Distribution of chlorophyll *a* concentrations throughout Kalāhuipuaʻa Fishpond, Kohala Hema, Hawaiʻi

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Abstract

Loko iʻa provide a natural and sustainable way to cultivate aquatic species within man-made or naturally formed enclosures, which creates an optimal environment for micro-organisms to grow. Kalāhuipuaʻa fishpond is a collection of seven *loko iʻa* located in Kohala Hema, Hawaiʻi. 161 chlorophyll *a* samples collected by The Nature Conservancy in the year of 2019 was analyzed in a fluorometer to investigate the influence *loko iʻa* has on nearshore coral reef communities and the distribution pattern of chlorophyll a concentrations found within the *loko iʻa* and the offshore coastal waters. There was a significant difference in chlorophyll *a* concentration within Kalāhuipuaʻa as well as the inside and the outside of the *loko iʻa*. An inversly related correlation in chlorophyll *a* concentrations as distance offshore increased was observed in both the *ʻili kai* (surface water) and *lepo kai* (benthic water). 161 samples were analyzed for chlorophyll *a*, which varied from MIN to MAX µg/L. Kalāhuipuaʻa fishpond complex displayed a significant difference in chlorophyll *a* concentrations between the inside and the outside of the ponds as well as a significant inverse correlation in chlorophyll *a* concentrations as distance offshore increases in both *ʻili kai* and *lepo kai*. Lastly, there was a significant difference displayed in chlorophyll *a* distribution throughout the 19 stations that were analyzed at Kalāhuipuaʻa fishpond complex. The lowest concentrations were observed at P1 which is located in the man-made pond and at P5 for the highest concentration which is located in Hopeʻala, and site P5 and P19 showing the most variability.

Introduction and Background

Loko iʻa (fishponds) are traditional aquacultural systems engineered by the aboriginal people of Hawaiʻi to support communities by raising and farming fish. *Loko iʻa* provide a natural and sustainable way to cultivate aquatic species within man-made or naturally formed enclosures. They were an innovative traditional natural resource management tool that was a key component to a community's sustenence and survival, essentially providing a sustainable refrigerator for the people of that community (The Kohala Center 2015).

Loko iʻa use the *waikai* or brackish water created by the mixing of the *wai* (freshwater) from a freshwater source and the *kai* (seawater) from the ocean. The man-made walls called the *kuapā*, enclose the brackish water, which creates an optimal environment for micro-phytoplankton to grow. The *mākāhā* (sluice gate) provides the breath of the *loko iʻa*, allowing the flood tides to bring oxygenated *kai* into the *loko iʻa* and the ebb tides to exhale deoxygenated brackish water out of the *loko iʻa*. The ebb tides also provides a highly concentrated channel of nutrient rich brackish water through the mākāhā from within the loko iʻa to the outer regions of the adjacent ocean. The *pua* (fingerlings) in the outer regions follow this trail and swim into the *loko iʻa* and begin to consume and intake the nutrients within the *loko iʻa*. Over time, the *pua* mature and grow too large to exit the *mākāhā*, becoming a resident of the *loko iʻa*; where it will continue to mature, and provide sustenance to members of the *ahupuaʻa* (smaller land division generally from mountain to sea) or become the spawners within the offshore fisheries.

This aspect of the *loko iʻa* being able to recruit and support new fish populations sustainably and efficiently is what makes these ancient innovations so ingenious and extensive. The Hawaiian people were one of the only known indigenous populations throughout Oceania to practice a pure form of fishpond aquaculture (Keala et. al 2007). This is beneficial in creating a surplus of fish with very minimal effort, conserving the amount of energy needed to maintain a *loko iʻa*. The health of a *loko iʻa* were said to be a reflection upon the community's health and well-being (Kauahi 2018). Upon the arrival of Captain Cook to Hawaiʻi in 1778, at least 360 fishponds existed and produced approximately 900 metric tons of fish per year in the archipelago (Costa-Pierce 1987). Nearly 200 years later, the great abundance of *loko iʻa* has decreased from approximately 360 to only 28 properly functioning *loko iʻa* after shifts in social dynamics, morals and beliefs (Madden & Paulsen 1977). In recent years, there has been a ressurgence of *loko iʻa*; more than 50 are in the process of being restored with the help of *kiaʻi loko iʻa* (fishpond caretakers), scientists, various organizations and agencies, students, and local communities (Kauahi 2018).

Chlorophyll a

Chlorophyll *a* is a pigment found within photoautotrophic organisms like algae and phytoplankton, which is located within the chloroplasts or the powering stations of photoautotrophic organisms, where their energy is created. Chlorophyll *a* is directly correlated to and can be an indicator of photoautrophic abundance and biomass within a given body of water. Since chlorophyll *a* reflects the amount of phytoplankton biomass within the water, the analysis of chlorophyll *a* will serve as a proxy to further investigate and study the autotrophic foundation of the *loko iʻa*. A *loko iʻa* is like a ranch, where the foundational species, like grass and other feeding materials at the base level, are the target species and main constituent to maximizing the production of the upper trophic consumers, conducing a bottom-up control. The term *mahi iʻa* is an exchangeable term for *kiaʻi loko iʻa*, since their function at the pond is not only to tend, manage, and protect *i'a* within the pond, but to monitor, maintain, and ensure cultivation of phytoplankton and microalgae continues within the *loko i'a*. The presence of freshwater inputs and saltwater inputs from tidal influence through the mākāhā is essential to reducing salinity levels to create favorable environments for algal growth to occur (Anthony 2018). These areas were found to support a variety of green, brown, and red algae forms (Abbott 1947). The *kuapā* in this sense acts as the retaining fence that holds livestock within the *loko iʻa*. In addition to retaining *iʻa* within the pond, the *kuapā* stalls the mixing processes between *wai* and *kai*, thus, controlling the residence time to facilitate beneficial blooms of benthic algae and phytoplankton to support herbivorous and invertebrate-consuming piscivores (Hiatt 1947b; Kawika et al. 2020). Besides the optimal salinity levels and residence times to support these foundational colonies, pond depth is another important factor to provide sufficient light penetration to stimulate algal growth (Abbott 1947). Some other factors that can affect biological productivity in *loko i'a* are latitude, season, irradiance, temperature, flow, and nutrient loading (Mallin et al. 1993).

Site Description

Kalāhuipuaʻa (The herd of pigs) is located in the *ahupuaʻa* of *Waikoloa*, *Kohala Hema* on the *mokupuni* of *Hawaiʻi* (Clark 2002). *Kalāhuipuaʻa* is a complex of seven main *loko iʻa* that is currently managed by The Nature Conservancy (TNC) and the Mauna Lani Resort Association (MLRA). This *loko iʻa* complex includes *Kalāhuipuaʻa*, *Kahinawao*, *Waipuhi*, *Waipuhi iki*, *Hopeʻala*, *Milokūkahi* and *Manokū* (see figure 1)(The Kohala Center 2015). The two ponds open to the sea are *Lāhuipuaʻa* and *Waipuhi*, where the *kuapā* separates these ponds from the adjacent bays. *Makaīwa* Bay, *Keawanui* Bay, and *Nunuki* Inlet are the adjacent coastal waters that enter through the *mākāhā* into the *loko iʻa* on daily incoming and outgoing tidal curents (Kikuchi & Belshé 1971, The Kohala Center 2015). After inquiries from a *kiaʻi* of *Kalāhuipuaʻa,* further research and investigation has been conducted by TNC to monitor and document the conditions of reef resources, in order to better understand the effects of *loko iʻa* on nearshore water quality and adjacent coral reef communities. This helps TNC to fulfill the agencies needs to enrich lives and to conserve land and water in order to promote a thriving diversity of life, while instilling nature conservancy within people (The Nature Conservancy 2021).

TNC's over-arching research objectives are to improve understanding in the shifts in salinity over time at *Kalāhuipuaʻa* complex; describing spatial water quality gradient and any connectivity between the *loko iʻa* and adjacent nearshore coral communities; examining potential water quality effects on *loko iʻa* and nearshore coral communities from recent resort renovations; assessing the influence of water quality gradients and connectivity on nearshore fisheries and adjacent coral communities. This information will update and inform the status and trends of water quality on coral reef ecology to *kiaʻi loko iʻa* and resort managers with hopes of assisting and guiding sustainable land-use and conservation initiatives. For this study, I assisted with analyzing the 2019 chlorophyll *a* samples. I was also granted permission to conduct research on this data to study the distribution and relationships of chlorophyll *a* throughout *Kalāhuipuaʻa* fishpond. Within this study was a comparison between the chlorophyll *a* concentrations within and outside of the *loko iʻa*; as well as an analysis of the distribution patterns of chlorophyll *a* from within the pond to the adjacent bays offshore.

Methods

TNC Sampling

Site selection were based on previously conducted studies at *Kalāhuipuaʻa* to monitor changes over time, where 18 sites within the *loko iʻa* and three (0-500m) transect offshore measured and obtained six sets of water quality data from July 2018 and November 2019. The data recorded measurement of physical water quality parameters (Temperature, dissolved oxygen, pH, turbidity, specific conductivity, and salinity), inorganic nutrient and silicate concentrations (Nitrate, ammonia, phosphate, and silicate), and chlorophyll *a* (Falinski K 2021). Fish and benthic data were also collected at 206 random sites in order to evaluate reef conditions and eventually, both of these data sets were used to evaluate the effects of *loko iʻa* on nearshore coral reef communities.

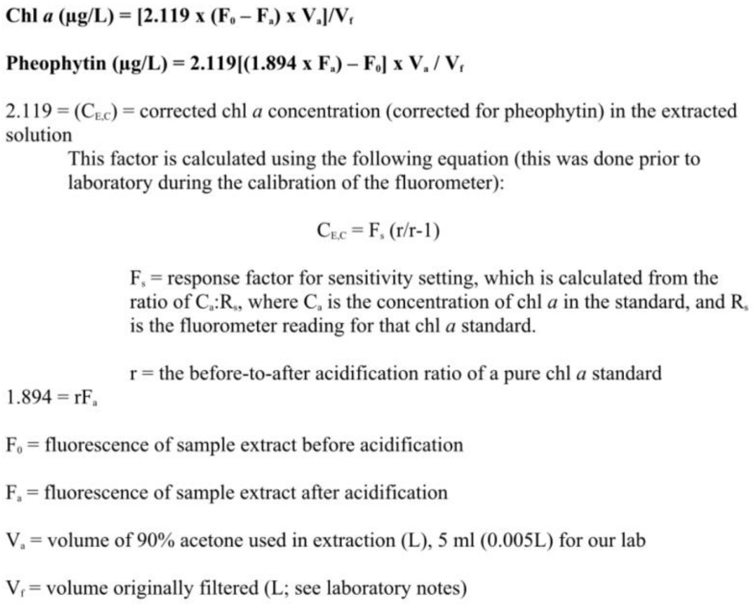
Lab Analysis

161 of the chlorophyll *a* samples collected in the year of 2019 were transported to the University of Hawaiʻi at Hilo (UH Hilo) Analytical Lab and stored at -80°C (USEPA). Since the Chlorophyll *a* pigment is sensitive to light, the lights in the room were turned off to prevent changes in absorbance of pigments, where a red-light lamp was set up to increase visibility without damaging the samples (USEPA). Each sample was prepared by transferring the filter paper from the sample into a 10 mL glass screw cap vial with forceps, followed by an addition of

5 mL of 90% acetone solution to the 10 mL glass screw cap (USEPA). The 10 mL screw cap vials with the filter paper and acetone were sealed and shaken vigorously and placed on a storing rack, which was wrapped in aluminum tinfoil to prevent light absorbance in the samples (USEPA). The chlorophyll *samples* were then placed in the 4°C refrigerator for the chlorophyll *a* extraction process for at least 4 hours (USEPA).

After the extraction process, the chlorophyll *a* absorbance was acquired by using a fluorometer. The chlorophyll *a* samples were removed from the refrigerator and each filter was extracted and disposed with a forceps, then centrifuged on the maximum setting for 8 minutes (USEPA). A blank 10 mL screw cap vial filled with 5 mL of 90% acetone and a standard was recorded before and after the analysis of the chlorophyll *a* sample (USEPA). After obtaining the absorbance of the blank vial and standard, each were placed in the fluorometer, and the absorbance was recorded in the notebook. If chlorophyll *a* sample exceeded the fluorometer scale and read “OVER”, a second dilution was performed where 1 mL of the chlorophyll *a* sample solution that was “OVER” was extracted and transferred to another clean and dry 10 mL screw cap vial, where 5 mL of 90% acetone was added to the screw cap vial and inserted back into the fluorometer. This same dilution process was performed again, if the fluorometer resulted with another “OVER” measurement.

After completing the chlorophyll *a* absorbance analysis, the data were transferred to Microsoft Excel and the absorbance values were converted to chlorophyll *a* and pheophytin values using the equation below.



Chl *a* (µg/L) = [2.119 x (F_0 – F_a) x V_a]/V_f

Pheophytin (µg/L) = 2.119[(1.894 x F_a) – F_0] x V_a / V_f

2.119 = ($C_{E,C}$) = corrected chl *a* concentration (corrected for pheophytin) in the extracted solution

This factor is calculated using the following equation (this was done prior to laboratory during the calibration of the fluorometer):

$$C_{E,C} = F_s\ (r/r-1)$$

F_s = response factor for sensitivity setting, which is calculated from the ratio of C_a:R_s, where C_a is the concentration of chl *a* in the standard, and R_s is the fluorometer reading for that chl *a* standard.

r = the before-to-after acidification ratio of a pure chl *a* standard

1.894 = rF_a

F_0 = fluorescence of sample extract before acidification

F_a = fluorescence of sample extract after acidification

V_a = volume of 90% acetone used in extraction (L), 5 ml (0.005L) for our lab

V_f = volume originally filtered (L; see laboratory notes)

Statistical analysis

To determine if there was difference in chlorophyll *a* concentration within the *loko iʻa* versus the adjacent bay, a two sample T-test for normally distributed data and a Mann-Whitney for non-normal data were used.

To determine if there is a trend between chlorophyll *a* concentration and distance off-shore, a correlation between the chlorophyll *a* samples for both the *ʻili kai* and *lepo kai* along the 0 – 500m transect offshore.

To determine if there is a difference in chlorophyll *a* distribution within Kalāhuipuaʻa fishpond complex, a One-way Analysis of Variance (ANOVA) for normal data and a Kruskal-Wallis tests for non-normal data were used. A Tukey test was used to determine the specific variance throughout the *loko iʻa.*

All statistical analyses were conducted in the 2020 version of Minitab.

Results

1)

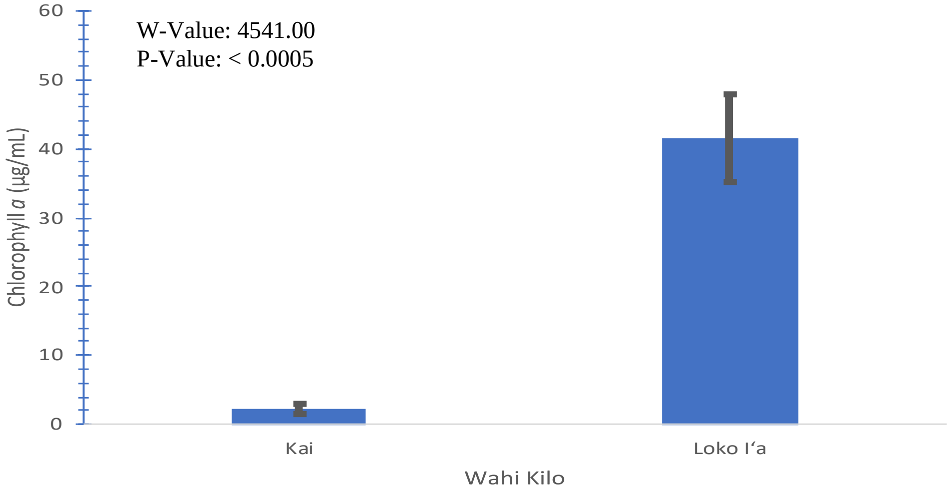
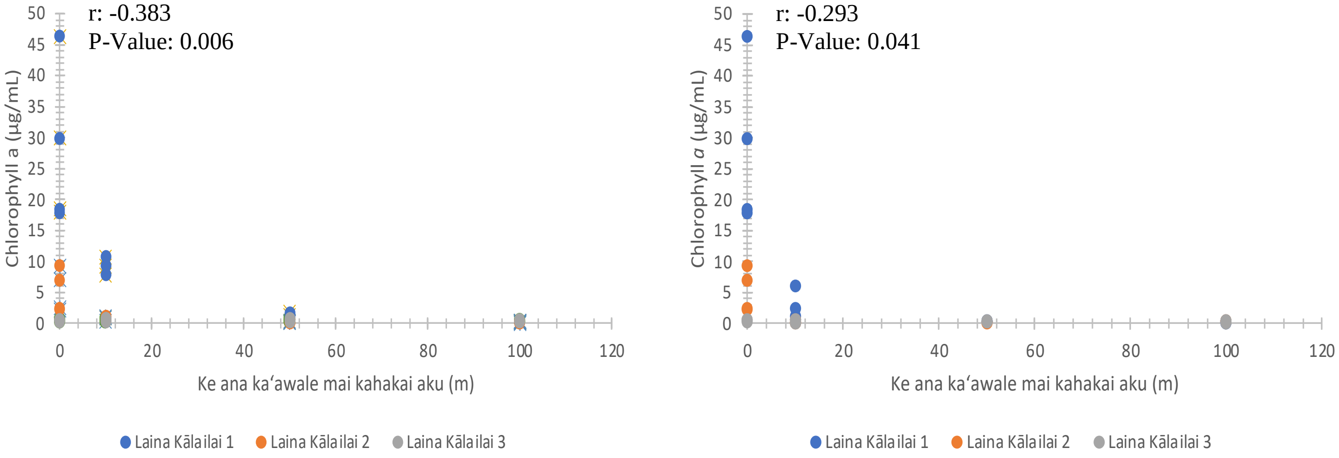


Figure 1. Mann-Whitney statistical analysis of chlorophyll a distribution between inside- and outside of the Kalāhuipuaʻa fishpond complex, concluded with a significant different P-value of greater than 0.0005.

2)

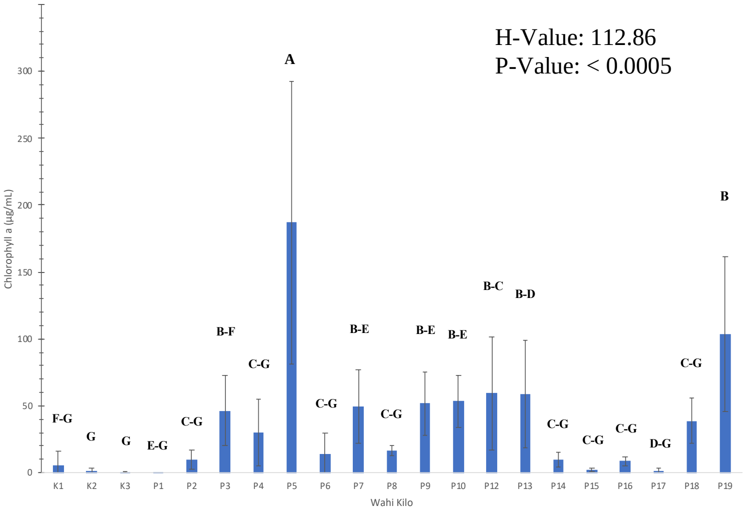


A) ʻIlikai

B) Lepokai

Figure 2. A) Correlation statistical analysis of chlorophyll *a* distribution as distance inscreases offshore (0-500m) in the ʻilikai was significantly different with a P-value of 0.006. B) Correlation statistical analysis of chlorophyll *a* distribution as distance inscreases offshore (0-500m) in the lepokai was significantly different with a P-value of 0.041.

4)



5)

Figure 4. Kruskal-Wallis statistical analysis of chlorophyll *a* distribution within Kalāhuipuaʻa fishpond complex, concluded with significantly difference with a P-value greater than 0.0005, where figure 5 displays a map of the chlorophyll *a* distribution after a tukey analysis of the different sampling sites.

161 samples were analyzed for chlorophyll *a*, which varied from MIN to MAX µg/L. The chlorophyll *a* concentration on the inside of Kalāhuipuaʻa fishpond complex exhibited a significantly higher chlorophyll *a* concentration than the adjacent waters on the outside of the *loko iʻa* (figure 1).

There was also a negative and inverse correlation in chlorophyll *a* concentration as distance off shore increased in both the *ʻili kai* (surface waters) and the *lepo kai* (benthic), where the *ʻili kai* chlorophyll *a* samples exhibited a more significant correlation then the *lepo kai* (figure 2).

Lastly, there was a significant difference displayed in chlorophyll *a* distribution throughout the 19 stations that were analyzed at Kalāhuipuaʻa fishpond complex. The lowest concentrations were observed at P1 which is located in the man-made pond and at P5 for the highest concentration which is located in Hopeʻala, whereas, sites P5 and P19 also showed the most variability throughout the sampling sites (figure 4 & 5).

Discussion and Conclusion

Kalāhuipuaʻa fishpond complex displayed a significant difference in chlorophyll *a* concentrations between the inside and the outside of the ponds as well as a significant inverse correlation in chlorophyll *a* concentrations as distance offshore increases in both *ʻili kai* and *lepo kai*. The higher chlorophyll *a* concentrations on the inside of the *loko iʻa* further supports the there is an increase in primary productivity occurring within the *kuapā* of Kalāhuipuaʻa. The slightly greater significant differences in chlorophyll *a* concentrations between *ʻili kai* and *lepo kai* as distance offshore increases also supports that the water column area is another factor either due to water stratification or light availability (Abbott 1947).

Kalāhuipuaʻa displays high concentrations of algae supporting fish and other communities within the *loko iʻa*. There is a difference in chlorophyll *a* distribution throughout the pond, where sites with A, B, B-C, B-D, and B-E exhibited higher concentrations, sites with B-F, C-G, and F-G exhibited intermediate concentrations, and sites with D-G, E-G, and G exhibited low concentrations. The average salinity data from TNCs report showed that Hopeʻala had a more limited salinity range between around 5 – 7 ppt, compared to the other *loko iʻa* within Kalāhuipuaʻa (Falinski et al. 2021). This could be indicative of *pūnāwai* (ground water discharge) presence, elongated residence time, and/or narrow ranged salinity influences. Contrary, the chlorophyll *a* concentrations compared to the salinity in Kalāhuipuaʻa fishpond did not exhibit similar qualities to the *loko iʻa* on the Hilo Hanakahi coast (Honokea, Hale o Lono, and Waiāhole/Kapalaho). Honokea had higher chlorophyll concentrations in higher salinity regions, whereas Hale o Lono and Waiāhole exhibited this peak in lower salinity regions (Anthony 2018). This narrow salinity range at Hopeʻala may be inferring a difference in nutrient inputs from *pūnāwai* that are then dispersed throughout the Kalāhuipua'a.

Building on the dispersal and distribution of chlorophyll *a*, the *loko iʻa* also transports this additional source of algae to fishes in the offshore communities. The negative inverse relationship between chlorophyll *a* concentration as distance increases offshore, shows us that the phytoplankton and algae communities are being eaten by offshore fish communities. This can infer that these autotrophic organisms do not have a very long residence time after they exit the pond through tidal influence. This supports that *loko iʻa* are integrated aquacultural systems connecting watershed ecosystems to offshore fisheries ecosystems (Costa-Pierce 2002).

The algal foundations of loko iʻa are very crucial in the health and productivity of loko iʻa, where the intricate balance between mixing fresh- and saltwater influences the productivity of algal communities which power and support fish communties within the loko iʻa. During the 2018 renovations of the Maunalani Resort, salinity decreases and shifts from a brackish to a more freshwater dominant environment were observed within both Waipuhi and Waipuhi iki, which is presumed to be the natural states of these ponds, further indicating a possibly influence in water quality characteristics of these ponds from resort discharge and run off. The input of sewage, animal manure, atmospheric deposition, fertilizers and invasive species are anthropogenic sources of nitrogen and phosphorus to coastal waters can result in eutrophication and harmful algal blooms. This should be monitored closely to prevent severely detrimental fish kills at Kalāhuipuaʻa.

The function of *loko iʻa* are to optimize and maintain healthy levels of algal communities in order to rear fish to support communities. About 85 - 90% of Hawaiʻis food is imported (Shultz Afuvai 2012), which poses a threat to Hawaii's food security and makes the communities of Hawaiʻi more vulnerable to natural disasters and global events that may disrupt imports. Kalāhuipuaʻa has the resources and potential to promote, sustain more *loko iʻa* initiatives to strengthen coastal resiliency in communities by using the unique traditional practices that were established and designed for the islands and found nowhere else in the world (Anthony 2018).

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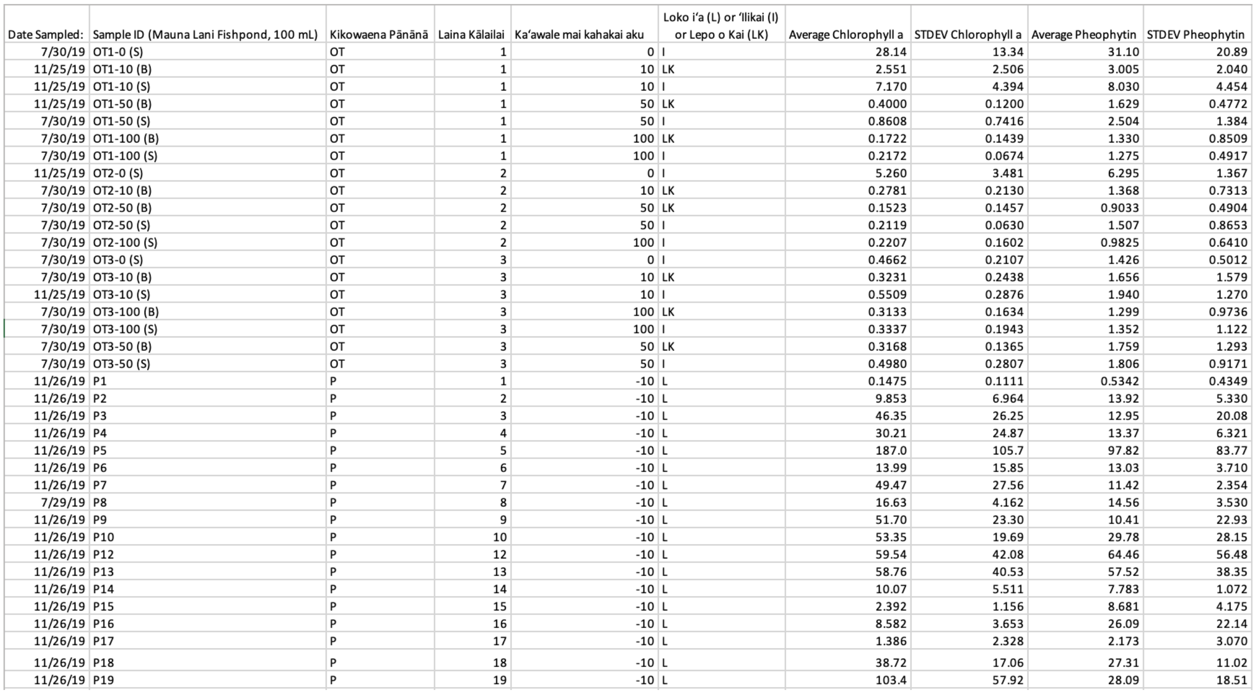
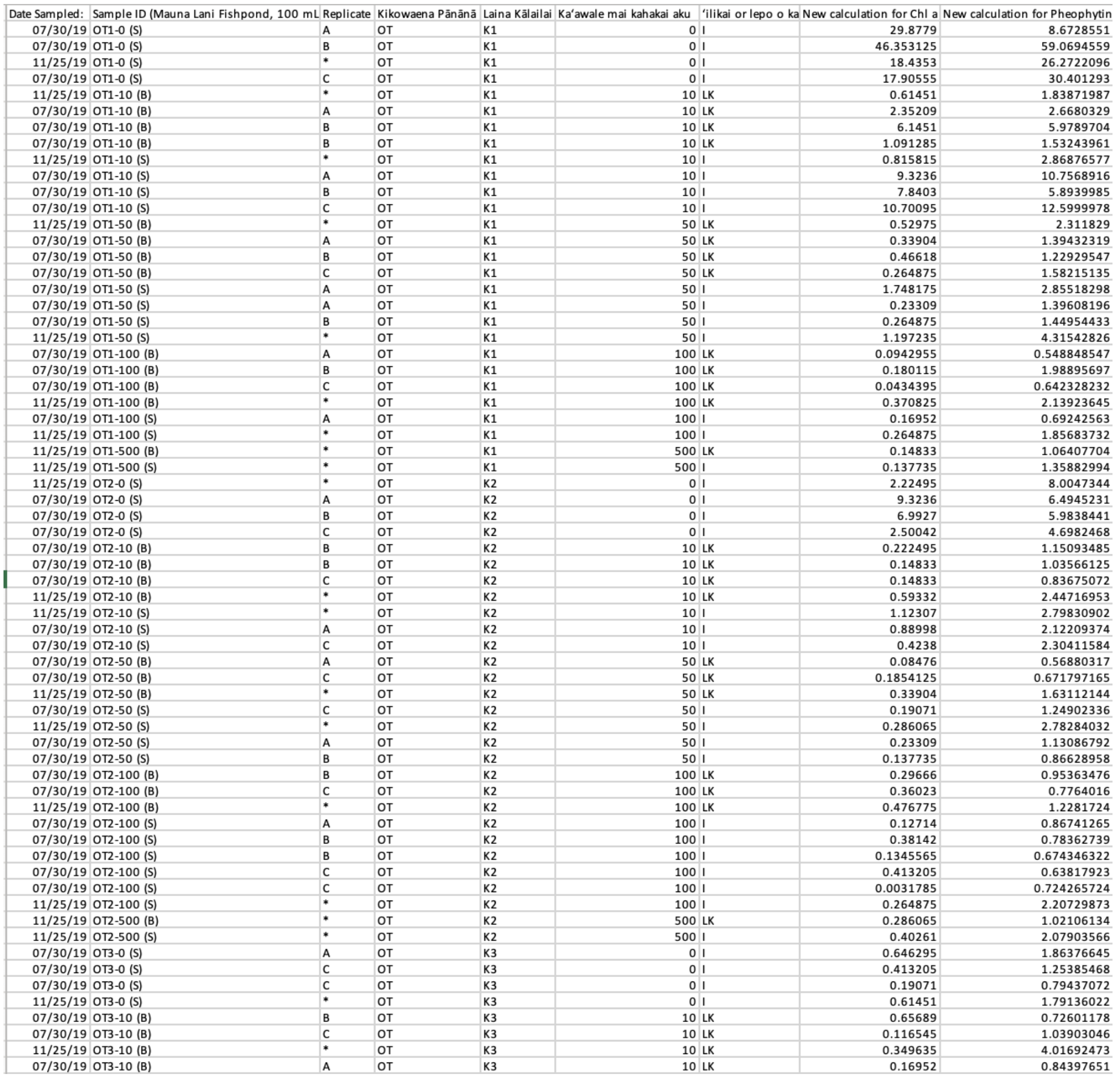
Appendix

Table 1. Average raw chlorophyll and pheophytin data



Date Sampled:	Sample ID (Mauna Lani Fishpond, 100 mL)	Kikowaena Pānānā	Laina Kālailai	Kaʻawale mai kahakai aku	Loko iʻa (L) or ʻIlikai (I) or Lepo o Kai (LK)	Average Chlorophyll a	STDEV Chlorophyll a	Average Pheophytin	STDEV Pheophytin
7/30/19	OT1-0 (S)	OT	1	0	I	28.14	13.34	31.10	20.89
11/25/19	OT1-10 (B)	OT	1	10	LK	2.551	2.506	3.005	2.040
11/25/19	OT1-10 (S)	OT	1	10	I	7.170	4.394	8.030	4.454
11/25/19	OT1-50 (B)	OT	1	50	LK	0.4000	0.1200	1.629	0.4772
7/30/19	OT1-50 (S)	OT	1	50	I	0.8608	0.7416	2.504	1.384
7/30/19	OT1-100 (B)	OT	1	100	LK	0.1722	0.1439	1.330	0.8509
7/30/19	OT1-100 (S)	OT	1	100	I	0.2172	0.0674	1.275	0.4917
11/25/19	OT2-0 (S)	OT	2	0	I	5.260	3.481	6.295	1.367
7/30/19	OT2-10 (B)	OT	2	10	LK	0.2781	0.2130	1.368	0.7313
7/30/19	OT2-50 (B)	OT	2	50	LK	0.1523	0.1457	0.9033	0.4904
7/30/19	OT2-50 (S)	OT	2	50	I	0.2119	0.0630	1.507	0.8653
7/30/19	OT2-100 (S)	OT	2	100	I	0.2207	0.1602	0.9825	0.6410
7/30/19	OT3-0 (S)	OT	3	0	I	0.4662	0.2107	1.426	0.5012
7/30/19	OT3-10 (B)	OT	3	10	LK	0.3231	0.2438	1.656	1.579
11/25/19	OT3-10 (S)	OT	3	10	I	0.5509	0.2876	1.940	1.270
7/30/19	OT3-100 (B)	OT	3	100	LK	0.3133	0.1634	1.299	0.9736
7/30/19	OT3-100 (S)	OT	3	100	I	0.3337	0.1943	1.352	1.122
7/30/19	OT3-50 (B)	OT	3	50	LK	0.3168	0.1365	1.759	1.293
7/30/19	OT3-50 (S)	OT	3	50	I	0.4980	0.2807	1.806	0.9171
11/26/19	P1	P	1	-10	L	0.1475	0.1111	0.5342	0.4349
11/26/19	P2	P	2	-10	L	9.853	6.964	13.92	5.330
11/26/19	P3	P	3	-10	L	46.35	26.25	12.95	20.08
11/26/19	P4	P	4	-10	L	30.21	24.87	13.37	6.321
11/26/19	P5	P	5	-10	L	187.0	105.7	97.82	83.77
11/26/19	P6	P	6	-10	L	13.99	15.85	13.03	3.710
11/26/19	P7	P	7	-10	L	49.47	27.56	11.42	2.354
7/29/19	P8	P	8	-10	L	16.63	4.162	14.56	3.530
11/26/19	P9	P	9	-10	L	51.70	23.30	10.41	22.93
11/26/19	P10	P	10	-10	L	53.35	19.69	29.78	28.15
11/26/19	P12	P	12	-10	L	59.54	42.08	64.46	56.48
11/26/19	P13	P	13	-10	L	58.76	40.53	57.52	38.35
11/26/19	P14	P	14	-10	L	10.07	5.511	7.783	1.072
11/26/19	P15	P	15	-10	L	2.392	1.156	8.681	4.175
11/26/19	P16	P	16	-10	L	8.582	3.653	26.09	22.14
11/26/19	P17	P	17	-10	L	1.386	2.328	2.173	3.070
11/26/19	P18	P	18	-10	L	38.72	17.06	27.31	11.02
11/26/19	P19	P	19	-10	L	103.4	57.92	28.09	18.51

Table 2. All raw data or chlorophyll *a* and Pheophytin. *Kikowaena pānānā* (survey site), *laina kālailai* (transect), *ka'awale mai kahakai aku* (distance from shore), *'ili kai* (surface water), *lepo kai* (benthic water).



Date Sampled:	Sample ID (Mauna Lani Fishpond, 100 mL	Replicate	Kikowaena Pānānā	Laina Kālailai	Ka'awale mai kahakai aku	'ilikai or lepo o ka	New calculation for Chl a	New calculation for Pheophytin
07/30/19	OT1-0 (S)	A	OT	K1	0	I	29.8779	8.6728551
07/30/19	OT1-0 (S)	B	OT	K1	0	I	46.353125	59.0694559
11/25/19	OT1-0 (S)	*	OT	K1	0	I	18.4353	26.2722096
07/30/19	OT1-0 (S)	C	OT	K1	0	I	17.90555	30.401293
11/25/19	OT1-10 (B)	*	OT	K1	10	LK	0.61451	1.83871987
07/30/19	OT1-10 (B)	A	OT	K1	10	LK	2.35209	2.6680329
07/30/19	OT1-10 (B)	B	OT	K1	10	LK	6.1451	5.9789704
07/30/19	OT1-10 (B)	B	OT	K1	10	LK	1.091285	1.53243961
11/25/19	OT1-10 (S)	*	OT	K1	10	I	0.815815	2.86876577
07/30/19	OT1-10 (S)	A	OT	K1	10	I	9.3236	10.7568916
07/30/19	OT1-10 (S)	B	OT	K1	10	I	7.8403	5.8939985
07/30/19	OT1-10 (S)	C	OT	K1	10	I	10.70095	12.5999978
11/25/19	OT1-50 (B)	*	OT	K1	50	LK	0.52975	2.311829
07/30/19	OT1-50 (B)	A	OT	K1	50	LK	0.33904	1.39432319
07/30/19	OT1-50 (B)	B	OT	K1	50	LK	0.46618	1.22929547
07/30/19	OT1-50 (B)	C	OT	K1	50	LK	0.264875	1.58215135
07/30/19	OT1-50 (S)	A	OT	K1	50	I	1.748175	2.85518298
07/30/19	OT1-50 (S)	A	OT	K1	50	I	0.23309	1.39608196
07/30/19	OT1-50 (S)	B	OT	K1	50	I	0.264875	1.44954433
11/25/19	OT1-50 (S)	*	OT	K1	50	I	1.197235	4.31542826
07/30/19	OT1-100 (B)	A	OT	K1	100	LK	0.0942955	0.548848547
07/30/19	OT1-100 (B)	B	OT	K1	100	LK	0.180115	1.98895697
07/30/19	OT1-100 (B)	C	OT	K1	100	LK	0.0434395	0.642328232
11/25/19	OT1-100 (B)	*	OT	K1	100	LK	0.370825	2.13923645
07/30/19	OT1-100 (S)	A	OT	K1	100	I	0.16952	0.69242563
11/25/19	OT1-100 (S)	*	OT	K1	100	I	0.264875	1.85683732
11/25/19	OT1-500 (B)	*	OT	K1	500	LK	0.14833	1.06407704
11/25/19	OT1-500 (S)	*	OT	K1	500	I	0.137735	1.35882994
11/25/19	OT2-0 (S)	*	OT	K2	0	I	2.22495	8.0047344
07/30/19	OT2-0 (S)	A	OT	K2	0	I	9.3236	6.4945231
07/30/19	OT2-0 (S)	B	OT	K2	0	I	6.9927	5.9838441
07/30/19	OT2-0 (S)	C	OT	K2	0	I	2.50042	4.6982468
07/30/19	OT2-10 (B)	B	OT	K2	10	LK	0.222495	1.15093485
07/30/19	OT2-10 (B)	B	OT	K2	10	LK	0.14833	1.03566125
07/30/19	OT2-10 (B)	C	OT	K2	10	LK	0.14833	0.83675072
11/25/19	OT2-10 (B)	*	OT	K2	10	LK	0.59332	2.44716953
11/25/19	OT2-10 (S)	*	OT	K2	10	I	1.12307	2.79830902
07/30/19	OT2-10 (S)	A	OT	K2	10	I	0.88998	2.12209374
07/30/19	OT2-10 (S)	C	OT	K2	10	I	0.4238	2.30411584
07/30/19	OT2-50 (B)	A	OT	K2	50	LK	0.08476	0.56880317
07/30/19	OT2-50 (B)	C	OT	K2	50	LK	0.1854125	0.671797165
11/25/19	OT2-50 (B)	*	OT	K2	50	LK	0.33904	1.63112144
07/30/19	OT2-50 (S)	C	OT	K2	50	I	0.19071	1.24902336
11/25/19	OT2-50 (S)	*	OT	K2	50	I	0.286065	2.78284032
07/30/19	OT2-50 (S)	A	OT	K2	50	I	0.23309	1.13086792
07/30/19	OT2-50 (S)	B	OT	K2	50	I	0.137735	0.86628958
07/30/19	OT2-100 (B)	B	OT	K2	100	LK	0.29666	0.95363476
07/30/19	OT2-100 (B)	C	OT	K2	100	LK	0.36023	0.7764016
11/25/19	OT2-100 (B)	*	OT	K2	100	LK	0.476775	1.2281724
07/30/19	OT2-100 (S)	A	OT	K2	100	I	0.12714	0.86741265
07/30/19	OT2-100 (S)	B	OT	K2	100	I	0.38142	0.78362739
07/30/19	OT2-100 (S)	B	OT	K2	100	I	0.1345565	0.674346322
07/30/19	OT2-100 (S)	C	OT	K2	100	I	0.413205	0.63817923
07/30/19	OT2-100 (S)	C	OT	K2	100	I	0.0031785	0.724265724
11/25/19	OT2-100 (S)	*	OT	K2	100	I	0.264875	2.20729873
11/25/19	OT2-500 (B)	*	OT	K2	500	LK	0.286065	1.02106134
11/25/19	OT2-500 (S)	*	OT	K2	500	I	0.40261	2.07903566
07/30/19	OT3-0 (S)	A	OT	K3	0	I	0.646295	1.86376645
07/30/19	OT3-0 (S)	C	OT	K3	0	I	0.413205	1.25385468
07/30/19	OT3-0 (S)	C	OT	K3	0	I	0.19071	0.79437072
11/25/19	OT3-0 (S)	*	OT	K3	0	I	0.61451	1.79136022
07/30/19	OT3-10 (B)	B	OT	K3	10	LK	0.65689	0.72601178
07/30/19	OT3-10 (B)	C	OT	K3	10	LK	0.116545	1.03903046
11/25/19	OT3-10 (B)	*	OT	K3	10	LK	0.349635	4.01692473
07/30/19	OT3-10 (B)	A	OT	K3	10	LK	0.16952	0.84397651

11/25/19	OT3-10 (S)	*	OT	K3	10	I	0.82641	3.80536377
07/30/19	OT3-10 (S)	A	OT	K3	10	I	0.74165	1.68316408
07/30/19	OT3-10 (S)	B	OT	K3	10	I	0.434395	1.12847345
07/30/19	OT3-10 (S)	C	OT	K3	10	I	0.201305	1.14370906
07/30/19	OT3-100 (B)	A	OT	K3	100	LK	0.25428	0.72132879
07/30/19	OT3-100 (B)	B	OT	K3	100	LK	0.1091285	0.647678707
07/30/19	OT3-100 (B)	C	OT	K3	100	LK	0.455585	1.09781152
11/25/19	OT3-100 (B)	*	OT	K3	100	LK	0.434395	2.72922962
07/30/19	OT3-100 (S)	A	OT	K3	100	I	0.307255	0.74412923
07/30/19	OT3-100 (S)	B	OT	K3	100	I	0.23309	0.74251879
07/30/19	OT3-100 (S)	C	OT	K3	100	I	0.180115	0.89021309
11/25/19	OT3-100 (S)	*	OT	K3	100	I	0.61451	3.03218305
07/30/19	OT3-50 (B)	A	OT	K3	50	LK	0.186472	0.773981702
07/30/19	OT3-50 (B)	B	OT	K3	50	LK	0.44499	1.5441153
07/30/19	OT3-50 (B)	C	OT	K3	50	LK	0.2119	1.07628248
11/25/19	OT3-50 (B)	*	OT	K3	50	LK	0.4238	3.63965797
07/30/19	OT3-50 (S)	A	OT	K3	50	I	0.180115	0.87126923
07/30/19	OT3-50 (S)	B	OT	K3	50	I	0.8476	1.57721408
11/25/19	OT3-50 (S)	*	OT	K3	50	I	0.561535	3.06621419
07/30/19	OT3-50 (S)	C	OT	K3	50	I	0.40261	1.70963039
11/25/19	OT3-500 (B)	*	OT	K3	500	LK	0.362349	0.412454874
11/25/19	OT3-500 (S)	*	OT	K3	500	I	0.10595	1.17276055
11/26/19	P1	*	P	P1	-10	L	0.12714	1.17051441
07/29/19	P1	A	P	P1	-10	L	0.3019575	0.451060935
07/29/19	P1	B	P	P1	-10	L	0.1239615	0.294697806
07/29/19	P1	C	P	P1	-10	L	0.0370825	0.220553996
11/26/19	P2	*	P	P2	-10	L	19.60075	19.9919174
07/29/19	P2	A	P	P2	-10	L	8.58195	10.0777521
07/29/19	P2	B	P	P2	-10	L	3.07255	8.8620818
07/29/19	P2	C	P	P2	-10	L	8.15815	16.7530259
11/26/19	P3	*	P	P3	-10	L	20.02455	19.9469946
07/29/19	P3	A	P	P3	-10	L	82.693975	-16.72198255
07/29/19	P3	B	P	P3	-10	L	40.0491	20.9501292
07/29/19	P3	C	P	P3	-10	L	42.644875	27.6368456
11/26/19	P4	*	P	P4	-10	L	67.119325	10.12426415
07/29/19	P4	A	P	P4	-10	L	15.6806	10.6513654
07/29/19	P4	B	P	P4	-10	L	15.0449	22.84282
07/29/19	P4	C	P	P4	-10	L	22.99115	9.8764471
11/26/19	P5	*	P	P5	-10	L	97.8978	39.01894815
07/29/19	P5	A	P	P5	-10	L	310.1951125	55.30298638
07/29/19	P5	B	P	P5	-10	L	240.1091875	75.4955201
07/29/19	P5	C	P	P5	-10	L	99.9373375	221.4689272
11/26/19	P6	*	P	P6	-10	L	37.5063	8.7167184
07/29/19	P6	A	P	P6	-10	L	3.92015	14.7395521
07/29/19	P6	B	P	P6	-10	L	9.3236	17.197804
07/29/19	P6	C	P	P6	-10	L	5.19155	11.4790468
11/26/19	P7	*	P	P7	-10	L	9.1117	10.3057565
07/29/19	P7	A	P	P7	-10	L	56.3654	9.2750749
07/29/19	P7	B	P	P7	-10	L	70.827575	14.7039529
07/29/19	P7	C	P	P7	-10	L	61.55695	11.376911
07/29/19	P8	A	P	P8	-10	L	20.23645	18.5037437
07/29/19	P8	B	P	P8	-10	L	12.0783	11.6962443
07/29/19	P8	C	P	P8	-10	L	17.5877	13.4802304
11/26/19	P9	*	P	P9	-10	L	25.11015	9.8412717
07/29/19	P9	A	P	P9	-10	L	49.69055	29.873662
07/29/19	P9	B	P	P9	-10	L	81.952325	-21.6161309
07/29/19	P9	C	P	P9	-10	L	50.061375	23.5355211
11/26/19	P10	*	P	P10	-10	L	24.26255	13.5304507
07/29/19	P10	A	P	P10	-10	L	67.860975	14.02385985
07/29/19	P10	B	P	P10	-10	L	60.444475	19.7827721
07/29/19	P10	C	P	P10	-10	L	60.8153	71.79172
11/26/19	P12	*	P	P12	-10	L	8.2641	8.6906547
07/29/19	P12	A	P	P12	-10	L	111.2475	33.2941518
07/29/19	P12	B	P	P12	-10	L	61.55695	78.67497365
07/29/19	P12	C	P	P12	-10	L	57.10705	137.1622343
11/26/19	P13	*	P	P13	-10	L	6.9927	16.2135285
07/29/19	P13	A	P	P13	-10	L	106.05595	35.8335614
07/29/19	P13	B	P	P13	-10	L	61.186125	100.2629219
07/29/19	P13	C	P	P13	-10	L	60.8153	77.7590359
11/26/19	P14	*	P	P14	-10	L	7.73435	6.5682643
07/29/19	P14	A	P	P14	-10	L	9.34479	7.396846275
07/29/19	P14	B	P	P14	-10	L	17.94793	9.10390208
07/29/19	P14	C	P	P14	-10	L	5.265715	8.06129051
11/26/19	P15	*	P	P15	-10	L	2.20376	5.39272786
07/29/19	P15	A	P	P15	-10	L	1.112475	5.08216722
07/29/19	P15	B	P	P15	-10	L	3.92015	10.5719029
07/29/19	P15	C	P	P15	-10	L	2.3309	13.6766617
11/26/19	P16	*	P	P16	-10	L	6.67485	8.5749573
07/29/19	P16	A	P	P16	-10	L	5.19155	18.2041171
07/29/19	P16	B	P	P16	-10	L	13.5616	58.5197873
07/29/19	P16	C	P	P16	-10	L	8.8998	19.0423935
11/26/19	P17	*	P	P17	-10	L	4.8737	6.7767739
07/29/19	P17	A	P	P17	-10	L	0.203424	0.628211454
07/29/19	P17	B	P	P17	-10	L	0.1006525	0.586062425
07/29/19	P17	C	P	P17	-10	L	0.3655275	0.700452402
11/26/19	P18	*	P	P18	-10	L	13.24375	15.8350751
07/29/19	P18	A	P	P18	-10	L	48.9489	34.5935226
07/29/19	P18	B	P	P18	-10	L	45.24065	38.63329015
07/29/19	P18	C	P	P18	-10	L	47.4656	20.1639802
11/26/19	P19	*	P	P19	-10	L	21.08405	7.6158979
07/29/19	P19	A	P	P19	-10	L	117.1807	31.00764485
07/29/19	P19	B	P	P19	-10	L	157.0443875	51.811669
07/29/19	P19	C	P	P19	-10	L	118.293175	21.93874865