Data Article

Dataset of terrestrial fluxes of freshwater, nutrients, carbon, and iron to the Southern California bight, U.A.A.∗

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Abstract

The Southern California Bight (SCB) is an upwelling-dominated, open embayment on the U.S. West Coast and receives discharges of anthropogenically-enhanced freshwater, nutrients, carbon, and other materials. These inputs include direct point sources discharged from wastewater treatment (WWT) plants via ocean outfalls and point, non-point, and natural sources discharged via coastal rivers. We assembled a daily time series over 1971–2017 of discharges from large WWT plants ≥ 50 million gallon per day (MGD) and 1997–2017 from small WWT plants and coastal rivers. Constituents include nitrogen, phosphorus, organic carbon, alkalinity, iron, and silica. Data from research studies, several government and non-government agency databases containing discharge monitoring reports, river flow gauges, and other collateral information were compiled to produce this dataset. Predictive models and expert analysis addressed unmonitored sources and data gaps. The time series of terrestrial discharge and fluxes are provided with location of coastal discharge point or tributary. The data are deposited in a repository found in Sutula et al. [1].

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Specifications Table

| Subject | Pollutant |
|---------|-----------|
| Specific subject area | Coastal exports, terrestrial discharge, nutrients and carbon |
| Type of data | Figures Tables in Excel file |
| How data were acquired | Access databases of primary data sources, including hard copy and electronic. |
| Data format | Analyzed and filtered (Excel spreadsheet) |
| Parameters for data collection | Institutional knowledge and National Pollutant Discharge Elimination System Permits were used to identify the point sources discharging to rivers and the ocean in the Southern California Bight. Water quality sampling and gauge data were collected for known Bight coastal rivers and streams at the scale of the National Hydrography Dataset Plus (NHD+) from multiple data sources, comprising of point, non-point, and natural sources. Predictive models were used to predict flow and water quality for unmonitored watersheds and/or missing data for specific constituents. |
| Description of data collection | Collaborated with organizations to collect identified point and non-point sources. |
| Data source location | Primary data sources: Southern California Coastal Water Research Project US Environmental Protection Agency Enforcement and Compliance History Online California Integrated Water Quality System Project California Environmental Data Exchange Network Santa Barbara Coastal Long Term Ecological Research US Geological Survey California Department of Water Resources California State Water Resources Control Board Los Angeles Department of Public Works Orange County Public Works Los Angeles City Sanitation Los Angeles County Sanitation District Orange County Sanitation District City of San Diego International Boundary & Water Commission Tetra Tech Two predictive models were used for rivers: Hydrologic Simulation Program FORTRAN (HSPF) [2] Rationale model (rainfall-runoff model) [3,4]. |
| Data accessibility | Data can be downloaded from this repository: https://doi.org/10.5281/zenodo.4448224 |

Value of the Data

- This record consists of spatially and temporally explicit time series data of flow and constituent concentrations compiled for a period of over 20 years for 75 rivers, 23 coastal wastewater treatment plants, and 18 inland WWT plants discharging into the Southern California Bight (SCB). A portion of these data were not previously readily available to the public until now. Data gaps were addressed through expert analysis. Constituent fluxes include nitrogen (N), phosphorus (P), carbon (C), iron (Fe), silica (Si), and carbonate system parameters (alkalinity and pH).
- This dataset can support several disciplines related to coastal ecology and oceanography (coastal nitrogen and carbon cycling, phytoplankton ecology, harmful algal blooms, fisheries and food webs, coastal hypoxia, acidification, etc.), point and non-point source management, and marine policy.
- These data are useful for coastal nutrient and carbon export studies, trend analyses, source attribution, and modeling applications.
- These data from a densely populated and highly urbanized region can benefit predictive and global studies focused on nutrient, carbon, and freshwater export.

1. Data Description

This article presents a dataset of daily flow and constituent data for 75 rivers, 23 WWT plants discharging to ocean outfalls, and 18 WWT plants discharging to coastal rivers in the Southern
Table 1
Locations delineating the stretch of coast that encompasses each subregion in the ‘natural_rivers.xlsx’ file and in Sutula et al. [5].

| Subregion          | Latitude (-N) Start | Longitude (-E) Start | Latitude (-N) End | Longitude (-E) End |
|--------------------|---------------------|----------------------|-------------------|--------------------|
| Santa Barbara      | 34.3433             | -119.4218            | 34.4763           | -120.4858          |
| Ventura            | 34.0205             | -118.7796            | 34.3433           | -119.4218          |
| Santa Monica       | 33.7618             | -118.4228            | 34.0205           | -118.7796          |
| San Pedro          | 33.6664             | -118.0175            | 33.7618           | -118.4228          |
| Orange County      | 33.1906             | -117.3849            | 33.6664           | -118.0175          |
| North San Diego    | 32.8136             | -117.2715            | 33.1906           | -117.3849          |
| South San Diego    | 32.5300             | -117.1228            | 32.8136           | -117.2715          |

California Bight (SCB). Riverine inputs that contain these point, non-source and natural sources are summarized as well. Constituent data include nitrogen (N), phosphorus (P), carbon (C), iron (Fe), silica (Si), and carbonate system parameters.

The repository contains five files, each for a type of flow: rivers, large publicly owned treatment works (POTW) defined as flows  50 million gallons per day or 2.19 m³ s⁻¹, small POTWs with flows < 2.19 m³ s⁻¹, inland POTWs discharging to watersheds, and river runoff.

Table 2 names all land-based sources discharging to the SCB, lists the location of discharge, and denotes the latitude and longitude of discharge to the ocean.

The spreadsheet ‘rivers_1997_2017_daily.xlsx’ contains the data from 1997 to 2017 for 75 rivers alphabetically. River constituents include daily discharge volume and seasonal mean concentrations of ammonium, nitrate+nitrite, phosphate, silicate, total N, total P, organic N, organic P, total organic C, and total dissolved Fe, alkalinity, and salinity. These data include point, non-point and natural sources combined.

File ‘major_potw_1971_2017.xlsx’ contains data from 1971 to 2017 for the four large POTWs in the SCB, Hyperion Treatment Plant (htp), Joint Water Pollution Control Plant (jwpcp), Orange County Sanitation District (ocsd), and Point Loma Wastewater Treatment Plant (plwtp). Constituents in this file are discharge volume, ammonium, nitrate, nitrite, phosphate, silicate, total N, total P, organic N, organic P, total organic C, total and dissolved Fe, alkalinity, salinity, dissolved oxygen, temperature, pH, and biological oxygen demand.

The file ‘minor_potw_1997_2017.xlsx’ contains data from 1997 to 2017 for the 19 small POTWs alphabetically. Constituents in this file are discharge volume, ammonium, nitrate, nitrite, phosphate, silicate, total N, total P, organic N, organic P, total organic C, total and dissolved Fe, alkalinity, salinity, dissolved oxygen, temperature, pH, and biological oxygen demand.

Fig. 1 shows the sum of volume fluxes, total N, and total P fluxes as time series for the period 1997–2017 from rivers, large POTWs, and small POTWs.

The ‘inland_POTW.xlsx’ file contains averaged data from the year 2009, unless otherwise noted, for the 18 inland POTWs. The region and city are given for each plant. The discharge volume, total N, total P, dissolved inorganic N, and dissolved inorganic P are listed for each plant.

The ‘natural_rivers.xlsx’ file contains summarized annually averaged input of natural riverine sources for each subregion of the SCB. The latitude and longitude locations of division between subregions are shown in Fig. 1 of Sutula et al. [5] and described explicitly here in Table 1. The approximate watershed area of each region is given and constituents in this file are total N, total P, dissolved inorganic N, and dissolved inorganic P.

2. Experimental Design, Materials and Methods

Data were collected over several months from primary data sources that include government agencies, private organizations, and online database tools. The list of sources contacted and from which data were compiled include: Southern California Coastal Water Research Project (SCCWRP), U.S. Environmental Protection Agency Enforcement and Compliance History Online
| Discharge Name                        | Discharge Point          | Latitude (° N) | Longitude (° E) |
|--------------------------------------|--------------------------|---------------|----------------|
| Agua Hedionda Lagoon                | Coast                    | 33.1377       | -117.3550      |
| Aliso Creek                          | Coast                    | 33.2614       | -117.4510      |
| Arroyo Burro Creek                   | Coast                    | 34.4019       | -119.7431      |
| Arroyo Honda Creek                   | Coast                    | 34.4665       | -120.1415      |
| Arroyo Sequit Creek                  | Coast                    | 34.0394       | -118.9380      |
| Arroyo Trabuco Creek                 | Coast                    | 33.4560       | -117.6844      |
| Atascadero Creek                     | Coast                    | 34.4105       | -119.8300      |
| Ballona Creek                        | Coast                    | 33.9561       | -118.4570      |
| Bell Canyon                          | Coast                    | 34.4264       | -119.9153      |
| Bolsa Chica Westminster Channel     | Anaheim Bay              | 33.7286       | -118.0950      |
| Bonita Creek                         | Newport Bay              | 33.5868       | -117.8840      |
| Buena Vista Creek                    | Buena Vista Lagoon       | 33.1599       | -117.3670      |
| Calleguas Creek                      | Coast                    | 34.0986       | -119.0990      |
| Canada De La Gaviota                 | Coast                    | 34.4673       | -120.2269      |
| Carbon Canyon                        | Coast                    | 34.0278       | -118.6550      |
| Carpinteria Creek                    | Coast                    | 34.3849       | -119.5310      |
| Chollas Creek                        | Coast                    | 32.6596       | -117.2470      |
| Costa Mesa Channel                   | Newport Bay              | 33.5868       | -117.8840      |
| Coyote Creek                         | Tributary to San Gabriel River | 33.7358   | -118.1280      |
| Cristianitos Creek                   | Tributary to San Mateo Creek | 33.3770 | -117.5990      |
| Devereux Lagoon                      | Devereux Lagoon          | 34.4090       | -119.8900      |
| Dominguez Channel                    | Coast                    | 33.7085       | -118.2474      |
| E Garden Grove Wintersburg Channel   | Bolsa Bay                | 33.6767       | -118.0410      |
| Encinas Creek                        | Coast                    | 33.0818       | -117.3200      |
| Escondido Creek                      | Coast                    | 33.0100       | -117.2920      |
| Franklin Creek                       | Coast                    | 34.3914       | -119.5358      |
| Goleta Tecolotito Creek              | Coast                    | 34.4105       | -119.8300      |
| Laguna Canyon                        | Coast                    | 33.5331       | -117.7900      |
| Las Flores Canyon                    | Coast                    | 34.0270       | -118.6420      |
| Las Flores Creek                     | Coast                    | 33.2843       | -117.4760      |
| Little Sycamore                      | Coast                    | 34.0468       | -118.9710      |
| Los Angeles Harbor                   | Harbor                   | 33.7350       | -118.2130      |
| Los Angeles River                    | Coast                    | 33.7408       | -118.2190      |
| Los Penasquitos Lagoon               | Los Penasquitos Lagoon  | 32.9221       | -117.2710      |
| Malibu Creek                         | Creek                    | 34.0294       | -118.6820      |
| Marle Canyon                         | Creek                    | 34.0209       | -118.7220      |
| Mission Bay                          | Mission Bay              | 32.7529       | -117.2610      |
| Mission Creek                        | Coast                    | 34.4126       | -119.6864      |
| Montecito Creek                      | Coast                    | 34.4089       | -119.6420      |
| Moro Canyon                          | Coast                    | 33.5567       | -117.8280      |
| Otay River                          | Mission Bay              | 32.6596       | -117.2470      |
| Pena Canyon                          | Coast                    | 34.0305       | -118.6090      |
| Prima Desheca Canada                 | Coast                    | 33.4279       | -117.6410      |
| Redondo Beach King Harbor            | Harbor                   | 33.8379       | -118.3950      |
| Refugio Creek                        | Coast                    | 34.4657       | -120.0693      |
| Revolon Slough                       | Coast                    | 34.0986       | -119.0990      |
| Rincon Creek                         | Coast                    | 34.3705       | -119.4790      |
| Salt Creek                           | Coast                    | 33.4757       | -117.7290      |
| San Diego Creek                      | Newport Bay              | 33.5868       | -117.8840      |
| San Diego River                      | Coast                    | 32.7529       | -117.2610      |
| San Dieguito River                   | Coast                    | 32.9661       | -117.2820      |
| San Gabriel River                    | Coast                    | 33.7358       | -118.1280      |
| San Jose Creek                       | Tributary to San Gabriel River | 34.4105 | -119.8300      |
| San Juan Creek                       | Coast                    | 33.4521       | -117.6920      |
| San Luis Rey River                   | Coast                    | 33.1993       | -117.3970      |
| San Marcos Creek                     | Batiquitos Lagoon        | 33.0818       | -117.3200      |
| San Mateo Creek                      | Coast                    | 33.3770       | -117.5990      |
| San Onofre Creek                     | Coast                    | 33.3713       | -117.5930      |
| San Pedro Creek                      | Coast                    | 34.4105       | -119.8300      |

(continued on next page)
Table 2 (continued)

| Discharge Name                                           | Discharge Point        | Latitude (° N) | Longitude (° E) |
|----------------------------------------------------------|------------------------|----------------|-----------------|
| Santa Ana Delhi Channel                                  | Newport Bay            | 33.5868        | −117.8840       |
| Santa Ana River                                          | Coast                  | 33.6292        | −117.9660       |
| Santa Clara River                                        | Coast                  | 34.2196        | −119.2740       |
| Santa Margarita River                                    | Coast                  | 33.2221        | −117.4210       |
| Santa Monica Canyon                                      | Coast                  | 34.015         | −118.5310       |
| Segunda Deshecha                                         | Coast                  | 34.4279        | −117.6410       |
| Solstice Canyon                                          | Coast                  | 34.0182        | −118.7680       |
| Sweetwater River                                         | Mission Bay            | 32.6596        | −117.2470       |
| Tecolote Creek                                           | Mission Bay            | 32.7529        | −117.2610       |
| Tijuana River                                            | Coast                  | 32.5464        | −117.1360       |
| Topanga Creek                                            | Coast                  | 34.0297        | −118.5960       |
| Trancas Canyon                                           | Coast                  | 34.0229        | −118.8470       |
| Tuna Canyon                                              | Coast                  | 34.0297        | −118.5960       |
| Ventura River                                            | Coast                  | 34.2717        | −119.3150       |
| Walnut Canyon                                            | Coast                  | 33.9987        | −118.8100       |
| Zuma Canyon Lagoon                                       | Coast                  | 34.0054        | −118.8290       |

Large POTW

| Discharge Name                                           | Discharge Point        | Latitude (° N) | Longitude (° E) |
|----------------------------------------------------------|------------------------|----------------|-----------------|
| Hyperion Treatment Plant                                  | Ocean                  | 33.9120        | −118.5214       |
| Joint Water Pollution Control Plant                       | Ocean                  | 33.6892        | −118.3167       |
| Orange county Sanitation District                         | Ocean                  | 33.5767        | −118.0100       |
| Point Loma Wastewater Treatment Plant                     | Ocean                  | 32.6653        | −117.3236       |

Small POTW

| Discharge Name                                           | Discharge Point        | Latitude (° N) | Longitude (° E) |
|----------------------------------------------------------|------------------------|----------------|-----------------|
| Aliso Creek Ocean Outfall                                | Ocean                  | 33.5453        | −117.8150       |
| Avalon Wastewater Treatment Facility                     | Ocean                  | 33.3049        | −118.3630       |
| Southern Regional Tertiary Treatment Plant               | Ocean                  | 33.1611        | −117.3930       |
| Carpinteria Sanitary District Wastewater Treatment Plant | Ocean                  | 34.3849        | −119.5310       |
| El Estero Wastewater Treatment Facility                  | Ocean                  | 34.3888        | −119.6710       |
| Encina Ocean Outfall                                     | Ocean                  | 33.1103        | −117.3510       |
| Fallbrook Wastewater Treatment Plant                     | Ocean                  | 33.1611        | −117.3930       |
| Goleta Sanitary District                                 | Ocean                  | 34.4017        | −119.8241       |
| Hale Ave. Resource Recovery                              | Ocean                  | 33.0048        | −117.2990       |
| Montecito Sanitary District Wastewater Treatment Facility| Ocean                  | 34.4098        | −119.6560       |
| Oceanside Ocean Outfall                                  | Ocean                  | 33.1611        | −117.3930       |
| Oxnard Wastewater Treatment Plant                        | Ocean                  | 34.1262        | −119.1890       |
| San Clemente Island Wastewater Treatment Plant           | Ocean                  | 33.0102        | −118.5480       |
| San Elijo Water Reclamation Ocean Outfall                | Ocean                  | 33.0048        | −117.2990       |
| San Juan Creek Outfall                                   | Ocean                  | 33.4362        | −117.6990       |
| South Bay International Wastewater Treatment Plant       | Ocean                  | 32.5373        | −117.1880       |
| South Bay Water Reclamation Plant                        | Ocean                  | 32.5373        | −117.1880       |
| Summerland Sanitary District                             | Ocean                  | 34.4142        | −119.6090       |
| Terminal Island Water Reclamation                       | Ocean                  | 33.7154        | −118.2540       |

Inland POTW

| Discharge Name                                           | Discharge Point        | Latitude (° N) | Longitude (° E) |
|----------------------------------------------------------|------------------------|----------------|-----------------|
| Burbank Water Reclamation Plant                          | Los Angeles River      | 33.7408        | −118.2190       |
| Camarillo Valley Wastewater Treatment Plant              | Calleguas Creek        | 34.0986        | −119.0990       |
| Glendale Water Reclamation Plant                         | Los Angeles River      | 33.7408        | −118.2190       |
| Hill Canyon Wastewater Treatment Plant                   | Calleguas Creek        | 34.0986        | −119.0990       |
| Los Angeles County Sanitation District                  | San Gabriel River      | 33.7358        | −118.1280       |
| Long Beach Wastewater Reclamation Plant                  | San Gabriel River      | 33.7358        | −118.1280       |
| Los Coyotes Water Reclamation Plant                     | San Gabriel River      | 33.7358        | −118.1280       |
| Michaelson Treatment Plant                               | San Diego Creek        | 33.5868        | −117.8840       |
| Ojai Valley Wastewater Treatment Plant                   | Ventura River          | 34.2717        | −119.3150       |
| Padre Dam Wastewater Reclamation Facility                | San Diego River        | 32.7529        | −117.2610       |
| San Jose Water Reclamation Plant                         | San Gabriel River      | 33.7358        | −118.1280       |
| Saugus Water Treatment Plant                             | Santa Clara River      | 34.2196        | −119.2740       |
| Simi Valley County Sanitation                            | Calleguas Creek        | 34.0986        | −119.0990       |
| Tapia Wastewater Treatment Plant                         | Malibu Creek           | 34.0294        | −118.6820       |
| Tillman Treatment Plant                                  | Los Angeles River      | 33.7408        | −118.2190       |
| Valencia Wastewater Reclamation Plant                    | San Gabriel River      | 33.7358        | −118.1280       |
| Ventura Wastewater Reclamation Plant                     | Santa Clara River      | 34.2196        | −119.2740       |
| Whittier Narrows Water Reclamation Plant                 | San Gabriel River      | 33.7358        | −118.1280       |
Fig. 1. Time series of each flow type of volume flux, total N, and total P fluxes summed for 1997–2017. b), d), and f) are zoomed in version of a), c), and e) to show the magnitudes of each flow type. Data plotted here come from files ’rivers_1997_2017_daily.xlsx’, ’major_potw_1971_2017.xlsx’, and ’minor_potw_1997_2017.xlsx’.

(EPA ECHO), California Integrated Water Quality System Project (CIWQS), California Environmental Data Exchange Network (CEDEN), Santa Barbara Coastal Long-Term Ecological Research (SBC LTER [6]), U.S. Geological Survey (USGS), California Department of Water Resources (DWR), California State Water Resources Control Board, Los Angeles Department of Public Works (LADPW), Orange County Public Works (OCPW), Los Angeles City Sanitation (LASAN), Los Angeles County Sanitation District (LACSD), Orange County Sanitation District (OC San), City of San Diego, International Boundary & Water Commission (IBWC) and Tetra Tech.

Data for the time period of 1997–2017 were prioritized. Often, data for the large and small POTWs were reported at a monthly or quarterly basis and were extrapolated to daily values. Data gaps in constituent concentrations were addressed through expert analyses. These analyses included interpolation between data points, extrapolation from historical sampling, and/or using ratios of related constituents to calculate other constituents (e.g., biological oxygen demand is related to total organic carbon).
Large POTW data extend over the time period of 1971–2017. Data were collected through online electronic databases (i.e. EPA ECHO, CIWQS after 2007) and by direct request from the respective sanitary districts (before 2007).

River flow data were largely collected from gauge data from the organizations SCCWRP, USGS, CEDEN, DWR, LADPW, and OCPW. Where flow data were missing, a rainfall-runoff model was used, which is originally described in Ackerman and Schiff [3] and employed to quantify nutrient and carbon loading in Sengupta et al. [4]. River alkalinity and silicate were derived based on an empirical statistical model based on geology, soils and other natural gradients per the methodology of Olson and Hawkins [7] (see also supplemental information in Sutula et al. [5]).

Santa Margarita River watershed discharge and constituents were modeled based from a Hydrologic Simulation Program-FORTRAN (HSPF) model of that watershed [2].

Three-quarters of the Tijuana River watershed lies in Mexico. Dry weather and low-volume wet weather flow from the Tijuana River, which include in-stream discharges from Mexican primary wastewater treatment plants, are diverted at the U.S.-Mexican border and sent for treatment at the South Bay International Treatment Plant and other wastewater facilities in Mexico. Occasionally, sewage spills and large storm events cause “transboundary” discharges that flow freely (undiverted) to the Tijuana River and the U.S. coastal waters. Tijuana River flow and constituent data were derived from the IBWC Tijuana River gauge at the international border and their 2018–2019 water quality report, respectively [8]. IBWC-reported transboundary flows were incorporated into the flow data as well.

Riverine constituent concentration data were derived from SCCWRP research study data, SBC LTER [6], and CEDEN unless otherwise noted. Instantaneous constituent concentration values from these datasets were aggregated into four periods: 1) winter storm, 2) summer storm, 3) winter dry weather (base flow) and 4) summer dry weather. “Summer” is defined as May through October, while “winter” is designated as November through April. For each river, wet weather storm flows were designated by taking the median of all flows during the months of November to April (Southern California wet/winter season). Flows greater than twice this wet weather median were considered storm events and were assigned summer storm or winter storm concentrations based on which month the flow occurred. Wet weather concentrations were assigned to these storm days plus each of the three days following a wet weather event, which is defined by SCB stormwater managers as the typical time to return to base flow conditions. All remaining days were designated as dry weather base flow and assigned their respective seasonal concentrations.

Ethics Statement

Not applicable.

CRediT Author Statement

Martha Sutula: Conceptualization, Methodology, Funding acquisition, Project administration, Visualization, Writing - original draft; Minna Ho: Conceptualization, Methodology, Data curation, Validation, Visualization, Writing - original draft; Ashmita Sengupta: Conceptualization, Methodology, Data curation, Writing - original draft; Fayçal Kessouri: Funding acquisition, Project administration; Karen McLaughlin: Data curation, Writing - review & editing; Kenny McCune: Data curation, Methodology Daniele Bianchi: Validation, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.
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