Marine Pollution Bulletin 62 (2011) 2780–2786

Contents lists available at SciVerse ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Assessing water quality in Marine Protected Areas from Southern California, USA

Kenneth Schiff[a,*], Brenda Luk[a], Dominic Gregorio[b], Steve Gruber[c]

[a] Southern California Coastal Water Research Project, Costa Mesa, CA, USA
[b] State Water Resources Control Board, Sacramento, CA, USA
[c] Weston Solutions, Carlsbad, CA, USA

ARTICLE INFO

Keywords:
Southern California
Marine protected area
Storm water
Water quality

ABSTRACT

Despite the regulatory mandate to maintain "natural water quality", there are ⩾271 storm drain discharges that potentially threaten the 14 designated marine water quality protected areas in Southern California called Areas of Special Biological Significance (ASBS). After sampling 35 site-events, the geomean concentrations of total suspended solids, nutrients, total and dissolved trace metals, and polycyclic aromatic hydrocarbons in the ocean following storm events were similar between reference drainages and ASBS discharge sites. Concentrations of chlorinated hydrocarbons were nondetectable and no post-storm sample exhibited significant toxicity to the endemic purple sea urchin (*Strongylocentrotus purpuratus*) near ASBS discharge sites. A reference-based threshold was developed and, despite the similarities in average concentrations, there were some individual ASBS discharge sites that were greater than reference background. Cumulatively across all ASBS, the constituents that were most frequently greater than the reference-based threshold were nutrients and general constituents, followed by dissolved and total trace metals.

1. Introduction

Coastal municipalities and other agencies subjected to nearshore water quality regulation face a difficult task. The public demands equal access to the shoreline and, at the same time, mandates protection of water quality to maintain the integrity of marine ecosystems. Public access, especially in highly populated urban centers is almost always to the detriment of coastal marine life. This is routinely observed in terms of habitat loss (Boesch et al., 2001), harvesting of seafood and other marine resources (Cohen, 1997), and the introduction of pollutants (Daskalakis and O'Connor, 1995; Schiff et al., 2000). Almost by definition, natural water quality is in the absence of coastal development and public access (Halpern et al., 2008).

Southern California epitomizes this conundrum. Approximately 17.5 million people live within an hour's automobile drive to the beach and is home to the sprawling urban centers of Los Angeles and San Diego, two of the nation's eight largest cities (US Census Bureau, 2009). Over 1.5 billion gallons of treated wastewater are discharged to the ocean every day (Lyon and Stein, 2009). In a typical rainy season, over double this volume is discharged via surface runoff (Ackerman and Schiff, 2003). Surface runoff following storm events will carry the accumulated anthropogenic pollutants from urban activities such as residential application of fertilizers and pesticides (Schiff and Sutula, 2004), trace metals from brake and tire wear (Davis et al., 2001), and atmospheric fallout from mobile and non-mobile sources (Sabin et al., 2006). Exacerbating these potential threats to the environment, sanitary and storm water systems are separate in Southern California. Therefore, storm water runoff receives virtually no treatment prior to entering the ocean (Lyon and Stein, 2009).

The dilemma between water quality protection and urbanization reaches a climax in Southern California at Areas of Special Biological Significance (ASBS). The ASBS are marine water quality protected areas whose standard is "no discharge of waste" and maintenance of "natural water quality" (SWRCB, 2005). Over 2800 km of shoreline in Southern California are designated as ASBS. While state regulatory agencies have been effective at minimizing point source discharges, there are at least 271 storm drain outfalls (SCCWRP, 2003). These storm drains can discharge urban runoff, but also natural runoff from undeveloped portions of their respective watersheds. Nutrients, trace metals, and some organic constituents found in urban runoff are also natural components of the ecosystem (Yoon and Stein, 2008). The dichotomy between natural versus anthropogenic inputs ultimately clashes because the state regulatory structure does not numerically define natural water quality.

In order to address the dilemma between water quality protected areas and development in the coastal zone, the goal of this study was to assess the water quality in Southern California ASBS. Specifically, the study was designed to answer two questions: (1) what is the range of natural water quality near reference drainage

* Corresponding author. Address: Southern California Coastal Water Research Project, 3535 Harbor Blvd, Suite 110, Costa Mesa, CA 92688, USA. Tel.: +1 714 755 3202; fax: +1 714 755 3299.
E-mail address: kens@sccwrp.org (K. Schiff).

0025-326X/$ - see front matter
doi:10.1016/j.marpolbul.2011.09.009

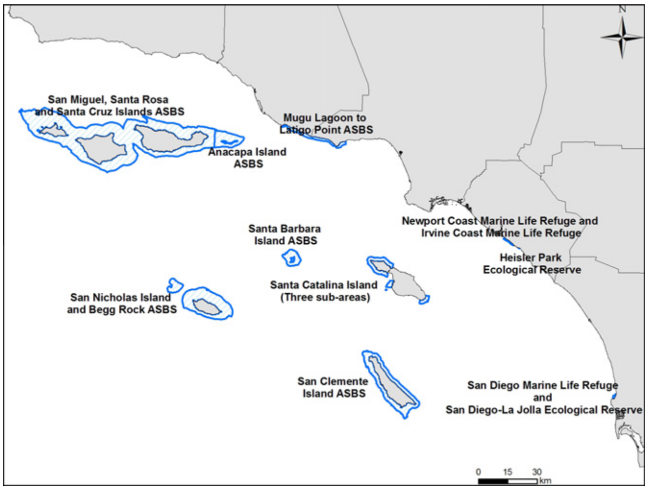

Fig. 1. Map of Areas of Special Biological Significance (ASBS) in Southern California.

locations? and (2) how does water quality near ASBS discharges compare to the natural water quality at reference drainage locations? These two questions address the primary lack of information faced by both ASBS dischargers and regulators that stymies management actions, if they are necessary. The first question aims to quantify what is meant by "natural water quality" by visiting locations presumptively free of anthropogenic contributions. The second question compares the natural water quality levels derived from the first question to water quality near ASBS discharges to determine the level of existing water quality protection.

2. Methods

There are 34 ASBS in California, 14 of which occur in Southern California (Fig. 1). The majority (78%) of ASBS shoreline in Southern California surrounds the offshore Channel Islands, but a significant fraction (35 km) occur along the six mainland ASBS.

This study had two primary design elements. The first design element was a focus on receiving water. All samples were collected in receiving waters near reference drainage or ASBS discharges; no effluent discharge samples were collected as part of this study. The second design element was a focus on wet weather. Dry weather was not addressed in this study.

2.1. Sampling

Sixteen sites were selected for wet weather sampling in this study (Table 1). Six of the sampling locations were reference drainage sites (representing natural water quality) and 10 were ASBS discharge sites. Reference site selection followed five criteria: (1) the site must be an open beach with breaking waves (i.e., no embayments); (2) the beach must have drainage from a watershed that produces flowing surface waters during storm events; (3) the reference watershed should be similar in size to the watersheds that discharge to ASBS; (4) the watershed must be comprised of primarily (>90%) open space; and (5) neither the shoreline nor any segment within the contributing watershed can be on the State's 2006 list of impaired waterbodies (e.g., §303d list). All but one of the reference drainage sites was located within an ASBS.

A total of 35 site-events were sampled (Table 1). Twelve site-events were sampled near reference drainage locations, and another 23 site-events were sampled near ASBS discharge locations. Up to three storm events were sampled per site. A storm was defined as any wet weather event that resulted in surface flow across the beach into the ocean receiving water. Rainfall during sampled events ranged from 0.1 to 9.8 cm. Pre-storm samples were collected prior to (<48 h) rainfall, and post-storm samples were collected immediately following (<24 h) rainfall, with most post-storm samples collected less than 6 h after rainfall cessation. Approximately 89% of all post-storm samples also had a pre-storm sample collected. Samples were collected in the ocean at the initial mixing location in the receiving water. Both pre- and post-storm samples were collected by direct filling of pre-cleaned sample containers just below the water surface.

2.2. Laboratory analysis

All water samples were analyzed for 93 parameters: (1) general constituents including total suspended solids (TSS), dissolved organic carbon (DOC), and salinity; (2) nutrients including nitrate (NO_3-N), nitrite (NO_2-N), ammonia (NH_3-N), total nitrogen (TN), total phosphorus (TP), and ortho-phosphate (PO_4-P); (3) dissolved

Table 1
Reference drainage and ASBS discharge sites, and their respective sampling effort, collected immediately prior to and immediately following storm events in Southern California.

ASBS number	ASBS name	Site name	Latitude	Longitude	Reference or discharge	Number pre-storm samples	Number post-storm samples
ASBS 21	San Nicolas Island	Barge Landing	33.21967	−119.44728	Discharge	2	2
ASBS 21	San Nicolas Island	Cissy Cove	33.21448	−119.48459	Discharge	1	1
ASBS 21	San Nicolas Island	Reference Site	37.26600	−119.49828	Reference	2	2
ASBS 21	San Nicolas Island	Reverse Osmosis site	33.24281	−119.44433	Discharge	1	1
ASBS 24	Malibu	Solstice Beach	34.03255	−118.74216	Reference	1	1
ASBS 24	Malibu	Arroyo Sequit	34.04441	−118.93393	Reference	1	1
ASBS 24	Malibu	Broad Beach	34.03339	−118.85090	Discharge	3	3
ASBS 24	Malibu	Nicholas Canyon	34.04172	−118.91574	Reference	3	3
ASBS 24	Malibu	Westward Beach	34.01030	−118.81721	Discharge	2	2
ASBS 25	Santa Catalina island	Two Harbors Pier	33.44194	−118.49821	Discharge	1	2
–	–	Italian gardens	33.41011	−118.38176	Reference	1	2
ASBS 29	San Diego	Avienda de la Playa	32.85466	−117.25899	Discharge	3	3
ASBS 31	La Jolla	San Diego Marine Life Refuge	32.86632	−117.25469	Discharge	1	3
ASBS 32	Newport Coast/Crystal Cove	Newport Coast/Crystal Cove	33.58867	−117.86759	Discharge	3	3
ASBS 33	Heisler Park	El Moro Canyon	33.56033	−117.82205	Reference	3	3
ASBS 33	Heisler Park	Heisler Park	33.54301	−117.78958	Discharge	3	3
					Discharge	20	23
					Reference	11	12
					Total	31	35