

The validity chlorophyll-a estimation by sun induced fluorescence in estuarine waters

*An analysis of long-term (2003-2011) water quality
data from Tampa Bay, Florida (USA)*

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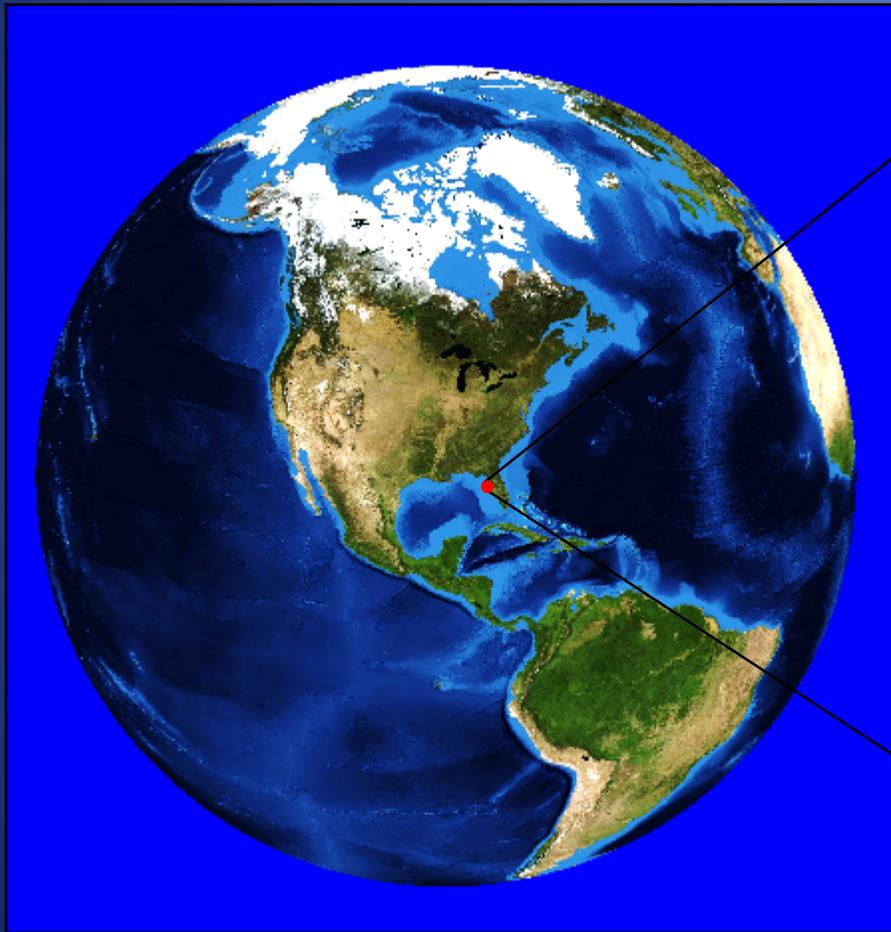
Chlorophyll Fluorescence

- Is it a better measure of chlorophyll a in Case II waters?
 - Ahn (2007) – “reliably estimate *in situ* chlorophyll- α concentrations from >0.2 to $82 \mu\text{g l}^{-1}$ ”
 - Gover and Kin (2007)- “express FLH as a function of chlorophyll concentration and solar zenith angle.”
 - Hu (2005) – “satisfactory mapping of the red tide...overestimate chlorophyll 20-fold”

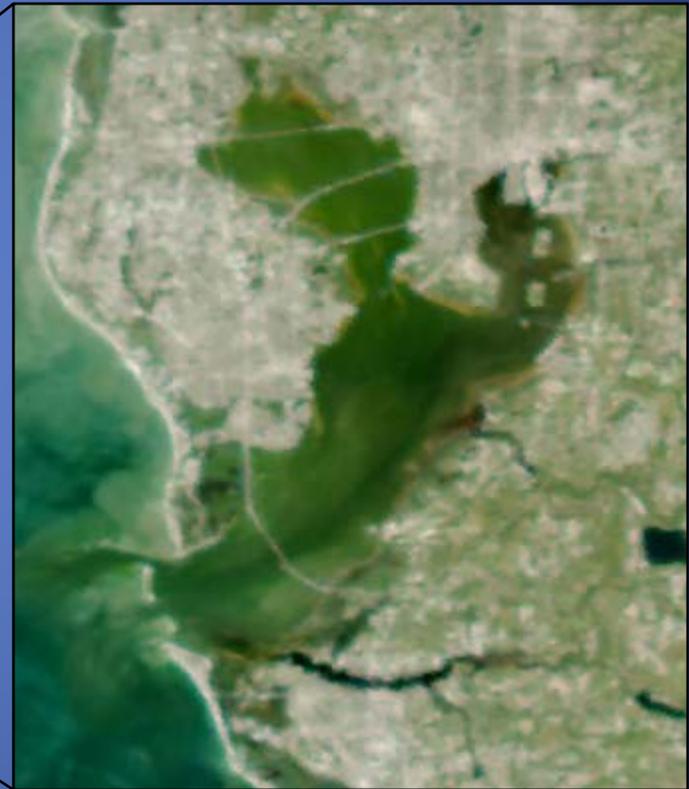
Chlorophyll Fluorescence

- Is it a better measure of chlorophyll a in Case II waters?
 - McKee (2007) – “MODIS FLH signal breaks down for $MSS > 5 \text{ mg l}^{-1}$... estimated FLH of about only 30% of the true value of FLH.
 - Hliang (2004) – “best correlation (FLH x chlorophyll- α) when in situ chlorophyll- α was < 4 and total suspended matter $< 4 \text{ } \mu\text{g l}^{-1}$ ”
 - Gilerson (2006) – “strongly overestimate fluorescence values in coastal waters”

Tampa Bay, Florida (USA)



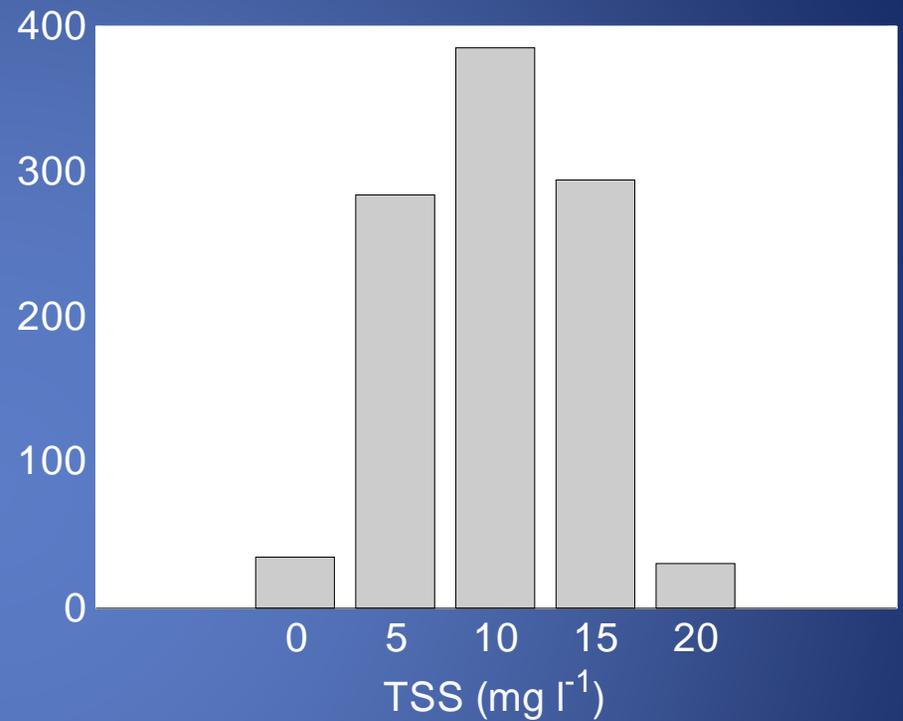
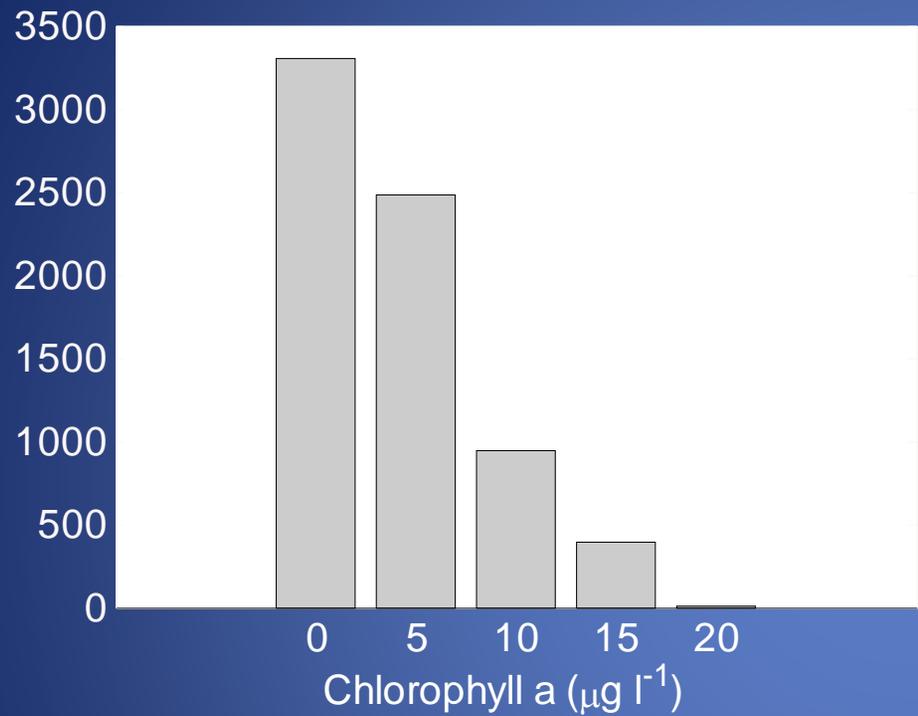
NASA GSFC (2004), Ryan (2006)



MODIS Aqua – October 15, 2003

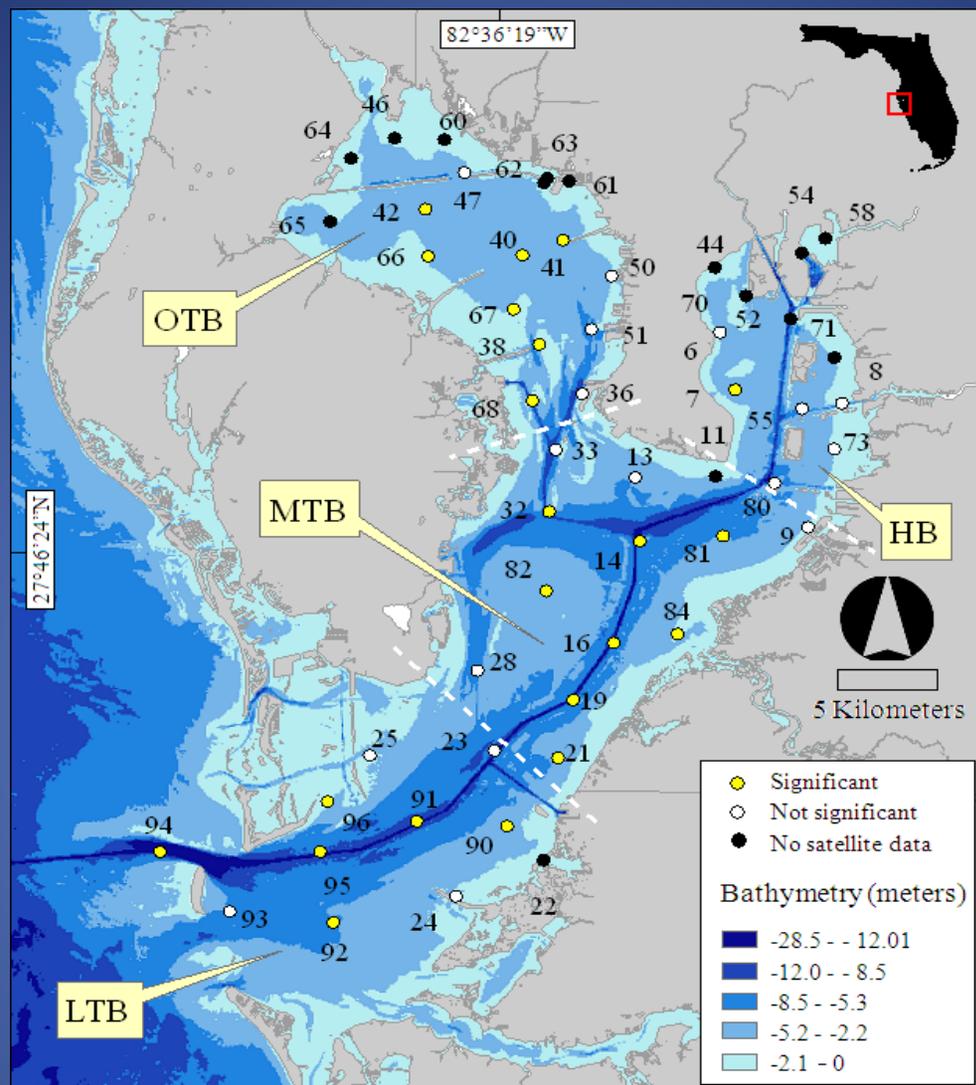
Methods

- *In situ* water quality data collected by EPCHC between 2000 and 2011 using FDEP SOPs including.
- 3242 MODIS Aqua files processed to level 3 in SeaDAS 6.4
 - Default atmospheric correction (Gordon and Wang, 1994; Strumpf et al., 2003)
 - Land, cloud and saturated radiance masks applied
 - Further manual QA/QC process to remove images with cloud contamination and severe scan angle
- Satellite (n=18000)/*in situ* (n=7552) correlations
 - FLH x chl – α
 - FLH x water quality parameters (N, P, NTU, BOD, DO, pH, Salinity, Temperature)
- PCA of correlation between FLH and water quality parameters



Results – In situ Data

Histogram of *in situ* measurements of chlorophyll a and total suspended solids (TSS), 2003-2011.



Results – Significant match-ups by site between MODIS FLH and *in situ* chl- α

Map of Tampa Bay, Florida (U.S.A.) showing the 54 the stations monitored by the Environmental Protection Commission of Hillsborough County (EPCEC)

**Results – Correlations
(MODIS FLH x *in situ*
chlorophyll- α) for significant
individual sites and
subregions.**

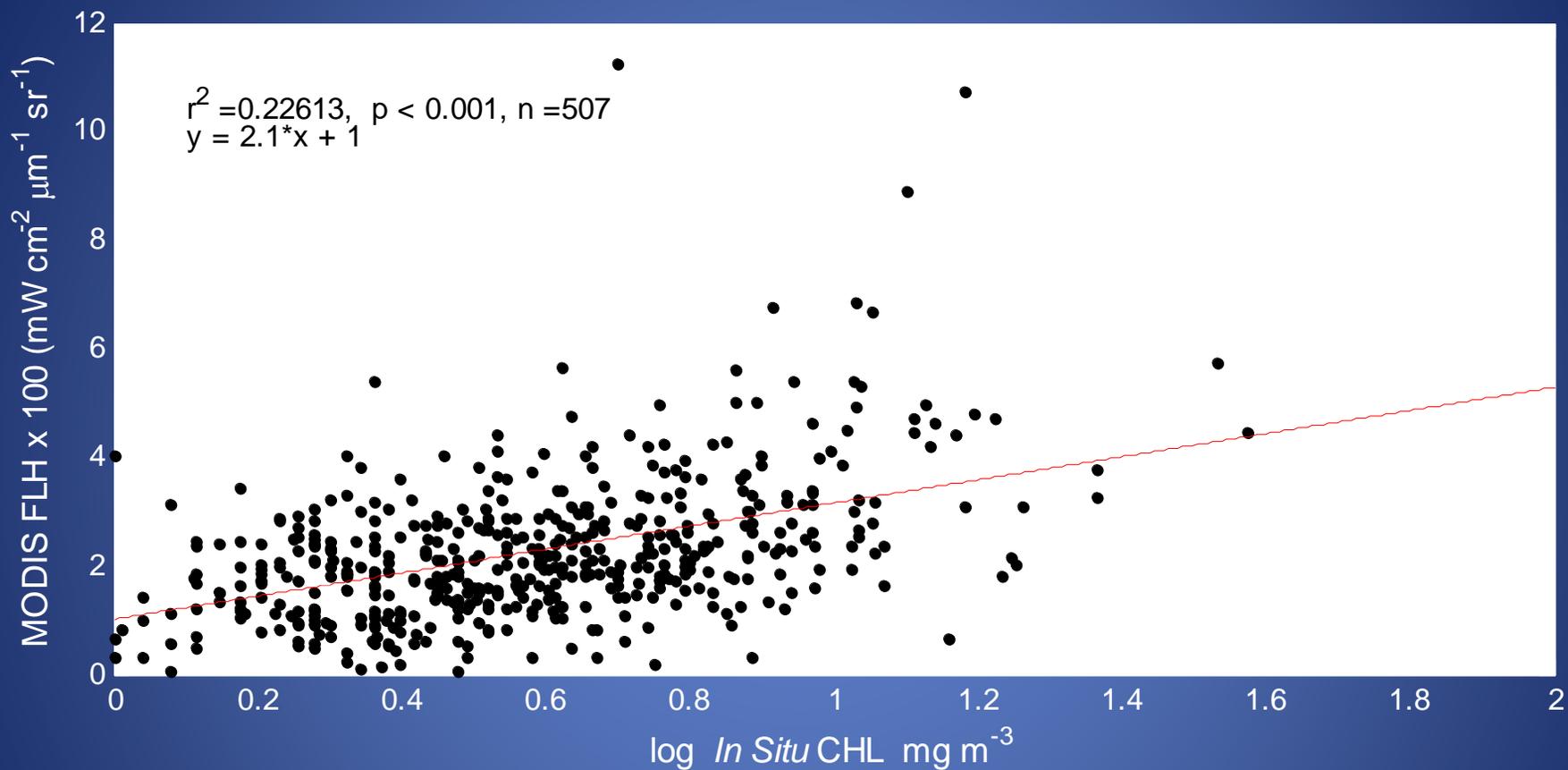
Individual sites

- r^2 ranged from 0.67 ($n=28$, $p<0.01$) to 0.22 ($n=25$, $p= 0.016$)
- Best sites were MTB14, HB7, OTB68 and MTB32.

Subregions

- r^2 of 0.64, 0.40, 0.38 and 0.16, for sub-regions HB, MTB, OTB and LTB

Station	Distance to structure (m)	Depth (m)	Distance to Shore (m)	r^2	n	NTU
MTB14	5600	7.4	5,600	0.67**	28	2.05
HB7	1180	3.5	1,180	0.64**	11	4.53
OTB68	1530	4.8	1,530	0.49**	13	2.62
MTB32	3000	7.5	3,000	0.48**	28	2.94
LTB96 †	624	2.3	7,578	0.46*	12	3.56
OTB40	72	4.8	4,620	0.44**	28	2.74
OTB41	110	3.5	2,300	0.43**	15	2.96
OTB67	72	2.5	2,360	0.42**	26	3.19
OTB38	590	2.3	2,676	0.40**	23	2.61
MTB81	3520	7.5	3,520	0.38**	23	2.65
MTB82	5130	3.7	5,130	0.37**	34	2.28
MTB21	1765	4.9	1,765	0.35*	16	2.79
MTB19	2800	7.8	2,800	0.34**	21	2.14
LTB92	5080	5.8	5,940	0.34**	32	2.45
LTB90	1860	4.3	1,860	0.31*	16	2.81
MTB84	1150	1.8	1,150	0.29*	15	3.88
MTB16	2800	7.5	2,800	0.29**	28	2.29
LTB94	800	3.6	2,100	0.28**	38	2.63
LTB95	1890	8.2	8,654	0.26**	25	2.75
OTB42	1638	3.4	1,638	0.26*	18	3.31
LTB91	4290	9.1	4,290	0.23**	33	2.01
OTB66	2010	2.6	2,010	0.23*	25	3.63

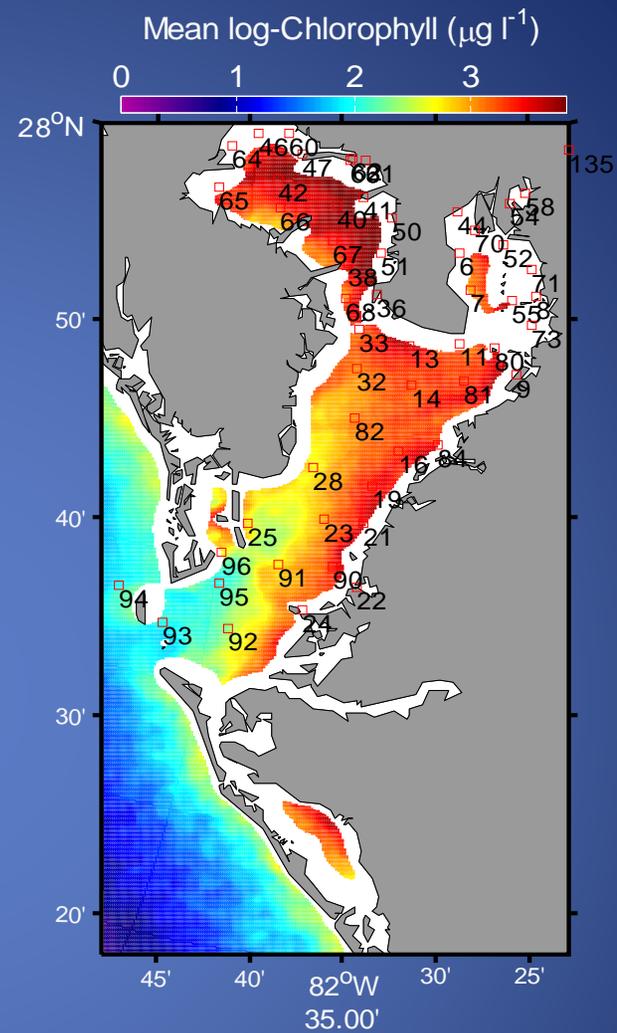
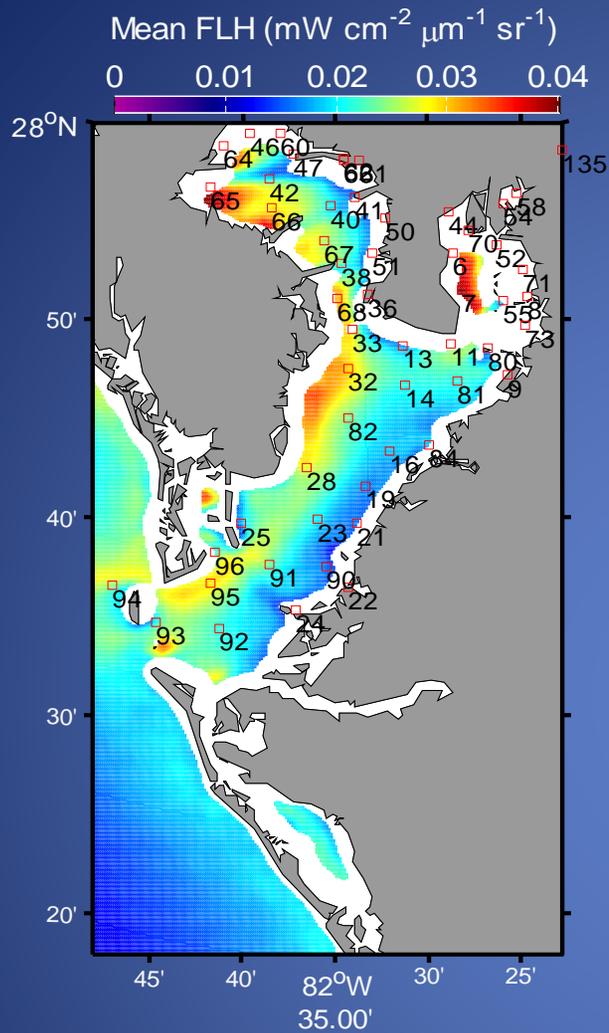


Results – Pooled, bay-wide correlations.

– Correlations (MODIS FLH x in situ chlorophyll- α) for all significant sites.

Factors Affecting Correlations

- Average distance to shoreline and structures was 3,386 m and 2,160 m, respectively.
- The average depth for the significant sites was 5.0 m
- Correlations increase with increasing distance from the shoreline and structures, but shows little change with increasing depth



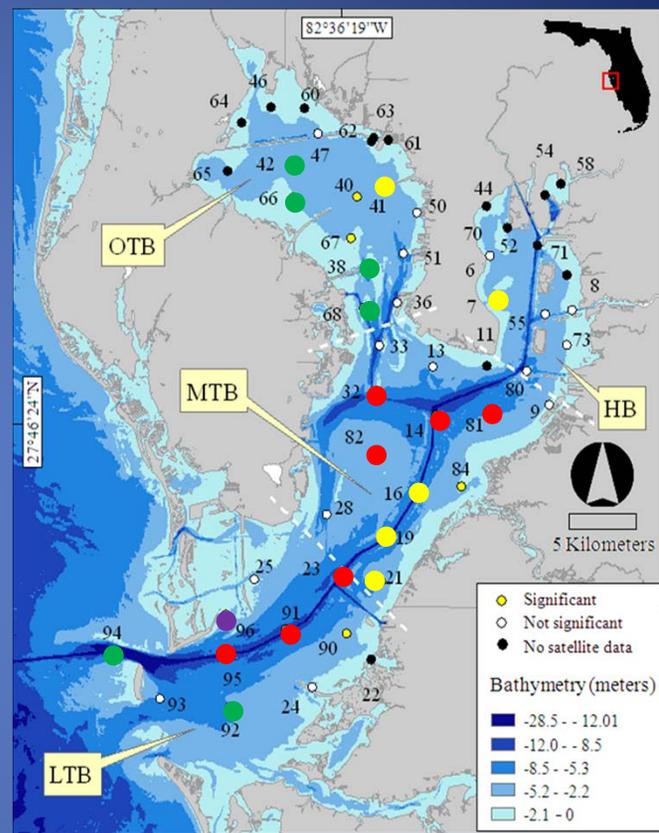
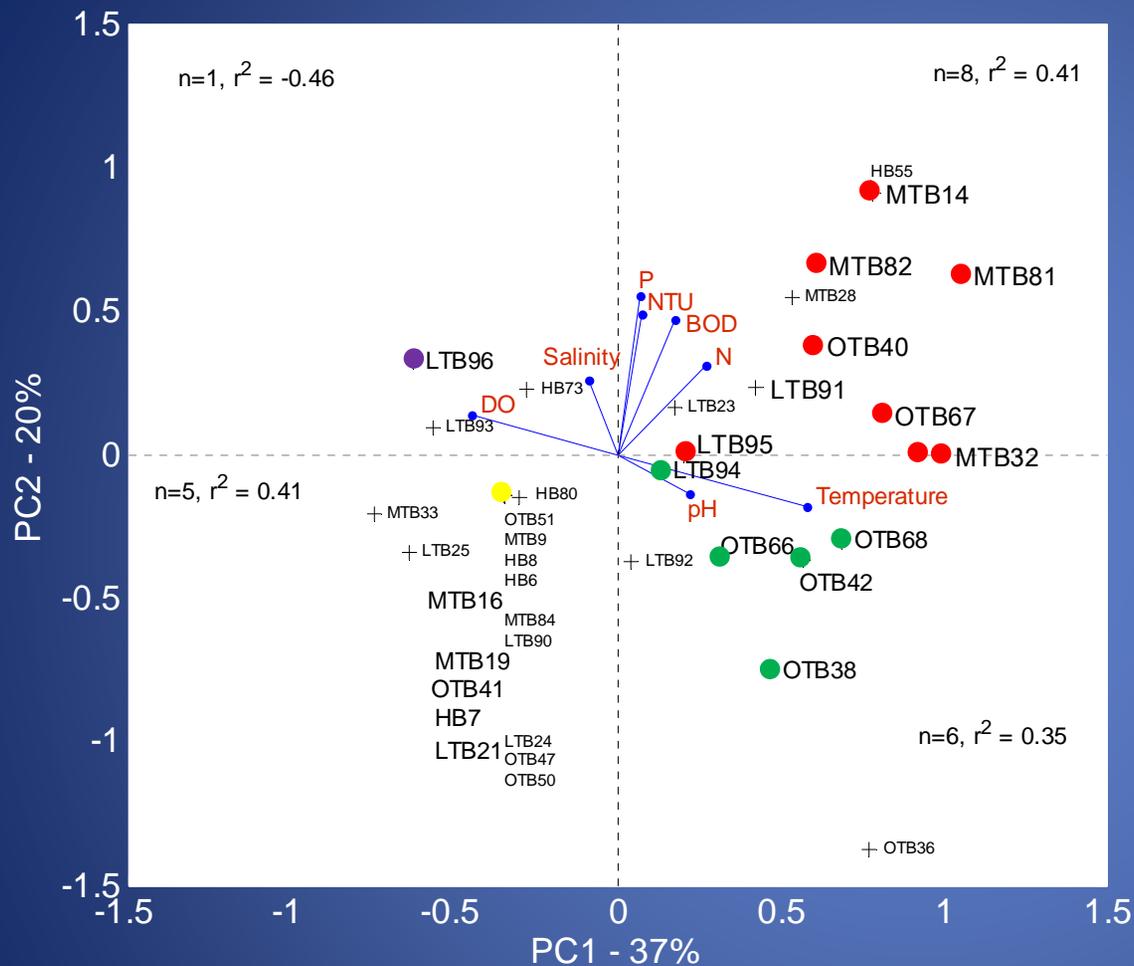
Results – Spatial patterns

The long term mean FLH and chlorophyll (OC3M) products from 2003-2011. The red squares indicate the in situ sampling station with the associated station numbers.

Variables <i>Satellite / in situ</i>	Mean	Max	Min	Stations
FLH/N	0.27	0.41	0.20	94,82,81, 28,
FLH/P	0.24	0.37	0.14	82, 67,40,32
FLH/BOD	0.78	0.85	0.71	82,81
FLH/DO	-0.37	-0.18	-0.48	67,66,42,40,38,32,14
FLH/NTU	0.29	0.46	0.17	94,82,14,7
FLH/pH	-0.23	-0.23	-0.23	7
FLH/PSU	0.15	0.15	0.15	23
FLH/Temp	0.37	0.66	0.14	95,91,84,82,81,68,67,66,42,40,38,23

Results – FLH Correlation (r) with in situ water quality variables (p<0.05)

N= total nitrogen (mg l⁻¹) , P= total phosphorous (mg l⁻¹), bod = biological oxygen demand (mg l⁻¹), do= surface dissolved oxygen (mg l⁻¹), NTU= turbidity (NTU), sal= salinity (PSU), temp = surface water temperature (°C) by station.



Results – Principle component analysis results of the correlations between FLH and the eight water quality sampling parameters by site.

Conclusions

- Poor proxy for the measurement of chl- α concentration of Tampa Bay overall or by subregions.
- Sites ($p > 0.01$) that have a positive loading along PC1 and PC 2 in the multivariate analysis tend to lie along the main channel of Tampa Bay in deep water.
- Average depth of these sites was 7.0 m, the average distance from structures was 3368 m and they were over 5 km from shore.
- The average correlation (FLH/chlorophyll- α) of these sites was $r^2 = 0.46$.
- further sampling of the TP, TN, turbidity and BOD should be considered