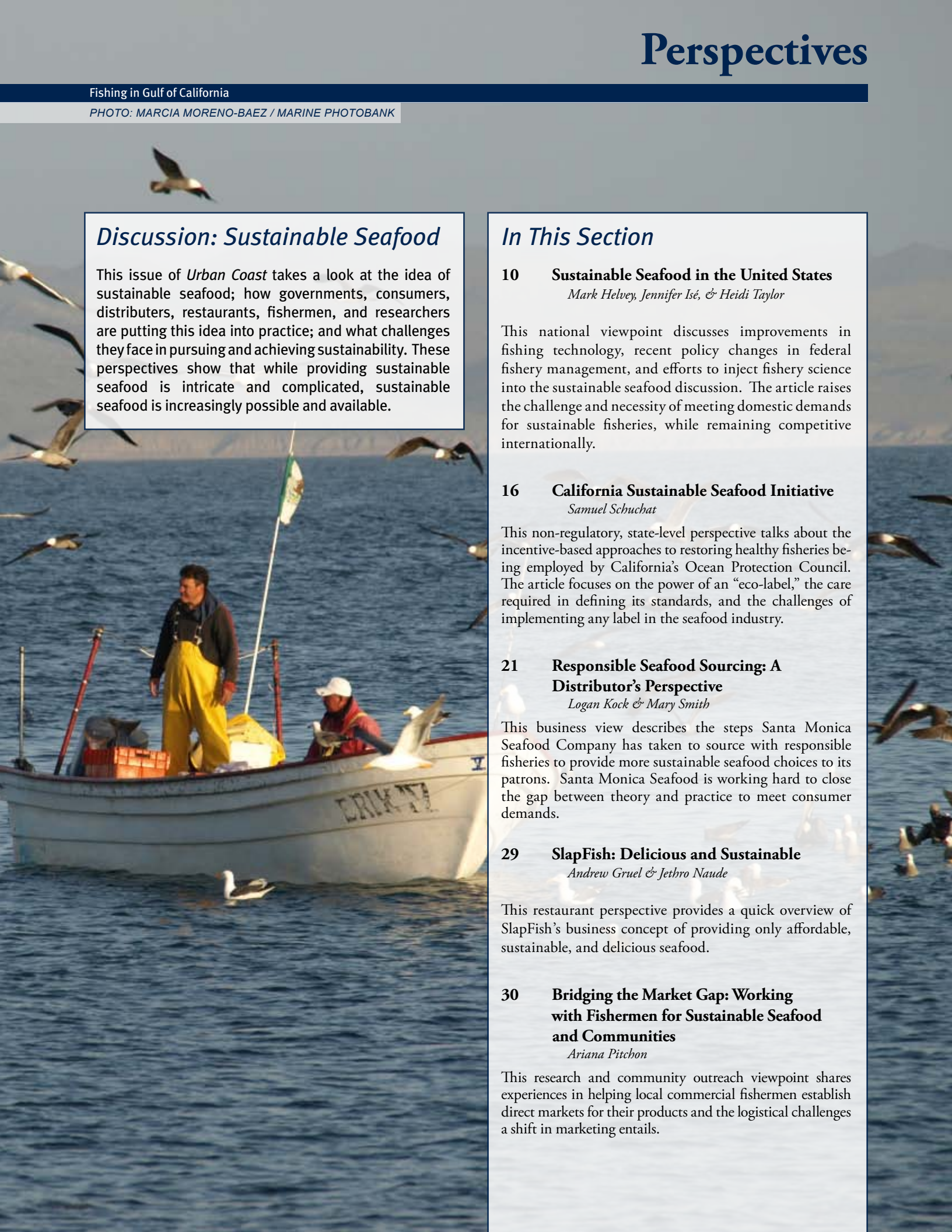
The lawsuit stalling the Plan is an example of the difficulties the Conservancy faces in protecting the public interest. The Conservancy must balance the needs and concerns of residents living adjacent to public recreational lands with the public's right to safe access and recreational opportunities on public parkland.

As the loss of natural resources accelerates, it is our responsibility to assure that precious public dollars are spent conserving and guaranteeing the rights of future generations to experience and enjoy public land safely and respectfully. Land protected with tens of millions of dollars of State bond funds and other public funds must be open to all Californians, not just the neighbors directly adjacent to the parks.

While this, like many of the Conservancy's initiatives, will still take many years of planning (and negotiating, acquiring, and defending), our more than 30 years of effort have taught us that projects of great scope and vision still can—and will be—realized.

ANTONIO GONZALEZ *is Chairperson of the Santa Monica Mountains Conservancy and President of the William C. Velasquez Institute. He is a lifelong resident of the Los Angeles area.*

Perspectives



Fishing in Gulf of California

PHOTO: MARCIA MORENO-BAEZ / MARINE PHOTOBANK

Discussion: Sustainable Seafood

This issue of *Urban Coast* takes a look at the idea of sustainable seafood; how governments, consumers, distributers, restaurants, fishermen, and researchers are putting this idea into practice; and what challenges they face in pursuing and achieving sustainability. These perspectives show that while providing sustainable seafood is intricate and complicated, sustainable seafood is increasingly possible and available.

In This Section

School of Pacific Sardines

PHOTO: DAVE RUDIE

Sustainable Seafood in the United States

MARK HELVEY, JENNIFER ISÉ, & HEIDI TAYLOR

The United States is a major seafood-consuming country ranked third behind China and Japan in total fish and shellfish consumption. In 2009, the average U.S. resident consumed 15.8 pounds of seafood; about three quarters was fresh and frozen finfish and shellfish, and almost a quarter was canned seafood, primarily tuna. Seafood provides not only an excellent and delicious source of protein but also multiple health benefits. Most notably, seafood is low in saturated fat and rich in essential nutrients, such as omega-3 fatty acids that protect against cardiovascular disease and promote brain development.

In addition to this appetite for seafood, U.S. consumers are placing a higher value on sustainably harvested seafood. Starting in the mid-1990s, the concept of environmental or ecological sustainability ignited public concerns about how fishing operations were conducted. These concerns led to efforts to ensure that fishing be conducted in ways that minimized harm to marine ecosystems. The sustainable seafood movement gained momentum, particularly within the last decade, as more people have become concerned about the consequences of fishing, specifically, overfishing, bycatch, and habitat impacts. Eco-labeling programs have emerged to identify seafood harvested according to accepted standards such as the United Nations Food and Agriculture Organization (FAO) Code of Conduct for Responsible Fisheries. Unfortunately, these consumer awareness efforts often fail to acknowledge that seafood harvesting by U.S. fishermen in federal waters has improved greatly since the 1970s and is currently comprehensively managed for sustainability.

Federal Governance and Sustainability

Seafood harvested in the United States is managed under various state and federal authorities, with the individual coastal states responsible for managing fisheries that occur in state waters, in most cases, within three nautical miles offshore. Domestic federal fisheries occur within the U.S. Exclusive Economic Zone (EEZ) that usually extends from 3 to 200 nautical miles offshore. In 1976, Congress passed the Magnuson-Stevens Fishery Conservation and Management Act (MSA), the nation's fishing law, which established eight regional fishery management councils. These councils, consisting of relevant state and federal authorities, and commercial and recreational fishing stakeholders, recommend management measures to the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NOAA Fisheries), within the Department of Commerce for fishing activities in the EEZ. Regional council recommendations, in the form of Fishery Management Plans (FMPs) and regular plan updates, are approved by NOAA Fisheries if the recommendations are consistent with all applicable laws. On the U.S. West Coast, the Pacific Fishery Management Council (Pacific Council) recommends fishery management measures for salmon, groundfish, coastal pelagic species (sardines, anchovies, and mackerel), and highly migratory species (tunas, sharks, and swordfish) in the EEZ off the coasts of Washington, Oregon, and California. These recommended measures apply to commercial and recreational fishermen.

Figure 1. Commercial Passenger Fishing Vessel

The primary purpose of the MSA and its subsequent amendments is to ensure that domestic fisheries are sustainably managed to contribute to the nation's food supply and economy, as well as to provide recreational opportunities. However, whether undertaken recreationally or commercially, fishing is primarily a food production system and, like farming, comes with ecological impacts (Figure 1). For example, fishing can impact fish habitats, and can unintentionally catch non-targeted marine animals. Consequently, the MSA requires that fishing be coupled with precautions to minimize these physical and biological impacts.

The MSA includes ten national standards that all FMPs must address:

1. Prevent overfishing while achieving optimum yield.
2. Use the best available science in preparing conservation and management measures.
3. Manage stocks as a unit throughout their range.
4. Allocate harvests fairly and equitably.
5. Utilize fishery resources efficiently.
6. Account for variations in fisheries, fishery resources, and catches.
7. Minimize costs and unnecessary duplication in management measures.
8. Sustain participation of fishing communities, in a manner consistent with conservation goals, and minimize adverse economic impacts to such communities.
9. Minimize the catch of non-target species (called "bycatch") and bycatch mortality.
10. Promote fishermen's safety while at sea.

Federal fisheries are also managed with consideration for the sustainability of coastal fishing communities. This is usually overlooked in sustainable seafood discussions. There are business costs to fishing. Fishermen, as well as ports and waterfronts, often make substantial long-term investments that support fishing activities. Fishery managers strive to balance these ecological, social, and economic factors.

Federal fisheries also comply with other laws, such as the Endangered Species Act (ESA), which protects endangered and threatened species, and the Marine Mammal Protection Act (MMPA), which safeguards marine mammals.

Fisheries science is also evolving to better understand species and habitat relationships, as well as how these are affected by chemical and physical ocean processes. This will allow managers to include more of these ecosystem dynamics in decisions. This approach is known as "ecosystem-based fishery management."

Sustainable Fish Stocks

The MSA has always required prevention of overfishing, but in the 2007 MSA amendments, Congress specified annual catch limits as another means of protection. Catch limits for commercial and recreational fisheries ensure that exploitation rates do not exceed established thresholds based on the best available science and factor in scientific uncertainty. The Pacific Council recently amended its four FMPs to establish annual catch limits.

Other management measures are also employed to control how many fish are removed each season. Examples include bag limits, harvest guidelines, quotas, trip and landing limits, area restrictions, depth restrictions, size limits, seasonal closures, and gear restrictions (e.g., the minimum mesh size for nets). The West Coast sardine fishery, for instance, is closed when harvest quotas are reached (Figure 2). NOAA Fisheries implements fishing regulations that specify these measures for a fishery, based on Pacific Council recommendations, and NOAA's Office of Law Enforcement enforces the regulations. NOAA Fisheries also places fishery observers on some U.S. commercial fishing vessels to monitor the catch and to collect data about the fishing activities. Observer programs log more than 60,000 observer days annually, in efforts to monitor 42 different fisheries around the nation. NOAA has been using observers to collect data since 1972. On the West Coast, NOAA Fisheries places observers on commercial fishing boats harvesting groundfish, swordfish, and tuna species, and is considering a program for the coastal pelagic fisheries (e.g., sardine).

Figure 2. Aerial of San Pedro–Based Vessel *Eileen* Wrapping a School of Sardines

PHOTO: NICK JURLIN

Minimizing Bycatch

Federal fishery managers also use three strategies—avoidance, deterrence, and gear selectivity—for minimizing bycatch, while attempting to balance the need for fishing. The method that best applies to a particular fishery depends on known behaviors of the targeted species and the non-target species, the practicality of the approach, and the latest research on the effectiveness of alternative gear, as well as compliance with relevant laws.

To avoid interactions between fishing gear and non-target marine species, managers commonly designate times and areas closed to fishing. This strategy is especially useful for gear types such as nets to avoid spawning or nursery areas and migratory routes. Such closures may be implemented annually or seasonally depending on the characteristics of the non-target species. For example, the Southern California Bight is closed to drift gillnets used to catch swordfish during El Niño years (Figure 3). This avoidance measure prevents interactions with loggerhead sea turtles that migrate up from Central American waters to feed during these warm-water periods. Additionally, an area of 214,000 nautical square miles, stretching from Point Conception to northern Oregon, is closed to these same nets every year between August and November to prevent interactions with leatherback sea turtles that migrate annually from Southeast Asia to feed in the rich marine waters off the U.S. West Coast.

While avoidance strategies seem simple and direct in achieving a particular conservation objective, such measures may result in displacing fishing to other areas, thereby shifting the problem elsewhere, sometimes without achieving the intended objective. Time and area closures also affect fishermen by limiting, or even eliminating, opportunities to fish. To simultaneously achieve both objectives of harvesting ample fish while minimizing interactions with fewer non-target species in the same area, technology can be employed, such as deterrence devices and selective fishing gears. Compliance with these solutions usually places less of an economic burden on fishermen than a full fishing closure. A good example is the requirement that California drift gillnet fishermen attach acoustic pingers to their nets. The pingers emit detectable signals that deter marine mammals away from the gear. Pingers were first required in the fishery in 1998, and since then, there has been a significant decrease in interactions between fishing gear and marine mammals in the West Coast swordfish fishery (Figure 4).

Gear selectivity is an important and preferred strategy, which, in addition to protecting marine life, allows fishermen to continue working and supplying local seafood to U.S. consumers. Examples include the use of Bycatch Reduction Devices (BRDs) and Turtle Exclusion Devices (TEDs) in U.S. shrimp fisheries along the East Coast and Gulf of Mexico. These devices allow non-target fish and sea turtles to escape from trawl nets.

U.S. pelagic longline swordfish fisheries started using gear modifications and new methods to improve selectivity in the mid-1990s. NOAA Fisheries scientists successfully worked with longline fishermen to perfect the use of

Figure 3. Time/Area Closures to Minimize Turtle Impacts

IMAGE: NOAA FISHERIES

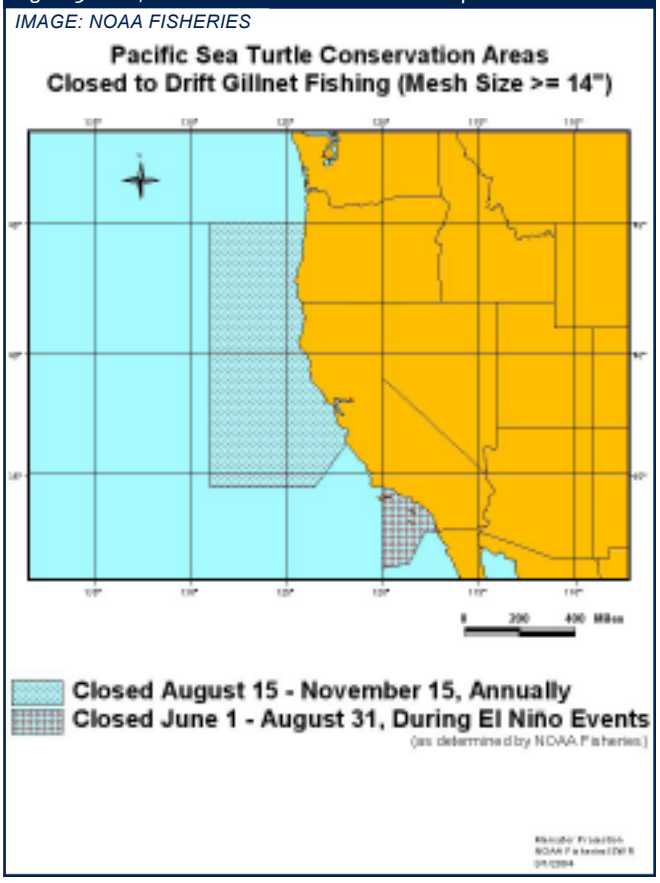


Figure 4. Southern California–Based Fishing Vessel Lands a Swordfish

PHOTO: PETE DUPUY

circle hooks and mackerel bait in place of traditional "J" hooks and squid bait in order to reduce sea turtle interactions and post-hooking mortalities. As shown in figure 5, the catch rates of leatherback, loggerhead, and all sea turtles combined decreased by 85%, 90%, and 89%, respectively, after federal regulations requiring the use of circle hooks and mackerel bait were implemented (Gilman et al. 2007). Circle hooks have proven successful in domestic and foreign shallow-set longline fisheries because the hooks cannot be swallowed (i.e., "gut-hook") by sea turtles, which is usually fatal. This also benefits undersized fish, marlins, and sharks that can be released alive. U.S. pelagic longline fishermen are also required to use bycatch release and removal gear (e.g., turtle de-hookers, line cutters) and are trained in specific techniques to assist in handling a sea turtle, removing a hook, and resuscitating a sea turtle to maximize its survival rate once released.

Fishing at a Higher Conservation Standard

Many U.S. seafood consumers may be unaware of the many laws and policies that require U.S. fishermen to fish sustainably and with more environmentally responsible measures compared to many of their counterparts throughout the world. Consumers trying to make sustainable seafood choices have often overlooked this significant factor. Most U.S. consumers are also unaware that the majority of the seafood they consume is not caught in U.S. waters. The most recent analysis shows that about 84% of the seafood consumed in the U.S. is imported. This is a dramatic increase from the 66% imported just a decade ago (NOAA Fisheries 2010).

Some imported seafood comes from countries that do not have comparable laws for protecting sensitive marine species and habitats or for preventing overfishing. U.S. fishermen, targeting federally managed stocks, are managed under the MSA and must comply with the MMPA and ESA. Therefore, U.S. fishermen are held to much higher conservation standards than fishermen from other countries. Unfortunately, these standards are neither universally adopted nor accepted by the majority of the world's fishing nations, especially by small-scale or coastal fisheries. Small-scale fisheries contribute to more than half of the world's fish catch and probably pose the greatest risk to marine ecosystems because they lack strong governance systems and enforcement (FAO 2010). These small-scale fisheries occur primarily in the coastal areas of developing countries.

Other Sources of Seafood

Farmed seafood production, or aquaculture, has expanded dramatically outside the United States in the last three decades and now supplies half of the world's seafood demand, according to the FAO (2010). The U.S. aquaculture industry, though vibrant and diverse, currently meets less than 10% of the U.S. demand for seafood. However, U.S. consumption of farmed seafood is high, since most of the seafood consumed in the U.S. is imported, and aquaculture comprises almost half of seafood imports to the United States.

figure 5. Pre-Regulation (1994–2001) and Post-Regulation (2004–2007) Turtle Take Rates in the Hawaii-Based Longline Swordfish Fishery

IMAGE: GILMAN ET AL. 2007

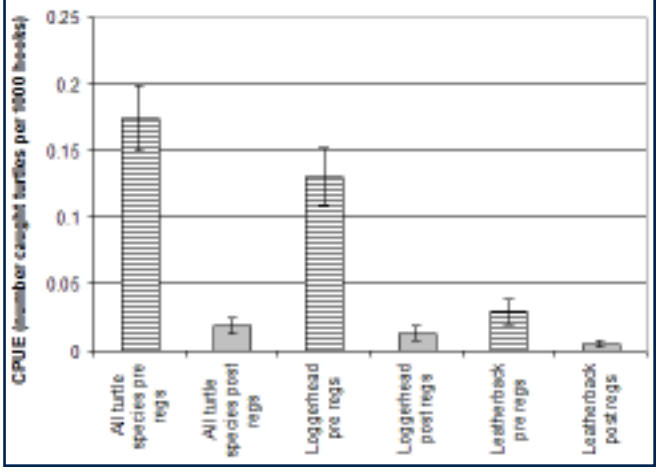


Figure 6. Hubbs SeaWorld Research Institute's (HSRI) White Seabass Broodstock

PHOTO: HSRI

Although the United States has been successful in developing marine shellfish aquaculture, finfish aquaculture for food purposes has lagged far behind. There are exceptions such as salmon hatcheries in Northern California and Hubbs SeaWorld's white seabass program in San Diego (Figure 6). However, these land-based efforts, which are still considered aquaculture, are conducted for stock enhancement purposes rather than food production.

Part of the lag in aquaculture in the United States has to do with concerns about the ecosystem impacts on coastal and marine species and habitats. Recognizing these and other concerns, in 2011 the U.S. Department of Commerce and NOAA released policies for sustainable marine aquaculture (NOAA Fisheries 2011) and how it may supplement the growing demand for healthy seafood, create jobs in coastal communities, and restore vital ecosystems. This new focus may be the catalyst for developing and expanding sustainable aquaculture in the United States.

Informing the Public

The importance of sustainable fish stocks and sustainable fishing practices has become well entrenched in a growing portion of this nation's consciousness. Outreach efforts to mobilize public opinion and change consumer behavior toward sustainable seafood have been under way for years and include a variety of methods, such as boycotts, seafood guides, eco-labeling, and retailer pressure. These various efforts share the common goals of increasing public awareness and seeking support for sustainable seafood, but these campaigns may seem inconsistent and confusing to consumers. Too many competing messages can be overwhelming for consumers, creating mistrust toward the seafood industry and fisheries managers. NOAA Fisheries developed the FishWatch program to provide consumers with accurate, current, and unbiased information about U.S. seafood, in an easily accessible online tool.

FishWatch (www.FishWatch.gov) is designed to help U.S. consumers make informed decisions about the seafood they eat based on neutral, scientific information (Figure 7). The program does not advocate for particular consumer decisions but rather is designed to help consumers understand the management and science requirements involved with building and maintaining sustainable fisheries in the United States. A critical element of NOAA Fisheries' mission is to make fisheries data and information available to the public in a timely fashion. FishWatch does this by providing consumers with relevant seafood facts, taken from a variety of NOAA sources, including fish stock assessments, fishery evaluations, and fishery management plans and amendments. These science-based sources are used to ensure that the information on FishWatch is considered the most accurate and up-to-date information on seafood available in the United States.

FishWatch currently includes only those marine species managed by NOAA Fisheries under U.S. federal management. For example, varieties of tuna (e.g., albacore), salmon, Pacific sardines, lingcod, and other familiar species harvested by U.S. fishermen are included. Currently, imported species (e.g., orange roughy) and farmed species (e.g., tilapia, catfish) are not included, but revisions to the site are under way to include information on these species as well. FishWatch also details the health benefits of eating seafood, including guidelines for mothers, young children, and the elderly, and the site supplies nutritional facts for each species. Additionally, FishWatch provides information to help select, store, and cook seafood. Lastly, the latest scientific research and seafood news are posted on the site.

Figure 7. FishWatch Logo

LOGO: NOAA FISHERIES

Final Thoughts

Despite the growing resolve for sustainable seafood in the United States and other developed countries, pressure on global fisheries continues and will likely increase. The FAO estimates that today's population of just over 7 billion people will reach 9.1 billion in 2050 and will require a 70% increase in global food production (2010). Nearly all of that population growth will occur in developing countries, which, for the most part, rely on seafood for livelihoods and day-to-day subsistence. Consequently, there will be even greater pressure to harvest seafood as an important source of protein, and much of the harvesting will be done in fisheries that are not being managed with similar objectives for sustainability as in the United States.

It is essential for the United States to maintain a leadership role in ocean stewardship to ensure that wild capture fisheries and marine aquaculture efforts are sustainably conducted and demonstrated globally. Certainly, the United States will continue to play a major role in that effort by transferring to other fishing nations research and developments in cleaner fishing technologies and by remaining a strong advocate for conservation and management in international fisheries organizations, such as the Inter-American Tropical Tuna Commission. To be a strong leader, the United States must also maintain a robust fishing industry and domestic seafood supply rather than continuing to rely heavily on other countries to provide the majority of the seafood the United States consumes (Figure 8). The best way for the United States to accomplish these objectives is to ensure that strong, productive, and sustainable U.S. wild capture and aquaculture fisheries are maintained. The first step in doing that is to support the U.S. fishing industry. U.S. fishermen provide high-quality, sustainable seafood to this nation's homes and restaurants. So the next time you want to buy seafood, look for seafood caught in the U.S.A.—it is sustainable.

Figure 8. California-Based Fishing Vessel Equipped with Drift Nets and Harpoon

PHOTO: NOAA FISHERIES

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References

Food and Agriculture Organization of the United Nations. 2010. The State of World Fisheries and Aquaculture Fisheries 2010. http://www.fao.org/fishery/sofia/en.

Gilman, Eric, Donald Kobayashi, Thomas Swenarton, Nigel Brothers, Paul Dalzell, and Irene Kinan. 2007. "Reducing Sea Turtle Interactions in the Hawaii-based Longline Swordfish Fishery." Biological Conservation 139: 19–28.

National Marine Fisheries Service. 2011. Fisheries of the United States 2010. http://www.st.nmfs.noaa.gov/st1/fus/fus10/FUS_2010.pdf.

———.2011. National Shellfish Initiative. http://www.nmfs.noaa.gov/aquaculture/policy/shellfish_initiative_homepage.html.

Overfishing Menhaden Fish

PHOTO: JOHN SURRICK-CHESAPEAKE BAY FOUNDATION / MARINE PHOTOBANK

"All of the world's fishing stocks will collapse before mid-century, devastating food supplies, if overfishing and other human impacts continue at their current pace, according to a global study."

-Marla Cone, *Los Angeles Times*, November 2, 2006

"The world's oceans are degenerating far faster than predicted and marine life is facing extinction due to a range of human impacts—from overfishing to climate change—a report compiled by international scientists warned."

-Anna Tomforde, *San Francisco Chronicle*, June 22, 2011

California Sustainable Seafood Initiative

SAMUEL SCHUCHAT

Introduction

Humans have been consuming seafood throughout history. Remnants of shells and fish bones along California's coastline are reminders that Native Americans formerly feasted on the bounty of the shoreline. Although the look of California's coastline and its seafood industry has changed, Californians continue to love and consume seafood. There is one problem, though: the ability to harvest fish long ago outpaced the ability of most species to reproduce. Today's fishermen are essentially the last hunter-gatherers, but they are hardly primitive. The modern fisherman is equipped with sonar fish finders, large boats with powerful engines, miles of long lines with thousands of baited hooks, bottom trawls, traps, and more.

Until recently, the policy of the United States was to encourage greater capacity and more fishing by domestic fleets. For a long time, the oceans were believed to be inexhaustible sources of food. During the last several decades, it has become common knowledge that this is not true, but changing course has proved to be difficult and slow.

Legislative Progress toward Sustainability

In 1998, the California State Legislature passed, and Governor Davis signed, the Marine Life Management Act (MLMA) introduced by California State Assemblyman Keeley. The MLMA mandated the comprehensive management of marine resources so that individual species are addressed in the context of ecosystems and fisheries are managed with master plans. The MLMA was followed by the Marine Life Protection Act (MLPA) of 1999, introduced by California State Assemblyman Shelley, which established a mandate to set aside portions of California's coastal waters as Marine Reserves, where little or no fishing would be allowed.

The Ocean Protection Council (OPC) was created in 2004 by legislation authored by Senator John Burton, and signed

into law by Governor Schwarzenegger. Although the OPC has a general mandate to reform policy regarding the ocean, fisheries have been a priority on the OPC's agenda almost from the beginning. The OPC has accomplished the following:

- Worked in Moro Bay with the Nature Conservancy to establish a community-based fishing institution that incentivizes lower-volume, higher-value fisheries, which can help the long-term ecological and economic sustainability of the Central Coast.

- Provided approximately $20 million to support the implementation of the MLPA.

- Provided $2 million in seed money to the Environmental Defense Fund to create the California Fisheries Fund—a revolving loan fund to spur fishery reform (e.g., provide loans for new gear or gear modifications, make vessel purchases or improvements, acquire fishing permits or quota purchase, and upgrade capital equipment for dockside infrastructure).

- Created a collaborative fishery research organization to get scientists and fishermen working together on management issues.

- Authorized funding for one of the first Community Fishing Associations (CFAs), which promotes collaboration and sustainability, along the West Coast—the San Francisco CFA.

In 2009 the California Legislature passed, and the governor signed, AB 1217 (introduced by California Assemblyman Monning), which required the OPC to create a "voluntary sustainable seafood promotion program" for California, which must include "a protocol to guide entities on how to be independently certified to internationally-accepted standards for sustainable seafood." In other words, the OPC was mandated to create an ecolabel program for California fish.

A Sustainable Seafood Label for California

The traditional methods of managing fisheries have been about what fisherman cannot do:

- *Do not fish out of season.*

- *Do not catch females.*

- *Do not keep fish over or under the designated size restrictions.*

- *Stop fishing when a set amount of fish has been caught, and so on.*

Figure 1. Popular Farmers Market

As the quotations at the beginning of this article suggest, traditional methods have left something to be desired. They also have the disadvantage of seeming punitive to fishermen. Thus, there is growing interest in market-based approaches to fishery management, which seek to align the interests of fishermen directly with conserving the stocks of fish they catch.

Ecolabeling is a type of market-based incentive, one based on consumer demand. The theory is that consumers will prefer, and may even pay a premium for, fish that are labeled as sustainable, similar to the organic label on vegetables, meat, and milk, for example. An ecolabel for California fish also offers the opportunity to tap into the growing interest in locally sourced food (Figure 1).

Unfortunately, there are a bewildering number of different ecolabels for fish alone; as many as 17 are in use or in development all over the world (Accenture and World Wildlife Fund 2009). An advisory panel of 25 people, including fishermen, fish processors and retailers, restaurateurs, nongovernmental organizations, scientists, and state and federal government officials helped the OPC establish a recommendation (OPC 2010). The advisory panel met for a total of seven days on four separate occasions in various locations around the state. Meetings were open to the public and included public comment. Based on these discussions, the language of AB 1217, and public comment, the OPC drafted an initial proposal in May 2011.

Understanding California's Ecolabel: Marine Stewardship Council Basics

The foundation of the California sustainable seafood program must, according to AB 1217, be consistent with the United Nations Food and Agricultural Organization (FAO) Guidelines for Ecolabeling Fisheries (Section 35617 of the Public Resources Code as directed by AB 1217). Currently, the Marine Stewardship Council (MSC) certification program for sustainable seafood is the most consistent with these guidelines, as well as the only internationally accepted standard. Should another certification program become available that also meets the FAO Guidelines for

Figure 2. Chilean Seabass with MSC Ecolabel

PHOTO: GERICK BERGSMA 2011 / MARINE PHOTOBANK

Ecolabeling, OPC staff will explore the program as another option to potentially use for certifying California fisheries. The MSC is a nonprofit, nongovernmental, international organization, established in 1996 by a partnership between the World Wildlife Fund and Unilever, promoting sustainable fishing practices and seafood markets.

The MSC operates a certification and ecolabel program based on a scientifically robust standard for assessing whether wild-capture fisheries are ecologically sustainable and well managed. Fish products from fisheries that meet the MSC's standard are eligible to use the MSC's blue ecolabel or otherwise make a claim that they are MSC-certified. The MSC's Chain of Custody standard for seafood traceability ensures that the MSC ecolabel is displayed only on seafood from an MSC-certified sustainable fishery. Each company in the supply chain must get a certificate from an independent, third-party certifier if the product will ultimately display the MSC ecolabel (Figure 2).

AB 1217 states that certified fisheries must conform to the following principles, which are also the three principles at the core of the MSC certification process:

Principle 1: A fishery must be conducted in a manner that does not lead to over-fishing or depletion of the exploited populations and, for those populations that are depleted, the fishery must be conducted in a manner that demonstrably leads to their recovery. (The intent of this principle is to ensure that the productive capacities of a fishery are maintained at high levels and not sacrificed in favor of short-term interests.)

Principle 2: Fishing operations should allow for maintaining the structure, productivity, function, and diversity of the ecosystem (including habitat and associated dependent and ecologically related species) on which the fishery depends.

Principle 3: The fishery is subject to an effective management system that respects local, national, and international laws and standards and incorporates institutional and operational frameworks that require use of the resource to be responsible and sustainable.

To be eligible for and receive MSC certification, the fishery must meet or exceed these three core principles for sustainable fishing. Based on these standards, the MSC assessment process includes 31 specific questions about the fishery's performance and management to determine a fishery's sustainability. These performance indicators are grouped under each of the MSC's three main principles described above.

The MSC is a third-party standard: the MSC sets the standards, but other certifiers actually examine the fishery and apply the standards. Certifiers are paid by the client (e.g., the fishery), and the MSC is paid a royalty for the use of its logo, but otherwise is not paid during the certification process. Certification decisions can be appealed to the MSC, which is constantly updating its standards and methods through a public process (Figure 3).

Understanding California's Ecolabel: Customizing the MSC Standards

To benefit from the advantages of the MSC and to address some criticisms of the MSC from some members of the OPC's advisory panel, the OPC proposal recommended that in addition to meeting the MSC criteria, California fisheries will also be required to meet a higher standard for two performance indicators: the stock status and the bycatch of endangered, threatened, and protected species. California fisheries will have to obtain a score of at least 80 out of 100 for these two performance indicators to receive the California sustainable seafood certification.

Although the MSC process involves scientists, the OPC proposal also recommended the Ocean Science Trust (OST) be involved in developing recommendations about the scientific peer review process for this ecolabel program and recommended the most appropriate role for the OPC's

Figure 3. Hastings MSC-Certified Fishery

PHOTO: © MSC / MARINE PHOTOBANK

Science Advisory Team in the certification process. For example, there may be opportunity for scientific peer review throughout various steps of the certification process. This second layer of review (including the MSC's peer review) will add credibility, transparency, and independence.

The process of certifying a fishery through the MSC is lengthy and can be expensive. Therefore, before initiating the certification process, the OPC will work with specific fisheries to evaluate whether they meet the following minimum criteria:

- Degree to which they can meet the standards promulgated by the MSC;
- Support from the state or federal management agency, U.S. Department of Fish and Game, and/or the Pacific Fishery Management Council;
- Establishment of a CFA or similar entity that can serve as a co-client with the OPC to the MSC;
- Fish are landed in California by California-licensed fishermen (Figure 4); and
- Target fish species are not listed on a federal or state endangered or threatened species list.

Once a certifier has been appointed, the assessment process can proceed. Fisheries wishing to gain certification against the MSC fisheries standard are encouraged by the MSC to undergo a pre-assessment in which third-party certifiers evaluate, at a provisional level, and provide a report regarding a fishery's performance against the MSC fisheries standard. This allows any potential issues in a fishery's performance to be identified, and enables potential fishery clients to prepare accordingly for a full assessment.

Subject to the availability of funds, the OPC may fund a pre-assessment for fisheries that are interested in going through all the steps to become certified. The pre-assessment may identify strategies for improving management and might examine the use of existing and new risk-based methodologies for assessing fisheries where information on biological stocks and the fisheries may be insufficient for established scientific assessment techniques.

Figure 4. Squid Shipment from Monterey, CA

PHOTO: GERICK BERGSMA 2010 / MARINE PHOTOBANK

If a fishery is ready, then the next step is full assessment—the detailed, public, rigorous process that a third-party certifier will follow to see whether the fishery meets the MSC standard. The process starts when the fishery client (the OPC and fishery serve as co-clients) signs a contract with the certifier, and the certifier notifies the MSC that the fishery is entering full assessment. This is a seven-step process, led by the appointed certifier and its expert assessment team, to determine whether the fishery meets the MSC standard. Each fishery has its panel of experts, separately assembled. The process involves consulting with stakeholders, reviewing performance indicators, scoring the fishery, identifying ways that the fishery can strengthen its performance (if needed), conducting peer review, and making a final determination about whether the fishery meets the MSC standard. The process will likely take six months to a year per fishery (if not longer, should there be objections at any stage of the process). After a fishery is assessed, and if it is found to be certifiable, it must also arrange for annual audits thereafter (Marine Stewardship Council 2009).

The California Sustainable Seafood Certified ecolabel will include the MSC label, another logo to indicate its California origin, and the name of the port where the seafood was landed. Certified fisheries can use the MSC label, the California label only, or both. In addition, the OPC plans to include a wealth of additional information about the fish and the fishermen available on a website and accessible via a bar code on each California ecolabeled product or package.

Finally, the OPC also proposed that fish using the California ecolabel must be sold using their scientific name, as well as whatever name is in use colloquially. A recent *New York Times* article (Rosenthal 2011) highlights studies by DNA scientists who have consistently found that 20-25 % of seafood products (e.g., red snapper, wild salmon, and Atlantic cod) are mislabeled and disguised as species that are less desirable, cheaper, or more readily available. Despite growing concern about where food comes from, consumers are frequently served the wrong fish—a completely different species from the one they paid for in the market or restaurant (Figure 5). A little Latin will go a long way toward truth in marketing!

Addressing Health Concerns

The OPC is well aware that nearly all fish and shellfish contain traces of mercury, which comes largely from coal-fired, electricity-generating plants. Generally speaking, the higher up on the food chain and the longer lived, the more mercury a species has. Swordfish, for example, have high

Figure 5. Fish Taco with Pollock (Common Name: One of Many for This Species)

PHOTO: JIM GILLMORE / AT-SEA PROCESSORS ASSOCIATION / MARINE PHOTOBANK

Figure 6. Local Marketplace in Seattle, WA

PHOTO: SARAH WOODARD

mercury levels; shellfish quite low. Other toxins, such as lead, chlorine, bromine, PCBs, dioxins, and biotoxins, are also frequently found in fish. The Office of Environmental Health Hazard Assessment (OEHHA 2007) monitors freshwater, recreationally caught fish for toxins. However, there is currently no coordinated or routine statewide monitoring system to test for most of the toxins found in seafood that could cause health concerns to humans. Although a fisheries toxicity monitoring and testing program would be good to have, it goes beyond the intent and goal of AB 1217 to address sustainable fishing practices and to showcase California fishermen and seafood.

Despite the roadblocks, the OPC is currently working with several state and federal agencies on developing a monitoring program to test marine fisheries—specifically with the California ecolabel in mind. Any toxicity monitoring program must be developed with the agencies that have the regulatory authority and expertise in implementing and addressing these issues. The goal is to have a program in place that routinely tests and monitors seafood that is labeled with the California ecolabel.

Current Status of the California Ecolabel

The OPC officially adopted the above-described protocol at its December 2011 meeting (OPC 2011). Once some fisheries are certified, the OPC can begin implementing the marketing program portion of AB 1217 and will promote the ecolabel and certified fisheries.

Conclusion

There is a growing desire on the part of the public in California to have a connection to food producers and to know that food is healthy. This is evident at the weekly farmers markets, in the ever-expanding aisles of organic foods in the supermarkets, and in restaurant menus that go into (sometimes excruciating) detail about the provenance of the food served. It is exciting to be at the beginning of what is hopefully California's journey to fully sustainable fisheries and seafood. Seafood is the last frontier for local food (Figure 6); many California consumers would be surprised to learn that sometimes even fish caught locally are then processed out of state, or even halfway around the world. If California is successful, it will be a giant step toward a more sustainable local seafood supply. Perhaps other seafood-consuming states (and nations) will follow the example, and perhaps people will start seeing headlines about seafood that are more positive and optimistic.

References

Accenture and World Wildlife Fund International. 2009. World Wildlife Study: Assessment Study of On-Pack, Wild-Capture Seafood Sustainability Certification Programmes and Seafood Ecolabels.

Cone, Marla. 2006. "Overfishing Threatens Catastrophe, Study Finds." Los Angeles Times, November 2. http://www.latimes.com/news/nationworld/world/la-me-oceans-webnov03,0,4569492.story.

Marine Stewardship Council. 2009. Get Certified! Fisheries. http://opc.ca.gov/webmaster/ftp/project_pages/CSSI/MSC_Get%20certified_FINAL_lowres[1].pdf.

Office of Environmental Health Hazard Assessment. 2007. Fish. http://oehha.ca.gov/fish.html.

Ocean Protection Council. 2010. Advisory Panel. http://www.opc.ca.gov/2010/03/california-sustainable-seafood-initiative/.

Ocean Protection Council. 2011. California Voluntary Sustainable Seafood Program: Protocol Adoption. http://www.opc.ca.gov/webmaster/ftp/pdf/agenda_items/20111216/6._CASustainableSeafoodProgram/2011.12.16_CSSP_StaffRec_FINAL.pdf.

Rosenthal, Elisabeth. 2011. "Tests Reveal Mislabeling of Fish." New York Times, May 26, 2011. http://www.nytimes.com/2011/05/27/science/earth/27fish.html?_r=1&ref=dnadeoxyribonucleicacid.

Tomforde, Anna. 2011. "Dire Forecast of Marine Life Catastrophe." San Francisco Chronicle, June 22, 2011. http://www.sfgate.com/cgi-bin/article cgi?f=c/a/2011/06/21/MNLT1KoMF9.DTL.

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Santa Monica Seafood Facility Tour

PHOTO: SANTA MONICA SEAFOOD

Responsible Seafood Sourcing: A Distributor's Perspective

LOGAN KOCK & MARY SMITH

Introduction

In recent years, the seafood industry, especially in the United States, has become increasingly aware of how critical sustainable resources are to their businesses. This awareness is due, in part, to industry observations and experiences with seafood resources as well as the considerable influence this nation's environmental non-governmental organizations (NGOs) have with the public over environmental issues. With the issues of sustainability and seafood sourcing rising to the forefront, the United States strives to be the world leader in sound environmental practices. To achieve sustainability, numerous factors, parties of interest, and implications must be taken into account. Ongoing global cooperation, research, policies, and enforcement will be necessary to continue seafood production without resource depletion. Distributors, such Santa Monica Seafood Company, find themselves at the heart of addressing the intersection of theory, practice, and regulation, not just in the United States but also on a global scale.

Santa Monica Seafood Company (www.SantaMonicaSeafood.com) has been family owned since 1939, employs fourth-generation family members, and purchases more than 20 million pounds of seafood annually for distribution in Southern California, Nevada, and Arizona (Figure 1). Santa Monica Seafood's annual double-digit growth during the last eight years has made sourcing seafood the company's number one challenge and is what motivated the company nine years ago to embark on the journey of responsible sourcing. Santa Monica Seafood quickly realized that knowledgeably addressing the issue of sourcing responsibly involved the challenge of addressing complicated questions and then translating the answers into customer-friendly products.

Recognizing a Problem

Recognizing that there is a problem is the first step toward developing a solution, and around 2000, U.S. environmental NGOs set out to draw attention to the issue of overfishing and related habitat destruction. Santa Monica Seafood's first encounters with one of these awareness efforts involved the controversy surrounding farmed salmon and polychlorinated biphenyl (PCB) contamination (Easton, Luszniak, and Von der Geest 2002; Houlihan 2003; Hites et al. 2004). Although these articles' findings were heavily scrutinized (Krause 2007),

Figure 1. Santa Monica Seafood Truck

PHOTO: SANTA MONICA SEAFOOD

the public initially responded with alarm. At the time, Atlantic salmon was Santa Monica Seafood's highest volume commodity, and the public uproar caused the company to call into question its product and motives.

Alarming scientific findings, vocal environmental advocates, and dire predictions pervaded the news. SeaWeb's "Give Swordfish a Break" campaign advocated from 1988 to 2000[1] and resulted in positive and negative impacts. The Atlantic swordfish stocks were indeed suffering, but the campaign unintentionally impacted the Pacific fishery and even today continues to affect the Atlantic fishery (Ruais 2010). Environmental NGOs also warned of the imminent demise of Chilean seabass (Handwerk 2002) and orange roughy (Lack, Short, and Willock 2003). In these early years, it seemed the environmental NGOs were winning the hearts and minds of the American public but trading objective, timely, balanced, and contextual reporting for sensationalism and sound bites. The public was alarmed, and needed to be, and the campaigns grabbed attention and raised awareness, but the initial reactions and solutions were overreactions.

Santa Monica Seafood recognized the inconsistencies of messaging and credibility, became immediately concerned, and resolved to become informed and proactive. There was so much confusion over what the issues were that Santa Monica Seafood had many questions and so did customers. One thing was for sure; Santa Monica Seafood had been in business long enough to know that it is not profitable to start dropping product lines without serious consideration. Being the first seafood distributor to drop a product as widely loved as farmed salmon would have ensured huge financial hardship for the company. Santa Monica Seafood recognized that to effect change, the company would need to educate employees and customers to make informed choices instead of just depriving people of the option and thereby causing them to seek the product elsewhere. This realization led Santa Monica Seafood to develop a responsible sourcing process.

Understanding the Problem

"Sustainable" is an ill-defined, almost political term. The idea of sustainability is often simplified, but in actual application, sustainability is a highly dynamic, multidimensional concept that is constantly evolving. Understanding and accounting for the complex dynamics of biology, fisheries, fishing methods, fishing nations, stock management, eco-interactions, regulations, farming systems, farming impacts, fish diseases and infestations, health and safety issues, and traceability for several hundred wild and farmed species is difficult at best (Figure 2). The newer dimensions of certification schemes, social welfare issues, and carbon footprint concerns makes accounting for all variables even more complicated.

Figure 2. Indonesian Fishery Crates

Clearly, Santa Monica Seafood's veteran buyers, with more than 100 years of combined experience, had a lot more to learn. First, Santa Monica Seafood joined a group of academic scientists, restaurant owners and operators, and the Aquarium of the Pacific to create the Sustainable Seafood Forum in 2004. Over each of the next four years, the forum met for two days every quarter to discuss, teach, and learn from each other and from international, guest scientists. These meetings helped establish a network of expertise and rapport that Santa Monica Seafood continues to reference for vetting purposes. In 2004, Santa Monica Seafood also began attending SeaWeb's annual Seafood Choices Alliance[2] three-day symposiums, which bring the fishing and aquaculture industry together with environmental NGOs, academics, food service, and retail interests from all over the world to discuss issues, trends, and solutions. These symposiums helped Santa Monica Seafood expand its network of related, diverse interests, which the company used for further vetting and information gathering.

Santa Monica Seafood attended and networked at various meetings and symposiums (Figure 3) to better understand the issues, evaluate suppliers, train salespeople, and advise customers. Recognizing sustainability as a constant work-in-progress, Santa Monica Seafood's goal was to engage sources that were tackling the issues and encourage these sources through purchasing. The company refers to this philosophy as "responsible sourcing." "Sustainable" may be the perfection to strive for, but until then, Santa Monica Seafood wanted to ally itself with suppliers that were already using best practices or were at least on a positive trajectory.

Developing a Solution

Within this landscape of concerns, controversy, vocal environmental NGOs, questions, and a certain amount of enlightenment, Santa Monica Seafood developed its Responsible Sourcing Program. The company considered its core beliefs, the viability of the business, and the responsibility the company had to provide quality, safe,

and sustainable products to customers. The company's Responsible Sourcing Program is based on two primary objectives:

- Sourcing – Staying abreast of fishery issues in order to better qualify products and suppliers, using science-based guidance (Figure 4).

- Promotion – Educating customers to meet their particular responsible sourcing goals and understand the issues.

Note: In addition to these two primary objectives, Santa Monica Seafood also considers promoting positive industry changes through influence and donations as well as general environmental responsibility, food safety, and internal production improvements to be important parts of the company's Responsible Sourcing Program.

Objective One: Sourcing

Seafood Watch® Resources

Santa Monica Seafood uses a variety of tools, resources, and lessons learned to evaluate the farms, fisheries, and suppliers from which the company sources. These resources originate from networking and participating at various aforementioned events and groups as well as reading daily and monthly periodicals, such as *Intrafish*[3], *Seafood Business*[4], John Sackton's Seafood.com, SeafoodSource.com, and several others. However, the most robust and comprehensive tools Santa Monica Seafood uses are the ones developed by the Monterey Bay Aquarium (MBAq) Seafood Watch® program[5]. Seafood Watch® is a program that helps consumers and businesses make choices for healthy oceans. Recommendations indicate which seafood items are "Best Choices (green)" (Figure 5), "Good Alternatives (yellow)," and which ones you should "Avoid (red)." Seafood Watch® recommendations are science-based and peer-reviewed, use ecosystem-based criteria, and have supporting, comprehensive reports.

Seafood Watch® with its wallet card (Figure 6) is often criticized by the seafood industry for being too broad in scope, over-simplified, and not giving credit where it is due. What most industry people do not recognize is that this card is supported by a wealth of scientific review and a pragmatic ranking process for each rated species (e.g., yellowfin tuna; Seafood Watch 2010). Working within the limits of the program's resources and staff, Seafood Watch's approach reverts to the lowest common denominator for the overall recommendations and rarely assigns specific farms or sub-fisheries a better rating as long as other underperforming farms and fisheries exist within that country or region. This frustrates some

Figure 3. International Seafood Show

PHOTO: SANTA MONICA SEAFOOD

Figure 4. Squid Processing Plant in China

PHOTO: SANTA MONICA SEAFOOD

Figure 5. Seafood Watch® "Best Choice" Label

PHOTO: GERICK BERGSMA 2011 / MARINE PHOTOBANK

Figure 6. Seafood Watch® Wallet Cards

IMAGES: SEAFOOD WATCH ®

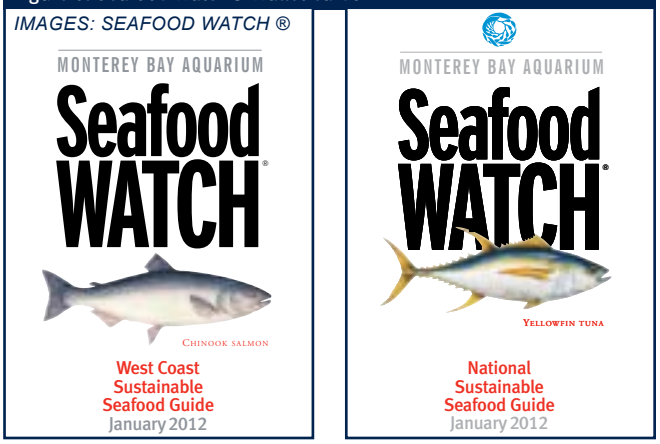
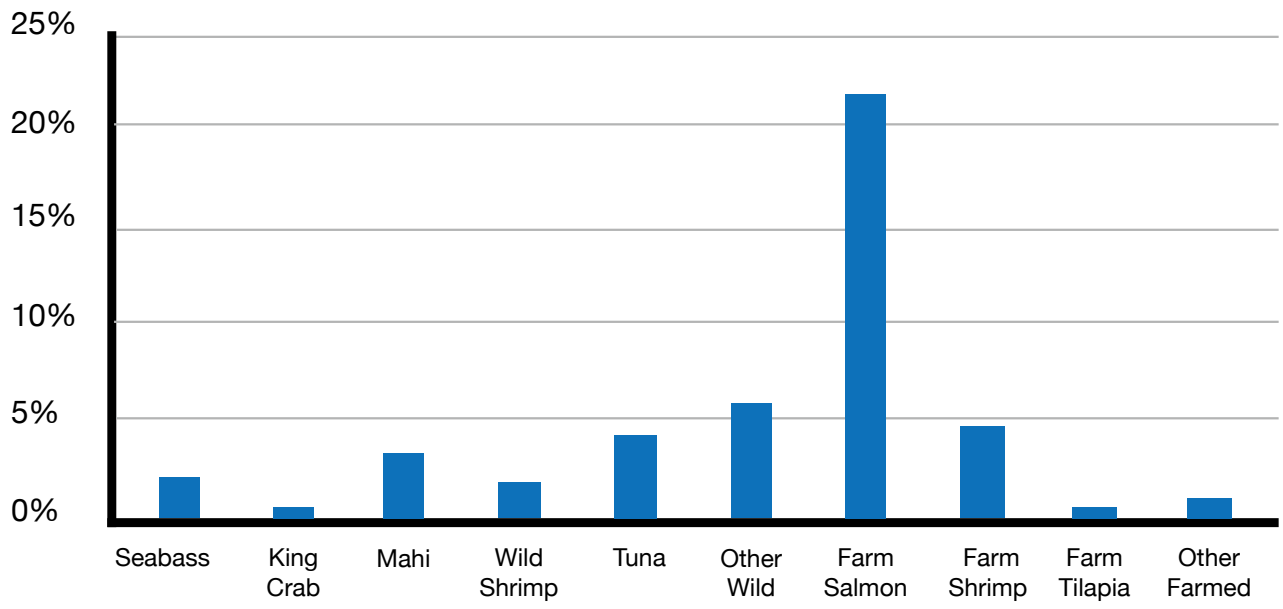


Figure 7. Percentage of Red Pounds of Total Purchases

IMAGE: SANTA MONICA SEAFOOD



producers and has the potential to discourage responsible, often costly, efforts by a producer to become more sustainable if that producer will still be grouped with underperformers.

Seafood Watch® redesigned its focus and process in late 2011 and announced the changes in January 2012 (Hedlund 2012). Seafood Watch® concentrated on internal improvements to enhance its process and reach. Specific changes include revising the criteria for assessment ease and clarity, working on a system of seafood eco-certification referrals in order to incorporate and draw parallels between other certifying programs, and introducing an accreditation program for outsourcing the Seafood Watch® process for more producer-specific applications. These exciting changes effectively address many of the aforementioned criticisms and afford Seafood Watch®, and the industry as a whole, additional tools to further improve their resource assessments.

Partnering with Seafood Watch ®

Before these latest changes, Santa Monica Seafood had already partnered with Seafood Watch® in 2009 for MBAq's Major Seafood Buyer Program in which Santa Monica Seafood agreed to work hard to reduce its dependence on the "avoid (red)" species with the help of Seafood Watch's metrics, education, and technical resources. Santa Monica Seafood applied the Seafood Watch® metric system to create a baseline analysis of Santa Monica Seafood's purchasing activities. This analysis enabled Santa Monica Seafood to identify and focus its efforts on the high-volume, "red" species (Figure 7) in order to evaluate better sourcing of these species, according to Seafood Watch® criteria.

As part of the baseline analysis, Santa Monica Seafood submitted a list of its 2,100 products and product specifics, such as species name, origin, wild/farmed, and capture/culture method, to Seafood Watch® for specific evaluation and color-coded ranking. Seafood Watch® functioned as a certifier for these 2,100 products, and the rankings were uploaded to Santa Monica Seafood's electronic purchasing and sales system. Santa Monica Seafood also instituted a numerical ranking system to coincide with the color-coded rankings (unrated = 0, red = 1, yellow = 3, and green = 4). Santa Monica Seafood then calculated a weighted average per product and product groupings, much like a grade point average in school. Santa Monica Seafood named these averages the responsible sourcing scores. These data allowed Santa Monica Seafood to dissect, graph, and analyze its purchases from the last few years according to various trends. Trend analysis helps Santa Monica Seafood to set goals, track progress, and report to the MBAq.

Introducing "Blue"

To address the company's dependence on "red" species while also encouraging sources to transition to more sustainable practices, Santa Monica Seafood created an additional, transitional ranking level between "red" and "yellow," which Santa Monica Seafood named "blue" (blue = 2). For species with an overall "red" rating, Santa Monica Seafood uses Seafood Watch® criteria to more specifically evaluate the specific farm and wild fisheries from which Santa Monica Seafood sources. In most cases, Santa Monica Seafood will not rate a fishery "blue" unless Santa Monica Seafood has actually visited the fishery and seen firsthand that the issues,

which gave the overall fishery a "red" designation, are being addressed by that specific fishery (Figure 8). Santa Monica Seafood does not expect complete solutions or perfection, but as long as the fishery or farm is on a positive trajectory, Santa Monica Seafood will support, engage, and encourage the fishery or farm through purchasing and a "blue" ranking (Figure 9).

Additionally, some fisheries and aquaculture operations involved in Sustainable Fishery Partnership or World Wildlife Foundation Aquaculture Improvement Plans/Fishery Improvement Plans may also be ranked "blue." Santa Monica Seafood also assigns a "blue" rating to "red" fisheries that have obtained a higher rating from some other recognized organization, such as the Marine Stewardship Council (MSC), Global Aquaculture Alliance, or the Vancouver Aquarium, a practice similar to what Seafood Watch® is exploring as part of its program improvements.

Fresh Catch of Yellowfin Tuna in Indonesia

PHOTO: SANTA MONICA SEAFOOD

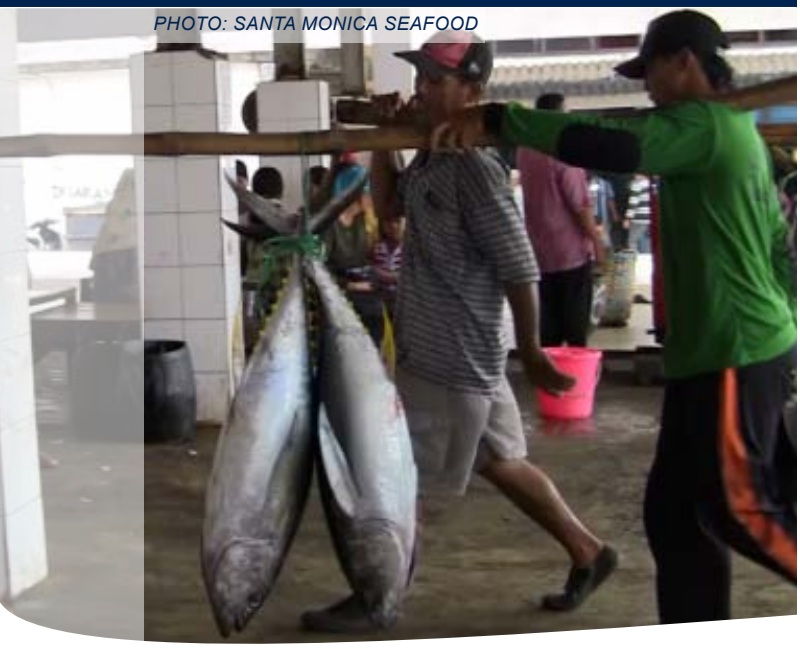


Figure 8. Logan (author) Inspecting an Indonesian Aquafarm

PHOTO: SANTA MONICA SEAFOOD

Figure 9. Santa Monica Seafood Tours a Processing Plant in Thailand

PHOTO: SANTA MONICA SEAFOOD

Shifting from "Red" to "Blue": Yellowfin Tuna Example

Santa Monica Seafood takes several considerations into account when evaluating the potential shift from a "red" species to a more sustainable option. Shifting the company's purchasing from "red" to "green" is ideal, but easy changes have already been made. At this point, this switch is not usually feasible or immediately available. Therefore, shifting from "red" to "blue" is an important first step. First, Santa Monica Seafood consults Seafood Watch® reports. For example, Seafood Watch® rates foreign, longline-caught yellowfin tuna as "red" and U.S.-caught as "yellow"

Figure 10. Seafood Watch ® Recommendations for Yellowfin Tuna

IMAGE: © MONTEREY BAY AQUARIUM

Thunnus albacares

YELLOWFIN			
Atlantic (U.S.)	Troll/pole	Best Choice
Eastern Pacific (U.S.)	Troll/pole	Best Choice
Western and central Pacific	Troll/pole	Best Choice
Western and central Pacific	Unassociated purse seine	Best Choice
Hawaii	Longline	Good Alternative
Atlantic (U.S.)	Longline	Good Alternative
Atlantic (imported)	Troll/pole	Good Alternative
Eastern Pacific (imported)	Troll/pole	Good Alternative
Indian Ocean	Troll/pole	Good Alternative
Indian Ocean	Unassociated purse seine	Good Alternative
Atlantic Ocean	Unassociated purse seine	Good Alternative
Eastern Pacific	Unassociated or dolphin purse seine	Good Alternative
Pacific (imported)	Longline	Avoid
Indian Ocean	Longline	Avoid
Atlantic (imported)	Longline	Avoid
All oceans	Floating object purse seine	Avoid

(Seafood Watch 2010; Figure 10). Unfortunately, there are just not enough U.S.-caught yellowfin available for Santa Monica Seafood to buy throughout the year. U.S. purse seine-caught yellowfin can only be canned, and U.S. and foreign troll/pole-caught yellowfin are rated "green" and "yellow," respectively, but this capture method lowers the quality of the meat below the expectations of Santa Monica Seafood's customers. With the company's options narrowed, Santa Monica Seafood studies the Seafood Watch® report to determine what sustainability issues contributed to the "red" ranking for foreign, longline-caught yellowfin, namely, bycatch and fishery management in this example, and Santa Monica Seafood seeks to source with those fisheries that are addressing these sustainability issues (Figure 11). Additionally, Santa Monica Seafood can get an official rating for those select fisheries by applying the Seafood Watch® assessment process.

Shifting from "Red" to "Blue": Common Thresher Shark Example

Santa Monica Seafood felt it was important to correct the public's perception that all sharks are endangered because of finning and that all shark fisheries are destructive. These issues have been addressed in the California drift net common thresher shark fishery (Figure 12). Despite healthy common thresher populations, strong regulations, and minimized bycatch issues, boycott campaigns and public perception pressured Santa Monica Seafood and other distributors and retailers to stop selling this species. This loss of sales unfairly punished the California drift gillnet fishery with unintended impacts to fishing communities up and down the coast. The demand for thresher shark, despite its affordability, great eating properties, and nutritional benefits, was simply not there.

The National Oceanic and Atmospheric Administration (NOAA) FishWatch program clearly states that the California common thresher shark is not overfished (FishWatch 2011). However, shark finning and bycatch are so contentious as a whole that Santa Monica Seafood wanted to further study the particular issues surrounding common thresher before stocking it again. Employees attended relevant workshops at the Aquarium of the Pacific and in San Diego. Santa Monica Seafood employees learned the following, which allowed them to confidently conclude that the common thresher population is healthy and the management plan effective:

- Endangered species and marine mammal bycatch has all but been eliminated due to area and temporal closures and new gear designs (Heberer 2011).
- Bycatch of other species, including pregnant female and juvenile threshers, has been greatly reduced (Kohin 2011).
- Finning is not a local catch issue, since finning is illegal in the United States, and shark fin sales are also illegal in many states, including California (AB 376 [Fong, Huffman]).

With so much sound information available, Santa Monica Seafood felt assured in its decision to shift thresher shark from "red" to "blue" and promote it to customers, regardless of public opinion. Santa Monica Seafood took a very public stance by

Figure 11. Fishery Longlines in Sri Lanka

PHOTO: SANTA MONICA SEAFOOD

Figure 12. Thresher Shark with Data Tag

PHOTO: SCOTT AALBERS, PFLEGER INSTITUTE OF ENVIRONMENTAL RESEARCH (PIER)

offering common thresher in its two retail stores and has ensured that employees were adequately educated to confidently promote common thresher. Six months later, Seafood Watch® elevated California and Hawaii common thresher shark from "red" to "yellow" (Seafood Watch 2011), and Santa Monica Seafood's decisions were additionally affirmed.

Objective Two: Promotion

Santa Monica Seafood, with wholesale and retail lines of business, interacts with a variety of consumers, chefs, managers, and corporate sustainability officers (Figure 13). Not surprisingly, these customer groups differ with respect to their needs, priorities, product knowledge, and levels of sophistication regarding the products they buy. For all groups, concerns about food safety far exceed concerns about sustainability.

The typical consumer generally has little awareness or interest in sustainability and is more concerned about freshness, taste, cost, and ease of preparation. Conversely, other individuals care deeply about sustainability and are very outspoken. Santa Monica Seafood is proud of the availability of information for consumers and continues to augment the company website with balanced references.

Chefs, on the other hand, realize that they are in a good position to influence public perception (Figure 14). However, they are generally most concerned about freshness, variety, origin, and cost. Chefs have sustainability in mind, but from Santa Monica Seafood's experience, only about 25% actually research the issues or are willing to pay any premium. Most chefs consider the issue of sustainability to be part of their distributor's responsibilities and trust the distributor to take care of it.

Addressing the needs of corporate sustainability officers is the most challenging, and this customer group encourages the biggest changes in Santa Monica Seafood's responsible sourcing program by constantly raising standards. Accountability, traceability, local sourcing, and social impact concerns put new requirements on Santa Monica Seafood's purchasing practices, which must, in turn, be pushed down to the suppliers.

Santa Monica Seafood does various things to promote sustainability and help build the trust between the company and its customers. Throughout Santa Monica Seafood's distribution area, the company hosts demonstrations and tours (Figure 15) as well as sustainability luncheons and dinners featuring sustainable products, with short presentations by speakers from NOAA, the MSC, the MBAq, and others (Figure 16). Santa Monica Seafood also prints the Seafood Watch® product rankings on each line item of every invoice as well as providing the responsible sourcing score at the bottom of the invoice. Upon request, Santa Monica Seafood can also provide a breakdown of a restaurant's purchases by risk category over time and will consult with the restaurant about how to improve its responsible sourcing score.

Figure 13. Display at a Santa Monica Seafood Event

PHOTO: SANTA MONICA SEAFOOD

Figure 14. Chefs at a Seafood Show

PHOTO: SANTA MONICA SEAFOOD

Figure 15. Santa Monica Seafood Facility Tour

PHOTO: SANTA MONICA SEAFOOD

Figure 16. Display and Educational Information at Event

PHOTO: SANTA MONICA SEAFOOD

Conclusion

There is a paradox between short-term profitability and long-term resource management. Trading off present earnings for future assurance in an industry as old and as highly fragmented as the seafood industry is a challenging mind shift, but since the United States imports 85% of its seafood from dozens of countries overseas, this mind shift needs international appeal to effect change. Market pressures, certification schemes, and influence are not enough. Long-term resource management requires cooperation between and within countries and must be institutionalized with regulation, enforcement, and short-term consequences.

Until governments take a stronger lead, distributors are the bridge between supply and demand. Sustainability is an important concern, but it is also a complicated issue. Sifting through the numerous contributing factors and agenda-driven rhetoric can be frustrating for everyone in the value chain. Consumers, chefs, restaurateurs, retailers, and corporations have entrusted Santa Monica Seafood to source seafood responsibly, and in turn, Santa Monica Seafood provides its customers the knowledge to make informed choices. Distributors are sophisticated buyers motivated by a sense of responsibility for the products they sell to expectant markets and customers. Santa Monica Seafood is proud to play a role in U.S. responsible sourcing and will continue to strive to meet the challenges of sustainability.

[1] http://www.seaweb.org/initiatives/swordfish/index.html

[2] http://www.seafoodsummit.org/

[3] http://www.intrafish.com/global/news/

[4] http://www.seafoodbusiness.com/magazine.aspx

[5] http://www.montereybayaquarium.org/cr/cr_seafoodwatch/sfw_recommendations.aspx?c=ln

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References

AB 376 (Fong, Huffman). 2011.

Easton, M. D. L., D. Luszniak, and E. Von der Geest. 2002. "Preliminary Examination of Contaminant Loadings in Farmed Salmon, Wild Salmon and Commercial Salmon Feed." Chemosphere 46 (7): 1053-74.

FishWatch. 2011. U.S. Seafood Facts: Pacific Common Thresher Shark.

http://www.nmfs.noaa.gov/fishwatch/species/pac_common_thresher.htm.

Handwerk, Brian. 2002. "U.S. Chefs Join Campaign to Save Chilean Sea Bass." National Geographic. http://news.nationalgeographic.com/news/2002/05/0522_020522_seabass.html

Heberer, Craig. 2011. "The Nuts and Bolts of a Federally Managed Fishery" and "Bycatch Reduction Efforts." Presentations at the Thresher Shark Information Sharing Meeting, Long Beach, CA.

Hedlund, Steven. 2012. "Seafood Watch Makes 'Top-to-Bottom Revisions.'" SefoodSource.com. January 31. http://www.seafoodsource.com/newsarticledetail.aspx?id=13932.

Hites, R. A. et al. 2004. "Global Assessment of Organic Contaminants in Farmed Salmon." Science 303:226-29.

Houlihan, Jane. 2003. "PCBs in Farmed Salmon: Results from Tests of Store-Bought Farmed Salmon Show Seven of 10 Fish Were so Contaminated with PCBs that They Raise Cancer Risk." Environmental Working Group. http://www.ewg.org/reports/farmedpcbs.

Kohin, Suzanne. 2011. "Shark Bycatch in U.S. West Coast Swordfish Fisheries." Presentation at the U.S. West Coast Swordfish Workshop: Working towards Sustainability, San Diego, CA, May 10. http://swr.nmfs.noaa.gov/sfws/index.html.

Krause, Vivian. 2007. "Farmed Salmon and Aquaculture." Letter to Dr. David Suzuki, Vancouver, BC, Canada, May 11. http://fairquestions.typepad.com/files/letter-to-david-suzuki-11may07-8.pdf.

Lack, M., K. Short, and A. Willock. 2003. Managing Risk and Uncertainty in Deep-Sea Fisheries: Lessons from Orange Roughy. New South Wales, Australia: TRAFFIC Oceania and WWF Endangered Seas Programme. http://www.mar-eco.no/__data/page/89/WWF-orange_roughy.pdf.

Ruais, Rich. 2010. "Tom Strickland Letter." Letter from American Bluefin Tuna Association and Blue Water Fishermen's Association to Tom Strickland, Department of Interior, U.S. Fish and Wildlife Service, Salem, NH, March 29. http://theabta.com/FWSPostCites.pdf.

Seafood Watch. 2010. Seafood Report: Yellowfin Tuna. http://www.montereybayaquarium.org/cr/cr_seafoodwatch/content/media/MBA_SeafoodWatch_YellowfinTunaReport.pdf.

———. 2011. Seafood Report: Sharks and Dogfish. http://www.montereybayaquarium.org/cr/cr_seafoodwatch/content/media/MBA_SeafoodWatch_SharksReport.pdf.

Delicious and Sustainable

SlapFish (www.slapfishsocal.com) is a new gourmet fast casual restaurant whose focus is sustainable seafood—fast, friendly, and ridiculously fresh seafood that's deliciously appetizing and refreshingly responsible. SlapFish proudly serves hungry seafood aficionados at the restaurant's first location of many in Huntington Beach, California. The motivation behind SlapFish is to serve affordable AND sustainable seafood, proving to consumers that it does not have to cost a fortune to eat responsibly.

Affordable

SlapFish maintains their low prices by sourcing well-managed and underutilized species of seafood directly from the source. Our sister company, Status Seafood (http://statusseafood.com/), is a wholesale importer with years of experience working directly within the chain of custody. Given the amount of fraud and mislabeling in the seafood industry, it became apparent to SlapFish that a new purchasing model must be established in order to ensure the traceability of the products. This model entails investing large amounts of capital into purchasing bulk quantities from the source and subsequently selling any unused product. This process allows for SlapFish's transparency and lower pricing. Additionally, due to a fast casual restaurant concept's ability to change its menu on a daily basis, SlapFish also capitalizes on seasonality and price fluctuations.

Sustainable

The SlapFish menu is reviewed by a team of experts and scientists in conservation and marine biology at the Aquarium of the Pacific's sustainable seafood program, Seafood for the Future. SlapFish also uses FishWatch, part of NOAA Fisheries Service, the U.S. authority on marine fisheries science, conservation, and management, and the World Wildlife Foundation.

Some of the responsible and delicious seafood choices served at SlapFish are: Wild Pacific Albacore Tuna from Washington and Oregon; Cold Water Rock Lobster, Mahi Mahi, and White Seabass from California; Sea Bream from South Africa; Dungeness Crab from California and Oregon; and Carlsbad Oysters, Mussels, and Clams from Carlsbad, California. While carbon footprint is considered, an effective cost benefit analysis reveals that sourcing seafood that is properly managed and fully sustainable outweighs the costs of travel.

Behind SlapFish

SlapFish is the creation of owners Chef Andrew Gruel and Jethro Naude, two seafood junkies and successful entrepreneurs who have over 20 years experience in restaurant operations, fishing communities, and the business of conservation.

Chef Andrew Gruel (left) and Jethro Naude (right)
PHOTO: ALAN DE HERRERA

Chef Andrew Gruel is well known in Southern California for his advocacy of seasonal and sustainable cuisine, having recently started and managed the Aquarium of the Pacific's sustainable seafood program--Seafood for the Future.

Jethro Naude has a zeal for the business of seafood, stewardship, and economics. Mr. Naude successfully started, managed, and is still operating Status Seafood, a wholesale seafood distribution company that specializes in fresh and frozen sustainable seafood.

SlapFish Grand Opening
PHOTO: JOHN WOLANIN

Fish Taco
PHOTO: ALAN DE HERRERA

Major Crunchy
PHOTO: ALAN DE HERRERA

Taking a Break from Fishing

PHOTO: JOHN HOLLENBECK

Bridging the Market Gap: Working with Fishermen for Sustainable Seafood and Communities

ARIANA PITCHON

The issues surrounding sustainable seafood are not limited to the harvested ocean and coastal resources, but include the fishing communities (i.e., the people) that must work in collaboration with scientists, legislators, and other stakeholders to ensure that fisheries in all contexts remain sustainable. Fishing communities have the power to encourage their members to accept alternative, more sustainable market strategies that appeal to today's seafood buyers (e.g., restaurants, grocery stores, and consumers). Therefore, fishing communities' support is paramount for a given sustainability initiative to be successful (McCay and Jentoft 1996).

To help fishing communities adapt to changing markets, understanding these communities is important. Fishing communities vary according to geography, gear/species, and history. Some fishing communities have existed for generations and are family-based, insular, and cooperative. Others, as is the case with many in Los Angeles County, are dispersed, multi-ethnic, and independent. This independence can act as one of multiple barriers to successful adoption of alternative market strategies in the face of ever-increasing regulations and decreasing access.

Many commercial fisheries in California have experienced declines in stock abundance, increased restrictions on harvest, and changes in demand. Commercial fishermen also face reductions in the size of available fishing grounds due to Marine Protected Areas (MPAs), prospective wave farms, and other commercial fishing exclusion zones. For decades, the economic structure of California's commercial fisheries has been based on a commodity model for processing and marketing a relatively high volume of landings but selling at relatively low prices. In this model, fishermen profit by catching as many fish as possible as efficiently as possible. However, this traditional marketing system does not easily allow fishermen to maximize the potential economic value of the state's marine fisheries while achieving sustainable resource use.

Southern California's commercial fisheries should be encouraged to meet changing economic and regulatory conditions with product or market innovations that can enhance the value of fisheries, keep communities stable, and support sustainability. New approaches to existing challenges should use an adaptive learning process and be based on innovative models that preserve the marine

Figure 1. Interviewing Local Terminal Island Fishermen

PHOTO: ANA PITCHON, CSUDH

resource and Southern California's commercial fishing heritage. An inside look at the supply and demand of seafood in the Los Angeles area will aid in promoting this shift of management because although theories are good, practice proves challenging (Figure 1).

There are three sides to this problem: regulations, fishermen, and the market. For any change to occur, these sides need to cooperate. Fishery regulations need to be designed so that seafood is sustainable, but regulations should also ensure that a significant decrease in catch will not compromise the future of the fishery. Fishermen need to adapt their harvesting and marketing strategies, and restaurant and grocery store owners (i.e., the market) need to work with fishermen to resolve the logistical issues with supply. The sardine fishery is an excellent example of this multi-sided problem. Fishermen harvest sardines using the traditional high-volume, low-value strategy. The Pacific Fishery Management Council's (2010) current season management plan for sardines has set a maximum harvest guideline of 72,039 metric tons. These sardines are caught in large purse seine nets and then rapidly processed, frozen, and shipped abroad for purposes other than direct human consumption (e.g., fish feed and fertilizer). This fishing method leaves locally caught sardines battered and torn, and therefore unsuitable to serve on a plate. Meanwhile, sardines are making a comeback in restaurants. Sardines are increasingly recognized for their flavor, sustainability, and health benefits (high in important fatty acids yet low in mercury). However, because the local sardine industry does not produce a restaurant-quality product, the sardines eaten in Los Angeles restaurants primarily come from abroad. If local sardines were harvested in a way that left them intact, this product could be sold at a much higher price. Additionally, if the catch could be delivered fresh daily, local restaurants could put locally caught sardines on the menu. In this way, an operator of a small live bait vessel could actively harvest sardines for direct sale to restaurants, as is the case in San Diego[1]. Direct sale would increase the value of sardines and show that a decrease in catch can potentially be more profitable than the current, traditional model.

The shift to higher-value, higher-quality, and lower-volume product is gaining momentum with seafood buyers. Furthermore, consumers are increasingly interested in eating locally produced foods, as the *locavore* movement gains popularity (Gogoi 2008). Although some grocery stores and fish markets are hesitant due to issues of sustained supply, restaurants are interested in innovation and have a bit more leeway when it comes to change. Some smaller restaurants change their menu daily and are used to working with the seasonality of locally available

Figure 2. Torrance Farmers Market: Fresh Seafood Stand

PHOTO: ALEXX SALAZAR, CSUDH

Figure 3. Fishing Industry Memorial, San Pedro

PHOTO: MARKO GARMONO, CSUDH

ingredients (Figure 2). It is also in a restaurant's best interest to set trends, such as a new food item or a new source for that item. Some chefs are already catering to the *locavore* trend and are eager to be the first down at the docks (an unusual and often surprising activity in Los Angeles) to purchase sea urchin and sardines. One local chef even wanted to put pictures of the fishermen on his website with descriptions of the seafood's origin.

Many fishermen in the Los Angeles area want to engage in direct marketing, and many restaurant owners and grocery stores are eager to participate in "boat-to-table" dining. However, the need for a high level of cooperation from very independent fishermen is proving to be one of the largest barriers to rapid acceptance and implementation of any new marketing strategies.

An introduction between some San Pedro–based fishermen and two local Los Angeles chefs at new, trendy, small restaurants had the great potential of coupling interested producers and consumers. Both sides were excited about the prospects of selling and buying locally and directly. The restaurants wanted to support local producers and obtain the freshest food available. Interestingly, the fishermen were as interested in the prospect of direct selling for economic reasons as they were in selling locally from a more philosophical standpoint (Figure 3). To them, there was a stronger sense of pride in having their catch consumed locally than having it sold, processed, and distributed halfway around the world. However, the potential partnership snagged on such issues as licensing, transport, and supply, which would most appropriately be resolved within the fishing community.

Under the traditional system, fishermen sell their catch to a wholesaler who is licensed with a certified scale, has a distribution system, and balances out fluctuations in landings by purchasing from a large number of fishermen. To sell directly to a restaurant, grocery store, or consumer, a fisherman needs to account for each factor. Obtaining a license and a certified scale is a matter of time and money. However, providing a steady and continuous supply is a challenge for many fishermen for many reasons outside their control, such as boat maintenance, foul weather, and regulatory seasons. Transporting the catch is another hurdle because a refrigerated truck is necessary to get the catch from the docks to other parts of Los Angeles, and this is cost prohibitive for most fishermen. Finally, the time spent selling and delivering their catch is time that fishermen could be fishing, so finding the right balance is another hurdle. Some fishermen have begun tackling these issues by considering a cooperative, in which they would join together and operate for mutual benefit.

Cooperatives are assembling in other parts of California and the United States in various forms, such as the San Diego Fishermen's Working Group and North Carolina's Walking Fish (www.walking-fish.org). The Fishermen's Working Group functions as a marketing association targeting the local consumer. Walking Fish, on the other hand, is a community-supported fishery that connects local, pre-paying members to a share of a local fishermen's seasonal catch, much like community-supported agriculture does. Forming these cooperatives is not simple and depends on space, start-up funds, perceived or actual demand, and, most importantly, cooperation. This last variable has been known to be an insurmountable hurdle to success or to even starting the process. Although fishermen in a region may agree that a new strategy for economic sustainability is positive and feasible, they struggle to organize around the idea. To understand why, one must consider the established characteristics of the fishermen and their specific

fishing community. To form a local cooperative, Los Angeles fishermen need to overcome their tendency toward independence to cooperate (Jentoft and Davis 1993; Thomas, Johnson, and Riordan 1995).

The fact that fishermen are notoriously independent is widely acknowledged and discussed in academic literature. In *Anthropology of Fishing* (1981), James Acheson discusses the general themes addressed in maritime anthropology, such as the socio-cultural characteristics of fishing communities and of the people themselves, including what constitutes a sense of community and how that community functions. He discusses cultural characteristics that place this group of people in a complex population, culturally and socially defined by their work. Smith (1977), Johannes (1981), McGoodwin (1989), Pollnac (1988), and Pollnac and Poggie (1991) support this characterization, adding that variables such as work environment, resource availability, relative isolation, characteristics of independence, hazards, and lack of control all contribute to the unique structure of fishing communities, the people who comprise them, and the multiple social, cultural, economic, environmental, and institutional problems they face (Figure 4).

As resource use changes, due to regulatory measures or environmental change, so do the corresponding, informal social institutions that will emerge to regulate resource use. For example, if fishermen relocate to alternate fishing grounds, this could change social networks and challenge pre-existing internal enforcement structures. This could be another barrier, as the status quo is established and institutionalized in its own right. Fishermen have networks, alliances, and hierarchies; and the threat of disruption can be enough to block change, even though change may lead to increased stability and resilience. Group characteristics also play an important role in shaping the effectiveness of a cooperative or new management strategy. Group size, for instance, can be critical to successful cooperation. When local fishermen were approached about the potential of forming a cooperative, the overwhelming response was that it was essential to keep the cooperative small. The literature supports this idea. Olson (1965) argued that smaller group size best facilitates the collective action required for successfully governing a resource. Ostrom, Gardner, and Walker (1994a) agree, stating that relatively homogenous and small groups tend to be the most robust.

A community sustains human interactions in the social and environmental contexts and relies on cooperation to function (Argyle 1991; Axelrod 1984). For people within a community to cooperate, individuals must perceive

Figure 4. San Pedro Fishing Vessel

PHOTO: MARKO GARMONO, CSUDH

Figure 5. Small-Scale Commercial Fishing Vessels, Terminal Island

PHOTO: ANA PITCHON, CSUDH

their existence as part of the integrated whole and act in ways that are not driven solely by egocentric values (Jentoft, McCay, and Wilson 1998). Some fishermen in Los Angeles have, at times, cooperated and acted as a united group. Furthermore, most fishermen in Los Angeles continue to fish in spite of declining catch and income. They continue mainly because they do not want to do anything else, although they could. Fishing is a way of life with its own culture, and many fishermen simply cannot fathom an alternative. Thus, there is hope for Los Angeles fishermen to cooperate in a way that will allow them to develop harvesting and marketing strategies, which will enhance the fishermen's economic and social well-being and allow them to continue fishing as the availability of the resource fluctuates and regulations change.

Fishermen in Southern California are not unique among fishermen worldwide regarding changes in resource availability, access restrictions, and the need for revising strategies and corresponding institutions in light of these changes. Fishermen recognize the need to adapt, but the challenge lies in actually making adjustments before imminent collapse forces the issue. Ideally, fishermen will voluntarily adjust their harvesting and marketing strategies because current sentiments and the market support these more immediate, less painful changes. A variety of groups, from fine dining establishments to farmers markets to elementary schools, are beginning to follow the *locavore* trend (Gogoi 2008). Buying and selling in a local market benefits the community, the environment, and the local economy. Supplying the *locavore* movement would be advantageous for small-scale fishermen (Figure 5) in Los Angeles County and may provide the best incentive for improving the sustainability of California commercial fisheries. Finally, keeping communications open and ongoing will be key to working through logistical hurdles and achieving cooperation. Fishermen in San Pedro are currently renewing their efforts toward cooperation by continuing to discuss a cooperative. They are also on the lookout for less formal opportunities to coordinate, such as making joint capital purchases and procuring and sharing commercial scales. Despite the difficulties, there is hope for fishermen, seafood, and communities to become more sustainable, while maintaining their quality of life and economic and social resilience.

1 San Diego's Everingham Bros. Bait Co. sells to the local Sea Rocket Bistro.

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References

Acheson, James. 1981. "Anthropology of Fishing." Annual Review of Anthropology 10: 275–316.

Argyle, Michael. 1991. Cooperation: The Basis of Sociability. London: Routledge.

Axelrod, Robert. 1984. The Evolution of Cooperation. New York: Basic Books.

Gogoi, Pallavi. 2008. The Rise of the 'Locavore.'" Business Week, May 20. http://www.businessweek.com/bwdaily/dnflash/content/may2008/db20080520_920283.htm.

Jentoft, S. and A. Davis. 1993. "Self and Sacrifice: An Investigation of Small-Boat Fisher Individualism and its Implications for Producer Cooperatives." Human Organization 52(4): 356-367.

Jentoft, S., Bonnie McCay, and D. Wilson. 1998. "Social Theory and Fisheries Co-management." Marine Policy 22 (4-5):423–36.

Johannes, R. E. 1981. Words of the Lagoon: Fishing and Marine Lore in the Palau District of Micronesia. Berkeley: University of California Press.

McGoodwin, James. 1989. Crisis in the World's Fisheries: People, Problems, and Policies. Stanford, CA: Stanford University Press.

McCay, Bonnie and Svein Jentoft. 1996. "From the Bottom Up: Participatory Issues in Fisheries Management." Society and Natural Resources 9: 237-250.

Olson, E. 1965. The Logic of Collective Action. Cambridge, MA: Harvard University Press.

Ostrom, Elinor, Roy Gardner, and James Walker, eds. 1994a. "Cooperation and Social Capital: Theoretical Choices for Doing Policy Analysis Surmounting CPR Dilemmas." In Rules, Games, and Common Pool Resources, 319–30. Ann Arbor: University of Michigan Press.

Pacific Fishery Management Council. "2010 Pacific Sardine Harvest Specifications and Management Measures." Fishery Management Plan: Current Season Management. Last modified February 18, 2010. http://www.pcouncil.org/coastal-pelagic-species/current-season-management/.

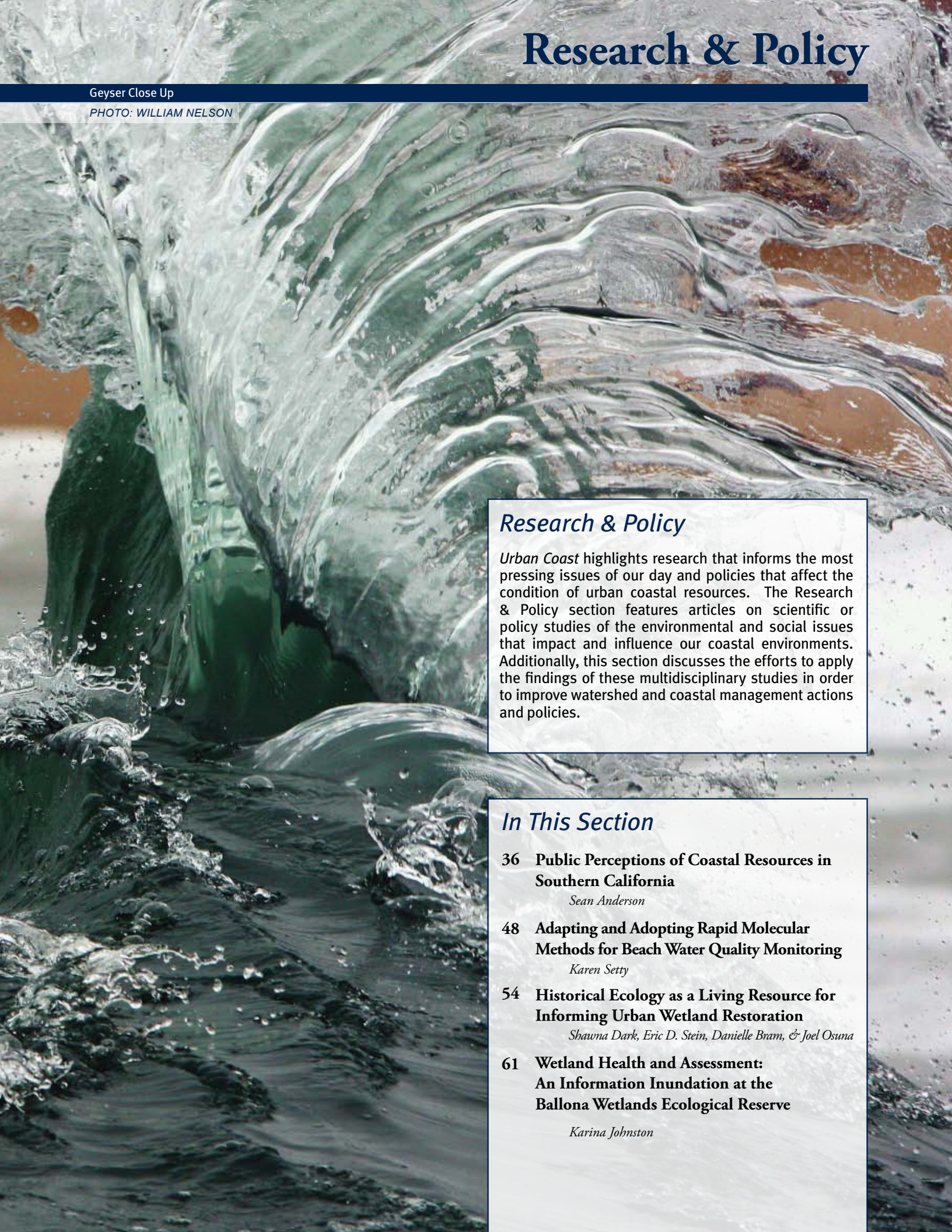
Pollnac, Richard B. 1988. "Social and Cultural Characteristics of Fishing Peoples." Marine Behavioral Physiology 14: 23–39.

Pollnac, R., and John Poggie. 1991. "Psychocultural Adaptation and Development Policy for Small-scale Fishermen's Cooperatives in Ecuador." Human Organization 50 (1): 43–49.

Smith, M. E., ed. 1977. "Introduction." In Those Who Live From the Sea: A Study in Maritime Anthropology, 1–23. St. Paul, MN: West.

Thomas, J. S., G. D. Johnson, and C.A. Riordan. 1995. "Independence and Collective Action – Reconsidering Union Activity Among Commercial Fishermen in Mississippi." Human Organization 54(2):143-152.

Research & Policy



Geyser Close Up

PHOTO: WILLIAM NELSON

Research & Policy

Urban Coast highlights research that informs the most pressing issues of our day and policies that affect the condition of urban coastal resources. The Research & Policy section features articles on scientific or policy studies of the environmental and social issues that impact and influence our coastal environments. Additionally, this section discusses the efforts to apply the findings of these multidisciplinary studies in order to improve watershed and coastal management actions and policies.

In This Section

Public Opinion Poll Survey

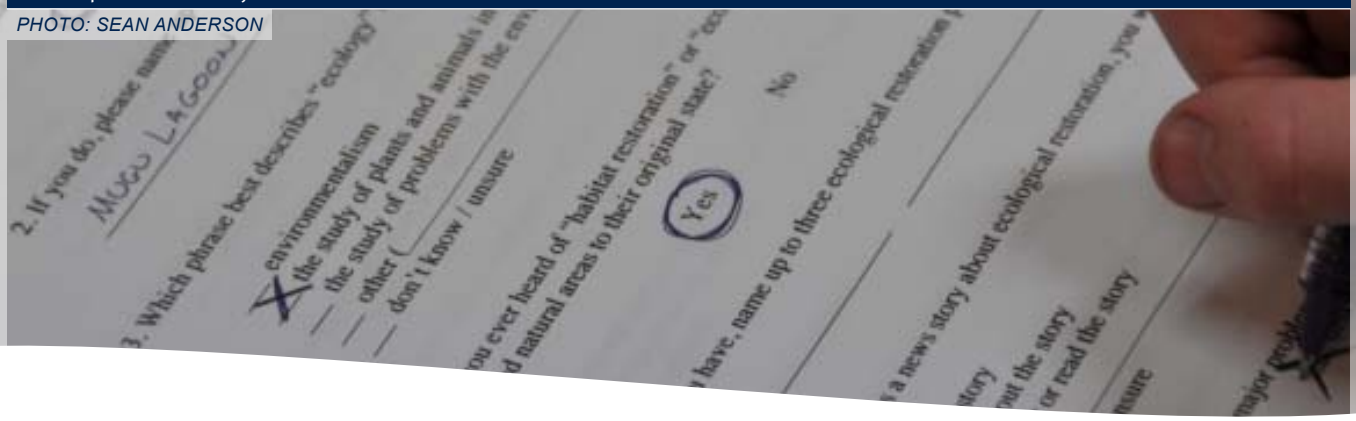


PHOTO: SEAN ANDERSON

Public Perceptions of Coastal Resources in Southern California

SEAN ANDERSON

Abstract

Fostering a healthy coastal zone is arguably one of the most difficult challenges faced by the modern resource manager. California is at the epicenter of the long-term global trend of evermore-populous coastal strands with increasingly disparate and complex resource demands and development pressures. In such a situation, understanding the public's perceptions of various resources is key to shaping effective policy, conducting truly community-based conservation efforts, and effectively targeting scarce public dollars. Annual sampling of such public perceptions provides a better understanding of where the public currently stands on various issues and provides a long-term baseline with which to compare the efficacy of various future management efforts.

The coastal zone exerts a disproportional pull on almost every aspect of society; more than 50% of humans now reside within 50 km of the sea (Hinrichsen 1998), and that proportion is growing each year. Only 8% of the counties in the United States abut a coastline, but these coastal counties now account for nearly half of the U.S. population (U.S. Census Bureau 2011), including seven of the ten most populous counties (Wilson and Fischetti 2010). The five coastal counties of the Southern California Bight—Santa Barbara, Ventura, Los Angeles, Orange, and San Diego—comprise 0.4% of the area of the United States, but hosted 5.6% of this nation's population and 7.4% of its gross domestic product in 2008 (Pacheco and Ache 2011). Statewide, one component of the coastal zone—the beach—generated $61 billion a year (2001 dollars, California Department of Boating and Waterways and Conservancy 2002), with beach recreation worth an estimated $8.3 billion to the state and $5.5 billion to the rest of the United States annually (King and Symes 2003). Approximately two-thirds of California residents visit the beach annually (Public Policy Institute of California 2003) with an estimated 129 million visits per year made to Southern California beaches alone (Dwight et al. 2007) (Figure 1).

Despite the popularity and importance of the coastal zone, coastal zone management has generally proceeded in a relatively traditional manner wherein public agents primarily engage with motivated special interest groups such as environmental groups or developers The public has historically participated in management debates in California (e.g., Proposition 20 birthed the California Coastal Act of 1976, post-oil spill moratoriums on new offshore oil drilling leases); however, recent broad-base activism and engagement are increasingly the exception rather than the norm. Often current public engagement comes during extremely contentious or high-profile debates (e.g., proposed offshore liquefied natural gas terminals, celebrity home development in the coastal zone, desalination plant construction). An increasing body of scholarship (under the auspices of organizations such as the National Ocean Economics Program and the Santa Monica Bay Restoration Project) has begun to elucidate some underlying public perceptions of California coastal resources, generally focusing upon valuation of coastal strand recreation/human

Figure 1. Populated Coast in Manhattan Beach

PHOTO: SARAH WOODARD

Figure 2. Slurry Lines for Beach Nourishment to McGrath State Beach

health to date. Having an ongoing tool with which to sample the public's opinion about their understanding of the coastal zone and their impressions of the management actions taken to date could augment this emerging socio-economic understanding and improve management efforts. To be of maximal utility to managers, such a tool should be continuous, broad-based, and not driven by any particular controversial issue.

Few efforts to understand public attitudes toward multiple coastal zone resources have been undertaken in recent years. Typically, these have been on a national scale (e.g., National Oceanic and Atmospheric Administration 2003) and so lack sufficient granularity to understand local attitudes or have been too narrowly focused on a particular topic (e.g., Natural Resources Defence Council 2010) to be broadly useful. Recent attempts to examine regional trends can provide sufficient detail/data for county/local analyses, but tend to focus on short-term economic valuation of a single particular coastal-dependent activity (e.g., Bell, Bonn, and Leeworthy 1998) and generally fail to sample all user groups (particularly non-consumptive resource users) or residents (National Oceanic and Atmospheric Administration 2003) or fully assess more indirect impacts/externalities. Examples of such sampling in Los Angeles County (Pendleton, Martin, and Webster 2001) have shown something of a disconnect between the objective assessment of coastal resource states and the generally negative public assessment of those resources. Such focused efforts tend to work well for justifying a given management action or decision (e.g., beach nourishment; Figure 2) but are of limited value when attempting to understand broader attitudes of the public as a whole to the coastal zone overall. A welcome exception to this trend is the emerging efforts of the California Coast Online Survey. Although the survey is still in development, major strides in gathering such an explicit, regional, longitudinal understanding of coastal zone user behavior (but apparently not views of given management actions) via web-based polling is currently under way (see Pendleton and LaFranchi 2009).

The California State University Channel Islands (CSUCI) Survey of Public Opinion of Coastal Resources represents an initial effort to quantify the public's understanding of and attitude toward various coastal resources and issues within coastal Southern California. This tool seeks to test the hypotheses that the general public:

1. Understands the current condition of coastal resources.
2. Frequently consumes or actively engages coastal resources.
3. Is aware of current coastal management efforts.
4. Is satisfied with current management efforts.

Methods

Opinion Polling Overview

Since 2005, students enrolled in CSUCI's Coastal and Marine Management (ESRM 462) class have conducted an annual CSUCI Survey of Public Opinion of Coastal Resources across southern Santa Barbara, Ventura, and northern Los Angeles counties in early fall (September through October). The results from each year's survey are incorporated into the course and provide various points of departure for discussions revolving around coastal management. This survey was originally not intended for use outside CSUCI classrooms. However, after repeated requests from various coastal managers for summaries of the polling data, annual sampling (from 144 surveys in 2005 to 1,486 in 2010) and scope of questioning were greatly expanded after the 2007 survey (Table 1).

Survey respondents were volunteers haphazardly encountered in public places (malls, parks, etc.) during daylight hours and not compensated. Owing to the location of the CSUCI campus, approximately 60% of the surveys were conducted within Ventura County, with the remainder split roughly equally between Santa Barbara and Los Angeles counties. Within any given location, sampling was haphazard (Connaway and Powell 2010). No more than 25 surveys were conducted within any one location in any given year to minimize any bias of this non-probability sampling (Fink 2003). Individual sampling locations were selected randomly from among publicly accessible areas (malls, parks, etc.) across the region. Question order was randomized for each survey in the first two years, but fixed for all subsequent surveys. All surveys used a printed questionnaire and were in English. A Spanish language version of this poll was piloted in 2010, but only data from the English language version are reported here.

Respondents covered a range of individuals whose composition differed somewhat from the overall coastal population

Table 1. Survey Overview

Year	# of Polls	Poll Version	# of Questions
Overall (2005-2010)	5,085	-	-
2005	144	3.2	24
2006	703	3.3	25
2007	494	4.2	27
2008	1,226	4.6	38
2009	1,032	4.7	39
2010	1,486	4.9	53

composition (within the five coastal county region). Survey participants were somewhat older (36±16, mean±1 standard deviation; median age = 31 vs. mean age 20–24; Pacheco and Ache 2011), more likely to have a college degree (37% vs. 29%; U.S. Census Bureau 2011), and vote regularly (76% vs. 42% of eligible voters voting in the 2010 elections; California Secretary of State 2011) relative to the local California population overall, but were otherwise similar in terms of income (most respondents' annual household income exceeded $60,000 vs. the median income bracket of $75,000–$99,999 in coastal populations; Pacheco and Ache 2011) and other metrics. Television and the Internet are equally dominant (both approximately 75% overall) as a source of news for survey participants.

Table 2. 2010 Poll Questions

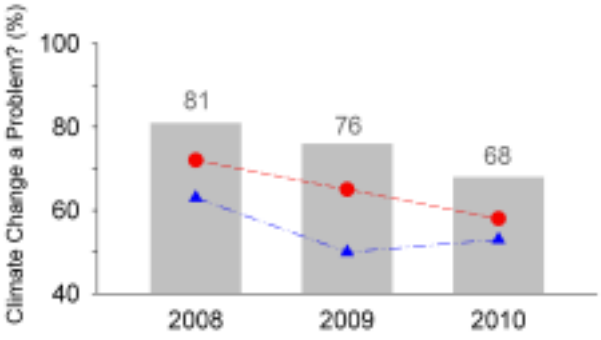
Category	# of Questions	Representative Question
Coastal Science	2	Which phrase best describes "ecology"?
Existing Conditions	8	If you believe wetlands have changed, by how much have they increased or decreased?
Management: Management Awareness	6	Which approaches to protect fish and shellfish populations are you familiar with?
Evaluation of Management	9	California is adequately managing our coastal and marine resources.
Desired Management	8	After the *Deepwater Horizon* oil spill, my attitude towards offshore oil and gas drilling:
Valuation	4	Would you favor spending the following amounts every year for the foreseeable future?
Behavior/Demographics	17	When was the last time you visited any of the California Channel Islands?

Figure 3. CSUCI Restoration Ecology Students in Ojai

PHOTO: SEAN ANDERSON

Figure 4. Climate Change Attitudes

IMAGE: SEAN ANDERSON



Climate Change attitudes. Borick et al. 2011 and Leiserowitz et al. 2011 data from national phone surveys.

Questions

A core of questions centering on ecological restoration and coastal wetlands have been asked each year, with additional questions added in subsequent years as various management issues have risen to the forefront (e.g., BP's *Deepwater Horizon* Oil Spill, wildfires in Malibu, Marine Protected Area implementation, etc.). As a result, the 2010 survey contains more than twice (53) the number of questions of the original 2005 survey (24; Table 1). This 2010 survey typically required 10–15 minutes to complete.

Questions fall into one of five broad categories (Table 2) that span public perception of science, awareness of the existing coastal conditions, perception of management efforts (which in turn is comprised of three distinct sub-categories), valuation of coastal resources, and personal behavior/demographics. Questions involving contingent valuation of resources require more sophisticated analyses and are not presented in this paper. Unless noted, data here are presented as the aggregation of all survey years. Most results are presented as the proportion of the total responses.

Rarely did responses vary much between survey years. When responses differed by more than 5% per year, data are reported by survey year.

Results

General Perceptions of Science and Nature

Most people (66%) identified ecology as the study of plants and animals in their environment and (72%) described the main motivation of scientists as primarily "seeking to objectively understand nature" (Figure 3). Additionally, most (>70%) respondents each year felt the ecological functioning of an area should be a primary (if not the primary) consideration for valuing natural areas. This is heartening given the increasing attention anti-science and anti-environment critiques have garnered in recent national debates about managing natural resources (e.g., Morello 2011).

In line with other national polls (Borick, Lachapelle, and Rabe 2011; Freedman 2011; Leiserowitz et al. 2011), this CSUCI survey has documented a steady erosion of concern surrounding climate change (Figure 4). Eighty-one percent of those sampled felt climate change was a major problem that needed to be dealt with

immediately when first asked about it in 2008. Concern eroded to only 68% feeling that way as of 2010. This may well be due to the politicization of the climate change issue (Morello 2011). Attitudes toward another traditionally controversial environment issue, endangered species, do not show such erosion of support in the coastal zone. Respondents who felt endangered species protections should be kept as is or strengthened have remained in the majority (fluctuating between 54% and 78%) with support peaking in 2010 (78%). However, willingness to use endangered species as a measure of the value of a given area has diminished roughly in line with the erosion of support for climate change since 2007.

Economic concerns have shifted to the forefront for most Americans during the economic upheaval of recent years. Interestingly, while this may have had an indirect effect upon people's attitudes toward climate change and other issues, only a fraction of people (<43%) have ever believed economic concerns should be used to determine the value of a given natural area, consistent with historic attitudes measured in California (Public Policy Institute of California 2003). Economic concerns are the only potential factor for valuing natural areas examined that has never achieved a plurality in the six years of this polling.

Activities in the Coastal Zone

Exercise and passive leisure activities dominated most people's coastal zone activities in the preceding six months. More than half of respondents recently ate, walked, played, and/or swam in the coastal zone (Figure 5). Roughly 40% of the sampled populations went to the coastal zone weekly (or more frequently) with nearly two-thirds going at least monthly. Multiplying aggregate reported natural area visitation frequency by the proportion of user-identified locations specifically in coastal areas finds 75% of the population visiting at least one coastal site per year. This is identical to the Southern California Bight coastal site visitation rate estimated by a Public Policy Institute of California (2003) poll before the onset of this survey sampling and similar to the 61% of Pendleton and LaFranchi (2009) during this polling study for beaches between Los Angeles and San Francisco. Relatively few (6–15%) respondents engage in activities requiring substantial equipment/capital investments or particular zoning (sailing, boating, diving, off-road vehicle driving, and horseback riding; Figure 6). Anglers, spearfishers, and hunters are scant (<16%) in the coastal zone, consistent with their long-term decline across the country as a whole (U.S. Fish and Wildlife Service and Bureau 2006).

When asked the last natural area visited, responders gave wide-ranging responses spanning Africa to the Americas. Nonetheless, locations within the Southern California Bight dominated (78%) the recent itineraries of those living here. The beach (61% of all responses) and coastal mountains (15%) were the most popular destinations. The most popular coastal locations within the Bight included Beaches within the City of Ventura (9% of coastal Bight responses), sites within the Santa Monica Mountains (6%),

Figure 5. Recreation at County Line Beach

PHOTO: SEAN ANDERSON

Figure 6. Recreational Diving

PHOTO: CHRIS STAFFIELD

Figure 7. Visiting Leo Carrillo State Beach

PHOTO: SEAN ANDERSON

Oxnard/Ormond Beaches (3%), Zuma/Point Dume Beaches (2%), sites within the Topatopa Mountains (2%), and Malibu Beach (2%). It is important to note here that this question of where people most recently visited is perhaps the most biased of this polling. As this sampling was clearly biased toward Ventura County and most people do not necessarily travel far to go on a hike or walk, it is not surprising that Ventura County destinations dominated specific responses. An additional confounding factor is the disproportionate number of coastal recreational sites available in Santa Barbara and Ventura counties relative to more urbanized stretches of the Bight. Traveling to either mountainous protected areas or public beaches to find relatively natural areas in which to recreate (Figure 7) is in part a simple consequence of the development/obliteration of most natural coastal plain areas, the channelization of creeks, and more across the Bight.

Figure 8. View of Anacapa Island from Santa Cruz Island

PHOTO: CHRIS STAFFIELD

Reflecting the logistical challenge of getting out to any of California's offshore Channel Islands, approximately one-third (34%) of the Southern California Bight population has never been to an island, and an additional third (33%) had not been to an island within the previous year. For those who have made the journey, island destination tracks closely with proximity to mainland harbors. More than half (53%) of visitors have been to Santa Catalina Island (directly out from the Los Angeles/Long Beach Harbor), followed by Anacapa (44%) and Santa Cruz (41%) just off the coast from Ventura, Channel Islands, and Port Hueneme Harbors (Figure 8).

Awareness of Existing Coastal Conditions

Most responders rank pollution (first) as the greatest threat to coastal areas generally (Figure 9), consistent with American perspectives on environmental threats historically (Markham 1994). Outright destruction/fragmentation (second) of areas and overharvesting (third) are secondary, and invasive species (fourth) are perceived as the least problematic. This carries into their perception of threats to specific coastal resources. Perceived threats to wetlands follow an identical pattern (although the magnitude of difference between rankings is somewhat less) and a very similar pattern for threats to California's fisheries. The palette of potential threats to fisheries was expanded to include ocean acidification and altered temperature, which are two climate change-related threats (Solomon et al. 2007). Again, pollution was identified as the greatest threat, followed by overharvesting, habitat destruction/fragmentation, acidification, temperature, and invasive species.

Coastal scientists do not have an absolute objective rubric to determine which threats pose the greatest risk to any one resource, let alone the coastal zone as a whole. Most managers and indeed members of the public understand multiple factors interact to produce coastal zone challenges. Indeed, pollution remains an ongoing challenge to managers (Dorfman and Rosselot 2011) decades after the onset of the modern pollution control era (Figure 10). However, even a cursory examination of existing policy priorities (Ventura County Watershed Protection District 2005), funded management activities (Santa Monica Bay Restoration Commission n.d.), and academic research (Hunt & Associates 2008) shows that pollution is but one of various threats to coastal resources. Yet the perceived pollution primacy trumps even harvesting as the key factor believed to influence harvested fish stocks. Recently, declining budgets have limited beach access (the most popular coastal destination) by park closures, but this comes in the wake of almost two decades of increasingly frequent sewage-driven beach

Figure 9.Perceived Resource Threat

IMAGE: SEAN ANDERSON

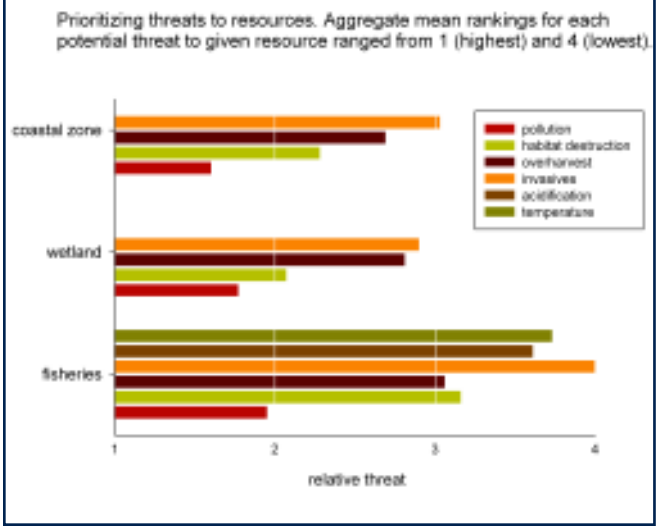


Figure 10.Superfund Site Sign

PHOTO: SEAN ANDERSON

Figure 11. No Swimming Sign

PHOTO: SEAN ANDERSON

closures/swimming advisories across the Bight that have limited access and harmed beach-related tourism, particularly in Orange County (Barboza 2010). These chronic closures have likely amplified the perceived threat of pollution to the coast generally (Figure 11). De-emphasis of threat categories in the public's eye ultimately influences management via underfunding and/or deprioritization (Cohen, March, and Olsen 1972). Deprioritization of invaders has been seen most recently in the elimination of the division within California Department of Fish and Game responsible for invasive plant control. The need for researchers and managers to adequately communicate the plethora of threats facing the coastal zone will only grow in this emerging era of reduced budgets and management scope.

Most people are unfamiliar with the public agencies principally responsible for managing resources in the coastal zone. Most people are familiar with the U.S. Coast Guard (85%), California Coastal Commission (66%), and California Coastal Conservancy (51%). Forty-two percent have heard of the U.S. National Oceanic and Atmospheric Administration. Other agencies are familiar to less than a third of responders. Awareness of these less-known agencies seems somewhat more correlated with news coverage. For example, awareness of California's Ocean Protection Council halved between 2009 and 2010 as the somewhat contentious multi-year Marine Protected Area planning process for the Bight ended.

Evaluation of Coastal Management

Only 17% of respondents feel that coastal and marine resources are adequately managed (Figure 12). The remainder are almost evenly split between those who feel managers are not adequately managing these resources (43%) and those who are unsure or do not know enough to make an informed opinion (40%). That nearly half the population cannot evaluate current coastal zone management is consistent with the general lack of awareness of the agencies responsible for doing so. When the management in question is specific enough and press coverage abundant, respondents are much more likely to express an opinion. For example, when asked about high-profile coastal disasters, Southern Californians believe essentially the same amount of rebuilding should occur no matter whether the event was fire in the Malibu Hills (41% want all or most rebuilt, 23% are unsure) or failed levees in New Orleans (44% want all or most rebuilt, 16% are unsure).

Independent of the public's evaluation of current management, they strongly believe (59%) that the ocean is less healthy now than 50 years ago (Figure 13). Only 12% believe ocean health has improved over that time. They feel similarly that marine fish stocks are less healthy now (55%) than 50 years ago. Further refinement of the CSUCI questionnaire is necessary to determine if respondents feel this has been a slow, consistent degradation or if local conditions had previously improved and then recently seemed to decline. Informal post-survey discussions with respondents suggest that at least some are basing their aggregate ocean health assessment primarily upon apparent contamination/water quality concerns.

Figure 12. Perceived Management Efforts

IMAGE: SEAN ANDERSON

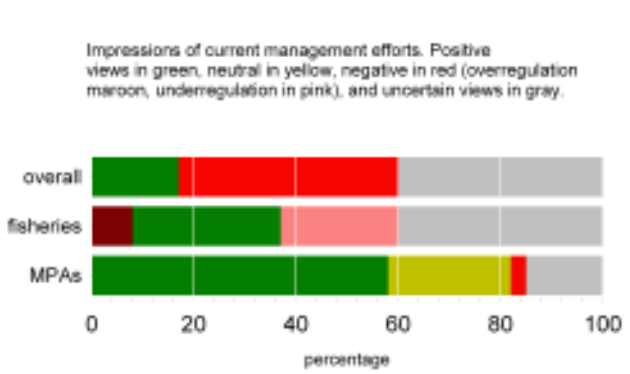
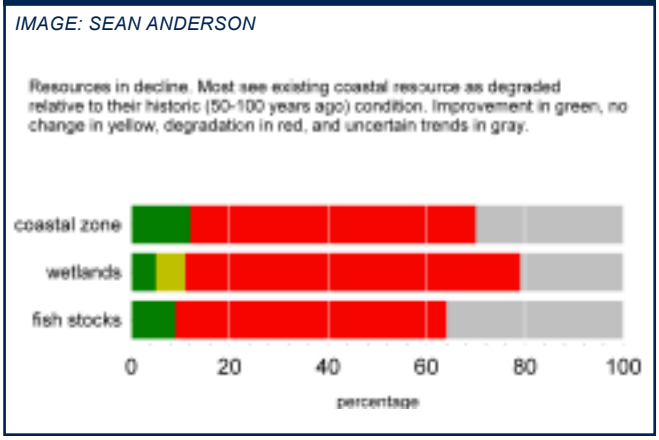


Figure 13. Perceived Resource Trends

IMAGE: SEAN ANDERSON

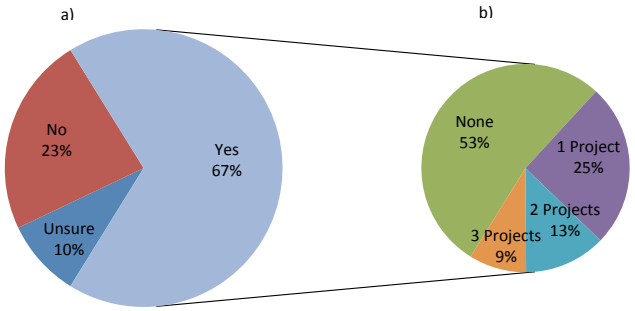


Long Grade Creek Restoration on CSUCI Campus

Figure 14. Aggregate Survey Responses

a) "Have you ever heard of 'ecological restoration' (returning damaged natural areas to their original state)?"

b) With limited success, those that responded "yes" were asked to correctly name up to three restoration projects.



Focal Topic 1: Ecological Restoration in the Coastal Zone

Recovering and rehabilitating degraded ecological systems in the coastal zone are increasingly popular tools used to achieve multiple policy goals. Restoration is used throughout the Southern California Bight to recover subtidal reef communities degraded by power plants (Southern California Edison Company 2008), suppress non-native invasive species (Wildscape Restoration and Rincon Consultants 2011), boost populations of endangered species (U.S. Army Corps of Engineers 2003), improve water quality (Selkirk 2011), and increase recreational opportunities from surfing to biking to bird watching (Moffatt & Nichol 2005). All too often, however, the agencies and groups responsible for these restorations fail to adequately engage with the public or give them a deep sense of ownership or understanding of the value of such projects. For example, roughly two-thirds of respondents claim they would want to read/watch a news story about restoration efforts (63%) and claimed to have heard of ecological restoration (67%). However, when pressed, less than half (47%) of those claiming to know of such projects could actually name one anywhere on the planet (Figure 14). Aggregating across all survey years, only 17% of overall respondents correctly named a single restoration effort and 15% could name multiple restorations.

A closer examination of restoration projects correctly identified by the public is illustrative of which projects have garnered the most public attention. Happily for local proponents of restoration, coastal restoration projects are by far the most readily identified (76%), whether or not they are located in the Southern California Bight. Two-thirds of the most frequent restorations identified outside the Bight are coastal projects (interestingly, one-third of these are clearly associated with a marine oil spill). Only efforts to recover the ecological functioning within Yosemite and Yellowstone National Parks are popular enough to vie with coastal restoration projects in the mind of the public.

As noted earlier, the overrepresentation of Ventura County canvassing locations has biased sampling to favor locations in and around Ventura County. In the case of restoration project identification, however, the bias is difficult to interpret since restoration projects are not evenly distributed across the Southern California Bight. A more even distribution of sampling effort across the Bight would surely have increased the representation of projects in Orange and San Diego counties. That said, Ventura County and the Santa Monica Mountains (Ventura and Los Angeles counties) currently house the greatest number of coastal restoration projects across the Bight, including many with very high local and even national profiles (Matilija Dam removal, Ormond Beach Wetlands, Malibu Lagoon, etc.).

Identified restoration projects in the Bight were dominated by coastal salt marsh and estuarine restoration efforts. Riparian projects were the next most described projects, followed distantly by efforts in other ecological communities. The notoriety of a given project does not necessarily seem to be tied to project size or expenditures to date. For example, Malibu Lagoon is one of the smallest coastal wetland restoration projects currently under way within the Bight but was the fifth most identified restoration. Although all of these popular projects have a substantial, associated price tag (tens to hundreds of millions of dollars), not all have expended that amount to date or depended primarily upon public funding. Similarly,

the second most popular location (Mugu Lagoon; Figure 15) is a military base that restricts access while two other identifiers are offshore islands, meaning direct use and ease of access are not necessarily good predictors. The single unifying factor for all these popular restoration projects is controversy. This can come from threats to

Figure 15. Mugu Lagoon Restoration

PHOTO: SEAN ANDERSON

ecological health (as with the Halaco Superfund dump overlying a large chunk of the Ormond Beach Wetland site; Figure 16), human health (as with the poor water quality currently in Malibu Lagoon that can sicken beachgoers), or recreational opportunities (as with Matilija Dam's erosion of coastal surfing spots across Ventura's coastline). That controversy, if managed properly, can ultimately lead to an engaged public who are deeply connected to the project, have a clear vested interest in seeing the project succeed, and even actively engage with planning, implementing, and monitoring the restoration (witness the efforts to restore the Bolsa Chica Wetlands).

Figure 16. Halaco Superfund Dump

PHOTO: SEAN ANDERSON

Crab Burrows at Carpinteria Salt Marsh

PHOTO: SEAN ANDERSON

Focal Topic 2: Wetlands in the Coastal Zone

Wetlands are interesting ecological communities from ecological and policy perspectives. Often described as "not" systems because they are neither fully terrestrial nor fully aquatic systems, these transitional communities have historically been viewed as areas of little value and their destruction often an explicit policy goal (Mitsch and Gosselink 2000). In recent decades, the importance of these systems has grown dramatically such that strong national, state, and local polices seek to conserve and expand these systems, 91% of which have been destroyed in California since the late 1800s (Dahl 1990).

Most respondents (68%) correctly described the fact that California wetlands have decreased over the past 150 years (Figure 13). However, the respondents' estimates of the magnitude of that change varied widely. The most popular (29% overall) estimate is somewhere between 25% and 48%. Only 11% of overall respondents correctly identified the magnitude of loss. This underestimate of loss may be related to the fact that most people feel pollution of wetlands ranks as their greatest threat (see above) rather than outright destruction of these systems. When asked what action the respondents would support to repair wetlands (if the majority were degraded), only once has any option ever garnered a plurality of support (52% favored using tax dollars in 2005). In aggregate, the most common

Figure 17. Aggregate Survey Responses

a) "Do you know of any 'wetlands' within 50 miles of your home?"

b) With mostly success, those that responded "yes" were asked to correctly name up to three nearby wetlands / projects.

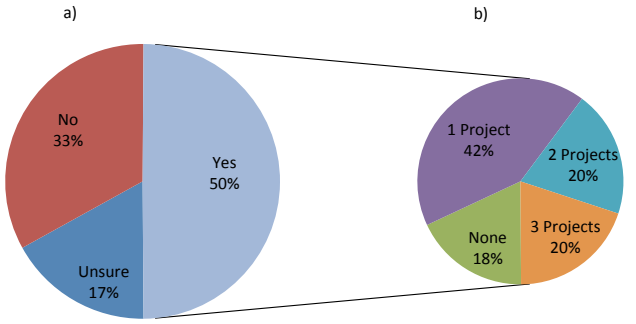
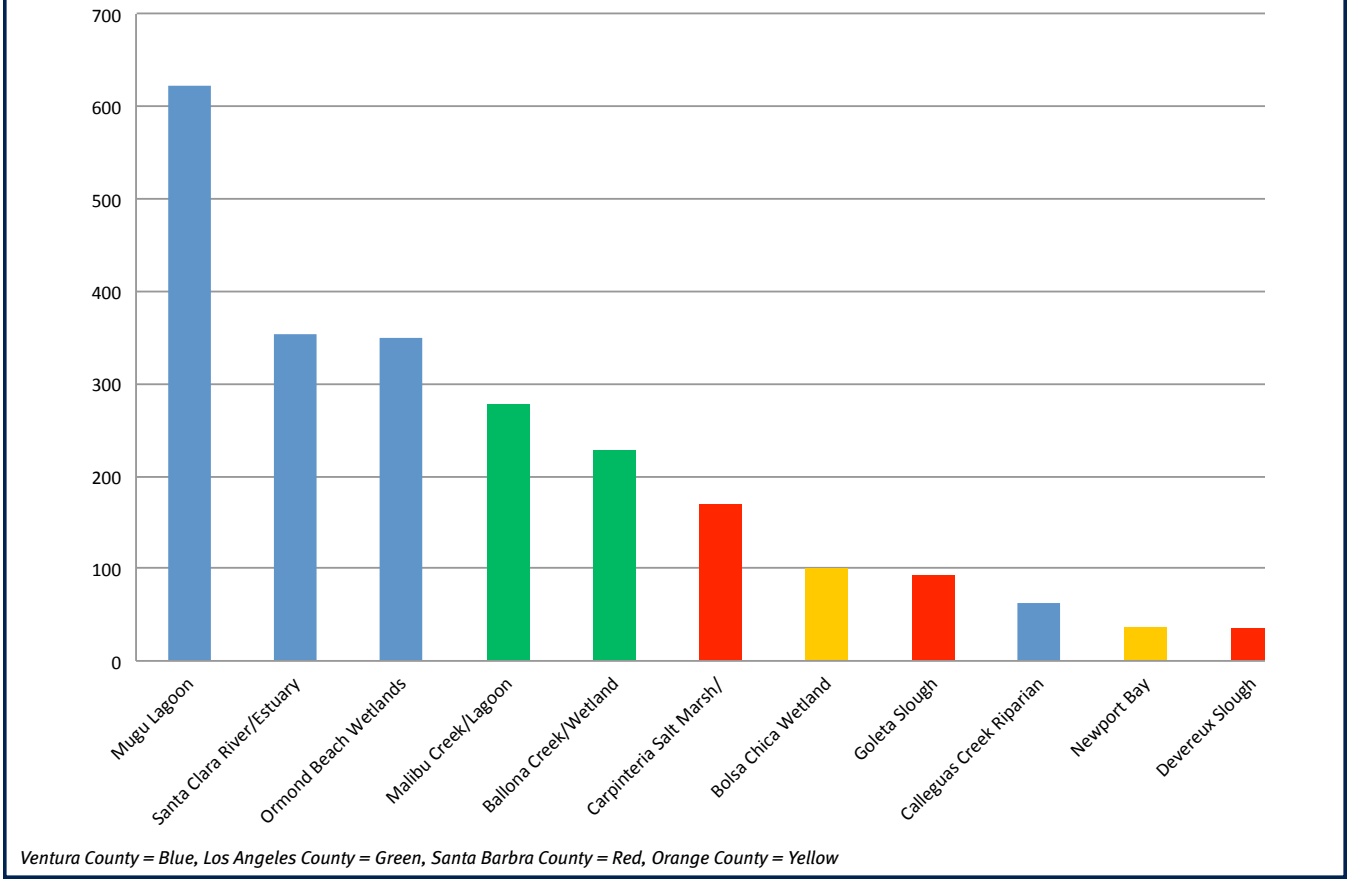


Figure 18. Mugu Lagoon

response was *unsure/I don't know*. The lack of support for contributing personal monies or supporting the public allocation of funds for such projects prior to the 2008 onset of the global financial crisis does not bode well for such efforts in this emerging era of economic austerity.

Wetland systems are widespread across Southern California, yet only half of respondents claimed they knew of a wetland within 50 miles of their home (Figures 17 & 18). Happily, when asked to be specific, many more respondents who said they knew of a local wetland could accurately name one or more wetlands (82%) than could name a restoration (47%). Nearly half (43%) of all people polled overall could correctly name a local wetland in the Southern California Bight; 22% could name a single wetland, and 21% could name multiple wetlands. Unlike the identification of restoration projects, the main factor in someone being able to name a wetland seems to simply be the size. There was a good deal of overlap between the most popular wetlands and restoration sites. Six of the top 11 identified wetlands also housed the most popular restoration projects: Mugu Lagoon (Ventura County), Santa Clara River/Estuary (Ventura County), Ormond Beach (Ventura County), Malibu Creek/Lagoon (Los Angeles County), Ballona Creek/Wetland (Los Angeles County), and Bolsa Chica Wetlands (Orange County) (Figure 19).

Figure 19. Aggregate Survey Responses: Most Identified Wetlands within Southern California



Ventura County = Blue, Los Angeles County = Green, Santa Barbra County = Red, Orange County = Yellow

Local Seafood Restaurant

PHOTO: SEAN ANDERSON

Focal Topic 3: Seafood Consumption

California historically had some of the most productive nearshore fisheries on the planet, but has experienced significant declines in commercial landings in recent decades owing to depressed fish stocks and more stringent fisheries management. Overall reduction in California commercial vessels (4,000 in 1982 to 2,700 in 1999 to 2,560 in 2011; California Department of Fish and Game 2011) correlated with Californian finfish and shellfish landings halving between 1970 and 1990 (Kildow and Colgan 2005), while overall U.S. landings more than doubled (driven principally by expanded Alaskan production and fish farming). The decline of locally sourced seafood and the local fishing industry can been seen by comparing the rankings of the most profitable fishing ports in the United States (National Ocean Economics Program 2011). In 1981, the Southern California Bight hosted the second (Los Angeles), third (San Diego), fifteenth (Port Hueneme/Oxnard/Ventura), and forty-ninth (Santa Barbara) most profitable commercial fishing ports in the United States by landed value. By 2007, those same ports had fallen to twenty-ninth (Los Angeles) and forty-second (Port Hueneme/Oxnard/Ventura) or dropped off national rankings all together by landing less than $1.5 million worth of fish each year (National Ocean Economics Program 2011).

With such a diminished fishing profile, it is no surprise an aggregate 36% of those polled felt unable to determine if marine fish stocks have improved or declined over the last half century, and an aggregate 40% felt unable to judge the adequacy of current fishing regulations (Figure 12). Most people had heard of size limits (75%) and seasonal closures (69%) to manage fisheries, but only a minority knew of gear limitation (35%) or Marine Protected Area (MPA, 38%) approaches. When asked separately if respondents knew of MPAs, 50% said they did. The discrepancy between the 38% and 50% may be ascribed to the inherent error of this survey tool or to the fact that one question simply asked if they had heard of MPAs (50%) while the other asked if they were familiar with MPAs for regulating fisheries (38%). In any event, the vast majority (58%) felt MPAs were positive, and very few (3%) felt MPAs were detrimental.

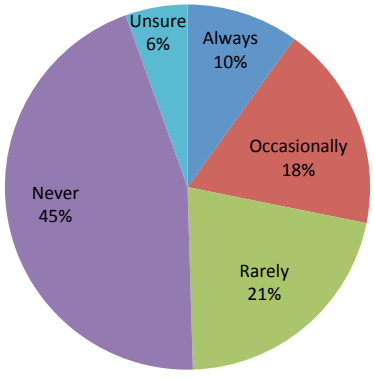
Seafood is popular here in Southern California (Figure 20). An aggregate 37% eat seafood weekly and 68% monthly. Seafood eaters consumed 5.4 ± 28.3 (mean ± 1 standard deviation) ounces of seafood in the week before the 2010 fall survey (the first year this question was asked). Few of these consumers see the need to be selective about the sourcing of their seafood; 45% never ask about its source when purchasing, and only 10% always or nearly always ask (Figure 21). It is, therefore, not surprising that few respondents (26%) had heard of so-called sustainable seafood. Most (74%) had heard of the Dolphin Safe label

Figure 20. California Fish Crates

PHOTO: SEAN ANDERSON

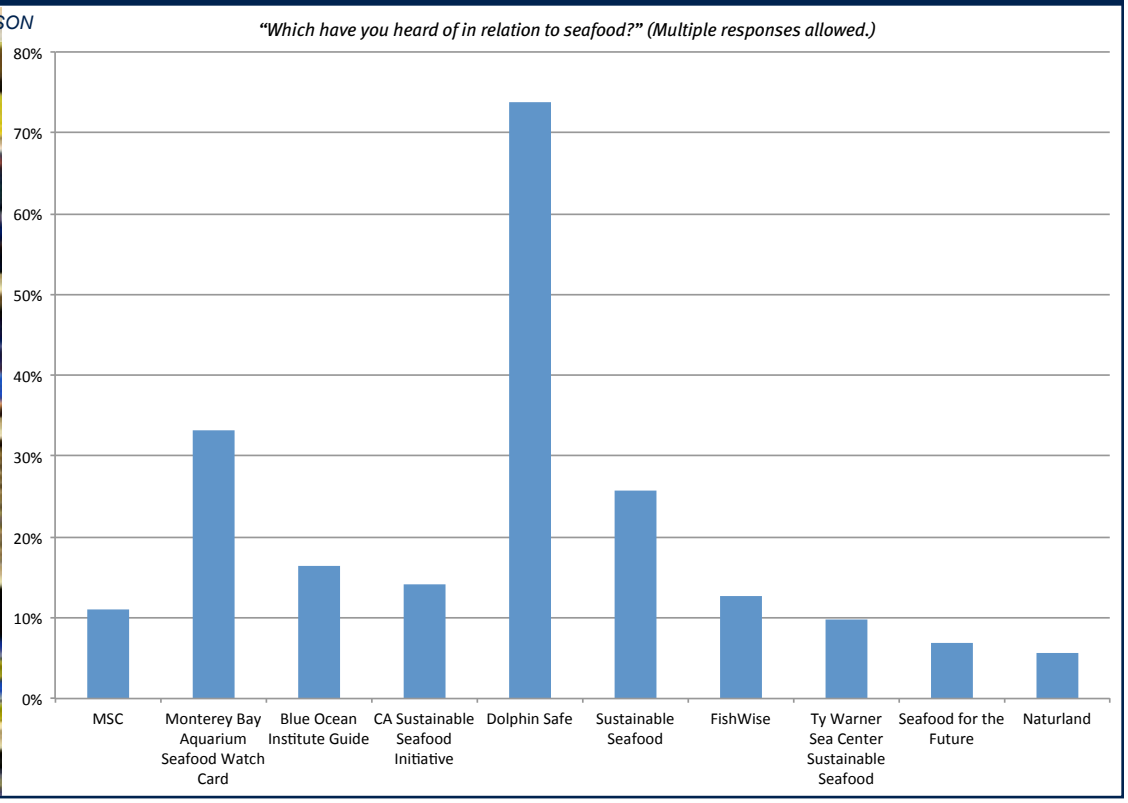
Figure 21. Aggregate Survey Responses

"When purchasing seafood, you ask where it comes from...?"



Figures 22 & 23. Canned Tuna at the Supermarket & Aggregate Survey Responses


PHOTO: SEAN ANDERSON



that is now ubiquitous on canned tuna (Figure 22), but no other ecolabel or seafood buying guide has achieved such penetration (Figure 23). The most popular seafood buying guide (the Monterey Bay Aquarium's Seafood Watch wallet card/smart phone app) was familiar to only one-third (33%) of respondents. The younger, regional seafood buying guides based out of Santa Barbara (Ty Warner Sea Center Sustainable Seafood program) and Long Beach (Seafood for the Future) were known to only 10% and 7% (respectively) of the public. The most famous third-party seafood certification organization, the Marine Stewardship Council, was known to only 11% of respondents despite being in the marketplace since 1999.

Yields from wild-caught fisheries are declining globally (UN Food and Agriculture Organization 2009) as the human population continues to grow. However, many consumers (49%) do not know what to make of farmed seafood. More feel farming should be reduced or eliminated (31%) than feel it should be expanded (21%). This finding appears to be a consequence of the negative press mariculture practices, particularly salmon farming, have garnered in recent years (e.g., Farmed Salmon Exposed 2008).

Conclusions

As with most such efforts to take the pulse of the general population, this ongoing effort shows a multifaceted populace. Southern Californians very much enjoy their coastal resources, engaging in consumptive and non-consumptive uses of them. The public is aware of many high-profile or contentious management efforts, but generally not the main entities or agencies engaged in that management. A robust and holistic understanding of the state of managed resources is lacking. Coastal resources are understood to have degraded over time, and most people are dissatisfied with the current trajectory of stewardship.

Although resource managers may find the lack of awareness of their various efforts disappointing, these data harbor a positive aspect. Restorations, wetlands, and recreation destinations are surprisingly well-known. Many people in coastal Southern California are not fully aware of the condition of their coast or the challenges stewards of those resources grapple with daily. This ignorance does not equate to hostility toward effective resource management, however. Indeed, when informed and included, this survey has illuminated a population largely supportive of effective management that bolsters the health of the coast. The challenge for all who work along urban coasts is to seize upon that existing and nascent support for effective management. Engaged citizens passionate enough to educate their fellow citizens and draw them into active management of these systems are out there.

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References

Barboza, Tony. 2010. "Major sewage spill could keep O.C. beaches closed through the weekend." The Los Angeles Times, March 26.

Bell, Frederick W., Mark A. Bonn, and Vernon R. Leeworthy. 1998. Economic Impact and Importance of Artificial Reefs In Bay County, Florida. Office of Fisheries Management and Assistance Service Florida Department of Environmental Protection.

Borick, Christopher P., Erick Lachapelle, and Barry G. Rabe. 2011. "Climate Compared: Public Opinion on Climate Change in the United States and Canada." Issues in Governance 39:1–13.

California Department of Boating and Waterways, and California State Coastal Conservancy. 2002. California Beach Restoration Study. Sacramento, CA.

California Department of Fish and Game. 2011. Commercial Fishing Licenses and Permits. California Department of Fish and Game.

California Secretary of State. 2011. Report of Voter Registration. California Secretary of State.

Cohen, Michael D., James G. March, and Johan P. Olsen. 1972. "A Garbage Can Model of Organizational Choice." Administrative Science Quarterly 17 (1):1–25.

Connaway, Lynn Silipigni, and Ronald R. Powell. 2010. Basic Library Research for Librarians, Fifth Edition. Santa Barbara, CA: Libraries Unlimited.

Dahl, T. E. 1990. Wetland Losses in the United States 1780's to 1980's. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service.

Dorfman, Mark, and Kirsten Sinclair Rosselot. 2011. Testing the Waters: A Guide to Water Quality at Vacation Beaches. Natural Resources Defence Council.

Dwight, Ryan H., Mitchell V. Brinks, Gajapathi Sharavana Kumar, and Jan C. Semenza. 2007. "Beach Attendance and Bathing Rates for Southern California Beaches." Ocean & Coastal Management 50: 847–858.

Farmed Salmon Exposed. 2008. The Problem. Farm Salmon Exposed. http://www.farmedsalmonexposed.org/theproblem_2008.html.

Fink, Arlene. 2003. The Survey Kit, 2nd ed. Thousand Oaks, CA: Sage.

Freedman, Andrew. 2011. "Public Remains Confused about Global Warming, but Less So." In Capital Weather Gang. Washington, DC: The Washington Post.

Hinrichsen, Don. 1998. Coastal Waters of the World: Trends, Threats, and Strategies. Washington, DC: Island Press.

Hunt & Associates. 2008. Southern California Steelhead Recovery Planning Area Conservation Action Planning (CAP) Workbooks Threat Assessment. Santa Barbara, CA: National Oceanic and Atmospheric Administration.

Kildow, Judith, and Charles S. Colgan. 2005. California's Ocean Economy. National Ocean Economics Program.

King, Philip, and Douglas Symes. 2003. The Potential Loss in Gross National Product and Gross State Product from a Failure to Maintain California's Beaches. Report to the California Department of Boating and Waterways.

Leiserowitz, A., E. Maibach, C. Roser-Renouf, N. Smith, and J. D. Hmielowski. 2011. Climate Change in the American Mind: Public Support for Climate & Energy Policies in November 2011. New Haven, CT: Yale Project on Climate Change Communication.

Markham, Adam. 1994. A Brief History of Pollution. New York: St. Martin's Press.

Mitsch, W. J., and J. G. Gosselink. 2000. Wetlands, 4th ed. New York: Wiley & Sons.

Moffatt & Nichol. 2005. Final Malibu Lagoon Restoration and Enhancement Plan. Long Beach, CA: California State Coastal Conservancy.

Morello, Lauren. 2011. "New Science Panel Chairman to Probe 'Quality' of Climate Science." The New York Times, January 6.

National Ocean Economics Program. 2011. Top Fishing Port Database. NOEP indexed and standardized NMFS database.

National Oceanic and Atmospheric Administration. 2003. Socioeconomic Research and Monitoring Recommendations for Marine Protected Areas in the Channel Islands National Marine Sanctuary. Silver Spring, MD: National Oceanic and Atmospheric Administration.

Natural Resources Defence Council. 2010. Gulf Coast Seafood Consumption Survey.

Pacheco, Percy A., and Brent Ache. 2011. Woods and Poole 1970-2040 Data Aggregate: Time Series Demographic Statistics Census Trends (1970-2000) Variables for 50 Miles Buffer from Coastline in the State, edited by W. a. P. E. Washington, DC: NOAA's Spatial Trends in Coastal Socioeconomics.

Pendleton, Linwood, Nicole Martin, and D. G. Webster. 2001. "Public Perceptions of Environmental Quality: A Survey Study of Beach Use and Perceptions in Los Angeles County." Marine Pollution Bulletin 42:1155–60.

Pendleton, Linwood, and Chris LaFranchi. 2009. The California Coast Online Survey: Southern California Module. Report to the Santa Monica Bay Restoration Foundation.

Public Policy Institute of California. 2003. Special Survey on Californians and the Environment. In PPIC Statewide Survey: November 2003. San Francisco: PPIC.

Santa Monica Bay Restoration Commission. n.d. Programs and Projects. Available from http://www.santamonicabay.org/smbay/ProgramsProjects/tabid/79/Default.aspx.

Selkirk, Mary. 2011. Matilija Dam Ecosystem Restoration Project Fine Sediment Study Group Final Report.

Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Mille, eds. 2007. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

Southern California Edison. 2008. Coastal Development Plan for the SONGS Artificial Reef Mitigation: Adopted Findings and Conditions, edited by C. C. Commission. Ventura, California: California Coastal Commission.

United Nations Food and Agriculture Organization. 2009. The State of World Fisheries and Aquaculture 2008. Rome, Italy: United Nations.

U.S. Army Corps of Engineers. 2003. Mission Creek Section 206 Draft Preliminary Restoration Plan. Los Angeles, California: United States Army Corps of Engineers.

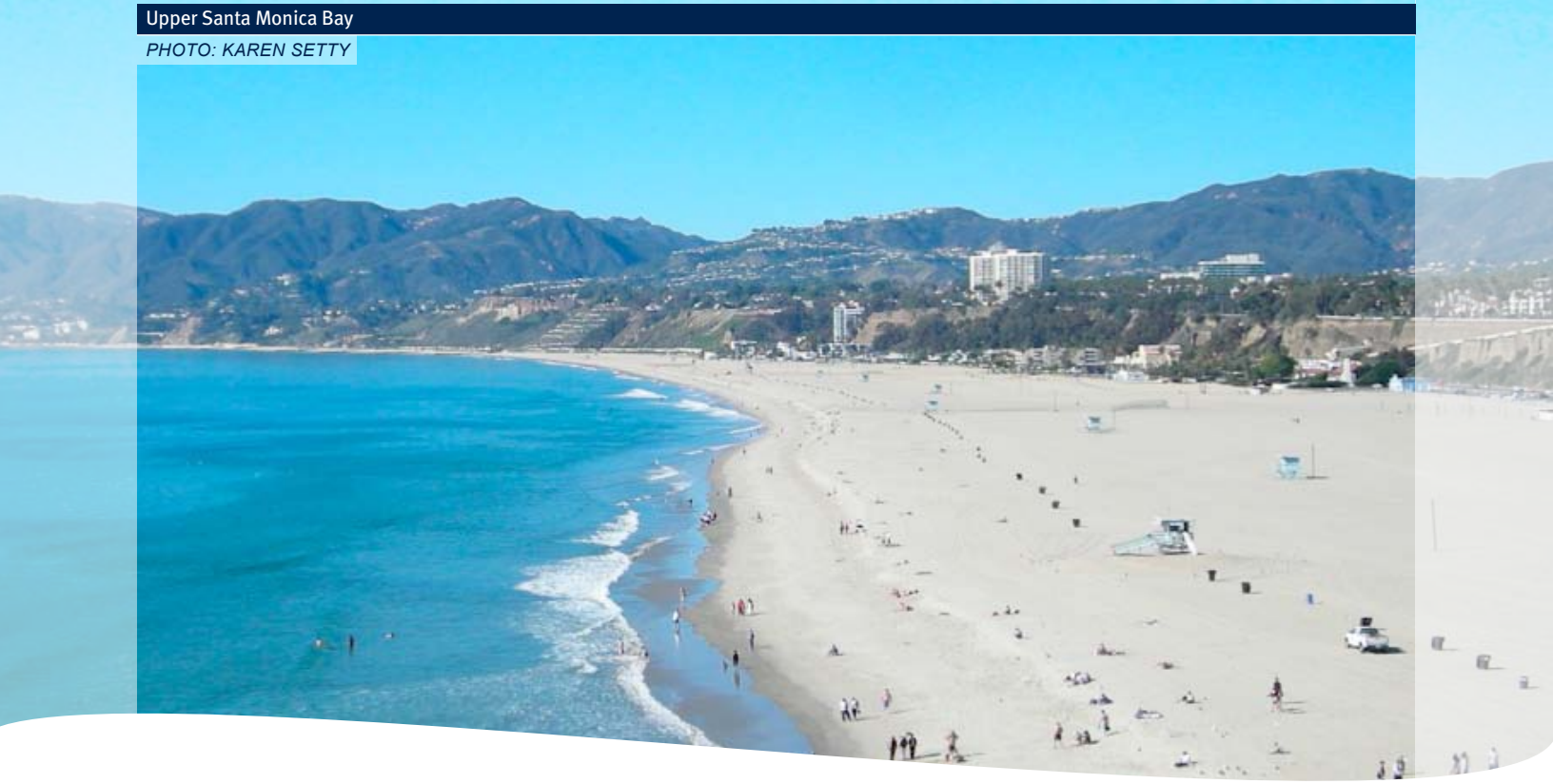
U.S. Census Bureau. 2011. Statistical Abstract of the United States. Washington, DC: U.S. Census Bureau.

U.S. Fish and Wildlife Service, and U.S. Census Bureau. 2006. 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. Washington, DC: U.S. Fish and Wildlife Service, and U.S. Census Bureau.

Ventura County Watershed Protection District. 2005. Integrated Watershed Protection Plan; Fiscal Year 2005 Zone 3. Ventura County, CA: Ventura County Watershed Protection District.

Wildscape Restoration, Inc., and Rincon Consultants. 2011. Calleguas Creek Watershed Arundo/Tamarisk Removal Program Environmental Impact Report. Somis, California: Ventura County Resource Conservation District.

Wilson, Steven C., and Thomas R. Fischetti. 2010. "Coastline Population Trends in the United States: 1960 to 2008 Population Estimates and Projections." In Current Population Reports. Washington, DC: U.S. Department of Commerce.



Upper Santa Monica Bay

PHOTO: KAREN SETTY

Adapting and Adopting Rapid Molecular Methods for Beach Water Quality Monitoring

KAREN SETTY

Abstract

Protecting the public from potentially harmful pathogens requires periodic monitoring of recreational waters. For many years, scientists and managers have relied on culturing indicator bacteria from samples to count how many are present, leaving a significant time gap between when the sample is collected and when results become available to make decisions about issuing health warnings. Rapid molecular analytical methods offer a new paradigm in which more timely knowledge of water contamination issues would be available to help prevent exposure-related illness. The most advanced rapid method to date, quantitative polymerase chain reaction (qPCR), takes just a few hours and is on track for nationwide approval in 2012 (U.S. EPA 2007). In addition to research and development, efforts to transition potential new methods and ensure their real-world applicability are critical. Two pilot projects applying a rapid method at Los Angeles and Orange County beaches have demonstrated the feasibility of faster results.

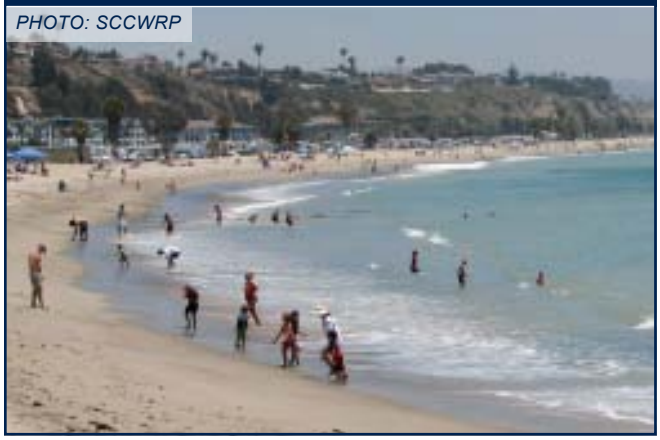
Introduction

The safety of swimming in America's rivers, lakes, and oceans was called into question as increasing urban and industrial development of the nineteenth and twentieth centuries led to more and more pollutant loading into waterways. As the environmental movement gained steam, the 1972 U.S. Clean Water Act set goals for rehabilitating waterways to recapture their once swimmable status. The same year, the newly formed U.S. Environmental Protection Agency (U.S. EPA) conducted a series of studies to improve national bathing water quality criteria. The criteria in place at the time had been proposed by the Department of the Interior in 1968, using an analytical method that dated to the turn of the century (U.S. EPA 1986; National Research Council [NRC] 2004; Dufour and Shaub 2007).

The prevailing trend was to isolate and culture "fecal indicator bacteria," strains of bacteria not necessarily implicated in causing illness, but well correlated with the presence of fecal pollution and the pathogens that

Figure 1. Popular Doheny State Beach

PHOTO: SCCWRP



do make people sick. Culturing means putting the sample in contact with a growth medium (bacterial food source) and waiting to see how many bacteria reach a growth endpoint, such as nutrient metabolism or reproduction to form visible colonies. Such tests typically require 18 to 96 hours for accurate results. Once the bacteria in the sample are quantified, their number can be related back to an observed relationship of how often people contract illness from that degree of exposure, based on epidemiology studies (Wade et al. 2003). The predominant fecal indicator bacteria used were total coliforms and fecal coliforms.

The 1968 federal guidelines and subsequent EPA guidance in 1976 advocated a similar fecal coliform enumeration approach. Based on new information, though, the focus shifted to *E. coli* for freshwater and enterococci for marine waters in 1986 (U.S. EPA 1976, 1986). States are allowed to adopt criteria more stringent than federal standards, and California did so in 1997 with Assembly Bill 411 (AB 411). Based in part on a Santa Monica Bay Restoration Project epidemiology study (SMBRP 1996), AB 411 requires at least weekly testing during the summer for multiple indicators at highly frequented beaches with nearby storm drains (Figure 1). This bill also closes beaches to swimmers when a known contamination source, such as a sewage spill, affects the area. Exceeding one of the California Department of Public Health's recommended water quality thresholds without a known or suspected sewage source leads to posting of a warning sign at the beach.

California's current beach monitoring program is one of the strongest in the nation, but the program still relies on methods based on bacterial growth endpoints. Research has found most sources of beach water contamination are intermittent and last less than one day (Leecaster and Weisberg 2001). This means results that lead to posting or removal of warnings are usually received one or two days after the contamination was present. Such delayed results set up decision-makers for failure. Public health managers could potentially miss contamination events completely or cut visitation and revenues to beaches that no longer pose a threat. Faster alternative methods for beach water quality monitoring have not yet been widely used outside research laboratories, but steps have been taken to build a foundation for better public health protection.

Speeding up Microbiological Tests

Recent advances in molecular biochemistry, genetics, and imaging technology have set the stage for newer, faster methods to complement or replace the growth-based approaches of the last century. The basic goal—identifying when a sample may contain potentially harmful pathogens—can be addressed in many ways. Thus, a number of methods and method permutations have been proposed by scientists for water quality and food testing, such as detecting tiny viruses called phages that infect human fecal bacteria; multiplying characteristic genetic sequences in bacterial DNA millions of times to allow easier detection; and attracting target bacteria with tiny antibody-coated magnetic beads, and then separating and rupturing them to detect the concentration of an essential cellular component.

On the West Coast, the Southern California Coastal Water Research Project (SCCWRP) has spearheaded rapid method testing for marine beaches. SCCWRP began investigating beach water quality issues and testing molecular methods in the late 1990s. Initial studies aimed to sort through the various rapid methods proposed for recreational water monitoring applications and determine which held the greatest promise. As a third-party evaluator, SCCWRP compared and contrasted a number of rapid methods performed by research personnel and end users at public laboratories. SCCWRP also ran samples in conjunction with epidemiology investigations and compared the methods' aptitudes for predicting swimmer illness at Southern California's nonpoint-source influenced beaches (Figure 2). SCCWRP and the EPA concluded one technology was a clear leader and was ready to move ahead to the application stage.

Figure 2. Popular Swimming Beach

PHOTO: JASON GREGORY

Figure 3. Children Playing at Doheny

PHOTO: SCCWRP

Quantitative polymerase chain reaction (qPCR) uses a bioengineered enzyme and temperature cycling to exponentially amplify the specified bacterial DNA present in a water sample. As the targeted genetic sequence becomes more abundant, it is detected using a probe, which fluoresces only in the presence of its specific DNA target. The pattern of rising fluorescence can be tracked with imaging software and compared to known controls to determine the number of "cell equivalents" in the sample. Quantification is an important component of the test because presence/absence information alone does not translate to known thresholds of swimmer illness risk and cannot be compared to historical or side-by-side data from growth-based cell enumeration. Detecting cell components, rather than waiting for cell growth, means the test can be performed quickly, allowing for same-day results. Depending on the method permutation, a sample can be run in just two to four hours. Since most beach contamination issues in California stem from the state's threshold for enterococci, and enterococci have the strongest association with adverse health risks, scientists have focused the qPCR method on this type of bacteria.

First Run: An Orange County Demonstration Project

In 2009, SCCWRP's Commission formed a Rapid Methods Task Force (Task Force; see insert, page 53) to effectively and efficiently translate qPCR technology development into an applicable method. The Task Force consisted of eight representatives from federal, state, and local regulatory agencies—a county health department, wastewater treatment agencies, city government, and an environmental nonprofit. Although a few kinks in the technology had to be worked out, the Task Force thought conducting a pilot demonstration the following year was feasible and began prepping for a 2010 pilot rollout. The U.S. EPA plans to approve a new, national method in 2012, but the Task Force agreed that locally-relevant trials under California's specific environmental conditions were needed to inform the national criteria development and improve local public health agencies' ability to protect swimmers (Figure 3).

Between July 6 and August 31, 2010, Orange County Sanitation District, Orange County Public Health Laboratory, and South Orange County Wastewater Authority, the three local laboratories that regularly monitor Orange County beaches, processed water samples from nine locations using both their regular, growth-based methods and qPCR (Griffith and Weisberg 2011). The goal was not only for the labs to process the samples for both methods, but also for the labs to process the samples quickly and efficiently enough for public health officials to access the information by noon, allowing them to immediately transmit warnings if poor water quality presented a risk to swimmers. SCCWRP provided training and quality assurance during the project, and used the data to evaluate method performance and differences between the two types of methods.

Lessons Learned

The demonstration project was a success in terms of a number of aspects. The project put theory into practice and resulted in greater insight about the challenges facing rapid water monitoring. The project showed that qPCR technology is easily transferable to typical end users, even those who have never performed this type of molecular testing. The project also revealed that logistical considerations were just as important as technical issues. Even a perfectly tuned method falls short if it is too difficult to execute or costs too much, and the demonstration project identified several small method modifications that will enable even better success in the future.

One of the main logistical challenges was achieving same-day warnings in time for swimmers to make an informed decision before entering the water. The Task Force made public notifications of beach water quality conditions before noon a priority (Figure 4). Although the qPCR method takes only about two hours, numerous

Figure 4. Sample of Notification Screen

IMAGE: MIOCEAN

Figure 5. Electronic Sign above Beach Parking Entrance Booth

PHOTO: JOHN GRIFFITH

other steps take place before and after the test is run, such as collecting samples and delivering the resulting information to beachgoers. Several modifications were made to help participants achieve the noon deadline. First, sampling began at 7:00 AM, earlier than usual but still respectful of daylight hours for worker safety. Second, sampling was limited to a subset of beaches, and samples from priority beaches were returned first to the laboratory, substantially reducing the typical sample collection time of four hours. Finally, the County developed new electronic means of providing timely updates to the public, including a Twitter feed. In addition, the County partnered with the Orange County–based nonprofit Miocean to use electronic signage at the beach (Figure 5), allowing them to share results with the public almost instantaneously.

Owing to such timing issues, the groups participating in the demonstration learned qPCR use at select sites is preferable to blanket application at all sites, leading the groups to target only a handful of the regularly monitored beaches. Sparsely visited beaches or those with consistently favorable water quality, such as open ocean beaches with no consistent pollution source, may not warrant the extra driving distance and time to collect a sample. Meanwhile, those beaches with poor cleanliness history or throngs of visitors offer greater return (in terms of health protection) when rapid method samples are prioritized. Likewise, beaches monitored five days per week derive greater public benefit from more accurate, same-day warnings than those sampled only once a week. In addition, rapid methods are not intended to replace existing water quality monitoring methods in all applications. In a beach monitoring application, rapid methods may offer the substantial benefit of timely public health warnings. In contrast, ongoing permit compliance monitoring for wastewater and stormwater dischargers, which is used to inform periodic regulatory review and identify problem beaches for cleanup, does not require the same urgency.

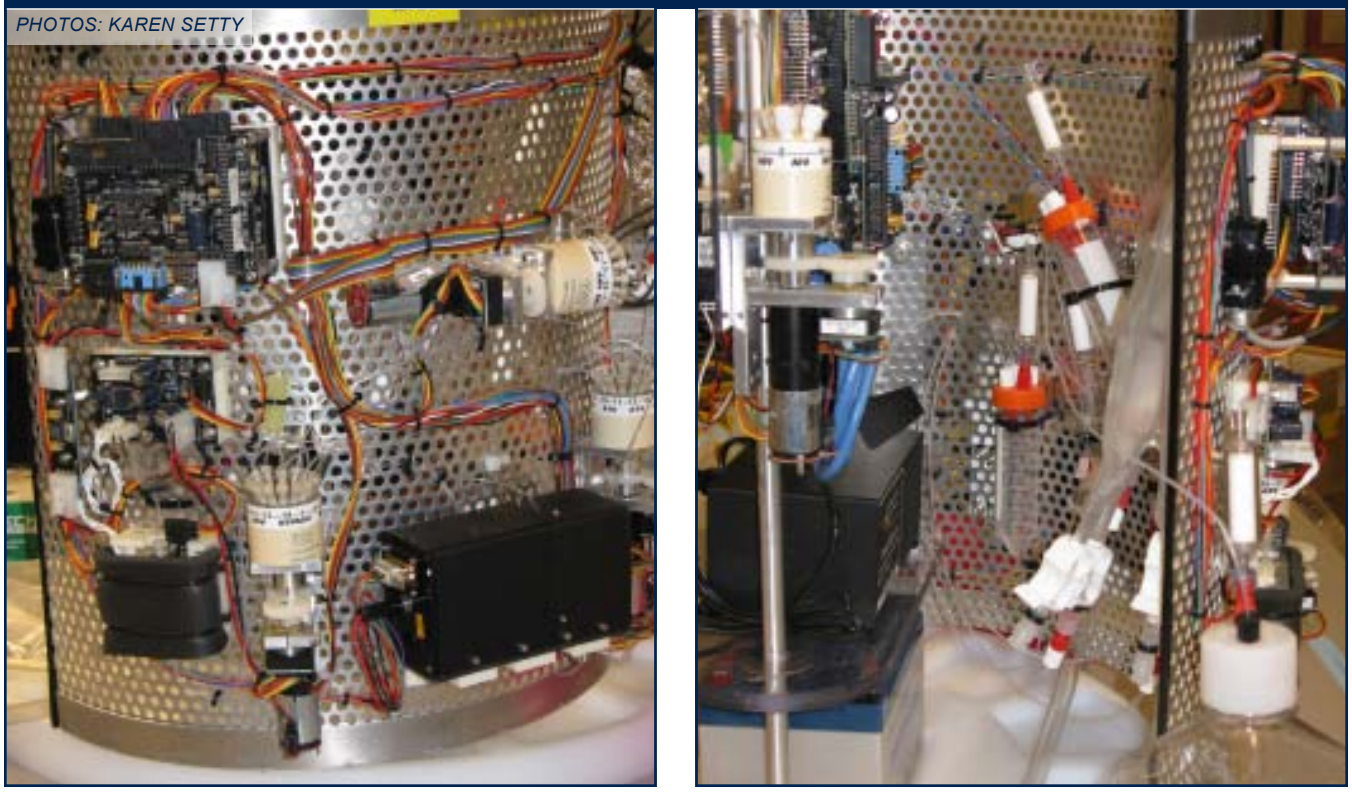
Relatively few technical issues were encountered during the demonstration, but opportunities remain for short- and long-term improvements. The main concern confronting researchers was avoiding inhibition of the normally predictable rapid reaction that multiplies genetic material. Substances naturally present in environmental samples, such as tannins, can slow or stop DNA replication and cause odd results. Using controls, researchers found that such inhibitory substances affected qPCR results in about 14% of the Orange County pilot samples (Griffith and Weisberg 2011). Investigators continue to explore multiple solutions to address inhibition without sacrificing time. Another technical issue related to qPCR, which detects genetic material, is differentiating live, viable bacteria from dead, nonviable bacteria such as those found in disinfected wastewater.

Round Two: Bringing Rapid Testing to Los Angeles County Beaches

As 2010 ended, members of the Rapid Methods Task Force mulled over next steps. Promulgation of the new EPA criteria was still two years away, and it seemed an opportune time to continue building on what was learned in Orange County. A few agencies responsible for beach water quality testing in Los Angeles (LA) County decided to try qPCR in their neighborhoods

Figure 6. Front and Rear Internal Components of In-Situ Sample Processor

PHOTOS: KAREN SETTY



in 2011. SCCWRP again provided training and quality assurance during the summer trial. Three laboratories, the City of LA Bureau of Sanitation's Environmental Monitoring Division, the LA County Department of Public Health, and the LA County Department of Public Works, collected samples four days a week at eight sites between Malibu and Long Beach, and the City of LA ran qPCR tests side-by-side with their usual methods from July 11 to August 31. This time, the results were not used to make warning and closure decisions because, as was learned in Orange County, this requires significant logistical adjustments. Depending on the outcome of the demonstration, the agencies may repeat the process again in 2012 with public notification in mind.

Future Prospects

The Southern California trials were the first in the nation to apply rapid methods to routine beach monitoring. These demonstrations produced a great deal of information to aid the U.S. EPA as the agency works concurrently to approve a rapid method for nationwide use by October 2012 (U.S. EPA 2007, 2011). The trials modified the EPA's trajectory by showing the practicality of applying rapid methods only at select sites for select monitoring applications, as well as the utility of offering some flexibility in the method permutation. The qPCR method used in the trial, for instance, used newer reagents than the EPA currently uses, cutting a significant 45 minutes from the processing time.

Approving qPCR as a nationally-acceptable alternative method will require further attention to regulatory and management issues, such as:

1. Balancing initial capital and ongoing operational costs with steady or shrinking budgets.
2. Ensuring suppliers are ready and willing to provide test materials at a reasonable rate.
3. Developing standard protocols to train and certify laboratory personnel.
4. Providing guidance on which beaches or sites should be prioritized for rapid testing.
5. Adjusting workforce hours as needed to adapt to sampling schedules.

As evident in the demonstrations, the qPCR technology itself is realistic and becoming simpler. Reagent suppliers are working to develop products that could reduce the number of steps needed to conduct the method, thereby reducing room for error. Quality assurance and quality control checks have already been automated to save time. Over the longer term, researchers and manufacturers will pursue further method automation. Some potential directions include mobile laboratories that process samples at the beach, or ultimately a portable hand-held device that lifeguards could use for instantaneous results.

More tangibly, several marine laboratories along the West Coast, including the Monterey Bay Aquarium Research Institute, SCCWRP, Stanford University, and the National Oceanic and Atmospheric Association, are partnering to develop an automated in-situ environmental sample processor for rapid microbiological testing (Figure 6). The device, which autonomously runs a qPCR analysis and sends data by satellite to researchers' computers every two hours, can be mounted underwater to any pier or mooring. This technology could resolve timing issues and eliminate many of the existing obstacles to rapid method adoption. These devices would also fill in the data gaps between daily samples, providing a greater understanding of how water quality fluctuates throughout the day. Within the next year, researchers plan to pilot this technology by deploying it on a Southern California pier.

Investing in the basic technologies behind rapid qPCR also allows laboratories to conduct other types of molecular analyses without a sharp learning curve. Adapting the test protocol to a different type of target organism, for example, might involve only switching a few reagents. Another potential advantage of rapid monitoring is the ability to quickly respond to contamination events with follow-up upstream sampling to find the contamination source. Microbial source tracking and identification methods that would allow municipalities to detect and potentially resolve chronic pollution inputs are currently being developed as part of the California Clean Beaches Initiative Task Force's Source Identification Protocol Project.

In summary, the field of rapid water monitoring technology has experienced accelerated progress in recent decades, and managers will soon have more options for providing timely water quality notifications at high-risk beaches. The pilot demonstrations in Orange County and LA County set a helpful precedent for other areas looking to try out rapid methods. Subsequent early adopters can learn from these experiences and explore new possibilities for refining the testing and notification process. As the science of waterborne illness prevention continues to advance, the future holds promise of safer and more swimmable rivers, lakes, and oceans.

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References

Dufour, A., and S. Shaub. 2007. "The Evolution of Water Quality Criteria in the United States, 1922–2003." In Statistical Framework for Recreational Water Quality Monitoring, edited by L. J. Wymer, 1–12. Chichester, England: Wiley-Interscience.

Griffith, J. F., and S. B. Weisberg. 2011. "Challenges in Implementing New Technology for Beach Water Quality Monitoring: Lessons from a California Demonstration Project." Marine Technology Society Journal 45:65–73.

Leecaster, M. K., and S. B. Weisberg. 2001. "Effect of Sampling Frequency on Shoreline Microbiology Assessments." Marine Pollution Bulletin 42:1150–4.

National Research Council. 2004. Indicators for Waterborne Pathogens. Washington, DC: National Academies Press.

Santa Monica Bay Restoration Project. 1996. A Health Effects Study of Swimmers in Santa Monica Bay, Summary.

United States Environmental Protection Agency. 1976. Quality Criteria for Water. PB-263 943.

———. 1986. Bacteriological Ambient Water Quality Criteria for Marine and Fresh Recreational Waters. 440/5-84-002.

———. 2007. Critical Path Science Plan for the Development of New or Revised Recreational Water Quality Criteria. 823-R-08-002.

———. May 2011. Recreational Water Quality Criteria: Update to 1986 Criteria. http://water.epa.gov/scitech/swguidance/standards/criteria/health/recreation/update.cfm

Wade, T.J., N. Pai, J. N. Eisenberg, and J. M. Colford, Jr. 2003. "Do U.S. Environmental Protection Agency Water Quality Guidelines for Recreational Waters Prevent Gastrointestinal Illness? A systematic Review and Meta-analysis." Environmental Health Perspectives 111:1102–9.

Late 1800s Irrigation Map (Hall 1888)

MAP: CALIFORNIA STATE ARCHIVES

Historical Ecology as a Living Resource for Informing Urban Wetland Restoration

SHAWNA DARK, ERIC D. STEIN, DANIELLE BRAM, & JOEL OSUNA

Abstract

In the urban environments of California, much of the academic understanding of wetland and riparian ecology is derived from systems highly modified by human activities. Therefore, identifying appropriate un-impacted reference conditions or distinguishing natural processes from anthropogenic effects can be difficult. Research in historical ecology provides valuable insight into historical reference conditions and the driving forces of ecosystem change. New tools and technology allow scientific components of historical ecology to evolve such that standardized approaches to hypothesis testing are now available. The technical rigor imparted by these tools makes historical analysis more valuable for understanding ecosystem function and for developing sound restoration planning.

Introduction

The urban watersheds of the California coast provide a unique opportunity to explore the value of historical ecology research for developing contemporary wetland and riparian restoration plans. Studies have demonstrated that restoration and mitigation planning would be greatly improved if done within the context of ecosystem function (Kentula 1997, 2007; Kershner 1997; National Research Council [NRC] 2001; White and Fennessy 2005). Unfortunately, in the urban environments of California, much of the current understanding of wetland and riparian ecology is derived from systems highly modified by human activities. Thus, identifying appropriate functional reference conditions or distinguishing natural processes from anthropogenic effects can be difficult. Recent historical ecology studies in California have provided new and surprising evidence of wetland resources previously not recognized, particularly in Southern California where evidence suggests wetland ecosystems were larger and more diverse than previously thought (Stein et al. 2010; Grossinger et al. 2011; San Dieguito River Park 2010). This suggests that historical ecology not only provides important information about functional reference conditions but also sheds light on previous misconceptions about the historical environment.

The value of historical ecology has been questioned in the urban coastal regions of Southern California where natural hydrologic processes are unlikely to be fully recoverable. Arguably, historical ecology may provide confusion in the face of a systematic incapability to return wetland ecosystems to their pre-development condition, often due to the permanent loss of natural hydrodynamic processes that were present prior to human contact. Understanding the historical template is as important as understanding the contemporary condition. Knowledge of historical ecosystem components is key to creating management and restoration plans that

make sense relative to the contemporary landscape. The historical perspective provides an understanding of the relationship between physical settings that support natural wetland functions, the driving forces behind ecosystem degradation, and, perhaps most importantly, the value of wetland ecosystems that remain intact (Stein et al. 2010). Considerable evidence supporting the importance of historical ecology in contemporary wetland management, even in highly urbanized areas, now exists (Kentula 1997; White & Fennessy 2005; Stein et al. 2010). In addition, new technical tools provide shared access to data collected for historical ecology projects creating an opportunity for cross-disciplinary collaboration and ongoing discovery of historical reference conditions beyond traditional reports.

Defining Historical Ecology

Historical ecology seeks to identify the complex history of interactions between human groups and their environment with an emphasis on how humans have reshaped the biophysical environment (Ballee 2006; Rhmetulla and Mladneoff 2007). A key component of historical ecology is that it is an interdisciplinary approach that synthesizes information from different disciplines, data sources, and scientific perspectives (Swetnam, Allen, and Betancourt 1999). The application of this knowledge in turn provides a foundation for understanding ecosystem function, human modification, and management of ecosystems. Land managers should understand that historical ecology is not meant to provide a blueprint for the future, but rather, is meant to provide a foundation of understanding in light of contemporary landscapes where reference conditions do not exist (Stein et al. 2010). Historical ecology also provides several ancillary benefits, including the availability of "living" tools that allow for access to data collected during historical research. These tools are considered "living" because they can continually be updated with new data and therefore represent a dynamic document. They also allow for the sharing and ongoing use of historical data, promoting cross-disciplinary collaboration by scientists and land managers.

Like any scientific endeavor, historical ecological research should be designed to test hypotheses, challenge existing theories, and create new questions about the context of the contemporary environment. For historical ecologists to contribute to the scientific understanding of urban coastal systems, the researchers' findings must be validated with multiple data sources as well as repeated and compared with studies across similar systems (Swetnam et al. 1999; Grossinger et al. 2007). Traditional researchers would not draw conclusions based on a single data point, nor should historical ecologists. The continual process of validating and refining conclusions should be viewed as iterative, ongoing, and subject to change, as new evidence about historical reference conditions surfaces.

Duck Hunting Scene

PHOTO: LOS ANGELES PUBLIC LIBRARY

Surprisingly, this synthetic nature of applied historical ecology often serves as a focal point in the criticism of its application (Swetnam et al. 1999). Historical ecology can be subject to a lack of precise information, fragmentary evidence, and ambiguous interpretations, largely because historical data sources were originally developed for purposes other than wetland mapping or assessment. However, using traditional strategies for increasing objectivity and confidence in historical interpretations provides a strong scientific foundation for this research. For example, a repeatable and transparent analytical process results from a combination of comparative analyses, testing with multiple, independent data sources, and drawing conclusions from converging lines of evidence (Swetnam et al. 1999). Grossinger et al. (2007) take this a step further and provide a framework for quantifying converging lines of evidence through a systematic classification of certainty associated with the interpretation of each historical wetland mapped. This quantification of uncertainty provides a programmatic framework for assessing the value of historical interpretations and serves as an opportunity to create methodological standardization across historical ecology research projects.

Figure 1. Sample Portion of Online Metadata Catalog

CREDIT: CALIFORNIA STATE UNIVERSITY, NORTHRIDGE (CSUN)

Subset Records by Reference Type: All
Subset by Primary Source:
Subset by Collector:

	Reference Type	Author	Journal / Publisher	Found (Y/N)	Acquired (Y/N)	Useful (Y/N)	Original Scan Aquired (Y/N)	Title	Year	Primary Source	Call #	Secondary Source	Call #	Tertiary Source	Call #	Geographic Area	Watershed	Scale	Description	Keywords	Collector
Select	Text	Mesmer, L.		Yes	Yes	Yes		Soil Survey of the Los An ...	1904	Google Book Search						Los Angeles County			Soil survey for Los Angel ...	soils, hydric soils	S. Dark
Select	Map	Unknown		Yes	Yes	Yes	Yes	Map Showing Part of the R ...	1887	LA County Department of Public Works	MR022-020					Rancho Rincon de los Buey ...			Plat map scanned by LA Co ...	sycamore, valley floor habitats	S. Dark
Select	Map	Mesmer, L.		Yes	Yes	Yes	Yes	Soil Map: Los Angeles She ...	1903	University of Alabama, Department of Geography						Los Angeles County		1:62,500	Great soils map, really g ...	soils, hydric soils, cienegas	S.Dark
Select	Text	Salvator, Ludwig		Yes	No	Yes		Los Angeles in the Sunny ...	1929	First-person Narratives of California's Early Years	F869.L8 L94					General Study Area			Very general description ...	Springs, rivers	S. Dark
Select	Map	Jonas, C		Yes	Yes	Yes	Yes	Index map to county surve ...	1950	Library of Congress Map Collections	G1528.L6 R3 1950					LA Basin		1:24000	General index map for sur ...	Surveyor index	S.Dark
Select	Text	Davidson, A.		Yes	Yes	Yes		Catalog of the Plants of ...	1896	Archive.org	None					Los Angeles County			Key to plants in Los Ange ...	plants	S. Dark
Select	Text	Grinnell, J.		Yes	Yes	Yes		Birds of the Pacific Slop ...	1898	Archive.org	None					Los Angeles County			Birds of LA County. Usefu ...	Birds	S. Dark
Select	Map	Solano, A.		Yes	Yes	Yes	Yes	Map of Those Parts of the ...	1868	LA County Department of Public Works	3204					Rancho La Ballona			Plat map scanned by LA Co ...	lagoon	S. Dark
Select	Map	Thompson, G		Yes	Yes	Yes	Yes	Plat of the Rancho San An ...	1868	Los Angeles County Building and Safety	1-169					Rancho San Antonio			Plat map of Rancho San An ...	creek	S. Dark

Methods in Historical Ecology

Historical ecology methodology can be divided into three broad categories: data collection, data compilation, and synthesis/interpretation. To date, historical ecological research has relied on maps, textual data, and photographs. All three categories of data are of equal importance and are used collectively to support historical findings at any given location. Systematic and consistent cataloging and attributing of this data are essential for ensuring all appropriate data are included in the interpretation process and for retrieving the data efficiently. Ongoing historical analysis of wetland conditions, for example, involves research by numerous agencies and individuals over time. Being able to share data dynamically is a critical function to reduce repetition of effort, to allow for collaborative viewing of data, and to facilitate regional synthesis and ongoing investigations. To support the ongoing collaborative nature of this research, an online metadata catalog was created. The catalog provides the means to organize and query historical documentation by spatial location, wetland descriptions, time period, and source. The metadata catalog also allows for data to be uploaded to a website via ftp so current and future team members are able to download and access the data dynamically (Figure 1). Bibliographic tables and information about source institutions may also be downloaded from this online database, creating a secondary product for stakeholder use. This type of database creates a living tool for discovering new information and allows different hypothetical questions to be created that can be explored by future researchers.

Maps

Maps usually serve as a primary source for historical ecology projects and are easily assimilated and processed in Geographical Information Systems (GISs). Historical ecology projects often deal with a tremendous volume of maps that are scanned and georeferenced using a GIS. Common map sources used on recent projects include historical topographic maps, General Land Office plat maps, and historical soil survey maps (Figure 2a–c). These maps are routinely collected for wetland historical ecology projects and often serve as a starting point for

preliminary interpretation and mapping. In addition to these common map sources, regional collections provide another source of historical maps specific to the project area. In some cases, these maps are more useful than standard maps, providing more detail of the study area. In the Los Angeles County–Ballona Historical Ecology project, the early Los Angeles County Solano Reeves Collection at the Huntington Library and draft W. H. Hall Irrigation maps from the California State Archives (Figure 3) became extremely valuable sources for interpreting historical wetland patterns due to the maps' high level of detail and focus on water resources.

Textual Data

Textual data include, but are not limited to, historical newspaper articles, written histories and accounts by indigenous peoples, and land survey notes. Textual data sources provide critical support to historical mapping efforts and therefore are an essential component of the metadata catalog, where they can be queried as necessary. The following are examples from a recent project on the Ballona watershed by Stein et al. (forthcoming):

> *In the medium part of this southwest course [Ballona Creek] is bordered on either side by a rich plain of several thousand acres in area, and which, to some extent, it has served in irrigation for a long number of years. The lands irrigated are all within the rancho La Ballona[,] and the waters have for many years been considered as appurtenant thereto. –Hall (1888)*

> *Coldwater Canyon Creek; Ballona Creek basin; Los Angeles County; an intermittent stream, 3 or 4 miles long, draining a small area in the Santa Monica Mountains, and flowing southward and southeastward into Rodeo de las Aguas Rancho. Near the mouth of its canyon it receives streams draining from Franklin and Higgins canyons. –Lee (1912)*

Textual data help to elucidate historical conditions and explain details on maps that are not self-evident. Therefore, textual data should be viewed as being as important as map data. This importance imparts a need for appropriate cataloging and attributing of the data in the metadata catalog.

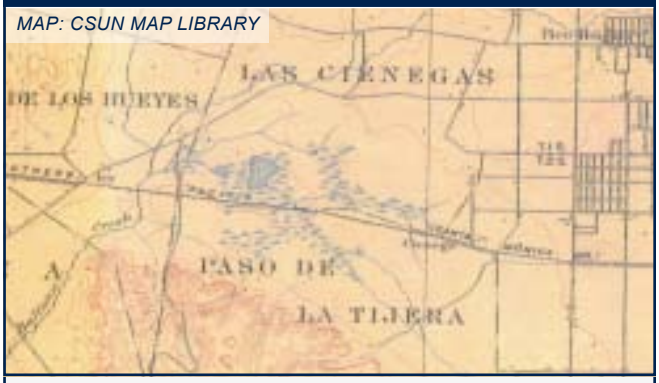
Photographs

Photographs provide explicit confirmation about the attributes of a mapped feature such as the presence of a river mouth or depressional wetlands. In addition, some photographs, which are not necessarily focused on ecology, often provide significant insight. Most of these photographs depict enough of the landscape to allow supporting evidence to be derived. For example, the Ballona Historical Ecology project used a set of

Figure 2. Historical Maps of What Is Now Culver City at the Base of Baldwin Hills

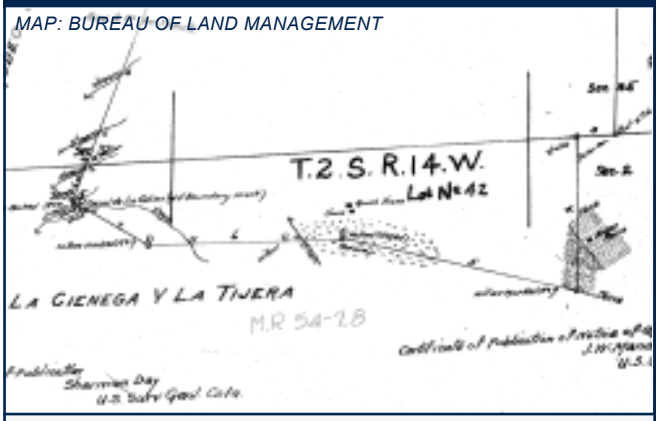
2 a. Historical Topographic Map, Santa Monica Quad (Giffin 1902)

MAP: CSUN MAP LIBRARY



2 b. General Land Office Survey Map, Plat of Rancho Las Cienegas (Hancock 1858)

MAP: BUREAU OF LAND MANAGEMENT



2 c. Historical Soil Map of Los Angeles County (Nelson 1916)

MAP: CSUN MAP LIBRARY

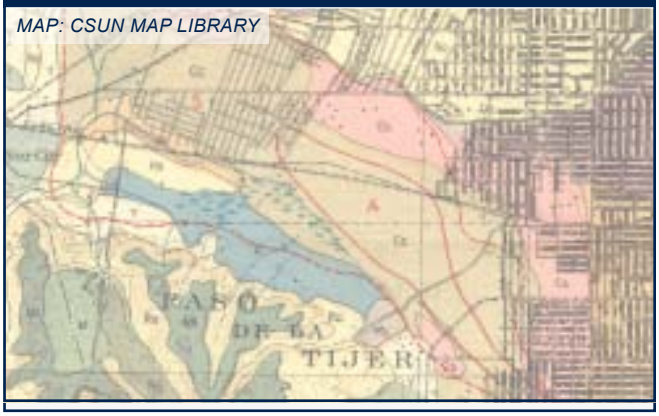
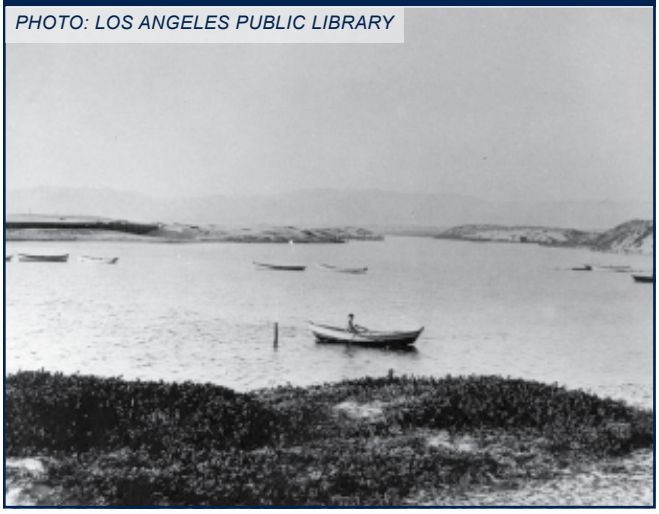


Figure 3. Draft Irrigation Map (Hall 1888)

MAP: CALIFORNIA STATE ARCHIVES

Figure 4. Photograph of Ballona Lake, Circa 1910

PHOTO: LOS ANGELES PUBLIC LIBRARY



photographs depicting recreational use of Ballona Lake (Figure 4). Photographs such as this were likely intended to focus on boating, hunting, and other activities around the water body. However, these photographs also provide significant ecological information such as depicting an outlet to the ocean and possible dredging activity that may have modified the hydrological features in the area.

Compilation and Synthesis

Synthesis and interpretation of what are often hundreds of data sources is the heart of historical ecological research. Compilation should follow general rules of geospatial analysis, and confidence in the final mapped polygons should be assigned using the structured system described above. However, because each specific historical ecology project is driven by its own unique set of data, the precise approach leading to the ultimate map varies by project, based on the different data sources available. Synthesizing a map or model of historical ecological features usually begins with interpreting and analyzing data sources that are the most reliable for the mapping period. Often, primary sources, mainly maps, are used to draw initial wetland polygons on a feature-by-feature basis. This mapping is often followed by crosschecking with all other sources, such as textual data and photographs, which may refer to or depict the feature in question. If corroboration exists, the other sources contribute to defining the feature's attributes as supporting sources in addition to the initial digitizing source. However, if the feature is depicted differently in terms of size, shape, or identification, further analysis is required. Surrounding features that may have a link or relate to the feature in question are also considered. The initially drawn features are iteratively refined using additional data sources. As data sources are overlaid, each is attributed (Grossinger et al. 2007). The attribution of these sources is based on information queried from the metadata catalog, thereby providing a spatially explicit connection between the various datasets used for synthesis. Once the "final" form of a feature is mapped, a historical wetland classification is assigned and compared to a contemporary classification.

Quantifying Certainty

Measuring and quantifying certainty is critical to the final interpretation and usefulness of historical ecology data. According to Grossinger (2005), feature attributes are developed to capture the estimated certainty of a mapped feature's interpretation, size, and location. Each feature is assigned these attributes to provide a concise assessment indicating the confidence in a feature's presence and habitat classification as well as how spatially accurate the feature is (Grossinger and Askevold 2005). Certainty levels are based primarily on the number, type (e.g., General Land Office and historical topographic maps), and quality (e.g., degree of detail and/or spatial accuracy) of the data sources (Table 1). For example, a wet meadow feature supported by numerous and highly detailed independent data sources would be assigned a "high" value for interpretation certainty. However, a wet meadow referenced in only one or two more-contemporary historical documents may receive a lower value. Estimation of certainty is critical to the scientific credibility of any study and reinforces why conclusions about historical conditions must be based on corroboration of multiple lines of independent evidence. Ultimately, land managers and other stakeholders can use these objective classifications of certainty to guide the decision-making process and help determine how extensively results are applied to various land management and restoration activities.

Table 1. Sample of Certainty Levels for Interpretation, Size, and Location (Grossinger et al. 2007)

Certainty Level	Interpretation	Size	Location
High/"Definite"	Feature definitely present before European American modification	Mapped feature expected to be 90%–110% of acutal feature size	Expected maximum horizontal displacement < 50 meters (150 feet)
Medium/"Probable"	Feature probably present before European American modification	Mapped feature expected to be 50%–200% of actual feature size	Expected maximum horizontal displacement < 150 meters (500 feet)
Low/"Possible"	Feature possibly present before European American	Mapped feature expected to be 25%–400% of actual feature size	Expected maximum horizontal displacement < 500 meters (1,600 feet)

Valuing Historical Ecology

Historical ecological studies have and will continue to challenge the contemporary understanding of historical reference conditions throughout the urban coast of California. For example, a recent study suggested that the estuaries along the south coast were closed much more than previously expected (Jacobs, Stein, and Longcore 2010). Studies have also suggested that wetlands were larger, more diverse, and more dynamic than the current theoretical understanding of urban wetlands have suggested (Stein et al. 2010; Grossinger 2011). Historical ecology, therefore, plays a relevant and important role identifying critical components of the theoretical understanding that may indeed be faulty or poorly supported. In addition, as with traditional science, almost every historical ecology study generates new hypotheses for further testing, creating a rich and diversified knowledge base for wetland reference conditions.

From an applied perspective, the challenge is to bridge this evolving knowledge to contemporary landscape management plans. The knowledge of reference conditions often creates considerable debate about what should be restored, how, and where. This debate is an extremely valuable process that leads to the development of management plans that are more successful and sustainable. In most urban environments, the expectation that systems can be restored to their natural hydrodynamics is unrealistic. For example, results from the San Gabriel River Historical Ecology project showed that there were vast alkali meadow complexes along the transition zone from the estuary to inland freshwater systems (Stein at al. 2010). These areas are now completely urbanized, and the hydrological conditions that supported such wetlands no longer exist. Likewise, historical ecology produces results that should be viewed as a snapshot in time, and a snapshot may not always be comprehensive enough to be the basis for exact management plans.

Other impacts on the application of historical ecology include climate change issues, development impacts, and major shifts in the natural environment due to natural events such as earthquakes, flooding, and fire. For example, the San Gabriel River in Los Angeles County had many courses over a 100-year period and supported a variety of different wetland ecosystems in different locations as the river changed course (Figure 5). Thus, the findings from historical ecological research should not be viewed as the detailed prototype for restoration and management (Swetnam et al., 1999). Applicability largely depends on the extent of human modification, the confidence of historical interpretations, and the intended purpose of restoration. Historical ecological studies also do not dictate one specific endpoint, but may support numerous alternatives for a particular project. In fact, the ensuing debates about restoration and the iterative process by which further understanding is developed are valuable outcomes of historical ecological research.

Figure 5. Map Demonstrating the Various Courses of the San Gabriel River over the Past 100 Years (Stein et al. 2007)

Historical Ecology

New technologies, such as online geodatabases, metadata catalogs, and web-based mapping applications, will continue to contribute living tools that provide knowledge about historical reference conditions. These living tools support a more collaborative process in the application of historical ecology by providing detailed and multiple lines of evidence supporting a particular interpretation. Historical ecology products are unique compared to traditional reports, but are extremely important in that they provide delivery systems that better convey the inherent dynamism of the coastal wetland ecosystems of California. New technologies produce historical ecology products in a more accessible format for conveying information and are thus likely to be more useful to stakeholders as well as scientists. Therefore, the further development of technological tools should be prioritized on historical ecology projects.

The urban coast of California will continue to be a place of dynamic wetland conditions and debate about how to restore these systems. The regulatory and ecological impetuses for restoration have created an opportunity for serious debate about how the future of wetland ecosystems will unfold. Historical ecology provides the foundation for this debate and creates a process whereby stakeholders, scientists, and policymakers may work collaboratively to better understand the multitude of options for the future.

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References

Ballee, W. 2006. Time and Complexity in Historical Ecology. New York: Columbia University Press.

Giffin, C. E. 1902. "Santa Monica Quadrangle." (1:62,500). California State University: Map Library, Northridge, CA.

Grossinger, R. M. 2005. "Documenting Local Landscape Change: The San Francisco Bay Area Historical Ecology Project." In The Historical Ecology Handbook, edited by D. Egan and E. A. Howell, 425–41. Washington, DC: Island Press.

Grossinger, R. M., and R. A. Askevold. 2005. Historical Analysis of California Coastal Landscapes: Methods for the Reliable Acquisition, Interpretation, and Synthesis of Archival Data. SFEI Report No. 396. Oakland, CA: San Francisco Estuary Institute.

Grossinger, R. M., E. D. Stein, K. Cayce, R. Askevold, S. Dark, and A. Whipple. 2011. Historical Wetlands of the Southern California Coast: An Atlas of US Coast Survey T-sheets, 1851-1889. Technical Report 589. Southern California Coastal Water Research Project. Costa Mesa and Oakland, CA: San Francisco Estuary Institute.

Grossinger, R. M., C. Striplen, R. A. Askevold, E. Brewster, and E. E. Beller. 2007. "Historical Landscape Ecology of an Urbanized California Valley: Wetlands and Woodlands in the Santa Clara Valley." Landscape Ecology 22: 103–20.

Hall, W. H. 1888. "Detail Irrigation Map: Santa Monica Sheet." California State Archives, Sacramento, CA.

Hancock, H. 1858. "Plat of the Rancho Las Cienegas." Bureau of Land Management, Sacramento, CA.

Jacobs, D., E. D. Stein, and T. Longcore. 2010. Classification of California Estuaries Based on Natural Closure Patterns: Templates for Restoration and Management. Technical Report 619. Costa Mesa, CA: Southern California Coastal Water Research Project.

Kentula, M. E. 1997. "A Comparison of Approaches to Prioritizing Sites for Riparian Restoration." Restoration Ecology 5: 69–74.

———. 2007. "Monitoring Wetlands at the Watershed Scale - Foreword." Wetlands 27: 412–15.

Kershner, J. L. 1997. "Setting Riparian/Aquatic Restoration Objectives within a Watershed Context." Restoration Ecology 5: 14–24.

National Research Council. 2001. Compensating For Wetland Losses Under The Clean Water Act. Washington, DC: National Academy Press.

Nelson, J. W., C. J. Zinn, A. T. Strahorn, E. B. Watson, and J. E. Dunn. 1916. "Soil Survey of the Los Angeles Area." Washington, DC: United States Department of Agriculture.

Rhemtulla, J. M., and D. J. Mladenoff. 2007. "Why History Matters in Landscape Ecology." Landscape Ecology 22: 1–3.

San Dieguito River Park. 2010. San Dieguito Lagoon Wetland Restoration Project. http://www.sdrp.org.

Stein, E. D., S. Dark, T. Longcore, R. Grossinger, N. Hall, and M. Beland. 2010. "Historical Ecology as a Tool for Assessing Landscape Change and Informing Wetland Restoration Priorities." Wetlands 30: 589–601.

Stein, E. D., S. Dark, T. Longcore, N. Hall, M. Beland, R. Grossinger, J. Casanova, and M. Sutula. 2007. Historical Ecology and Landscape Change of the San Gabriel River and Floodplain. Technical Report 499. Costa Mesa, CA: Southern California Coastal Water Research Project.

Swetnam, T. W., C. D. Allen, and J. L. Betancourt. 1999. "Applied Historical Ecology: Using the Past to Manage for the Future." Ecological Applications 9: 1189–1206.

White, D., and Fennessy, S. 2005. "Modeling the Suitability of Wetland Restoration Potential at the Watershed Scale." Ecological Engineering 24: 359–77.

Ballona Wetlands

PHOTO: SMBRF

Wetland Health and Assessment: An Information Inundation at the Ballona Wetlands Ecological Reserve

KARINA JOHNSTON

Abstract

Coastal estuarine wetlands function as unique transitional areas between land and ocean and, in some places in Southern California, represent opportunities to restore degraded habitats to healthy wetland systems. Many of these wetland systems have suffered a significant number of anthropogenic stressors, and understanding the functionality of these systems is imperative for developing appropriate restoration actions. Monitoring programs, including baseline surveys, can provide pre-restoration assessments of the site, inform management actions, and help to understand the physical and biological functioning of the site. These monitoring programs are also tools used to detect change, develop restoration programs, and determine between-site variability with natural or reference wetlands.

The 600-acre Ballona Wetlands system encompasses the largest opportunity for coastal wetland restoration in the Santa Monica Bay and Los Angeles County. In 2009, the Santa Monica Bay Restoration Commission began assessing the current, biological condition of the Ballona Wetlands Ecological Reserve to increase the comprehensive knowledge of the site, inform adaptive restoration management, and assist in developing a long-term monitoring program. The baseline program incorporated comprehensive biological, chemical, and physical surveys across a two-year period. Results indicate a highly degraded system in many of the upland habitats due to the presence of dredge spoils and anthropogenic impacts. The results also indicate a muted tidal marsh system dominated by native vegetation but with limited natural functionality. Several restoration actions are discussed that would address many of these limitations and issues.

Introduction

While the specific definition of coastal wetland varies considerably based on country and even state (Turner et al. 2000), all coastal wetlands are unique transitional areas between land and ocean and contain distinctive and diverse groups of organisms capable of living in this challenging interface. Freshwater input from watersheds combined with tidally influenced saltwater conditions leads to habitats filled with organisms idiosyncratically adapted to conditions under which many life forms would not be able to survive.

Habitat Loss and Stressors

Since wetlands cover only a small fraction of Earth's surface, estimates of wetland area can be highly variable based on region, wetland type, anthropogenic factors, and other conditions, but scientists agree that significant wetland habitat loss has incurred on a global scale (Dahl and Allord 2004; Zedler and Kercher 2005). California has experienced more than 90% wetland loss since the time of European settlement (Dahl 1990; Sutula et al. 2008a), due mostly to agriculture and coastal urbanization. Drainage and other factors have converted many historically wetland areas into upland habitats.

Some of the most significant stressors to Southern California wetlands include dikes and levees, restricted tidal exchange and reduced flushing, and encroaching invasives (Sutula et al. 2008a, 2008b). Additional stressors unique to individual wetlands include, in no specific order, non-point source discharges, heavy metal impairments, bacteria and pathogen impairments, pesticide or trace organics impairments, nutrient impairments, predation and habitat destruction, habitat fragmentation, noise and light pollution, trash, excessive debris and runoff, culverts, paving, excessive human use, vector control, dredging,

Figure 1. Ballona Creek Trash Boom

modified hydrology, point source discharges, physical structural restrictions, and many others (Sutula et al. 2008a; Figure 1). Modified hydrology, common in Southern California, can cause altered sediment transport, physical barriers to movement of water, restriction of water movement across the site, and a decreased overall hydrologic capacity (Haltiner et al. 1997). Overall wetland health is impacted by different stressors in different regions; most of these stressors are anthropogenic.

Wetland Services and Values

Wetlands are valuable in an economic and ecological context. The economic valuation of wetlands is becoming more recognized in scientific literature (Dahl and Allord 2004) and is highly dependent on the individual characteristics of the site and surrounding environs. One of the more commonly cited economic benefits in recent literature is the ability of wetlands to sequester carbon (Brevik and Homburg 2004; Zedler and Kercher 2005). A superficial understanding of wetland value in the context of biodiversity and habitat value is generally understood. Even small wetlands exhibit vital services and are not as isolated as once believed (Semlitsch and Bodie 1998). They can be crucial for maintaining biodiversity in a region, especially for those populations philopatric to smaller areas (e.g., salamanders) (Semlitsch and Bodie 1998). However, wetland ecosystems are incredibly complex and have a multitude of components and variables, which taken alone are not descriptive of the system as a whole.

Zedler and Kercher (2005) define the primary global ecosystem services of coastal wetlands as biodiversity support, water quality improvement, flood abatement, and carbon management (Brevik and Homburg 2004; Crooks et al. 2011; Greb, DiMichele, and Gastaldo 2006). Additional ecosystem and economic services include, but are not limited to, groundwater recharge, rare species habitats, nutrient cycling, pollution control, fish nursery areas, avifauna Pacific Flyway connections, habitat value for other plants and animals, erosion resistance, air purification, moderation of temperature extremes, heavy metal retention, renewable resources, recreational benefits, cultural values, and many more (Clarkson et al. 2004; Kazmierczak 2001; Lin and Terry 2003; Page et al. 1997; Turner et al. 2000; Zedler 2001; Zedler and Kercher 2005). These benefits provide a strong argument for preserving, conserving, and restoring such unique and valuable habitats.

The objective of the Federal Clean Water Act (CWA) is to restore and maintain the chemical, physical, and biological integrity of the nation's waters, including estuarine waters and wetland habitats. In California, the California Wetlands Conservation Policy was created in 1993 by Governor Pete Wilson to eliminate the loss of wetlands in California. Wetland restoration is conducted for many reasons, primarily to restore functionality and the aforementioned services. The overall goals vary by individual project but strive to minimize the effects of anthropogenic impacts over time. Optimally, conditions are restored to those of similar reference sites, which may include remaining natural sites or previously restored wetlands.

Importance of Monitoring

When planning and assessing wetland restoration projects, it is important to understand the biological conditions and the physical processes of the site, e.g., topography, hydrology, climate, geomorphology (Neckles et al. 2002). Physical alterations of a site can drastically alter the functioning of the restored tidal wetland system (Haltiner et al. 1997), as the primary influence on the structure and function of a salt marsh is often related to inundation (Neckles et al. 2002; Figure 2). Determining the health of individual wetlands is important to restoration project managers, and allows an assessment of whether the goals of the project have been met (Stein et al. 2007, Sutula et al. 2008b). One of the major issues in wetland protection and restoration is the lack of integrated, comprehensive, and transferrable data.

Monitoring programs gather scientifically valid information about a system (Yoccoz, Nichols, and Boulinier 2001, Stein et al. 2007, Sutula et al. 2008b). Agencies, scientists, and other organizations broadly recognize the importance of wetland monitoring, as wetlands have a high degree of within-site and between-site variability (Kentula 2007; National Research Council 2001; Zedler 1982, 2001). Scientifically accurate assessments are needed to make informed societal decisions (Karr 1987), and to preserve biological systems for the direct protection of human health.

Figure 2. Post-Rain Ballona Salt Pan

Figure 3. Map of Ballona Wetlands Ecological Reserve

Monitoring methods can be highly variable based on project goals, compliance requirements, and site variability (Neckles et al. 2002), but the methods must be capable of detecting changes temporally and spatially. Monitoring can assist in scientific and management objectives (Finlayson and Spiers 1999). Management assistance occurs in developing restoration programs, evaluating the efficacy of management policies, and improving the decision process (Yoccoz et al. 2001; Martin, Kitchens, and Hines 2006). Biological goals include assessing biodiversity, detecting species invasions, detecting significant or negative changes over time, or tracking conservation of rare species (Martin et al. 2006). Often comparing a monitoring site to reference wetlands can provide a valuable assessment tool to determine between-site variability and a more informed direction toward project goals (Brinson and Rheinhardt 1996; Neckles et al. 2002).

The Ballona Wetlands Baseline Assessment Program

The 600-acre Ballona Wetlands system encompasses the largest opportunity for coastal wetland restoration in the Santa Monica Bay and Los Angeles County (Figure 3); the system is one of approximately 40 coastal wetlands along the 1,045 miles of the Southern California coast between Point Conception and Mexico. In 2004, the State of California took title to the former Ballona Wetlands in Los Angeles and designated the wetlands as a permanent State Ecological Reserve. The property is owned by two state agencies, the California Department of Fish and Game (540 acres) and the State Lands Commission (60 acres, including a 24-acre freshwater treatment wetland).

The Ballona Wetlands Ecological Reserve (BWER) is an important wetland site located in the second most populous region in the United States (Figure 4). In 2009, under the auspices of the California Department of Fish and Game (CDFG) and the California State Coastal Conservancy (SCC), the Santa Monica Bay Restoration Commission (SMBRC) began assessing the current biological condition of the BWER. Site-specific monitoring data are currently being collected throughout the BWER as part of an intensive Baseline Assessment Program (BAP) and long-term

Figure 4. Ballona (foreground) and Development (background)

Figure 5. Student Survey Volunteers

PHOTO: SMBRF

Figure 6. Water Quality Sampling in Ballona Creek

PHOTO: SMBRF

monitoring program. The BAP was developed in partnership with the aforementioned agencies and wetland scientists in the region to collect biological, chemical, and physical data by employing a broad range of scientific monitoring methods.

In the past, scientists surveying the BWER focused largely on individual aspects of the ecosystem or on a limited area. The BAP provides a comprehensive baseline biological assessment, which is vital for determining the biotic integrity of the ecosystem. Biotic integrity can be defined as "the capability of supporting and maintaining a balanced, integrative, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region" (Karr and Dudley 1981). Integrative monitoring can give a balanced perspective to environmental assessments (Karr 1987).

The BAP encompassed a two-year period, including protocol development with scientific review, coordination with regional restoration programs, implementation of the assessment protocols, data analysis and reporting, and external scientific review. The goals of the BAP were to:

1. Provide a measure of pre-restoration baseline conditions at the BWER.
2. Increase comprehensive knowledge of the health and functioning of the site in an urban environment.
3. Assess ecological processes, cross-habitat comparisons, species interactions, and potential recovery.
4. Fill data gaps at the BWER and develop protocols for addressing data gaps at other wetland projects.
5. Inform adaptive management and long-term restoration plans.
6. Inform a site-specific and regional long-term monitoring program.
7. Identify stressors to the site.
8. Establish an informed, scientifically valid basis for improved watershed management to protect, prevent, and reduce pollution to the BWER.
9. Contribute chemical and ecological data from the BWER to local, regional, and national databases.

Methods

In September 2010, the SMBRC completed the first year of surveys at the BWER. The first year of surveys incorporated monitoring and assessment strategies of biological, chemical, and physical components of the BWER ecosystem (Figure 5). Vegetation, seed core, terrestrial invertebrate, soil, and elevation surveys were conducted on permanent transects randomly located throughout all habitat types at the BWER. Additional biological data collection included surveys for small and large mammals, herpetofauna, ichthyofauna, benthic invertebrates, birds, and submerged aquatic vegetation. Water quality data collected included dissolved metals, fecal indicator bacteria, nutrients, and additional parameters.

Chemical Analyses

Extensive water quality surveys were a vital component of the BAP. Comprehensive temporal and spatial data on the distributions of metals, nutrients (nitrates, nitrites, and orthophosphates), and fecal indicator bacteria (total coliform, *E. coli*, and enterococci) were derived using several methods. Two 24-hour studies for fecal indicator bacteria and nutrients were conducted within the wetland tidal channels, Fiji Ditch, and Ballona Creek (Figures 3 & 6) to assess conditions throughout the entire tidal cycle. Dissolved metals were sampled at eight water stations throughout the BWER on a quarterly basis. Runoff from twelve locations at small drainages and ponding areas during three storms (›1 inch) were also analyzed for metals to determine stormwater contamination in the BWER. Samples from terrestrial soils were also analyzed for phytoavailable trace metals.

Vegetation

A primary goal of the BAP was an intensive cross-habitat vegetation assessment. Vegetation cover surveys were conducted on stratified random transects throughout each habitat. In addition to vegetation surveys, terrestrial invertebrate,

soil, and elevation surveys were conducted on a subset of these transects to evaluate ecosystem-level function of the habitat. The objective of the vegetation surveys was to determine the average percent cover of species using transect- and habitat-level assessments (Figure 7).

Several methods were used to accurately assess percent cover and diversity because of the differing conditions across multiple habitats (e.g., plant height and density, species diversity, topography). The tidally influenced lower marsh habitats were surveyed via the laser quadrat method. Size class estimate percent cover was employed to survey the upland dune, scrub, and grassland habitats; canopy heights were also recorded. Targeted surveys for all plant species of special concern were conducted throughout the BWER. Species lists and relative abundances were tallied and analyzed across several variables, including habitat, area, and native or non-native classifications. Plant cover was also correlated with elevation.

Vertebrates

Ichthyofauna surveys were conducted three times during the first year of baseline assessment: September 2009, April 2010, and July 2010. Sampling methods employed a combination of blocking nets and beach seines, minnow traps, and shrimp trawls. Surveys were conducted in Ballona Creek, Fiji Ditch, and the tidal channels within Area B of the BWER (Figure 3). Six permanent stations were positioned within the BWER: three in the Fiji Ditch and three in the tidal channels. These stations were a subset of the invertebrate, sediment, and water quality sampling stations. Additionally, five 250 m trawls were conducted in Ballona Creek.

Herpetofauna surveys during the first baseline year were conducted over the course of three seasons (early fall, spring, and early summer) in four habitat types (seasonal wetland, upland grassland, upland scrub, and dune). To obtain comprehensive information, several sampling methods were used throughout the site. Pitfall and driftnet arrays were employed in several of the major habitats; site searches, cover board flipping, and targeted surveys for a California Species of Special Concern, the California legless lizard, were conducted within potential habitat areas.

Mammal surveys during the first baseline year were conducted with baited Sherman live traps and pitfall traps for small mammals and baited wildlife motion camera stations (Critter Cams) for medium and large mammals (Figure 8). Habitats targeted for small mammals included seasonal wetland, upland grassland, scrub, and high marsh. The Critter Cams were located throughout the BWER and deployed for approximately two to four weeks at each station.

Although birds are one of the most commonly observed groups of organisms at the BWER, they are seldom studied comprehensively or scientifically. Site-wide surveys were performed quarterly in October 2009 and January, April, and July 2010 to produce digitized spot-maps, which display the spatial and temporal

Figure 7. Combination of Native and Invasive Plants

Figure 8. Preparing a Camera Station

distribution of birds on the reserve, as well as their observed relative abundances. During fall and winter of the baseline year, post-rain rapid-count censuses were also conducted. Waterbird surveys were conducted on a semi-monthly basis. Between March and June 2010, supplemental visits were made to several of the more productive breeding habitats around the reserve in an effort to fully document nesting occurrences and site usage by nesting species that fell outside the scheduled April and July surveys. Potential nesting areas of special-status species were also visited. Protocol surveys were performed for two special-status species: the least Bell's vireo (*Vireo bellii pusillus*) and Belding's Savannah sparrow (*Passerculus sandwichensis beldingi*). Volunteer waterbird and raptor censuses were conducted monthly and contribute additional information to the professional-level avian surveys.

Invertebrates

Benthic infaunal and epifaunal communities provide essential ecosystem services and support. The presence or absence of certain infaunal taxa within the tidal channels can indicate water quality, identify anthropogenic stressors to the estuary, and gauge the potential to support other trophic levels. For the BAP, infaunal benthic invertebrate sampling was conducted semiannually in seven locations within tidal channels: two in Area A and five in Area B (Figure 3). Existing protocols were used and adapted to the specific needs of the BWER. Presence and relative abundance were calculated for general taxonomic groups at each location. Average densities, as individuals/ m^2, were calculated for each station by month and core size.

Figure 9. Sampling Preparation, Including a Sticky Trap (center)

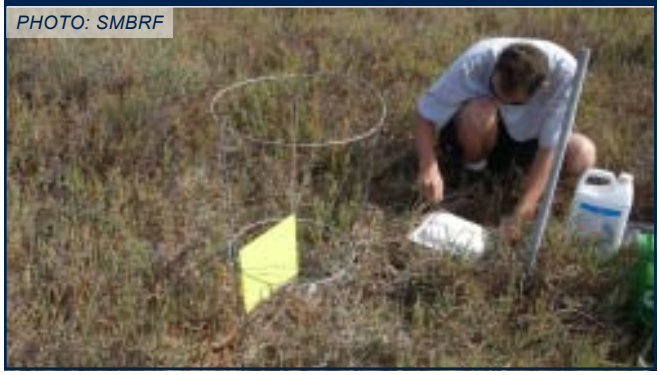

Figure 10. Water Quality Sampling in Ballona's Main Tide Channel

Species-level taxonomic identification will be conducted in year 2. Epifaunal benthic invertebrate surveys for the California horn snail (*Cerithidea californica*) were conducted using transects on the mudflat habitats and assessed as average densities per transect (individuals/m^2) as part of a regional assessment.

Flying aerial arthropod biomass surveys were also conducted using sticky traps (Figure 9). The objective was to extrapolate productivity using arthropod biomass by invertebrate weight and size class for each habitat.

Summary Results

Chemical Analyses

Bacteria levels at most sites consistently exceeded Total Maximum Daily Load (TMDL) targets, sometimes by several orders of magnitude, while nutrient levels were typically below recommended targets. Dissolved copper, lead, and selenium were consistently above dry weather TMDL levels in each quarter and at most stations (Figure 10). Zinc, copper, boron, barium, cadmium, lead, lithium, mercury, selenium, silver, and tin all exceeded acute toxicity levels for seawater during at least one quarterly sampling event[1]. Stormwater exceeded the TMDL wet weather numeric target for copper at seven of the twelve stations. Lead, selenium, and zinc all exceeded the TMDL wet weather numeric target at least once. Aluminum, boron, and cadmium exceeded acute toxicity levels1 at multiple stations.

Vegetation

Preliminary results from the first year of the BAP indicated dominant cover of non-native plant species in the upland habitats and dominant cover of native species within the marsh habitats (Figure 11), though the native habitats tended to have a lower overall species richness. The most common native species in the tidal marsh habitats based on percent cover, included common pickleweed (*Salicornia virginica*), marsh jaumea (*Jaumea carnosa*), alkali weed (*Cressa truxillensis*), and Parish's pickleweed (*Salicornia subterminalis*). The most common non-native species in upland areas included ice plant (*Carpobrotus edulis*), black mustard (*Brassica nigra*), ripgut chess (*Bromus diandrus*), and crown daisy (*Chrysanthemum coronarium*), though many additional species were identified, with several highly invasive species expanding their range during the baseline years (e.g., *Arundo donax, Euphorbia spp*.).

Percent native cover was negatively correlated with elevation; percent non-native cover was positively correlated with elevation. Inundated areas had the lowest non-native cover. Elevation, native cover, and non-native cover were significantly different among habitat types; the low salt marsh habitat had the highest native plant average percent cover (91.0 ± 5.2%). The upland grassland and scrub habitats had the highest non-native plant average percent cover (77.1 ± 1.1%, and 58.8 ± 1.1%, respectively).

Vertebrates

The beach seine surveys identified eight native species (Table 1) and one non-native species, western mosquitofish (*Gambusia affinis*). In the wetland and ditch sites, 2,618 fish were caught using the beach seine method, 286 were caught in the minnow traps, and 10 fish were caught in the trawls of Ballona Creek. Arrow goby, killifish, and topsmelt had the highest relative abundances. Macroinvertebrates caught in the surveys were also identified. The most common invertebrate collected in the seines was the California horn snail (*Cerithidea californica*).

The herpetofauna pitfall traps had widely varying success rates, depending on the habitat. The dune habitat had a

Figure 11. Water Droplets on Pickleweed

Table 1. Fish Results

	COMMON NAME	SCIENTIFIC NAME	STATUS
FISH	Arrow / cheekspot goby	*Clevelandia ios or Ilypnus gilberti*	Native
	California killifish	*Fundulus parvipinnis*	Native
	Diamond turbot	*Hypsopsetta guttulata*	Native
	Longjaw mudsucker	*Gillichthys mirabilis*	Native
	Pacific staghorn sculpin	*Leptocottus armatus*	Native
	Round stingray	*Urobatis halleri*	Native
	Striped mullet	*Mugil cephalus*	Native
	Topsmelt	*Atherinops affinis*	Native
	Western mosquitofish	*Gambusia affinis*	Non-native

Table 2. Herpetofauna Results

	COMMON NAME	SCIENTIFIC NAME	STATUS
HERPETOFAUNA	Baja California treefrog	*Pseudacris hypochondriaca hypochondriaca*	Native
	California kingsnake	*Lampropeltis getula californiae*	Native
	California legless lizard	*Anniella pulchra*	Native, California Species of Special Concern
	Great Basin fence lizard	*Sceloporus occidentalis longipes*	Native
	San Diego alligator lizard	*Elgaria multicarinata webbii*	Native
	San Diego gopher snake	*Pituophis catenifer annectens*	Native
	Southern Pacific rattlesnake	*Crotalus oreganus helleri*	Native
	Western side-blotched lizard	*Uta stansburiana elegans*	Native

Table 3. Mammal Results

	COMMON NAME	SCIENTIFIC NAME	STATUS
MAMMALS	Botta's pocket gopher	*Thomomys bottae*	Native
	California ground squirrel	*Spermophilus beecheyi*	Native
	Coyote	*Canis latrans*	Native
	Desert cottontail	*Sylvilagus audubonii*	Native
	Domestic cat	*Felis cattus*	Non-native
	Domestic dog	*Canis familiaris*	Non-native
	House mouse	*Mus musculus*	Non-native
	Human	*Homo sapien*	Native
	Raccoon	*Procyon lotor*	Native
	Rat (unknown species)	*Rattus* sp.	Non-native
	South Coast marsh vole	*Microtus californicus stephensi*	Native, California Species of Special Concern
	Striped skunk	*Mephitis mephitis*	Native
	Virginia opossum	*Didelphis virginiana*	Non-native
	Eastern fox squirrel	*Sciurus niger*	Non-native
	Western harvest mouse	*Reithrodontomys megalotis*	Native

Figure 12. Karina (author) Holding a California Kingsnake

Figure 13. Sorting Invertebrate Samples

significantly greater overall capture rate than any of the other habitats (34.62%). Herpetofauna identified during the first baseline year included eight species (Table 2). Great Basin fence lizards (*Sceloporus occidentalis*) were the most commonly caught herpetofauna species, and they were found throughout the site. Gopher snakes and California kingsnakes (Figure 12) were common throughout the upland habitat types and bermed areas (e.g., gas company roads). Amphibian and reptile surveys continued in year 2 using cover board array surveys to provide a better assessment of the snake population, reduce site impacts, and survey more habitat areas.

The California legless lizard, a California Species of Special Concern, was confirmed in several locations during the first-year BAP surveys, including one dune habitat area where the species had not been found in almost twenty years, according to previous BWER reports.

Nine native and six non-native mammal species were live captured via Sherman trap or observed via Critter Cams during the first baseline year (Table 3). Of the three species caught in the small mammal live traps, western harvest mice were the most common and found in all surveyed habitat types except upland scrub. The South Coast marsh vole was the only Species of Special Concern captured or observed during the first baseline year; this species was found only in the high marsh habitats.

A total of 156 avifauna species and distinctive subspecies were recorded during the first year of baseline assessment with all survey types combined. A total of 11 special status species were confirmed on-site during the quarterly surveys: Belding's Savannah sparrow, brown pelican (*Pelecanus occidentalis*), Cooper's hawk (*Accipiter cooperii*), elegant tern (*Thalasseus elegans*), least Bell's vireo, loggerhead shrike (*Lanius ludovicianus*), long-billed curlew (*Numenius americanus*), northern harrier (*Circus cyaneus*), peregrine falcon (*Falco peregrinus*), Vaux's swift (*Chaetura vauxi*), and white-tailed kite (*Elanus leucurus*). The California gnatcatcher (*Polioptila californica*) was seen on-site after the first year of baseline surveys was completed and is included in year 2.

Invertebrates

Benthic invertebrate density at the BWER, when averaged for all cores and all organisms combined, increased with increased distance from the tide gates. Seasonal variations in composition and abundance were recorded at all sampling stations (Figure 13). The group of organisms that consistently had the highest proportion of the samples at each station was gastropods, dominated by the California horn snail, when all samples for each station were combined. The groups that were the next highest proportion of the samples were mollusks and gammarids.

During the California horn snail epifauna surveys, the main tide channel of Area B was found to have the highest average number of snails (77.3 individuals/m^2) in June; the western (outflow) tide channel had the highest average number of snails (102.4 individuals/m^2) in September.

Aerial arthropod productivity was based on the average available biomass per meter squared per day. Productivity refers to the rate of *available* aerial arthropod biomass on a particular transect or averaged within a particular habitat type during the time of sampling, and is not an indication of the *active production* of the system or habitat as a whole. Results of flying invertebrate data indicate the lowest productivity in the brackish marsh (3.50 ± 0.59 mg/m^2/day) and fairly uniform productivity in the low salt marsh, mid salt marsh, and salt pan habitats (14.9 ± 3.96, 14.9 ± 3.07, and 14.7 ± 4.12 mg/m^2/day, respectively). The upland grassland had the highest aerial arthropod productivity (29.0 ± 11.1 mg/m^2/day) and the highest level of variability between transects (Figure 14). Species-level terrestrial surveys will be conducted in year 2.

Discussion and Restoration Recommendations

Monitoring allows assessments that contribute key components of adaptive restoration management. Additionally, the comprehensive nature of the baseline surveys allows more extensive analyses across a range of ecological factors. These data can be used for analyses of individual biological or physiochemical parameters, or as part of higher-level ecological assessments and evaluations. For example, vegetative cover can be analyzed in conjunction with elevation, inundation, soil characteristics, or even invertebrate productivity by transect or habitat level to determine the overall health and functionality of a

system. Additionally, the individual factor assessments will help to determine sensitive areas within the site based on rare species presence, and to help answer targeted questions about presence and abundance for a number of parameters.

The results suggest that areas with higher degrees of anthropogenic impacts (e.g., fill soils, berms, and disturbed areas) have more non-native species and that marsh habitats have a higher presence of native species (e.g., vegetation, mammals). Upland grassland and scrub habitats had the highest overall cover of non-native vegetation, although there was a high degree of habitat patchiness throughout Areas A and C (Figure 3). Restoration actions should thus seek to remove berms and focus restoration efforts on highly disturbed areas to increase the potential for native species to thrive and/or recolonize disturbed habitats. Plants that are highly invasive and have been spreading during the baseline program should receive removal precedence and might need to be removed before the start of the full-scale restoration process (e.g., *Arundo donax*).

The native cover within the marsh habitats was likely related to areas with more frequent inundation and lower, more natural marsh elevations. The tide gate continues to restrict tidal inundation and the natural hydrologic impacts of a full tidal cycle, including restricted water movement, water column stratification, decreased sediment movement, and channel widening. A tidal connection between the wetland habitat and Ballona Creek should be permanently reestablished to achieve a fully tidal coastal wetland system reconnected to the watershed. This will encourage native diversity and improve water quality. A tidal connection will also encourage wetland habitats (e.g., mudflats) not currently present as significant portions of the BWER to be further used by benthic invertebrates and juvenile fish as a nursery habitat.

When habitat- and ecosystem-level assessments are compared, the unique characteristics of several systems are revealed. For example, the Fiji Ditch and tidal channels of Area B (Figure 3) appear to function differently. Soil characteristics, fish composition, and benthic composition all differed between stations. This is likely due to the full tidal connection of the Fiji Ditch to Marina del Rey for stingrays, and the use of the wetland channels as nursery habitats for the juvenile flatfish. The steep banks and narrow width channels would have a higher wetland habitat value with more gradual sloping. This would allow for better transitional zones, and more tidally exposed area. Additionally, the dune habitats displayed unique characteristics when compared with the other habitat types within the BWER, such as the presence of several rare plant species (Figure 15), the California legless lizard, and soils with unique infiltration capabilities.

Data suggest that the restoration project at the BWER should work toward sustaining higher ecological function and biotic integrity, with goals that include biological, chemical, hydrological, and physical parameters. This higher-level functionality can be encouraged by reducing habitat fragmentation, establishing natural elevation levels, gradual gradients, and transition zones, and increasing native plant biodiversity to incorporate more Southern California wetland species.

Figure 14. Monarch Butterfly on Coyote Brush

Figure 15. Sand Verbena

Future Directions

Surveys at the BWER will continue with a refinement of protocols based on data gaps identified during the baseline years. Further comparisons of the two years of baseline data will allow higher-level ecological analyses, and a measure of short-term temporal variability (especially when assessing highly mobile species such as fish). Further in-depth water quality analyses will continue to address questions raised by the data collected in year 1, such as the association of particular constituents of concern with resuspended sediment. Regional data collection will begin to compare the functionality of the BWER to other wetlands within the region.

[1] Toxicity levels based on Environmental Protection Agency (EPA) Ambient Water Quality Criteria

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References

Brevik, E. C., and J. A. Homburg. 2004. "A 5000-year Record of Carbon Sequestration from a Coastal Lagoon and Wetland Complex, Southern California, USA." Catena 57: 221–32.

Brinson, M. M., and R. Rheinhardt. 1996. "The Role of Reference Wetlands in Functional Assessment and Mitigation." Ecological Applications 6 (1): 69–76.

Clarkson, B. R., B. K. Sorrell, P. N. Reeves, P. D. Champion, T. R. Partridge, and B. D. Clarkson. 2004. Handbook for Monitoring Wetland Condition. A Ministry for the Environment Sustainable Management Fund Project (5105), New Zealand.

Crooks, S., D. Herr, J. Tamelander, D. Laffoley, and J. Vandever. 2011. "Mitigating Climate Change through Restoration and Management of Coastal Wetlands and Near-shore Marine Ecosystems: Challenges and Opportunities." Marine Ecosystem Series 121: 1–69.

Dahl, Thomas E. 1990. Wetlands Losses in the United States 1780's to 1980's. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service; Jamestown, ND: Northern Prairie Wildlife Research Center Online. (Version 16JUL97)

Dahl, T. E., and G. J. Allord. 2004. History of Wetlands in the Conterminous United States. US Geological Survey, 19–26. Washington, DC: U.S. Fish and Wildlife Service.

Finlayson, C. M. and A. G. Spiers, eds. 1999. A Compendium of Information for Managing and Monitoring Wetlands in Tropical Australia. Supervising Scientist Report 148. Canberra, Australia: Supervising Scientist.

Greb, S. F., W. A. DiMichele, and R. A. Gastaldo. 2006. "Evolution and Importance of Wetlands in Earth History." In Wetlands through Time: Geological Society of America Special Paper 399, ed. S. F. Greb and W. A. DiMichele, 1–40. Boulder, CO: The Geological Society of America, Inc.

Haltiner, J., J. B. Zedler, K. E. Boyer, G. D. Williams, and J. C. Callaway. 1997. "Influence of Physical Processes on the Design, Functioning, and Evolution of Restored Tidal Wetlands in California (USA)." Wetlands Ecology and Management 4 (2): 73–91.

Karr, J. R. 1987. "Biological Monitoring and Environmental Assessment: A Conceptual Framework." Environmental Management 11(2): 249-256.

Karr, J. R., and D. R. Dudley. 1981. "Ecological Perspective on Water Quality Goals." Environmental Management 5: 55-68.

Kentula, M. E. 2007. "Foreword: Monitoring Wetlands at the Watershed Scale." Wetlands 27 (3): 412–15.

Lin, Z., and N. Terry. 2003. "Selenium Removal by Constructed Wetlands: Quantitative Importance of Biological Volatilization in the Treatment of Selenium-Laden Agricultural Drainage Water." Environmental Science and Technology 37: 606–15.

Martin, J., W. M. Kitchens, and J. E. Hines. 2006. "Importance of Well-Designed Monitoring Programs for the Conservation of Endangered Species: Case Study of the Snail Kite." Conservation Biology 21 (2): 472–81.

National Research Council. 2001. Compensating for Wetland Losses under the Clean Water Act. Washington, DC: National Academy Press.

Neckles, H. A., M. Dionne, D. M. Burdick, C. T. Roman, R. Buchsbaum, and E. Hutchins. 2002. "A Monitoring Protocol to Assess Tidal Restoration of Salt Marshes on Local and Regional Scales." Restoration Ecology 10 (3): 556–63.

Page, G. W., E. Palacios, L. Alfaro, S. Gonzalez, L. E. Stenzel, and M. Jungers. 1997. "Numbers of Wintering Shorebirds in Coastal Wetlands of Baja California, Mexico." Journal of Field Ornithology 68 (4): 562–74.

Semlitsch, R., and R. Bodie. 1998. "Are Small, Isolated Wetlands Expendable?" Conservation Biology 12 (5): 1129–33.

Stein, E. D., M. Sutula, R. Clark, A. Wiskind, and J. Collins. 2007. Improved Monitoring and Assessment of Wetland and Riparian Areas in California through Implementation of a Level 1, 2, 3 Framework. Technical Report 555. Costa Mesa, CA: Southern California Coastal Water Research Project.

Sutula, M., J. N. Collins, A. Wiskind, C. Roberts, C. Solek, S. Pearce, R. Clark, A. E. Fetscher, C. Grosso, K. O'Connor, A. Robinson, C. Clark, K. Rey, S. Morrissette, A. Eicher, R. Pasquinelli, M. May, and K. Ritter. 2008a. Status of Perennial Estuarine Wetlands in the State of California: Final Report to the Surface Water Ambient Monitoring Program and the State Water Resources Control Board. Technical Report 571. Costa Mesa, CA: Southern California Coastal Water Research Project.

Sutula, M., J. N. Collins, R. Clark, C. Roberts, E. Stein, C. Grosso, A. Wiskind, C. Solek, M. May, K. O'Connor, E. Fetscher, J. L. Grenier, S. Pearce, A. Robinson, C. Clark, K. Rey, S. Morrissette, A. Eicher, R. Pasquinelli, K. Ritter. 2008b. California's Wetland Demonstration Program Pilot – A Final Project Report to the California Resources Agency. Technical Report 572. Costa Mesa, CA: Southern California Coastal Water Research Project.

Turner, R. K., J. C. J. M. van den Bergh, T. Söderqvist, A. Barendregt, J. van der Straaten, E. Maltby, E. C. van Ierland. 2000. "Ecological-Economic Analysis of Wetlands: Scientific Integration for Management and Policy." Ecological Economics 35: 7-23.

Yoccoz, N. G., J. D. Nichols, and T. Boulinier. 2001. "Monitoring of Biological Diversity in Space and Time." Trends in Ecology and Evolution 16 (8): 446–53.

Zedler, J. B. 1982. The Ecology of Southern California Coastal Salt Marshes: A Community Profile. Report from U.S. Fish and Wildlife Service, Biological Services Program. Washington, DC: U.S. Department of the Interior.

Zedler, J. B. 2001. Handbook for Restoring Tidal Wetlands. CRC Marine Science Series. Boca Raton, FL: CRC Press.

Zedler, J. B., and S. Kercher. 2005. "Wetland Resources: Status, Trends, Ecosystem Services, and Restorability." Annual Review of Environment and Resources 30: 39–74.

Case Studies

Kayaking over Kelp Forest off Palos Verdes Peninsula

PHOTO: GUANGYU WANG

Case Studies

Urban Coast includes detailed project reports regarding the various efforts to improve the condition of our coastal environments. The Case Studies section focuses on specific projects implemented to protect and manage coastal resources while also involving and educating the public. Understanding the specifics of particular projects, the successes, and the lessons learned informs and provides implications for future efforts.

In This Section

Coastal Stewards Kayak to Assateague Island with Wild Horses

PHOTO: NICO SARBANES

"Dude I was in the freaking Marsh today at work . . . omg what an experience?!"

–Ahtyla Brown, Coastal Steward (Facebook © status during second week of training)

Coastal Stewards Program: Diversifying Environmental Education

CARRIE SAMIS

This past summer, the Maryland Coastal Bays Program (MCBP), a National Estuary Program located on the Eastern Shore of Maryland, hired 17 Coastal Stewards, ages 15 to 23. The Coastal Stewards program is made possible through a unique partnership program of the MCBP, Assateague Island National Seashore, and Assateague State Park. Having completed its third year, the program has been making a difference since its beginning, but there have also been struggles along the way.

Background

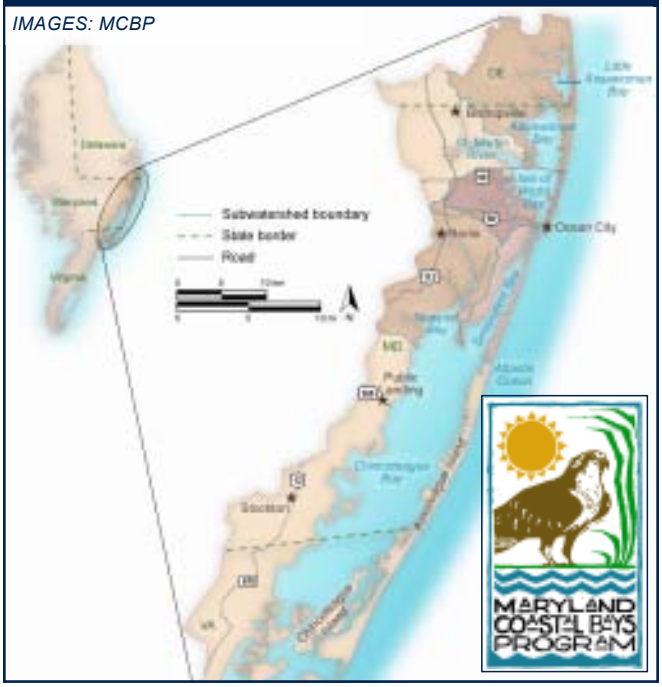
Children are growing up ever-more disconnected from nature. Nationally, nearly half of youth age five and under are children of color. According to U.S. Census data (2010), Maryland is quickly becoming a minority-majority state. Nearly 46% of Marylanders are people of color. The Maryland State Department of Education recently reported that Maryland students now represent that minority-majority. African American communities are concentrated in cities, such as Baltimore, and on the Eastern Shore. In Worcester County, several towns, including Berlin, Pocomoke, and Snow Hill, have communities of color representing 30 to 45% of the local population, and the Eastern Shore is one of the poorest regions of the state. The long-standing local history of people "working on the water" is quickly fading, as commercial fisheries for blue crabs and oysters, necessarily, endure increasing regulations due to populations dipping to critical levels. Agricultural communities, including farms and large chicken feeding operations, which are concentrated on the Eastern Shore, are also under pressure from development and increasing regulations. Identifying and communicating best practices for development, agriculture, and commercial fishing, as well as preserving large tracts of land, are critical to maintaining the quality of the coastal bays watershed (Figure 1).

Environmental organizations have been largely ineffective at engaging minorities. In 2007, the Yale School of Forestry & Environmental Studies published *Diversity and the Future of the U.S. Environmental Movement*, edited by Emily Enderle. In it, Marcelo Bonta, with the Center for Diversity & the Environment, and Charles Jordan, with the Conservation Fund, warn, "In ten years, if we find ourselves in a similar place, facing the same diversity issues as today, then we have failed miserably and the sustainability and relevance of our movement will be gravely at risk." It doesn't take a scientist to conclude that there are potentially debilitating ramifications for environmental-related organizations whose staff, boards, volunteers, and support groups are not representative of the local population.

Too many environmental organizations, which exist to protect biological diversity, fail to fully recognize the value

Figures 1 & 2. Map of Maryland Coastal Bays & MCBP Logo

IMAGES: MCBP



of cultural diversity. As a National Estuary Program, the MCBP (Figure 2) focuses on the watershed—and everything and everyone within it. Recognizing that diverse points of view will help the MCBP realize our mission to protect the coastal bays, we strive to create a culture within our organization that inspires respect and understanding of the value of biological and cultural diversity in and around our coastal bays.

History

Much of the MCBP's work revolves around building relationships. We are building relationships to benefit not only the coastal bays but also the communities within our watershed. Relationship building, to better engage minorities, began more than a decade ago. Then in 2007, the MCBP partnered with the U.S. Environmental Protection Agency (U.S. EPA), Maryland Department of the Environment, and Maryland Department of Natural Resources, and signed a Memorandum of Understanding (MOU) with the historically black University of Maryland, Eastern Shore (UMES). The MOU with UMES was the result of more than a year of planning and strategizing conducted by the Minority Outreach and Involvement Steering Committee at the MCBP, with significant leadership from the U.S. EPA.

The MOU established a model partnership called Linking Environmental and Academic Programs (LEAP). LEAP partners worked together to generate funding and start new programs, which were designed to link students with scientific and technical experts and to provide meaningful learning opportunities and field experiences.

Within the first year, the LEAP partners along with Assateague State Park and Assateague Island National Seashore were providing year-round programming for high school students enrolled in the Upward Bound program at UMES. Upward Bound partners, including graduate students from UMES, work with local high school students from the Lower Eastern Shore, to provide marine and estuarine science programs, hands-on outdoor experiences, and exposure to future career possibilities in science, education, and outreach (Figure 3).

The MCBP recognized a need to reach out to minority communities within the coastal bays, watershed, and surrounding region, and developing a multi-agency MOU with a minority-serving institution was a critical step early in the process. The formal partnership has since resulted in extended, year-round programs, one-day annual events, and the multi-day green jobs symposium "Get Out. Get Green. Get Paid." Most importantly, the MOU fostered trust and confidence among partners, now working closely together to address common goals.

Coastal Stewards: Getting Started

Armed with partnerships and the successes of the Upward Bound program, the MCBP, along with Assateague Island National Seashore, Assateague State Park, and Delmarva Low-Impact Tourism Experiences, created the Coastal Stewards program because we wanted to expand upon the environmental and cultural work-related experiences available to local students.

Figure 3. Coastal Stewards at Beach Cleanup

PHOTO: JIM RAPP

Figure 4. Coastal Stewards Logo

LOGO: MCBP

The Coastal Stewards program (Figure 4) began in the spring of 2009, with a commitment from the National Park Service (NPS) to provide funding for supplies and staff support. We started planning to hire a crew of students for the 2009 summer without knowing how we would pay their wages. We wrote grants and extensively networked. We knew we had a strong program, but we needed more funding.

We were feeling a bit discouraged, but then federal stimulus money was funneled through Maryland to our local Work Force Alliance, a state agency with regional offices throughout Maryland, specifically to provide workforce development opportunities for youth. The stimulus funding from the American Recovery and Reinvestment Act of 2009 would pay for Coastal Stewards' student wages. The partnership received the funding, recruited and hired 11 students, and started the 2009 summer program within two weeks. As soon as the summer ended, we started to seek funding for the next year. Again, we wrote grants, networked, made our case, and even had encouraging results to share from our pilot year.

In late 2009, the MCBP's Policy Committee voted to establish a Diversity Advisory Committee, further formalizing our commitment to deliberate inclusivity. The committee has representatives from the U.S. EPA, the National Association for the Advancement of Colored People (NAACP), UMES, Salisbury University, Maryland Department of Natural Resources, Assateague Island National Seashore, NPS, local government agencies, and citizens. The Diversity Advisory Committee is responsible for institutionalizing minority outreach and participation within the MCBP and building upon existing projects and programs, such as the Coastal Stewards program, designed to foster greater participation by minorities in natural resources and the environment (Figure 5).

The MCBP gained experience and formalized our diversity programming, but obtaining full funding in 2010 for Coastal Stewards remained challenging. We secured funding for supplies and training, but it was not until the last minute that we had the money to pay student wages—again. This time the money came from the Maryland Department of Natural Resources, a LEAP Partner, but for fewer students.

This past year, the third year of the program, we were fortunate to receive funding from the U.S. EPA. Knowing that we had secured funding several months ahead of time, rather than only a couple of weeks, allowed us to recruit more effectively, plan more, and focus on enhancing the program.

Seeking and seizing every opportunity we could to promote the program helped tremendously. Because the partners included local non-profit, state, and federal agencies, we had access to, and could accept, funds from multiple sources. Not relying on a sole funding source worked to our benefit. Showing buy-in and funding support from multiple sources was a testament to confidence in the program and lessened the burden on already cash-strapped agencies and organizations with shrinking budgets. We leveraged support in any way we could.

We knew the program was working. We were seeing results. We felt a strong sense of professional and personal commitment to our Coastal Stewards. The determination of the staff representing the primary partners was unflagging.

A funding promise from the U.S. EPA for 2012 will allow us to further fine-tune the program. The U.S. EPA is now the major funder for Coastal Stewards. Financial support for the program from U.S. EPA Headquarters and strong staff support from both Headquarters and EPA Region 3 has enabled us to grow and enhance the program significantly. We are confident that strong support from the NPS and the Maryland Department of Natural Resources will also continue.

Program Activities and Contributions

Since the Coastal Stewards' inception, a group of young people from the Eastern Shore of Maryland has received training, developed new skills, been mentored by leaders in the field, learned about our shared cultural heritage,

Figure 5. Aerial of Maryland Habitat and Urbanization

PHOTO: MCBP

Figure 6. Coastal Stewards Help Band Royal Terns

developed new relationships with peers, become more environmentally literate, earned a paycheck in a green job, and made overwhelmingly positive contributions that benefit local people and our coastal bays.

During the first three summers of the program, Coastal Stewards joined forces with other local volunteers and organizations to improve local habitats—planting more than 3,000 native plants, removing invasive species, and installing fencing to protect nearly two miles of dunes on Assateague Island. Coastal Stewards have also worked to improve water quality—constructing 60 rain barrels for installation; removing hundreds of stakes during the final phase of a successful marsh restoration project along Isle of Wight Bay; helping to maintain a bioretention site adjacent to Chincoteague Bay, buffer zones along Sinepuxent Bay, and a rain garden at the historic Germantown School; and removing an estimated five tons of marine debris and trash along our coasts.

Additionally, our Coastal Stewards have contributed to scientific data collection—participating in the National Aquarium's annual dolphin count, working with the Maryland Department of Natural Resources to band more than 1,500 brown pelicans on islands in the Chesapeake and coastal bays and nearly 200 royal terns in the coastal bays (Figure 6), and documenting reptiles and amphibians in Worcester County for the Maryland Herp Atlas. All of these projects support terrestrial and aquatic wildlife monitoring programs, which help scientists better understand the range, distribution, reproduction, and migratory patterns of species of concern.

This past summer, Coastal Stewards continued to assist with projects designed to help improve water quality in the coastal bays—planting marsh grasses to stabilize the shorelines and provide habitat, helping to maintain planted bioretention buffers that absorb nutrients and runoff, and cleaning up debris from our waterways and adjacent land. The Coastal Stewards also constructed 20 more rain barrels, which will collect rainwater that can be used to water gardens, and labeled storm drains this past fall in order to remind residents and visitors that whatever goes into drains eventually flows to our bays.

In addition to fieldwork, Coastal Stewards conduct educational programs and support MCBP outreach activities, engaging more than 10,000 visitors and residents each summer. Our Stewards share their passion for and knowledge of local ecosystems, encourage conservation efforts, and facilitate connections to nature for young and old, alike. Coastal Stewards also attend local cultural events such as Blessing of the Combines (Figures 7 and 8), the Tawes Crab and Clambake, and Maryland Coast Day. These events are important because they celebrate cultural heritage and ways of living that depend upon preserving local traditions, maintaining green spaces and healthy waterways, and living in a sustainable way.

Successes

From the beginning, MCBP wanted to create the Coastal Stewards program to pipeline young minority students into green jobs. It is working. Nature is inspiring, but so is a paycheck from a green job. Several of our former Coastal Stewards have earned positions with the National Park Service, the Maryland Park Service, the Maryland Civic Justice Corps, and the Maryland Conservation Corps.

Figure 7. Sign at the Eastern Shore

Figure 8. Coastal Stewards at Blessing of the Combines Event

Figure 9. Maryland Governor with a Coastal Steward

PHOTO: CARRIE SAMIS

When we first signed our MOU with UMES, we hired a summer intern, Nick Clemons, from UMES. He worked with our science coordinator and assisted with education and outreach activities during his internship. The following summer, he enrolled in graduate school at UMES and secured a seasonal position with our partner, Assateague Island National Seashore. Now, Nick has a Master's degree in Natural Resource Science and is a full-time employee with the National Park Service. He continues to work with the Upward Bound Marine and Estuarine Science Program and helps to manage the Coastal Stewards program. He is an incredible role model for the students engaged in our programs.

We continue to receive positive feedback about and success stories from this program. Clarisse Young, one of the youngest Coastal Stewards, is excited about the variety of experiences the program offers. On the third day of training, she and her fellow Coastal Stewards met Maryland Governor Martin O'Malley (Figure 9) and kayaked with him to visit Skimmer Island, the site of recent restoration work and a critical nesting area for two state-endangered species—black skimmers and royal terns. Danielle Miller, a senior at Snow Hill High School, says, "This job has helped me develop my personality and open up to new people. It's also helped me learn more about the local environment. Now, I plan to major in biology and chemistry." Joriee Dorman, a senior at Bowie State University, just returned for her third summer as a Coastal Steward. "Being a Coastal Steward has been so much more than a job. My entire perspective has changed: about our world, how I view the environment, and what I can do to make an effective change in my community," she says. "Being a Coastal Steward has affected me personally. I never knew all of the opportunities that environmental education could offer. I'm seriously considering a career in environmental education now."

The program strives to offer a connection to the local environment that could appeal to anyone, not just biology or environmental science majors. While a few Stewards are pursuing degrees in science, other Coastal Stewards are studying history, education, business, and psychology. Stephen Castaneda, a senior at Hampton University, is a music major. He has noticed that many local, young African Americans do not go outdoors much, except when they play sports. He hopes to change that. He now recognizes the importance of all people feeling a sense of connection with nature and becoming more environmentally literate. "Everyone must assume some responsibility for caring for our natural resources," he says.

Lessons Learned

Before becoming involved in Coastal Stewards, many of our students were unfamiliar with the estuary. We quickly realized their employment was a summer of firsts. Our Stewards did not learn about the local coastal bays in school, and they had never been to Assateague Island. Some had never been to the beach, even though they lived only 20 to 30 minutes away from the coast. They had never been in a motor boat, had never kayaked (Figure 10), and few had ever been fishing. We learned that an important part of our program was simply providing access. We were also surprised to discover minimal exposure to nature is not specific to urban areas. Our Coastal Stewards, who live in a very rural region, had little understanding of, or experience in, local environments.

We have realized that environmental stewardship can be inspired by a simple moment or opportunity within a range

Figure 10. Coastal Stewards Ready to Kayak

PHOTO: JIM RAPP

of experiences. For some of our Stewards, we need to offer the occasion to spend more time outdoors. For other Stewards, we need to wade into the marsh and walk through the woods together. For some, we need to extend an invitation to visit the beach, which, just a few decades ago, their grandparents and great-grandparents were prohibited from enjoying. And for others, we need to share something more tangible, such as a reusable shopping bag, a reusable water bottle, an energy-efficient light bulb, or a delicious homemade, locally-harvested meal.

We have also learned that some of our Coastal Stewards are already committed, passionate, and caring for our environment, but benefit greatly from a reminder that people matter, too. Communities, culture, and individuals of all backgrounds matter, care, and can make a difference. We are all inextricably linked to the natural world, but people may care about nature and the environment for very different reasons. We help empower our Stewards by encouraging them to focus on the fact that many people care and that their differing reasons are okay. The program creates an atmosphere conducive to the enthusiastic sharing of an appreciation for nature, while also teaching people skills and providing resources that can help people make a difference.

Most groups that review, fund, or demonstrate interest in our program are interested in the population of students involved in the program. One might quickly label them minority, underserved, at-risk, disadvantaged, and/or underrepresented. The younger students attend area high schools, all of which are fed by Title I elementary schools—the poorest in the state, in the most underserved region of Maryland. Most of the older students attend historically black colleges and universities. As the MCBP's Educational Coordinator, the more I become involved with the students, the less comfortable I am labeling them as a group and lumping them into those categories. As I have become more culturally aware and personally invested in the lives of our Coastal Stewards, I see them as individuals, not statistics. Each of us faces a unique set of challenges as we navigate our lives. Rarely, if ever, do we fully understand the struggles of another person. We can, however, strive to recognize, acknowledge, and nurture the strength and talent that each individual brings to the table. I think it is important to remember that—every day.

The MCBP and partnering program staff care deeply about this program. We are making environmental improvements in our watershed, but equally if not more importantly, the program is changing lives. As an environmental educator for more than 17 years, I can say this is the most challenging, most rewarding, and most effective program of my career. I knew the staff was hoping to achieve multiple benefits for the students and our agencies/organizations, but we did not realize the extent to which our own perspectives would be altered and our lives enriched as we learned from our Stewards.

Moving Forward

Thanks to a commitment of continued funding for 2012 from the U.S. EPA, we have several next steps planned to further promote and supplement the Coastal Stewards program. Most immediately, we plan to hire a full-time, year-round Coastal Steward. Additionally, we have the funding for a Master's or PhD-level person, who will be responsible for documenting the successes and challenges of our diversity-related work and gathering similar information from other National Estuary Programs. The goal is to identify best practices, share information on overcoming barriers, and develop case studies that may benefit other National Estuary Programs and partners as they move forward with their efforts to increasingly and more effectively engage all communities within their watershed.

To move forward as effective, environmentally-related organizations, we must aim to foster the next generation of environmental stewards. Every effort should be made to do this with care, deliberation, and respect. Fostering meaningful, positive connections with nature and providing the encouragement and the tools needed to affect change is key. Let us focus on small steps, incremental change, positive reinforcement, and empowerment.

If you're interested in learning more about the Maryland Coastal Bays Program's diversity initiatives, please contact Carrie Samis at csamis@mdcoastalbays.org. You can follow Coastal Stewards on Facebook, Twitter, and Foursquare.

References

Enderle, Emily. 2007. Diversity and the Future of the U.S. Environmental Movement. New Haven, CT: Yale University, School of Forestry & Environmental Studies.

U.S. Census Bureau. 2010. Statistical Abstract of the United States. Washington, DC: U.S. Census Bureau.

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Palos Verdes Coastline

PHOTO: PVPLC

Filiorum: A Dream Fulfilled

WILLIAM AILOR

Abstract

This article describes the formation and evolution of a community-based organization, the Palos Verdes Peninsula Land Conservancy, which preserved critical habitat along the Los Angeles County coastline. The article highlights the organization's successful strategy for building community and statewide support that led to the preservation of more than 1,400 acres of spectacular open space over a 20-year period. Key to this preservation was the acquisition of the Upper Filiorum property in late 2009 that provided a critical link for maintaining diverse flora and fauna, including threatened and endangered species.

In the beginning . . .

Filiorum: Latin for, in this case, land belonging "to the sons."

Filiorum is the name given by previous owners to a 315-acre parcel of undeveloped land on the Palos Verdes Peninsula, 190 acres of which were recently preserved as open space. While the land is magnificent in its own right, its acquisition was even more significant because it marked the completion of a 20-year community effort to preserve coastal habitats. Filiorum, or more properly, Upper Filiorum as will be explained later, denotes the final link creating a preserve of nearly two square miles of open space on the Palos Verdes Peninsula.

Background

The Palos Verdes Peninsula is a prominent headland forming the southern boundary of Santa Monica Bay (Figure 1). Rising more than 400 meters above the ocean, the Peninsula hosts spectacular views of Santa Monica Bay and the local mountain ranges. The area's habitat, predominantly coastal sage scrub, is generally limited to coastal areas and hosts diverse flora and fauna, many of which are endemic (Rundel 2007). Adapted to the Mediterranean climate, coastal sage scrub belongs to the California floristic province that has been included as one of the world's 25 biodiversity hot spots (Conservation International 2011). As well demonstrated in California, including the Palos

Figure 1. Preserves on Palos Verdes Peninsula

MAP: PVPLC

Verdes Peninsula, areas in the Mediterranean climate zone have been enthusiastically colonized—much to the detriment of the native flora and fauna.

The Peninsula has been host to human habitation for perhaps thousands of years, but significant changes took place when Europeans began colonizing the area during the eighteenth century. At first, the Peninsula was used to graze cattle, but following droughts and overgrazing, the economic use shifted to farming starting in the late nineteenth century (Gales 1988). The introduction of non-native grasses and weeds combined with grazing cattle and farmers' cultivation resulted in significant habitat degradation (Figure 2).

As land use changed during the twentieth century, outright loss of habitat was incurred through the construction of homes, roads, and commercial buildings. Structures to direct stormwater away from houses and into Santa Monica Bay were erected, their volumes exacerbated by the hardening of the land surface. Yet after 300 years of ranching, farming, and construction, many unique animal and plant species persisted in the remaining patches of habitat. Most notable is the endemic Palos Verdes blue butterfly (*Glaucopsychae lygdamus palosverdesensis*; Figure 3) that was believed to be extinct before being rediscovered in 1994 at the U.S. Military's Defense Fuel Supply Point in San Pedro. Birds such as the California gnatcatcher (*Polioptila californica californica*) and costal cactus wren (*Campylorhynchus brunneicapillus*), and plants such as the California crossosoma (*Crossosoma californicum*), green liveforever (*Dudleya virens ssp insularis*), and south coast saltbush (*Atriplex pacifica*) found refuge on the Peninsula, albeit in reduced numbers.

Figure 2. Palos Verdes Peninsula in 1918

PHOTO: PVPLC

Figure 3. Palos Verdes Blue Butterfly

PHOTO: ANN DALKEY

Figure 4. Hiking in the Forest Preserve

PHOTO: WILLIAM AILOR

The rural characteristics of the Peninsula remained before World War I, for it was not the most convenient place to live. The Peninsula was remote and not close to highways. This feature attracted residents who were looking for something different: a more rural way of life where horses could be kept and where weekend activities included hikes on local trails (Figure 4).

As time progressed, the Peninsula became more attractive, surface streets improved, and more and more people were willing to accept the somewhat longer commutes. Development of the remaining open space progressed at a deliberate pace. The cities of Palos Verdes Estates and Rolling Hills Estates were formed and assumed their unique identities—Palos Verdes Estates as a semi-planned community where more than 30% of the land was preserved as open space, and Rolling Hills Estates, which prides itself on its semi-rural features, including miles of horse trails and equestrian facilities.

As open space was consumed for development, residents saw the very features that brought them to the Peninsula diminish, and land use conflicts increased. In the late 1960s and early 1970s, plans were in place that would have allowed extensive, high-density development along the Palos Verdes coastline, and the land was being modified to accommodate this development. A local organization, Save Our Coastline (SOC), was formed to stop the development and put forth a new vision, one of a low-density, primarily residential community that preserved as much open space as possible.

A local organization, Save Our Coastline (SOC), was formed. In 1973, SOC's efforts led to the incorporation of the City of Rancho Palos Verdes and the development of a Coastal Specific Plan (part of the City's General Plan) that captures the low-density, semi-rural vision for the City at that time. Although the new plan provided direction, the plan also allowed for development of several large areas of open space and failed to settle the discussion of land use matters. Many residents viewed the open space as "special," or important to preserve, because of the wildlife that called these acres home and the tranquil beauty these areas added to the community.

Use of open space became increasingly contentious—environmental groups filed lawsuits to ensure developers were sensitive to habitat and wildlife protection in their developments. Developers circulated glossy brochures trying to build public support for their proposals. Development became a significant issue in local elections.

A similar debate was held in San Pedro at White Point, where key U.S. military and Los Angeles fishing, harbor, and port facilities spurred more aggressive development. In this area, a 102-acre block of open space, a former military site, was unused, but was off-limits to residents (Figure 5). Eventually the parcel was transferred from the U.S. government to the City of Los Angeles, and demands for access to this parcel for hiking and other uses increased. However, the City had no funds to manage the property, and it sat surrounded by barbed wire.

In general, many agreed that open space should be preserved and made available for public access, but few good options were available for making this happen. Community members and leaders recognized that landowners had rights to develop their properties, rights that could not be denied. City planners and city councils did their best to ensure that environmental concerns were addressed when new developments were proposed, but open space land was being consumed at an alarming rate. The community needed some new options to ensure that large areas of remaining open space were permanently protected from development.

Land Acquisition

The Palos Verdes Peninsula Land Conservancy (Conservancy or PVPLC) was formed in 1988 to add a new dimension to open space preservation: land would be preserved by acquisition

Figure 5. Pre-Preservation White Point with Restricted Access & Derelict Military Building

PHOTOS: WILLIAM AILOR

from willing sellers or donors. Rather than fight with landowners about development proposals, the organization would work to acquire property in transactions favorable to both sides. Acquisition could be by the Conservancy alone, or the organization would work in partnership with local cities to help them acquire land. If the land was acquired by a city, the organization would accept a conservation easement over the preserved area to add a layer of protection, ensuring that the property's conservation values were maintained and preserved.

Table 1. Details of Key Land Preservation Projects from 1992 to 2009

Year	Property	Size (Ac)	Funding	Acquisition Details
1992	Lunada Canyon	22	Donation	Land owner took tax write-offs; no funds were required for the acquisition.
1994	Chandler Preserve	28	Donation/Bond purchase	Conservancy received a donation, and the City of Rolling Hills Estates purchased a portion with an LA County bond funds.
1996	Forrestal	160	Bond purchase	Conservancy facilitated and the City of Rancho Palos Verdes purchased property using LA County and CA State bond funds.
2000	Three Sisters	99	Bond purchase	City of Rancho Palos Verdes using LA County bond funds.
2003	White Point	102	Various grants for restoration	U.S. Military deeded property to City of Los Angeles in the late 1970s; Conservancy entered 25-year agreement to manage and restore the property as recommended by local residents.
2005	Portuguese Bend	399	Donation/Bond purchase	Conservancy raised $4 million in private donations, and the balance was obtained from LA County and State bond funds.
2009	Upper Filiorum	190	Donation/Bond purchase	$5.5 million in State bond funds augmented by $400,000 raised by the Conservancy, $607,045 from the City of Rancho Palos Verdes, and $10,913 from LA County.

In the beginning, land preservation was a dream—no one believed a small group of motivated individuals could raise the funds required to preserve land in an area where land values can approach $1 million per acre. One landowner was quoted as saying, "They're nice people, but they don't have any money."

Shortly after its incorporation, the Conservancy established a small committee to develop a map showing developable areas and to look at how development might progress. Some properties had features that made preservation more feasible: a few were owned by long-time residents who might find donation palatable; others included steep, unbuildable or difficult-to-develop areas that could put the per-acre cost in a reasonable range; and still others were government-owned, but were not actively managed or open to public access. The organization began tracking these areas and developed strategies for acquiring the various parcels of land.

The first acquisition, Lunada Canyon, was a donation of 22 acres of developable open space by the E.K. Zuckerman family. Ken Zuckerman, the family's representative, noted that he strongly supported the Conservancy's concept for preserving land, and he promised to structure the donation to maximize the benefit to the young organization. The family took a tax write-off for the donation, and no funds were required for the acquisition—a great feature for an organization that had little money at the time. The donation became official in 1992, and the new Lunada Canyon Preserve was dedicated in a public ceremony. This first acquisition was a key step in the organization's evolution (Figure 6).

Since the organization had limited credibility and hence, limited fundraising potential, an alternative means for financing acquisitions was essential. At about the same time as the Lunada Canyon dedication, the Conservancy became aware that voters in Los Angeles County and the State of California had set aside funds specifically for land preservation and that new county initiatives were being proposed where funds could be earmarked for acquisitions in specific regions—but funds would go to cities only. Proposals were drafted by the Conservancy, and city councils for three Peninsula cities, although skeptical, approved submission of the proposals. Voters once again approved the measures, and funds were available.

In the ensuing years, the Conservancy collaborated with local cities and used county and state funds, augmented with donations (Table 1). Each acquisition was different. In one, the land was owned by eight family heirs, and a deal was structured where a portion of the property was acquired immediately and each heir would donate his or her share of the remaining property over time. This property was subsequently named the Linden H. Chandler Preserve (Figure 7). In another case, land was preserved when a citizens' committee developed recommendations that the

Figure 6. Volunteer Invasive Removal in Lunada Canyon Preserve

PHOTO: PVPLC

Figure 7. Linden H. Chandler Preserve

PHOTO: WILLIAM AILOR

Figure 8. People Enjoying a Monthly Nature Walk Event

land be maintained as a natural area, including the Conservancy's assurances that it would assume management responsibilities. Fulfilling its promise, the Conservancy entered into a 25-year management agreement with the City of Los Angeles to restore native habitat and manage the site, now called the White Point Nature Preserve.

Two parcel acquisitions stood out in their complexity and significance. The first, known as the Hon property after the developer who owned the land, contained 399 acres including areas of quality habitat and associated wildlife. This parcel is in the Portuguese Bend Landslide Moratorium area where restrictions exist on development because of a long-term, slow-moving landslide in the area. Development of this area had been a point of major contention for many years, primarily because many felt that development might aggravate the slide and threaten additional homes. A golf course had once been proposed for this slide area, but moving golf holes never gained wide acceptance.

In addition to securing State and County funds, the primary challenge of the Hon property acquisition was the requirement that the Conservancy raise $4 million in private donations in less than a year. With the acquisition completed at the end of 2005, the Palos Verdes Nature Preserve (PVNP) and its eight individual properties named as reserves became a reality. Only one major acquisition remained to complete the dream envisioned almost 20 years earlier: the Filiorum property.

Although not the largest parcel, the Filiorum property was perhaps one of the most difficult and essential. It was difficult because it closely followed the acquisition of the Hon property and fundraising would be a challenge. It was also difficult because the landowner had goals to develop some areas of the 315-acre property, some of which were inside the landslide moratorium area, and there was concern that a recent court decision related to properties in the Landslide Moratorium Area had possibly increased the development potential. Despite these difficulties, acquisition of this property was essential because it connected the Three Sisters parcel, acquired in 2000 using LA County funds, and its trail network to the larger Portuguese Bend and Forrestal properties (Figure 8), and would create a total preserve on the south side of the Peninsula of approximately two square miles in area.

The City of Rancho Palos Verdes and the Conservancy formed a negotiating team to work with the landowner to resolve issues, establish the acres to be acquired, and negotiate a price and agreement. After a year of effort, a final agreement was reached in September 2009 that called for the acquisition of approximately 190 acres of open space by the end of that year. Once again, voter-approved State funds were to be used to acquire this Upper Filiorum parcel, but the trigger was approximately $400,000 in funding from private donors.

Escrow closed on Upper Filiorum in December 2009, and the preserve was complete: the community had achieved the vision established by some of its first residents and made a large area of preserved open space a permanent part of its quality of life. After this purchase was completed, more than 1,400 acres were preserved as open space, including 850 contiguous acres within the nearly 1,100-acre PVNP (Figure 1). Under the Conservancy's helm, these lands are managed and native habitat restored while hiking, bicycling, and horseback riding opportunities were also provided for all.

Changing Responsibilities

Each conserved parcel has unique features and requirements that must be addressed. In the Chandler Preserve, habitat is restored with the goal of returning the Palos Verdes blue butterfly to the wild (Figure 9). In 2009, this was accomplished successfully, as demonstrated by the appearance of progeny in 2010 and again in 2011. The White Point Nature Preserve, formerly a 102-acre parcel covered with tons of debris and very little native habitat,

Figure 9. Chandler Preserve Habitat

Figure 10. Post-Preservation White Point

now features grassland surrounded by hillsides with coastal sage scrub habitat (Figure 10). The previously absent, but now abundant, California gnatcatchers at this site are joined with many coastal sage scrub denizens, including migrants and winter visitors, such as Western meadowlarks (*Sturnella magna*) and burrowing owls (*Athene cunicularia*).

Table 2. List of NCCP Covered Species and Their Listing Status

Common Name	Scientific Name	Status
Aphanisma	*Aphanisma blitoides*	California Native Plant Society (CNPS) List 1B
South Coast Saltscale	*Atriplex pacifica*	CNPS List 1B
Catalina Crossosoma	*Crossosoma californicum*	CNPS List 1B
Island Green Dudleya	*Dudleya virens* ssp. *insularis*	CNPS List 1B
Santa Catalina Island Desert-thorn	*Lycium brevipes* var. *hassei*	CNPS List 1B
Woolly Seablite	*Suaeda taxifolia*	CNPS List 4
Palos Verdes Blue Butterfly	*Glaucopsyche lygdamus palosverdesensis*	Federally Endangered
El Segundo Blue Butterfly	*Euphilotes battoides allyni*	Federally Endangered
Coastal California Gnatcatcher	*Polioptila californica californica*	Federally Threatened, State Species of Concern
Cactus Wren	*Campylorhynchus brunneicapillus*	NCCP Focal Species

Table 3. Past and Present NCCP and Grant-Funded Restoration Projects

Preserve	Acres Restored or Enhanced	Date	Project
White Point	80 plus	2003–ongoing	Coastal sage scrub (CSS), grassland habitats
Chandler	5	2006–2012	Palo Verdes blue butterfly (PVB) habitat (USFWS grant)
	0.15	2003–2008	Riparian habitat
Forrestal	2	2003–2006	Riparian habitat
Lunada	2	2001–2003	CSS (USFWS grant)
	1	2004–2005	Wetland restoration
Friendship Park	8	2008–2009	PVB habitat
McCarrell Canyon	2	2009–2010	CA Coastal Conservancy upland sediment reduction grant
Fishing Access	1.5	2009–2010	CA Coastal Conservancy upland sediment reduction grant
Alta Vicente	5	2008–ongoing	Phase I NCCP restoration (CSS, PVB, cactus scrub)
	5	2009–ongoing	Phase II NCCP restoration (CSS, PVB, cactus scrub). To be planted/seeded this year.
	5	2010–ongoing	Phase III NCCP restoration (CSS, PVB, cactus scrub). Site preparation only in 2010.
Three Sisters	21	2008–ongoing	Los Angeles World Airports mitigation project
Portuguese Bend	15 plus	2010–ongoing	Wildfire recovery, NCCP restoration
Portuguese Bend	9.5	2010–2015	DFG mitigation grant for wildfire recovery

Note: This is a general overview of restoration projects initiated by the Conservancy. It is not comprehensive and does not include volunteer or scout projects.

As the largest preserve, the PVNP contains many species of special concern—plants and animals that have been imperiled by loss of habitat throughout the Peninsula and elsewhere in Southern California (Table 2). To provide additional protection for these species, the Conservancy participated in developing the Natural Communities Conservation Plan (NCCP), written for the City of Rancho Palos Verdes by the California Department of Fish and Game (DFG) and the U.S. Fish and Wildlife Service (USFWS). The plan provides for protecting and managing the natural wildlife, including species protection and habitat restoration, while specifying lands that might be used for development. The purchase of the Portuguese Bend property initiated the NCCP development, and the purchase of the Upper Filiorum parcel moved plan development to the final stages. The PVNP constitutes the conserved land in the NCCP within the City of Rancho Palos Verdes.

The NCCP prescribes management of existing PVNP resources and facilities and defines restoration goals and monitoring programs. The Conservancy is the designated preserve manager and is responsible for restoring 250 acres of habitat that focuses on species of special concern, also known as covered species (Table 2). In moving from acquisition mode to conservation, the Conservancy endorsed its role under the NCCP well before the document's completion. In 2006, the process began with a Conservancy-managed DFG grant to comprehensively survey the property for all but the still privately-held Upper Filiorum parcel, including focused surveys of covered species, their locations, and their populations. The survey data were incorporated into the NCCP and serve as a benchmark for assessing change within the PVNP, whether from restoration activities or natural events. In fact, the discovery during the survey of the endangered El Segundo blue butterflies (*Euphilotes battoides allyni*) on the cliffs at Vicente Bluffs prompted the species' inclusion in the covered species list.

Moving Forward

With a 50-year completion goal for restoring the 250 acres under the NCCP, the Conservancy realized that grants enabling restoration of additional acres would greatly benefit the habitat and wildlife. Indeed, this has been the practice of the Conservancy for not only PVNP but also all its managed preserves (Table 3). At White Point Nature Preserve, for example, grants and volunteer help enabled the Conservancy to transform a debris-laden, tumbleweed landscape into coastal sage scrub and grassland habitat (Figure 11). Over the years, the Conservancy has built upon this success and pursued a diversity of projects.

Knowing that quality habitat benefits water quality in Santa Monica Bay, two restoration projects were targeted in specific watershed areas at Fishing Access and McCarrell Canyon. Funded through the Santa Monica Bay Restoration Commission, these

Figure 11. Volunteer Restoration at White Point

PHOTO: PVPLC

Figure 12. Three Sisters Reserve

two projects enhance the quality of native habitat while providing better stabilization to reduce sediment loading. Additionally, El Segundo blue butterflies benefited by sowing host plant seeds and adding container plants in the Fishing Access area. In McCarrell Canyon, native lemonade berry (*Rhus integrifolia*) has begun to re-sprout following the removal of non-native acacia trees. More of the native lemonade berry are scheduled for planting and will provide additional forage and cover for the spotted towhee (*Pipilo erythrophthalmus*) and other wildlife.

In addition to the Palos Verdes blue butterfly habitat added to the Chandler Preserve, a grant enabled the Conservancy to release the butterfly in the wild at San Pedro's Friendship Park in 2010. As a direct result of this grant, the official number of places on the Peninsula with Palos Verdes blue butterflies rose to three, helping assure the long-term preservation of the species in the event of a fire or other problem at one of the other sites.

Within the PVNP, mitigation funds from Los Angeles World Airports allowed for a 21-acre restoration in the Three Sisters Reserve (Figure 12). As the newly planted coastal sage scrub and grasslands mature, the habitat will become host to California gnatcatcher, cactus wrens, and more. Already, removal of non-native black mustard (*Brassica nigra*) and fennel (*Foeniculum vulgare*) has encouraged the return of western meadowlarks to the site.

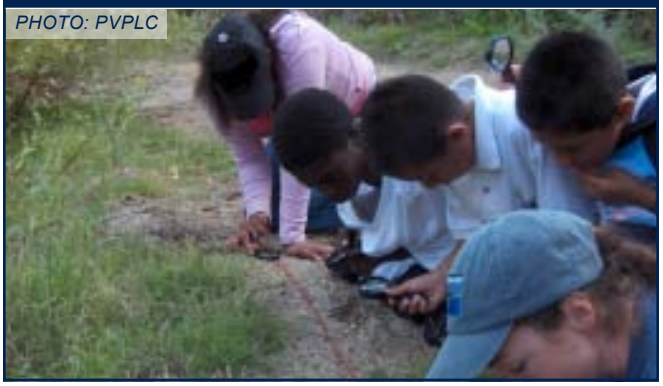
Following the 2009 Portuguese Bend Reserve wildfire, the Conservancy's Upper Filiorum Capital Campaign included funds targeted for NCCP habitat restoration within 15 acres of the burn area. The planned coastal sage scrub habitat restoration was supplemented with an additional grant from DFG to add more to the Palos Verdes blue butterfly habitat and expand the existing cactus wren habitat.

Between the Three Sisters and Portuguese Bend reserves lies the newly incorporated Upper Filiorum Reserve containing 190 acres of quality coastal sage scrub habitat tucked within a mix with tracts of ruderal and non-native vegetation. The opportunities that this key piece represents to the overall health and robustness of local native plants and wildlife cannot be overstated. The future of the natural inhabitants of the PVNP, and of the quality of the open space experience for preserve visitors, becomes brighter as restoration activities move towards fully-integrated linkages between existing islands of coastal sage habitat.

Summary

A motivated community with a clear focus can preserve land, even in a very challenging environment. Key factors in successful land preservation within the Peninsula include the following: the basic, but initially unfocused, support in the community; the group of dedicated and creative volunteers who established and maintain a non-confrontational, preservation-focused nonprofit organization–the Conservancy; the new preservation strategies introduced by the Conservancy; the strong support provided by elected officials and staff as the Conservancy developed and as preservation opportunities arose; and the generosity of South Bay individuals who provided and continue to donate their talent and resources to the cause. Over the past 20 years, the Conservancy has emerged as an integral part of the Palos Verdes community. Major land acquisitions goals have been met, and the Conservancy is at the forefront of the property's evolution–a steward for natural resources committed to enhancing educational and enjoyment opportunities for visitors (Figure 13). In the years to come, coastal sage habitat, along with bluff, grassland, and even riparian habitats, will increase in extent and quality to support a diverse, natural community. Best of all, the preserves, with their spectacular views and rich flora and fauna, are open for all to enjoy.

Figure 13. PVPLC Educational Program



References

Conservation International. 2011. Biodiversity Hotspots. http://www.biodiversityhotspots.org/ Pages/default.aspx (accessed April 11, 2011).

Gales, D. 1988. Handbook of Wildflowers, Weeds, Wildlife, and Weather of the South Bay and Palos Verdes Peninsula. Palos Verdes Peninsula, CA: FoldaRoll.

Rundel, P. W. 2007. "Sage Scrub." In Terrestrial Vegetation of California, edited by M. G. Barbour et al., 3rd ed., 208–28. Los Angeles: University Press.

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Aerial of Colorado Lagoon (foreground) with Marine Stadium and Alamitos Bay (background)

PHOTO: CITY OF LONG BEACH

The Complexity of Urban Tidal Wetlands Restoration Projects Exemplified at Colorado Lagoon

ERIC ZAHN

Abstract

Colorado Lagoon is one of the last remaining restorable pieces of coastal salt marsh habitat on the Southern California coast. This 18-acre water body has been the focus of a decade-long conservation effort aimed at improving the site's degraded environmental health. The main goal of the Colorado Lagoon Restoration Project is improving the water quality to promote better conditions for wetlands wildlife as well as marine recreational opportunities. Storm drain upgrades and a culvert cleaning completed in November 2010 have already led to less trash and urban runoff entering the lagoon, as well as improved tidal residence times. The dredging of more than 75,000 cubic yards of contaminated sediments commenced in January 2012 in order for the lagoon to meet state water quality standards. The most critical part of this project will be restoring a tidal channel that once connected Colorado Lagoon to Alamitos Bay. A design for this tidal channel has been chosen, and $10 million in funding is needed. There has been a complex process by which the various necessary components of this restoration project have come together. Navigating these complexities has been a challenge for the project partners, and this case study demonstrates the benefits of supporting similar challenging conservation efforts along our urban coast.

Introduction

Restoring ecosystems along the urbanized coast is complex. Coastlines host a mosaic of biodiverse habitats, while also acting as the most attractive places for humans to dwell. With more than 18 million people living in five coastal counties of Southern California (U.S. Census Bureau 2010), finding a balance between the needs of these urbanized areas and the needs of coastal wildlife is a challenge. No ecosystem has received as much conservation consideration along California's coastline as the coastal salt marsh. This attention is befitting, since more than 75% of the region's salt marsh plant community's historic range has been lost since the arrival of Europeans (Speth 1969; Zedler 1982), with much of the remaining acreage in degraded or recently restored conditions.

Airports, agricultural fields, power plants, marinas, shipping ports, golf courses, neighborhoods, and oil fields have all been developed where there was once salt marsh. Meanwhile, these places have also become major recreational hubs for hiking, biking, birding, fishing, kayaking, and sometimes swimming. Increased edge effects (i.e., impacts from the urbanization due to increased fragmentation of natural habitats) and multiple land uses have intensified the complexity of properly conserving coastal wetland systems. One site that truly exemplifies the challenges of balancing this intricate environmental system and land use conflicts is the Colorado Lagoon in Long Beach, California. After years of poor urban planning, this lagoon is finally getting some much-needed restorative attention and is prospering as ecological functions improve.

Environmental Setting

Colorado Lagoon is a human-made geomorphological feature located within the historical range of the Los Cerritos Wetlands, which once boasted more than 2,400 acres of coastal wetlands at the heart of the incredibly diverse California Floristic Province.

Figure 1. Map of Historical Extent of Alamitos Bay Overlaid with Current Urban Infrastructure

MAP: L. RICH

This wetlands' acreage has been reduced to just 500 acres of open space, much of which is still privately owned and operated for industrial purposes (Figure 1). Conversely, Colorado Lagoon has been managed by the City of Long Beach since the 1920s as a park and marine recreational area. In 1923, the naturally occurring tidal wetlands of Alamitos Bay were dredged to form the Lagoon and Marine Stadium. The lagoon became the site of the 1932 Los Angeles Olympic U.S. Diving Trials and was separated from Marine Stadium (the site for rowing competitions) by tide gates designed to maintain an adequate water depth during diving events. In the late 1960s, the north end of Marine Stadium was filled for a never-executed, cross-town freeway. Instead, this filled area became part of Marina Vista Park.

Presently, all that remains on-site is an 18-acre tidal water body connected to Alamitos Bay via a 1,000-foot box culvert that runs under Marina Vista Park into Marine Stadium (Figure 2). A golf course, parking lots, recreational beaches, parks, and residential areas border the lagoon. Development entirely surrounds the lagoon's edges and impacts the lagoon through 11 storm drains. Over time, this has led to the lagoon accumulating one of the worst water quality conditions in the state. Heal the Bay ranked Colorado Lagoon as one of the "Top 10 Biggest Beach Bummers" in the organization's 2011 Annual Beach Report Card; since spring 2007, the lagoon's beaches have received "F" grades each year regardless of the season (Heal the Bay 2011). This poor water quality is of great concern, since thousands of people come to Colorado Lagoon every summer to swim and fish.

Surprisingly, this site hosts a sliver of heritage salt marsh plant community that emerges from amid the many impacts. Despite the urban constraints, Colorado Lagoon hosts 16 native salt marsh plant species and more than 75 species of marine birds, such as the state and federally endangered California least tern (*Sterna antillarum browni*) (Chambers Group 2004; Sonnenberg, pers. comm.). This protected bird and other migratory bird species flock to the lagoon to forage on 21 species of marine fish and other available food sources (Figure 3). The presence of juvenile white seabass (*Atractoscion nobilis*) and California halibut (*Paralichthys californicus*) has led to the recognition of the site as a nursery and population source for critical commercial fisheries. The lagoon is also a home for innumerable marine invertebrate species that inhabit this estuary. A recent study found evidence of 23 species of bivalves in the lagoon (Burnaford, Henderson, and Pernet 2011), which demonstrates its capacity as a marine ecosystem at a low trophic level. When compounded by numerous cnidarians, annelids, gastropods, insects, and crustaceans, the nutritional resources for marine predators become quite evident, and the web of life becomes as complex as its urbanized environment.

Figure 2. Colorado Lagoon's Existing Conditions and Pre-Restoration Constraints

MAP: LSA ASSOCIATES, INC.

Figure 3. Turbot from Colorado Lagoon

PHOTO: ERIC ZAHN

Project Partners

Restoration projects depend on strong partnerships and collaboration among all parties of interest. Creating the proper alliances, which effectively further the objectives of the restoration, can take time. The Friends of Colorado Lagoon (FOCL) is a coalition of concerned citizens whose mission is to restore and preserve an important urban wetland in their community. FOCL promotes cooperative solutions to ensure a healthy balance among recreation, flood management, water quality, wildlife habitat, and native plant communities in Colorado Lagoon. FOCL serves as the lagoon's voice and provides a sounding board for those in the community who share a passion for this local, coastal treasure. This 501(c)3 non-profit organization was formed in 1999 and has advocated, alongside the City of Long Beach, for the lagoon's restoration.

The City of Long Beach's Department of Parks, Recreation, and Marine and Department of Public Works have been cooperatively managing the lagoon restoration project since its inception. The City had been the lagoon's long-time landowner until a recent land swap traded the lagoon to the holdings of the State Lands Commission. However, this ownership shift should not affect the City's dedication to the restoration project and will not thwart any of the conservation efforts.

Funding partners are numerous for this project, and the total cost is estimated to easily exceed $25 million. Thus far, funding has been provided in varying dollar amounts from (in no significant order) the State Coastal Conservancy, State Water Resources Control Board, Port of Long Beach, Army Corps of Engineers, Rivers and Mountains Conservancy, National Oceanic and Atmospheric Administration (NOAA), Southern California Wetlands Recovery Project, U.S. Fish and Wildlife Service, and the California Coastal Commission. Many of these entities have also acted as permitting agencies, along with the Department of Toxic Substances Control and the California Department of Fish and Game.

Project Approach

Phasing is often one of the best implementation strategies for a complex restoration project. The Colorado Lagoon Restoration Project has been developed as a two-phase project. Phase 1 is concerned with improving the condition of the lagoon proper through storm drain improvements, culvert cleaning, dredging of contaminated sediments, and intertidal revegetation. Phase 2 involves day-lighting the connection between the lagoon and Marine Stadium by creating a tidal channel through Marina Vista Park. The objective of Phase 1 is to remove the existing contaminants and prevent current contamination sources from entering the lagoon. Phase 2 intends to improve the tidal regime of the lagoon so that it more closely resembles that of the Pacific Ocean. Both phrases are necessary to completely restore the structure and function of the lagoon's ecosystem.

The project is phased for several reasons. Project cost is one of the leading reasons for dividing this singular project into approachable sub-projects. At around $12 million, the cost of Phase 1 is so large that Phase 1 was divided into Phase 1a (storm drain upgrading and culvert cleaning) and Phase 1b (dredging, resloping, and revegetating). Other important reasons for this phasing included consensus building and political motivations. Initially, Phase 2 met resistance from some community members due to the assumed impacts to existing active recreation facilities. To appease all constituents, Long Beach City Council voted to have the Phase 2 concept studied in greater depth before accepting it, thus delaying implementation of Phase 2 without halting the project in its entirety.

Project Progress

On October 14, 2008, the Long Beach City Council certified the Environmental Impact Report (EIR) for the Colorado Lagoon Restoration Project. The Colorado Lagoon EIR included phases 1 and 2 and was based on the findings of a feasibility study completed in 2004.

Phase 1: Lagoon Improvements

Phase 1a was initiated in September 2009 and completed in November 2010. The first completed component was the creation of a 600-foot bioswale, constructed between the golf course and the lagoon (Figure 4). This bioswale transformed a drain,

Figure 4. Bioswale Before Planting

PHOTO: ERIC ZAHN

Figure 5. 4th Street Storm Drain Improvements

PHOTO: ERIC ZAHN

Figure 6. Inside the Low Flow Diversion Vault

PHOTO: D. PIRAZZI

which formerly transferred runoff directly to marine waters, into a phytoremediation system designed to filter out fertilizers and other pollutants before reaching the wetlands. Phytoremediation works by utilizing the symbiotic bacteria that naturally live in the roots of many species of aquatic plants. These bacteria break down inorganic and organic pollutants in soils and water, which allows the plants to uptake the pollutants as part of the plants' metabolic processes. As water passes slowly through the bioswale, the plants will remove much of the harmful nitrates, phosphates, and other chemicals used in the golf course landscaping before the pollutants enter the lagoon.

The chief component of Phase 1a was improving the area's three largest storm drains by installing low flow diversion systems and trash separation devices (Figure 5). The dry weather drainage that would normally enter the lagoon through these drains was redirected into a vault, which releases the wastewater into the sewer system during much of the year (Figure 6). The remaining storm drains have all been diverted as part of Los Angeles County's Termino Avenue Drain Project, which occurred at the same time as Phase 1a. Data indicates that the trash separation devices had an immediate impact and are reducing the amount of trash littering the lagoon's banks. Weekly trash collections averaged 32.31 pounds of trash from March 2009 to November 2010, but this weight has been reduced by nearly 50% to 17.17 pounds of trash per week since the separation devices were activated in November 2010 (Parker pers. comm.).

The last element of Phase 1a was the cleaning of the culvert connection between the Lagoon and Marine Stadium (Figure 7). This sensitive endeavor required the lagoon be cut-off from tidal influence for nearly two weeks in order to complete the cleaning. However, the removal of three feet of marine sediment, running the entire length of the culvert, decreased the residence time of tidal waters entering the lagoon from 8.5 days to 7.7 days, according to modeling completed by Moffat & Nichol (2010). This decrease in residence time brings the tidal flushing rate much closer to the 6.0-day residence time in Marine Stadium. However, the 1.7 day difference (which is due to the culvert's small size and perch above mean low tide) still affects the lagoon's overall health; therefore, more improvements to the tidal connection are needed to bridge the gap (Table 1).

The final cost for the Phase 1a construction work, excluding design, came to $4,397,841. This phase was funded through the American Recovery and Reinvestment Act (ARRA), dispersed through the State Water Resources Control Board (Lopez pers. comm.), as well as a $1.3 million contribution from the Port of Long Beach.

Phase 1b mobilized in January 2012 and is scheduled to be completed by April 2013. This portion of the project will include massive construction equipment for dredging and bank resloping as well as a community-based revegetation component. The planned dredging has been the most scrutinized part of Phase 1, since the dredging intends to remove the numerous organic and inorganic pollutants that contaminate the lagoon's sediment. Initial estimates indicated that

Figure 7. 1,000-Foot Culvert: During and Post-Cleaning

PHOTOS: D. PIRAZZI

Note the remnant stain from the removed marine sediment.

Table 1. Differences in Tidal Flushing Rates: Pre- and Post-Project; Note 4a was not analyzed because it was added late in the study.

CREDIT: MOFFAT & NICHOL

Modeling Scenario	Residence Time (Days) In:		
	Colorado Lagoon	Marine Stadium	Mother's Beach
Pre-Project Lagoon and Culvert	*8.5*	*6.9*	*5.3*
Post-Phase 1 Project Condition - Dredged Lagoon and Cleaned Culvert; No Open Channel	*7.7*	*6.0*	*4.9*
Alternative 1 - Parallel / Second Culvert	7.5	6.0	4.9
Alternative 2 - Open Channel with Bridges	7.2	6.0	4.9
Alternative 3 - Combination Open Channel and Culverts	7.4	6.0	4.9
Alternative 4 - Maximum Wetland	7.3	6.0	4.9

22,500 cubic yards of sediment would need to be removed from the western arm. However, the Regional Water Quality Control Board set total maximum daily loads (TMDLs) for chlordane, dieldrin, lead, zinc, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and dichlorodiphenyltrichloroethane (DDT) for this 303(d) listed water body in late 2009 (Los Angeles Regional Water Quality Control Board 2009). Further studies discovered that around 75,000 cubic yards of sediment throughout the entire lagoon needs to be removed in order for the lagoon to meet strict, new water quality standards.

Throughout the water quality standards revision process, the appropriateness of using NOAA's effects range low (ERL) and effects range median (ERM) values for TMDLs was heavily debated because these levels do not represent toxicity thresholds for marine organisms. Instead, these levels represent a low- and mid-point, respectively, within the range of bulk chemical concentrations in sediment and do not directly relate to sediment toxicity (O'Conner 2004). These redefined contamination level standards were eventually accepted for the project, leading to an increase in the implementation cost, particularly due to the expense of the required stabilization process and the increase in the amount of sediment being defined as contaminated. All of the contaminated sediment will be tested upon removal, and the sediment determined to be hazardous will be stabilized on-site so that it can be trucked to the Port of Long Beach for use in the Middle Harbor Redevelopment Project. Depending on the hazardous constituents identified, the sediment will be stabilized using a variety of techniques including cement stabilization.

The dredging, along with proper resloping of the banks to increase intertidal habitat, should be completed by July 2012 for about $7 million. FOCL will then manage the revegetation of the intertidal and upland habitats. FOCL has already begun salvaging nine salt marsh plant species that inhabit the soon-to-be-disturbed shorelines. These plants will be nurtured in a nearby growing space and returned to the lagoon in the 2012–2013 planting season.

Phase 2: The Open Channel

Although all of the Phase 1 improvements are integral to recovering the health of this urban ecosystem, the ultimate, long-term solution is reconnecting the marine habitat to full tidal flushing. FOCL has been advocating for restoring a tidal channel that once connected Colorado Lagoon to Marine Stadium. Upon certifying the restoration project's EIR, the Long Beach City Council requested an additional study to take a closer look at alternatives that could improve the site's tidal circulation (Figure 8). Loss of park space was considered in this study as well as maximizing salt marsh habitat and fundability and minimizing construction and maintenance costs. Another constraint examined in the design study were the two roadways that fall between the lagoon and Marine Stadium that must either be bridged or outfitted with short underground culverts. This study analyzed four alternatives and was completed in June 2010 by Moffat & Nichol. All of the alternatives were designed to have similar tidal conditions (Table 1). The alternatives are as follows:

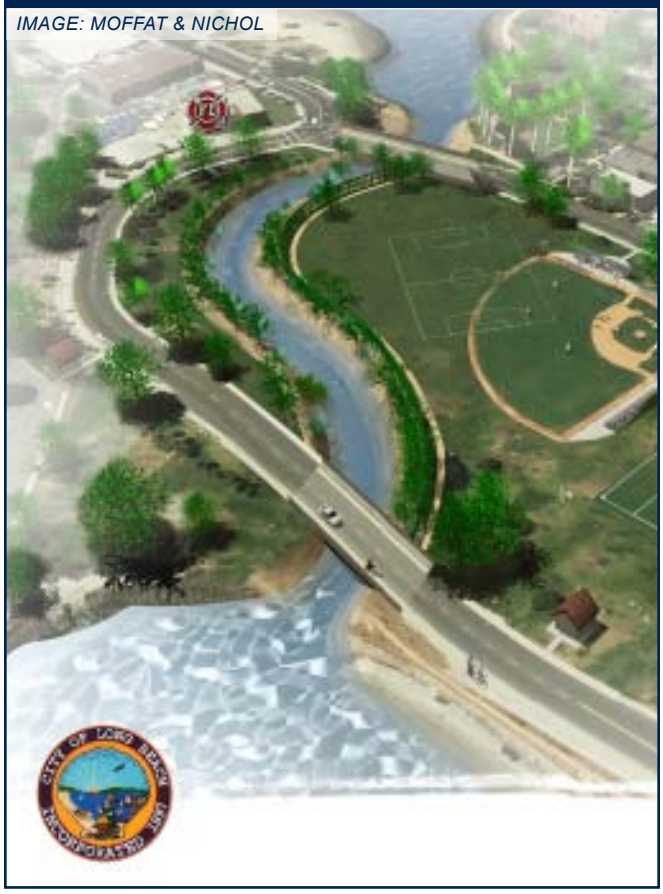
- Alternative 1: Installation of a second, parallel underground culvert (0 acres of wetlands created)

Figure 8. Culvert: Pre-Project

PHOTO: ERIC ZAHN

Figure 9. Illustration of Post-Project; Most Similar to Alternative 2

IMAGE: MOFFAT & NICHOL



- Alternative 2: Complete open tidal channel with two automobile bridges at each end and the existing culvert left in place (1.98 acres of wetlands created; Figure 9)

- Alternative 3: Incomplete open tidal channel with short culverts at each end running under the roads and the existing culvert left in place (1.47 acres of wetlands created)

- Alternative 4: Incomplete open tidal channel with one bridge on the Marine Stadium end and one short culvert on the lagoon end and the existing culvert abandoned (2.21 acres of wetlands created)

These alternatives polarized members of the community who cherished park space for active recreation and supported Alternative 1 versus those who supported the creation of new wetlands in alternatives 2, 3, or 4. Interestingly enough, resources agencies that were part of the project's technical advisory committee asked City staff and consultants to investigate a fifth alternative, 4a, with a similar open channel to Alternative 4, except at the channel's lagoon end where the underground culvert is replaced with a bridge. The resultant Alternative 4a has an open channel along its entire length similar to Alternative 2, but with a maximum channel width of 230 feet resulting in a maximum wetlands habitat area of 2.40 acres (Moffatt & Nichol 2010). This additional alternative was analyzed and added late in the study. Its addition further alienated supporters of Alternative 1 and became the chosen alternative for the wetlands advocates. Alternative 4a is as follows:

- Alternative 4a: Complete open tidal channel with two automobile bridges at each end and the existing culvert abandoned (2.4 acres of wetlands created)

Alternative 1 anticipated no long-term impact on park space and was the second most affordable alternative to construct at $6.8 million. However, this alternative had the highest cost at $8.4 million for maintenance over 50 years and would create zero acres of new wetlands habitat. Additionally, culvert removal is often funded, but sources of funding are scarce for new culvert construction, as required for Alternative 1. Alternative 3 was the least costly alternative, at $5.7 million, while Alternative 4a was the most expensive to construct, at $9.4 million. However, due to its natural conditions, Alternative 4a was projected to have the lowest maintenance cost at $4.0 million over 50 years (Table 2; Moffatt & Nichol 2010).

Ultimately, the community overwhelmingly supported Alternative 4a, and the Long Beach City Council approved this alternative on November 16, 2010. The next steps for Phase 2 are to complete a summary report on the new mitigation laws, determine a funder, produce 100% engineering designs, finalize permitting, and break ground. This phase may take anywhere from three to ten years to begin construction.

Funding the second phase of the Colorado Lagoon Restoration Project will be challenging. However, the Port of Long Beach has repeatedly expressed interest in being the sole funder due to the requirement to mitigate future impacts on intertidal and subtidal marine habitats. As the port expands, the Port of Long Beach must create similar habitat elsewhere. Historically, the Port of Long Beach has funded coastal salt marsh restoration projects at the Bolsa Chica Wetlands, Upper Newport Bay, and Anaheim Bay, but never within the Long Beach city limits where the port's impacts are greatest (Short 1988). The Port of Long Beach would receive mitigation credits for its involvement in Phase 2, but the amount of credit the port would be eligible for by funding the creation of 2.40 acres of tidal wetlands habitat has yet to be determined. Nevertheless, the fact that a site that was converted from wetlands to parkland is now proposed to be turned back into wetlands is a rare occurrence in Southern California, and this forward-thinking

Table 2. Cost Estimates for Phase 2 Alternatives 1–4a

CREDIT: MOFFAT & NICHOL

Alternative	Construction Cost	Maintenance Cost	Total Long-Term Cost
1	$6.8M	$8.4M	$15.2M
2	$9.0M	$4.7M	$13.7M
3	$5.8M	$7.1M	$12.9M
4	$7.3M	$5.0M	$12.3M
4a	$9.4M	$4.0M	$13.4M

Figure 10. Godwit in Colorado Lagoon

PHOTO: M. DEED

project should prove to be attractive to all funding agencies advocating coastal wetlands restoration projects.

Conclusion

Even very small coastal restoration projects can be extremely complex, especially when the coastal ecosystems are encompassed by Southern California's urban sprawl. The Colorado Lagoon Restoration Project, while lacking in acreage, has already overcome large hurdles and will continue to face challenges as it aims to set precedents for the need to invest resources towards converting developed tidal areas back into the coastal wetlands they once were (Figure 10). Non-sustainable and poorly devised urban planning from the past challenges our present-day coastal engineers, ecologists, and interest groups. These people are working hard to restore balance by allowing for both urban and natural environments, through the installation of natural and engineered solutions. The combination of bioswales, low flow diversion systems, trash separation devices, dredging of contaminated sediments, wetlands habitat revegetation, and improvements to the tidal connection will allow the health of Colorado Lagoon's coastal ecosystem to recover. This complex and relatively expensive restoration project deserves recognition and should act as motivation for similar restoration projects to endure the struggles of restoring ecosystems along the urban coast.

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References

Burnaford, Jennifer L., Scottie Y. Henderson, and Bruno Pernet. 2011. "Assemblage Shift Following Population Collapse of a Non-indigenous Bivalve in an Urban Lagoon." Marine Biology 15:1915–27. http://www.springerlink.com/content/1r7416lk62813601/.

Chambers Group. 2004. Habitat Assessment for the Colorado Lagoon Restoration Feasibility Study for the City of Long Beach. http://www.longbeach.gov/news/displaynews.asp?NewsID=2179.

Heal the Bay. 2011. "Heal the Bay's 2010-2011 Annual Beach Report Card." p 98. http://brc.healthebay.org/.

Los Angeles Regional Water Quality Control Board. 2009. "Los Angeles Region Integrated Report Clean Water Act Section 305(b) Report and Section 303(d) List of Impaired Waters 2008 Update."

LSA Associates, Inc. 2008. "Draft Environmental Impact Report, Colorado Lagoon Restoration Project, City of Long Beach, California." State Clearinghouse No. 2007111034.

Moffatt & Nichol. 2010. Alternatives Analysis Report, Phase 2 Study, Colorado Lagoon Restoration Project. Prepared in association with WRA and Blue Line Consulting for the City of Long Beach and Port of Long Beach. http://www.longbeach.gov/cd/property_services/project_development/colorado.asp.

O'Connor, T. P. 2004. "The Sediment Quality Guideline, ERL, Is Not a Chemical Concentration at the Threshold of Sediment Toxicity." Marine Pollution Bulletin 49 (5–6): 383–85.

Short, C. 1988. "Wetland Creation and Restoration Efforts Associated with Mitigation Banks." In US Fish and Wildlife Service Biological Report.

Speth, J. W. 1969. Status Report on the Coastal Wetlands of Southern California as of February 1, 1969. California Department of Fish and Game.

U.S. Census Bureau. 2010. "United States Census 2010." http://2010.census.gov/2010census/data/.

Zedler, J.B. 1982. The Ecology of Southern California Coastal Salt Marshes: A Community Profile. FWS/OBS-81/54. Washington, DC: U.S. Fish and Wildlife Service, Biological Services Program.

Case Studies

Elmer Avenue: Post-Project

PHOTO: COUNCIL FOR WATERSHED HEALTH

Sustainable Infrastructure: The Elmer Avenue Neighborhood Retrofit

EDWARD BELDEN, MICHAEL ANTOS, KRISTY MORRIS, & NANCY L.C. STEELE

Abstract

Southern California faces significant pollution along its beaches and reduced reliability of imported water from distant lands. Sustainable solutions are needed that integrate natural processes into the built environment to solve these problems. The Elmer Avenue Neighborhood Retrofit Project demonstrates a transformation of conventional paved landscapes from liabilities to assets that provide multiple benefits such as improved water quality, increased water supply, and new green space. This effort worked with residents and numerous stakeholders to install best management practices on public and private property that reduce flooding, increase groundwater recharge, prevent pollutants from reaching waterways, and reduce carbon emissions. An extensive monitoring program is under way at Elmer Avenue, and findings to date show that residents along the street are able to maintain the improvements, and more than 10 acre-feet of runoff for groundwater recharge was captured in the first year (rain year 2010–2011). As monitoring continues and the additional projects are built to work with the existing improvements, valuable information and lessons learned will assist designing, installing, and maintaining future green and sustainable infrastructure projects.

Introduction

Coastal resources are only as healthy as the water flowing into them. The health of watersheds and the quality of ecosystems are linked to the sustainability of the surrounding community. Urban development patterns have resulted in less infiltration and more polluted runoff entering rivers and the ocean. By restoring the natural hydrologic connections and ensuring more precipitation percolates into the ground, the Los Angeles region can greatly increase locally available water supplies (Los Angeles & San Gabriel Rivers Watershed Council 2010). Sustainable solutions to the problems of pollution and unsustainable water supplies can be implemented in new and existing public and private developments throughout the watersheds of Southern California as shown by the Elmer Avenue Neighborhood Retrofit Project.

Figure 1. Stormwater Infiltration

PHOTO: COUNCIL FOR WATERSHED HEALTH

In 2000, the Los Angeles Basin Water Augmentation Study was initiated by the Council for Watershed Health (formerly

the Los Angeles & San Gabriel Rivers Watershed Council 2002), as a long-term study to investigate the efficacy of using stormwater for groundwater recharge in the Los Angeles Basin. The study monitored six best management practice (BMP) installations on various land-use types across the region and determined that stormwater could be safely infiltrated to augment groundwater supplies under most conditions (Figure 1). Using the Los Angeles Basin Groundwater Augmentation Model (U.S. Department of the Interior: Bureau of Reclamation [USBR] 2007), the study found that in an average precipitation year, 384,000 acre-feet of stormwater could be available for recharge if the first 0.75 inch of each rain event is captured throughout the region. The opportunities for additional surface water storage are limited in the developed Los Angeles basin, but the groundwater aquifers have unused capacity of more than 1 million acre-feet (Metropolitan Water District of Southern California [MWD] 2007).

Based on the study findings, the Council for Watershed Health and its partners embarked on a demonstration project in a residential setting (Los Angeles & San Gabriel Rivers Watershed Council 2010). The Elmer Avenue Neighborhood Retrofit Project demonstrates an integrated, comprehensive approach to water resource management through the retrofit of a residential street in the northeast San Fernando Valley. A number of different BMPs and green infrastructure approaches are employed to promote water conservation, reduce and treat pollution, and encourage urban greening. The project is located in a flood-prone and open space–deficient portion of Sun Valley in the City of Los Angeles (Figure 2). The project includes enhancements in the public right-of-way and on thirteen private residential properties along a single block that work in concert to demonstrate low-impact design principles and sustainable stormwater management (See GWAM insert, page 94).

Infrastructure Retrofit

Sustainable stormwater management and green infrastructure use natural processes to capture and treat water and manage runoff at either the parcel or neighborhood scale. Elmer Avenue, located in the Sun Valley subwatershed of the Los Angeles River, has forty acres of residential land that drained to the roadway. This caused flooding problems, deteriorating street surfaces, and increased pollution along the block and downstream. Elmer Avenue did not have a traditional storm drain system to route flows off the street's surface. The flooding hazard suggested the need to install a traditional drainage system, presenting an opportunity to use a sustainable approach instead to reduce runoff and conserve water.

The Elmer Avenue Neighborhood Retrofit Project is designed to reduce, capture, treat, and infiltrate runoff from forty acres using an infiltration gallery under the street (Figure 3), bioswales along the public right-of-way, permeable surfaces for walkways and driveways, rain gardens and rain barrels to utilize and capture water from downspouts, as well as drought-tolerant landscaping and drip irrigation to lower water usage and utility bills. Infiltration is an effective stormwater management strategy along Elmer Avenue and in the Sun Valley area because the soil is highly permeable (Los Angeles County Department of Public Works [LADPW] 2004).

The project relies on an extensive partnership among nonprofits, municipalities, state and federal agencies, and local residents. Residents care for and maintain the new private property and public right-of-way features that reduce runoff and conserve water. The Council provided the residents of each home with a manual explaining how to maintain the vegetation and other features installed on their property; landscaping experts then trained all residents on three separate occasions. New sidewalks, solar street lights, street trees, and green space with native plants provide a park-like setting that attracts people from surrounding blocks, as well as birds, butterflies, and other wildlife (Figure 4). A comprehensive monitoring program is under way to answer questions about the quantity of water infiltrated,

Figure 2. Residence and Right-of-Way: Pre-Project

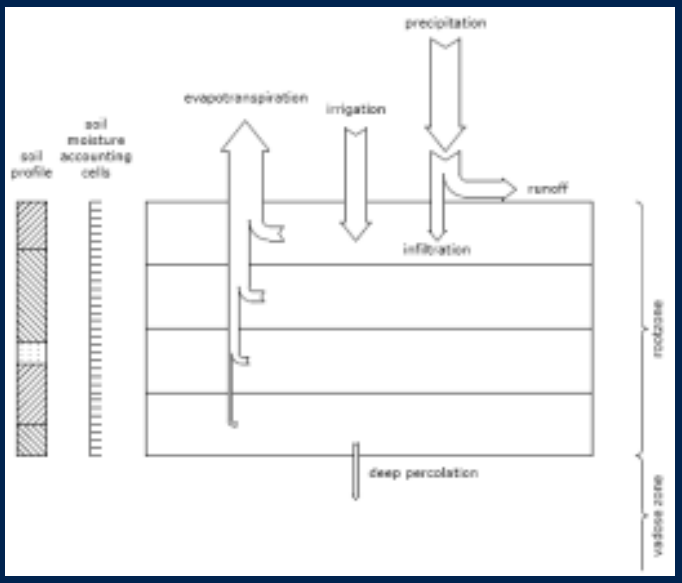
Figure 3. Infiltration Gallery

Figure 4. Residence and Right-of-Way Improvements

Ground Water Augmentation Model

GWAM was developed by the U.S. Department of Interior: Bureau of Reclamation and the Council for Watershed Health for use in the Los Angeles Basin Water Augmentation Study. The model estimates the amount of groundwater recharge and stormwater runoff generated within the urbanized portion of the Greater Los Angeles Region.

GWAM can also explore the potential for greater groundwater recharge if various capture strategies are implemented (Bureau of Reclamation 2007). Using runoff diversion-to-infiltration scenarios, the model shows the potential increase in groundwater recharge given changes to the urban landscape. The model can be used to evaluate multi-benefit approaches to solving supply and runoff problems by predicting the results of methods to capture stormwater via low impact design or other best management practices (BMPs).



Two mass balance principles are integral to the estimates made by this model. These principals are described in a simplified manner below, but the detailed GWAM user's manual is available for download at WatershedHealth.org.

First Principle:

The amount of infiltration generated when it rains as described with this generalized equation:

Infiltration = Precipitation – Bare Surface & Canopy Evaporation – Runoff

Infiltration	Volume of water (acre-feet) entering into the root zone
Precipitation	Hourly precipitation data (inches) from a 50-year record
Bare Surface & Canopy Evaporation	Volume of water intercepted and/or evaporated before it infiltrates or becomes runoff
Runoff	Runoff predicted by the model using the Soil Conservation Survey curve number procedure (USDA 1986)

Second Principle:

For deep percolation as described by the following generalized equation:

Deep Percolation = Previous Soil Moisture + Infiltration + Irrigation – Evapotranspiration

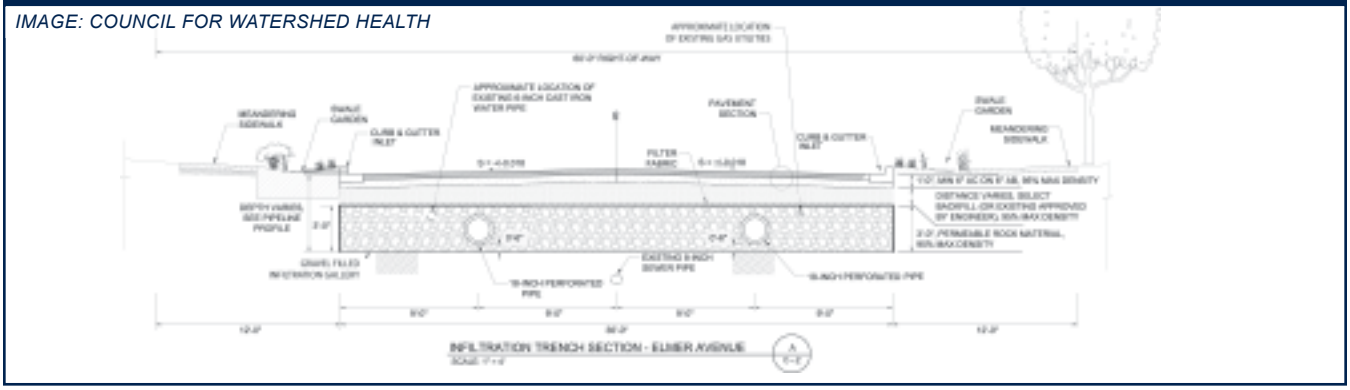
Deep Percolation	Volume of water predicted to infiltrate past the root zone and into the vadose zone
Previous Soil Moisture	Soil moisture from each previous daily time step in the model
Infiltration	As described above
Irrigation	Applied water to fulfill deficits in soil moisture
Evapotranspiration	Calculated within the model from California Irrigation Management System data and processed using accepted methods

The dynamics of runoff and infiltration in the model can be altered with user-selected diversions of runoff to infiltration. This allows the model to consider efforts to diminish runoff volume by retaining water as a potential recharge source. The diversions are set prior to the model run as a fraction of runoff (a percentage) or an absolute amount of runoff (a depth of water).

If no diversion is set, the model factors the saturated hydrologic conductivity of the soils as a limiting factor on infiltration. In impervious diversion scenarios, the diverted volume is routed past the root zone directly to the vadose zone, and therefore, the soil's capacity is not a factor. In pervious diversions, saturated hydrologic conductivity can be activated as a limiting factor, or left disabled, to imply that the unnamed BMP is capable of surface storage capacity, thus allowing as much time as is needed to completely drain the diverted volume into the root zone.

Figure 5. Cross-Section Schematic of Project

IMAGE: COUNCIL FOR WATERSHED HEALTH



pollutant load reductions, perceptions among homeowners, changes in the surrounding neighborhoods' landscapes, life-cycle costs, and changes in biological diversity.

Managing the Run-On to Elmer Avenue

The stormwater flowing to Elmer Avenue (run-on) from the 40-acre neighborhood to the north now enters catch basins that convey water into two infiltration galleries underneath the street. The bottomless catch basins allow particulates to settle out of the water before it enters the infiltration galleries. The two basins work in series, with water filling one before entering the next, which must also then fill before flow is conveyed to the gallery. The catch basins have no concrete bottoms, so some infiltration occurs there as well. The infiltration galleries below the street each consist of two 18-inch-diameter perforated pipes in a gravel bed five feet deep (Figure 5). Each gallery runs the 36-foot width of the street; the north gallery is 250 feet long, and the south gallery is 100 feet long.

The infiltration galleries are capable of infiltrating flow running on to Elmer Ave from "upstream" neighborhoods generated during a 2-year 24-hour storm (2.6 inches). The peak flow and volume of the 2-year storm are estimated to be about 10 cubic feet per second and 5 acre-feet, respectively. Based on historical rainfall data, the galleries are expected to infiltrate about 16 acre-feet of runoff annually.

Managing Runoff at Its Source

Runoff originating from the twenty-four homes on this block is managed with a variety of low-maintenance BMPs that apply low impact development (LID) and sustainable landscaping concepts. BMPs were installed on private property and on the public right-of-way, including the following:

- Vegetated bioswales running the length of Elmer Avenue on both sides of the street
- Permeable pavers
- Dry swales
- Rain barrels
- Native and drought-tolerant landscaping to replace existing lawns
- Gutters to direct rooftop runoff toward the rain barrels or swales
- Driveway drains to direct runoff to bioswales
- Street tree landscaping

Thirteen homeowners chose to have some or all of the LID improvements installed on their property. Each participating home received site-specific designs to meet individual needs such as additional parking with permeable pavers or drought-tolerant turf alternatives. The design for private property used a similar plant palette as the public right-of-way to provide a continuous landscape design. Installation of the private and public property designs was sequenced so grading and plantings occurred in similar timeframes and did not conflict with each other. The bioswales have curb inlets and driveway drains to direct flows into the system. The swales include plants and native soils to mimic natural treatment and infiltration processes (Figure 6).

Community and Project Integration

The project is unique in the region because it addresses stormwater runoff at its source with seamless integration of private property and public right-of-way improvements. This integration is primarily the result of engaging the homeowners as critical partners throughout the project. During final site selection, most homeowners indicated they were willing to have improvements installed along their street. Residents participated in developing

Figure 6. Residence and Right-of-Way Improvements: One Year Post-Project

PHOTO: COUNCIL FOR WATERSHED HEALTH

Figure 7. Residence Improvements

the conceptual and final designs through six community meetings and numerous door-to-door interactions. The final plant palette of native- and climate-appropriate vegetation includes the neighborhood's stated preferences for evergreens, blooming color, and variety, as well as reduced water and maintenance needs. The engagement continued throughout construction, when homeowners were provided a single point of contact to report problems and ask questions. This easy and familiar access point allowed the community to be more comfortable participating in the complex web of partners and project efforts.

Community involvement continues today with residents helping to monitor the landscapes. Maintenance and training days for all residents are held quarterly on Saturdays to cover the items in the maintenance manual. The manual provided to each house has a calendar of activities to be performed, from cleaning the inlets to trimming native plants, and includes contact numbers for additional resources (Figure 7).

Monitoring the Progress

The monitoring effort uses multiple indicators to answer five key management questions:

1. What effect do the BMPs have on water quality?
2. What effect do the BMPs have on water supply?
3. What are the operations & maintenance (O&M) needs of the BMPs?
4. How has the project affected the residents' relationship to watershed health?
5. What are the project's additional benefits?

The Council for Watershed Health is implementing the monitoring program with support from the City of Los Angeles, the study

Table 1. Elmer Avenue Project: Monitoring Program Summary

Question		Approach	Indicators	Frequency
Q1:	What effect do the BMPs have on water quality (WQ)?	Flow weighted sampling at inlets to galleries, lysimeter, swale monitoring; before and after soil and plant monitoring	**WQ:** Pollutants of concern, concentration and flow (loadings)	**WQ:** 7 storms for 1st year; 3 storms annually for following 4 years
			Soil: Pollutants of concern, loads and concentrations, bacteria functional genes	**Soil:** Before; 2 per year for 5 years
			Plants: Nutrients, organics, bacteria, metals	**Plants:** Before; 2 per year for 5 years
Q2:	What effect do the BMPs have on water supply?	Water balance approach including monitoring the infiltration system, swales, permeable pavers, and rain barrels	Flow into infiltration system, rain gauge, swale storage via pressure transducers, permeable pavers storage via pressure transducers, sub-meters of water use in swales and residential lot, residential water bills, evapotranspiration	Annually for 5 years
Q3:	What are the O&M needs of the BMPs?	Monitoring of BMPs using photos, observation, and residential surveys	Sediment and trash accumulation, number of cleanouts, BMPs' O&M needs	Monthly BMP evaluation; annual residential survey
Q4:	What is the effect of the project on the residents' relationship to the watershed?	Residential and neighborhood surveys	Residents' responses to BMP maintenance requirements, adoption of new BMPs	**Pre-construction survey:** 2006
				Post-construction survey: September 2011; annually for following 5 years
Q5:	What are the project's additional benefits?	Biological surveys, changes to impervious surface, greenhouse gas emission reductions	**Avifauna and insects:** Abundance and diversity of bird and insect species	**Avifauna and insect survey:** Annually in winter and spring
			Surfaces and carbon emission reductions: Square footage of pervious surface, vegetation and tree canopy, carbon dioxide equivalents	**Surfaces and carbon emission reductions survey:** Annually

partners, and students from local universities. Table 1 expresses the range of monitoring approaches employed. The monitoring effort was phased in over the first year (2010–2011).

Preliminary Data and Analysis

What effect do the BMPs have on water quality?

Water quality monitoring to assess the performance of the infiltration gallery and pre-treatment commenced in 2010. Each gallery has pre-treatment catch basins for settling out debris and sediment before allowing water to infiltrate for groundwater recharge. At present, two automated samplers and two automated flow sensors monitor water quality at two points: (1) along the street before the water enters the catch basin and (2) at the entrance to the infiltration gallery following catch basin pre-treatment. During the 2010–2011 storm season, time-weighted and flow-weighted composite samples were collected with accompanying flow measurements to determine event mean concentrations and pollutant loadings before the catch basins and as flow enters the infiltration gallery. Future monitoring will determine the effect of the bioswales on water quality (Figure 8). Total suspended solids (TSS), total and dissolved metals, nutrients, volatile organic compounds (VOCs), and conventional constituents, such as pH and electrical conductivity, are examples of the range of constituents that are monitored.

The preliminary findings indicate that settling of sediments in the catch basin is reducing the concentration of metals and TSS in the flow entering the infiltration gallery (Figure 9). No VOCs were identified in the samples from either the inlets or the infiltration gallery. It should be noted that these data are preliminary, and the number of data points is too small to determine statistical significance.

What effect do the BMPs have on water supply?

The quantity of water entering the two large infiltration galleries is monitored using area-velocity flow sensors (Hach-Sigma, CO) in the inlet pipes after the catch-basins. Between April 1, 2010 and December 18, 2011 (latest data available), 23 acre-feet of stormwater were recorded entering the galleries to be percolated to groundwater.

What are the O&M needs of the BMPs?

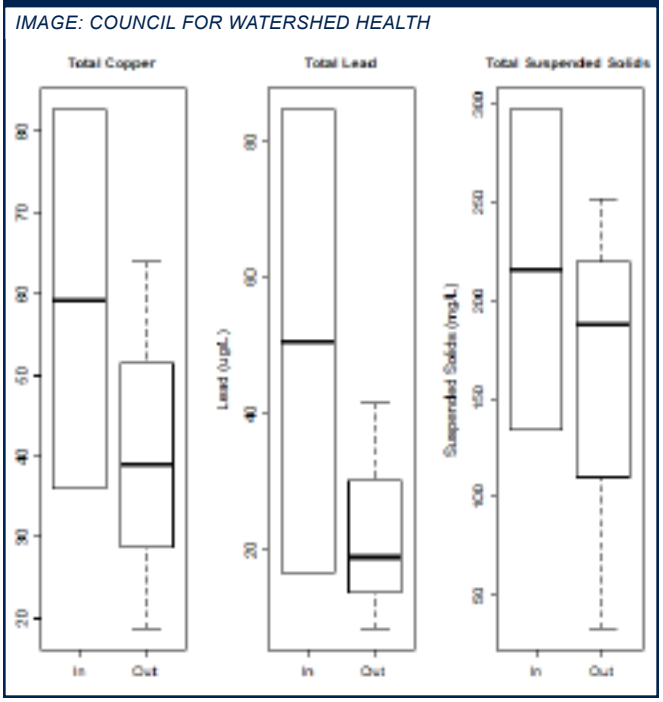
Monthly observational monitoring assesses the performance and maintenance requirements of the public right-of-way and private property improvements. Since surveys began in October 2010, the following have been observed:

Figure 8. Bioswale

PHOTO: COUNCIL FOR WATERSHED HEALTH

Figure 9. Concentrations of Stormwater Copper, Lead, and Total Suspended Solids at the Street Inlet vs. Catch Basin Outlet

IMAGE: COUNCIL FOR WATERSHED HEALTH



- Qualitative assessment suggests plant survival rate is high.

- Weed cover remains particularly low, which may be attributed to proactive residents who routinely weed the bioswales in front of their homes.

- Trash carried by the stormwater and the wind is caught in the bioswales and then removed by the residents.

- As was expected, mulch levels in the bioswales are decreasing since installation. Continued monitoring will determine the need and frequency to reapply mulch.

- Unexpected amounts of sediment are accumulating on the east side of Elmer Avenue causing some inlets and swales to require additional maintenance. The effect of the increased sediment is primarily an aesthetic concern, but will be assessed over time.

- The irrigation system is in good condition and appears to be supplying the plants with the required amount of water. Drip irrigation of the bioswales is scheduled to continue through July 2012.

- The rain barrels are in good condition; barrels are receiving water from the storms and are being used by the residents.

Visual surveys of Elmer Avenue's bioswales are conducted quarterly to assess the plants' health and growth. Photos are taken on a quarterly basis of each bioswale in a consistent manner to observe changes over time (Figure 10).

How has the project affected the residents' relationship to watershed health?

In January 2011, mail-in and door-to-door surveys were conducted of all residents on Elmer Avenue and Bakman Avenue (one block east). This survey was a repeat of a "before" survey conducted in October 2006. Bakman Avenue residents represent the views of residents on a street without stormwater improvements and serve as the control. On Elmer Avenue, 13 out of 24 households responded, while 9 out of 24 houses on Bakman Avenue responded. Where applicable, survey results were compared to the prior 2006 survey. The surveys (available at was.watershedhealth.org) found the following:

- 92% of respondents along Elmer Avenue felt that the hands-on training, maintenance manual, and project contacts were somewhat or very effective.

Figure 10. Bioswale Progress: June 2010 vs. July 2011

PHOTOS: COUNCIL FOR WATERSHED HEALTH

- 92% of Elmer Avenue respondents were satisfied with the walkability on their block in 2011, versus less than 2% in 2006. Bakman Avenue respondents, however, were split—50% were satisfied, and 50% were not.

- A majority of Elmer Avenue residents found maintenance of the elements installed in the public right-of-way to be easy or very easy, with most residents spending less than two times per month weeding the bioswales.

The results from the mail-in and door-to-door surveys along Elmer Avenue and Bakman Avenue suggest a positive impact from direct community outreach and education performed along Elmer Avenue but not along Bakman Avenue. Some highlights of the survey results:

- 100% of the 2011 survey respondents from Elmer Avenue agreed that rain falling on local homes can be captured and used to supply their community with water, versus 60% in 2006. In 2011, 80% of the residents on Bakman Avenue agreed (Figure 11).

- Only 22% of respondents from Bakman Avenue are familiar with the term "infiltration" while 69% respondents from Elmer Avenue are familiar with the term.

- 85% of Elmer Avenue respondents and 50% of Bakman Avenue respondents are familiar with the term "runoff."

- 60% of Elmer Avenue respondents are familiar with the term "watershed" while only 30% of Bakman Avenue respondents are familiar with the term.

An additional mail-in survey was sent to approximately 500 homes in the census block that surrounds the Elmer Avenue Neighborhood Retrofit Project. This additional survey sought to determine the awareness and influence, if any, of the project on the surrounding area. One of Elmer Avenue's potential impacts is educating and influencing surrounding neighborhoods on issues pertaining to water. Below are some preliminary findings from an 11% response rate (Bartrosouf 2011):

- 28% of respondents are familiar with the project.
- Of those who are familiar with the project, 88% feel influenced by its presence (Figure 12).
- 67% would consider purchasing a rain barrel if their neighbors had one.
- 80% of respondents feel that individuals can help reduce the amount of polluted water that flows to the ocean while adding to local potable water supplies.

What are the project's additional benefits?

Additional monitoring of the abundance and diversity of bird and insect species, and an evaluation of the reductions in carbon emissions from the site are ongoing. Rough calculations suggest that 10 acre-feet of recharged groundwater offsets the 4.3 tons of carbon emissions produced by the importation of a similar volume of water (Los Angeles Department of Water and Power [LADWP] 2011).

Conclusions and Lessons Learned

Monitoring results suggest that many of the goals of the Elmer Avenue Neighborhood Retrofit project are being met. Continued monitoring of the project, and additional monitoring at the upcoming Elmer Paseo project (details below), will provide further knowledge about the value of sustainable infrastructural retrofits in Southern California. Numerous agencies, homeowners, residents, and municipalities throughout the region regularly tour Elmer Avenue as an example of sustainable infrastructure (Figure 13).

Extensive outreach and community involvement are clearly critical components of the project's success. A survey of residents in the surrounding census block showed that those passing by have noticed the

Figure 11. Thriving Plants (foreground) and Rain Barrel (background)

Figure 12. Thriving Residence Improvements

Figure 13. Elmer Avenue: Post-Project

project, but additional educational signage or tours would better explain the various elements installed along the street.

Only thirteen of the twenty-four homes selected private property improvements when asked. However, once the improvements were installed, other homeowners expressed regret at passing up the opportunity. Similar future projects should budget explicitly for the late adopters, and/or consider an early physical demonstration of the amenities being offered.

The ageing infrastructure throughout Southern California represents an opportunity to apply the approaches and lessons learned along Elmer Avenue as streets are upgraded. Constructing a system of sustainable infrastructure will provide multiple benefits while replacing an historic single-purpose system that has reached its end-of-life.

Future Work

The work within the Elmer Avenue Neighborhood Retrofit now continues with the Elmer Paseo project, a 270-foot-long paved pedestrian walkway at the southern end of Elmer Avenue. The Paseo is the outlet for the full 40-acre Elmer Avenue watershed and an additional 20 acres of adjoining neighborhoods. The project, currently in its design phase (February 2012) will remove the asphalt surface of the Paseo and replace it with bioswales, a permeable walkway, and other community amenities, including plants, benches, and educational signage explaining how the elements along Elmer Avenue work. A subsurface BMP for additional infiltration is being considered.

Monitoring along Elmer Avenue and the Paseo will provide valuable information on the performance of the various BMPs, the influence of these types of demonstration projects on the community, and additional information on what works and what is needed to convert the urban landscape into a healthy watershed (Figure 14).

Water Augmentation Study Partners and Elmer Project Funders

Funding for the Elmer Avenue project was provided by grants and agreements from the U.S. Department of Interior Bureau of Reclamation and California Department of Water Resources (Prop 50). Additional funding and match support were provided by the Los Angeles City Bureau of Sanitation, the Los Angeles City Bureau of Street Services, the Los Angeles City Bureau of Street Lighting, the Los Angeles Department of Water and Power, the Los Angeles County Department of Public Works, the Metropolitan Water District of Southern California, the Water Replenishment District of Southern California, Dr. Bowman Cutter (UCR/Pomona College), TreePeople, the University of California Riverside, and the City of Santa Monica Environmental Programs Division.

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Figure 14. Residence and Right-of-Way: Post-Project

References

Bartrosouf, Alek. 2011. Decentralizing Stormwater Management: A Proactive Approach to Educate and Engage Communities (Master's Thesis, University of California Los Angeles).

Los Angeles County Department of Public Works. 2004. Sun Valley Watershed Management Plan. http://www.sunvalleywatershed.org/ceqa_docs/plan.asp.

Los Angeles Department of Water and Power. 2011. 2010 Urban Water Management Plan. http://www.ladwp.com/ladwp/cms/ladwp014334.pdf.

Los Angeles & San Gabriel Rivers Watershed Council. 2002. Water Augmentation Study Pilot Program Report.

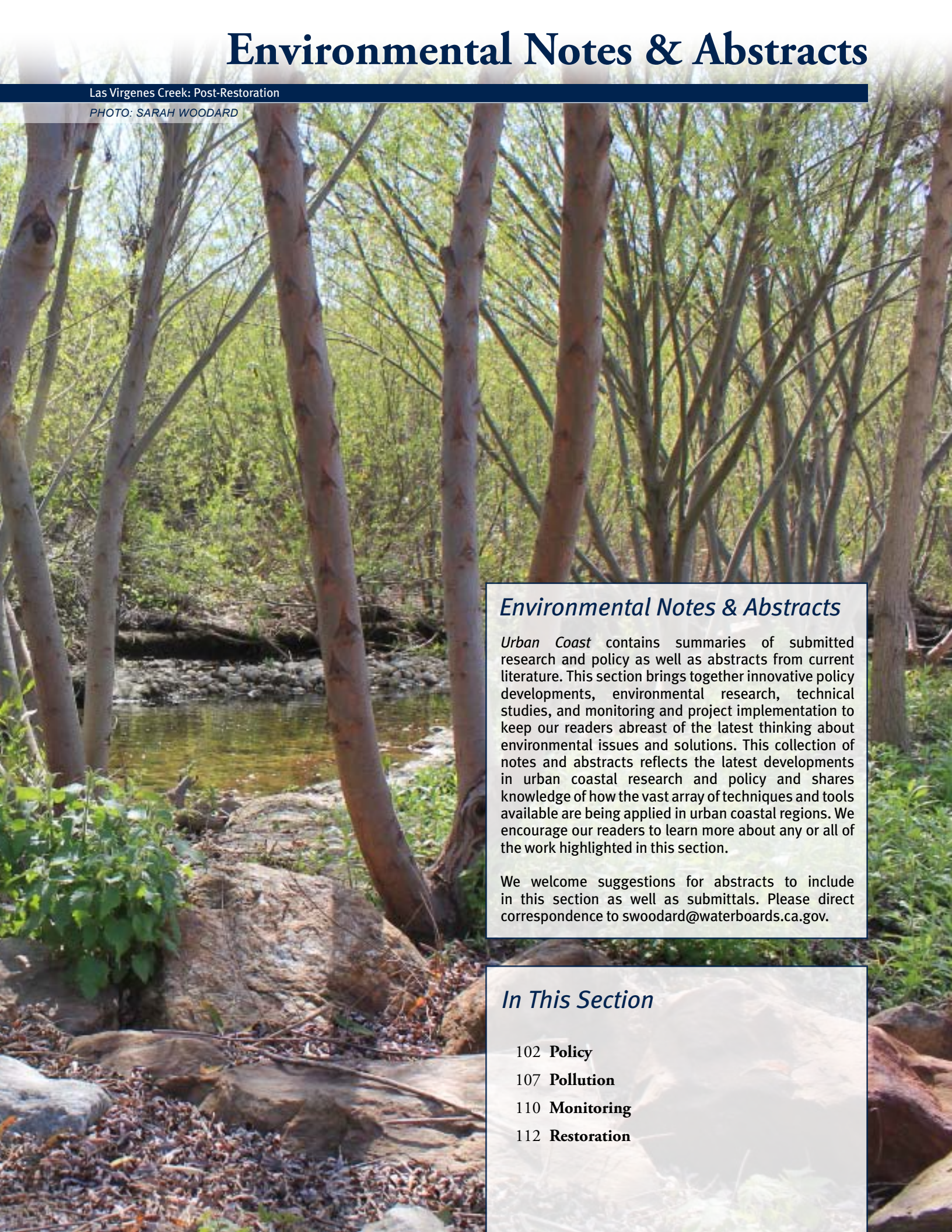
Los Angeles & San Gabriel Rivers Watershed Council. 2010. Water Augmentation Study: Research Strategy and Implementation Report. http://WAS.watershedhealth.org.

Metropolitan Water District of Southern California. 2007. Groundwater Assessment Study, Report Number 1308.

U. S. Department of Agriculture. 1986. Urban Hydrology for Small Watersheds. Technical Release 55 (TR-55) (Second Edition). Washington, DC: Natural Resources Conservation Service, Conservation Engineering Division.

U. S. Department of the Interior: Bureau of Reclamation. 2007. Los Angeles Basin Ground Water Augmentation Model: User's Manual and Technical Documentation, Version 4.1.40. Denver, CO: Bureau of Reclamation, Technical Services Center, Water Resources Division.

Environmental Notes & Abstracts



Las Virgenes Creek: Post-Restoration

PHOTO: SARAH WOODARD

Environmental Notes & Abstracts

Urban Coast contains summaries of submitted research and policy as well as abstracts from current literature. This section brings together innovative policy developments, environmental research, technical studies, and monitoring and project implementation to keep our readers abreast of the latest thinking about environmental issues and solutions. This collection of notes and abstracts reflects the latest developments in urban coastal research and policy and shares knowledge of how the vast array of techniques and tools available are being applied in urban coastal regions. We encourage our readers to learn more about any or all of the work highlighted in this section.

We welcome suggestions for abstracts to include in this section as well as submittals. Please direct correspondence to swoodard@waterboards.ca.gov.

In This Section

Policy

Coastal Project Management. Kamphuis, J. W. 2011. Coastal Management. 39(1):72-81.

Abstract

This article discusses the complex task of managing coastal projects, focusing specifically on those projects involving design and construction; management of projects that go beyond policy and analysis. Coastal design and decision-making are described and the tasks involved in managing coastal projects are defined. The article then concludes that neither coastal engineers nor coastal managers are educated for the contemporary tasks involved in managing coastal projects that involve design and construction. Possible opportunities to make changes in the practice and curricula of both coastal engineering and management are investigated, so that those complex projects can be managed adequately in the future.

Coastal Erosion as a Natural Resource Management Problem: An Economic Perspective. Landry, C. E. Coastal Management. 39(3):259-281.

Abstract

Natural forces render the coastal environment an evolving landscape, with the majority of coastline in the U. S. exhibiting net erosion in recent decades. This article provides an interdisciplinary introduction to economic dynamic optimization models for analyzing beach replenishment and explores differences between these theoretically based welfare economic models and typical applications of benefit-cost analysis employed by public agencies and consultants. Welfare economic models conceptualize benefits of beach area as service flows accruing to nearby residential property owners, recreational beach users, and local businesses, while the costs include pecuniary engineering expenditures, opportunity costs, as well as negative impacts on the coastal environment. Combining information on net benefits with an equation representing beach dynamics, this framework is capable of identifying the conditions under which beach replenishment is welfare-enhancing, and an optimal replenishment schedule can be derived. By congressional mandate, applications of benefit-cost analysis employed by public agencies focus attention on storm damage reduction, with limitations placed on assessment of recreational benefits. We provide an overview of empirical results and compare and contrast the two approaches.

Research and Policy Implications for Watershed Management in the Atlantic Coastal Plain. Drescher, S. R., N. L. Law, D. S. Caraco, K. M. Cappiella, J. A. Schneider, and D. J. Hirschman. 2011. Coastal Management. 39(3):242-258.

Abstract

Coastal plain research and policy strive to protect unique coastal habitats and natural resources while managing for stressors such as seasonal population fluxes and coastal hazards. There is a need to translate scientific findings to impact policy for effective coastal management at a watershed scale that reaches local communities. The Center for Watershed Protection (CWP) uses an Eight Tools of Watershed Protection (Eight Tools) framework for watershed planning and assessments to systematically identify opportunities for better practices and improve natural resource protection. This article uses four of the Eight Tools, which were recently adapted for the coastal plain, to demonstrate research to policy options: (1) land use planning; (2) forested riparian buffers; (3) stormwater management; and (4) non stormwater discharges—on-site wastewater discharge focus. It provides a synthesis of CWP's recent coastal plain research supplemented with additional coastal research to suggest ways where science may be more effectively integrated into policy and regulations that will protect and restore coastal resources at a watershed scale. Summarizing and presenting the science to policymakers can increase the validity and likelihood for environmental regulations that will ultimately be implemented at the local level.

Concepts and Science for Coastal Erosion Management – An Introduction to the CONSCIENCE Framework. Marchand, M., A. Sanchez-Arcilla, M. Ferreira, J. Gault, J. A. Jiménez, M. Markovic, J. Mulder, L. van Rijn, A. Stănică, W. Sulisz, and J. Sutherland. 2011. Ocean and Coastal Management. doi:10.1016/j.ocecoaman.2011.06.005

Abstract

The main objective of the Conscience project was to develop and test concepts, guidelines and tools for the sustainable management of erosion along the European coastline, based on the best available scientific knowledge and on existing practical experience. Four concepts are potentially capable of providing the nexus between scientific knowledge and management: coastal resilience, coastal sediment cell, favourable sediment status and strategic sediment reservoir. The project has tested the use of these concepts and found that they are useful, provided that they are positioned and linked within a logical structure that we shall call the Conscience "Frame of Reference", defined in time and space and supported through data and monitoring. Practical experience in six coastal sites in Europe has shown that the use of this Frame of Reference together with these concepts can make management objectives explicit and transparent. It can therefore support the design of an appropriate, resilience based coastal erosion management practice.

Near-Term Priorities for the Science, Policy and Practice of Coastal and Marine Spatial Planning (CMSP). Halpern, B. S., J. Diamond, S. Gaines, S. Gelcich, M. Gleason, S. Jennings, S. Lester, A. Mace, L. McCook, K. McLeod, N. Napoli, K. Rawson, J. Rice, A. Rosenberg, M. Ruckelshaus, B. Saler, P. Sandifer, A. Scholz, and A. Zivian. 2012. Marine Policy. 36(1):198-205.

Abstract

There is currently a rare opportunity to inform emerging efforts to implement coastal and marine spatial planning (CMSP) in the United States, Europe and elsewhere around the world. In particular, the newly formed US National Ocean Council is developing a strategic action plan for CMSP over the next 18–24 months. In order to identify priority needs for significantly advancing CMSP, a group of experts in the science, policy and practice of CMSP developed recommendations for (1) process development, (2) communication and engagement efforts, (3) tradeoff and valuation analyses, and (4) decision support. Some of these priorities are supported by existing activities in the United States and elsewhere. Others have yet to be addressed and merit immediate attention.

Examining Local Coastal Zone Management Capacity in US Pacific Coastal Counties. Tang, Z. H., M. K. Lindell, C. Prater, T. Wei, and C. M. Hussey. 2011. Coastal Management. 39(2):105-132.

Abstract

The coastal zone has critical natural, commercial, recreational, ecological, industrial, and esthetic values for current and future generations. Thus, there are increasing pressures from population growth and coastal land development. Local coastal land use planning plays an important role in implementing the U.S. Coastal Zone Management Act (CZMA) by establishing goals and performance policies for addressing critical coastal issues. This study extends the CZMA Performance Measurement System from the national level to the local land use level by measuring coastal zone land use plan quality and political context in fifty-three Pacific coastal counties. Plan quality is measured using an evaluation protocol defined by five components and sixty-eight indicators. The results indicate a reasonable correspondence between national goals and local coastal zone land use planning goals, but a slight gap might exist between the national/state versus local levels in the overall effectiveness of coastal zone management (CZM) efforts. The results show many U.S. Pacific coastal counties lack strong coastal zone land use plans because the average plan quality score was only 22.7 out of 50 points. Although these plans set relatively clear goals and objectives, they are somewhat weaker in their factual basis, identify a limited range of the available planning tools and techniques, and establish few coordination and implementation mechanisms. The regression analysis results indicate that CZM plan quality was not significantly related to any of the jurisdictional characteristics.

The Effectiveness of Environmental Monitoring and Enforcement: A Review of the Empirical Evidence. Gray, W. B., and J. P., Shimshack. 2011. Review of Environmental Economics and Policy. 5(1):3-24.

Abstract

Regulatory punishment for pollution violations is a mainstay of nearly every industrialized nation's environmental policy. This article reviews the existing empirical evidence on the impacts of environmental monitoring and enforcement actions. We first provide context by investigating the U.S. regulatory setting. We then briefly discuss how economists think about environmental enforcement. We next consider recent empirical evidence linking regulator actions to subsequent pollution discharges and compliance behavior. Since the literature primarily studies U.S. institutions, our review focuses mainly on the effects of Environmental Protection Agency and U.S. state activities. The consistent findings from this literature review are as follows: (1) environmental monitoring and enforcement activities generate substantial specific deterrence, reducing future violations at the targeted firm; (2) environmental monitoring and enforcement activities generate substantial general deterrence, reducing future violations at facilities other than the targeted one; and (3) environmental monitoring and enforcement activities generate not only reductions in violations but also significant reductions in emissions. We conclude by discussing policy implications and identifying gaps in the current state of knowledge.

A Broad-Scale Assessment of the Risk to Coastal Seagrasses from Cumulative Threats. Grech, A., R. Coles, and H. Marsh. 2011. Marine Policy. 35(5):560-567.

Abstract

Informing the management of coastal marine habitats at broad spatial scales is difficult because of the costs associated with collecting and analyzing ecological data at that scale. Spatially explicit assessments of the risk to coastal marine habitats from cumulative threats provide an alternative approach by identifying sites that are exposed to multiple anthropogenic threats at broad scales. In this study, qualitative measures of vulnerability were combined with geospatial data to evaluate the risk to coastal seagrasses at the scale of the Great Barrier Reef (GBR) region (similar to 26,000 km(2)) of Queensland, Australia. The risk assessment outputs identified agricultural, urban and industrial runoff, and urban and port developments as the major anthropogenic activities threatening coastal seagrasses. 'Hot spots' with multiple threat exposure were all in industrial port locations and the southern two-thirds of

the GBR. There is a distinct discontinuity in threat exposure along the GBR coast with 98% of seagrass meadows in the northern third exposed to only low levels of anthropogenic risk. The clustering of threat exposure is discussed in terms of coastal management policy. The approach outlined in this study provides management agencies a method of achieving maximum return for minimal investment in data collection at broad spatial scales by identifying sites where management intervention would be best targeted.

Using Science to Inform Controversial Issues: A Case Study from the California Ocean Science Trust. Pietri, D., S. McAfee, A. Mace, E. Knight, L. Rogers, and E. Chornesky. 2011. Coastal Management. 39(3):296-316.

Abstract

Connecting science and policy to promote the effective management of marine resources is a necessity and challenge acknowledged by scientists, policymakers, and stakeholders alike. As a leader on ocean issues, California has recognized the importance of integrating science into ocean and coastal management through specific policy choices. An example is the establishment of the California Ocean Science Trust (OST), a non-profit organization mandated to support management decisions with the best available science. The OST functions as a "boundary organization" bridging the often-disparate worlds of science and policy. Recently, while coordinating a scientific study on the controversial issue of decommissioning California's offshore oil and gas platforms, the OST encountered public misconceptions about the peer review process and how it can help ensure unbiased scientific information informs policy. The OST's experience with this study, and generally as a scientific knowledge broker, provides a practical perspective on techniques for navigating the choppy waters between science and policy. This article presents a critical reflection on the OST's experience coordinating the platform decommissioning study, examined through the framework of boundary organizations and salience, credibility, and legitimacy. It highlights lessons-learned from the project and shares recommendations for working toward the effective integration of science and policy.

Effects of Human Trampling on Macro- and Meiofauna Communities Associated with Intertidal Algal Turfs and Implications for Management of Protected Areas on Rocky Shores (Southern California). Huff, T. M. 2011. Marine Ecology–An Evolutionary Perspective. 32(3):335-345.

Abstract

Human visitation to coastal rocky shore ecosystems has numerous impacts via activities such as harvesting, rock-turning, pollution, and trampling. Human trampling, in particular, has been suggested to decrease the density and diversity of rocky shore organisms, especially large foliose algae. Inconsistent results have been seen in studies of the effects of human trampling on coralline algal turfs and the invertebrate communities (macro-and meiofauna) that inhabit them. Here, a relatively long-term manipulative trampling study based on realistic levels of human visitation was conducted in intertidal areas off Southern California dominated by coralline algal turf. Experimentally trampled plots ('impact plots') and control plots protected from foot traffic ('protected control plots') on turf-covered rocky intertidal benches were observed for 17 months in an area closed to human visitation. Control plots were also established at several other open-access sites ('open-access control plots') to determine whether patterns at the experimentally trampled site resembled those from sites where human visitation is allowed. Bare space increased in trampled plots as compared to pre-impact levels, but the percentage of bare rock in control plots did not change significantly. Trampled plots exhibited shifts in invertebrate community composition and significant declines in the abundances and richness of invertebrate taxa as compared to protected control plots throughout the experiment. Additionally, the trajectory of invertebrate community change through time in trampled plots was significantly different than that of both protected and open-access control plots. Nine months after trampling had ceased, the structure of the invertebrate communities from trampled plots was similar to protected control plots and bare space had decreased to pre-impact levels (ANOSIM analysis). However, trampled plots had significantly more taxa and higher Shannon diversity values than controls. These results indicate that to manage visitor impacts on rocky shore communities, 'no-access' zones may be as important as 'no-take' zones. However, the rapid recovery seen here also indicates that perhaps rotating or seasonal closures might be an effective management strategy to protect turf communities.

Managing Wastewater Effluent to Enhance Aquatic Receiving Ecosystem Productivity: A Coastal Lagoon in Western Australia. Machado, Daniel A. and J. Imberger. 2012. Journal of Environmental Management. 99(1):52-60.

Abstract

Large amounts of waste are generated in urban centers that if properly managed could promote ecological services. In order to promote nutrient cycling and productivity without endangering aquatic ecosystems, management of wastewater treatment and effluent discharges to receiving waters must be assessed on a case-by-case basis. We applied this premise to examine a municipal wastewater treated effluent discharge in a shallow oligotrophic coastal lagoon in Western Australia. Three-dimensional hydrodynamic-ecological modeling (ELCOM–CAEDYM) was used to assess the reaction of ecosystem for effluent quality. Two scenarios were evaluated for the summer 2000–2001 period, the actual or "current"

(conventional secondary treatment) and an "alternative" (involving substitution of biological nutrient removal by advanced treatment). The residence time of the simulated numerical domain averaged 8.4 ± 1.3 days. For the current scenario the model successfully estimated phytoplankton biomass, as chlorophyll-a concentration (Chl-a), that is within field-measured ranges and previously recorded levels. The model was able to reproduce nitrogen as the main limiting nutrient for primary production in the coastal ecosystem. Simulated surface Chl-a means were 0.26 (range 0.19–0.38) µg Chl-a/L for the current scenario and 0.37 (range 0.19–0.67) µg Chl-a/L for the alternative one. Comparison of the alternative scenario with field-measured Chl-a levels suggests moderate primary production increase (16–42%), within local historical variability. These results, suggest that such a scenario could be used, as part of a comprehensive wastewater management optimization strategy, to foster receiving ecosystem's productivity and related ecological services maintaining its oligotrophic state.

Cooperation of Science and Management for Harmful Algal Blooms: Domoic Acid and the Washington Coast Razor Clam Fishery. Chadsey, Meg, V. Trainer, and T. M. Leschine. 2012. Coastal Management. 40(1):33-54.

Abstract

Harmful algal blooms (HABs) may be increasing in frequency and intensity worldwide. Coastal economies suffer significant income losses when fisheries or beaches are closed to protect human health and subsistence fishing communities are at risk. Despite these hardships, managers must often conservatively close harvests across a wide area or for long periods, because they lack scientific information that would allow them to predict HAB events. The outer coast of Washington State has experienced several closures of the razor clam (Siliqua patula) fishery starting in 1991, due to domoic acid (DA) contamination caused by toxic blooms of the diatom Pseudo-nitzschia. Improved science-based management was needed to minimize the impact of DA on this fishery and the coastal communities that relied on it for income, tourism, and subsistence. The Olympic Region Harmful Algal Bloom (ORHAB) Partnership, comprised of state and tribal managers, scientists, and local stakeholders, evolved in response to this need; it has been successful in its mission. Here we examine ORHAB through the lens of the Institutional Analysis and Development framework, in order to identify key factors contributing to its success. The relevance of our findings for other ORHAB-like institutions in the Pacific Northwest and elsewhere is discussed.

Conceptualising Joint Knowledge Production in Regional Climate Change Adaptation Projects: Success Conditions and Levers for Action. Hegger, Dries, M. Lamers, A. Van Zeijl-Rozema, and C. Dieperink. 2012. Environmental Science & Policy. 18(1):52-65.

Abstract

Matching supply and demand for knowledge in the fields of global change and sustainability is a daunting task. Science and public policy differ in their timeframes, epistemologies, objectives, process-cycles and criteria for judging the quality of knowledge, while global change and sustainability issues involve value pluralities and large uncertainties. In literature and in practice, it is argued that joint knowledge production in projects through collaboration between (and within) science and policy serves as a means to bridge the gap between the two domains. However, an assessment framework for analysing the merits and limitations of such projects, identifying good practices and enabling adaptive management as well as social learning had not yet been developed. This paper aims to develop such a framework. We portray joint knowledge production projects as policy arrangements in which the degree of success depends on the actors involved, contents of dominant discourses, presence of rules and the availability of resources. Literature was discussed to specify these four dimensions into seven success conditions for joint knowledge production. Scholars, boundary organizations and actors in projects can use the framework for retrospective analyses of projects, providing joint knowledge production with the empirical basis it still requires. The framework can also be used for promoting reflection in action as well as for formative assessments enabling social learning.

Hydrologic Shortcomings of Conventional Urban Stormwater Management and Opportunities for Reform. Burns, Matthew J., T. D. Fletcher, C. J. Walsh, A. R. Ladson, and B. E. Hatt. 2012. Landscape and Urban Planning. 105(3):230-240.

Abstract

Conventional approaches to stormwater management for environmental protection fail because they do not address all of the changes to the flow regime caused by conventional stormwater drainage. In this paper, we contrasted the hydrologic effects of two conventional approaches to urban stormwater management – (a) drainage-efficiency focused and (b) pollutant-load-reduction focused – identifying their shortcomings and contrasting their hydrologic outcomes with those of a proposed alternative approach focused on restoring important elements of the natural flow regime. Under conventional approaches, both high-flow and low-flow hydrology remain perturbed. We suggest that urban stormwater management should emphasize the restoration or protection of natural hydrologic processes at small scales, with the aim of restoring natural flow regimes at larger scales downstream. We therefore suggest that, despite recent advances in managing stormwater to reduce pollutant loads and peak flow rates, a more complete approach is needed, one which includes as a goal the restoration or

protection of ecologically important elements of the pre-development hydrograph. We propose an approach, flow-regime management, which aims as much as possible to restore and protect ecological structure and function of urban streams by retaining the pre-urban frequency of untreated storm flows, reducing the total stormwater runoff volume through evapotranspiration or harvesting, and delivering filtered flow rates to match pre-urban baseflow rates. We note, however, that the cumulative effects of urban stormwater management at smaller scales on catchment-scale hydrology are not yet fully understood.

Amounts and Distribution of Recreational Beach Expenditures in Southern California. Dwight, Ryan H., S. N. Catlin, and L. M. Fernandez. 2012. Ocean & Coastal Management. 59(1): 13-19.

Abstract

Visitors (n = 2455) were surveyed at fourteen southern California beaches in the summer of 2009 to measure travel expenditures associated with a recreational beach trip. The majority of beach trips were made by California residents (88%), and most traveled by motorized vehicle (90%). Mean distance traveled per beach trip was 35.0 miles; mean time at the beach was 4.0 h; and mean age of adult visitors was 34.8 years. Amounts spent on different cost categories varied; Mean direct beach expenditures spent on parking, food, shopping, lodging and rentals were $46.09 per trip; mean fuel costs were $8.84 per trip; and mean equipment costs (beach gear) were $10.60 per trip. The combined Total Beach Expenditures (TBE) were $65.53 per trip. Beaches with amenities captured greater expenditures ($73.37 per trip) compared to beaches with less facilities ($11.78 per trip). Southern California beaches generate over $3.5 billion annually in beach related expenditures, and $2.5 billion of that is spent directly at beaches. Attendance patterns determine expenditure amounts resulting in more than half of direct beach expenditures occurring at only 20% of the regions most popular beach locations. The beach specific data and results on spending patterns can be helpful for a range of agencies and beach managers when researching the most economically effective maintenance or enhancement options for different sites. The values generated also provide baseline economic activity by beach which may be useful for compensation calculations in the event of a future loss or closure of a particular beach.

Trade-offs between environmental protection and economic development in China's fisheries policy: A political analysis on the adoption and implementation of the Fisheries Law 2000. Ferraro, Gianluca and M. Brans. 2012. Natural Resources Forum. 36(1): 38-49.

Abstract

The Rio Declaration of 1992 called for states to integrate environmental protection in their process of development in order to achieve the ultimate goal of sustainable development (Principle 4). The paper investigates to what extent the People's Republic of China (PRC) has integrated environmental protection into her fisheries policy. The environment/development nexus is analysed in relation to the adoption and implementation of the Fisheries Law of 2000. Official documents and, more importantly, interviews conducted in several organizations at multiple levels of governance disclose a complex reality beyond the formal commitment to sustainable fisheries. Diverging interests, goals and strategies can be traced beyond formal policy documents in Beijing, Guangdong and between the Centre and the Province. I nter-organizational divergences at the central and local levels, as well as between them, hinder the pursuit of environmental protection in the development of China's fisheries sector. The paper highlights the political complexity of pursuing more responsible fisheries in the multi-actor and multi-level political-administrative system of the PRC. Here, as well as in many other developing countries, economic development constitutes the policy priority. Environmental protection often remains not only an ambitious objective but also an unperceived need.

Sustainability of Deep-Sea Fisheries. Norse, Elliott A., S. Brooke, W. W. L. Cheung, M. R. Clark, I. Ekeland, R. Froese, K. M. Gjerde, R. L. Haedrich, S. S. Heppell, T. Morato, L. E. Morgan, D. Pauly, R. Sumaila, and R. Watson. 2012. Marine Policy. 36(2): 307-320.

Abstract

As coastal fisheries around the world have collapsed, industrial fishing has spread seaward and deeper in pursuit of the last economically attractive concentrations of fishable biomass. For a seafood-hungry world depending on the oceans' ecosystem services, it is crucial to know whether deep-sea fisheries can be sustainable.

The deep sea is by far the largest but least productive part of the oceans, although in very limited places fish biomass can be very high. Most deep-sea fishes have life histories giving them far less population resilience/productivity than shallow-water fishes, and could be fished sustainably only at very low catch rates if population resilience were the sole consideration. But like old-growth trees and great whales, their biomass makes them tempting targets while their low productivity creates strong economic incentive to liquidate their populations rather than exploiting them sustainably (Clark's Law). Many deep-sea fisheries use bottom trawls, which often have high impacts on nontarget fishes (e.g., sharks) and invertebrates (e.g., corals), and can often proceed only because they receive massive government subsidies.

The combination of very low target population productivity, nonselective fishing gear, economics that favor population liquidation and a very weak regulatory regime makes deep-sea fisheries unsustainable with very few exceptions. Rather, deep-sea fisheries more closely resemble mining operations that serially eliminate fishable populations and move on.

Instead of mining fish from the least-suitable places on Earth, an ecologically and economically preferable strategy would be rebuilding and sustainably fishing resilient populations in the most suitable places, namely shallower and more productive marine ecosystems that are closer to markets.

Pollution

Effects of the Pharmaceuticals Gemfibrozil and Diclofenac on the Marine Mussel (Mytilus spp.) and Their Comparison with Standardized Toxicity Tests. Schmidt, W., K. O'Rourke, R. Hernan, and B. Quinn. 2011. Marine Pollution Bulletin. 62(7):1389-1395.

Abstract

Human pharmaceuticals, like the lipid lowering agent gemfibrozil and the non-steroidal anti-inflammatory drug diclofenac are causing environmental concern. In this study, the marine mussel (Mytilus spp.) was exposed by injection to environmentally relevant and elevated (1 µg/L and 1000 µg/L) concentrations of both compounds and biomarker expression was observed. Gemfibrozil exposure induced biomarkers of stress (glutathione S-transferase and metallothionein) at both concentrations 24 h and 96 h after exposure, respectively. Biomarkers of damage (lipid peroxidation (LPO) and DNA damage) were significantly affected, as well as the biomarker for reproduction, alkali-labile phosphate assay, indicating the potential oxidative stress and endocrine disrupting effect of gemfibrozil. Diclofenac significantly induced LPO after 96 h indicating tissue damage. Additionally standard toxicity tests using the marine species Vibrio fischeri, Skeletonema costatum and Tisbe battagliai showed differences in sensitivity to both drugs in the mg/L range. Results indicate a suite of tests should be used to give accurate information for regulation.

Seabirds and Chronic Oil Pollution: Self-cleaning Properties of Gulls, Laridae, as Revealed from Colour-ring Sightings. Camphuysen, K. 2011. Marine Pollution Bulletin. 62(3):514-519.

Abstract

Mystery oil spills off the Dutch coast affected colonial, adult Lesser Black-backed Gulls prior to and within the breeding season. From colour-ringed individuals, it was demonstrated that most oiled birds survived and were clean within a few weeks and often bred successfully. Further evidence of self-cleaning properties of Larus-gulls is provided from a long-term colour-ringing project (1984–2009). In total 46 birds were reported 'oiled', two died, but the majority cleaned itself and survived for up to 20 years after being oiled. From colour-ring data and 30 years of beached bird surveys (1980–2010) it is demonstrated that the effects of chronic oil pollution is larger in winter than in summer; a reflection of seasonal differences in exposure and environmental conditions. The self-cleaning properties of gulls are such that long-term survival is not necessarily jeopardised and even in a breeding season, not all is lost in case of a spill.

Disruption of Sema3A Expression Causes Abnormal Neural Projection in Heavy Oil Exposed Japanese Flounder Larvae. Kawaguchi, M., J. Y. Song, K. Irie, Y. Murakami, K. Nakayama, and S. I. Kitamura. 2011. Marine Pollution Bulletin. 63(5-12):356-361.

Abstract

It has been well known that oil spills cause serious problems in the aquatic organisms. In particular, some species of teleosts, which develop on the sea surface thought to be affected by heavy oil (HO). During the embryogenesis, the nervous system is constructed. Therefore, it is important to study the toxicological effects of HO on the developing neurons. We exposed HO to eggs of Japanese flounder (Paralichthys olivaceus) and investigated the neural disorder. In larvae exposed by HO at the concentration of 8.75 mg/L, the facial and lateral line nerves partially entered into the incorrect region and the bundle was defasciculated. Furthermore, in the HO-exposed larvae, Sema3A, a kind of axon guidance molecule, was broadly expressed in second pharyngeal arch, a target region of facial nerve. Taken together, we suggested the possibility that the abnormal expression of Sema3A affected by HO exposure causes disruption of facial nerve scaffolding.

Marine Meiobenthic and Nematode Community Structure in Victoria Harbour, Hong Kong upon Recovery from Sewage Pollution. Liu, X. S., W. Z. Xu, S. G. Cheung, and P. K. S. Shin. 2011. Marine Pollution Bulletin. 63(5-12):318-325.

Abstract

Sediment quality, meiofaunal and nematode communities were monitored across six time points at two inside-harbour and three outside-harbour sites over a three-year period in Victoria Harbour, Hong Kong, after the implementation of a sewage treatment project. Twenty-one meiofaunal groups comprising mainly free-living nematodes and harpacticoid copepods and 188 species of free-living nematodes were identified. The outside-harbour area had a more diverse and significantly different nematode community structure as compared to that in the inside-harbour area. Such spatial

difference was highly correlated with the total Kjeldahl nitrogen content of the sediments. Over the study period, there was no significant improvement in sediment quality within the harbour. However, in the last sampling time, an increase in meiofaunal abundance and a closer similarity in nematode composition between one of the inside- and outside-harbour sites suggested signs of recovery of the meiofauna as a response to abatement of sewage pollution.

Temporal Distributions of Anthropogenic Al, Zn and Pb in Hong Kong Porites Coral During the Last Two Centuries. Wang, B. S., N. F. Goodkin, N. Angeline, A. D. Switzer, C. F. You, and K. Hughen. 2011. Marine Pollution Bulletin. 63(5-12):508-515.

Abstract

A 182-year long record of trace metal concentrations of aluminum, zinc and lead was reconstructed from a massive Porites coral skeleton from southeastern Hong Kong to evaluate the impacts of anthropogenic activity on the marine environment. Zn/Ca and Pb/Ca ratios fluctuate synchronously from the early 19th century to the present, indicating that the marine environment has been anthropogenically influenced since industrialization. Additionally, land reclamation, mining, and ship building activities are recorded by elevated Al/Ca ratios from 1900 to 1950. The coral record indicates that high levels of Zn, Pb and Al occur coincidentally with local wars, and may have contributed to partial colony mortality. Pb/Ca does not correlate well with hemispheric proxy records after 1950, indicating that coastal corals may be recording local rather than hemispheric contamination. Pb/Ca levels in Hong Kong, Guangdong and Hainan corals imply a continuous supply of Pb-based contamination to southern China not reflected in hemispheric signals.

Occurrence and Toxicity of Three Classes of Insecticides in Water and Sediment in Two Southern California Coastal Watersheds. Delgado-Moreno, L., K. Lin, R. Veiga-Nascimento, and J. Gan. 2011. Journal of Agricultural and Food Chemistry. 59(17):9448-9456.

Abstract

The occurrence of chlorpyrifos, diazinon, pyrethroids, and fipronil was investigated in two watersheds along the southern California coast. Paired surface water and sediment samples were collected under dry and wet (after significant rain events) weather conditions. Insecticide concentrations in water and sediment were higher following rain events than during the dry season. Chlorpyrifos was the most frequently detected compound (>88%). Pyrethroids were detected in 74 and 100% of the water and sediment samples, respectively, with-bifenthrin detected most frequently. Trans-permethrin was detected at the highest concentration followed by bifenthrin. Bifenthrin and trans-permethrin water concentrations were significantly correlated ($P < 0.01$) with the suspended solid level, suggesting transport facilitated by suspended particles. In 80% Of the wet season samples with 100% of Ceriodaphnia dubia mortality, chlorpyrifos concentrations were >100 ng L(-1). Sediment pyrethroid levels (0.5-1100 ng g(-1)) were frequently higher than the respective-Hyalella azteca LC(50) values, with bifenthrin as the primary contributor of H. azteca toxicity.

Coastal Pollution Limits Pelagic Larval Dispersal. Puritz, J. B. and R. J. Toonen. 2011. Nature Communications. 2,226.

Abstract

The ecological impact of large coastal human populations on marine ecosystems remains relatively unknown. Here, we examine the population structure of Patiria miniata, the bat star, and correlate genetic distances with a model based on flow rates and proximity to P. miniata populations for the four major stormwater runoff and wastewater effluent sources of the Southern California Bight. We show that overall genetic connectivity is high (F(ST)similar to 0.005); however, multivariate analyses show that genetic structure is highly correlated with anthropogenic inputs. The best models included both stormwater and wastewater variables and explained between 26.55 and 93.69% of the observed structure. Additionally, regressions between allelic richness and distance to sources show that populations near anthropogenic pollution have reduced genetic diversity. Our results indicate that anthropogenic runoff and effluent are acting as barriers to larval dispersal, effectively isolating a high gene flow species that is virtually free of direct human impact.

Impact of Urbanization and Agriculture on the Occurrence of Bacterial Pathogens and Stx Genes in Coastal Waterbodies of Central California. Walters, S. P., A. L. Thebo, and A. B. Boehm. 2011. Water Research. 45(4):1752-1762.

Abstract

Fecal pollution enters coastal waters through multiple routes, many of which originate from land-based activities: Runoff from pervious and impervious land surfaces transports pollutants from land to sea and can cause impairment of coastal ocean waters. To understand how land use practices and water characteristics influence concentrations of fecal indicator bacteria (FIB) and pathogens in natural waters, fourteen coastal streams, rivers, and tidal lagoons, surrounded by variable land use and animal densities, were sampled every six weeks over two years (2008 & 2009). Fecal indicator bacteria (FIB; Escherichia coli and Enterococci) and Salmonella concentrations, the occurrence of Bacteroidales human, ruminant, and pig-specific fecal markers, E. coli O157:H7, and Shiga toxin (stx) genes present

in E. coli, were measured. In addition, environmental and climatic variables (e.g., temperature, salinity, rainfall), as well as human and livestock population densities and land cover were quantified. Concentrations of FIB and Salmonella were correlated with each other, but the occurrence of host-specific Bacteroidales markers did not correlate with FIB or pathogens. FIB and Salmonella concentrations, as well as the occurrence of E. coli harboring stx genes, were positively associated with the fraction of the surrounding sub-watershed that was urban, while the occurrence of E. coli O157:H7 was positively associated with the agricultural fraction. FIB and Salmonella concentrations were negatively correlated to salinity and temperature, and positively correlated to rainfall. Areal loading rates of FIB, Salmonella and E. coli O157:H7 to the coastal ocean were calculated for stream and river sites and varied with land cover, salinity, temperature, and rainfall. Results suggest that FIB and pathogen concentrations are influenced, in part, by their flux from the land, which is exacerbated during rainfall; once waterborne, bacterial persistence is affected by water temperature and salinity.

Terrestrial Sources Homogenize Bacterial Water Quality During Rainfall in Two Urbanized Watersheds in Santa Barbara, CA. Sercu, B., L. C. Van De Werfhorst, J. L. S. Murray, and P. A. Holden. 2011. Microbial Ecology. 62(3):574-583.

Abstract

Microbiological contamination from runoff is a human health concern in urbanized coastal environments, but the contamination sources are often unknown. This study quantified fecal indicator bacteria and compared the distributions of human-specific genetic markers and bacterial community composition during dry and wet weather in urban creeks draining two neighboring watersheds in Santa Barbara, CA. In a prior study conducted during exclusively dry weather, the creeks were contaminated with human waste as indicated by elevated numbers of the human-specific Bacteroidales marker HF183 (Sercu et al. in Environ Sci Technol 43:293-298, 2009). During the storm, fecal indicator bacterial numbers and loads increased orders of magnitude above dry weather conditions. Moreover, bacterial community composition drastically changed during rainfall and differed from dry weather flow by (1) increased bacterial diversity, (2) reduced spatial heterogeneity within and between watersheds, and (3) clone library sequences more related to terrestrial than freshwater taxa. Finally, the spatial patterns of human-associated genetic markers (HF183 and Methanobrevibacter smithii nifH gene) changed during wet weather, and the contribution of surface soils to M. smithii nifH gene detection was suspected. The increased fecal indicator bacteria numbers during wet weather were likely associated with terrestrial sources, instead of human waste sources that dominated during dry weather flow.

Elevated Ammonium Concentrations from Wastewater Discharge Depress Primary Productivity in the Sacramento River and the Northern San Francisco Estuary. Parker, Alexander E., R. C. Dugdale, and F. P. Wilkerson. 2012. Marine Pollution Bulletin. 64(3):574-586.

Abstract

Primary production in the Northern San Francisco Estuary (SFE) has been declining despite heavy loading of anthropogenic nutrients. The inorganic nitrogen (N) loading comes primarily from municipal wastewater treatment plant (WTP) discharge as ammonium (NH_4). This study investigated the consequences for river and estuarine phytoplankton of the daily discharge of 15 metric tons NH_4–N into the Sacramento River that feeds the SFE. Consistent patterns of nutrients and phytoplankton responses were observed during two 150-km transects made in spring 2009. Phytoplankton N productivity shifted from NO_3 use upstream of the WTP to productivity based entirely upon NH_4 downstream. Phytoplankton NH_4 uptake declined downstream of the WTP as NH_4 concentrations increased, suggesting NH_4 inhibition. The reduced total N uptake downstream of the WTP was accompanied by a 60% decline in primary production. These findings indicate that increased anthropogenic NH_4 may decrease estuarine primary production and increase export of NH_4 to the coastal ocean.

Linking Chemical Contamination to Biological Effects in Coastal Pollution Monitoring. Beiras, Ricardo, I. Durán, S. Parra, M. B. Urrutia, V. Besada, J. Bellas, L. Viñas, P. Sánchez-Marín, A. González-Quijano, and M. A. Franco, et al. 2012. Ecotoxicology. 21(1):9-17.

Abstract

To establish the connection between pollutant levels and their harmful effects on living resources, coastal monitoring programmes have incorporated biological tools, such as the scope for growth (SFG) in marine mussels and benthic macrofauna community indices. Although the relation between oxygen-depleting anthropogenic inputs and the alteration of benthic communities is well described, the effects of chemical pollutants are unknown because they are not expected to favour any particular taxa. In this study, the combined efforts of five research teams involved in the investigative monitoring of marine pollution allowed the generation of a multiyear data set for Ría de Vigo (NW Iberian Peninsula). Multivariate analysis of these data allowed the identification of the chemical-matrix combinations responsible for most of the variability among sites and the construction of a chemical pollution index (CPI) that significantly ($P < 0.01$) correlated with biological effects at both the individual and the community levels. We report a consistent reduction in the physiological fitness of local populations of mussels as chemical pollution increases. The energy balance was more sensitive to pollution than individual physiological rates, but

the reduction in the SFG was primarily due to significantly decreased clearance rates. We also found a decrease in benthic macrofauna diversity as chemical pollution increases. This diversity reduction resulted not from altered evenness, as the classic paradigm might suggest, but from a loss of species richness.

Microbial Water Quality Before and After the Repair of a Failing Onsite Wastewater Treatment System adjacent to Coastal Waters. Conn, K. E., M. Y. Habteselassie, A. D. Blackwood, and R. T. Noble. 2012. Journal of Applied Microbiology. 112(1):214-224.

Abstract

Aims: The objective was to assess the impacts of repairing a failing onsite wastewater treatment system (OWTS, i.e., septic system) as related to coastal microbial water quality.

Methods and Results: Wastewater, groundwater and surface water were monitored for environmental parameters, faecal indicator bacteria (total coliforms, Escherichia coli, enterococci) and the viral tracer MS2 before and after repairing a failing OWTS. MS2 results using plaque enumeration and quantitative reverse transcriptase polymerase chain reaction (qRT-PCR) often agreed, but inhibition limited the qRT-PCR assay sensitivity. Prerepair, MS2 persisted in groundwater and was detected in the nearby creek; postrepair, it was not detected. In groundwater, total coliform concentrations were lower and E. coli was not detected, while enterococci concentrations were similar to prerepair levels. E. coli and enterococci surface water concentrations were elevated both before and after the repair.

Conclusions: Repairing the failing OWTS improved groundwater microbial water quality, although persistence of bacteria in surface water suggests that the OWTS was not the singular faecal contributor to adjacent coastal waters. A suite of tracers is needed to fully assess OWTS performance in treating microbial contaminants and related impacts on receiving waters. Molecular methods like qRT-PCR have potential but require optimization.

Significance and Impact of Study: This is the first before and after study of a failing OWTS and provides guidance on selection of microbial tracers and methods.

Diurnal Variation in Enterococcus Species Composition in Polluted Ocean Water and a Potential Role for the Enterococcal Carotenoid in Protection against Photoinactivation. Maraccini, Peter A., D. M. Ferguson, and A. B. Boehm. 2012. Applied and Environmental Microbiology. 78(2):305-310.

Abstract

Enterococcus species composition was determined each hour for 72 h at a polluted marine beach in Avalon, Santa Catalina Island, CA. Species composition during the day was significantly different from that at night, based on an analysis of similarity. Enterococcus faecium and E. faecalis were more prevalent at night than during the day, while E. hirae and other Enterococcus species were more prevalent during the day than the night. Enterococcus spp. containing a yellow pigment were more common during the day than the night, suggesting that the pigmented phenotype may offer a competitive advantage under sunlit conditions. A laboratory microcosm experiment established that the pigmented E. casseliflavus isolate and a pigmented E. faecalis isolate recovered from the field site decay slower than a nonpigmented E. faecalis isolate in a solar simulator in simulated, clear seawater. This further supports the idea that the yellow carotenoid pigment in Enterococcus provides protection under sunlit conditions. The findings are in accordance with previous work with other carotenoid-containing nonphotosynthetic and photosynthetic bacteria that suggests that the carotenoid is able to quench reactive oxygen species capable of causing photoinactivation and photostress. The results suggest that using enterococcal species composition as a microbial source tracking tool may be hindered by the differential environmental persistence of pigmented and nonpigmented enterococci.

Monitoring

An Innovative Statistical Approach for Analysing Non-continuous Variables in Environmental Monitoring: Assessing Temporal Trends of TBT Pollution. Santos, J. A., S. Galante-Oliveira, and C. Barroso. 2011. Journal of Environmental Monitoring. 13(3):673-680.

Abstract

The current work presents an innovative statistical approach to model ordinal variables in environmental monitoring studies. An ordinal variable has values that can only be compared as “less”, “equal” or “greater” and it is not possible to have information about the size of the difference between two particular values. The example of ordinal variable under this study is the vas deferens sequence (VDS) used in imposex (superimposition of male sexual characters onto prosobranch females) field assessment programmes for monitoring tributyltin (TBT) pollution. The statistical methodology presented here is the ordered logit regression model. It assumes that the VDS is an ordinal variable whose values match up a process of imposex development that can be considered continuous in both biological and statistical senses and can be described by a latent non-observable continuous variable. This model was applied to the case study of Nucella lapillus imposex monitoring surveys conducted in the Portuguese coast between 2003 and 2008 to evaluate the temporal evolution of TBT pollution in this country. In order to produce more reliable conclusions, the proposed model includes covariates that may influence the

imposex response besides TBT (e.g. the shell size). The model also provides an analysis of the environmental risk associated to TBT pollution by estimating the probability of the occurrence of females with VDS ≥ 2 in each year, according to OSPAR criteria. We consider that the proposed application of this statistical methodology has a great potential in environmental monitoring whenever there is the need to model variables that can only be assessed through an ordinal scale of values.

Assessment of Heavy Metal Pollution From a Fe-smelting Plant in Urban River Sediments Using Environmental Magnetic and Geochemical Methods. Zhang, C., Q. Qiao, J. D. A. Piper, and B. Huang. 2011. Environmental Pollution. 159(10):3057-3070.

Abstract

Environmental magnetic proxies provide a rapid means of assessing the degree of industrial heavy metal pollution in soils and sediments. To test the efficiency of magnetic methods for detecting contaminates from a Fe-smelting plant in Loudi City, Hunan Province (China) we investigated river sediments from Lianshui River. Both magnetic and non-magnetic (microscopic, chemical and statistical) methods were used to characterize these sediments. Anthropogenic heavy metals coexist with coarse-grained magnetic spherules. It can be demonstrated that the Pollution Load Index of industrial heavy metals (Fe, V, Cr, Mo, Zn, Pb, Cd, Cu) and the logarithm of saturation isothermal remanent magnetization, a proxy for magnetic concentration, are significantly correlated. The distribution heavy metal pollution in the Lianshui River is controlled by surface water transport and deposition. Our findings demonstrate that magnetic methods have a useful and practical application for detecting and mapping pollution in and around modern industrial cities.

Applying a Regional Coastal Wetland Monitoring Framework to Refine and Report on Wildlife and Habitat Delisting Criteria in the Bay of Quinte Area of Concern. Macecek, D., and G. P. Grabas. 2011. Aquatic Ecosystem Health & Management. 14(1):94-103.

Abstract

In most Canadian Areas of Concern, fish and wildlife populations and their habitats (i.e. Beneficial Use Impairments 3 and 14) have been listed as impaired. While much work has addressed other Beneficial Use Impairments, there has often been a lack of specific data and methodologies for evaluating fish and wildlife populations and their habitats. This article presents a methodology for refining delisting criteria for wildlife and habitat Beneficial Use Impairments in the Bay of Quinte Area of Concern using indices of condition in a coastal wetland monitoring framework. Data have been collected to provide information on loss of fish and wildlife habitat (water quality and submerged aquatic vegetation and aquatic macroinvertebrate communities) and degradation of fish and wildlife populations (fish, amphibian and breeding bird communities). Three potential models for delisting are presented using the submerged aquatic vegetation community data as an example. For all coastal wetland attributes considered through the framework, Bay of Quinte coastal wetlands were generally in better condition than other Canadian sites along the Lake Ontario shoreline.

Characterizing the Effects of Two Storms on the Coastal Waters of O'ahu, Hawai'i, Using Data from the Pacific Islands Ocean Observing System. Tomlinson, M. S., E. H. De Carlo, M. A. McManus, G. Pawlak, G. F. Steward, F. J. Sansone, O. D. Nigro, R. E. Timmerman, J. Patterson, S. Jaramillo, and C. E. Ostrander. 2011. Oceanography. 24(2):182-199.

Abstract

Pathogens (and other contaminants) associated with urban storm water runoff plumes have long been recognized as adversely affecting the water quality of the coastal ocean. An understanding of the temporal and spatial characteristics of stormwater plumes is a critical first step in protecting the health of people who recreate in coastal waters. Until recently, characterization of stormwater plumes was limited to expensive vessel-based sampling and satellites, which cannot always provide imagery of the nearshore areas, particularly during storms. With the advent of coastal ocean observing systems with their fixed sensor platforms and autonomous underwater vehicles, we have begun to better understand the temporal and spatial characteristics of stormwater plumes in the coastal ocean. The Pacific Islands Ocean Observing System (PacIOOS) provides continuous environmental monitoring of island coastal waters throughout the Pacific Ocean. This network of new ocean-based monitoring stations enabled the authors to study the effects of two storms on coastal water quality. We find that storm runoff from even a relatively small, partially urbanized watershed can profoundly affect the surface waters of the coastal ocean for days to weeks, both inshore and up to hundreds of meters offshore. Even in these coastal waters exposed to the open ocean, the lower salinities and higher turbidity values indicative

of stormwater plumes lingered for nearly two days along the southern coast of O'ahu, Hawai'i.

Chemical Contamination Baseline in the Western Basin of the Mediterranean Sea Based on Transplanted Mussels. Andral, B., F. Galgani, C. Tomasino, M. Bouchoucha, C. Blottiere, A. Scarpato, J. Benedicto, S. Deudero, M. Calvo, A. Cento, S. Benbrahim, M. Boulahdid, C. Sammari. 2011. Archives of Environmental Contamination and Toxicology. 61(2):261-271.

Abstract

The MYTILOS project aimed at drawing up a preliminary report on coastal chemical contamination at the scale of the Western Mediterranean (continental coasts of the Balearic Islands, Sicily, Sardinia, Corsica and Maghreb) based on a transplanted mussels methodology validated along the French coasts since 1996 by Ifremer and the Rhne M,diterran,e & Corsica water board. MYTILOS is backed up by the INTERREG III B/MEDOC programme, the PNUE/PAM-MEDPOL and Rhne M,diterran,e & Corsica water board. Three cruises (2004, 2005, 2006) have taken place to assess the first state of chemical contamination along the Western Mediterranean shores with the same methodology. Approximately 120 days were spent at sea deploying and retrieving 123 mussel bags. The results obtained for all studied contaminants were equivalent to those obtained along the French coast according the RINBIO network. These similarities relate to both the highest measured levels and background levels throughout the 123 stations. The areas of greatest impact were mainly urban and industrial centers and the outlets of major rivers, with a far higher midsea impact on the dilution of organic compounds than on metals. Metal levels measured in midsea zones were found to be similar to those in natural shellfish populations living along the coast. On a global scale we can observe that the contaminants levels in the Mediterranean Sea are in the same range as in other areas worldwide. Overall, the research demonstrates the reliability of this methodology for marine pollution monitoring, especially in the Mediterranean Sea.

Restoration

Differences in Relative Predation Vulnerability Between Native and Non-native Oyster Larvae and the Influence on Restoration Planning in an Estuarine Ecosystem. Fulford, R. S., D. L. Breitburg, and M. Luckenbach. 2011. Estuaries and Coasts. 34(3):618-629.

Abstract

The costs and benefits of non-native introductions as a restoration tool should be estimated prior to any action to prevent both undesirable consequences and waste of restoration resources. The suggested introduction of non-native oyster species, Crassostrea ariakensis, into Chesapeake Bay, USA, provides a good example in which the survival of non-native oysters may differ from that of native oysters, Crassostrea virginica, during the larval stage. Experiments were conducted to compare the predation vulnerability of native and non-native oyster larvae to different predator types (visual vs. non-visual, benthic vs. pelagic). The results suggest that the non-native larvae are more vulnerable to visual and non-visual pelagic predators. Although vulnerability was similar for larvae exposed to benthic non-visual predators, the consumption of one non-native strain was higher than the consumption of native C. virginica larvae. When vulnerability data are combined with predator feeding rates, the predation mortality for non-native larvae in the wild can be much higher than for native larvae. Small changes in larval mortality rates can yield large changes in total larval delivery to the reef for settlement, so these differences among species may contribute to differences in settlement success. These results provide an example of how a comprehensive examination of the perceived benefits of non-native introductions into complex ecosystems can provide important information to inform management decisions.

Restoration of Isolated and Small Coastal Sand Dunes on the Rocky Coast of Northern Spain. Gallego-Fernandez, J. B., I. A. Sanchez, and C. Ley. 2011. Ecological Engineering. 37(11):1822-1832.

Abstract

The coastal dunes of the Basque Country have suffered a significant anthropic process of regional-scale destruction and fragmentation. This has led to the loss of seven, and endangerment of 14, of the 37 species of plants recognized as exclusive to these dunes. In response to this situation, the restoration of one of the lost dune systems, the Laida Dune, began in 2002 with the installation of sand trapping devices and the plantation of two dune-building species of plants. This study shows the results of a program that monitored the process of natural colonization of plant species in the restored dune over a period of seven years, until the loss of the dune by the action of storms in 2008. The results show that the vegetation dynamics in the restored dune followed a process of primary succession, with a progressive increase in species number, coverage and heterogeneity. The establishment of species was driven by the strong environmental gradient present perpendicular to the coastline. The results indicate that natural colonization in this coastal sector is now possible due to the large number of dune species present, and in spite of the isolation of the restored dune system and the loss and fragmentation of the dune habitats in the region. Over the seven years, 42 plant species became established on the dune, of which 18 were dune-exclusive species, representing

62.1% of the total number of species of the same type in the region. Five of these species are considered to be rare or threatened. Comparison with reference data allowed the evaluation of the trajectory of the plant community assembly. The results indicate that the highest similarity to a reference dune system was to the one located closest to the restored dune.

Artificial Modifications of the Coast in Response to the Deepwater Horizon Oil Spill: Quick Solutions or Long-term Liabilities? Martinez, M. L., R. A. Feagin, K. M. Yeager, J. Day, R. Costanza, J. A. Harris, R. J. Hobbs, J. López-Portillo, I. J. Walker, E. Higgs, P. Moreno-Casasola, J. Sheinbaum, and A. Yáñez-Arancibia. 2011. Frontiers in Ecology and the Environment. E-view.

Abstract

The Deepwater Horizon oil spill threatened many coastal ecosystems in the Gulf of Mexico during the spring and summer of 2010. Mitigation strategies included the construction of barrier sand berms, the restriction or blocking of inlets, and the diversion of freshwater from the riverbeds to the coastal marshes and into the ocean, in order to flush away the oil, on the premise that these measures could reduce the quantity of oil reaching sensitive coastal environments, such as wetlands or estuaries. These projects result in changes to the ecosystems that they were intended to protect. Long-term impacts include alterations of the hydrological and ecological characteristics of estuaries, changes in sediment transport along the coastal barrier islands, the loss of sand resources, and adverse impacts to benthic and pelagic organisms. Although there are no easy solutions for minimizing the impacts of the Deepwater Horizon disaster on coastal ecosystems, we recommend that federal, state, and local agencies return to the strategic use of long-term restoration plans for this region.

The Willapa Bay Oyster Reserves in Washington State: Fishery Collapse, Creating a Sustainable Replacement, and the Potential for Habitat Conservation and Restoration. Dumbauld, B. R., B. E. Kauffman, A. C. Trimble, and J. L. Ruesink. 2011. Journal of Shellfish Research. 30(1):71-83.

Abstract

Oysters have been an important resource in Washington state since the mid 1800s and are intimately associated with recent history of the Willapa Bay estuary, just as they have defined social culture around much larger U.S. east coast systems. The Willapa Bay oyster reserves were set aside in 1890 to preserve stocks of the native oyster Ostrea lurida in this estuary, but these stocks were overfished and replaced with the introduced Pacific oyster Crassostrea gigas during the late 1920s. Pacific oysters have spawned and set naturally in this estuary on a fairly regular basis since that time, and have formed the basis of a sustainable fishery established on state oyster reserves. The fishery is managed as an annual sale of oysters to private aquaculture interests. Oysters are harvested mostly by hand from intertidal tracts, usually moved to better growing areas closer to the estuary mouth, and shell is required to be returned to the reserves to perpetuate the fishery. Although oyster harvest for human consumption will remain an important social management goal, these bivalves have been shown to provide a suite of other ecosystem functions and services. A survey of the reserves suggests that they represent 11.2% of the intertidal habitat in Willapa Bay and cover substantial subtidal areas as well. A comparison with historical maps suggests that most of the low intertidal area in the reserves formerly populated by native oysters is now covered primarily with eelgrass (Zostera marina), which potentially serves as important habitat for numerous other organisms, including juvenile salmon, Dungeness crab, and migratory waterfowl like black Brant. Native oysters can still potentially be restored to some of these areas, but the value of both introduced oysters and eelgrass as habitat and ecosystem engineers also deserves attention, and the reserves provide an excellent place to elucidate the role of these additional conservation targets at the landscape scale.

Characteristics, Restoration, and Enhancement of Southern California Lagoons. Elwany, M. H. S. 2011. Journal of Coastal Research. 59:246-255.

Abstract

The successful enhancement and restoration of coastal lagoons requires a comprehensive understanding of the physical and biological conditions in each lagoon and the processes that influence the lagoon's performance. Since lagoons differ substantially from one location to another, the problems that affect lagoon performance differ as well. Coastal lagoons in Southern California tend to be small with surface areas of a few hundred hectares or less and mean water depths of less than 2m. Careful monitoring studies of lagoons, together with historical reviews and data from previous studies, enable wetland scientists to recommend successful, cost-effective, environmentally sound plans for enhancement and restoration of Southern California lagoons.

Recent understanding of the settings and physical processes controlling lagoon performance will enable us to produce improved schemes to enhance these systems. Usually the biological performance of a wetland depends on improvement of the physical parameters, such as tidal flushing, water quality, freshwater flow reduction, and channel and basin sedimentation. Other factors that should be taken into consideration are the impacts of the wetland on adjacent beaches, the response of the wetland to dry and wet periods, any possible or expected future climate changes, and biodiversity management. This paper discusses cases of environmental impacts on selected Southern California lagoons, together with proposed or existing projects to reduce or mitigate these impacts.

Optimal Restoration: Accounting for Space, Time and Uncertainty. Wilson, K. A., M. Lulow, J. Burger, Y. C. Fang, C. Anderson, D. Olson, M. O'Connell, and M. F. McBride. 2011. Journal of Applied Ecology. 48(3):715-725.

Abstract

1. In general, conservation seeks to prevent further habitat loss but in many cases there is a need to reverse habitat degradation. Restoration of habitat is necessary to achieve biodiversity conservation goals but often it is a costly and time-intensive process. Prioritization of where and when habitat is restored can help to ensure the cost-effective delivery of desired outcomes.

2. We develop a restoration prioritization decision support tool to identify the combination of restoration sites and the schedule for their implementation most likely to deliver the greatest utility for a fixed budget and operational constraints. We use a case study to apply our prioritization approach in order to illustrate the data that can be employed to parameterise the analysis and the outputs that are able to inform restoration planning. We compare restoration schedules under alternative utility functions to demonstrate trade-offs associated with different objectives, assumptions and preferences for particular outcomes.

3. Our prioritization approach is spatially and temporally explicit and accounts for the costs and benefits of restoration, the likelihood of restoration success, the probability of stochastic events, feedbacks, time lags and spatial connectivity.

4. Through collaboration with restoration practitioners we derive quantitative and spatially explicit data on each site requiring restoration. We determine the relative priority for restoring each site and develop a restoration schedule over 20 years.

5. Our results showed that after 20 years a little over a half of the sites requiring restoration are likely be successfully restored, while the total expenditure at our site will be c. US$13 center dot 7 million - almost the entire budget of $14 million.

6. Synthesis and applications. Our restoration prioritization approach provides a schedule for where and when restoration should occur, and also provides operational guidance and support for cost-effective restoration planning such as informing the likely total cost of restoration.

Uprooting and Burial of Invasive Alien Plants: A New Tool in Coastal Restoration? Kollman, J., K. Brink-Jensen, S. I. Frandsen, and M. K. Hansen. 2011. Restoration Ecology. 19(3):371-378.

Abstract

Invasive alien plants are a problem for conservation management, and control of these species can be combined with habitat restoration. Subsoil burial of uprooted plants is a new method of mechanical control, which might be suitable in disturbed habitats. The method was tested in Rosa rugosa (Japanese Rose), an invasive shrub in north-western Europe with negative effects on coastal biodiversity. Two months after uprooting and burial in dunes of north-eastern Denmark, 89% of the 58 shrubs resprouted from roots and rhizomes; on average 41 resprouts per shrub. Resprout density was twice as high at former shrub margins compared with the center; resprouts were taller and originated from more superficial soil layers at the margin than in the center. Resprouting was negatively correlated with fragment depth, and no resprouts were observed from greater than 15 cm depth. The number of resprouts increased with fragment dry mass (0.5-168.5 g). After 18 months with harrowing the species was still resprouting, flowering, and fruiting, albeit with no difference between shrub margin and center. Resprouts were taller (26 cm) and coverage was higher (0-4%) after two compared with three times harrowing, whereas no difference was found in cover of native dune species (1-5%). The results show that even small fragments of R. rugosa resprout, and that resprouting persists despite repeated harrowing. Thus, careful subsoil burial of all fragments is necessary, special attention should be paid to the shrub margin, and follow-up treatments are needed. The effectiveness of the burial method is discussed for restoration of coastal dunes.

The Influence of Time on the Soil Seed Bank and Vegetation across a Landscape-Scale Wetland Restoration Project. Stroh, Peter A., F. M. R. Hughes, T. H. Sparks, and J. O. Mountford. 2012. Restoration Ecology. 20(1):103-112.

Abstract

Wicken Fen National Nature Reserve (NNR) in Cambridgeshire, U. K. is a wetland of international importance isolated in a landscape dominated by arable farming. The prospect of species extinctions within the NNR led to the creation of the Wicken Fen Vision, an ambitious project that will eventually expand the reserve boundary by the purchase and restoration of c. 50 km2 of arable land. We sampled three fields from each of three distinct age-categories of restoration land (5, 15, and 60 years post-arable), and three fields within the adjacent, undrained NNR, to determine (1) differences in seed bank composition across age-categories, (2) relationships between restoration age, the seed bank and standing vegetation, and (3) changes in species traits across age-categories. Historic arable management contributed to an apparent "vertical mixing" effect in the seed bank of the youngest two age-categories, with associated and significant differences in species functional traits across the study area. Almost all plants associated with NNR vegetation were absent from restoration area seed banks and standing vegetation. Seed bank species common to all ages-categories exhibited a bias toward moderate to high Ellenberg F (moisture) values, persistent seed banks, and lateral vegetative spread. Relatively short (c. 6 years) periods of drainage and plowing impact heavily upon seed bank diversity and soils, resulting in a lack of predrainage vegetation, even after decades of subsequent restoration adjacent to intact, species-rich habitat. However, the seed banks of highly degraded fields can contribute toward the creation of novel wetland vegetation assemblages over time and under suitable environmental conditions.

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