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Topic: Coastal Environments

Satellite Observations of the Southern California Bight:
Circulation, Seeps, and Run-Off

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This study uses ERS-1/2 Synthetic Aperture Radar (SAR) and RADARSAT
imagery, complemented by Advanced Very High Resolution Radiometer
(AVHRR) and SeaWiFS satellite imagery plus in situ measurements
(currents, wind) to describe several features of the Southern California
Bight, particularly the Santa Barbara Channel and Santa Monica Bay/Basin
regions. This region is a uniquely complex coastal environment affected by
wind-driven circulation, offshore islands and coastal promontories, with
strong relationship to the offshore California Current. In particular we
examine the extensive appearance of small (from 1-50 km in diameter)
coastal ocean eddies. Eddies are small (mostly < 20 km diameter),
predominantly cyclonic, and possibly seasonal in their distribution. These
eddies are smaller in size and are more abundant than previously reported.
In addition, we examine the characteristics of natural seeps and rain run-off
from the urban Los Angeles Basin. These observations are important in
their implications for plankton patchiness, nutrient availability, productivity,
larval transport and recruitment, and the impact and dispersal of pollutants.
Satellite Observations of the Southern California Bight: Surface Circulation, Oil Seepage, and Storm Water Runoff

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ABSTRACT: This synergistic, interdisciplinary study uses ERS-1 and ERS-2 Synthetic Aperture Radar (SAR) imagery, complemented by near-coincident satellite (SSM-AHRR: Ocean Color, SeaWIFS) and field (e.g. ship, mooring and drifter) data where available to describe small-scale coastal ocean phenomena in the Southern California Bight (SCB), particularly the Santa Barbara Channel and Santa Monica Bay/Basin regions. Though part of the California Current System, SCB circulation patterns are more complex than elsewhere off the U.S. Pacific coast, due in part to temporarily variable winds, eight nearshore islands, coastal promontories, narrow channels, submarine canyons, basins and ridges. Previous studies have noted the occurrence of small-scale (<50 km diameter) eddies, but these remain undersampled and are generally poorly described. These eddies have important ramifications for nutrient flux, plankton patches, productivity, larval transport and recruitment, and dispersal of pollutants in the SCB. Of related interest, periodic nutricline/pollutant pulses into the SCB are introduced by natural oil seeps and anthropogenic discharge via storm water plumes, and likewise require further characterization. Therefore, the goals of this study are to:
1. describe, qualitatively and quantitatively, the geophysical characteristics of SCB small-scale eddies;
2. assess their biological impact, particularly their role in fostering phytoplankton patchiness; and,
3. examine related coastal features of interest, including the temporal and spatial distribution of oil seepage and storm water plumes, and their potential biological effects, e.g. algal blooms.

METHODS

134 ERS-1/ERS-2 SAR images of the SCB from 1992–1998 were visually analysed for evidence of small-scale eddies and other coastal features (seepage, plumes, etc.) according to criteria established by SAR feature aliases and published studies.

Once detected, eddies and other coastal features were measured, mapped, and complemented, where available, by near-coincident satellite (AHRR) and field (NDRC busy) reconnaissance imaging (e.g. ship, mooring and drifter) data that were used to interpret and/or validate the SAR findings.

SeaWIFS data (1997–1999) from the UCSB and MMSA satellite monitoring activities were processed and similarly analysed for evidence of small-scale eddies and other features in the SCB.

RESULTS

187 small-scale eddies were detected in the ERS-1/2 SAR images of the SCB (e.g. Figures 2a and 3a), those ranging in size from ~1 to 10 km (Figure 5).

These eddies were predominantly cyclonic (93%), and were more common (~2x) during the fall and winter months than in spring and summer (Figure 5), though this might be an artifact given that stronger winds are characteristic of the latter period.

The eddies were sometimes to modestly persistent (days to weeks), and often recur in time and/or space, and they appeared to result from a number of mechanisms, including topographic forcing and current instabilities.

Phytoplankton patches associated with eddies observed in SCB SeaWIFS images (e.g. Figures 2d and 3d) were ~2 to 15 km wide and upwards of 50 km long, and typically characterized by chlorophyll-a concentrations significantly higher than those found in surrounding waters.

These enhancements generally appeared to result from the lateral entrance of highly productive offshore and nearshore waters, though other mechanisms are likely important contributors.

Thermal gradients upwards of 5°C were observed relative to adjacent waters, leading to strong frontal zones within many of these eddies (e.g. Figure 2a).

Oil seepage was extremely common in the Santa Barbara Channel and to a lesser extent in Santa Monica Bay (Figure 4a–b); large storm water plumes and algal blooms were often observed following periods of heavy rains in the SCB (Figure 4c–d).

CONCLUSIONS

These eddies are smaller in size and more abundant than previously reported, and they provide further evidence of the complexity, near-surface circulation characteristics of the SCB.

Small-scale coastal eddies appear to play an important role in the formation and maintenance of phytoplankton patches in the SCB, and they have important ramifications for higher trophic levels (e.g. larval transport and recruitment).

Oil seepage and storm water plumes appear to be important pollutant and nutrient contributions to SCB coastal waters, and thus have important biological ramifications (e.g. algal blooms et al).

The prevalence and persistent impact of these features necessitates high-resolution, coordinated ship-satellite investigations, particularly in eddy confluence. This effort will be enhanced by future availability of high-resolution ocean color imagery.