Results from Island-wide water monitoring during the summer of 2018.

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Summary:

Ratings of 2018 water samples fell within expected nutrient ranges for the inner and outer island zones of the Les Cheneaux Islands and reflected high quality water for recreational purposes as has been the case since this type survey began in 2001. Analytical values for all test sites were within range of samples quantified by the Univ Mich Biological Station during the previous five seasons. The relationship of three variables: Total Phosphorus, Soluble Reactive Phosphorus and Chlorophyll-a was different than expected in 2018. Samples from the same test sites will be compared in 2019 to determine if 2018 result were an exception to past findings or an indication of a new trend.

Results:

Variables quantified for Les Cheneaux water samples were: Total Phosphorus (TP), Soluble Reactive Phosphorus (SRP) and Chlorophyll-a (Chl-a). SRP is a component of TP and is, therefore, expected to be a value less than TP although, in some situations, TP and SRP values have been found to be about equal in concentration. Chlorophyll-a reflects the relative density of phytoplankton and is derived by extracting and photometrically measuring the chlorophyll-a species from phytoplankton samples. Since SRP is a primary phytoplankton nutrient, as Chl-a values increase the SRP is metabolized and, therefore, decreases. Conversely, as Chl-a levels decrease the SRP concentration typically increases. Past annual surveys have shown the expected relationship of these variables in that TP was in greater concentration than SRP and Chl-a was recovered in lower concentration than TP and SRP.

This was not the case for 2018 analytical results (Table 1: Appendix A). Mean seasonal values are shown in Table 2. For ease of observation, curves for variables at each station have been plotted on a scale appropriate for the specific station rather than plotting all data at the same scale (Fig. 1).

In general, TP values increased from May-Jun, dipped in Jul followed by an Aug increase and then a Sep decline. This pattern is most apparent at sites: 1,2,3,4,4a,7,8,9. The TP curve shape for site 4b was more a bimodal curve with May/Sep and Jun/Aug values being similar and the low point in Jul.

By comparison, some curve shapes for SRP had a seasonal upward trend (sites TS1 & 2). The relationship between TP and SRP, with TP being a greater concentration than SRP throughout the season, was observed for TS1,2,3&4. TP & SRP were similar at sites 4, 4A,4B,4C,6,7 and 8. TP was a lower titer at TS9.

None of the sample sites exhibited the expected titer of SRP/Chl-a where SRP was always at a higher titer than Chl-a. Chl-a was recovered in a higher concentration than SRP for all seasonal samples at sites TS3, 4B, 4C, 5, 6 and 7.

Two major anomalies were observed from the 2018 TSI data.

1) SRP values were reported as greater than TP for multiple samples at multiple sites. This inverse relationship was not expected, nor seen at such a frequency in previous year's data.
2) Chl-a values were greater than SRP values at a high frequency. This relationship has been observed rarely in previous years but, as with TP and SRP, not at such a high frequency and range of sites.

Questions raised by 2018 TSI dat:

1) Do Secchi water clarity values track with Chl-a results?
2) Did phytoplankton community differ in 2018 to a degree that those plankton species present contained more easily extracted Chl-a than in previous years?
3) New Chl-a standards were used for 2018 analysis. Were new standard concentrations accurate?

Chl-a vs Secchi readings: If Chl-a values are in question, then it would be expected that Secchi reading would validate seemingly high or low Chl-a values. That is, greater water clarity as measured by Secchi disk readings should be observed with lower Chl-a concentrations for measurements from each observation/sampling.

Fig. 3. Shows mean Secchi disk readings for all sample stations during the past three years relative to the bottom depth at each station. With exception of station TS4 in 2017, the water clarity as measured using the Secchi disk was remarkably consistent with year-to-year correlation coefficients of 0.93 or greater. With this level of Secchi consistency a comparison between water clarity vs Chl-a concentration can be made with confidence.

Fig. 4. Shows Chl-a values vs Secchi readings for all sample stations and for each sampling event in 2018. Included is the bottom depth so that one can compare water clarity vs actual depth at each site. Stations TS1-TS4 indicate higher water clarity based on Secchi readings was reflected by lower Chl-a and, therefore, lower phytoplankton concentrations. Shallower depth comparisons were more difficult to interpret, therefore the same values were plotted on a log scale shown in Fig. 5. The log plot magnifies differences such as the clarity and Chl-a shifts observed at station TS6.

Although the shifts can be better compared using the log plot, it must be remembered that Chl-a concentrations at sites TS7-TS9 are at oligotrophic levels and Chl-a measurements vs Secchi readings may not show all changes in concentration vs water clarity as lower phytoplankton levels.

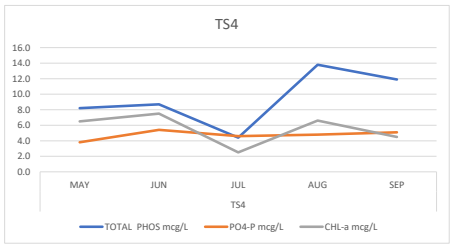
Trophic Index (Carlson). When the variables of TP, SRP and Chl-a are viewed over time as in Fig. 6 one sees that analytical values fall within trophic rating of oligotrophic to lower mesotrophic for TP and the mesotrophic rating for Chl-a. Therefore, while discrepancies among TP-SRP and Chl-a in 2018 data need reconciliation, those values are within the trophic range of the same variables as measured during the previous five years.

Finally, when Chl-a/TP and Chl-a/SRP ratios are compared one sees similar curves over the last five-year period (Fig. 7.). The correlation is better for Chl-a/TP with r = -.96 than for Chl-a/SRP with r= 0.79, although that is a respectable degree of correlation as well.

Table. 2. Mean 2018 seasonal values for TP, SRP and Chl-a <sht6 EN4>

	TP (1)	SRP	CHL-a
Mean	7.8	3.6	5.2
s	3.9	2	4.5
+/- s	3.9 - 11.7	1.6 - 5.6	0.7 -9.7

(1) Expressed as µg /L (ppb)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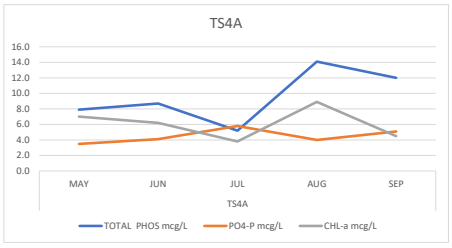
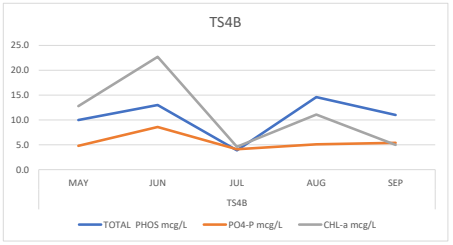
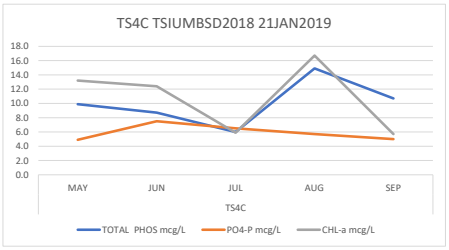
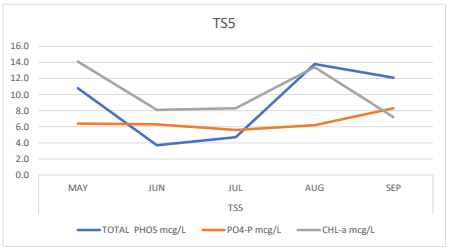
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
MAY
JUN
JUL
AUG
SEP
TS4
TOTAL PHOS mcg/L
PO4-P mcg/L
CHL-a mcg/L


TS4A
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
MAY
JUN
JUL
AUG
SEP
TS4A
TOTAL PHOS mcg/L
PO4-P mcg/L
CHL-a mcg/L


TS4B
25.0
20.0
15.0
10.0
5.0
0.0
MAY
JUN
JUL
AUG
SEP
TS4B
TOTAL PHOS mcg/L
PO4-P mcg/L
CHL-a mcg/L


TS4C TSIUMBSD2018 21JAN2019
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
MAY
JUN
JUL
AUG
SEP
TS4C
TOTAL PHOS mcg/L
PO4-P mcg/L
CHL-a mcg/L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14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
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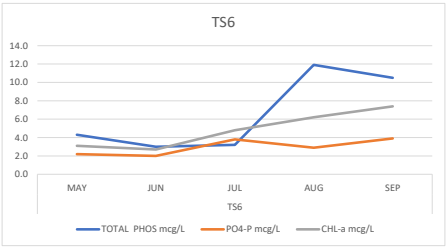
JUN
JUL
AUG
SEP
TS5
TOTAL PHOS mcg/L
PO4-P mcg/L
CHL-a mcg/L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6.0
4.0
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0.0
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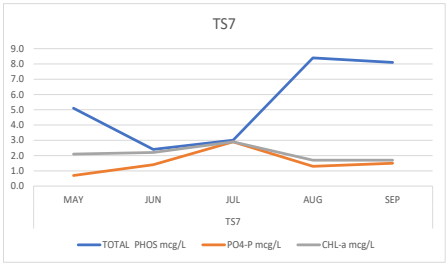
JUN
JUL
AUG
SEP
TS6
TOTAL PHOS mcg/L
PO4-P mcg/L
CHL-a mcg/L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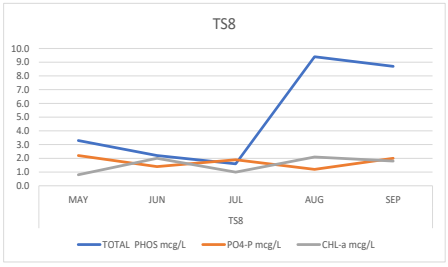
2.0
1.0
0.0
MAY
JUN
JUL
AUG
SEP
TS7
TOTAL PHOS mcg/L
PO4-P mcg/L
CHL-a mcg/L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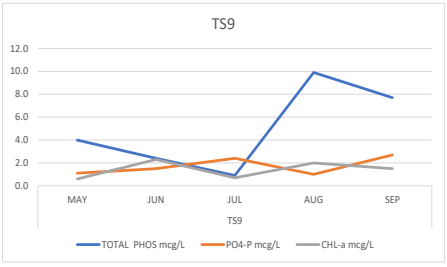
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
MAY
JUN
JUL
AUG
SEP
TS8
TOTAL PHOS mcg/L
PO4-P mcg/L
CHL-a mcg/L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6.0
4.0
2.0
0.0
MAY
JUN
JUL
AUG
SEP
TS9
TOTAL PHOS mcg/L
PO4-P mcg/L
CHL-a mcg/L

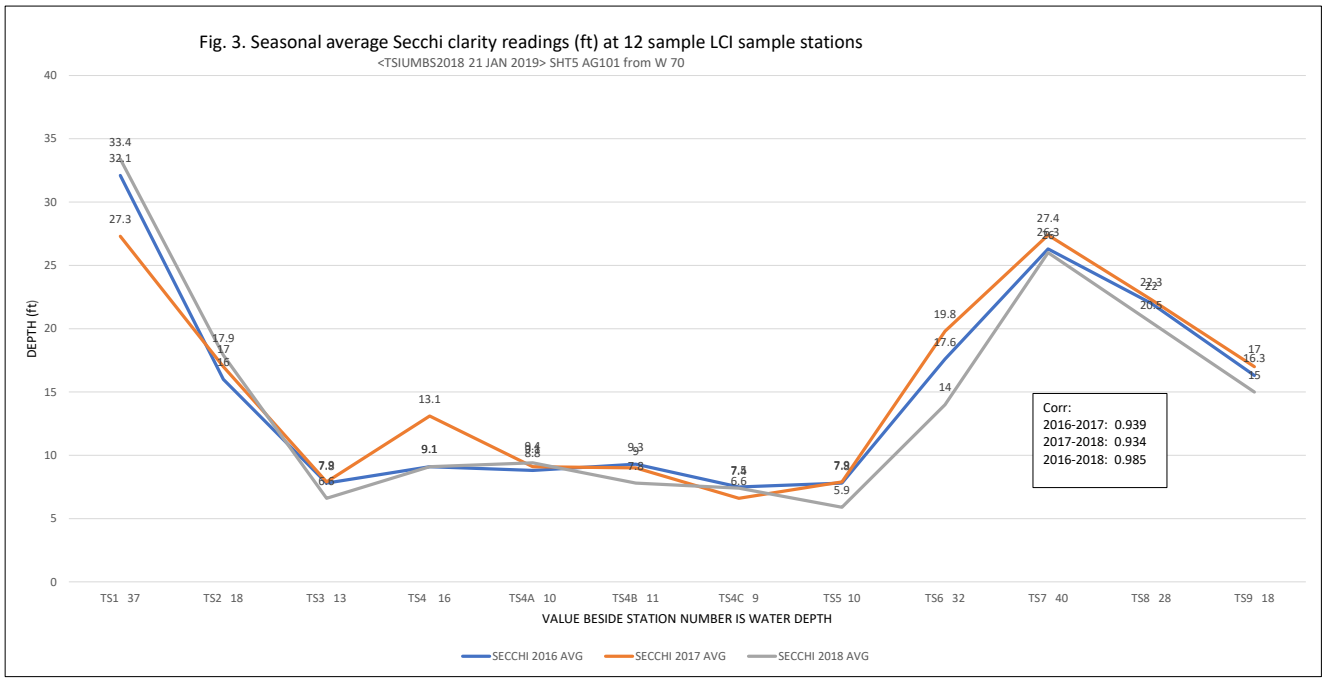
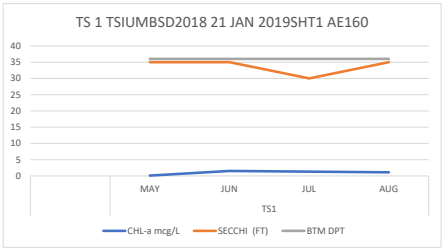
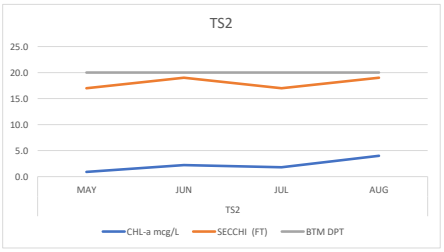
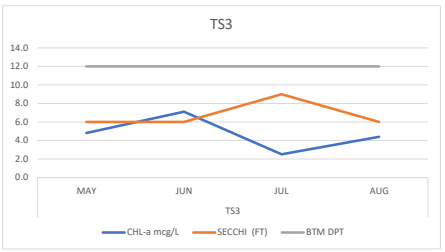


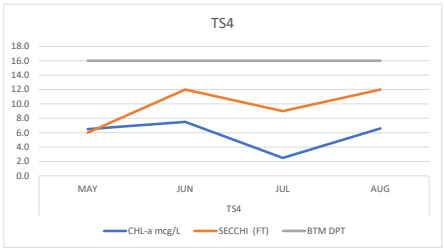
Fig. 3. Seasonal average Secchi clarity readings (ft) at 12 sample LCI sample stations
<TSIUMBS2018 21 JAN 2019> SHT5 AG101 from W 70
DEPTH (ft)
VALUE BESIDE STATION NUMBER IS WATER DEPTH
TS1 37
TS2 18
TS3 13
TS4 16
TS4A 10
TS4B 11
TS4C 9
TS5 10
TS6 32
TS7 40
TS8 28
TS9 18
Corr:
2016-2017: 0.939
2017-2018: 0.934
2016-2018: 0.985
SECCHI 2016 AVG
SECCHI 2017 AVG
SECCHI 2018 AVG

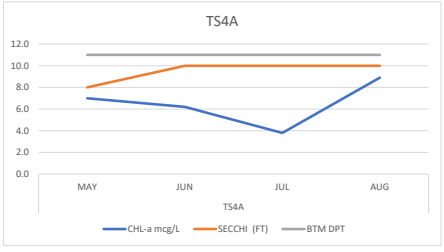
Fig. 4. Chl-a and Secchi disk values plotted monthly for 2018 to compare phytoplankton densities to water clarity. The bottom depth is also reported for each station to provide a perspective on water clarity vs total depth at any particular test station. <TSIUMBS2018 21 JAN 2019> SHT6 AW20 from sht1 ae160

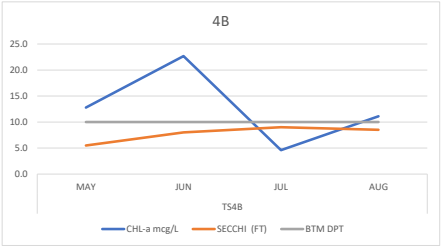


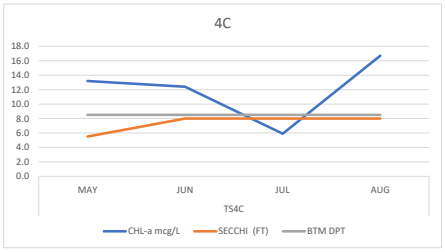


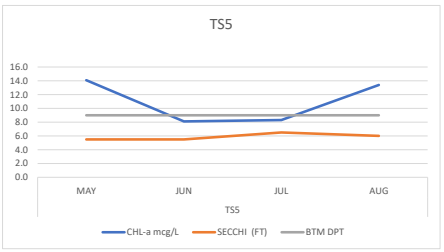


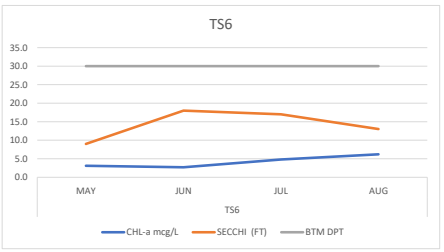


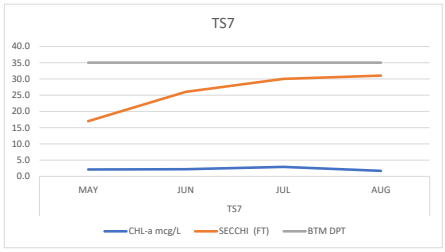


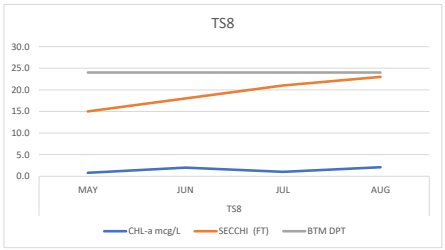












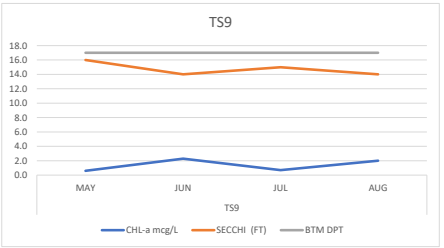


Fig. 5. Logarithmic plot to provide another view of the same data plotted for Fig. 2. Chl-a and Secchi disk values plotted montely for 2018 to compare phytoplankton densities to water clarity. The bottom depth is also reported for each station to provide a perspective on water clarity vs total depth at any particular test station. <TSIUMBSD2018 21 JAN 2019> SHT6 BX20

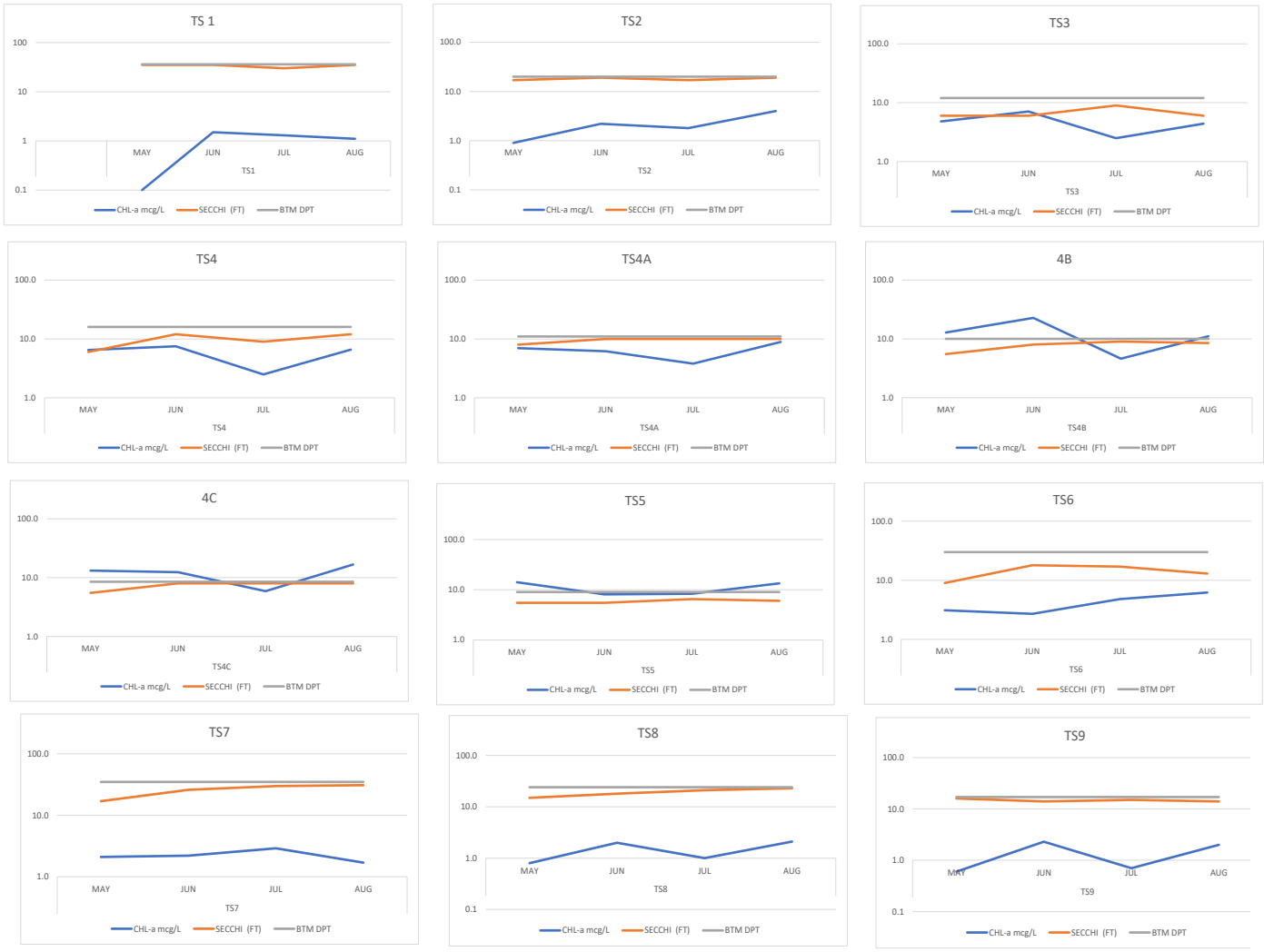


Fig. 6. Island-wide shifts in TP, SRP & Chl-a. Mean values are shown for each sample station through the season. Each plotted value represents 60 data points. TSIUMBSD2018 21 JAN 2019 SHT3 AN104

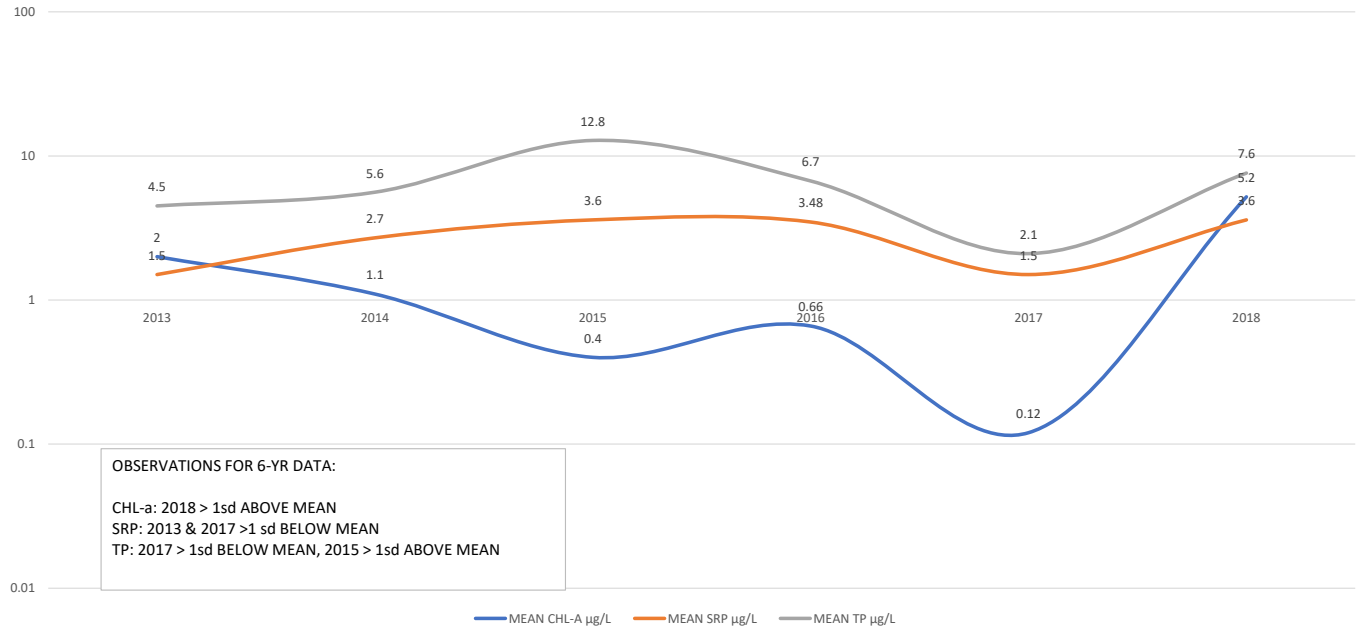


Fig 7. Chl-a/TP and Chl-a/SRP ratios plotted from seasonal means of 12 sample stations from 2013 through 2018. sht3 dj243

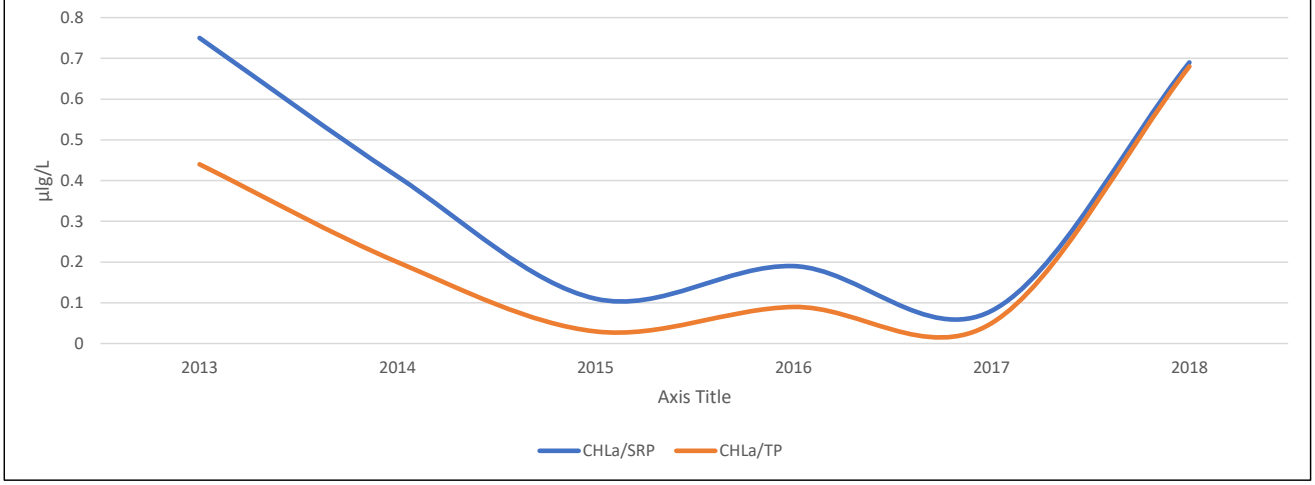


Fig. 8. Total P (µ/L or ppb) values were in the Oligotrophic-Mesotrophic range for the 2018 season. sht6 dr9

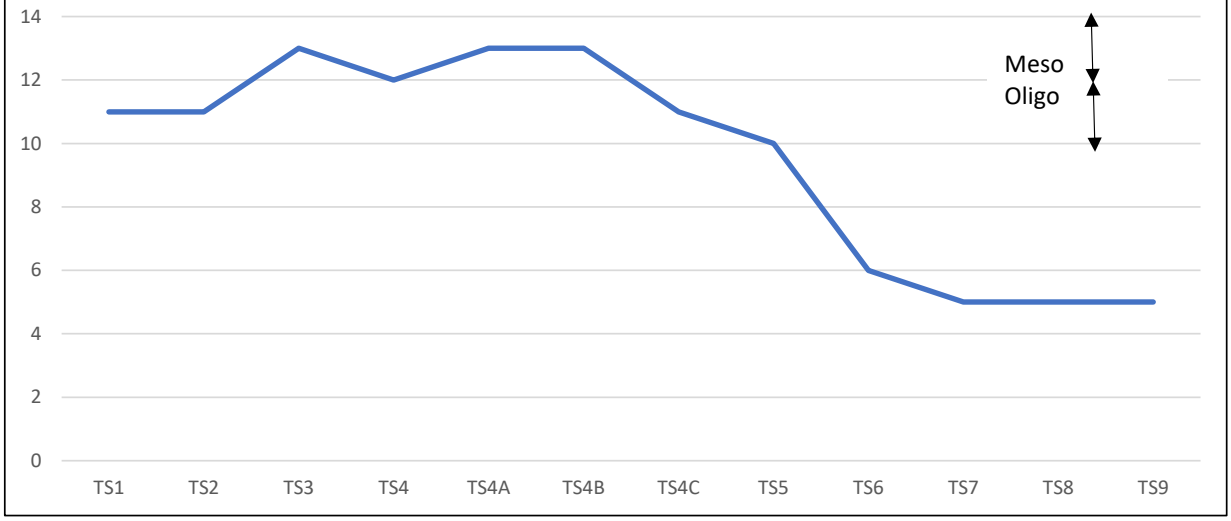


Fig. 9. Maximum Chl-a shown as mean values (µg/L or ppb)for each sample site during the 2018 season. sht6 dr22

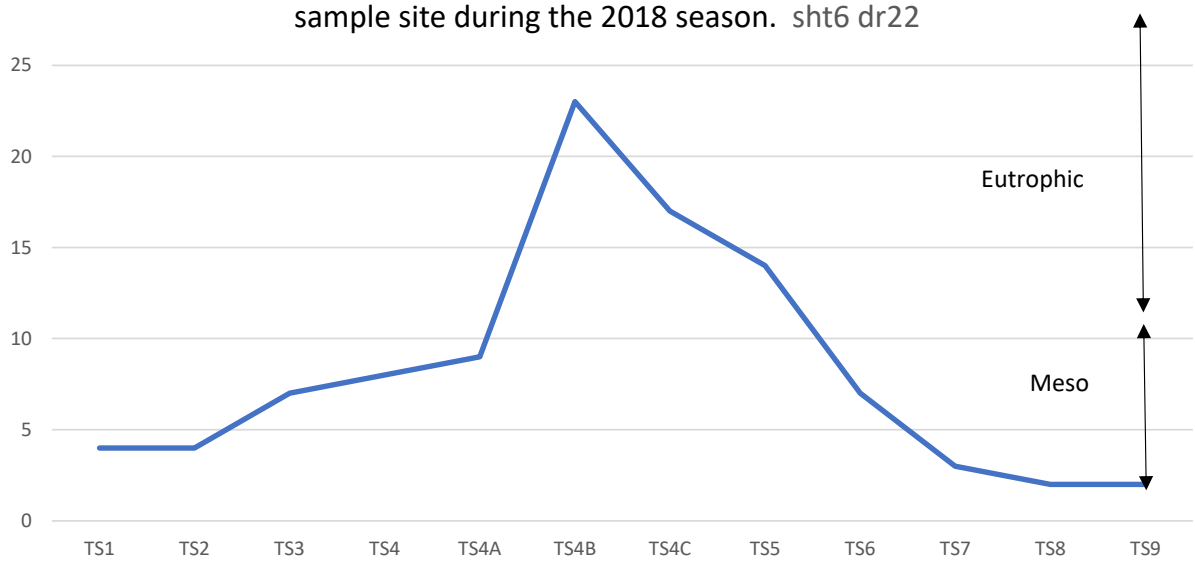
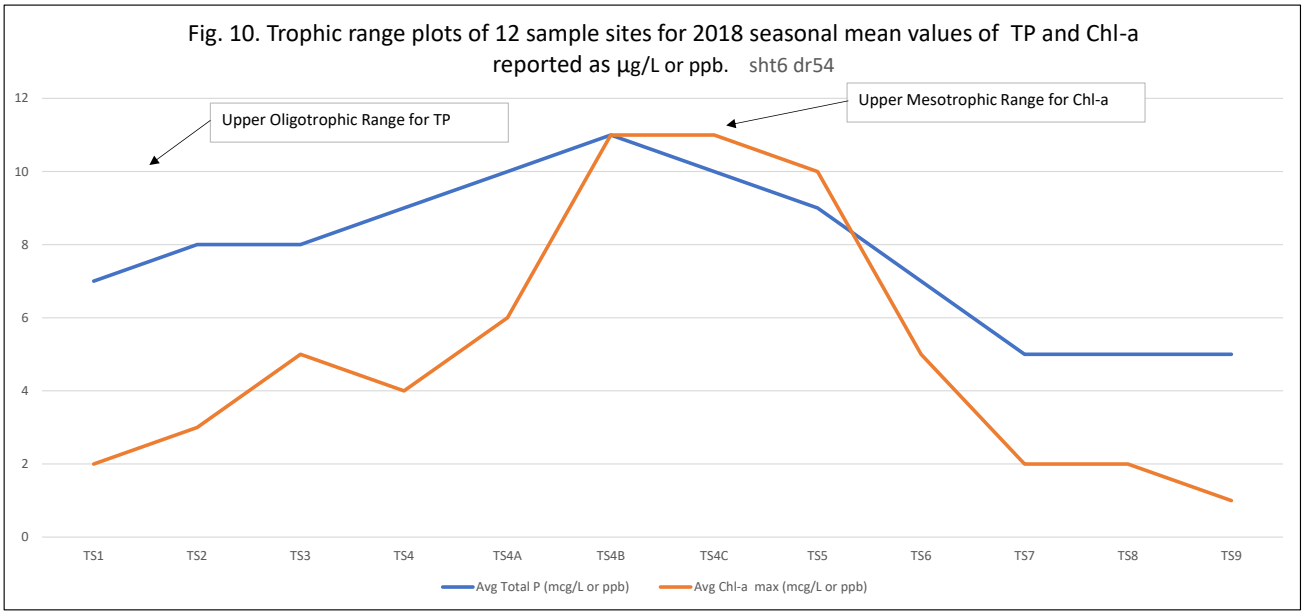


Fig. 10. Trophic range plots of 12 sample sites for 2018 seasonal mean values of TP and Chl-a reported as µg/L or ppb. sht6 dr54



Appendix A.

Table 1. TSI data from 2018

Table 1. TSI data from 2018 collection.
TSIUMBSD2018 21 JAN 2018 SHT6 F10 from sht1 h12 25Mar19

SITE	MONTH	DATE	TIME	SKY	WIND SP & DIR	WATER TMP C/F	SECCHI (FT)	FLTR VOL 4 CHLA	TOTAL PHOS mcg/L	PO4-P mcg/L	CHL-a mcg/L
TS1	MAY	23-May	:0830	C (B)	CALM	10.5	35 BTM	120 (C)	4.6	0.5	0.1
	JUN	25-Jun	:0832	C	8-10 E	15	34 BTM	120	5.1	1.3	1.5
	JUL	30-Jul	:0850	C	CALM	17.5	30 BTM	120	2.7	2.0	1.3
	AUG	30-Aug	:0830	PC	0-3 NNE	12	34.5 BTM	120	10.7	0.9	1.1
	SEP	29-Sep	:0923	OC	10-12W	12	NO	120	10.4	2.2	4.3
TS2	MAY	23-May	:0905	C	CALM	13.5	16.5 BTM	120	7.0	1.4	0.9
	JUN	25-Jun	:0846	C	5-7 E	17	19 (20)	120	6.6	2.5	2.2
	JUL	30-Jul	:0910	C	CALM	19.5	17 BTM	120	2.8	1.8	1.8
	AUG	30-Aug	:0848	PC	0-3NNE	17	19 BTM	120	12.3	2.5	4.0
	SEP	29-Sep	:0950	OC	8-10W	12.5	NO	120	10.1	3.6	3.6
TS3	MAY	23-May	:0928	C	CALM	15.5	6 (12D)	120	4.3	4.5	4.8
	JUN	25-Jun	:0906	C	10 SE	19.5	6(10)	120	9.5	5.6	7.1
	JUL	30-Jul	:0927	C	3 N	21	8.5 (12)	120	3.5	0.0	2.5
	AUG	30-Aug	:0910	PC	0-3E	18	6 (9.5)	120	13.1	3.7	4.4
	SEP	29-Sep	:1008	OC	8-10 W	12	NO	120	11.3	4.6	5.7
TS4	MAY	23-May	:0927	C	3 NW	15	6 (15.5D)	120	8.2	3.8	6.5
	JUN	25-Jun	:0920	C	10-15 E	18.5	12(19)	120	8.7	5.4	7.5
	JUL	30-Jul	:0940	C	3 NE	21	8.5(15)	120	4.4	4.6	2.5
	AUG	30-Aug	:0924	PC	0-3 E	17.5	10(15)	120	13.8	4.8	6.6
	SEP	29-Sep	:1021	OC	8-10 W	12	NO	120	11.9	5.1	4.5
TS4A	MAY	23-May	:1008	C	3 NW	14	7.5(10.5)	120	7.9	3.5	7.0
	JUN	25-Jun	:0935	C	12 E	19	10 BTM	120	8.7	4.1	6.2
	JUL	30-Jul	:0955	C	CALM	21	10 BTM	120	5.2	5.8	3.8
	AUG	30-Aug	:0938	PC	3-5 E	17	10 BTM	120	14.1	4	8.9
	SEP	29-Sep	:1036	OC	7-10W	11.5	NO	120	12.0	5.1	4.5
TS4B	MAY	23-May	:1030	C	5-7 WNW	15	5.5(10.5)	120	10.0	4.8	12.8
	JUN	25-Jun	:0953	C	12-15E	19	8(10)	120	13.0	8.6	22.7
	JUL	30-Jul	:1040	C	3-5 SE	22	9(10)	120	3.9	4.1	4.6
	AUG	30-Aug	:0955	PC	3-5 NNE	18	8.5(10)	120	14.6	5.1	11.1
	SEP	29-Sep	:1051	OC	7-10 W	11.5	NO	120	11.0	5.4	5.0
TS4C	MAY	23-May	:1050	C	5-7WNW	15.5	5.5(8.5)	120	9.9	4.9	13.2
	JUN	25-Jun	:1006	C	12-15SE	20	8(10)	120	8.7	7.5	12.4
	JUL	30-Jul	:1055	C	3-5 SW	22.5	8 BTM	120	6.0	6.5	5.9
	AUG	30-Aug	:1012	PC	0-3 E	18	8 BTM	120	14.9	5.7	16.7
	SEP	29-Sep	:1104		7-10W	11.5	NO	120	10.7	5.0	5.7
TS5	MAY	23-May	:1120	C	3 WNW	16	5.5(9.5)	120	10.8	6.4	14.1
	JUN	25-Jun	:1035	C	8-10 ESE	20	5.5(9)	120	3.7	6.3	8.1
	JUL	30-Jul	:1112	C	3-5 SSW	22	6.5(9)	120	4.7	5.6	8.3
	AUG	30-Aug	:1029	PC	0-3E	19	6(9.5)	120	13.8	6.2	13.4
	SEP	29-Sep	:1115	OC	7-10 W	12	NO	120	12.1	8.3	7.2

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- (B) C = Clear
- (C) = mL
- (PC) = PARTLY CLOUDY
- (OC) = OVERCAST

SITE	MONTH	DATE	TIME	SKY	WIND SP & DIR	WATER TMP C/F	SECCHI (FT)	FLTR VOL 4 CHLA	TOTAL PHOS mcg/L	PO4-P mcg/L	CHL-a mcg/L
TS6	MAY	23-May	:1143	C	5-7WNW	13	9(32)	120	4.3	2.2	3.1
	JUN	25-Jun	:1044	C	8-10 SE	18.5	18(25)	120	3.0	2.0	2.7
	JUL	30-Jul	:1130	C	5 SW	20	17(30)	120	3.2	3.8	4.8
	AUG	30-Aug	:1045	PC	3-5E	15	12.5(31)	120	11.9	2.9	6.2
	SEP	29-Sep	:1129	OC	7-10W	12.5	NO	120	10.5	3.9	7.4
TS7	MAY	23-May	:1208	C	7-10WNW	12	17(42 A)	120	5.1	0.7	2.1
	JUN	25-Jun	:1104	C	8-10 S	16	26	120	2.4	1.4	2.2
	JUL	30-Jul	:1140	C	3-5SE	19	30(35)	120	3.0	2.9	2.9
	AUG	30-Aug	:1102	PC	3-5 ESE	14	31(43)	120	8.4	1.3	1.7
	SEP	29-Sep	:1142	OC	7-10 W	10	NO	120	8.1	1.5	1.7
TS8	MAY	23-May	:1241	C	5-7WNW	11	15(24)	120	3.3	2.2	0.8
	JUN	25-Jun	:1132	C	7-8 SE	16	18	120	2.2	1.4	2.0
	JUL	30-Jul	:1200	C	0-3SE	14	21BTM	120	1.6	1.9	1.0
	AUG	30-Aug	:1122	PC	3-5 ESE	13	27.5	120	9.4	1.2	2.1
	SEP	29-Sep	:1158	OC	7-10 W	11	NO	120	8.7	2.0	1.8
TS9	MAY	23-May	:1300	C	5-7WNW	12	17 (B)	120	4.0	1.1	0.6
	JUN	25-Jun	:1150	C	8-10 SSE	16.5	14 BTM	120	2.4	1.5	2.3
	JUL	30-Jul	:1215	C	3-5SE	13	15 BTM	120	0.9	2.4	0.7
	AUG	30-Aug	:1135	PC	3-5 ESE	13	14 BTM	120	9.9	1.0	2.0
	SEP	29-Sep	:1209	OC	5-7 W	10	NO	120	7.7	2.7	1.5

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