Applying Particle Tracking Modeling in Wastewater Plumes to Support Monitoring Programs

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Context

- Wastewater discharge from outfalls forms buoyant and nutrient-rich marine plumes that can cause eutrophication and can contribute to acidification and deoxygenation.
- Monitoring programs around the world attempt to capture the impact of plumes through observational studies but can often miss the plume because of its ephemeral nature and varying ocean conditions.
- 3D numerical ocean modeling with particle tracking can be used to determine probability-based visitation frequency of the plume during different seasons and residence times.

Modeling Tool

- The Regional Ocean Modeling System (ROMS) can simulate the fate and transport of buoyant plumes.
- Particles are populated inside the plumes to track dilution and movement.
- Hourly ocean output and effluent data is used for diurnal variability.
- A particle residence time (e.g, 1 day, 2 days, etc) is applied to determine plume location within typical dispersion times.

Application

Using real, time-varying physical effluent properties as input (i.e., temperature, salinity, volume), summer and winter months are simulated, and a seasonally-averaged horizontal visitation frequency is calculated to determine the plume footprint.

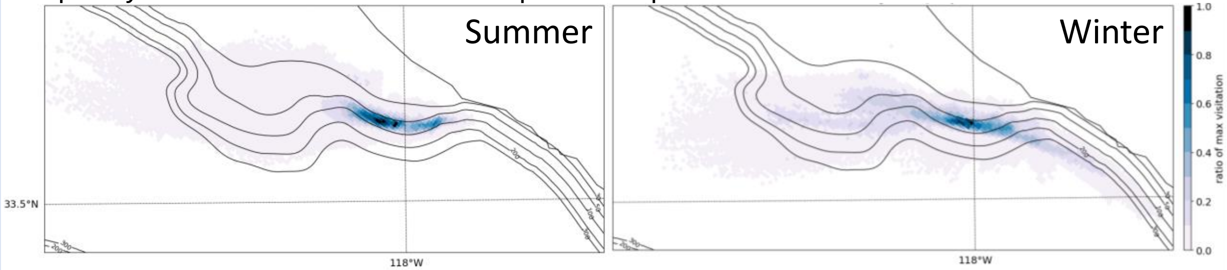

Fig 1. Averaged summer (left) and winter (right) visitation frequency (heatmap) of plume during the year 2000 with residence time of less than 1 day in Orange County, CA, USA. Contours are bathymetry.

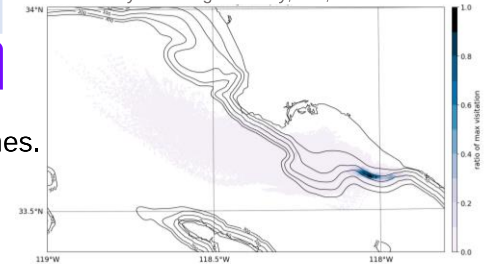

Fig 2. Averaged summer visitation frequency of plume with residence time of less than 2 days.

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Conclusions and Implications

- Observational programs and wastewater managers can use this modeling tool to improve plume monitoring by updating monitoring locations to better capture plume impact in the ocean.
- The model can produce heatmaps using multiple outfalls to inform regional monitoring.
- Plume footprint can be considered in future scenarios under changing ocean and effluent conditions, such as climate change and various treatment levels.