Final Report

Comprehensive Study of Effects from the Carmel Area Wastewater District Discharge on Carmel Bay Area of Special Biological Significance

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Submitted to:
Ed Waggoner
Carmel Area Wastewater District
P.O Box 221428 3945 Rio Road
Carmel, CA 93922

Submitted by:
Applied Marine Sciences
Santa Cruz, California

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1. Background

State Water Board resolution 84-78 permitted the Carmel Area Wastewater District (CAWD) to discharge municipal wastewater into the Carmel Bay Area of Special Biological Significance (ASBS), providing that certain requirements are met. This resolution specified that a comprehensive study must be performed every 10 years to determine whether changes to the ASBS are occurring because of the discharge. Such a comprehensive study was last completed June 1, 2013. The requirement for a comprehensive study is reiterated in Order R3-2014-0012, NPDES Number CA0047996. This order requires that the results of the Comprehensive Study be submitted by March 31st, 2023. This report is submitted in partial satisfaction of Order R3-2014-0012, NPDES Number CA0047996.

CAWD discharges highly treated municipal wastewater into Carmel Bay through a multiport diffuser at a depth of approximately 40 feet. For the five most recent calendar years from 2018 through 2022, the total annual volume discharged has ranged from 39 – 356 million gallons. The composition of the effluent changes seasonally in response to water requirements of the Pebble Beach Community Services District (PBCSD). PBCSD accepts a mix of treated wastewater and potable water produced by treatment of the wastewater with denitrification, as well as a microfiltration/reverse osmosis (MF/RO) plant located at the CAWD treatment facility. When all of the available potable water and CAWD effluent are being accepted by PBCSD, only the concentrate from the MF/RO facility is discharged to the ocean. Consequently, discharge volume can range from >1 million gallons per day (MGD), when all effluent is being discharged, to <0.13 MGD, when the MF/RO facility is treating all available wastewater.

The previous Comprehensive Study was completed in 2013. The study focused on spatial and temporal differences in persistent organic pollutants (POPs) and Fecal Indicator Bacteria (FIB) concentrations in the CAWD effluent discharge and Carmel Bay. The analysis used data from additional sources of water quality data to evaluate discharges into Carmel Bay. The current comprehensive study puts a strong emphasis on trends, using POP concentrations in resident mussels and fecal indicator bacteria at Carmel Bay compared with effluent data sources to evaluate whether changes in beneficial uses have occurred and whether changes have been associated with the CAWD discharge. POPs analyzed in this study are those that are consistently detected in central California ocean samples and for which Monterey Bay was recently recommended for placement on the 303d list; Chlordanes, Dieldrin, DDTs, and PCBs.

2. Data Sources

Several valuable sources of data were used to inform an evaluation of Beneficial Uses in the Carmel Bay ASBS, and the potential effects of CAWD discharge on the Beneficial Uses. These datasets are summarized in Table 1, and included the following:

Beneficial Uses:

1. **Shellfish Harvesting and Marine Habitat.** The status of these beneficial uses are demonstrated by concentrations of POPs in mussels adjacent to Carmel River Beach collected and analyzed by CCLEAN and their changes over time and exceedance of human health alert levels.
2. **Water Contact Recreation.** The status of this beneficial use is demonstrated by monthly measurements of fecal indicator bacteria (FIB) by the Monterey County Department of Health at Carmel Bay and exceedances of water-contact recreation water quality objectives and shellfish harvesting.
3. **Marine Habitat.** Another indicator of the condition of this beneficial use is the incidence of harmful algal blooms.

Potential Effects of CAWD Effluent on Beneficial Uses:

1. Wet- and dry-season concentrations and loads of POPs measured by CCLEAN in CAWD effluent.
2. Concentrations and loads of nutrients and bacteria measured monthly in effluent by CAWD.

Searches of scientific literature and region news outlets were search for information on harmful algal blooms in Carmel Bay and none were found. Despite the lack of documented harmful algal blooms, CAWD nutrient discharges were examined, as described in the next section.

Table 1. Data Sources

Data	POPs	FIBs	Nutrients	Source	Time Frame	Frequency
Carmel River Beach Mussel Tissue	X			CCLEAN	2013-2022	Once per year in the wet season
Carmel Bay @ Ocean Avenue		X		Monterey County Department of Health	2013-2022	Monthly (Wet and Dry season averages)
CAWD Effluent	X			CCLEAN	2013-2022	Two times per year (Wet and Dry Seasons)
CAWD Effluent		X	X	CAWD	2013-2022	Monthly (seasonally averaged)

3. Methods

Monitoring datasets were analyzed to address five priority questions that framed the assessment of effects on Beneficial Uses in the ASBS. The priority questions were:

1. **Has the CAWD discharge exceeded permit limitations over the past 10 years?**

This question is answered by comparing CAWD's effluent data against limits in their NPDES permit (Table 2, Table 3, and Table 4). Any temporal trends in exceedances or propensities of certain chemicals to approach or exceed permit limits are discussed.

Table 2. CAWD NPDES Effluent Limitations for POPs

Indicator	30-day Average	
	Concentration	Load
Chlordane	0.0028 µg/L	0.00007 lbs/day
DDT (total)	0.021 µg/L	0.00052 lbs/day
Dieldrin	0.0049 µg/L	0.00012 lbs/day
PCBs	0.0023 µg/L	0.000058 lbs/day

Table 3. CAWD NPDES Effluent Limitations for Ammonia

Indicator	6-Month Median	Daily Maximum	Instantaneous Maximum
Ammonia concentration	73,000 µg/L	290,000 µg/L	730,000 µg/L
Ammonia load	1,800 lbs/day	7,300 lbs/day	18,000 lbs/day

Table 4. CAWD NPDES Effluent Limitations for Fecal Indicator Bacteria

Indicator	Monthly Average	Single Sample Maximum
Total Coliform	230 per 100 mL	10,000 per 100 mL
Fecal Coliform *	24,000 per 100 mL	49,000 per 100mL
Enterococci *	4,300 per 100 mL	13,000 per 100 mL

* Only applicable to data since July 11, 2014 (Order R3-2014-0012, NPDES Number CA0047996)

2. **Have the concentrations or loads of contaminants in the CAWD discharge increased over time?**

This question is answered by examining data for total effluent volume, contaminant concentrations, and contaminant loads in the CAWD discharge for statistically significant changes over time. Effluent concentration data were tested with stepwise regressions to examine whether any changes over time were due to the passage of time i.e., (date) or flow volume (MGD). In this analysis, all tested variables are considered at once with the least significant variable removed sequentially until all insignificant variables are removed. This approach was necessary because changes in concentrations over time (e.g., Figure 1) could potentially be due to increased reclamation efforts that remove water from the effluent discharge, while maintaining a consistent contaminant load. Load data were plotted versus time, and regression slopes of the resulting trendlines were tested to reveal whether they were significantly different from zero at a probability of <0.05. Answering Question 2 reveals whether any contaminants are trending upward and/or nearing levels of concern.

3. **Have contaminant concentrations in water and mussels in the ASBS exceeded The California Ocean Plan or Human Health Alert Levels?**

This question is answered by comparison of the CCLEAN data for mussels and water samples from within and nearby the Carmel Bay ASBS to water quality objectives in the California Ocean Plan (Table 5 and Table 6) and OEHHA Human Health Alert Levels for fish and shellfish consumption (

Table 7). This information informs whether any recurring water quality exceedances have occurred.

Table 5. California Ocean Plan Water Quality Objectives for Ammonia

Indicator	6-Month Median	Daily Maximum	Instantaneous Maximum
Ammonia	600 µg/L	2400 µg/L	6000 µg/L

Table 6. California Ocean Plan Water Quality Objectives for Fecal Indicator Bacteria

Indicator	Median	Geometric Mean	Single Sample Maximum
Fecal Coliform REC-1 Water Quality Objective for Water Contact in Ocean Waters	--	200 per 100 mL	400 per 100mL
Enterococci REC-1 Water Quality Objective for Water Contact in Ocean Waters	--	30 per 100 mL	110 per 100 mL
Total Coliform Shellfish Harvesting Standard	70 per 100 mL	--	230* per 100 mL

*** > 10% of samples**

Table 7. OEHHA Human Health Advisory Tissue Levels for Fish/Shellfish Consumption

Indicator	Daily Consumption (7 meals per week)	No Consumption (0 meals per week)
Chlordane	80 ng/g	560 ng/g
DDT (total)	220 ng/g	2100 ng/g
Dieldrin	7 ng/g	46 ng/g
PCBs	9 ng/g	120 ng/g

4. **Have concentrations of contaminants in mussels or fecal indicator bacteria in water in the ASBS increased over time?**

This question is answered by examining CCLEAN data on contaminant concentrations in mussels from Carmel River Beach and the Monterey County Public Health data on fecal indicator bacteria from Carmel Bay, for statistically significant changes over time. Mussels tissue concentration data were plotted versus time, and regression slopes tested for statistical differences from zero at $p<0.05$. A similar approach was taken for data on FIBs. Answering Question 4 informs whether any contaminants or FIBs in the ASBS are trending upward and/or nearing levels of concern.

5. **Are concentrations of contaminants or fecal indicator bacteria in water or shellfish in the ASBS associated with discharges from CAWD?**

This question is answered by evaluating associations between a) contaminant loads in the CAWD discharge and contaminant concentrations in mussels from Carmel River Beach; and b) fecal indicator bacteria in the CAWD discharge and fecal indicator bacteria from Carmel Bay. Correlations between the CAWD discharge and concentrations focused on observations that exceeded human health alert levels or the California Ocean Plan.

Assessment Approach

To perform the Comprehensive Study, data and reported results were organized around the five questions presented above. The assessment evaluated the supporting evidence to determine whether changes have occurred in the ASBS over time, and the statistical probability that those changes are associated to the quality and quantity of discharged CAWD wastewater effluent. A positive finding for any question is further highlighted in the Conclusions section, and considerations for follow-on evaluations to aid future comprehensive reports is presented in the Recommendations. One caveat to the current assessment is that while it was also of interest to examine the potential influences of the Carmel River discharges in the ASBS, monitoring of the Carmel River by the CCLEAN

Program ceased in 2007. Therefore, it is currently not possible to assess current conditions or trends in POPs entering the ASBS from the Carmel River over time.

4. Results

1. **Has the CAWD discharge exceeded permit limitations over the past 10 years?**

Persistent Organic Pollutants (Chlordanes, DDTs, Dieldrin, and PCBs) measured in the CAWD discharge have consistently been below NPDES effluent limitations between 2013-2022. None of the Chlordane, Dieldrin, or DDT concentrations (Figure 1) or loads (Figure 2) had any exceedances during this period. Two occurrences of a 30-day average concentration above the PCBs effluent limit (0.0023 µg/L) occurred in October 2017 and October 2020 (both dry season), which measured 27% and 4% above the effluent limit, respectively. Neither occurrence was associated with a corresponding exceedance of the effluent load limit, however. This may largely be attributable to the relatively low CAWD discharge that occurred during the dry seasons of 2017-2021 (Figure 3Figure 2. 30-day Average Load of Chlordanes, DDTs, Dieldrin, and PCBs measured in CAWD wastewater, 2013-2022. Load was estimated from the 30-day composite sampling and flow measurements conducted by the CCLEAN Program.

Figure 3. 30-day Average CAWD Discharge, 2013-2022. Flow measured during 30-day composite sampling conducted by the CCLEAN Program.

Figure 4. Monthly Ammonia (NH3) concentration (mg/L, left axis) and load (lbs/day, right axis) measured in CAWD wastewater, 2013-2022. Load was estimated from the monthly grab samples collected by CAWD in partial fulfillment of its NPDES permit monitoring requirements.

Figure 5. Rolling six-month median of Ammonia (NH3) concentration (mg/L, left axis) and load (lbs/day, right axis) measured in CAWD wastewater, 2013-2022. Load was estimated from the monthly grab samples collected by CAWD in partial fulfillment of its NPDES permit monitoring requirements.

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Nutrient concentrations (ammonia, nitrate, and organophosphate) measured in the CAWD discharge have also largely been well below NPDES effluent limitations between 2013-2022. The highest ammonia concentrations occurred between June and August 2018 (Figure 4), which corresponded to a range of 136-174 mg/L that was approximately 40% below the daily ammonia effluent limit (290,000 µg/L or 290 mg/L; Table 3). Similarly, ammonia load peaked in April 2018 (334 lbs/day) that was more than an order of magnitude below the daily effluent limit (7,300 lbs/day). On the other hand, the six-month median concentration of ammonia was exceeded (Figure 5). The six-month median of ammonia concentration exceeded the effluent limitation during a four-month period between August and November 2018 (4 occurrences total). Two of those occurrences were concomitant with relatively high ammonia load (both 191 lbs/day), but well below the effluent load limit (1,800 lbs/day).

Finally, Fecal Indicator Bacteria (FIBs; total coliforms, fecal coliforms, and *Enterococcus*) measured in the CAWD discharge rarely exceeded permit limits. Total coliforms exceeded the monthly average effluent limit of 230 MPN/100ML once, in August 2018 (Figure 6). None of the monthly average concentrations of fecal coliform or *Enterococcus* had any exceedances during this period. In terms of instantaneous single sample maxima, total coliforms exhibited four samples above the effluent limit, which all occurred during a two-week period in late-August 2018 (Figure 7). In comparison, the instantaneous fecal coliform and *Enterococcus* concentrations were never close to the effluent limit, with maximum concentrations of 127 MPN/100mL and 93 MPN/100mL, respectively.

In summary, between 2013 and 2022, CAWD discharge exceeded NPDES effluent limitations for PCB concentrations twice (2017 and 2020 dry-season), for ammonia concentration four times (August through September 2018), and for total coliforms once for the monthly average (August 2018), and four times for the single sample maximum (8/13 – 8/26, 2018).

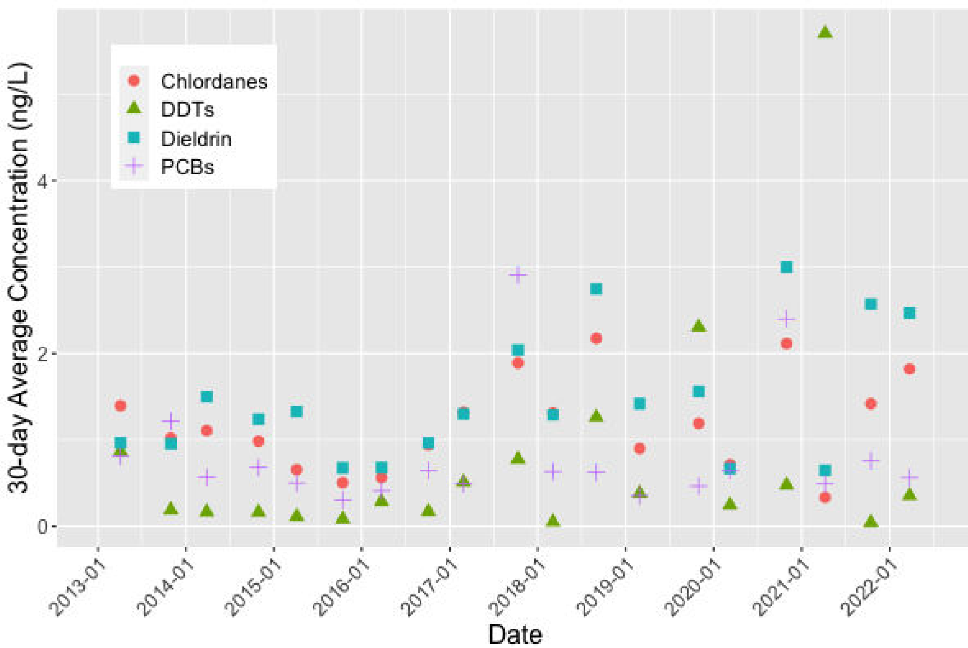

Figure 1. 30-day Average Concentration of Chlordanes, DDTs, Dieldrin, and PCBs measured in CAWD wastewater, 2013-2022. Concentration was measured by the 30-day composite sampling conducted by the CCLEAN Program.

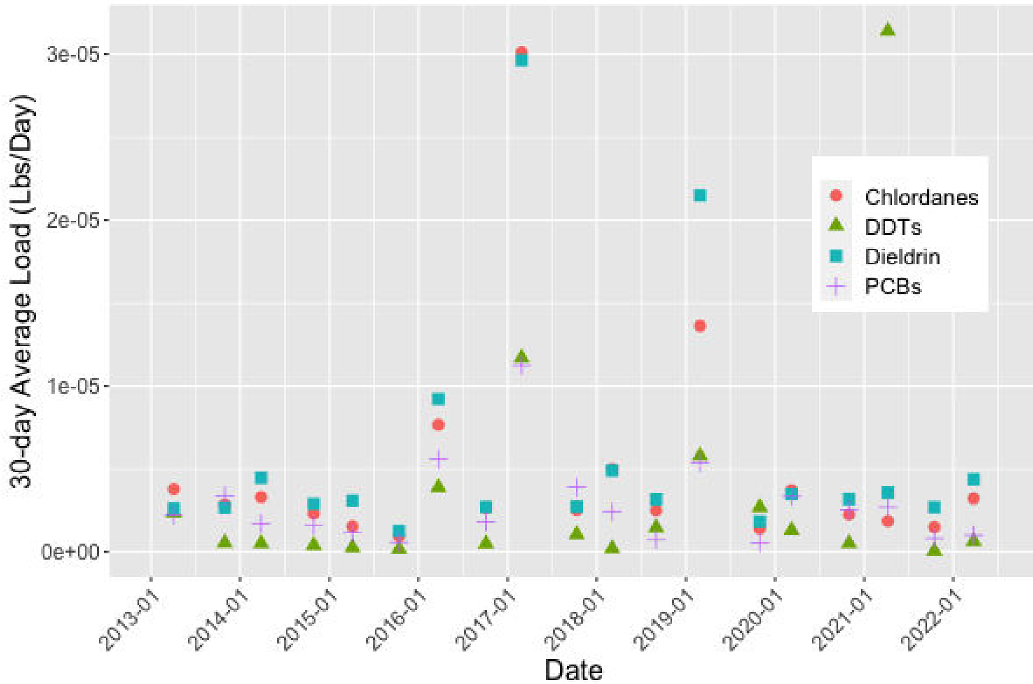

Figure 2. 30-day Average Load of Chlordanes, DDTs, Dieldrin, and PCBs measured in CAWD wastewater, 2013-2022. Load was estimated from the 30-day composite sampling and flow measurements conducted by the CCLEAN Program.

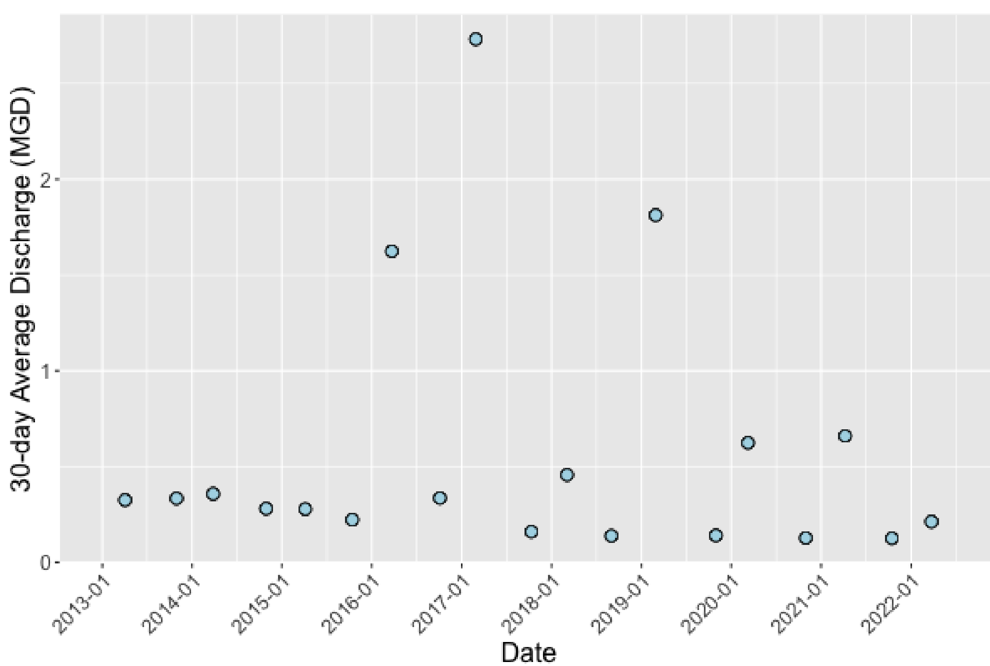

Figure 3. 30-day Average CAWD Discharge, 2013-2022. Flow measured during 30-day composite sampling conducted by the CCLEAN Program.

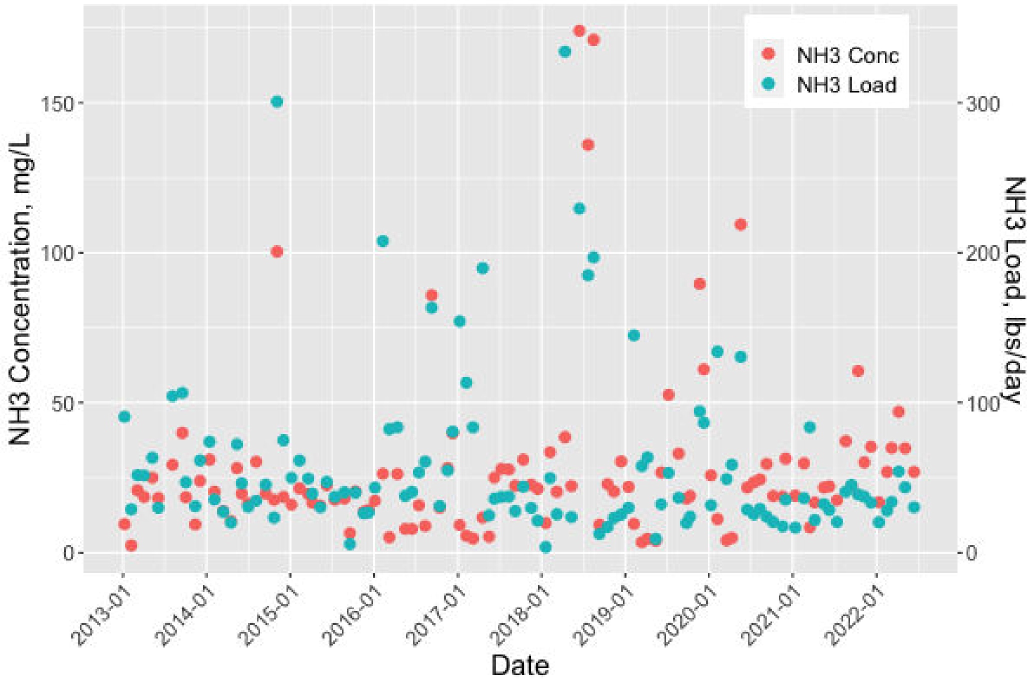

Figure 4. Monthly Ammonia (NH3) concentration (mg/L, left axis) and load (lbs/day, right axis) measured in CAWD wastewater, 2013-2022. Load was estimated from the monthly grab samples collected by CAWD in partial fulfillment of its NPDES permit monitoring requirements.

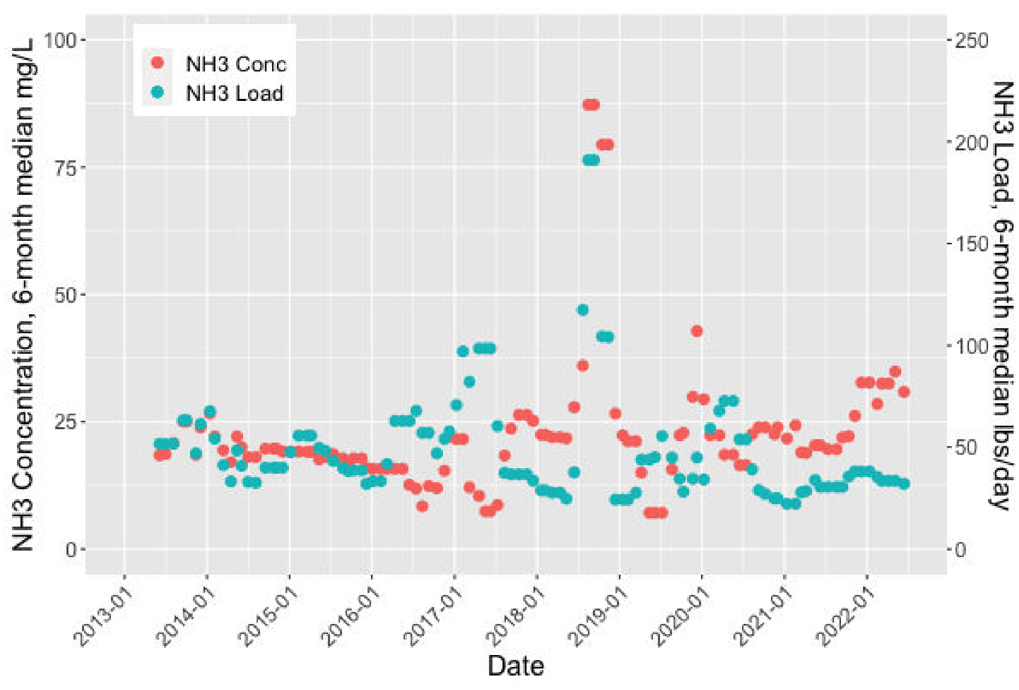

Figure 5. Rolling six-month median of Ammonia (NH3) concentration (mg/L, left axis) and load (lbs/day, right axis) measured in CAWD wastewater, 2013-2022. Load was estimated from the monthly grab samples collected by CAWD in partial fulfillment of its NPDES permit monitoring requirements.

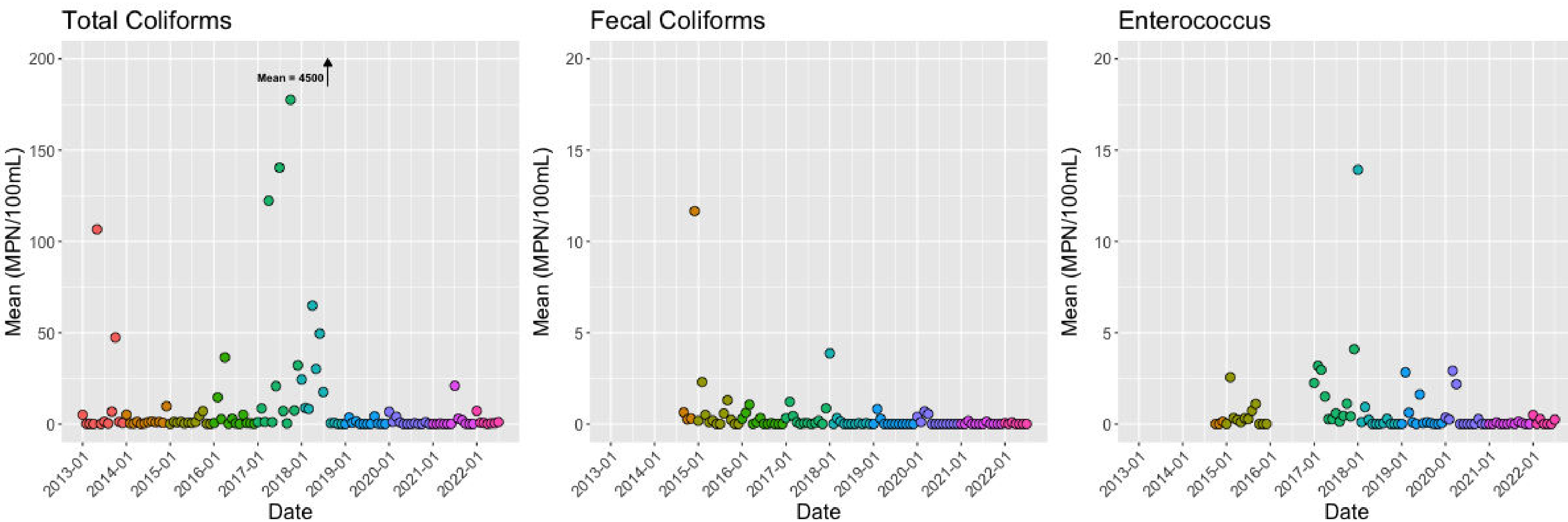

Figure 6. Monthly means for Fecal Indicator Bacteria (FIB) measured in CAWD wastewater, 2013-2022. Means were calculated from weekly grab samples collected by CAWD in partial fulfillment of its NPDES permit monitoring requirements. The maximum monthly mean for total coliforms was 4500 MPN/100 mL in 2018-08.

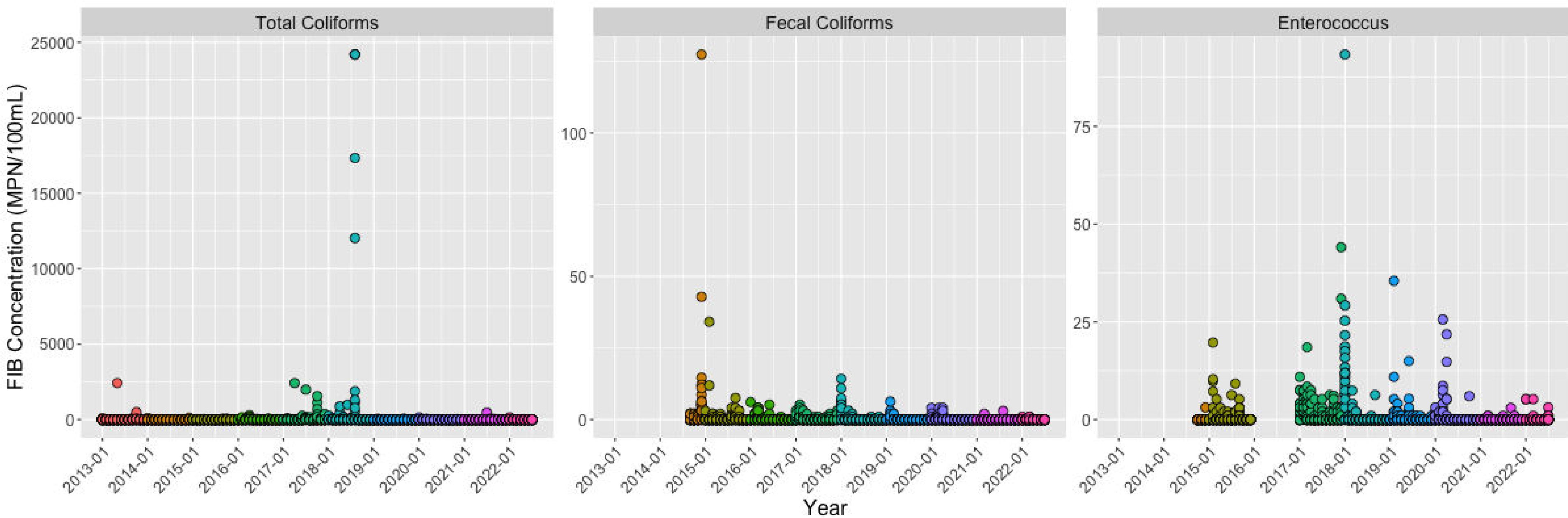

Figure 7. Concentrations of FIBs measured in CAWD wastewater effluent, 2013-2022.

2. Have the concentrations or loads of contaminants in the CAWD discharge increased over time?

Step-wise regressions of POP concentrations in CAWD effluent versus date and discharge volume found that Chlordanes, DDTs, and PCBs did not change with time or discharge volume (Table 8). Concentration of Dieldrin did, however, increase over time and was not affected by discharge volume. Trends in loads of DDTs and dieldrin trended upward over time, whereas loads of Chlordanes and PCBs trended downward over time, although none of the load trendlines was significantly different from zero (Table 9).

Table 8. Results of step-wise regressions to determine whether POP concentrations (ng/L) from CAWD have been significantly affected over the past 10 years by time or wastewater volume discharged.

POP	Model	F Ratio	Adj. R^2	Probability
Chlordanes	Not Significant			
DDTs	Not Significant			
Dieldrin	Dieldrin = -11.54 + 3.63e-9 Date	4.987	0.1734	0.0385*
PCBs	Not Significant			

* $p<0.05$

Table 9. Results of regressions to determine whether POP loads (Lbs/day) from CAWD have significantly changed over the past 10 years.

POP	Model	F Ratio	Adj. R^2	Probability
Chlordanes	Load/day = 0.00002 – 3.3e-15 Date	0.0311	-0.0569	0.8622
DDTs	Load/day = 0.00008 + 2.3e-14 Date	1.4373	0.0237	0.2470
Dieldrin	Load/day = -9.64e-7 + 1e-15 Date	0.0123	-0.0581	0.9132
PCBs	Load/day = 0.00001 – 2.5e-15 Date	0.1279	-0.0509	0.7251

As discussed in Question 2 on page 5, high variability in constituent concentrations through time can lead to confusing impressions of the effects of date. Contrary to the apparent general increases in nitrate and orthophosphate concentrations through time (Figure 8), step-wise regressions of nutrient concentrations in CAWD effluent found that nitrate and orthophosphate had a significant negative relationships with discharge volume, which means their concentrations were higher with lower discharge volumes, with no effect of date (Table 10), which suggested higher concentrations could be associated with increased water reclamation efforts. Nitrate also had significantly higher concentrations with lower discharge volumes and its concentrations have significantly increased with date, independent of discharge volume. Urea was also affected by date and discharge volume, as seen for nitrate. Concentrations of ammonia increased with decreased discharge volumes, independent of date. Total nitrogen did not change with either date or discharge volume.

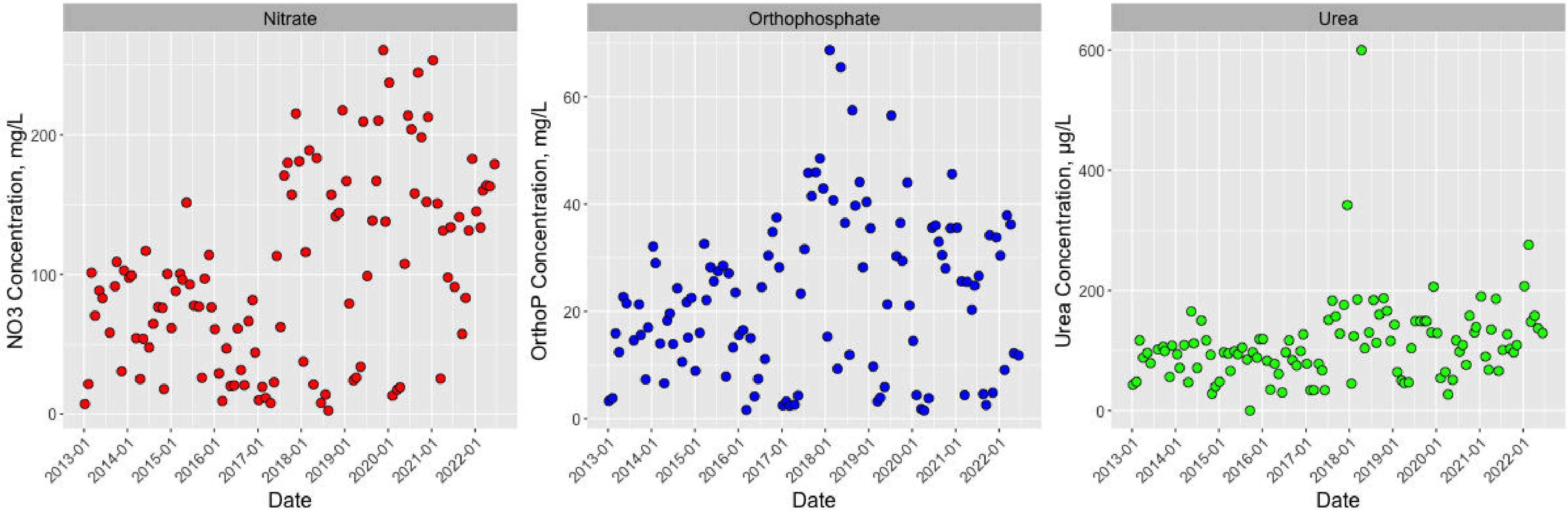

Figure 8. Monthly Nitrate (NO3, mg/L, left), Orthophosphate (mg/L, center), and urea concentration (µg/L, right) measured in CAWD wastewater, 2013-2022.

Orthophosphate was the only nutrient to exhibit a significant change in loads, which decreased over time, whereas decreases in ammonia loads were marginally non-significant (Table 11).

Regressions of 6-month median values for ammonia effluent concentrations and loads revealed that ammonia concentrations have increased significantly over time, whereas loads have decreased significantly over time (Table 12).

Table 10. Results of step-wise regressions to determine whether nutrient concentrations (ng/L) from CAWD have been significantly affected over the past 10 years due to time or wastewater volume discharged.

Nutrient	Model	F Ratio	Adj. R^2	Probability
NH3-N	Concentration = 33.93 – 15.86 MGD	11.25	0.0799	0.0011*
NO3	Concentration = -930.9 + 2.94e-7 Date – 63.71 MGD	49.66	0.4520	<0.0001*
Urea	Concentration = -540.8 + 1.85e-7 Date – 32.05 MGD	8.753	0.1179	0.0003*
Total N	Not Significant			
OrthoP	Concentration = 28.38 – 15.13 MGD	45.93	0.2757	<0.0001*

* p<0.05

Table 11. Results of regressions to determine whether nutrient loads (Kg/day) from CAWD have significantly changed over the past 10 years.

Nutrient	Model	F Ratio	Adj. R^2	Probability
NH3-N	Load/day = 178.5 – 4.24e-8 Date	2.8431	0.0154	0.0944
NO3	Load/day = -136.5 + 6.27e-8 Date	0.6314	-0.0031	0.4284
Urea	Load/day = -0.6384 + 2.3e-10 Date	0.5325	-0.0040	0.4670
Total N	Load/day N = 41.38 + 2.06e-8 Date	0.0618	-0.0005	0.8041
OrthoP	Load/day = 156.5 – 383e-8 Date	13.735	0.0974	0.0003*

* p<0.05

Table 12. Results of regressions to determine whether 6-month median ammonium concentrations (mg/L) and loads (Lbs/day) from CAWD have significantly changed over the past 10 years.

Parameter	Model	F Ratio	Adj. R^2	Probability
Ammonia	Concentration = -112.10 + 3.75e-8 Date	7.2417	0.0523	0.0082*
Ammonia	Load/day = 271.37 – 6.19e-8 Date	4.5071	0.0301	0.0360*

* p<0.05

3. **Have contaminant concentrations in water and mussels in the ASBS exceeded The California Ocean Plan or Human Health Alert Levels?**

POPs measured in ocean waters by the CCLEAN Program has frequently identified PCB concentrations or loads that exceed the California Ocean Plan, while Chlordanes, DDTs, and Dieldrin have also sometimes exceeded the Ocean Plan criteria. During 2013-2022, none of these contaminants exceeded human health alert levels based on mussels sampled by CCLEAN at Carmel River Beach. Mussels have exhibited average concentrations of Chlordane (0.34 ng/g), Dieldrin (0.44 ng/g), DDTs (1.26 ng/g), and PCB (0.22 ng/g) that were an order of magnitude or more below the OEHHA Advisory Tissue Levels (OEHHA ATLs; OEHHA 2016).

Fecal Indicator Bacteria (FIB) concentrations in ocean waters adjacent to Ocean Avenue in Carmel have also been generally below water quality objectives for water contact recreation and shellfish harvesting criteria listed in the California Ocean Plan (Figure 9). Total coliform exceeded the shellfish harvesting standard (Median = 230 MPN/100mL) on four occasions: November 2013, October 2016, January 2018, and January 2020. The highest median occurred in November 2013 that was 8-times higher (1935 MPN/100mL) than the standard. Geometric means for fecal coliforms exceeded the Ocean Plan threshold one time, in January 2020, and *Enterococcus* exceeded two times in January 2018 and January 2021.

Each of the FIB indicators had exceedances of the Ocean Plan objectives for single sample maxima (Figure 10). Total coliforms exceeded the single sample maximum 12 times between 2013 and 2022. Four occurrences were detected in 2018, three occurrences were detected in 2013, two occurrences were detected in 2016, and one occurrence in 2014, 2017, and 2020. The only year that exhibited exceedance of the Ocean Plan in > 10% of samples was for 2018 (4 of 38, 10.5%). Fecal coliform exceed the single sample maximum once, in August 2013, which coincided with an exceedance in the same month for total coliforms. Finally, *Enterococcus* exceeded the single sample maximum seven times; three times in 2018, two times in 2013, and once in 2020 and 2022.

The absence of harmful algal blooms reported for Carmel Bay in our search of the scientific literature and local news outlets is consistent with the current loads of nutrients from the CAWD discharge (Table 11) and no impairments of Carmel Bay beneficial uses by nutrients discharged by CAWD.

In summary, POP concentrations measured in mussel tissues in the ASBS have not exceeded human consumption thresholds, though CCLEAN has measured both concentration and loads in Monterey Bay waters that frequently do exceed the Ocean Plan (CCLEAN, 2021). In contrast, each of the FIB indicators have shown exceedances of the Ocean Plan objectives at Carmel Beach. Total coliforms exceeded the shellfish standard four times based on the 30-day median and once based on 10% of samples above the single sample maximum in a calendar year. Fecal coliforms exceeded the recreational water contact objective once based on the geometric mean, and once based on a single sample maximum. Lastly, *Enterococcus* exhibited two exceedances of the recreational water contact objective and seven exceedances of the single sample maximum. In total, 16 exceedances of the Ocean Plan based on FIBs sampled in the ASBS were observed during 2013-2022.

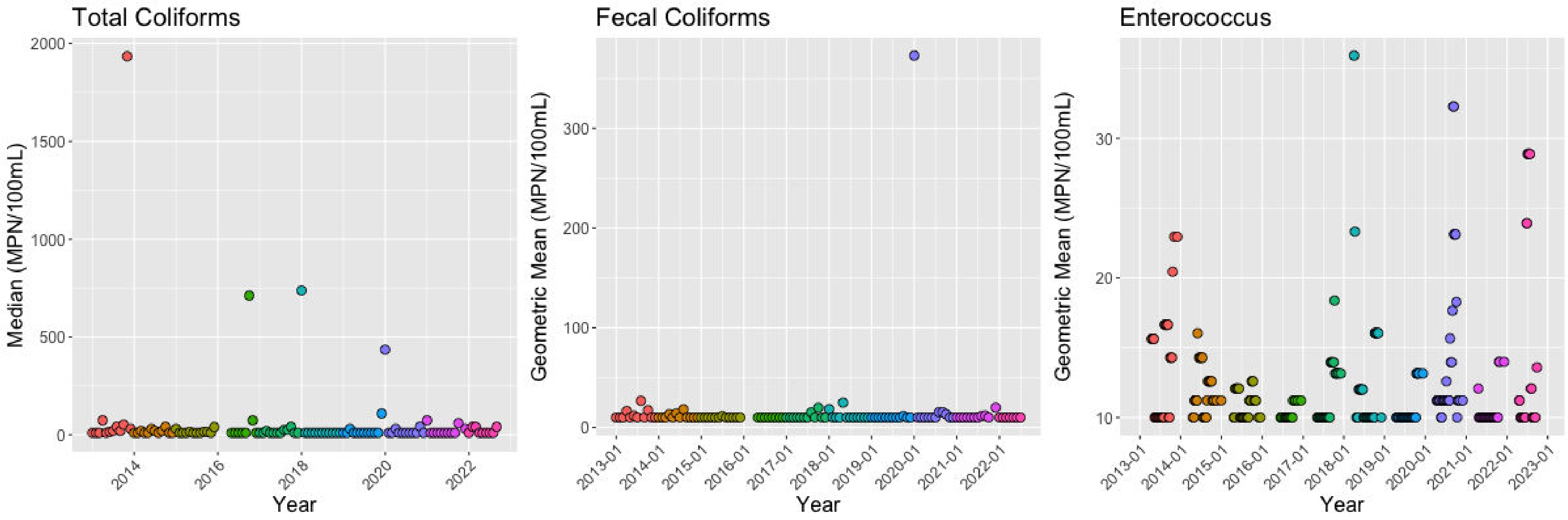

Figure 9. Median and Geometric Means (GMs) for FIBs collected at Ocean Avenue in Carmel, 2013-2022. Total coliform medians were calculated from the weekly observations. GMs for fecal coliforms reflect the 30-day average, and the GMs for *Enterococcus* reflect the 6-week rolling average of weekly observations, respectively.

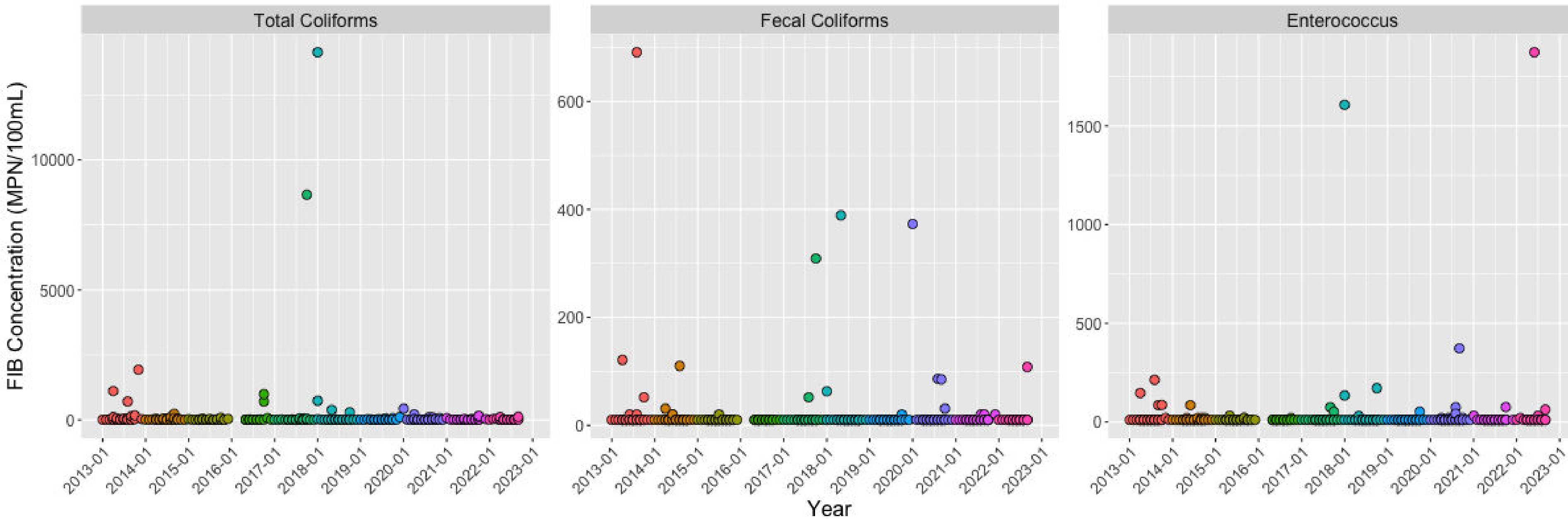

Figure 10. Concentrations of FIBs collected at Ocean Avenue in Carmel, 2013-2022.

4. **Have concentrations of contaminants in mussels or fecal indicator bacteria in water in the ASBS increased over time?**

During 2013-2022, POPs in mussels did not show any significant increases over time. DDTs have consistently exhibited the highest lipid-weight concentrations compared to the other three contaminants (Figure 11). Concentrations above 1000 µg/kg were observed in every year between 2013 and 2019 except for 2014, while the most recent three years have been ~ 40% lower, ranging between 526 – 735 µg/kg. Regression analyses of lipid-weight concentrations over time indicated declining slopes for all but PCBs. However, in all cases, the regression slopes were not statistically significant (Table 13).

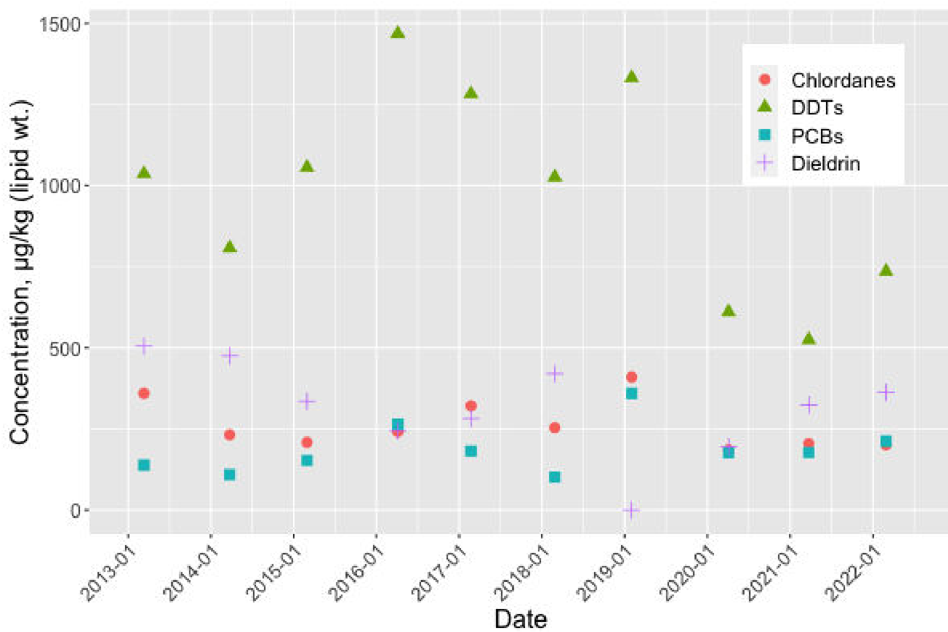

Figure 11. Lipid-weight concentrations of Chlordanes, DDTs, Dieldrin, and PCBs in mussels measured at Carmel River Beach, 2013-2022. Concentrations were determined from composite mussel samples collected during the wet season by the CCLEAN Program.

Table 13. Results of regressions to determine whether lipid-weight concentrations of legacy pesticides in mussels from Carmel River Beach have significantly changed over the past 10 years.

Pesticide	Model	F Ratio	Adj. R^2	Probability
Chlordanes	LW = 1193.5 – 2.6e-7 Date	0.9520	-0.0054	0.3578
DDTs	LW = 6317 – 0.0000015 Date	2.014	0.1012	0.1936
Dieldrin	LW = 2789 – 6.9e-7 Date	1.9934	0.0994	0.1957
PCBs	LW = -804.3 + 2.76e-7 Date	1.0598	0.0066	0.3334

FIB indicators from Carmel Bay have also not indicated a significant increase over time. Generally, sporadic high FIB concentrations were evident between 2013 and 2022. These spikes did not trend over time, though the dry season of 2018 was notable for having the highest mean concentrations for each FIB indicator (Figure 12). Regression slopes of mean concentrations have trended downwards for total coliforms and fecal coliforms, and upward for *Enterococcus*, with the latter observation driven by the relatively high wet season concentration in 2022. In each of the regression models, season had a positive coefficient, indicating that the dry season exhibited relatively higher concentrations than the wet season, notably in 2018 and 2020. None of these trends were statistically significant at $p < 0.05$ (Table 14). In Question 5 below, the potential contribution of CAWD discharge to changes in POPs in mussels and FIBs in ocean waters was evaluated.

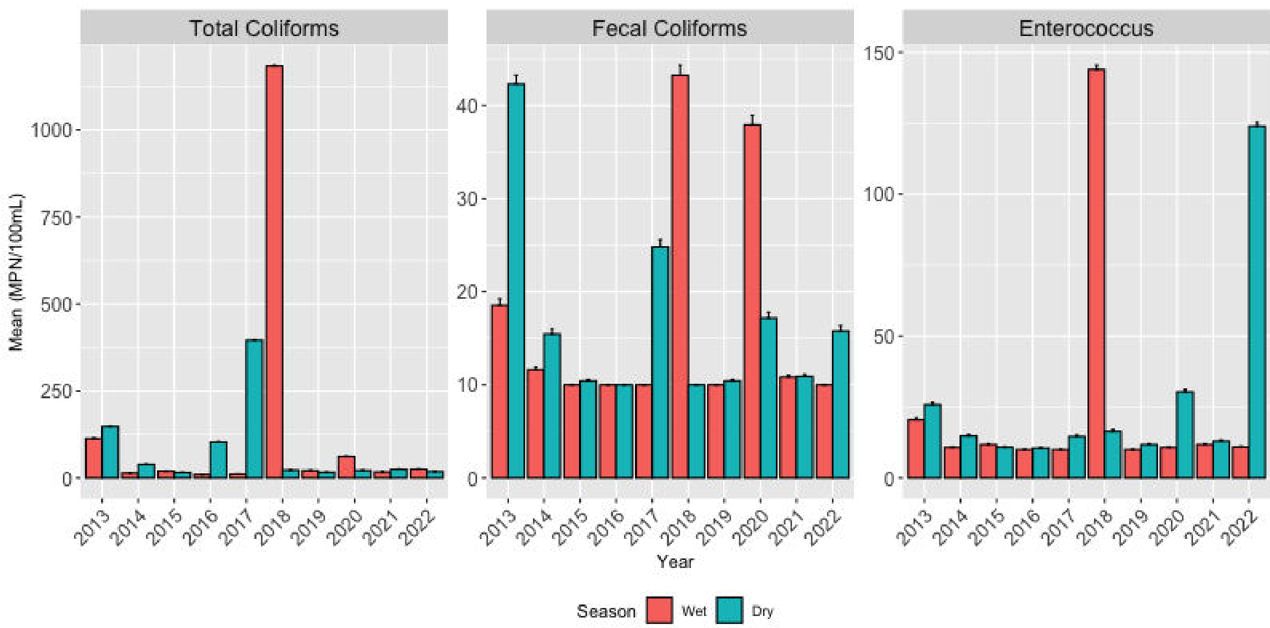

Figure 12. Lipid-weight concentrations of Chlordanes, DDTs, Dieldrin, and PCBs in mussels measured at Carmel River Beach, 2013-2022. Concentrations were determined from composite mussel samples collected during the wet season by the CCLEAN Program.

Table 14. Results of regressions to determine whether FIB concentrations in water from Carmel Bay have significantly changed over the past 10 years.

FIB Indicator	Model	F Ratio	Adj. R^2	Probability
Total Coliforms	FIB = 178.40 - 0.09 Year + 0.17 Season	0.408	-0.066	0.67
Fecal Coliforms	FIB = 48.68 - 0.02 Year + 0.03 Season	0.155	-0.098	0.86
Enterococcus	FIB = -95.96 + 0.05 Year + 0.25 Season	0.542	-0.051	0.59

5. **Are concentrations of contaminants or fecal indicator bacteria in water or shellfish in the ASBS associated with discharges from CAWD?**

Concentrations of POPs in shellfish and fecal indicator bacteria in water were not found to be associated with loads in CAWD wastewater discharges. CAWD effluent load of POPs were tested for statistically significant associations with lipid-weight POP concentrations in mussels. For Chlordanes and PCBs there was a positive slope to the regressions, while for DDTs and Dieldrin the slope was negative. In all four parameters, the slopes were not statistically significant ($p > 0.05$) and explanatory variance relatively low (< 0.3), indicated a lack of significant association (Table 15).

Table 15. Results of regressions to determine whether lipid-weight concentrations of legacy pesticides in mussels from Carmel River Beach have been affected significantly by loads from CAWD (Lbs/day).

Pesticide	Model	F Ratio	Adj. R2	Probability
Chlordanes	LW = 227.2 + 46699 Lbs/day	3.241	0.1994	0.1095
DDTs	LW = 1042 – 9295702 Lbs/day	0.706	-0.0338	0.4253
Dieldrin	LW = 389.7 – 19157128 Lbs/day	3.423	0.2121	0.1014
PCBs	LW = 154.5 + 8926885 Lbs/day	1.169	0.0185	0.3110

FIBs in CAWD effluent discharge also did not associate with FIB concentrations in the ASBS during 2013-2022. Seasonal-average effluent loads of FIBs were tested for statistically significant associations with FIB concentrations from Carmel Bay. In all three FIB indicators (total, fecal, Enterococcus), there was a minimal slope to the regression, which was highly unlikely ($p >> 0.05$) to be different from zero (Table 16).

Table 16. Results of regressions to determine whether FIB concentrations in water from Carmel Bay have been affected significantly by loads from CAWD (Lbs/day).

FIB Indicator	Model	F Ratio	Adj. R2	Probability
Total Coliforms	FIB = 56.0 – 0.0002 TC-Load	0.187	-0.015	0.667
Fecal Coliforms	FIB = 62.8 – 0.007 FC-Load	0.088	-0.022	0.769
Enterococcus	FIB = 49.1 + 0.003 EC-Load	0.108	-0.021	0.744

5. Conclusions

The Comprehensive Study has provided answers to each of the stated study questions, as follows:

1. *Has the CAWD discharge exceeded permit limitations over the past 10 years?*

Eleven exceedances of NPDES permit limits were observed during the 2013-2022 reporting period. These occurrences were coincident with 1) the 30-day seasonal average PCB concentrations during the dry season of 2017 and 2020; 2) the rolling six-month median of monthly ammonia concentrations between August and November 2018; 3) the monthly average of total coliforms in August 2018; and 4) the single sample maximum of total coliforms four times between 8/13 – 8/26, 2018.

2. *Have the concentrations or loads of contaminants in the CAWD discharge increased over time?*

There were few instances of significantly increased contaminant concentrations or loads since 2013. Concentrations of Dieldrin, nitrate, and urea have increased with time, while concentrations of ammonia, nitrate, urea, and orthophosphate were lower in higher discharge volumes, suggesting contaminant masses associated with water reclamation efforts. Loads of only orthophosphates have changed over time, with significant decreases since 2012.

3. *Have contaminant concentrations in water and mussels in the ASBS exceeded the California Ocean Plan or Human Health Alert Levels?*

No exceedances of OEHHA advisory tissue levels for human consumption of shellfish were associated with POP concentrations in mussels between 2013 and 2022. However, a total of 16 observations of FIBs were observed above the median, geometric mean, or single sample maxima listed in the Ocean Plan. *Enterococcus* exhibited nine of the 16 exceedances, total coliform exhibiting five, and fecal coliform exhibiting two exceedances. Most of these relatively high observations were sporadic and unrelated to season. Only in 2018, were several re-occurring exceedances apparent.

4. *Have concentrations of contaminants in mussels or fecal indicator bacteria in water in the ASBS increased over time?*

Concentrations in water and mussels in the ASBS have not significantly increased over time. Despite the observations of increasing CAWD concentrations of Dieldrin, there have been no increases over time of this or any other contaminant measured in mussels or in water from the ASBS. Moreover, concentrations of some POPs in mussels have been slowly declining.

5. *Are concentrations of contaminants or fecal indicator bacteria in water or shellfish in the ASBS associated with discharges from CAWD?*

Over the past 10 years, POP and FIB loads in CAWD wastewater discharge were not statistically associated to mussel contamination or FIB concentrations in the ASBS, respectively. The lack of significant regressions suggests other factors or sources contributed to the mussel contamination and exceedances of Ocean Plan recreational water contact and shellfish harvest standards observed over the time-series.

6. Recommendations

Considering the findings from the Comprehensive Study, additional information in two areas would be helpful for future comprehensive reports:

1) Fecal Indicator Bacteria measurements from additional discharges into the Carmel Area ASBS. All the Ocean Plan exceedances were for FIB indicators in waters at Carmel Bay adjacent to Ocean Avenue. As a result of the lack of associations with CAWD discharge, future analyses would benefit from FIB data from additional potential sources, such as the Carmel River and stormwater discharges.

2) Periodic measurements of POP loads from the Carmel River. This would enable more accurate and balanced examinations of the effects of POP loads from CAWD effluent, in the event that declines in mussel POP concentrations reverse in the future.

7. References

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