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December 9, 2025

TO: California Coastal Commissioners and Interested Public

FROM: Hollie Hall, Ph.D., Water Quality Analyst, Senior Environmental Scientist
Rachel Pausch, Ph.D., Ecologist, Senior Environmental Scientist

SUBJECT: **Tijuana River Pollution Crisis: Literature Review on Water Quality and Ecological Impacts**

Commission staff has prepared and is sharing the attached draft document, *Tijuana River Pollution Crisis: Literature Review on Water Quality and Ecological Impacts*, to invite review and contributions. The goal of this document is to help establish a shared research foundation that can be further built upon through feedback from researchers and stakeholders to help inform future research priorities and action-oriented responses to water quality degradation and potential ecological impacts caused by transboundary pollution in the Tijuana River system. Commission staff's goal is to adapt this draft compilation based on further guidance and input on how it can be improved, expanded, and made most useful to researchers, stakeholders and affected communities. This document is intended to be a living, evolving tool that will continue to grow as long as these issues remain relevant. Commission staff is sharing this document in draft form to reflect that evolution and in recognition of that fact that while we have attempted to be as comprehensive as possible in our search and compilation, relevant research or studies may have unintentionally been omitted. We therefore welcome and encourage contributions from stakeholders, partner agencies, researchers, and the public—whether additional studies, resources, or suggestions—so that this compilation is better able to reflect the most comprehensive and current understanding available.

Comments with the subject line **"Tijuana River Pollution"** may be submitted via email to **Hollie.Hall@coastal.ca.gov** and **Rachel.Pausch@coastal.ca.gov**. Staff will review and incorporate feedback into future updates to this compilation.

Tijuana River Pollution Crisis: Literature Review on Water Quality and Ecological Impacts

Hollie Hall, Ph.D., California Coastal Commission Water Quality Analyst
Rachel Pausch, Ph.D., California Coastal Commission Ecologist

Introduction

The Tijuana River watershed, which spans the US–Mexico border, faces chronic challenges driven by untreated sewage discharges, stormwater runoff, industrial pollution, sedimentation, and deteriorating infrastructure. The watershed is also home to a mosaic of habitat types through the river valley and the largest coastal wetland in southern California.

This draft document reflects Commission staff's effort to compile peer-reviewed research, theses, and other reports related to water quality and ecological findings in and around the Tijuana River Valley, Tijuana River Estuary, and directly offshore. Commission staff endeavored to be as comprehensive as possible in their search but additional relevant research and reports may be available and can be included when identified. Commission staff included papers that document water quality or ecological conditions in the area that may be related to pollution and sewage flows through the Tijuana River. Recent publications from 2017 onward are organized by topic—first by water quality and ecological themes, then alphabetically by the first author's last name. Each citation includes an abstract or an excerpt from the executive summary that highlights the document's key findings. Additional studies published in 2016 or earlier are listed as references at the end of the document.

This collection has been assembled to help establish a shared research foundation that can be further built upon through feedback from researchers and stakeholders to help inform future research priorities and action-oriented responses to water quality degradation and potential ecological impacts caused by transboundary pollution in the Tijuana River system. Commission staff's goal is to adapt this compilation with guidance on how it can be improved, expanded, and made most useful to researchers, stakeholders and affected communities. This document is intended to be a living, evolving tool that will continue to grow as long as these issues remain relevant. To that end, Commission staff welcomes and encourages contributions from the researchers, stakeholders and the public—whether additional studies, resources, or suggestions—so that this compilation can reflect the most comprehensive and current understanding available.

Water Quality

Overview

Studies have documented a complex mix of contaminants—including human pathogens, antibiotic-resistant genes, chemical compounds, and microplastics—affecting both riverine and coastal environments. Advanced monitoring methods such as metagenomic sequencing, remote sensing, and chemical analyses indicate that pollution originates from

multiple sources and frequently crosses the international boundary, especially during rainfall events. Sediment analyses reveal legacy pollutants such as PCBs and DDT, alongside newer contaminants from industrial and consumer products, while biological indicators show seasonal patterns tied to temperature and precipitation. Recent findings also indicate that pollutants can become airborne through sea spray, expanding exposure risks to nearby communities. While the volume of polluted water flowing across the border has decreased in 2025, it is not known whether the pollutant types and concentrations in the remaining transboundary flow are also decreasing, underscoring ongoing uncertainty about the true scope of cross-border contamination.

Although this growing body of research offers valuable insight into the types and sources of pollution, it appears that much of the existing work focuses on specific contaminants and far less published research is available examining broader water-quality conditions—such as turbidity, nutrient levels, salinity, and other basic physical and chemical parameters—that are essential to habitat health and ecological productivity. Based on our initial findings, it also appears that important areas may be understudied, including nonpoint source pollution from the U.S. side of the watershed, groundwater quality, and potential impacts from hazardous materials. As a result, it appears that while the current literature documents pollution in detail, it may not yet provide a complete picture and would benefit from additional work, including on how water-quality processes and coastal resources protected under the Coastal Act are being affected.

Scientific Studies

Allsing, N., Kelley, S. T., Fox, A. N., & Sant, K. E. (2022). Metagenomic analysis of microbial contamination in the US portion of the Tijuana River watershed. *International Journal of Environmental Research and Public Health*, *20*(1), 600. https://doi.org/10.3390/ijerph20010600

The Tijuana River watershed is binational, flowing from Tijuana, Mexico into San Diego and Imperial Beach, USA. Aging sewage and stormwater infrastructure in Tijuana has not kept pace with population growth, causing overflows into this watershed during major rainfall or equipment failures. The public health consequences of this impaired watershed on the surrounding communities remain unknown. Here, we performed untargeted metagenomic sequencing to better characterize the sewage contamination in the Tijuana River, identifying potential pathogens and molecular indicators of antibiotic resistance in surface waters. In 2019-2020, water samples were collected within 48 h of major rainfall events at five transborder flow sites and at the mouth of the river in the US portion of the Tijuana River and estuary. After filtration, DNA was extracted and sequenced, and sequences were run through the Kaiju taxonomic classification program. A pathogen profile of the most abundant disease-causing microbes and viruses present in each of the samples was constructed, and specific markers of fecal contamination were identified and linked to each site. Results from diversity analysis between the sites showed clear distinction as well as similarities between sites and dates, and antibiotic-resistant genes were found at each site. This serves as a baseline characterization of microbial exposures to these local communities.

Ayad, M., Li, J., Holt, B., & Lee, C. (2020). Analysis and classification of stormwater and wastewater runoff from the Tijuana River using remote sensing imagery. *Frontiers in Environmental Science*, *8*, 599030. https://doi.org/10.3389/fenvs.2020.599030

Urban runoff represents the primary cause of marine pollution in the Southern California coastal oceans. This study focuses on water quality issues originating from the Tijuana River watershed, which spans the southwest border of the United States and Mexico. Frequent discharge events into the coastal ocean at this boundary include stormwater and wastewater. This study focuses on differences in spectral features, as assessed by RapidEye, Sentinel-2 A/B, and Landsat-8 satellite data, along with physical and biological *in situ* data, to characterize and classify plumes into four key categories: stormwater, wastewater, open ocean/no plume, and mixed (when both types of plumes are present). Key spectral differences in the visible to NIR bands showed that stormwater had elevated reflectance (0.02 to 0.09), followed by mixed (0 to 0.08), wastewater (0 to 0.05), and open ocean/no plume (0 to 0.03) events. We also examined biophysical parameters and found that stormwater events had the highest values in remote sensing based estimates of colored dissolved organic matter (CDOM) (0.98 to 2.1 m^{–1}) and turbidity (12.4 to 45.7 FNU) and also had a large range for *in situ* variables of enterococcus bacteria and flow rates. This study also finds that the use of spectral features in a hierarchical cluster analysis can correctly classify stormwater from wastewater plumes when there is a dominant type. These results of this study will enable improved determination of the transport of both types of plumes and transboundary monitoring of coastal water quality across the Southern California/Baja California region.

Baumann, H., & Smith, E. M. (2018). Quantifying metabolically driven pH and oxygen fluctuations in US nearshore habitats at diel to interannual time scales. *Estuaries and Coasts, 41*, 1102–1117. https://doi.org/10.1007/s12237-017-0321-3

We compiled and examined 15 years (2002–2016) of high-frequency monitoring data from the National Estuarine Research Reserve System (NERRS) to characterize diel to interannual variability of pH and dissolved oxygen (DO, % saturation) across 16 diverse, shallow-water habitats along the US Atlantic, Gulf of Mexico, Caribbean, and Pacific coasts. We asked whether these systems exhibit a common pH/DO relationship, whether there were detectable interannual trends in temperature, pH, and DO within and across systems, and how pH/DO dynamics would relate to measured levels of nutrients and chlorophyll. Our analyses confirmed that large, metabolically driven, and thus concurrent fluctuations of pH and DO are a unifying feature of nearshore habitats. Moreover, we derived well-constrained relationships that predict (i) monthly mean pH or (ii) mean diel pH fluctuations across systems based on habitat mean salinity and (i) mean DO or (ii) mean diel DO fluctuations. This suggests that common metabolic principles drive diel to seasonal pH/DO variations within as well as across a diversity of estuarine environments. Yearly pH and DO anomalies did not show monotonous trends over the study period and differed considerably between sites and regions. However, weekly anomalies of means, diel minima, and diel ranges of pH and DO changed significantly over time and were strongly correlated to temperature anomalies. These general patterns lend strong empirical support to the notion that coastal acidification—in addition to being driven by eutrophication and atmospheric CO2 increases—is exacerbated simply by warming, likely via increasing community respiration. Nutrient and chlorophyll dynamics were inversely related in these shallow, well-mixed systems, but higher nutrient levels were still associated with lower pH and lower DO levels in most, but not all, systems. Our analyses emphasize the particular dynamics of nearshore habitats and the critical importance of NERRS and its system-wide monitoring program.

De la Torre Martinez, C. (2023). *Risk assessment of pharmaceutical concentrations caused by binational urban water pollution in the Tijuana River Valley.* University of York. URL not available.

Pharmaceuticals are biologically active, potentially ecotoxic compounds considered contaminants of emerging concern. Though subject to increasing research interest, studies have largely focused on high-income countries in Europe and North America, leaving gaps in research of surface water in regions such as Latin America. This study presents the first quantification of pharmaceutical concentrations in the binational Tijuana River located in the northwest U.S.-Mexico border between the cities of San Diego and Tijuana, where 8 sampling sites were monitored for a total of 70 compounds, 57 corresponding to pharmaceutical ingredients across 17 therapeutic classes, as well as 13 non-pharmaceutical compounds belonging to 6 chemical classes. Sampling was performed during the dry weather period in July, and detected 15 pharmaceuticals from eight therapeutic classes, as well as 2 non-pharmaceutical compounds from different chemical classes. Overall mean concentrations ranged from 15 ng/l to 16578 ng/l. The most abundant therapeutic classes found were analgesics, stimulants and antibiotics. A risk assessment of ecotoxicological effects calculated hazard quotients (HQ) considering apical and nonapical predicted no effect concentrations (PNEC) values for detected compounds determined that 7 compounds exceeded a HQ of 1 for apical or nonapical effects: caffeine, clarithromycin, erythromycin, ketoconazole, nicotine, paracetamol and bisphenol S, posing a potential risk to aquatic organisms present in the Tijuana River and Estuary. Concentrations of pharmaceuticals were highest in upstream sampling sites and in sites where transboundary sewage flows originating in Mexico were determined to be the main source of water pollution, with evidence of pollution from industrial flows as well, though some wastewater inputs of potential risk from U.S. sources were also identified. These findings provide a foundation for future water quality monitoring of pharmaceuticals and other contaminants of emerging concern in the Tijuana River Valley.

Espinoza, J. (2023). *Identification and assessment of constituents of emerging concern in the Tijuana River stormwater*. San Diego State University. https://digitalcollections.sdsu.edu/do/88d15855-673b-4c01-92e6-3bfe34f17695

Every year, thousands of chemical compounds are introduced into the market with little information tied to their potential environmental and public health impacts. These compounds, known as constituents of emergency concern (CECs) have become widespread in the waters of the Tijuana River Watershed (TRW). Tijuana Mexico has been struggling to maintain sewage infrastructure demands from a steadily growing population and booming industrial sector. Discharges of raw untreated sewage flows and crosses international boundary lines and outflows through into Tijuana River Valley (TRV) and out the Tijuana River Estuary (TRE) located in Imperial Beach, California. Research efforts are inconsistent, infrequent, and are limited in identifying CECs near the San Diego-Tijuana border. The extent and full impact of sewage, urban, and industrial runoff has yet to be understood as traditional monitoring methods mainly only look for a targeted list of pollutants. A non- targeted analytical approach can be useful in identifying and yielding a much higher number of CECs for environmental matrices. This study seeks to identify a comprehensive list of CECs in the transboundary outflows of stormwater from the Tijuana River using a novel analytical technique based on comprehensive two-dimensional gas chromatography coupled with time-of-flight mass spectrometry (GC×GC/TOF-MS). A total of 1,025 chromatographic features were detected and run through the National Institute of

Standards and Technology (NIST) Electron Impact (EI) mass spectral library where 392 compounds were tentatively identified based on their mass spectral similarity. Compounds were then categorized based on their usage and presence on the regulatory list. Out of the 392 tentatively identified compounds, 224 appeared on a regulatory list, 175 appeared in US EPA's Toxic Substance Control Act (TSCA), 182 are patented to be used in a variety of products, 129 have biological roles, 92 have industrial uses, 85 are food additives, 80 are used in consumer products, 50 are used in personal care products, 33 have different chemical roles, 31 have medicinal roles/ uses, and 17 have no information on their usage or regulations tied to them.

Harvey, M. E., Giddings, S. N., Pawlak, G., & Crooks, J. A. (2023). Hydrodynamic variability of an intermittently closed estuary over interannual, seasonal, fortnightly, and tidal timescales. *Estuaries and Coasts*, *46*(1), 84–108. https://doi.org/10.1007/s12237-021-01014-0

Small low-inflow intermittently closed estuaries are common in Mediterranean climates worldwide; however, despite their important contributions to ecosystem services and coastal resilience, their dynamics have been less well studied relative to classical (i.e., deeper, persistent freshwater inflow) estuaries. It is known that infragravity wave propagation into these estuaries can induce strong currents and that closures lead to stagnating flows and declining water quality; however, how the estuarine circulation (tidal and subtidal) dynamically drives and responds to these conditions remains largely unknown. Here we analyze over 4 years of hydrodynamic observations in Los Peñasquitos Lagoon, a low-inflow, intermittently closed estuary in Southern California, to examine wave propagation into the estuary, sill accretion, and the estuarine circulation response over tidal, fortnightly, seasonal, and interannual time scales, providing an unprecedented view as to how these systems respond to changing forcing. Wave observations near the estuary inlet show that wave energy inside the inlet, which contributes to sill accretion, is dependent on water level relative to the sill height and has a tidal variation due to wave-current interactions. Tidal phase averages of conditions during open, pre-closure, spring, neap, and closed conditions highlight the large dynamic range that these estuaries experience. During open, low sill conditions, circulation and stratification are consistent with stratification-induced periodic straining and subtidal exchange varies with the fortnightly cycle as observed in many classical estuaries. However, as the sill grows, tidal circulation weakens and becomes strongly sheared and the subtidal exchange no longer scales with a classical theoretical pressure-friction balance.

Howard, M. D. A., Smith, J., Caron, D. A., Kudela, R. M., Loftin, K., Hayashi, K., Fadness, R., Fricke, S., Kann, J., Roethler, M., Tatters, A., & Theroux, S. (2023). Integrative monitoring strategy for marine and freshwater harmful algal blooms and toxins across the freshwater-to-marine continuum. *Integrated Environmental Assessment and Management*, *19*(3), 586–604. https://doi.org/10.1002/ieam.4651

Many coastal states throughout the USA have observed negative effects in marine and estuarine environments caused by cyanotoxins produced in inland waterbodies that were transported downstream or produced in the estuaries. Estuaries and other downstream receiving waters now face the dual risk of impacts from harmful algal blooms (HABs) that occur in the coastal ocean as well as those originating in inland watersheds. Despite this risk, most HAB monitoring efforts do not account for hydrological connections in their monitoring strategies and designs. Monitoring efforts in California have revealed the

persistent detection of cyanotoxins across the freshwater-to-marine continuum. These studies underscore the importance of inland waters as conduits for the transfer of cyanotoxins to the marine environment and highlight the importance of approaches that can monitor across hydrologically connected waterbodies. A HAB monitoring strategy is presented for the freshwater-to-marine continuum to inform HAB management and mitigation efforts and address the physical and hydrologic challenges encountered when monitoring in these systems. Three main recommendations are presented based on published studies, new datasets, and existing monitoring programs. First, HAB monitoring would benefit from coordinated and cohesive efforts across hydrologically interconnected waterbodies and across organizational and political boundaries and jurisdictions. Second, a combination of sampling modalities would provide the most effective monitoring for HAB toxin dynamics and transport across hydrologically connected waterbodies, from headwater sources to downstream receiving waterbodies. Third, routine monitoring is needed for toxin mixtures at the land–sea interface including algal toxins of marine origins as well as cyanotoxins that are sourced from inland freshwater or produced in estuaries. Case studies from California are presented to illustrate the implementation of these recommendations, but these recommendations can also be applied to inland states or regions where the downstream receiving waterbody is a freshwater lake, reservoir, or river.

International Boundary and Water Commission United States and Mexico. (2020). Binational Water Quality Study of the Tijuana River and Adjacent Canyons and Drains. https://www.ibwc.gov/wp-content/uploads/2023/08/Min320_Binational_Report_TJ_River_Watershed_with_Appendix090120.pdf

This binational study, carried out under the framework of IBWC Minute 320, undertook a one-year monitoring effort (December 2018–November 2019) to characterize water and sediment quality in the Tijuana River Watershed and its adjacent canyon and drain tributaries. Monthly and quarterly sampling was conducted at eight sites spanning the US–Mexico border region—covering the Tijuana River, Alamar River, and six transboundary canyon/drain systems. Laboratory analyses measured 267 water-quality parameters (131 of which were not detected) and corresponding sediment parameters, with results evaluated against binational regulatory criteria. Findings revealed elevated concentrations of ammonia, biochemical oxygen demand (BOD), chemical oxygen demand (COD), fats/oils/greases, phosphorus, nitrates, and fecal-indicator bacteria—indicative of untreated wastewater influence. Key metals (copper, nickel, zinc) and the plasticizer DEHP were present at concerning levels, while others (e.g., hexavalent chromium, DDT, aldrin) were either not detected or found in low concentrations. Sediment results echoed water-quality outcomes, with persistent fecal-indicator bacteria and chemical signatures linked to transboundary flows. The study concludes that aging sanitation infrastructure, industrial discharges, and uncontrolled urban runoff pose significant water-quality risks in this binational watershed. The report recommends permanent joint monitoring, infrastructure upgrades, improved industrial pretreatment, and enhanced solid-waste control as critical steps for both countries.

Landin, L. I. (2021). Seasonal Trends and Spatial Patterns of Biological Oxygen Demand and Dissolved Oxygen in the United States Tijuana River Watershed. San Diego State University. https://digitalcollections.sdsu.edu/do/9d5ca179-477f-4f2e-93db-7a7f1793aca5

The Tijuana River Watershed is a vital ecosystem for a variety of species and humans that provides habitat and recreation. For hundreds of years, the Tijuana River Valley was inhabited by the Kumeyaay Native Americans, who managed the land through natural processes. As populations grew, the river valley faced various environmental and anthropogenic threats. Sewage pollution has been documented since the 1930s and is a well-known threat to the watershed and surrounding community. As human populations increase on both sides of the border, so does this issue. Biological oxygen demand (BOD) and dissolved oxygen (DO) are used as water quality indicators and can indicate high levels of pollutants. Spatial analyses of BOD revealed no spatial trends for the duration of this study. Longitudinal analyses of DO in the US–Tijuana River revealed weak downward trends in DO levels over time. Water temperature and precipitation data were gathered to evaluate the relationship with DO for the respective time scales to reveal potential environmental influences; however, none were statistically significant as to influence DO. Seasonality proved to have the greatest impact on DO in the US reaches of the Tijuana River and Estuary. Future climate projections hypothesize that global temperatures will continue to rise, and the San Diego region can expect more pronounced seasonality. The exacerbation of these extreme events could cause a greater change in annual DO between seasons and possibly more frequent environmental health issues.

McLamb, F., Feng, Z., Shea, D., Bozinovic, K., Vasquez, M. F., Stransky, C., Gersberg, R. M., Wang, W., Kong, X., Xia, X.-R., & Bozinovic, G. (2024). Evidence of transboundary movement of chemicals from Mexico to the US in Tijuana River Estuary sediments. *Chemosphere*, *348*, 140749. https://doi.org/10.1016/j.chemosphere.2023.140749

The Tijuana River Estuary (TRE) has been a public health hazard and point of contention between the United States and Mexico for decades, with sources of pollution on both sides of the border. The goal of our study is to determine the presence and dynamics of chemical contamination in the TRE. We sampled sediment from four TRE locations in the US during stable dry conditions and immediately after a wet weather period. Organic chemicals were initially screened with non-targeted analysis using gas chromatography high-resolution mass spectrometry (GC/HRMS) that tentatively identified 6978 chemicals in the NIST 20 database. These tentative identifications were filtered using the USEPA CompTox database to guide quantitative targeted analysis at detection limits below 1 ng/g dry weight sediment. Quantitative targeted analysis of 152 organic pollutants and 18 inorganic elements via GC/HRMS revealed generally higher concentrations of contaminants in dry weather sediments compared to wet weather sediments. The highest concentrations of all chemical classes were detected at the site closest to the US-Mexico border, followed by an urban area near Imperial Beach, California, US All sites exhibited a mixture of petrogenic and pyrogenic polycyclic aromatic hydrocarbons (PAHs). Current-use pesticides were dominated by pyrethroid insecticides and the thiocarbamate herbicide s-Ethyl dipropylthiocarbamate (EPTC), while the US-banned organochlorine pesticides were dominated by chlordanes, dieldrin, and dichlorodiphenyltrichloroethane (DDT) and its degradation byproducts. Polychlorinated biphenyl (PCB) concentrations were greatest at the site closest to the US-Mexico border but in the low nanogram-per-gram range. Phthalates were only found at the same site, with relatively high concentrations of bis(2-ethylhexyl) phthalate. This study provides positive identification and quantitative concentrations for organic pollutants in TRE sediments. Our data suggest that there are multiple sources of chemical contamination in the estuary, including possible transboundary movement of pollutants from Mexico.

Mladenov, N., Biggs, T., Ford, K., Garcia, S., Yuan, Y., Grant, A., Piazza, E., Rivera, E., Pinongcos, F., Keely, S. P., Summerlin, C., Crooks, J. A., & Liden, D. (2024). Evaluation of real-time fluorescence sensors and benchtop fluorescence for tracking and predicting sewage contamination in the Tijuana River Estuary at the US-Mexico border. *Science of the Total Environment*, *950*, 175137. https://doi.org/10.1016/j.scitotenv.2024.175137

Cross-border flow of untreated sewage from Mexico into the USA via the Tijuana River is public health issue with negative consequences for coastal communities. Here we evaluate the potential application of fluorescence-based, submersible tryptophan-like (TRP) and humic-like (CDOM) fluorescence sensors for real-time tracking of wastewater pollution in an estuarine environment. Sonde fluorescence measurements were compared with benchtop fluorescence, fecal indicator bacteria (FIB) concentrations, and real-time specific conductivity measurements in the Tijuana River Estuary during dry and wet weather conditions, and with and without cross-border flow. TRP and CDOM fluorescence concentrations were low during times without cross-border flow and two-three orders of magnitude higher during storm events and after cross-border sewage flow events. Major deterioration in water quality, including hypoxic conditions, was observed after consistent, long-term cross-border sewage flow. Real-time TRP and CDOM fluorescence concentrations had a significant linear relationship with fecal indicator bacteria (FIB) concentrations during dry weather periods with cross-border flow ($p < 0.001$) but were poorly correlated during stormflow and during less polluted periods with no cross-border flow. TRP and CDOM fluorescence acquired on discrete samples using a benchtop fluorometer correlated significantly ($p < 0.001$) with FIB concentrations under all cross-border flow conditions. Based on relationships between benchtop TRP fluorescence and percent wastewater, the greatest amount of untreated wastewater in the estuary's surface layer during cross-border flow events was estimated at >80 % and occurred during neap tides, when concentrated, sewage-laden freshwater flowed over dense saline seawater due to stratification and lack of mixing in the estuary. These results are important because exposure to untreated sewage poses severe health risks for residents and visitors to adjacent coastal areas. While benchtop fluorescence was more effective for estimating the degree of wastewater pollution, submersible TRP and CDOM sensors provided a real-time alert of sewage contamination, which can be utilized in other sewage impacted estuarine environments.

Pendergraft, M. A., Belda-Ferre, P., Petras, D., Morris, C. K., Mitts, B. A., Aron, A. T., Bryant, M., Schwartz, T., Ackermann, G., Humphrey, G., Kaandorp, E., Dorrestein, P. C., Knight, R., & Prather, K. A. (2023). Bacterial and chemical evidence of coastal water pollution from the Tijuana River in sea spray aerosol. *Environmental Science & Technology*, *57*(10), 4071–4081. https://doi.org/10.1021/acs.est.2c02312

Roughly half of the human population lives near the coast, and coastal water pollution (CWP) is widespread. Coastal waters along Tijuana, Mexico, and Imperial Beach (IB), USA, are frequently polluted by millions of gallons of untreated sewage and stormwater runoff. Entering coastal waters causes over 100 million global annual illnesses, but CWP has the potential to reach many more people on land via transfer in sea spray aerosol (SSA). Using 16S rRNA gene amplicon sequencing, we found sewage-associated bacteria in the polluted Tijuana River flowing into coastal waters and returning to land in marine aerosol. Tentative chemical identification from non-targeted tandem mass spectrometry identified anthropogenic compounds as chemical indicators of aerosolized CWP, but they

were ubiquitous and present at highest concentrations in continental aerosol. Bacteria were better tracers of airborne CWP, and 40 tracer bacteria comprised up to 76% of the bacteria community in IB air. These findings confirm that CWP transfers in SSA and exposes many people along the coast. Climate change may exacerbate CWP with more extreme storms, and our findings call for minimizing CWP and investigating the health effects of airborne exposure.

Piñon-Colin, T. D. J., Wakida, F. T., Rogel-Hernandez, E., Wakida-Kusunoki, A. T., Garcia-Flores, E., & Magaña, H. (2024). Microplastics in the sediments of the Tijuana River Basin, Mexico. *International Journal of Environmental Science and Technology, 21*(13), 8361-8374. https://doi.org/10.1007/s13762-024-05609-5

The current study evaluates the abundance and characteristics (shape, color and chemical composition) of microplastics (MPs) of the Tijuana River Basin, a binational river system shared by Mexico and the USA and located in the northwest corner of Mexico. The investigation was conducted on microplastics in the riverbed and river shoreline of 11 sites along the main tributaries of the Tijuana River. The median abundance of riverbed and river shoreline sediments was 118 and 183 MPs kg−1, respectively. The dominant shape found was fiber (65%) followed by fragments (19%) and films (10%); the predominant identified polymers were PP polypropylene (46%), PE polyethylene (34.3%) and PS polystyrene (11.4), with lower numbers of polyacrylic, polyamide (PA) and polyethylene terephthalate (PET). Eleven colors were recorded, the most abundant being black (43.7%) and transparent (22.6%). Wastewater treatment plant (WWTP) discharges, littering and inappropriate or insufficient solid waste management are the main sources of MPs. The results highlighted the widespread distribution of MPs in the Tijuana River Basin sediment.

Scrivner, E., Mladenov, N., Biggs, T., Grant, A., Piazza, E., Garcia, S., Lee, C. M., Ade, C., Tufillaro, N., Grötsch, P., Zurita, O., Holt, B., & Sousa, D. (2025). Hyperspectral characterization of wastewater in the Tijuana River Estuary using laboratory, field, and EMIT satellite spectroscopy. *Science of The Total Environment*, *981*, Article 179598. https://doi.org/10.1016/j.scitotenv.2025.179598

Hundreds of millions of liters of untreated wastewater are discharged into the Tijuana River annually, impacting communities on both sides of the US-Mexico border. Current monitoring methods are resource-intensive and limited in coverage. Optical satellite imaging may enable broader spatiotemporal monitoring, yet retrievals of bacterial concentrations and other key water quality indicators remain challenging. Here we investigate the utility of spectroscopic sensors to monitor the presence of wastewater in this estuarine-coastal system, as a proxy for bacterial concentrations and other water quality parameters. We prepared dilutions of untreated wastewater and uncontaminated seawater, measuring visible through shortwave infrared (VSWIR; 350–2500 nm) reflectance spectra of each sample. At high wastewater concentrations, a distinct spectral feature centered near 620 nm strongly correlated with paired water quality measurements ($R2 \geq 0.97$, p-value < 0.01). This feature is additionally observed in multispectral resolution, in field observations, and in hyperspectral satellite imagery. An example application of plume mapping with this feature is presented, representing one of the earliest adoptions of EMIT hyperspectral satellite imagery for water quality monitoring. These results are promising for the use of spectroscopic sensors to map and monitor wastewater pollution in the Tijuana River Estuary and potentially, similarly polluted coastal and estuarine systems.

Shahar, S., Sant, K. E., Allsing, N., & Kelley, S. T. (2024). Metagenomic analysis of microbial communities and antibiotic resistant genes in the Tijuana River, and potential sources*. Environmental Pollution*, *342*, Article 123067. https://doi.org/10.1016/j.envpol.2023.123067

The Tijuana River is a transborder river that flows northwest across the border from Baja California in Mexico into Southern California before discharging into the Pacific Ocean. The river is frequently contaminated with raw sewage due to inadequate sanitary infrastructure in Tijuana. To assess the type and degree of microbial contamination, water samples were collected monthly from a near-border and an estuarine site from August 2020 until May 2021. A portion of each sample was used for epifluorescent microscopy and DNA was extracted directly from the rest for shotgun metagenomic sequencing. After sequence quality checking and processing, we used the rapid taxonomic identifier tool Kaiju to characterize the microbial diversity of the metagenomes and matched the sequences against the Comprehensive Antibiotic Resistance Database (CARD) to examine antimicrobial resistance genes (ARGs). Bacterial and viral-like particle (VLP) abundance was consistently higher in the near-border samples than in the estuarine samples, while alpha diversity (within sample biodiversity) was higher in estuarine samples. Beta-diversity analysis found clear compositional separation between samples from the two sites, and the near-border samples were more dissimilar to one another than were the estuarine sites. Near-border samples were dominated by fecal-associated bacteria and bacteria associated with sewage sludge, while estuarine sites were dominated by marine bacteria. ARGs were more abundant at the near-border site, but were also readily detectable in the estuarine samples, and the most abundant ARGs had multi-resistance to beta-lactam antibiotics. SourceTracker analysis identified human feces and sewage sludge to be the largest contributors to the near-border samples, while marine waters dominated estuarine samples except for two sewage overflow dates with high fecal contamination. Overall, our research determined human sewage microbes to be common in the Tijuana River, and the prevalence of ARGs confirms the importance of planned infrastructure treatment upgrades for environmental health.

Steele, J. A., Blackwood, A. D., Griffith, J. F., Noble, R. T., & Schiff, K. C. (2018). Quantification of pathogens and markers of fecal contamination during storm events along popular surfing beaches in San Diego, California. *Water Research*, *136*, 137–149. https://doi.org/10.1016/j.watres.2018.01.056

Along southern California beaches, the concentrations of fecal indicator bacteria (FIB) used to quantify the potential presence of fecal contamination in coastal recreational waters have been previously documented to be higher during wet weather conditions (typically winter or spring) than those observed during summer dry weather conditions. FIB are used for management of recreational waters because measurement of the bacterial and viral pathogens that are the potential causes of illness in beachgoers exposed to stormwater can be expensive, time-consuming, and technically difficult. Here, we use droplet digital Polymerase Chain Reaction (digital PCR) and digital reverse transcriptase PCR (digital RT-PCR) assays for direct quantification of pathogenic viruses, pathogenic bacteria, and source-specific markers of fecal contamination in the stormwater discharges. We applied these assays across multiple storm events from two different watersheds that discharge to popular surfing beaches in San Diego, CA. Stormwater discharges had higher FIB concentrations as compared to proximal beaches, often by ten-fold or more during wet weather. Multiple lines of evidence indicated that the stormwater discharges contained

human fecal contamination, despite the presence of separate storm sewer and sanitary sewer systems in both watersheds. Human fecal source markers (up to 100% of samples, 20-12440 HF183 copies per 100 ml) and human norovirus (up to 96% of samples, 25-495 NoV copies per 100 ml) were routinely detected in stormwater discharge samples. Potential bacterial pathogens were also detected and quantified: *Campylobacter* spp. (up to 100% of samples, 16-504 gene copies per 100 ml) and *Salmonella* (up to 25% of samples, 6-86 gene copies per 100 ml). Other viral human pathogens were also measured, but occurred at generally lower concentrations: adenovirus (detected in up to 22% of samples, 14-41 AdV copies per 100 ml); no enterovirus was detected in any stormwater discharge sample. Higher concentrations of avian source markers were noted in the stormwater discharge located immediately downstream of a large bird sanctuary along with increased *Campylobacter* concentrations and notably different *Campylobacter* species composition than the watershed that had no bird sanctuary. This study is one of the few to directly measure an array of important bacterial and viral pathogens in stormwater discharges to recreational beaches, and provides context for stormwater-based management of beaches during high risk wet-weather periods. Furthermore, the combination of culture-based and digital PCR-derived data is demonstrated to be valuable for assessing hydrographic relationships, considering delivery mechanisms, and providing foundational exposure information for risk assessment.

Torres, N. (2023). Assessing Ecosystem Health through Contaminants in the Tijuana River National Estuarine Research Reserve. University of San Diego. https://doi.org/10.22371/02.2023.003

Although the Tijuana River Estuary (TRE) remains the largest, most-intact coastal wetland in Southern California, it has a history of major changes, much of this related to its location immediately north of the US / Mexico Border. One of the primary challenges is cross-border flows from the rapidly growing city of Tijuana, Baja California, Mexico, and the delivery of wastewater, debris, and sediment to sensitive coastal wetland ecosystems. There is a need to more fully investigate these environmental changes to assess the ecosystem health of the Tijuana River Estuary over time, especially related to pollution impacts. This can inform an understanding of changes in both species and stressors, and can also help assess the effectiveness of past management strategies. Since 1986, the NOAA Mussel Watch and California Surface Water Ambient Monitoring Programs have periodically collected data on chemical contaminants and biological indicators of water quality in the TRE. This project builds on these past monitoring efforts and established methodologies to assess status and trends of contaminants in sediment and organisms. This work was accomplished by conducting a thorough review of available datasets and literature to document past changes in the estuary and refine sampling approaches. Sampling was conducted at three locations in the Tijuana River Estuary to assess spatial variability. Compared to national thresholds, most contaminant concentrations were at relatively low levels in 2021, with some having decreased from previously higher levels in the 90s. When comparing species groups, fishes had the highest organic concentrations, indicating the ongoing processes of bioaccumulation and biomagnification. Levels of some organics in fish, such as total DDT and PBDEs, remain at levels which could be of some concern for sensitive piscivorous birds. Also, the highest concentrations were near a local urban outfall point rather than from the Tijuana River itself. Overall, this information improves our ability to document and interpret long-term trajectories of contaminant change in the ambient environment and key taxa. This project’s results include

communication and management tools depicting the estuary's ecosystem health over time.

Zimmer-Faust, A. G., Steele, J. A., Xiong, X., Staley, C., Griffith, M., Sadowsky, M. J., Diaz, M., & Griffith, J. F. (2021). A combined digital PCR and next generation DNA-sequencing based approach for tracking nearshore pollutant dynamics along the southwest United States/Mexico border. *Frontiers in Microbiology*, *12*, 674214. https://doi.org/10.3389/fmicb.2021.674214

Ocean currents, multiple fecal bacteria input sources, and jurisdictional boundaries can complicate pollution source tracking and associated mitigation and management efforts within the nearshore coastal environment. In this study, multiple microbial source tracking tools were employed to characterize the impact and reach of an ocean wastewater treatment facility discharge in Mexico northward along the coast and across the Southwest United States- Mexico Border. Water samples were evaluated for fecal indicator bacteria (FIB), *Enterococcus* by culture-based methods, and human associated genetic marker (HF183) and *Enterococcus* by droplet digital polymerase chain reaction (ddPCR). In addition, 16S rRNA gene sequence analysis was performed and the SourceTracker algorithm was used to characterize the bacterial community of the wastewater treatment plume and its contribution to beach waters. Sampling dates were chosen based on ocean conditions associated with northern currents. Evidence of a gradient in human fecal pollution that extended north from the wastewater discharge across the United States/Mexico border from the point source was observed using human-associated genetic markers and microbial community analysis. The spatial extent of fecal contamination observed was largely dependent on swell and ocean conditions. These findings demonstrate the utility of a combination of molecular tools for understanding and tracking specific pollutant sources in dynamic coastal water environments.

Ecology

Overview

Inland, the Tijuana River supports riparian forest within the Tijuana River Valley, which eventually transitions to salt marsh habitat at the Tijuana Estuary. Sediment from upriver is deposited onto the marsh plain during flood events, causing long term accretion and elevation rise across the estuary system. At the mouth of the river, water flows over the beach and leaves the estuary to enter the Pacific Ocean and the Tijuana River Mouth State Marine Conservation Area. The mouth of the estuary has historically been and currently is managed to remain open to prevent anoxic conditions. Tidal influence, river flows, sediment inputs, habitat loss, and climate all shape the ecology of the area.

The Tijuana River National Estuarine Research Reserve, Tijuana Slough National Wildlife Refuge, and other institutions support long-term monitoring efforts to provide insights into the ecology of the estuary and offshore. While sewage and wastewater have flowed through the river intermittently for decades, recent years have seen untreated wastewater flow more consistently through the river valley directly to the ocean. Ongoing monitoring efforts at the estuary noted lower species richness of fish and invertebrates in the estuary following periods of high flows. This decrease in species richness and in some cases, abundance, is thought to be linked to the hypoxia (i.e., low oxygen) within the estuary due to ongoing sewage inputs. Further upstream in the riparian communities of the Tijuana

River Valley, additional work has documented higher pest infestation rates of sampled willow species located closer to polluted flows than further away.

Within the marine environment, seabirds, dolphins and other species can be used as regional biomonitors for contaminants, although limitations exist in tracing monitored contaminants and their concentrations in wildlife at the top of the food web to transboundary pollution. In 2022, three stranded bottlenose dolphins were determined to have died from sepsis caused by a bacterium that is associated with exposure to feces and contaminated food, water, and soil. While the diagnosed disease, erysipelas, could not be linked directly to sewage inputs to the marine environment, the new appearance of this disease in the region proved concerning for local bottlenose dolphin populations.

Overall, increased sediment deposition and untreated flows have changed the landscape of the estuary and likely led to intermittent anoxic conditions within the estuary. However, factors such as the mobility of wildlife and their prey, the mobility of contaminants in environmental media, and varying susceptibility of species to the impacts of contamination confound directly linking transboundary pollution to impacts on single species and across complex food webs. While the body of evidence indicates that the types of pollution detected in transboundary flows can negatively impact wildlife, the mechanisms and scale of those impacts are less clear.

While the Tijuana River National Estuarine Research Reserve and other research groups have facilitated comprehensive monitoring of estuary conditions, it appears there is less published information documenting impacts on riparian communities in the Tijuana River Valley and within the marine communities offshore. Continued monitoring within these habitats would help to document changes that relate to the protection of marine resources, biological productivity, and environmentally sensitive habitat area under the Coastal Act.

Scientific Studies

Beheshti, K., Smith, R., Page, M., Schroeter, S., & Reed, D. (2024). *2023 Annual Report of the Status of Condition A: Wetland Mitigation.* San Onofre Nuclear Generating Station (SONGS) Mitigation Program. https://marinemitigation.msi.ucsb.edu/sites/default/files/documents/wetland/2024_annual_report-SONGS_wetland_mitigation_1.pdf

Condition A of the San Onofre Nuclear Generating Station's (SONGS) coastal development permit (CDP) requires Southern California Edison (SCE) and its partners to construct or substantially restore a minimum of 150 acres of tidal wetlands, excluding buffer zone and transition, as partial mitigation for the projected reductions in populations of adult nearshore fish throughout the Southern California Bight due to operations of the power plant. San Dieguito Lagoon, located in northern San Diego County, was chosen as the wetland mitigation site... Relative standards are measured in San Dieguito Wetlands and evaluated against natural wetlands in the region that serve as reference sites. San Dieguito Wetlands must be similar to the reference wetlands to satisfy the relative performance standard requirement. San Dieguito Wetlands passed eleven performance standards that pertain to water quality, bird density and species richness, fish and invertebrate species richness in main channel and tidal creek habitats, fish density in main channel and tidal creek habitats, algal cover, and Spartina canopy architecture. San Dieguito Wetlands failed to pass the remaining four relative 4 standards that pertain to invertebrate density in main channel and tidal creek habitats, cover of vegetation, and food

chain support (density of feeding birds). A goal of the restoration project is to not only achieve the required acreage of salt marsh habitat, but also the high cover of vegetation (typically > 85%) found in the reference wetlands (Mugu Lagoon, Carpinteria Salt Marsh, and Tijuana Estuary). There was a promising increase in the acres of > 85% cover at San Dieguito Wetlands from 36.4 acres in 2022 to 46.8 acres in 2023.

Berry, D. R. (2019). Understanding the relationship between sedimentation, vegetation and topography in the Tijuana River Estuary, San Diego, CA. University of San Diego. https://digital.sandiego.edu/theses/37/

The aim of this study is to identify and characterize key geomorphic properties and relationships within the study site, the Tijuana River Estuary. This is a first step in contributing data to and assisting current and future restoration projects in employing a holistic management approach. The study identifies specific physical parameters, grain size and metal concentrations, within the estuary whose relationship to one another is not mutually exclusive and therefore should be addressed in tandem. This study also tests a remote sensing method for use as a tool for monitoring habitat changes in the estuary.

Boland, J. M., & Woodward, D. L. (2019). Impacts of the invasive shot hole borer *(Euwallacea kuroshio*) are linked to sewage pollution in southern California: the Enriched Tree Hypothesis. PeerJ, 7, e6812. https://doi.org/10.7717/peerj.6812

The Kuroshio Shot Hole Borer (KSHB, *Euwallacea kuroshio*) and the Polyphagous Shot Hole Borer (*E. whitfordiodendrus*; Coleoptera: Curculionidae: Scolytinae) have recently invaded southern California and are attacking live trees in commercial agriculture groves, urban parks and native riparian forests. Among native forests the worst impacts observed to date have been in the Tijuana River Valley in south San Diego County, where approximately 30% of the native willows (*Salix* spp.), or 120,000 trees, have died as a result of a KSHB infestation. This paper examines wood densities, wood moisture contents, KSHB infestation rates, and KSHB-induced mortality rates in two willow species (*Salix lasiolepis* and *S. gooddingii*) at sites near and far from sewage input. Comparisons were made on two spatial scales: broadly among sites within San Diego County; and locally among sites within the Tijuana River Valley. The results showed that, on average, willow trees growing closest to sewage pollution had significantly lower wood density, higher wood moisture content, higher KSHB infestation rates, and higher KSHB-induced willow mortality rates than those growing farther away. We present the Enriched Tree Hypothesis to explain the link between sewage pollution and KSHB impacts; it is as follows: (A) Riparian trees subject to nutrient enrichment from frequent sewage pollution grow quickly, and their fast growth results in wood of low density and high moisture content. If attacked by the KSHB, the trunks and branches of these nutrient-enriched trees provide an environment conducive to the fast growth of the symbiotic fungi upon which the KSHB feeds. With an abundant food supply, the KSHB population increases rapidly and the trees are heavily damaged by thousands of KSHB galleries in their trunks and branches. (B) Riparian trees not subject to frequent sewage pollution grow more slowly and have denser, drier wood. Conditions in their trunks and branches are not conducive to the fast growth of the KSHB's symbiotic fungi. The KSHB generally ignores, or has low abundances in, these slow-growing trees. This new hypothesis explains current patterns of KSHB impact in San Diego County and focuses attention on the important roles of the environment and preexisting conditions of trees in determining the extent of KSHB impact. It highlights the Tijuana River Valley as an unusual site due to high sewage inputs and

predicts that the high KSHB-induced willow mortality seen there should not occur in other natural riparian habitats in southern California. Most importantly, by identifying sewage pollution (or nutrient enrichment) as a major risk factor for KSHB impacts, the hypothesis ratchets down the KSHB-threat level for most riparian sites in southern California and directs attention to other nutrient-enriched sites as those most at risk.

Clatterbuck, C. A., Lewison, R. L., Dodder, N. G., Zeeman, C., & Schiff, K. (2018). Seabirds as regional biomonitors of legacy toxicants on an urbanized coastline. *Science of The Total Environment*, *619–620*, 460–469. https://doi.org/10.1016/j.scitotenv.2017.11.057

Seabirds are often cited as sentinels of the marine environment, but are rarely used in traditional ocean and coastal contaminant monitoring. Four classes of persistent organic pollutants (POPs, n = 68) and three trace elements (mercury, selenium, and arsenic) were measured in the eggs of California least terns (*Sterna antillarum browni*), caspian terns (H*ydroprogne caspia*), double-crested cormorants (*Phalacrocorax auritus*), and western gulls (*Larus occidentalis*) that nest in the Southern California Bight. Building on a periodic five year regional monitoring program, we measured contaminant exposure and assessed the utility of seabirds as regional contaminant biomonitors. We found that the eggs of larger, more piscivorous species generally had the highest concentrations of POPs and trace elements while California least terns had the lowest concentrations, except for mercury which was higher in least terns. As expected, DDT concentrations were elevated near the Palos Verdes Superfund site. However, we also detected a previously unknown latitudinal pattern in PBDE concentrations in least terns. POP congener profiles also confirmed differences in contamination in urban least tern colonies closest to urban centers. Though toxicants were at detectable levels across species and sites, concentrations were below those known to cause adverse effects in avian taxa and are steady or declining compared to previous studies in this region. Our results suggest that regional seabird monitoring can inform site-specific remediation and support management and protection of regionally-threatened wildlife and coastal systems. Integration of seabird contaminant data with traditional sediment, water, bivalve and fish monitoring is needed to further our understanding of exposure pathways and food web contaminant transfer.

Danil, K., Colegrove, K. M., Delaney, M. A., Mena, A., Stedman, N., & Wurster, E. (2023). Systemic erysipelas outbreak among free-ranging bottlenose dolphins, San Diego, California, USA, 2022. *Emerging Infectious Diseases*, *29*(12). https://doi.org/10.3201/eid2912.230811

We diagnosed fatal *Erysipelothrix rhusiopathiae* sepsis in 3 stranded bottlenose dolphins (*Tursiops truncatus*) during summer 2022, in San Diego, California, USA. The previously undetected disease in this relatively small, regional population of dolphins most likely indicates an environmental or biological change in the coastal ocean or organisms.

De Wet, N. K. (2025). *Characterizing Fish Communities using Traditional and Emerging Monitoring Approaches in San Diego County Estuaries*. University of San Diego. https://digital.sandiego.edu/theses/77/

...This research aimed to characterize fish species richness and evaluate the benefits and limitations of different estuary monitoring approaches. Specifically, this study compared traditional methods (block net seining, enclosure traps) with contemporary approaches

(community science (iNaturalist) and eDNA metabarcoding) to assess species richness and composition in 2023 across five San Diego estuaries: Tijuana River Estuary, San Diego Bay (Sweetwater Marsh, South Bay Salt Ponds), Mission Bay (Kendall-Frost Marsh), Los Peñasquitos Lagoon, and San Dieguito Lagoon. Additionally, long-term traditional sampling data from 2013 to 2023 at Tijuana River Estuary and San Dieguito Lagoon were compared alongside abiotic variables, including salinity, temperature, and dissolved oxygen.

In 2023, iNaturalist reported the highest species richness at most sites, except Los Peñasquitos and San Dieguito Lagoon, where traditional sampling and eDNA, respectively, yielded more detections. Species richness was lowest at Tijuana River Estuary, consistent with evidence of degraded water quality. Despite strict adherence to sampling protocols, only 10 of 89 eDNA samples yielded sufficient sequence reads, likely due to filter clogging and PCR inhibition caused by high organic content. These findings underscore the value of integrating multiple monitoring approaches, highlight the potential of community science to enhance species inventories, and emphasize the need for improved eDNA protocols tailored to the unique challenges of Southern California estuaries.

Levin, L. A., Mendoza, G. F., Neira, C., Giddings, S. N., & Crooks, J. A. (2023). Consequences of Mouth Closure and Hypoxia-Induced State Changes in Low-Inflow Estuaries: Benthic Community and Trait-Based Response. *Estuaries and Coasts*, *46*(8), 2128–2147. https://doi.org/10.1007/s12237-022-01132-3

The southern California coastline hosts low-inflow estuaries that have mouths that periodically close. Low-inflow estuaries can become hypoxic and are then often opened mechanically. The consequences of mouth closure and hypoxia (< 2 mg L−1 O2) on macrobenthic densities, species richness, diversity, composition, and biological traits were evaluated for legacy data generated by the Pacific Estuarine Research Lab for Los Peñasquitos Lagoon (LPL) (1991–2006) and Tijuana Estuary (TJE) (1988–2004). LPL closed at least annually and TJE remained open during the study period. Effects were moderated by zone within the estuary (relative to the mouth) and season. Periodic closure in LPL was associated with raised macrofaunal density and diversity, especially at the mouth, and with suppressed seasonality. Closure favored soft-bodied (non-calcified) non-bioturbating, mobile, epifaunal taxa in LPL with planktotrophic development, large branchiae, and no vision. There were more spionid and capitellid polychaetes, *Traskorchestia traskiana*, *Cerithideopsis californica*, *Tagelus californianus*, and phoronids during closure. In contrast, hypoxia (< 2 mg L−1) measured during faunal sampling was associated with lower densities in LPL and different taxonomic composition, but no difference in taxon richness or diversity. There were more corophiid amphipods, small snails, tubificid oligochaetes, *Palaemon macrodactylus* (shrimp), and *Trichorixa reticulata* (insects) under hypoxic conditions, and retention of taxa with very large or small bodies and with vision. TJE densities were nearly double those of LPL; taxon richness and diversity (H') were also higher in TJE. TJE hosted more burrowing, large-bodied, highly calcified taxa with planktotrophic development and no vision than LPL. Differences in composition and traits between the two estuaries disappeared in the middle and upper reaches, where ocean flushing was more limited. Historical long-term monitoring data for benthos, such as the data set analyzed here, offer a valuable baseline for evaluating ecosystem response to changes induced by climate, infrastructure development, contamination, or restoration.

Maione, C., Vito, D., & Fernandez, G. (2024). Monitoring the Effects of Transboundary Water Pollution in Imperial Beach, California. The 2nd International One Health Conference, 14. https://doi.org/10.3390/msf2024025014

Transboundary water pollution is a major global challenge as its movement and impacts remain unsurveyed. Monitoring pollution along international borders can reveal some of the pathways by which sewage and chemicals enter water bodies, and can hence advance the implementation of measures to prevent leakages and discharges into international waters. In this paper, we surveyed the impacts of sewage pollution and chemicals along the US–Mexico international border, using Imperial Beach (California) as a main case study. Pollution was primarily attributed to the inflow of contaminated waters from the neighboring city of Tijuana (Mexico), where a malfunctioning wastewater treatment plant and a lack of sewage pipes being upgraded have caused direct leakage and toxic discharges into the Tijuana River. Reported effects from water pollution at the Tijuana River estuary in Imperial Beach include frequent beach closure, damages to coastal ecosystems, negative impacts on the fishery industry, and several effects on the health of beach users and surfers. Hence, the situation requires urgent measures oriented at coastal management at the mouth of the Tijuana River as well as the consistent monitoring and reporting of human health effects linked to beach uses.

Safran, S., Baumgarten, S., Beller, E., Crooks, J., Grossinger, R., Lorda, J., Longcore, T., Bram, D., Dark, S., Stein, E., & McIntosh, T. (2017). *Tijuana River Valley Historical Ecology Investigation.* San Francisco Estuary Institute. https://www.sfei.org/documents/tijuana-river-valley-historical-ecology-investigation

The Tijuana River Valley Historical Ecology Investigation addresses a regional data gap by reconstructing the landscape and ecosystem characteristics of the river valley prior to the major modifications of the late 19th and 20th centuries. The research presented here, funded by the California State Coastal Conservancy, supplies foundational information at the regional and system scale about how the Tijuana Estuary, River, and valley looked and functioned in the recent past, as well as how they have changed over time. The ultimate goal of this study is to provide a new tool and framework that, in combination with contemporary research and future projections, can support and guide ongoing restoration design, planning, and management efforts in the valley.

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Acknowledgements: We thank Dr. Jeff Crooks, Research Coordinator at the Tijuana Estuary Foundation and Tijuana River National Estuarine Research Reserve, as well as Dr. Corey Clatterbuck of the California Coastal Commission for their assistance in compiling these resources.