Multi-decadal variability in coccolithophore abundance in the North Pacific Subtropical Gyre

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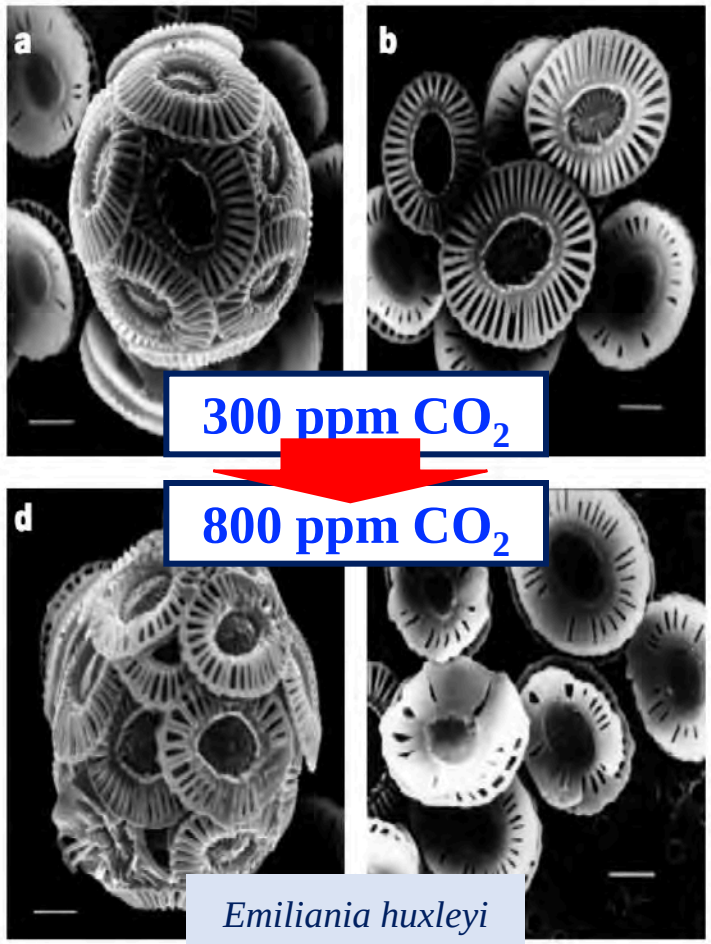
1. Introduction

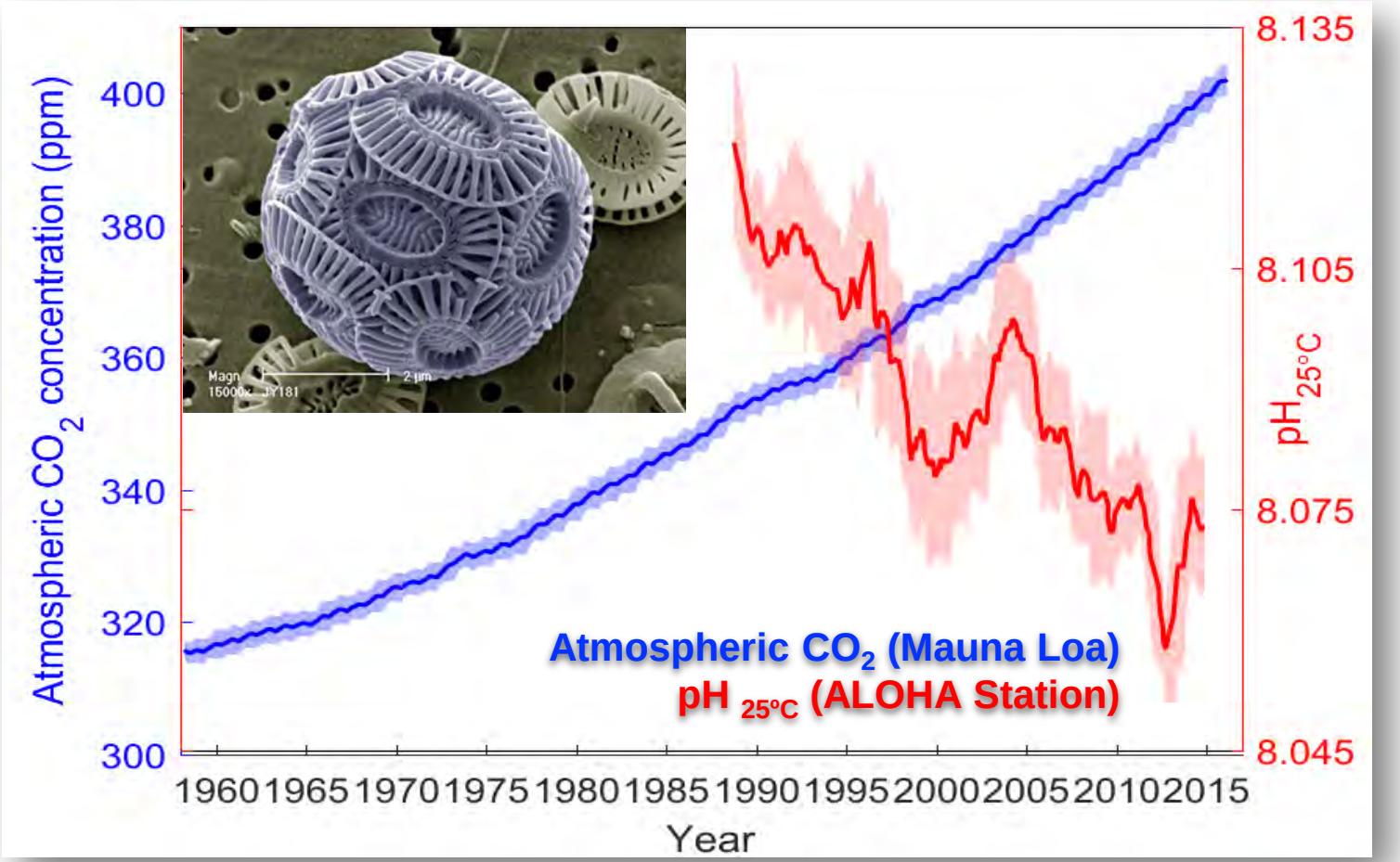
Ocean Acidification

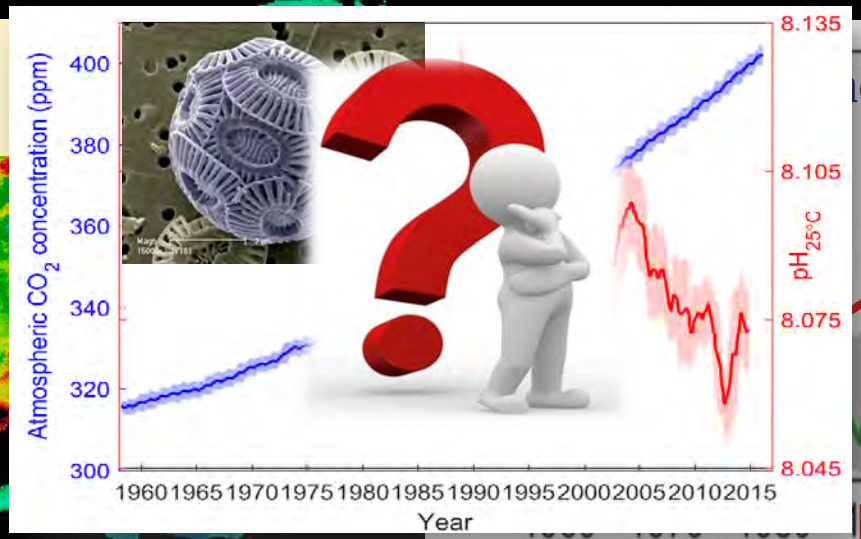
Ocean acidification
($\uparrow CO_2 + H_2O + \downarrow CO_3^{2-} \rightarrow \uparrow 2HCO_3^-$)

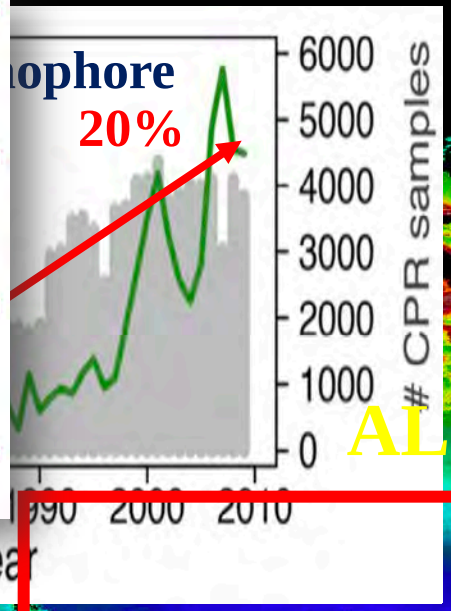
Marine Calcifiers
($Ca^{2+} + \downarrow CO_3^{2-} \rightarrow \downarrow CaCO_3$)

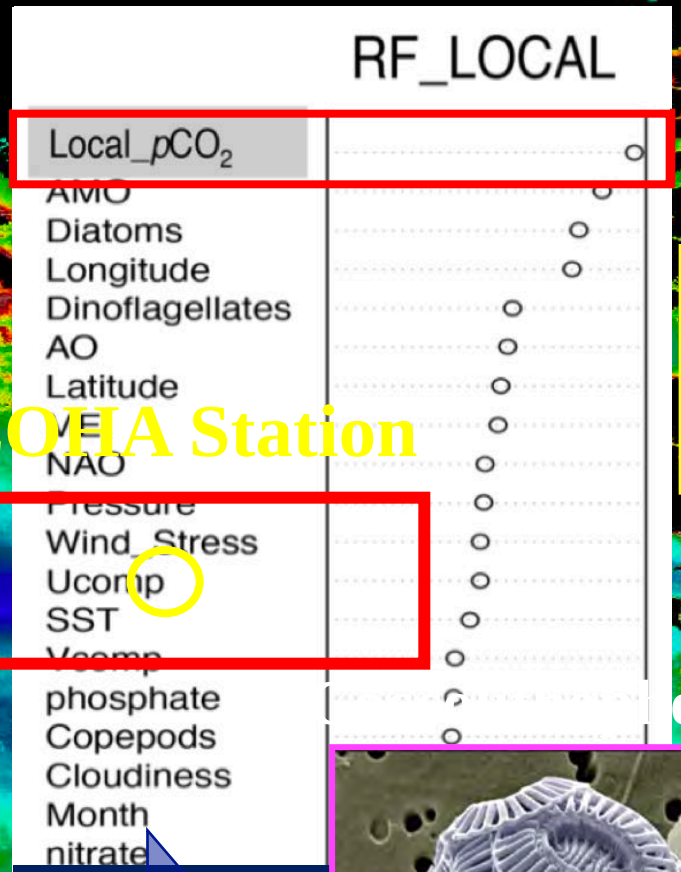
[Riebesell et al., 2000]



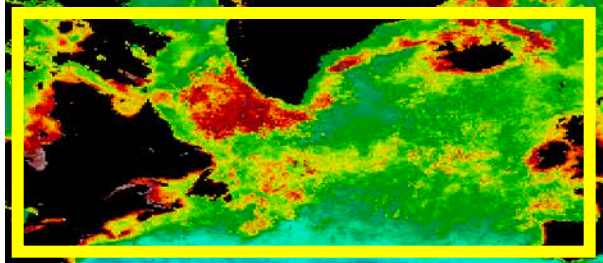






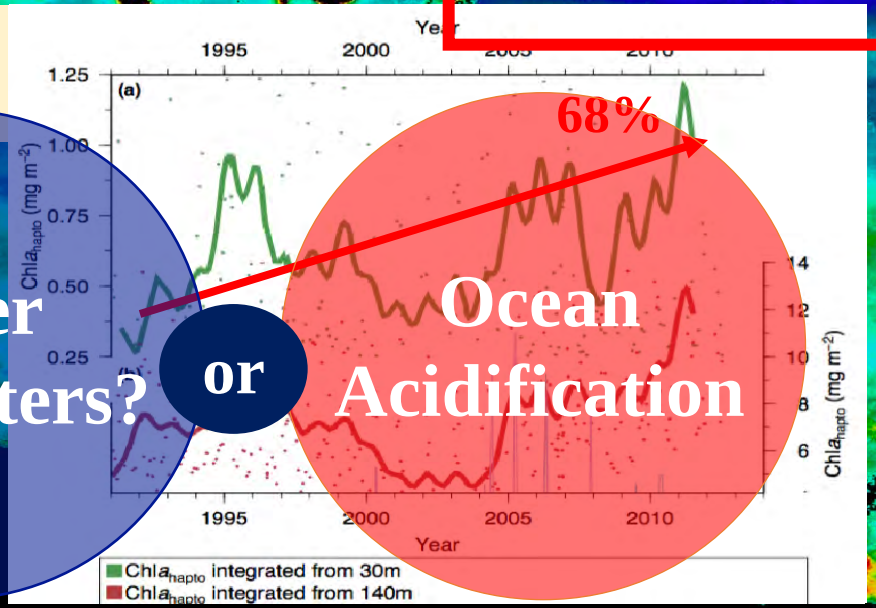


ALOHA Station



BATS

Krumhardt et al. [2016]



Other Parameters?

or

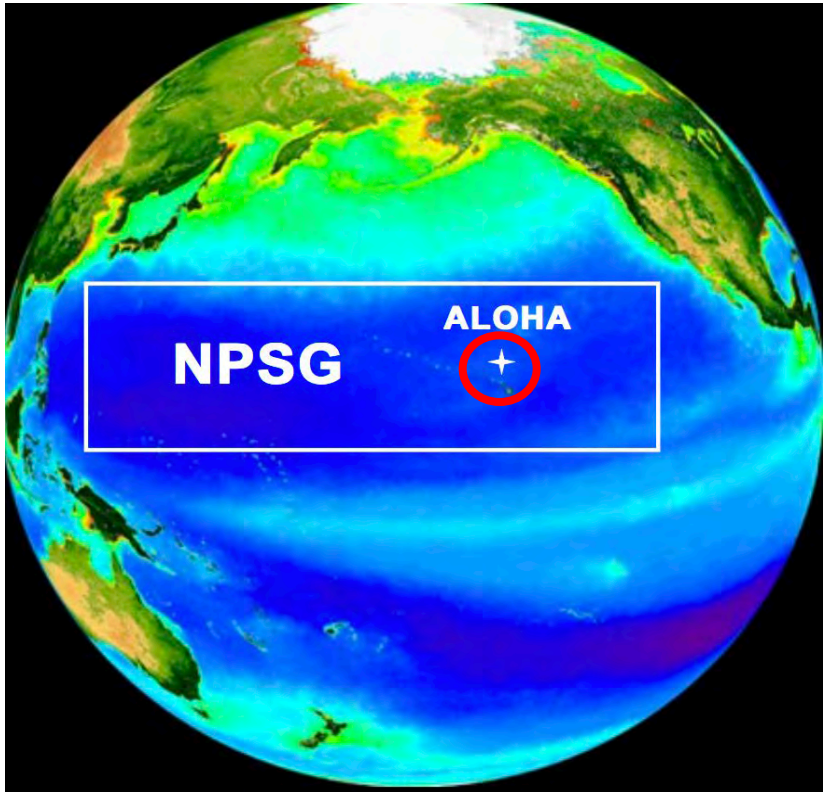
Ocean Acidification

ores "Average pH ~8.1"

"Pre… $CaCO_3$"
-Negati… w pH 7.7
(Bach et al. 2015)

Study Purpose

ALOHA Station
(22°45'N, 158°00'W)



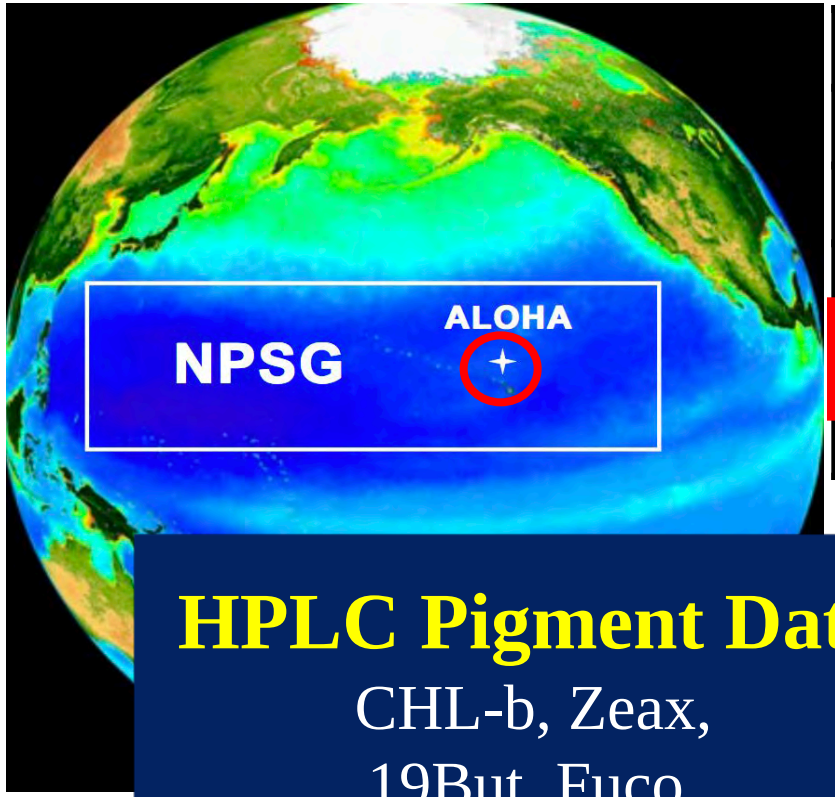
1. To investigate **Long-Term Trends** in **Coccolithophores Abundance**

2. To determine the **Relative Importance of Various Environmental Factors** on Trends in **Coccolithophores Abundance**

2. Data & Methods

Phytoplankton Functional Groups (PFGs)

From 1988 To 2016
ALOHA Station (22°45'N, 158°00'W)



Abundances- CHL-a Concentrations by Group [Mackey et al., 1996]
Pigment Data extracted by HPLC entered into CHEMTAX

Input Marker Pigment:CHL-a Ratio

Input ratios	CHL-b	Zeax	19But	Fuco	19Hex	CHL-a
Prochlorococcus	1.099	0.077	0.000	0.000	0.000	1.000
Cyanobacteria	0.000	0.476	0.000	0.000	0.000	1.000
Chrysophytes	0.000	0.000	1.111	0.156	0.156	1.000
Haptophytes	0.000	0.000	0.014	0.015	0.769	1.000
Diatoms	0.000	0.000	0.000	1.250	0.000	1.000

* Abbreviations include prasinoxanthin (prasino), zeaxanthin (zeax), 19′-butanoyloxyfucoxanthin (19′-but), 19′-hexanoyloxyfucoxanthin (19′-hex), fucoxanthin (fuco), and peridinin (perid).

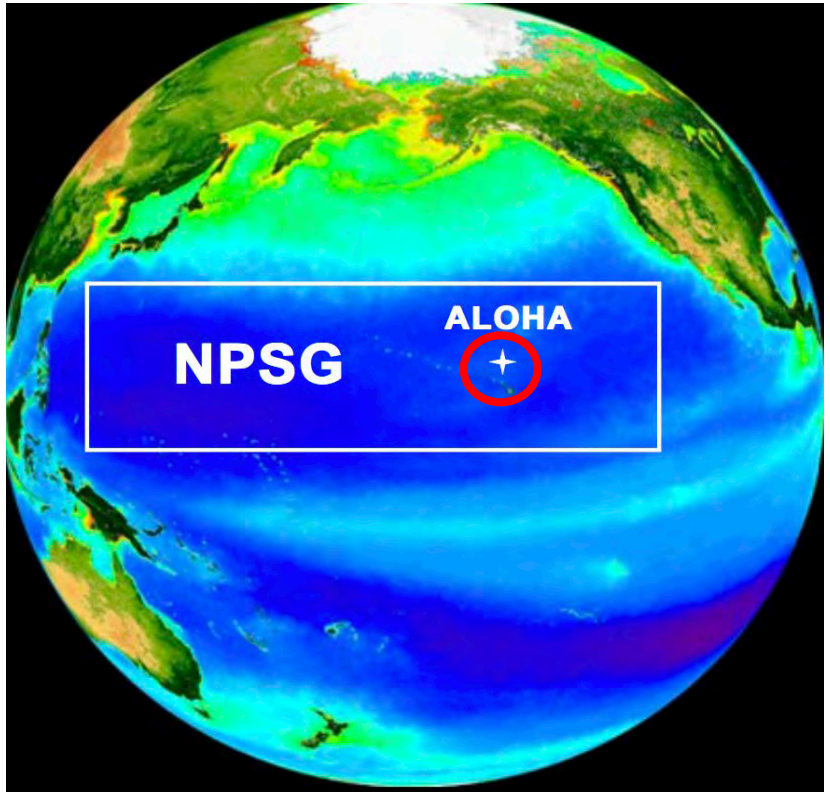
HPLC Pigment Data
CHL-b, Zeax,
19But, Fuco,
19Hex, CHL-a

CHEMTAX

CHL-a Concentrations by Group
Prochlorococcus,
Cyanobacteria, Chrysophytes,
Haptophytes, Diatoms

Environmental Parameters

From 1988 To 2016
ALOHA Station (22°45'N, 158°00'W)



➢ Carbon Chemistry Parameters

- Dissolved Inorganic Carbon, Total Alkalinity data
- pCO_2, HCO_3^-, CO_3^{2-}, pH, $\Omega_{aragonite}$, $\Omega_{calcite}$ (*in situ* temperature)
- CO_2 system calculations with CO_2SYS software [Mehrbach et al., 1973]

➢ Physical Parameters

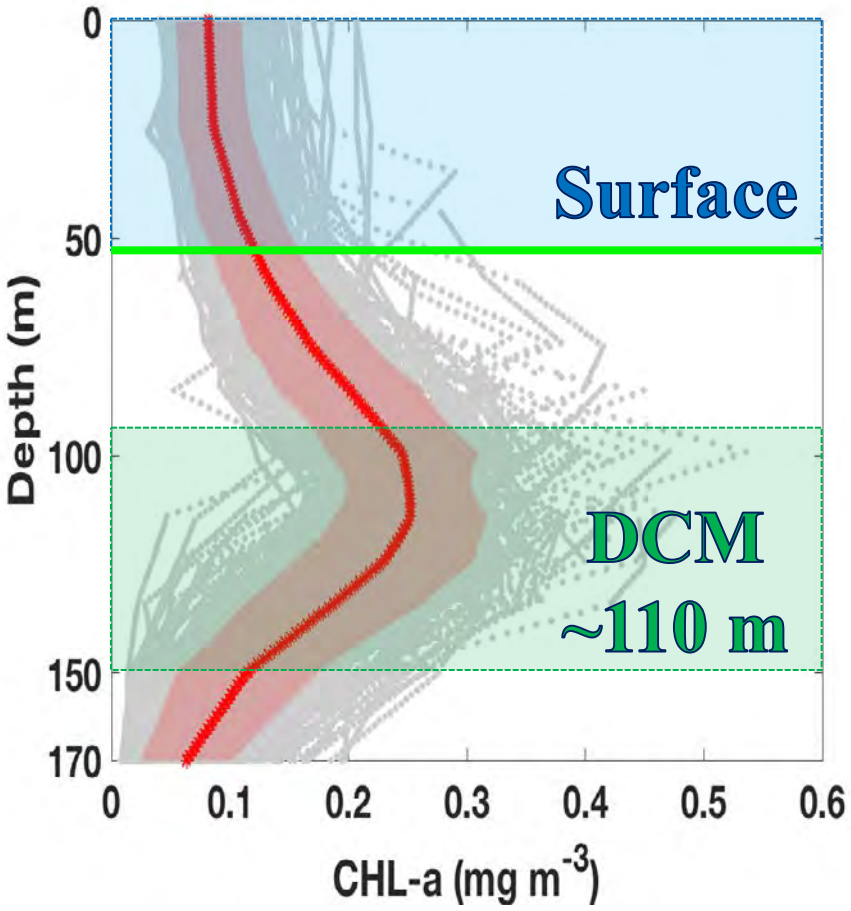
- Temperature, Salinity, Sigma-t
- Mixed Layer Depth (Sigma-t- 0.125 kg m^{-3} from surface waters)

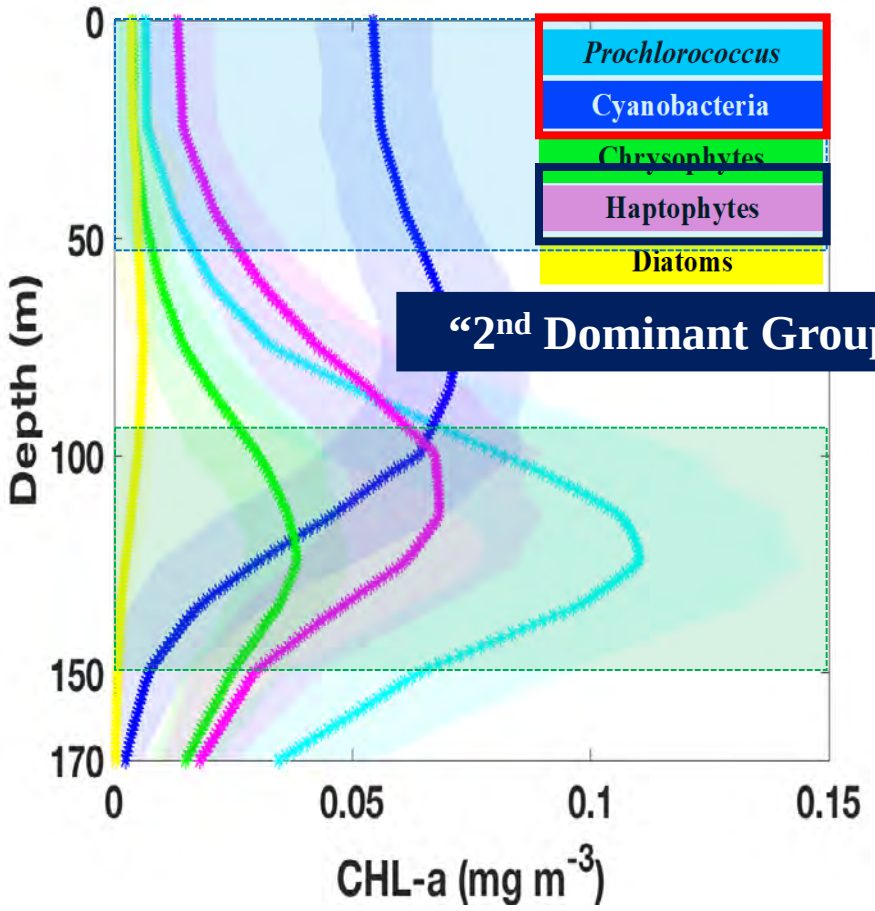
➢ Nutrients Parameters

- DIN (Nitrate + Nitrite), Phosphate, Silicate

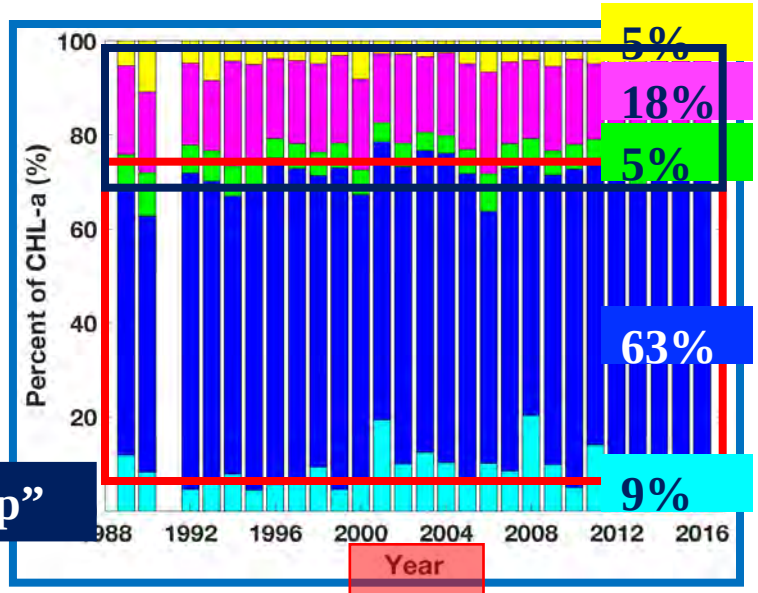
3. Results & Discussion

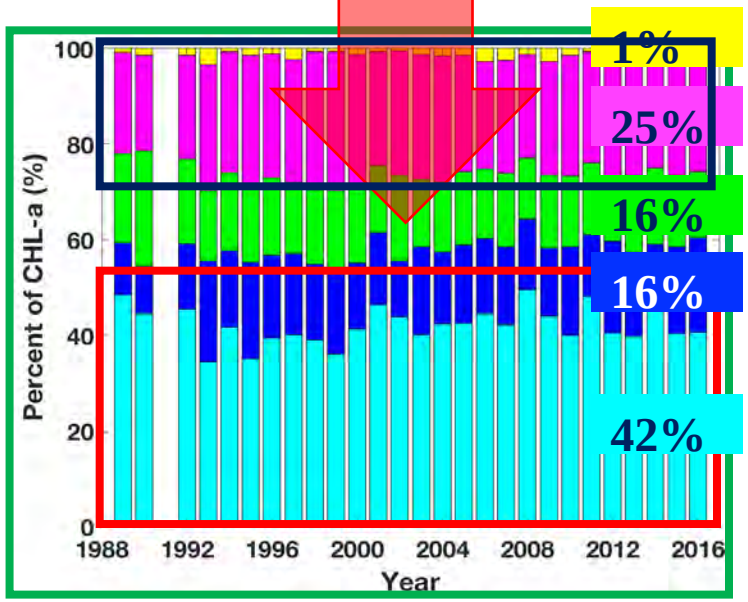
Vertical Patterns of CHL-a and PFGs





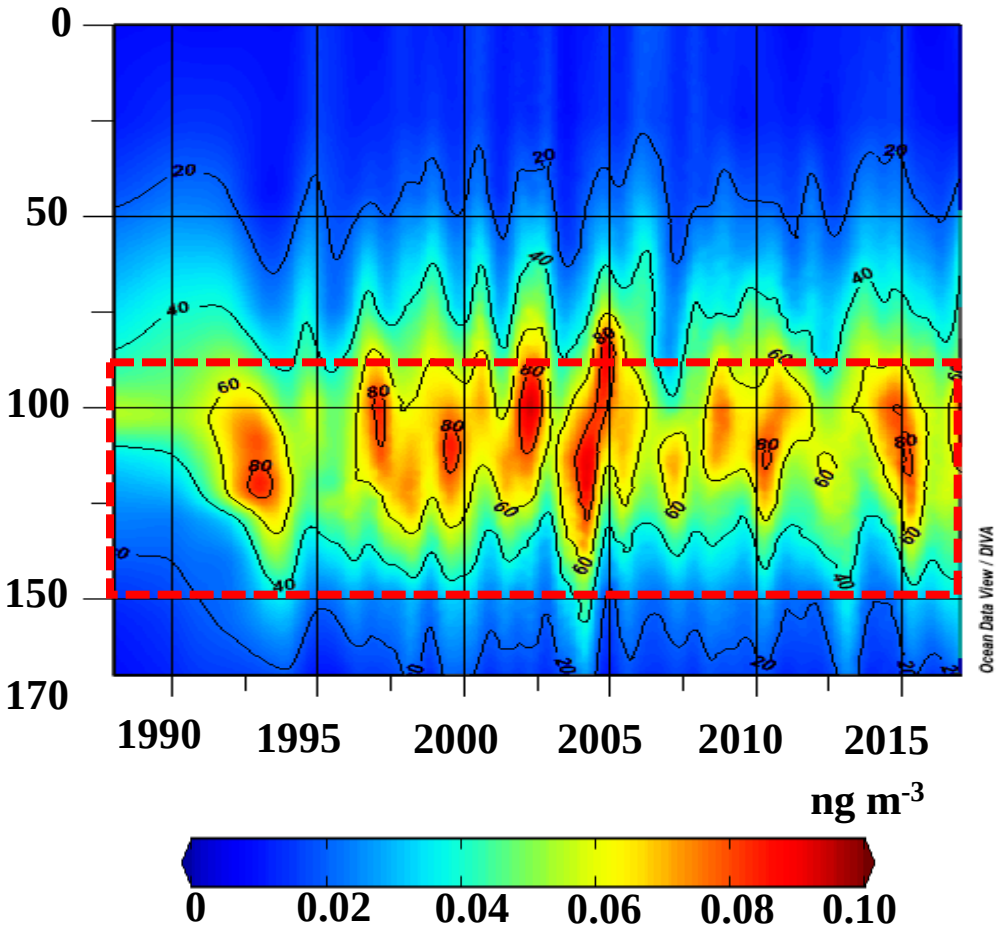
"2nd Dominant Group"





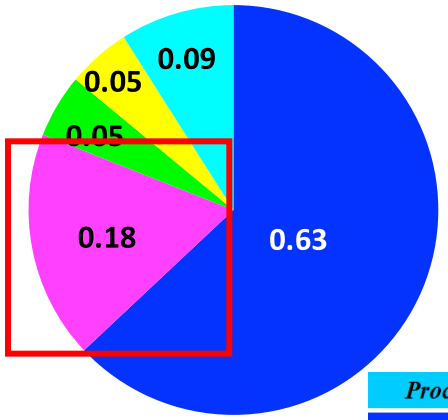
Trend in Coccolithophore

Haptophytes

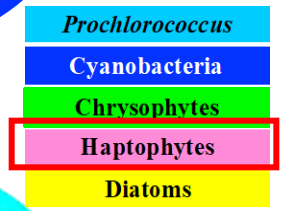


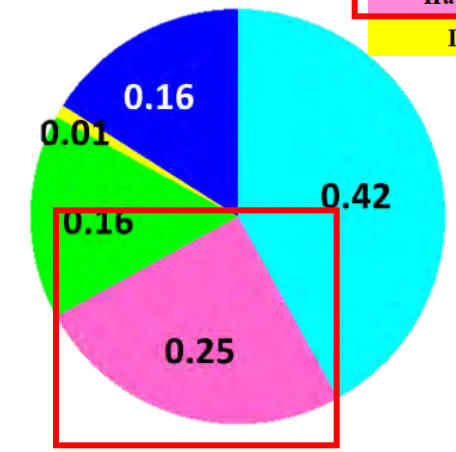
Total CHL-a = 1

Relative Ratio

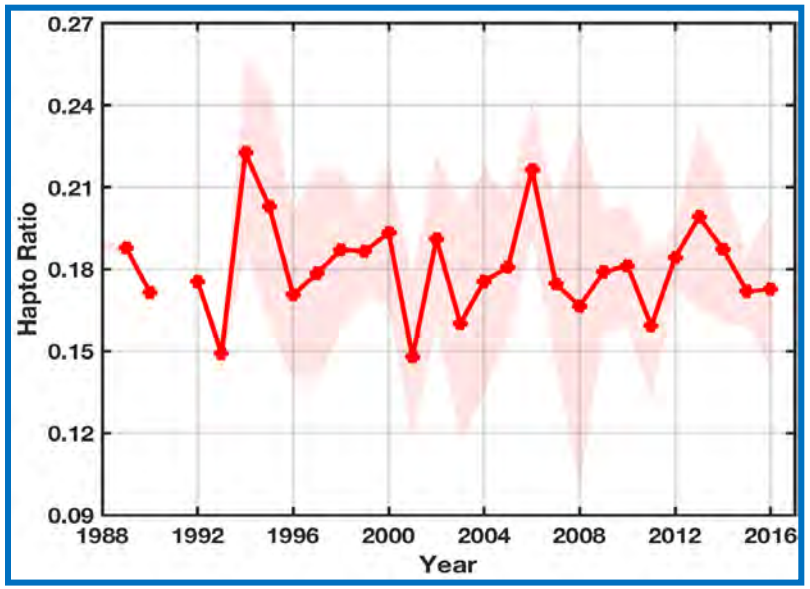


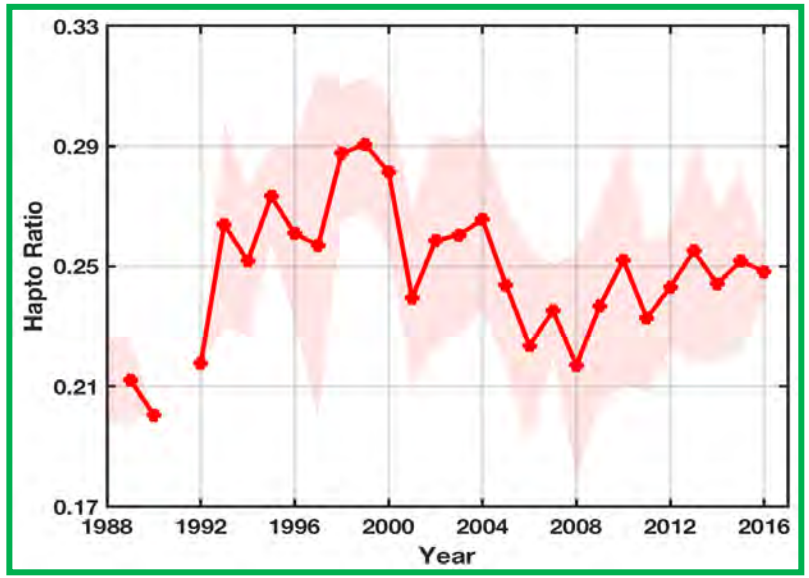
Surface
(0–60 m)



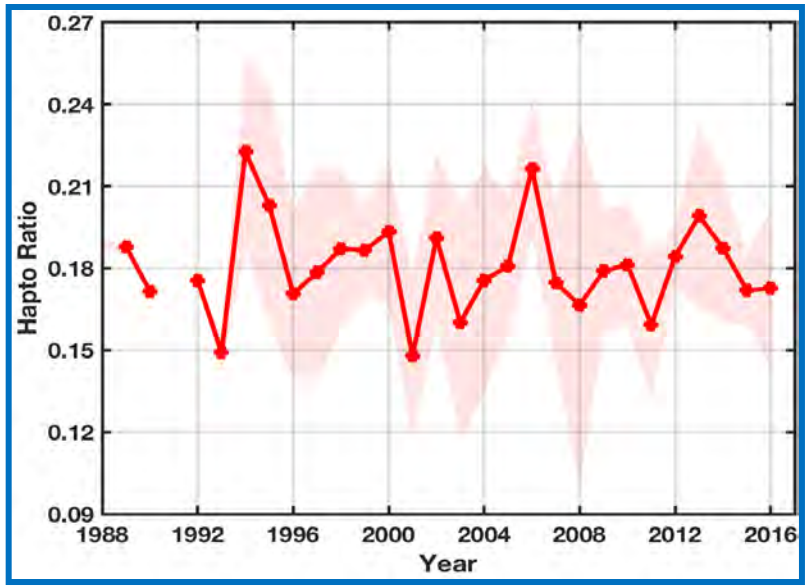


DCM
(90–150 m)



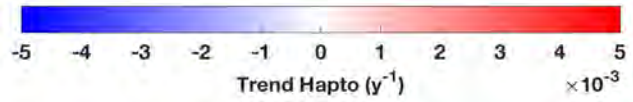


Trend in Coccolithophore

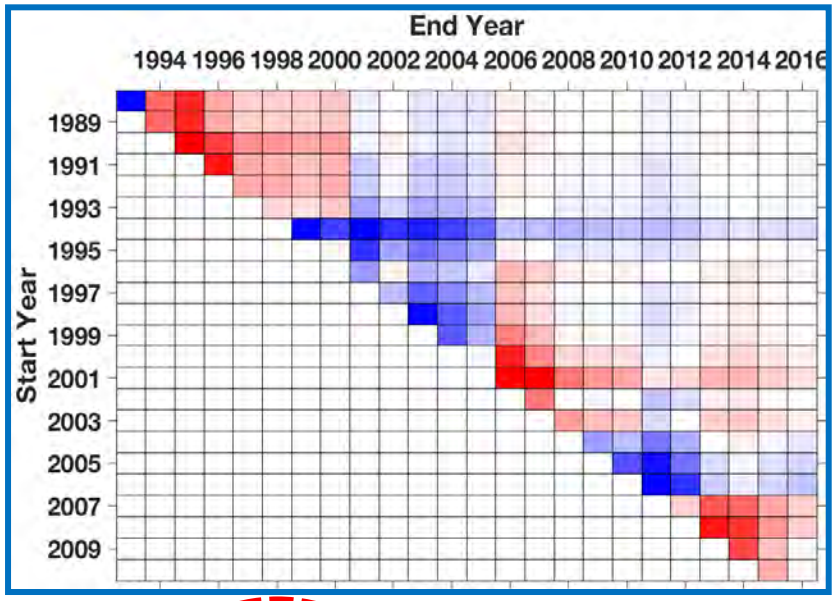


Linear Trend

(For a Range of Start and End Years)

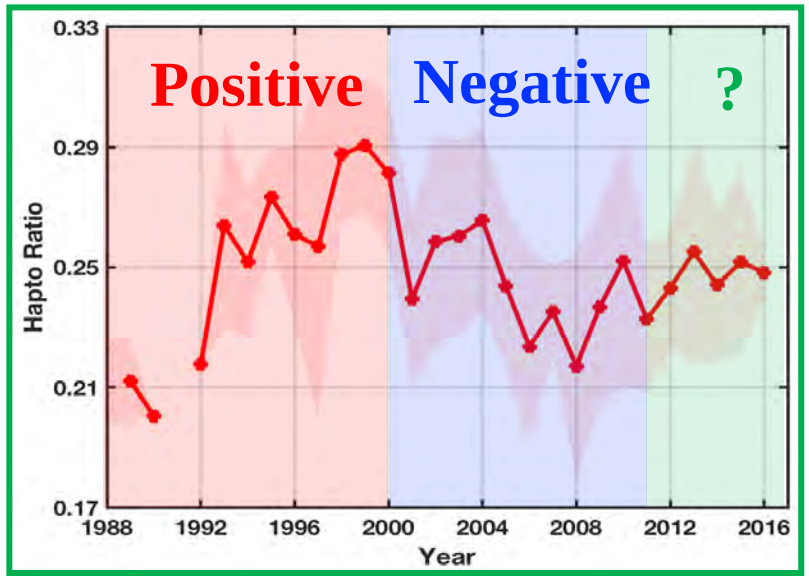


(☆: p<0.05)



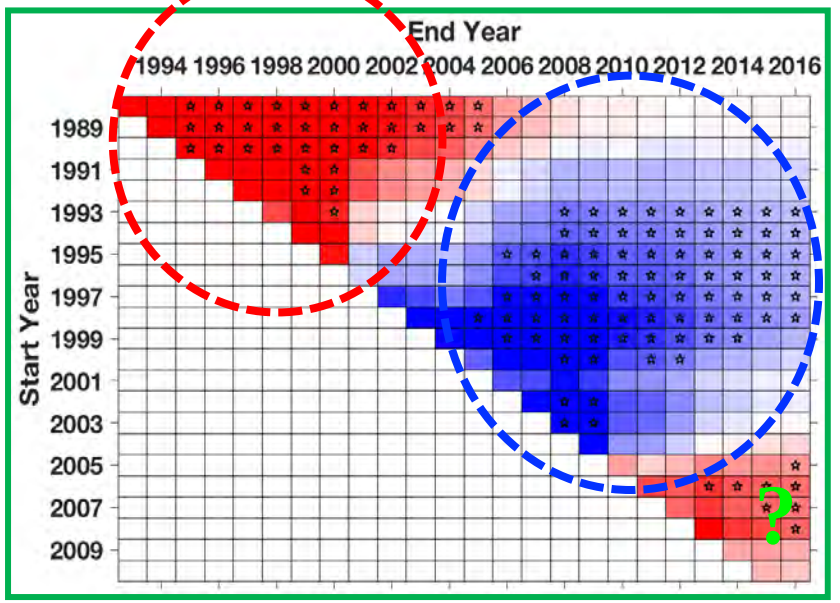
Surface

(0–60 m)



DCM

(90–150 m)



Surface
(0–60 m)

Diatom	Prochl	Cyano	Chryso	Sigma-t	T	Sal	MLD	DIC	Alk	pH	pCO_2	HCO_3^-	P	DIN	Si
+	-	-	+	-	-	+	+	+	-	+	+	+	+	-	+

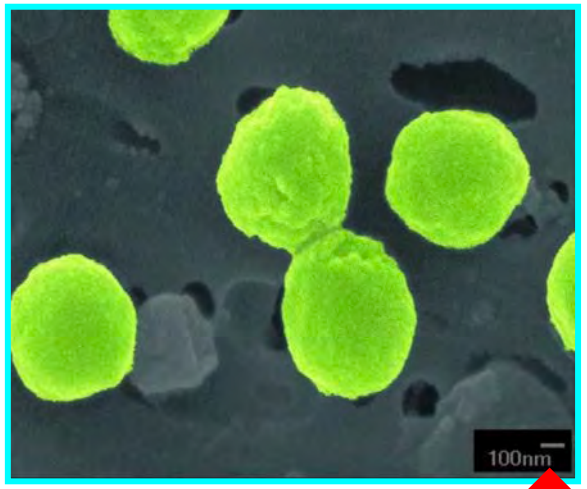
PFGs | Physical Factors | CO_2 parameters | Nutrients

DCM
(90–150 m)

Diatom	Prochl	Cyano	Chryso	Sigma-t	T	Sal	MLD	DIC	Alk	pH	pCO_2	HCO_3^-	P	DIN	Si
-	-	-	+	+	-	+	+	+	-	+	-	+	+	-	+

PFGs | Physical Factors | CO_2 parameters | Nutrients

DCM (90–150 m)

Environmental Factors → **?** → 

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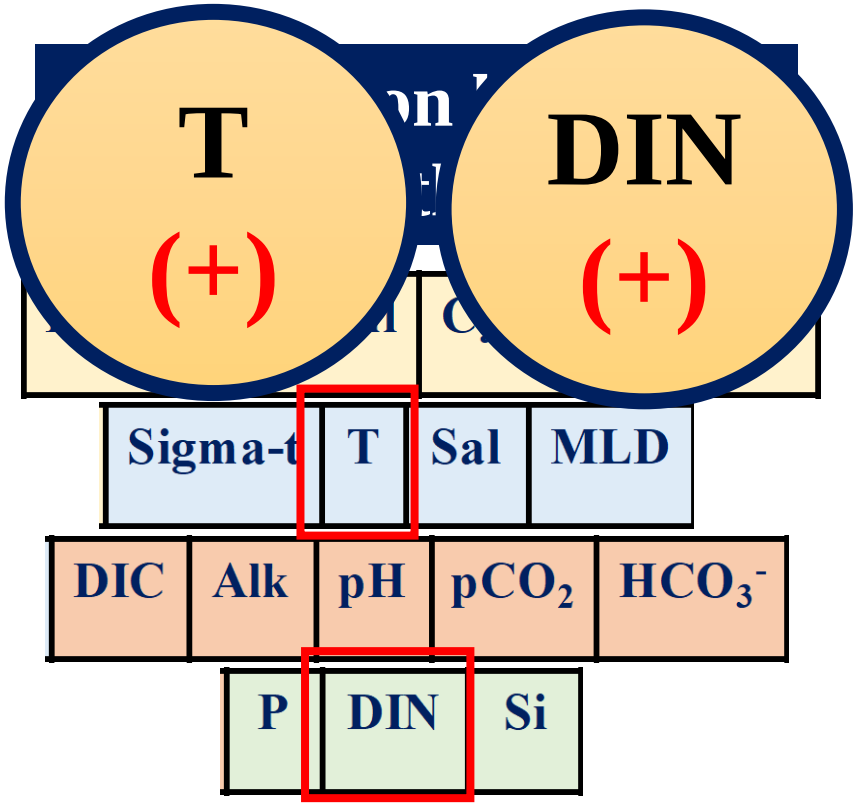
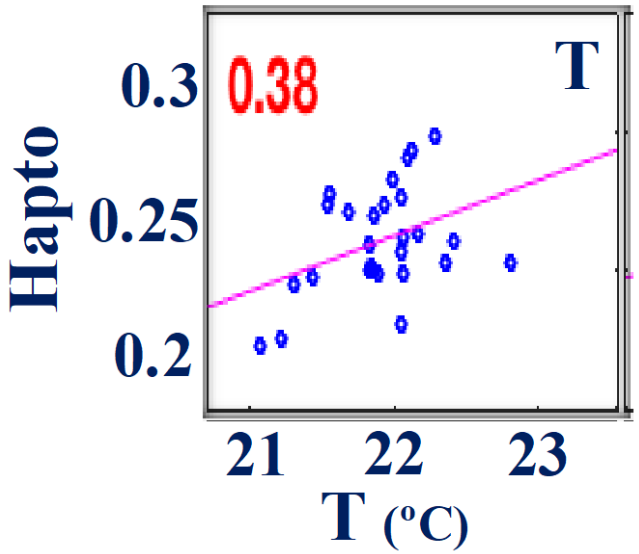
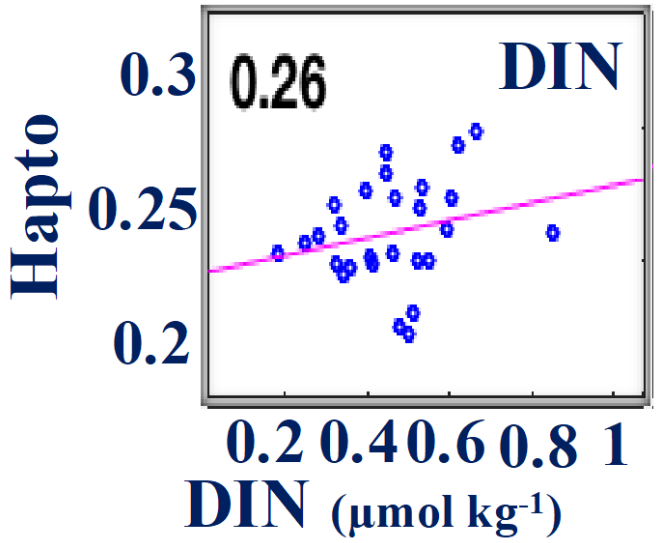


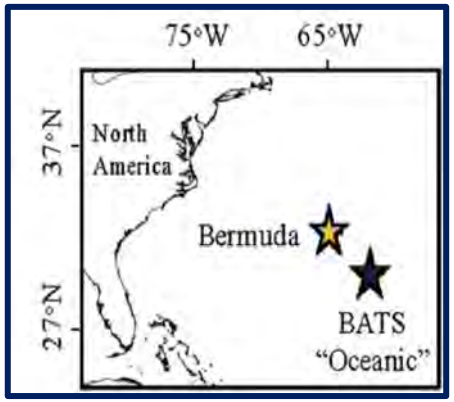
Prochlorococcus

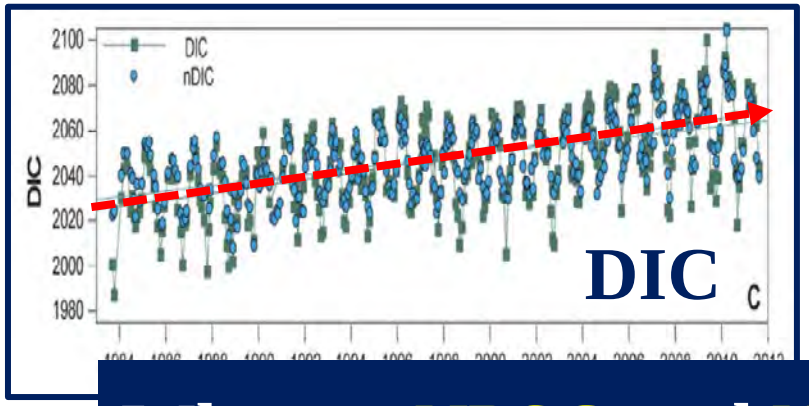


Haptophytes

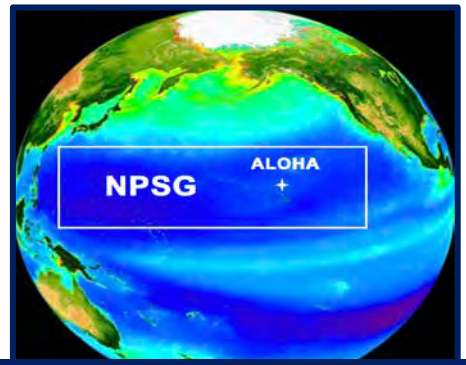


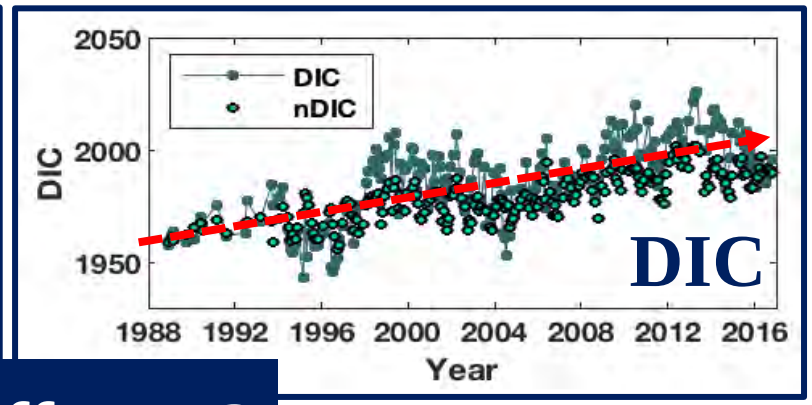
NASG





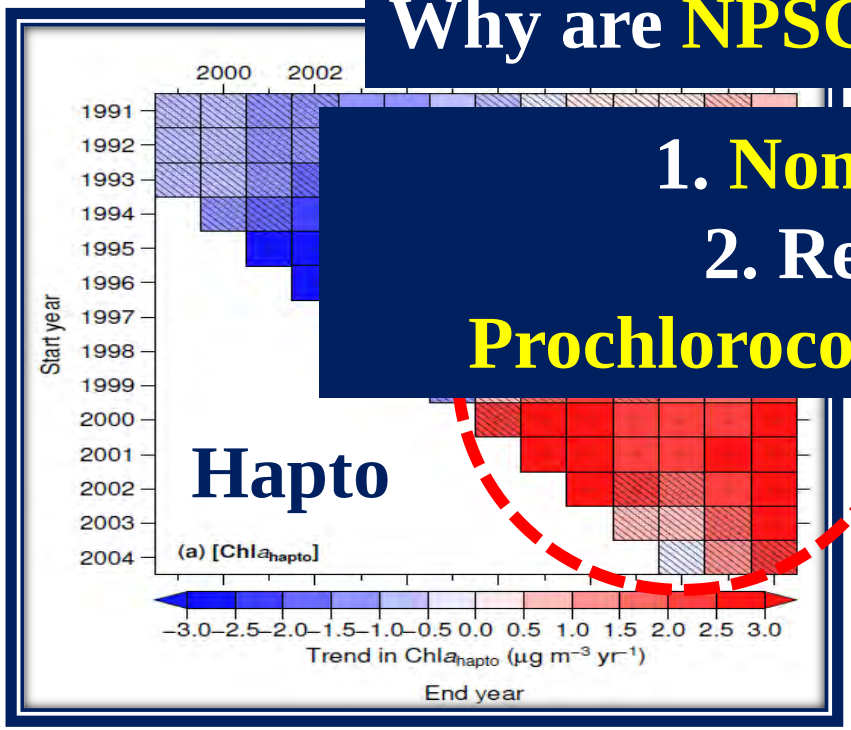
NPSG

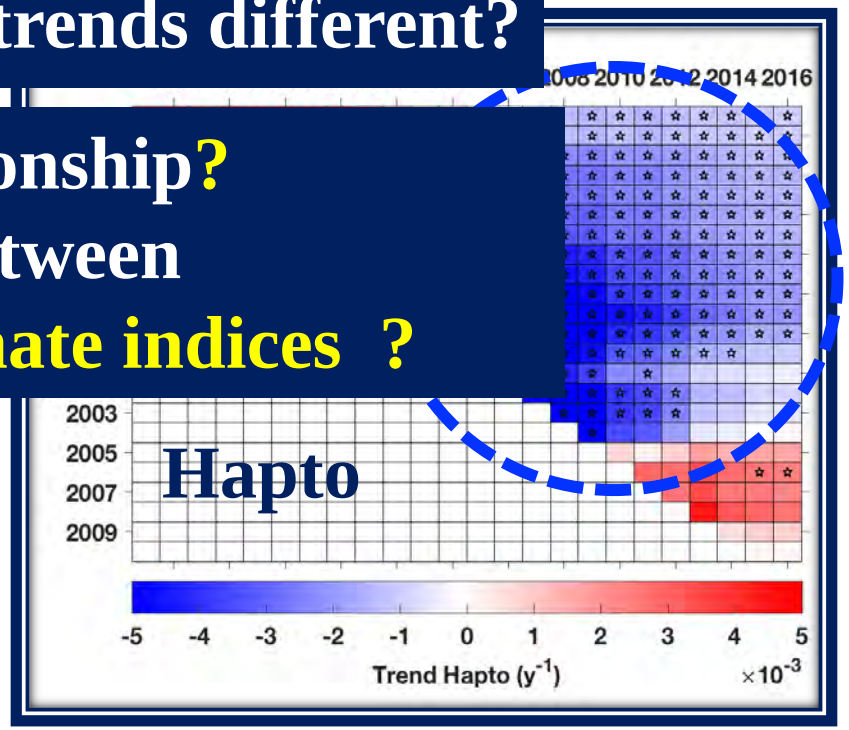




Why are NPSG and NASG trends different?

1. **Non-linear relationship?**
2. **Relationship between Prochlorococcus and climate indices ?**





5. Summary

1) Haptophytes (Coccolithophores) are 2nd Dominant Phytoplankton Group.

2) Maximum occurs at ~ 110 m depth.

3) Haptophytes rapidly increased until ~2000 and then decreased.
This trend was related to Changes in Prochlorococcus.

4) Future study is needed to understand Factors Driving the Decrease in Haptophytes Since ~2001.

Q & A

Thank You for Your Attention!!

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