Technical report on Temperature Patterns Associated with the EcoElectrica Outfall.

By

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Introduction

The operation of EcoElectrica, L.P. discharges a maximum of 21.4 x 10^6 gallons per day[1]. EcoElectrica's power plant relies on the use of cooling towers to mitigate the increase of temperature of cooling water used during operations. These waters are discharged through a diffuser system close to Bent #26 towards the western end of the pier (Figure 1). The design of the diffuser is such that water is directed towards the surface, minimizing its contact with the bottom fauna and flora. The turbulence caused by the ports can be observed in aerial photographs via the Google Earth Platform.

This work present efforts part of 2017 Biological Monitoring Program Plan to detect and distinguish the temperature signature associated with EcoElectrica's Outfall. The general assumption can be stated as: The effect of the Outfall on temperature should be stronger closer to the diffuser structure. Temperature measurements collected closer to the center of the diffuser should then be discernable from measurements made towards the perimeter of a circle or volume encompassing the structure. That is, the temperature should be higher than the background towards closer to the diffuser. Based on the above assumption, a volume of water surrounding the diffuser was examined along several transects and at different depths to evaluate if a significance increase in temperature was present closer to the diffuser during normal power plant operation conditions.

[1] Vance and Associates, 2001. Biological Monitoring Program Plan, EcoElectrica Co-Generation Project. Pre-Operation Environmental Studies; Post Operation Environmental Studies. August 2001. 129pp.

Methods

Detailed examination of the dispersal of the Outfall plume was conducted using SCUBA instead of shipboard approaches. Because field conditions and instrumentation do not usually allow for <1m navigation accuracy, three (3) transects were established by divers (Figure 2). Transects cross at the center and define a perimeter centered on the outfall diffuser (Figure 2). The end of transects were marked using PVC tubing in order to facilitate the repetition of measurements along the same area.

A special CTD package (consisting of a reel, buoy and a StarOddi mini CTD was operated from the bottom to ca. 0.5m depth, stopping on the way up approximately every meter. Measurements were conducted at 5m intervals along each transect. Divers were careful to wait a minimum of 1 minute when relocation the CTD package, as it was concluded based on laboratory trials that at least 30 seconds were necessary for temperature stabilization.

The work was conducted twice in December 2017 and 2018, since at those times background temperatures were expected not to be the highest during the year. This condition maximized the chance to detect the Outfall influence over the background temperatures of Guayanilla Bay. Graphical representations of the data, summary statistics and correlation analysis were conducted to evaluate if consistent temperature trends are present during sampling.

Results

Figure 3 presents the average temperatures of the three transects with distance from the their center. Table 1 presents average temperatures with depths at the sampling area. These data indicates that the area is well mixed and that just small differences in temperature are found within the area associated with the studied Outfall zone. Figure 4 shows a 3D representation of the data where black dots indicate the position of each station along each transect.

The data indicates that the average temperature was higher in 2017 (28.34; SD= .13; N=134) than in 2018 (27.43; SD=0.118;N=154). These differences respond to natural inter-annual differences of temperature evidenced in a separate report[2]. There was a slight increase of temperature at the perimeter of the Outfall zone during 2017 (an increase of Δ+0.12°C) while a slight decrease (Δ-0.07°C) was found during 2018. Regression analysis of temperature with distance from the center of transects was conducted (Figure 5; StatistXL, Ver 1.11) and showed

[2] Otero, 2020. **Technical report on Temperature Temporal Variability at the Intake and Discharge sites at Ecoelectrica's L.P. Pier. Comparison with six additional locations from Tallaboa and Guayanilla** Bay.

slight but statistically unsignificant increase towards the perimeter while a marginally statistical significant decreasing trends towards the on 2018.

Conclusions

The temperature measurements in the volume of water within the 30m radius centered at the central diffuser indicate slight significant changes towards away from the Outfall region. However, this changes are minimal and are not necessary consistent with the assumptions of this study. During 2017 temperature increased slightly towards the perimeter while it increased slightly towards the center in 2018. The overall pattern observed in this study was dominated by inter-annual differences in temperature and not by heat inputs due to outfall operation. Overall, the study did not find strong evidence that suggests the operation of EcoElectrica's outfall has a functionally significance effect on the environment and it confirms that, at the time of the study, no temperatures were detected exceeding 30°C.

Figures and Tables

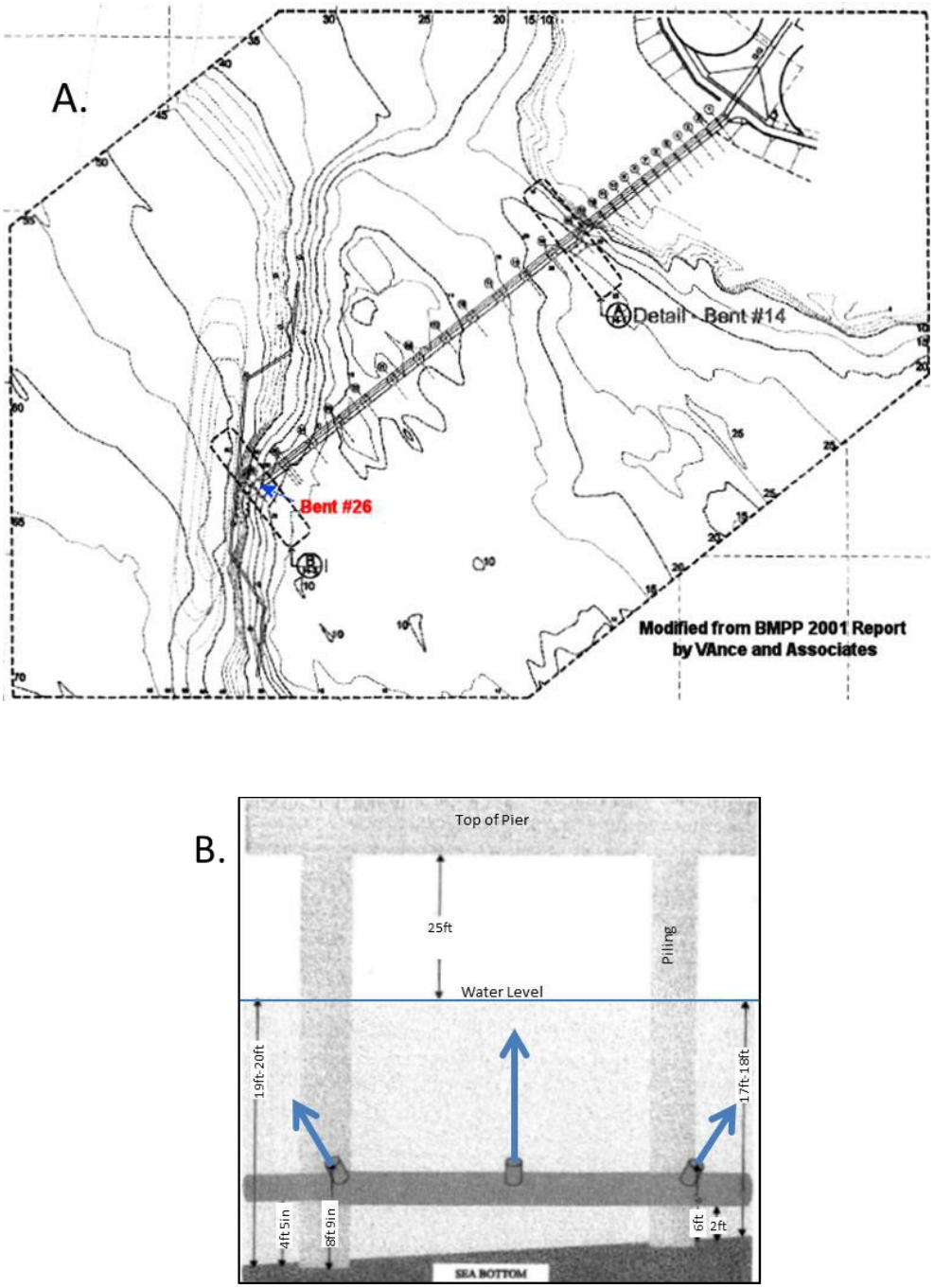


Figure 1. Schematics of EcoElectrica's pier. A) Location of the Outfall close to Bent #26 at the western end of the pier. B) Underwater layout of the Outfall and the general directions of the water flowing out of the three diffusers. The schematics were modified from BMPP 2001[3].

[3] Vance and Associates, 2001.Biological Monitoring Program Plan, EcoElectrica Co-Generation Project. Pre-Operation Environmental Studies; Post Operation Environmental Studies. August 2001. 129pp.

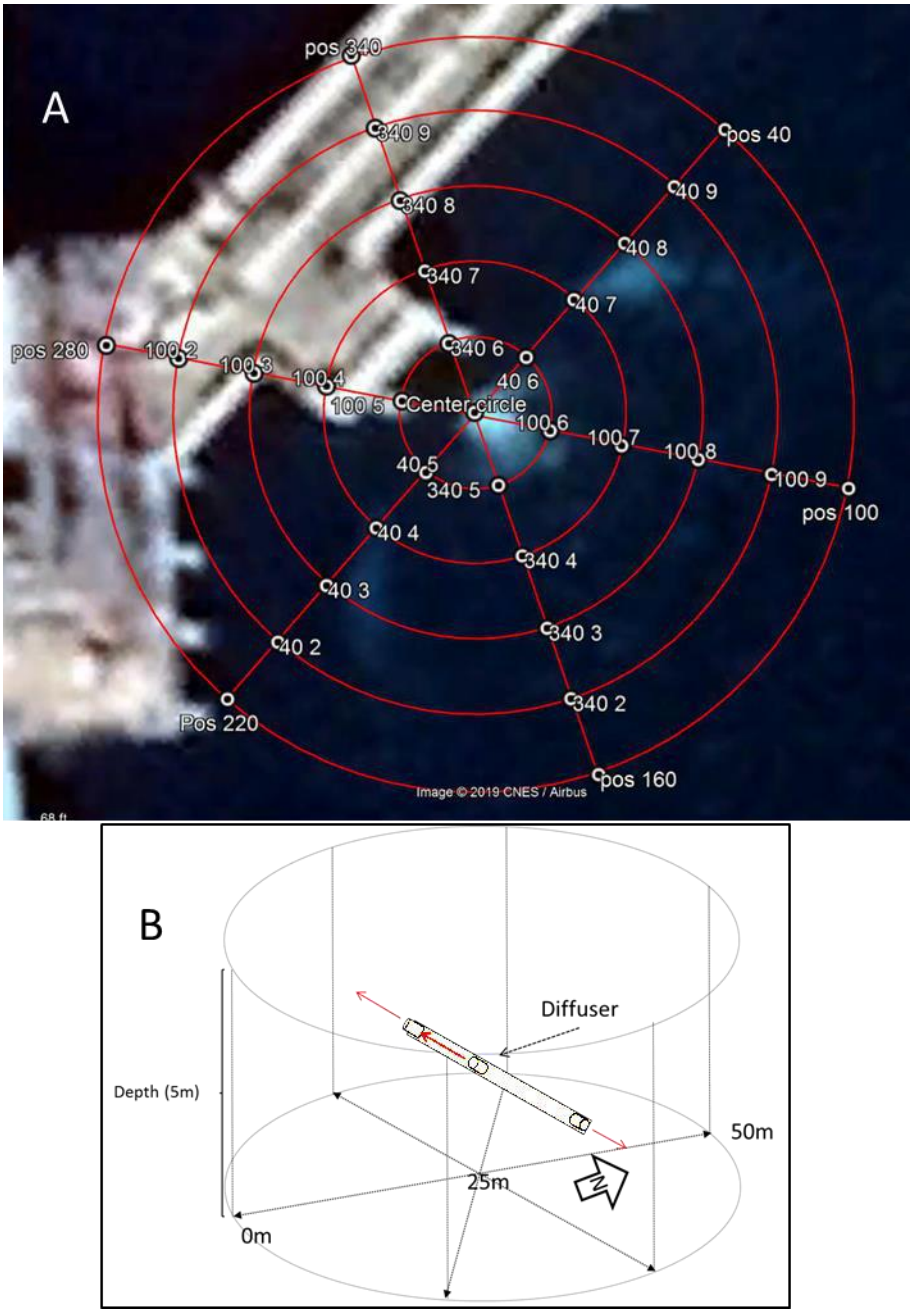


Figure 2. Details of the study site. A) Perimeter where temperature measurements were collected by divers showing the three transects intersecting at the central diffuser and showing the location of sampling stations. The aerial photo shows the three diffuser plumes as they arrive to the surface of the water. B) Representation of a water volume surrounding the Outfall diffusers. There are approximately 25m at each side of each transect from the central diffuser. Red arrows indicate the general direction of water movement.

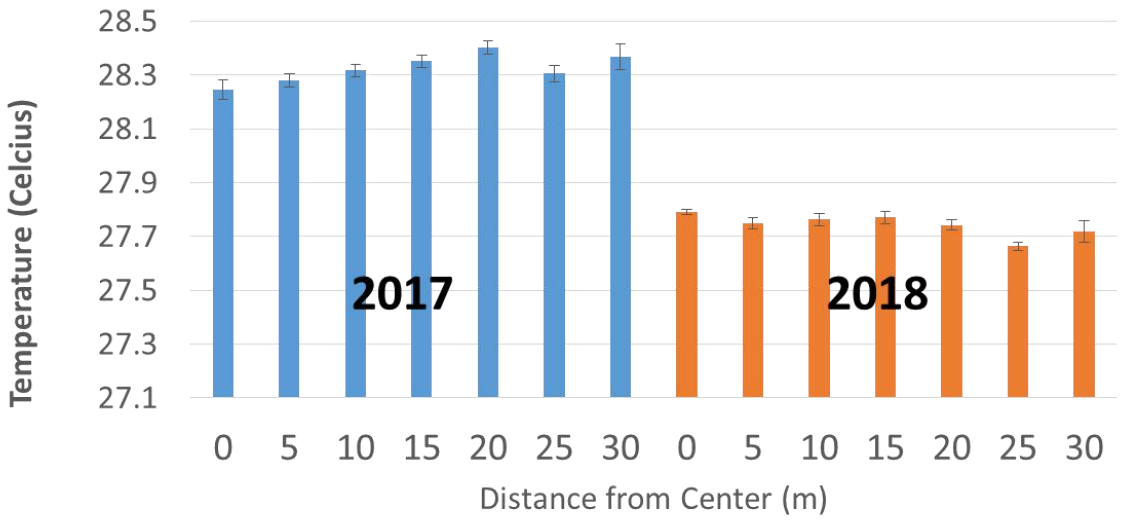


Figure 3. Average temperature at different distances from the central diffuser. Each bar represent the average of all values at the speciefed distance for all transects. Error bars are standard errors.

Table 1. Average temperature (°C) at each depth interval. Temperature readings for each transect and each depth interval were pooled to conduct the estmates. Higher values are represented with yellower colors and smaller with bluer colors.

Year	Depth (m)	Min	Max	Average	SE
2017	0-1	28.14	28.58	28.38	0.44
2017	1-2	28.11	28.58	28.34	0.47
2017	2-3	28.08	28.58	28.33	0.50
2017	3-4	28.08	28.52	28.31	0.44
2018	0-1	27.56	27.93	27.77	0.37
2018	1-2	27.56	27.91	27.73	0.35
2018	2-3	27.53	27.94	27.72	0.41
2018	3-4	27.53	27.91	27.74	0.38

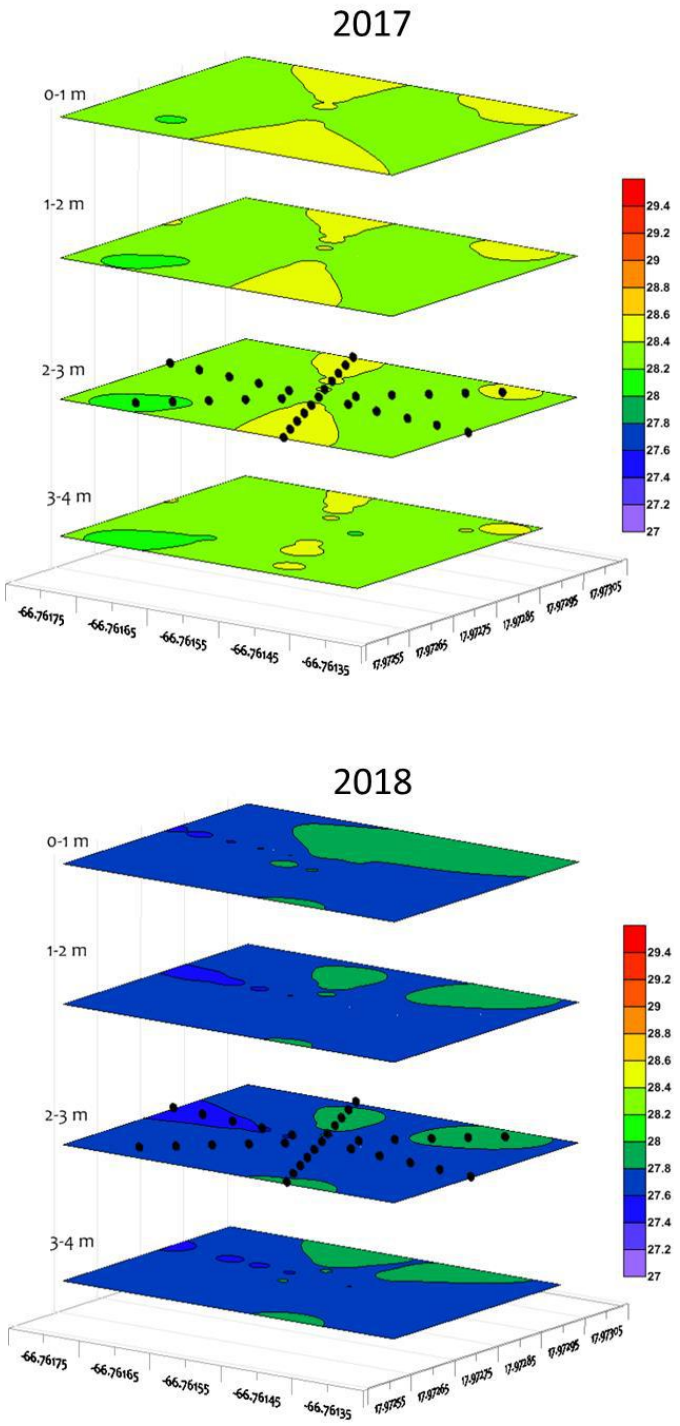
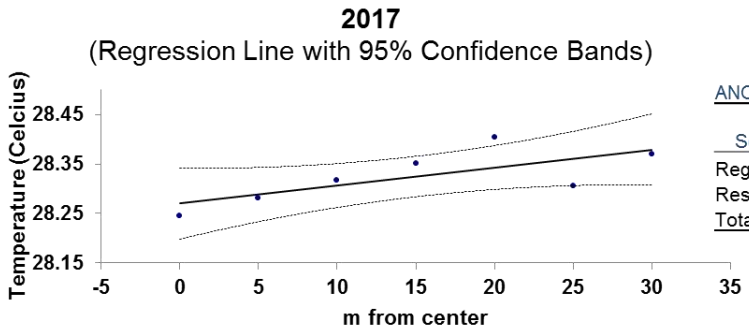


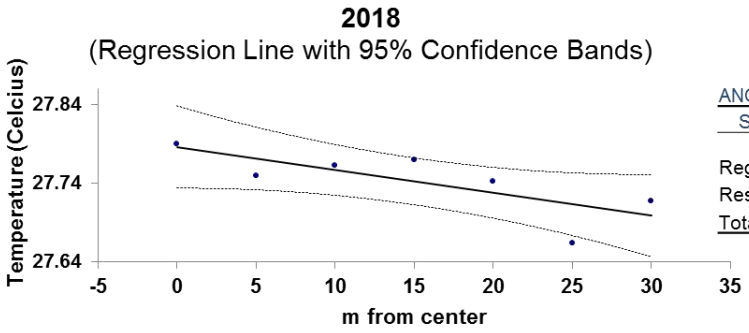
Figure. 4. Three dimensional distribution of temperature surrounding EcoElectrica's Outfall. Each depth interval described in Table 1 was plotted. Grapher 9 software was used to construct the contours. A color scale (27-29.6 °C) was kept the same that the background temperature differences between samplings could be appreciated. Black dots on the 2-3m slice indicates the position of sampling stations within the volume sampled.



ANOVA

Source	Sum Sq.	D.F.	Mean Sq.	F	Prob.
Regression	0.009	1	0.009	5.586	0.064
Residual	0.008	5	0.002		
Total	0.018	6			

P> 0.05; Not Signif.



ANOVA

Source	Sum Sq.	D.F.	Mean Sq.	F	Prob.
Regression	0.006	1	0.006	6.714	0.049
Residual	0.004	5	0.001		
Total	0.010	6			

P< 0.05; Signif.

Figure 5. Regression analysis of temperature vs distance from the central diffuser. It was assumed that a temperature effect of EcoElectrica's water discharge would be observed as a significant increase from that of Guayanilla bay background waters. A slight statistically not significant decrease (Δ=-0.12°C) of water temperature towards the Outfall was found in 2017 while a slight marginally statistically significant increase ((Δ=+0.07°C) was observed during 2018.