EcoEléctrica Biological Monitoring Project Plan Report: 2023 & Continuos Monitoring

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Introduction

The following report comprises the monitoring effort realized during the EcoEléctrica Biological Monitoring Program Plan (BMPP) for 2023. EcoEléctrica is located between Guayanilla Bay and Tallaboa Bay on the southern coast of Puerto Rico and hosts a diverse array of ecosystems and uses for the island of Puerto Rico (Figure 1). The EcoEléctrica plant includes a 545 mega-watts combined natural gas power plant (two combustion turbines and a steam turbine), a seawater desalination plant, and a marine unloading and storage terminal for liquefied natural gas (EcoEléctrica, 2015). The facility cools down their system inserting raw seawater near the shoreline of the pier into an 8-cell cooling tower to remove the excess heat from the condenser of the steam turbine system and processed wastewater. Consequently, the water is pumped to a cooling tower to remove the final excess heat before it is discharged through diffusers in the outfall a 51cm pipe (Vicente, 2001, 2008; Otero 2013a, 2013b). The intake pipe includes a mesh to protect marine organisms from entering the system, and this station the temperature reference for the discharge temperature (EcoEléctrica, 2015).

EcoEléctrica's discharge through the outfall is regulated under 40 CFR 125.123- "Criteria and Standards for the National Pollutant Discharge Elimination System (NPDES) Ocean Discharge Criteria" (Otero, 2013a) with the recommendations of National Pollutant Discharge Elimination System (NPDES), Fish and Wildlife Service (FWS) and National Oceanic and Atmospheric Administration (NOAA) (Centeno, 2023). The Biological Monitoring Program (BMPP) quantify the potential effects and impacts of the discharge of the EcoEléctrica facilities, in the water quality including (e.g., temperature, salinity, vertical attenuation coefficient of photosynthetically active radiation [KdPAR]), plankton, fishes, and benthic communities of Guayanilla and Tallaboa Bays (Vicente, 2001, 2008; Otero 2013a, 2013b, EcoEléctrica, 2015, Centeno, 2023). The acceptable temperature range for discarhge is 25-32.2°C and salinity range of 33-38 ppt (Vicente, 2001, 2008; Otero 2013a, 2013b, Centeno 2023). In addition, data from the Continuous Water Quality Monitoring will be shown. The water quality study parameters reported here are temperature, salinity, and Kd_{PAR}.

Methods

Station Surveys

As part of the Biological Monitoring Program (BMPP) water quality monitoring, monthly surveys were conducted at nine stations across Guayanilla and Tallaboa Bays, including the intake and outfall of the EcoEléctrica facilities (Figure 1). Surveys were not collected in June 2023 due to the atmospheric and ocean dangerous conditions in the southwest of Puerto Rico due to storms. To provide replicated casts, at each station, the Sontek Castaway CTD was deployed three times. The sampling for the intake and outfall were conducted by positioning the boat as close as possible to the center of the diffusers. The CTD collected continuous data through the water column on the downcast and upcast measuring temperature, depth and conductivity, creating depth profiles of seawater temperature, (precision = ±0.01 °C) and salinity (precision = ± 0.01 ppt) (SonTek, 2012).

Figure 1: Map of the EcoEléctrica Biological Monitoring Program Plan (BMPP) sampling stations in Guayanilla Bay and Tallaboa Bay, Puerto Rico.

The Vertical Attenuation Coefficient for Photosynthetic Available Radiation (Kd_{PAR}) is used to measure how the light (in the entire visible spectrum 300nm -700nm) penetrate the water column. A elevated Kd_{PAR} measurent means that the ratio of light that's been absorb or scatter in the water column is high, as the opposite for low Kd_{PAR} values. The improtantance of this

measuremnt is to tell how much Photosynthetic energy is available in the water column for the marine organisms. A LI-COR LI-1500 data logger with LI-192 underwater quantum sensor and LI-190R quantum sensor was used to measure photosynthetically active radiation (PAR) at two depths to calculate the coefficient of attenuation of PAR (KdPAR) for each site. At each station except for station 8, PAR was recorded above the boat (incident PAR), 1 m depth, and 3 m depth (Centeno 2023). Since station 8 is too shallow for 3 m depth measurements, PAR was recorded above the boat, 0.5 m depth, and 2 m depth at this station. KdPAR was calculated as per the following equation (LI-COR Biosciences, 2019):

$$KdPAR = \frac{1}{z_2 - z_1} ln \frac{PAR_{z_1}}{PAR_{z_2}}$$

where z_1 was the shallower depth (m) at which PAR was measured, z_2 was the deeper depth (m) at which the PAR was measured, PAR_{z1} was the PAR measurement at the shallower depth, and PAR_{z2} was the PAR measurement at the deeper depth.

Data Analysis and Visualization

All data were summarized into monthly reports provided to DNA Environment and the full data releases are attached to this report. All computer code to generate the figures and summary statistics in this report were conducted using the computer software R, to create fully reproducible workflows from the raw data to the report findings presented here. T-test was used to assess the significance of fixed effects (p-values < 0.05).

Results and Discussion

Temperature

Seawater temperature data were collected monthly using the replicate Sontek Castaway CTD casts at each station and were summarized as depth-averaged data for each sample station (Figure 2 A,B). Seawater temperature revealed a distinct mid-seasonal cycle with cooler temperatures (26-28.5°C) observed from December to April and warmer temperatures (30-31°C) observed from May to October (Figure 2A). Seawater temperatures at the intake and outfall stations followed a similar trend and were within the range of variability (range = 26.6 to 30.8 °C) observed at the other stations throughout the year (Figure 2B).

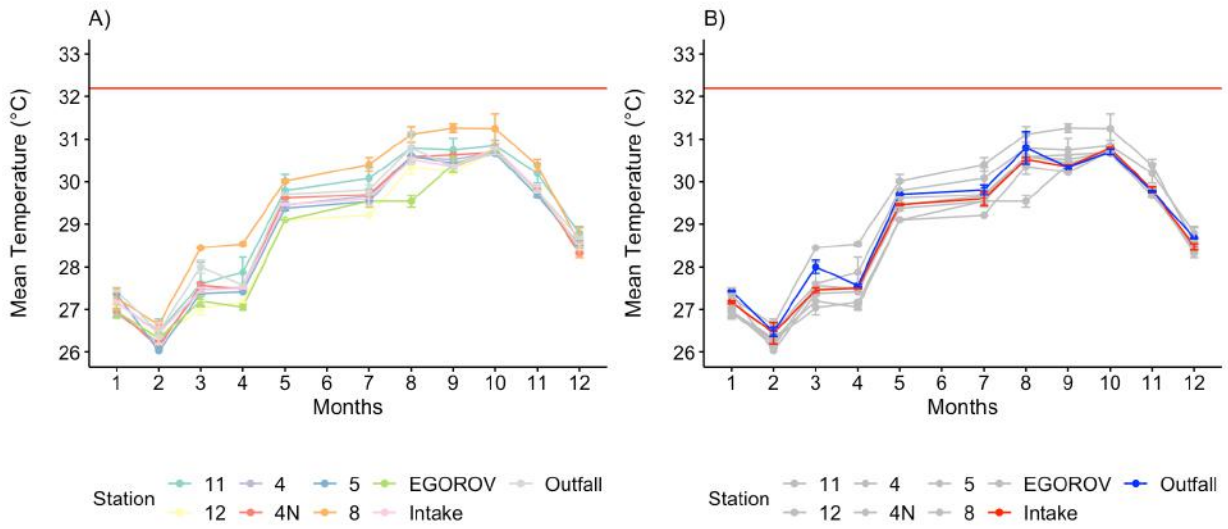

Figure 2: Seawater temperature data from the Sontek CTD casts at each station. A) Monthly depth-averaged seawater temperatures are plotted (± standard deviation) for the respective BMPP stations. B) Monthly depth-averaged seawater temperatures (± standard deviation) are plotted for the intake (red) and outfall (blue) stations relative to the other stations (gray) to highlight the data from those selected sites.

Salinity

Seawater salinity data were collected monthly using the replicate Sontek Castaway CTD casts at each station and were summarized as depth-averaged data for each sample station (Figure 3 A,B). Seawater salinity was highest (35.4 -36.3ppt) during the dry season months from January to June and declined throughout the remainder of the year to a minimum of 34.3-35.2 ppt from October to December (Figure 3A). Salinities at the intake and outfall stations followed a similar trend and were within the range of variability (range = 33.8 to 36.3 ppt) observed at the other stations throughout the year (Figure 3B).

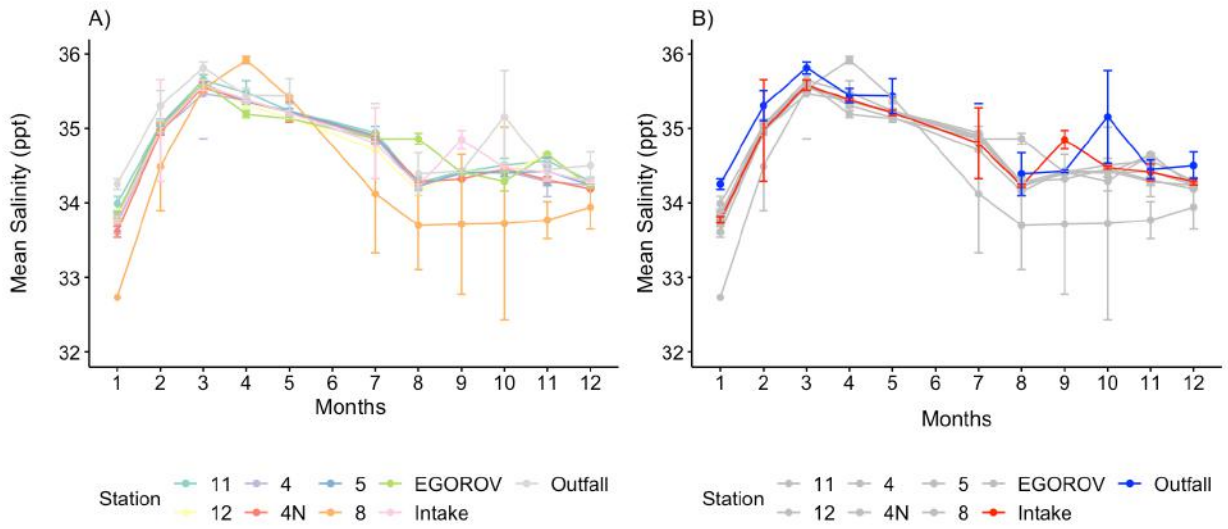

Figure 3: Seawater salinity data from the Sontek CTD casts at each station. A) Monthly depth-averaged seawater salinities (± standard deviation) are plotted for the respective BMPP stations. B) Monthly depth-averaged seawater salinities (± standard deviation) are plotted for the intake (red) and outfall (blue) stations relative to the other stations (gray) to highlight the data from selected sites.

PAR Vertical Attenuation Coefficient (Kd_{PAR})

In contrast to temperature and salinity, there was no clear patterns in (Kd_{PAR}) throughout the year (Figure 4A), showing high variability in each station. At station 8 and station 11, where the highest KdPAR value was generally observed throughout the year (Figure 4A), this was likely due to the proximity of station 8 to Rio Tallaboa, which increased KdPAR values from the river discharge. Additionally, the Tallaboa river outlet can reach station 11 . Conversely, the lowest KdPAR was observed at stations 12 and EGOROV (Figure 4C), which are the deepest and the furthest offshore, so it is likely less influenced by the riverine inputs and receives more direct oceanic influence, resulting in less light attenuation.

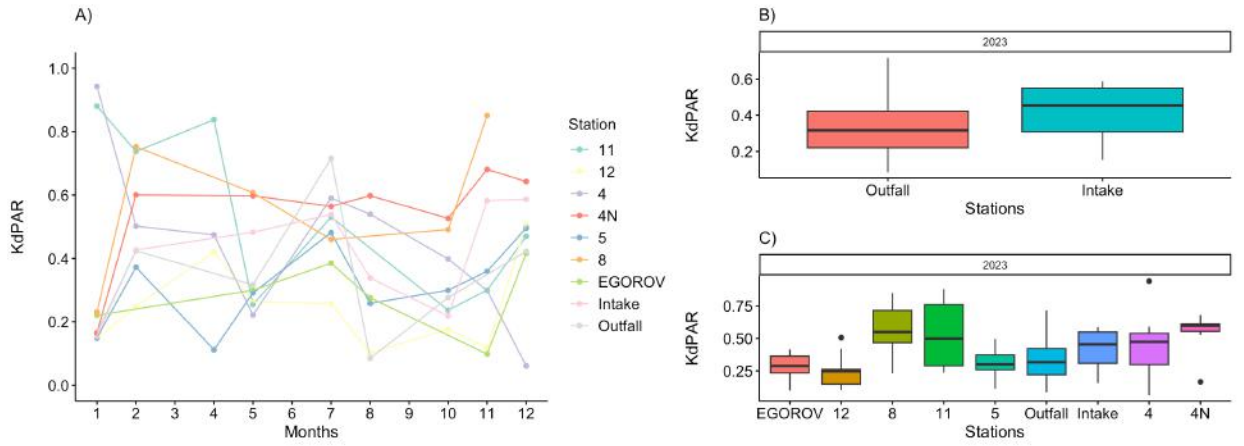

Figure 4: Photosynthetically active radiation vertical attenuation coefficient (Kd_{PAR}) for each station. A) Monthly seawater KdPAR are plotted for the respective BMPP stations from Figure 1 as individual points and colored by the respective station. B) Photosynthetically active radiation vertical attenuation coefficients (Kd_{PAR}) are plotted for the Intake and Outfall sites as box plots. C) Photosynthetically active radiation vertical attenuation coefficients (Kd_{PAR}) are plotted for all stations as box plots overlying the individual KdPAR for each month (gray circles).

Continuous Water Quality Monitoring

Seawater temperature data were collected daily using the Eureka Manta 35+ from April to August and HOBO's Pendant Temperature Logger at the Outfall were summarized as depth-averaged data for the station (Figure 5A). The range temperature for the Eureka Manta 35+ was 27.5- 30.5°C). In the other hand, the range temperature observed from the HOBO's the observed was 27.3- 30.9°C. Seawater max temperature data were collected daily using HOBO's Pendant Temperature Logger at the Intake and Outfall were summarized as depth-averaged data for the station (Figure 5B). The range temperature for the HOBO's was 27.0 31.0°C).

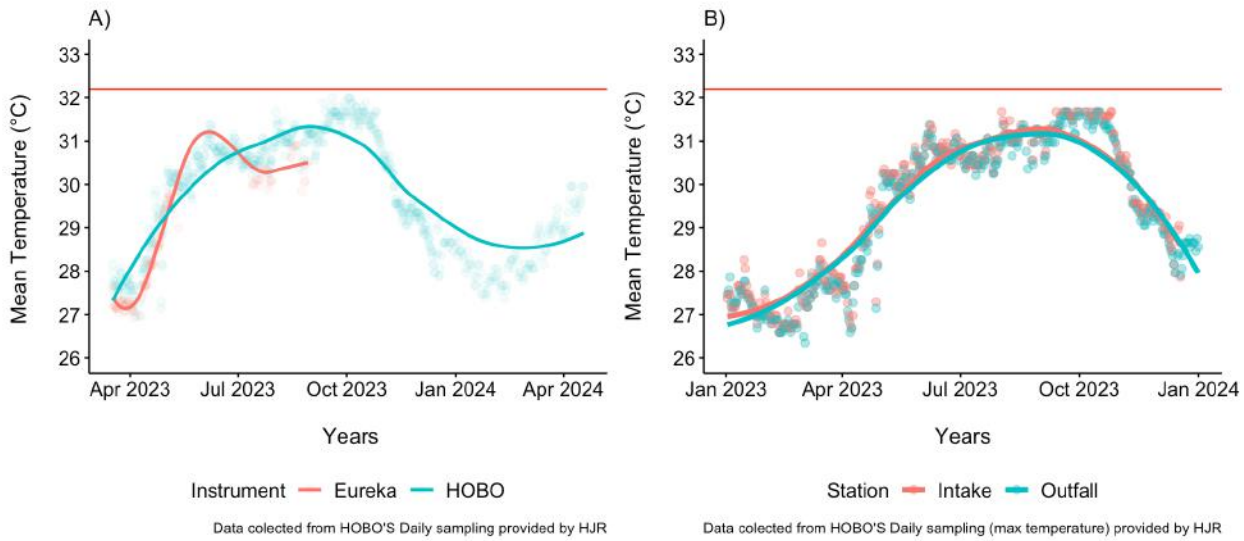

Figure 5A: Seawater temperature data from the Eureka Manta 35+ at the Outfall. A) Monthly depth-averaged seawater temperatures are plotted. B) Daily depth-averaged seawater temperatures (± standard deviation) are plotted for the intake (red) and outfall (light blue) stations.

Summary

Seawater was sampled monthly at 9 stations surrounding the EcoEléctrica facilities for temperature, salinity, and Kd_{PAR} throughout 2023 as part of the BMPP. Temperature and salinity followed similar seasonal fluctuations across all stations, reflecting expected patterns in seasonal warming and precipitation cycles for southwestern Puerto Rico. There was no clear seasonal trend in Kd_{PAR} observed across any of the stations with the highest Kd_{PAR} typically observed at the most inshore sites and decreasing offshore. The T-test for the temperature shown no significant difference between the outfall and intake, meaning the temperature in the water for both stations are the same. All seawater temperature and salinity measured at the intake and outfall were less than the 32.2°C and 38 ppt upper limits established by regulations (Vicente, 2001, 2008; Otero 2013a, 2013b, Centeno 2023). In conclusion, temperature, salinity, and Kd_{PAR} were measured monthly following the BMPP in 2022 and were within the established thresholds established by the regulatory permits.

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