EcoEléctrica Biological Monitoring Project Plan Report: 2022

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Introduction

EcoEléctrica is located between Guayanilla Bay and Tallaboa Bay in the southern coast of Puerto Rico and host a diverse array of ecosystems and uses for the island of Puerto Rico (Figure 1). The EcoEléctrica plant includes a 545 mega-watts combined cycle natural gas power plant, a seawater desalination plant, and a marine unloading and storage terminal for liquefied natural gas (EcoEléctrica, 2015). EcoEléctrica imports liquefied natural gas at the pier, stores it in the terminal, and then vaporizes it into natural gas for combustion in one of two combustion turbines attached to a single steam turbine (EcoEléctrica, 2015). A portion of the steam produced is subsequently used in a desalination plant to convert seawater into freshwater (Vicente, 2001, 2008; Otero 2013a, 2013b). To cool the facilities, raw seawater is pumped from near the shoreline of the pier into an 8-cell cooling tower to remove heat from processed wastewater and from the condenser of the steam turbine system. After that, the water is pumped to a cooling tower to remove excess heat before it is discharged through a 51 cm pipe in the outfall (Vicente, 2001, 2008; Otero 2013a, 2013b). The intake is designed with a mesh to protect marine organisms from entering the system, and the outfall includes a diffuser that is designed to return the seawater to the bay at approximately the same temperature as the intake (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). Within these recommendations, EcoEléctrica created a monitoring program, which is sufficient to assess the impact of the discharge on water, sediment, and biological quality (Otero, 2013a). The Biological Monitoring Program (BMPP) fulfills these requirements by quantifying the impacts of the discharge and potential effects of the EcoEléctrica facilities on the water quality (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). Most importantly, the outfall returning seawater is highly regulated and must be within an acceptable temperature range of 25-32.2°C and salinity range of 33-38 ppt (Vicente, 2001, 2008; Otero 2013a, 2013b). The water quality study parameters reported here are temperature, salinity, and KdPAR.

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 September 2022 owing to the landfall of Hurricane Fiona in Southwest Puerto Rico. At each station, the Sontek Castaway CTD was deployed three times to provide replicated casts. The outfall and intake station sampling were conducted by positioning the boat as close as possible to the center of the diffuser (intake) or outfall. The CTD collected continuous conductivity, temperature, and depth data through the water column on the downcast and upcast to create 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.

KdPAR was used to measure the amount of light that can be absorbed by the water for photosynthetic 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. Because station 8 was too shallow for 3 m depth measurements, PAR was recorded above the boat, 0.5 m depth, and 2 m depth at station 8. 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. This equation results in a single KdPAR measurement for each visit to each station as part of the BMPP.

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. Akaike Information Criterion (AIC) were used to find the best model (Aho K et al., 2014). The model with the lowest AIC value was assessed for assumptions using the performance package (Lüdecke et al., 2021). ANOVA 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 seasonal cycle with cooler temperatures (27-28°C) observed from December to April and warmer temperatures (28-30°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 = 24.68 to 30.92 °C) observed at the other stations throughout the year (Figure 2B).

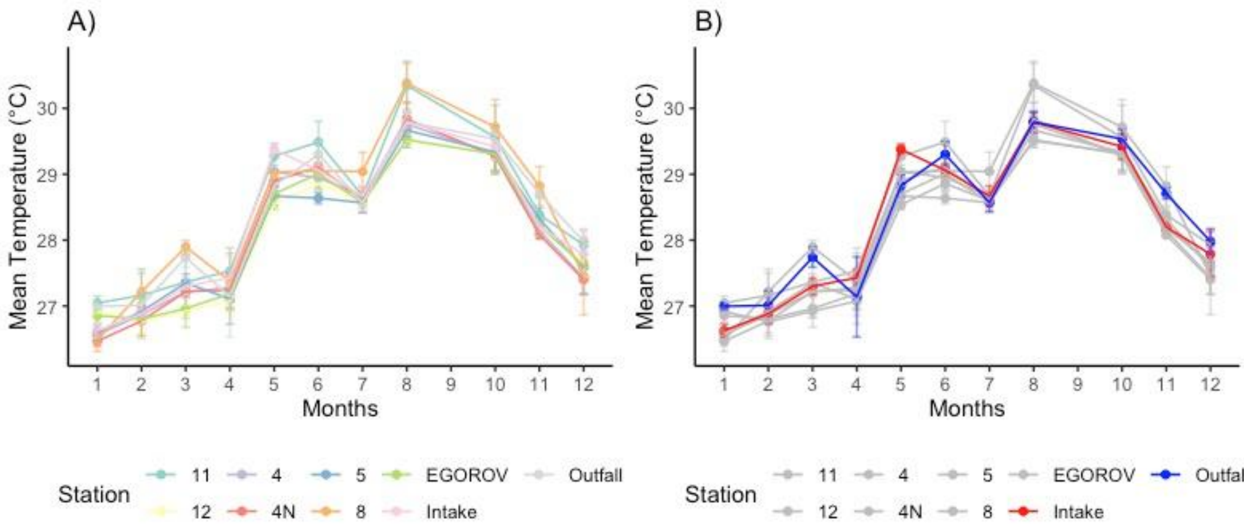

Figure 2: Seawater temperature data from the Sontek CTD casts at each station. A) Monthly depth-averaged seawater temperatures are plotted (± standard deviation) for the respective BMPP stations. B) Monthly depth-averaged seawater temperatures (± standard deviation) are plotted for the intake (red) and 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 (35-36 ppt) during the dry season months from January to June and declined throughout the remainder of the year to a minimum of 32-33 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 = 26.67 to 37.34 ppt) observed at the other stations throughout the year (Figure 3B).

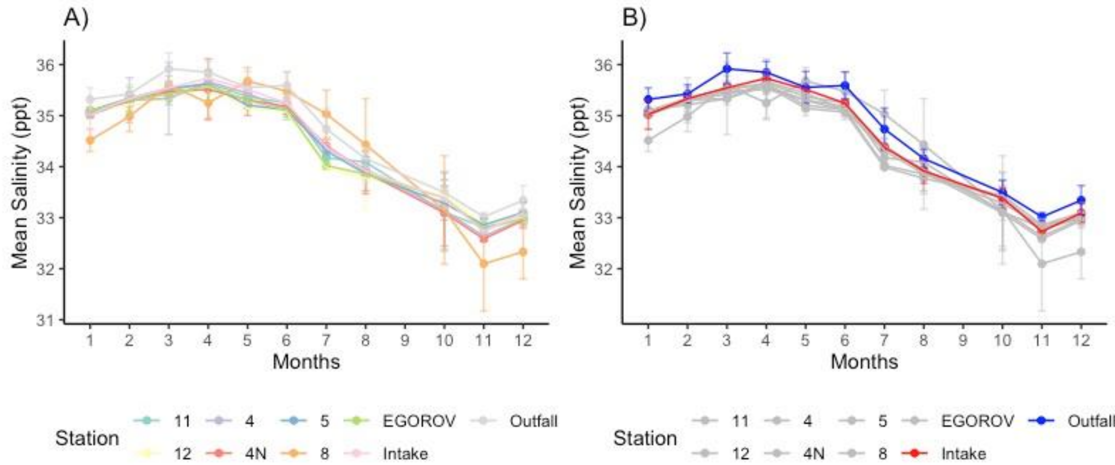

Figure 3: Seawater salinity data from the Sontek CTD casts at each station. A) Monthly depth-averaged seawater salinities (± standard deviation) are plotted for the respective BMPP stations. B) Monthly depth-averaged seawater salinities (± standard deviation) are plotted for the intake (red) and outfall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

PAR Vertical Attenuation Coefficient (KdPAR)

In contrast to temperature and salinity, there was no clear seasonal signal in KdPAR throughout the year (Figure 4A). However, there was an apparent trend between sites with generally higher KdPAR observed at the intake relative to the outfall (Figure 4B) and inshore relative to offshore (Figure 4C). For example, at station 8, 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 likely increased KdPAR from the river discharge. 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.

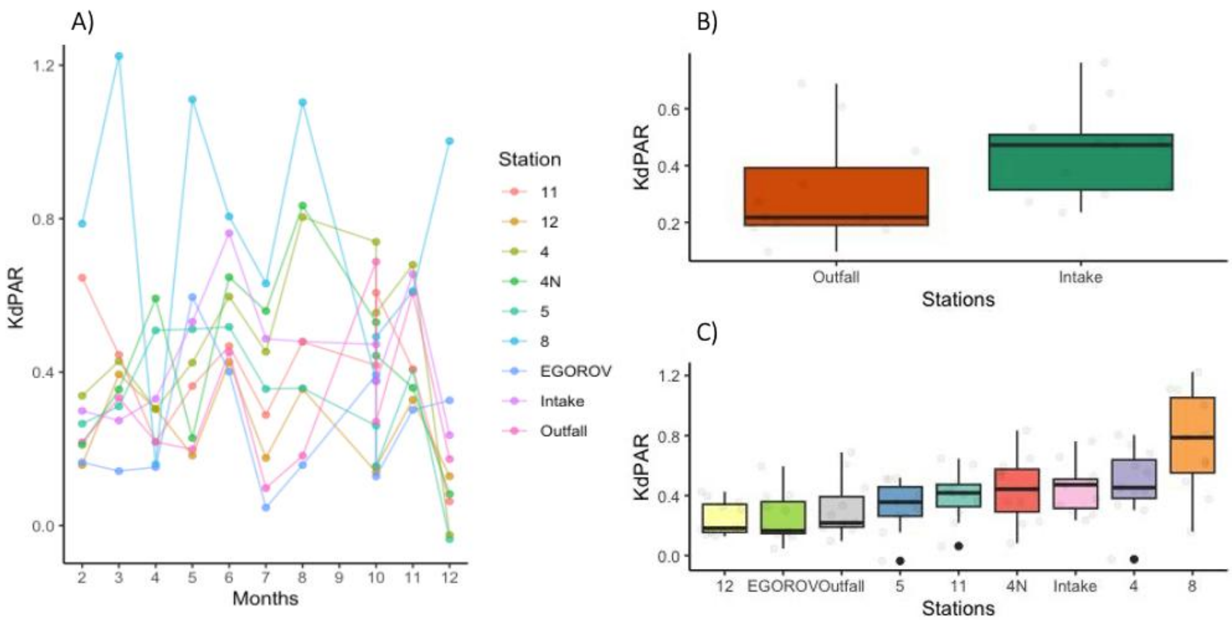

Figure 4: Photosynthetically active radiation vertical attenuation coefficient (KdPAR) for each station. A) Monthly seawater KdPAR are plotted for the respective BMPP stations from Figure 1 as individual points and colored by the respective station. B) Photosynthetically active radiation vertical attenuation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

Summary

Seawater was sampled monthly at 9 stations surrounding the EcoEléctrica facilities for temperature, salinity, and KdPAR throughout 2022 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 KdPAR observed across any of the stations with the highest KdPAR typically observed at the most inshore sites and decreasing offshore. 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). In conclusion, temperature, salinity, and KdPAR were measured monthly following the BMPP in 2022 and were within the established thresholds established by the regulatory permits.

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