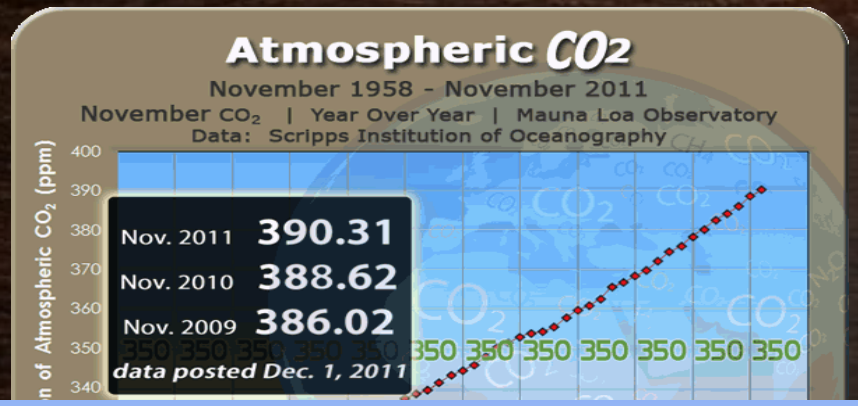
東沙環礁海水碳化學特性之初探

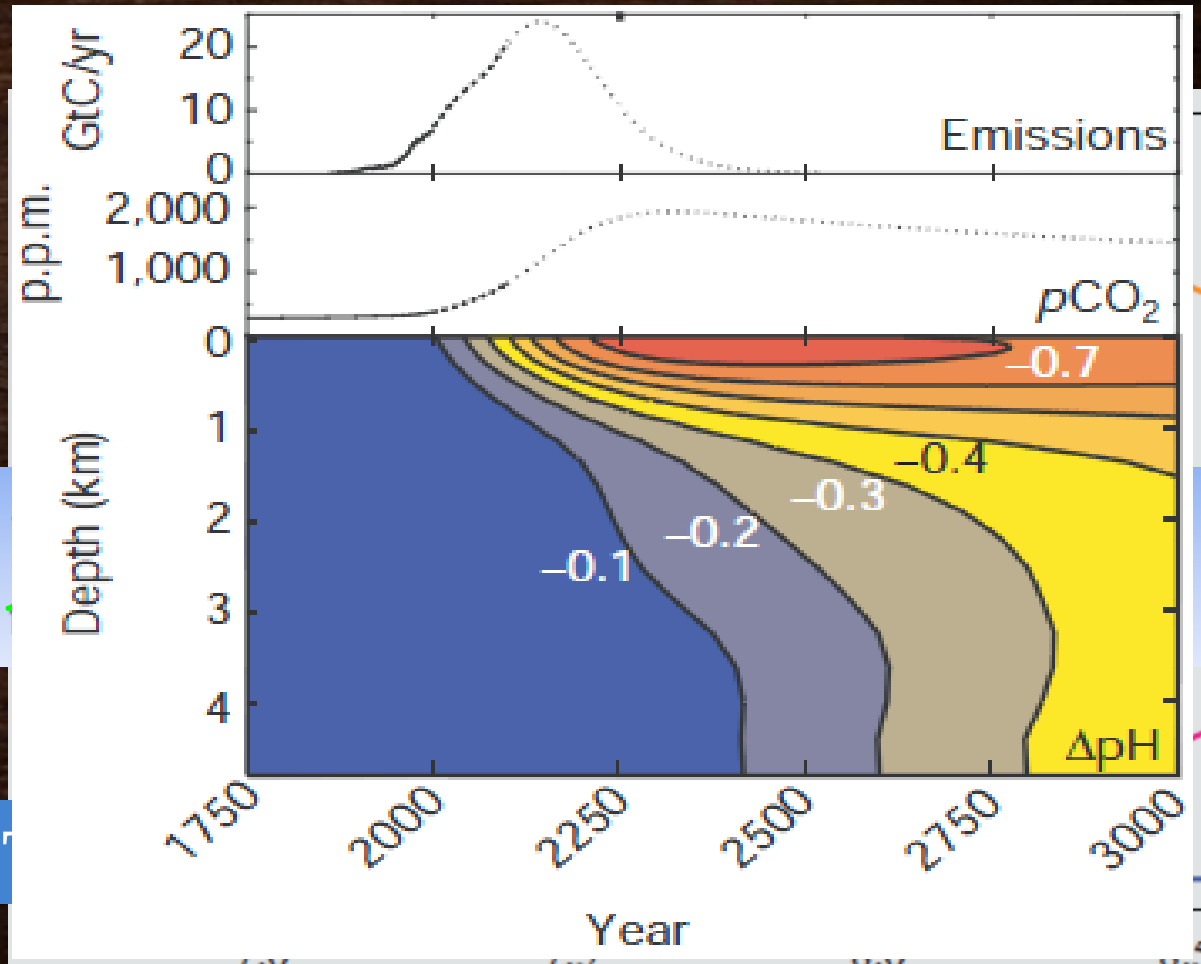
國立臺灣海洋大學 海洋環境化學與生態研究所

指導老師:周文臣 老師

姓名:劉亭之

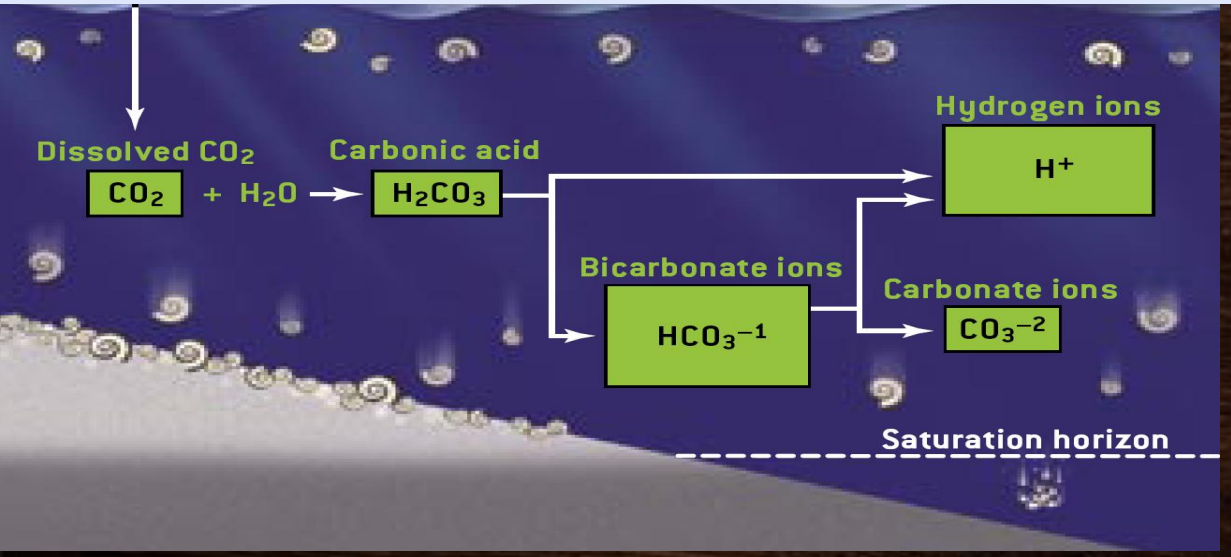
海洋酸化





Ω > 1 corresponds

Ω < 1 corresponds

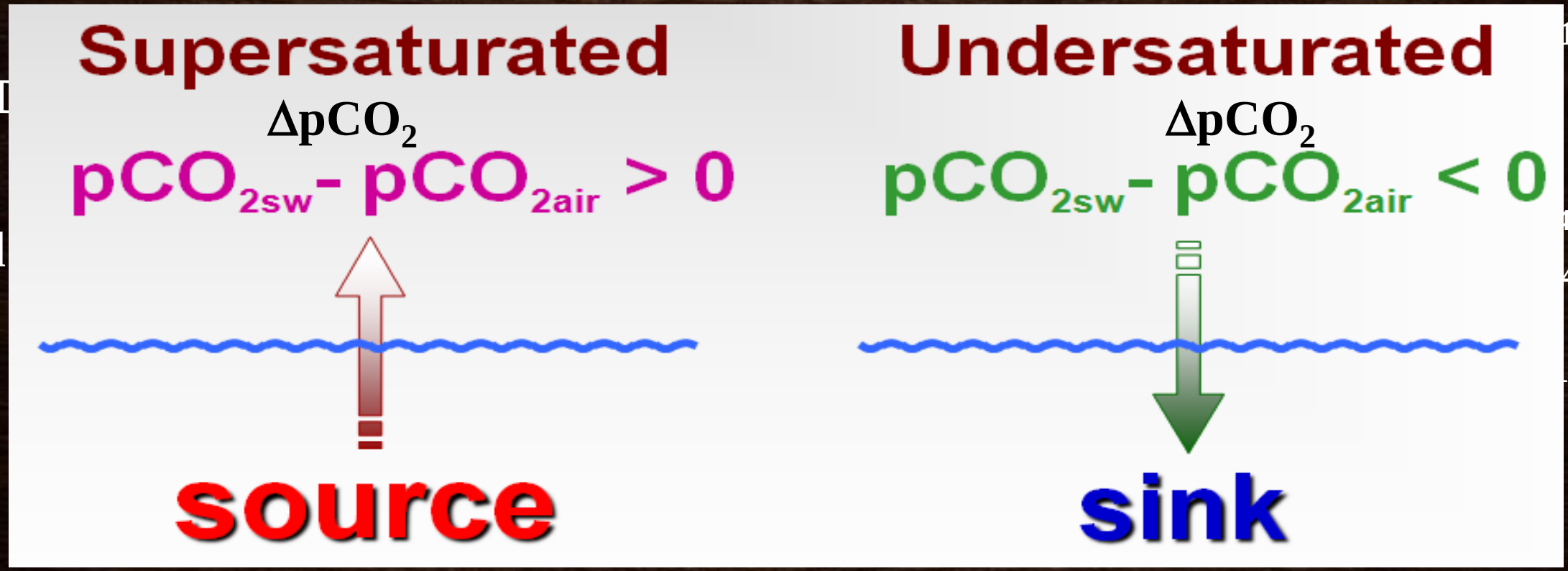


$$\Omega = \frac{[Ca^{2+}]_{sw} \times [CO_3^{2-}]^{pH_T}_{sw}}{[Ca^{2+}]_{sat} \times [CO_3^{2-}]_{sat}}$$

Caldeira et al. 2003, Nature

二氧化碳系統參數

pH(total scale) The partial pressure of carbon dioxide (pCO_2) $pH_T = -\log([H^+]_F + [HSO_4^-]) = -\log[H^+]_T$



1973

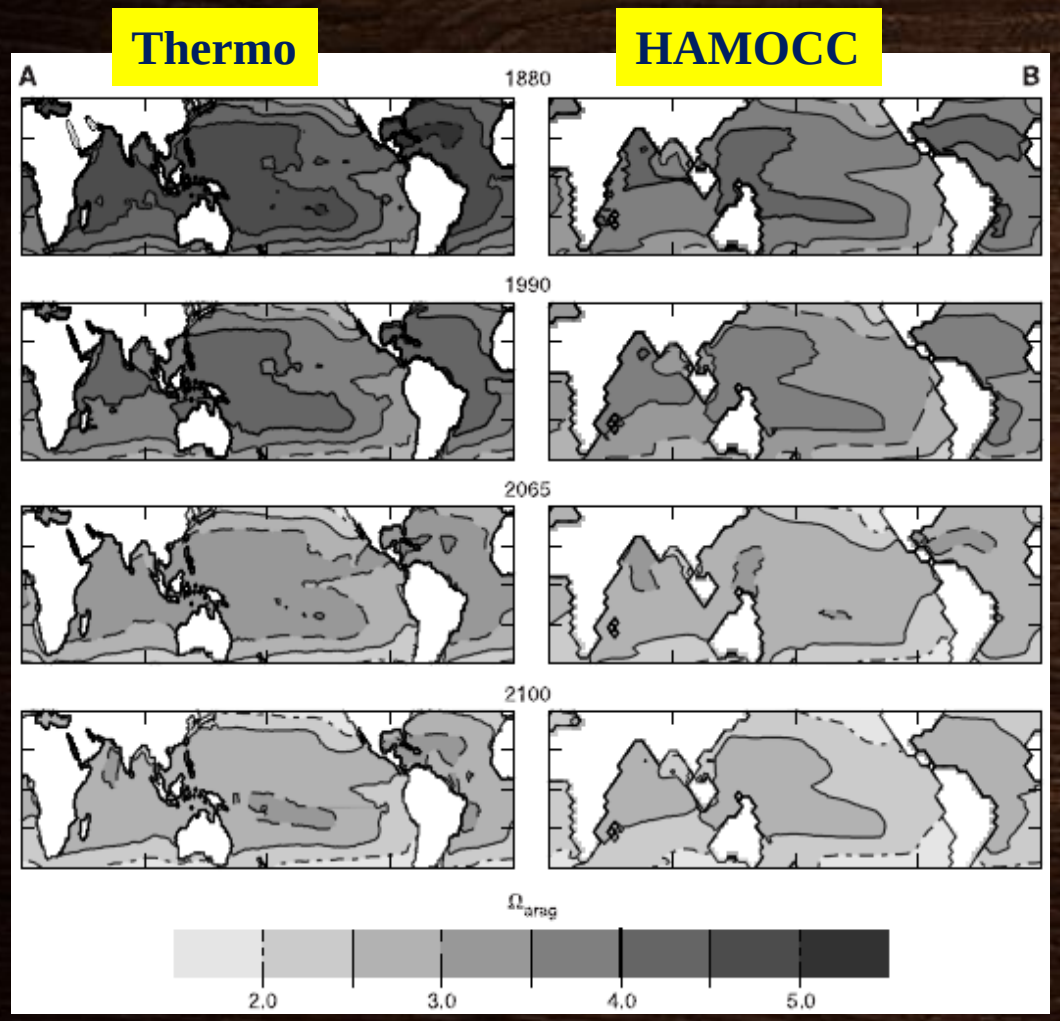
Total

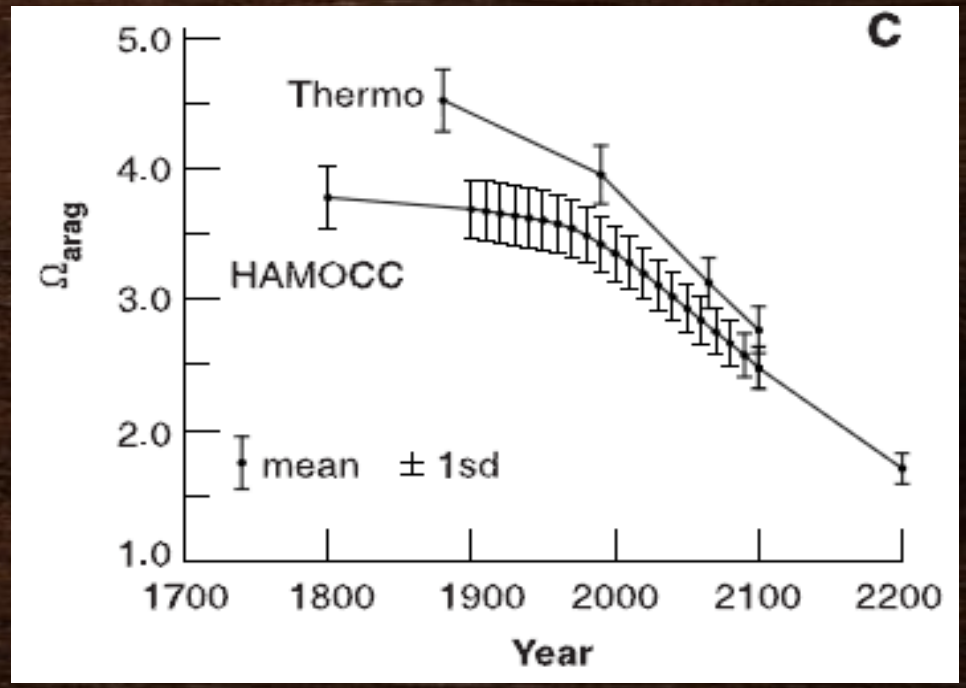
$^{2-}] +$

$^{-}] -$

1981

海洋酸化與飽和度



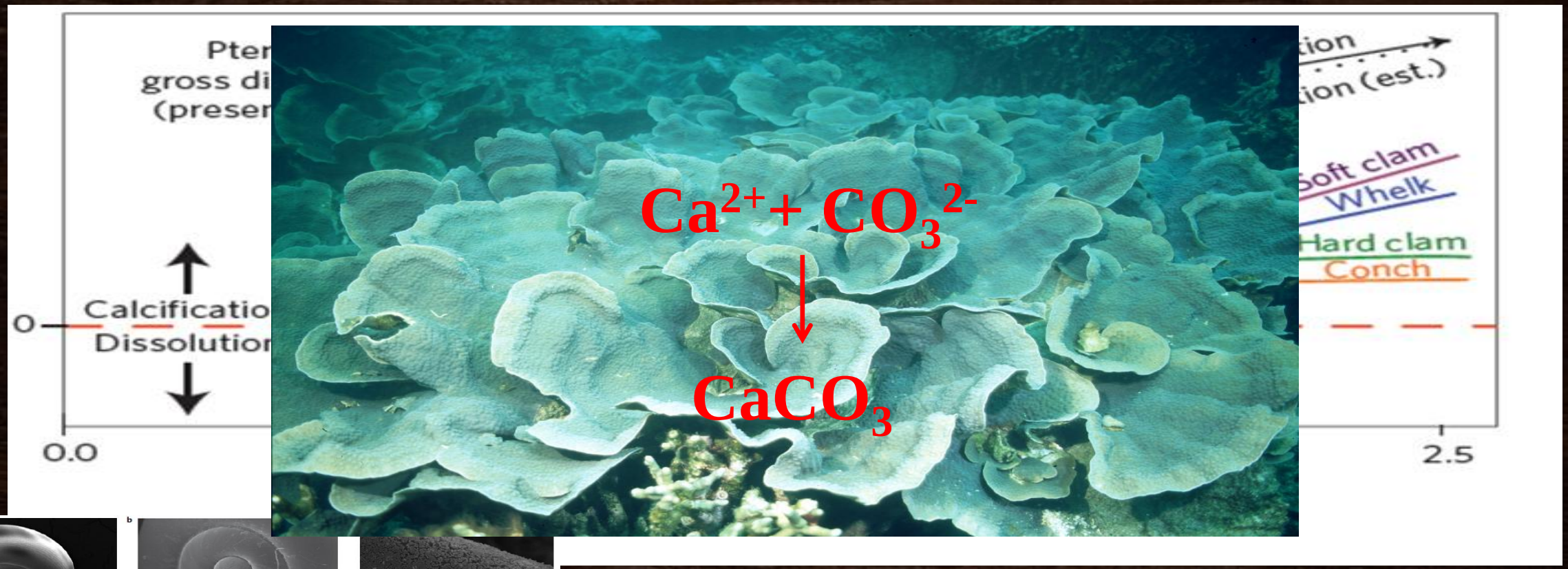


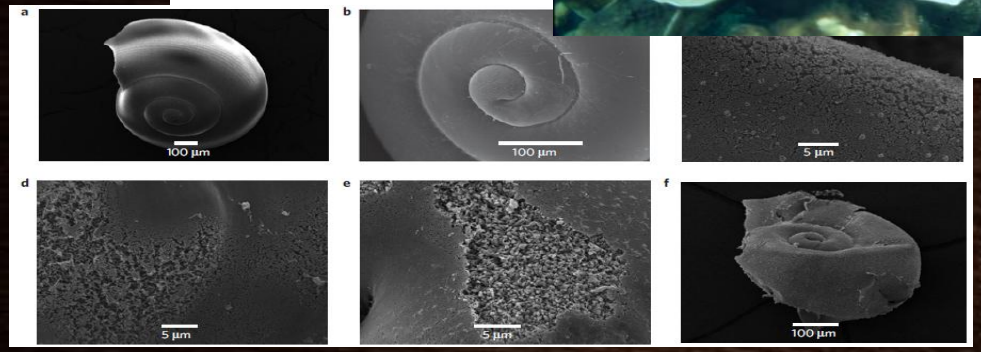
Thermo:
Constant alkalinity increased *pCO_2 atm*

HAMOCC:
Simulates response of the entire carbon system to increased *pCO_2 atm*

Kleypas et al. 1999,Science

酸化對於Shell-building organisms 的衝擊



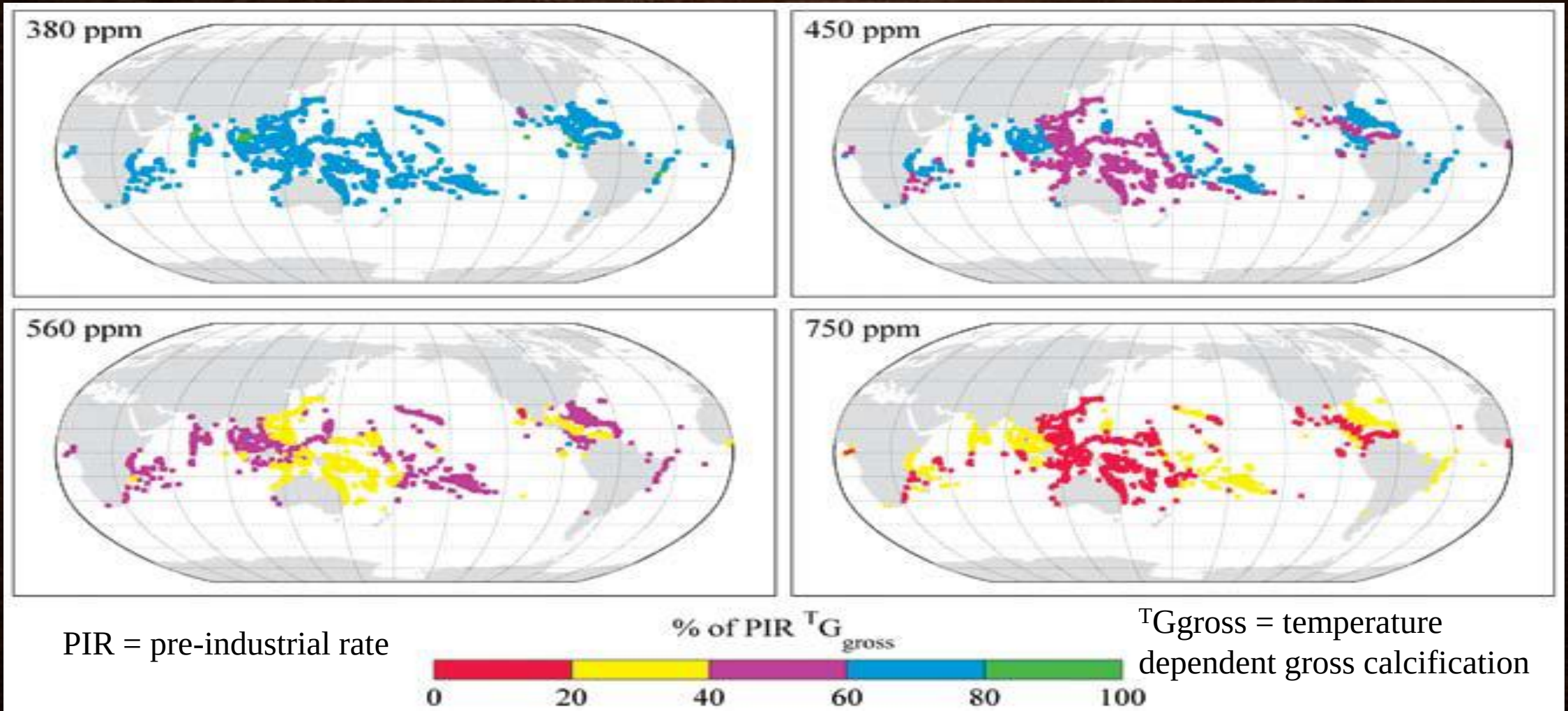


Coral reef ecosystems are especially vulnerable as their continued persistence is dependent on the deposition of $CaCO_3$ exoskeleton.

Bednarsek et al. 2012

Kleypas et al. 1999,Science

海水二氧化碳分壓與珊瑚鈣化速率



PIR = pre-industrial rate

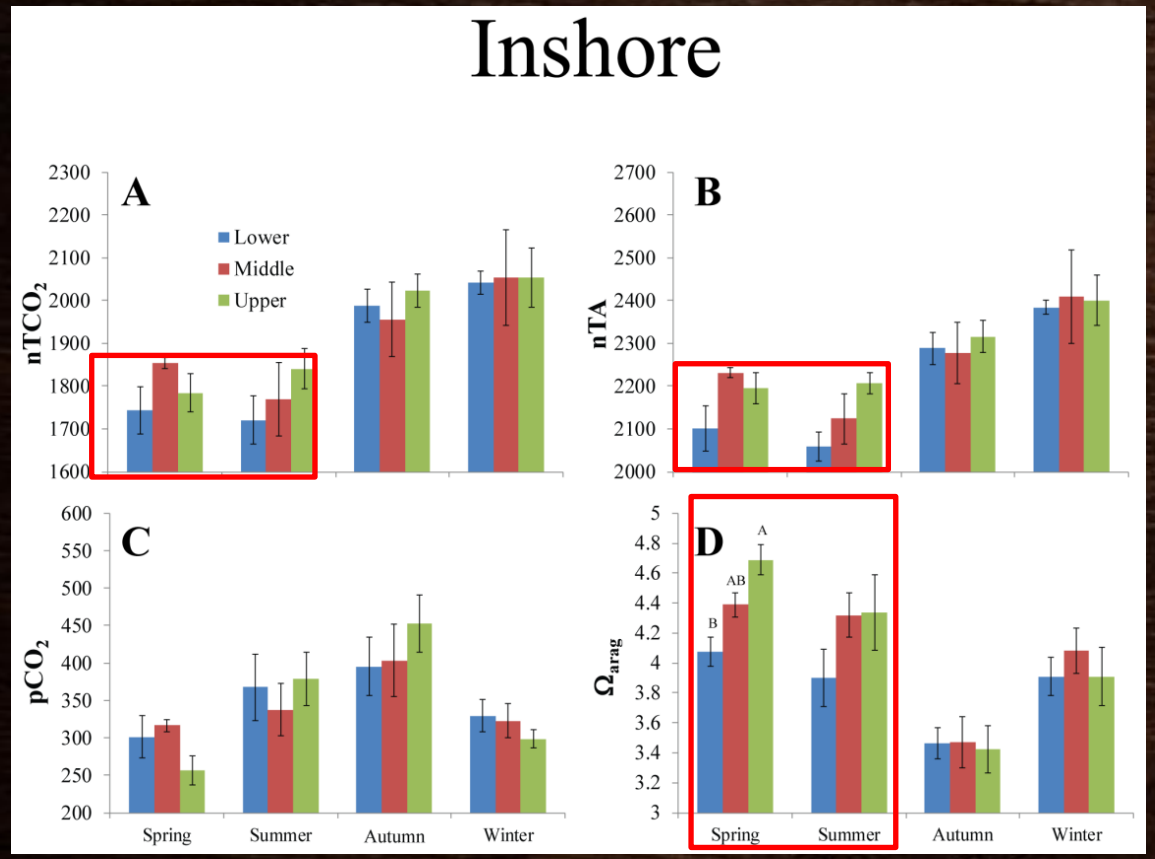
$^{T}G_{gross}$ = temperature dependent gross calcification

Calculated changes in reef building for coral reefs worldwide at four different atmospheric *pCO2 stabilization levels.*

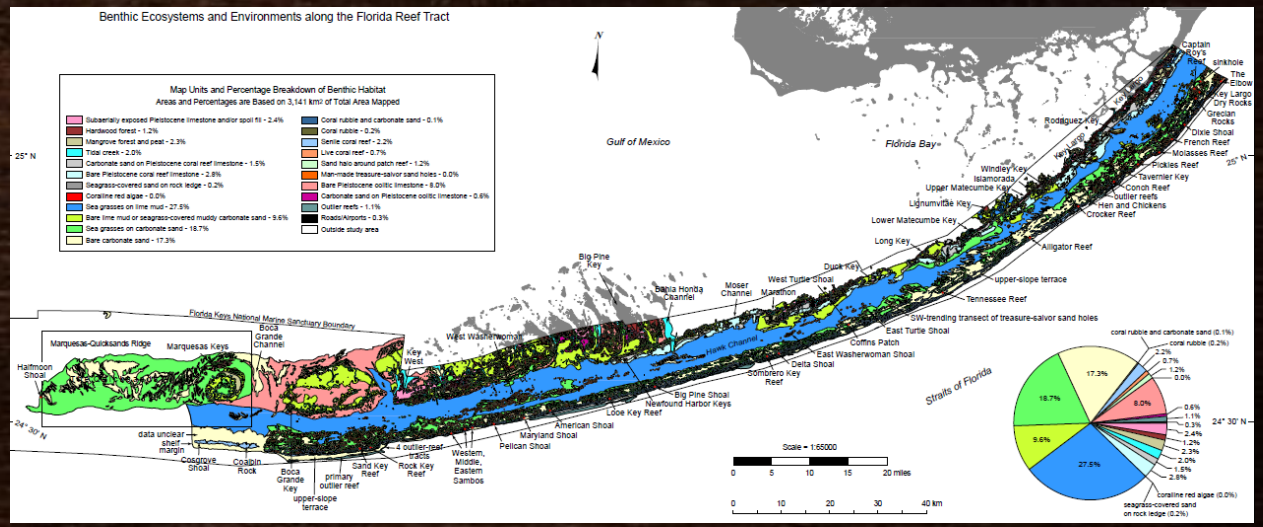
John et al. 2011

海草床與珊瑚礁系統

Manzello等人於2012年的研究指出，當海草床生長在珊瑚礁系統的附近時，此區域的海水碳酸鈣飽和值($\Omega_{aragonite}$)會上升，使得生長在此處的珊瑚對於海洋酸化有著較高的耐受性。



Manzello et al. 2012



實驗目標

東沙島沿岸海草床覆蓋率可達75%，估計其生產量為2615 g/DW/m^2/yr，為全球海草床平均的兩倍以上，是一個天然的碳匯(sink)系統，估計每年可儲存718公噸的碳。

林幸助 2010 ,東沙海域大型藻類生物量及海草物候、生產力調查

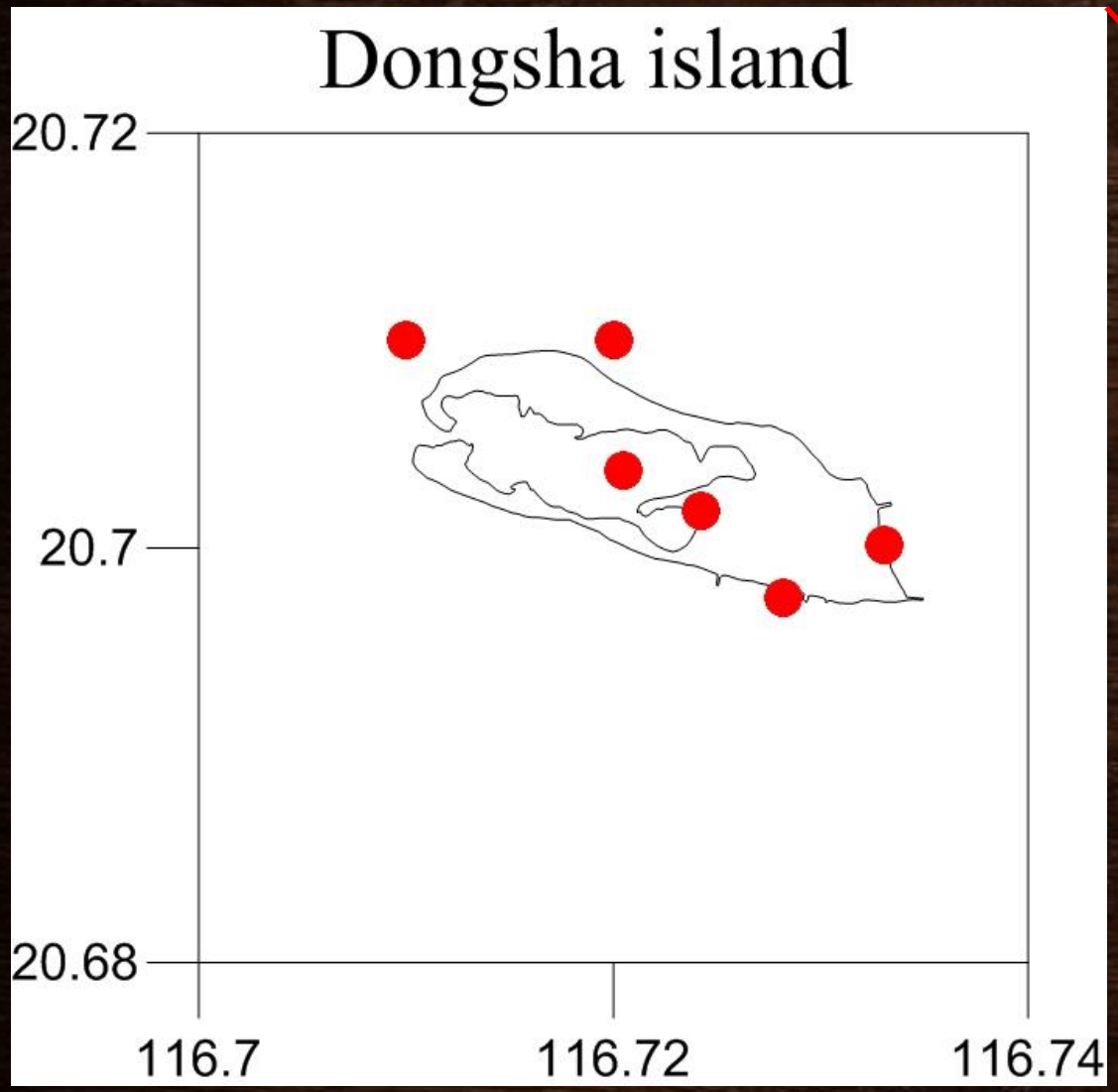
東沙擁有大量的海草床與珊瑚礁系統，其環境與Manzello等人所述的環境類似卻又較為複雜。有鑑於國內對於珊瑚礁系統的二氧化碳參數較少有系統的調查，故欲於東沙進行大規模的空間調查。

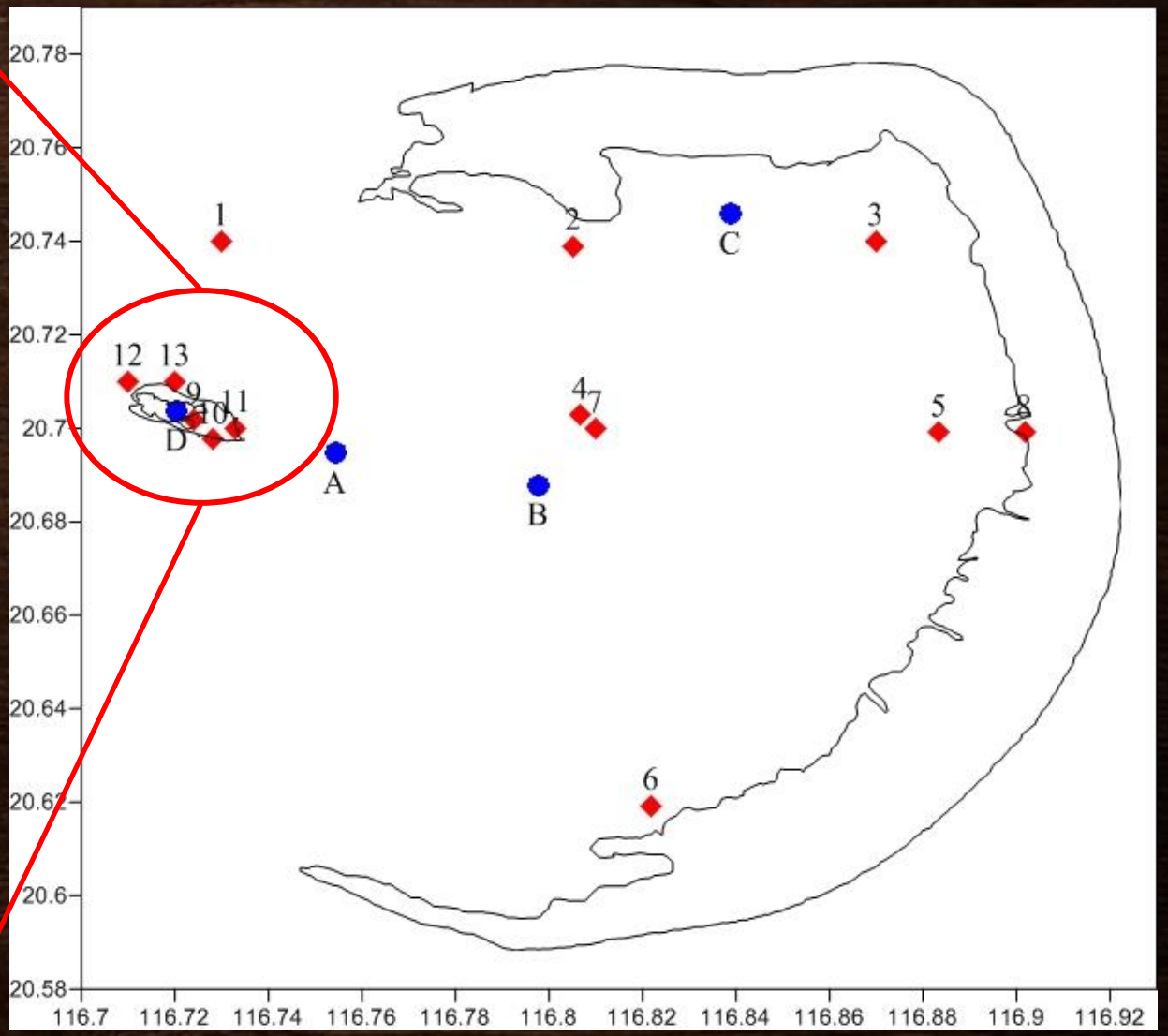
東沙採樣工作

- 於小潟湖岸邊白天每兩小時進行採水，以瞭解日夜變化對其水文參數之影響

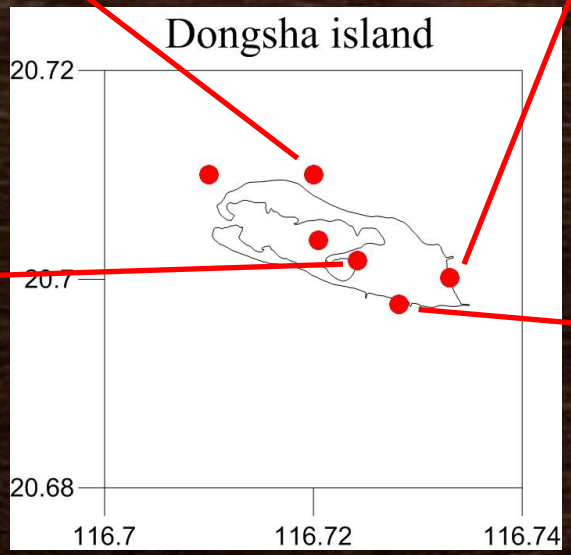
- 於環礁潟湖進行樣水採集，以進行空間分布調查

採水樣區圖

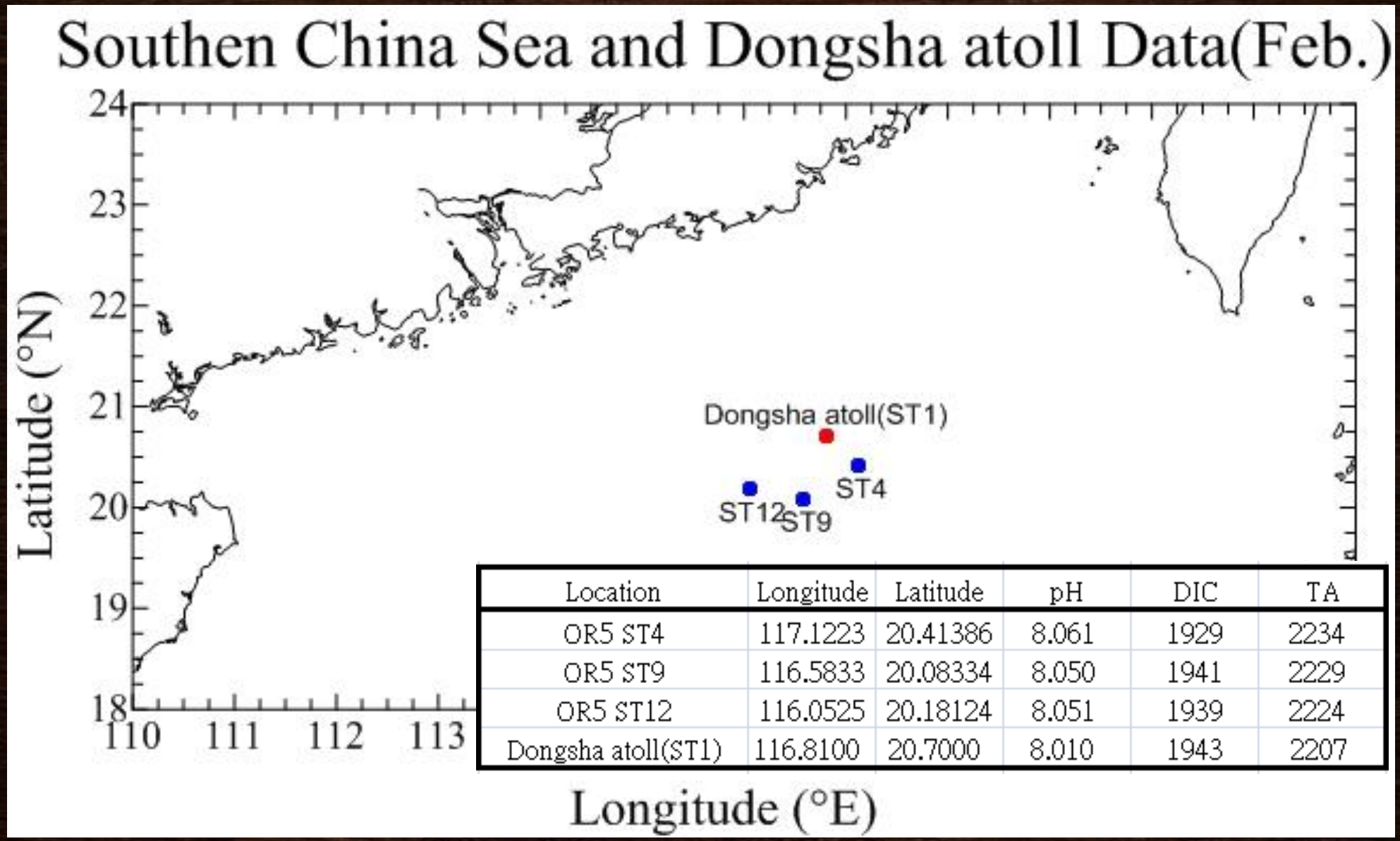

Dongsha island
20.72
20.7
20.68
116.7
116.72
116.74


20.78
20.76
20.74
20.72
20.7
20.68
20.66
20.64
20.62
20.6
20.58
116.7
116.72
116.74
116.76
116.78
116.8
116.82
116.84
116.86
116.88
116.9
116.92
1
2
3
4
5
6
7
8
9
10
11
12
13
A
B
C
D

東沙島周遭樣區

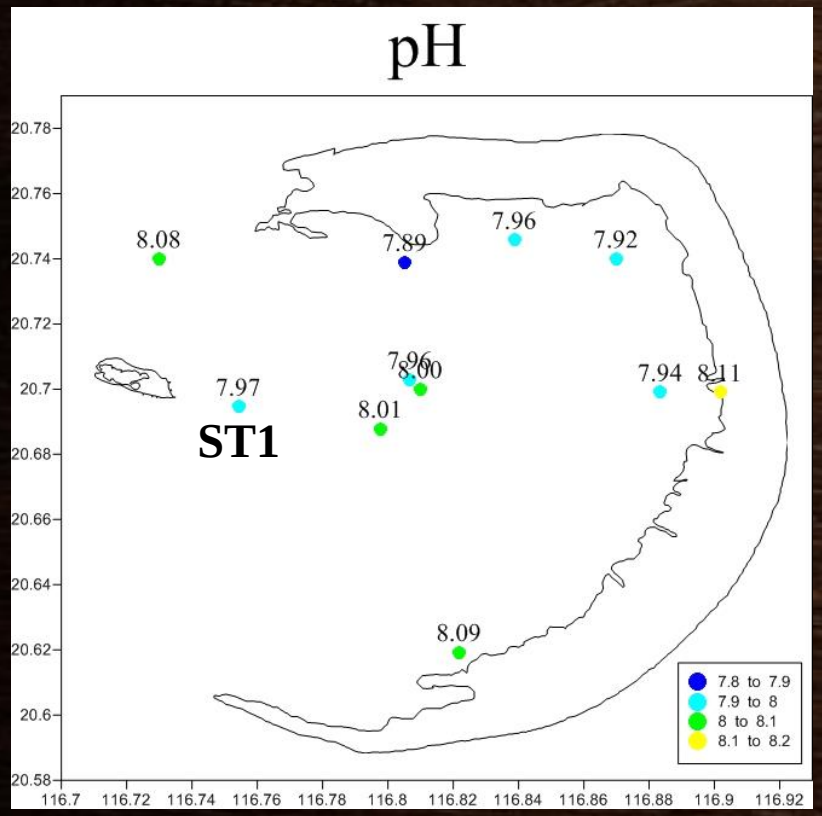


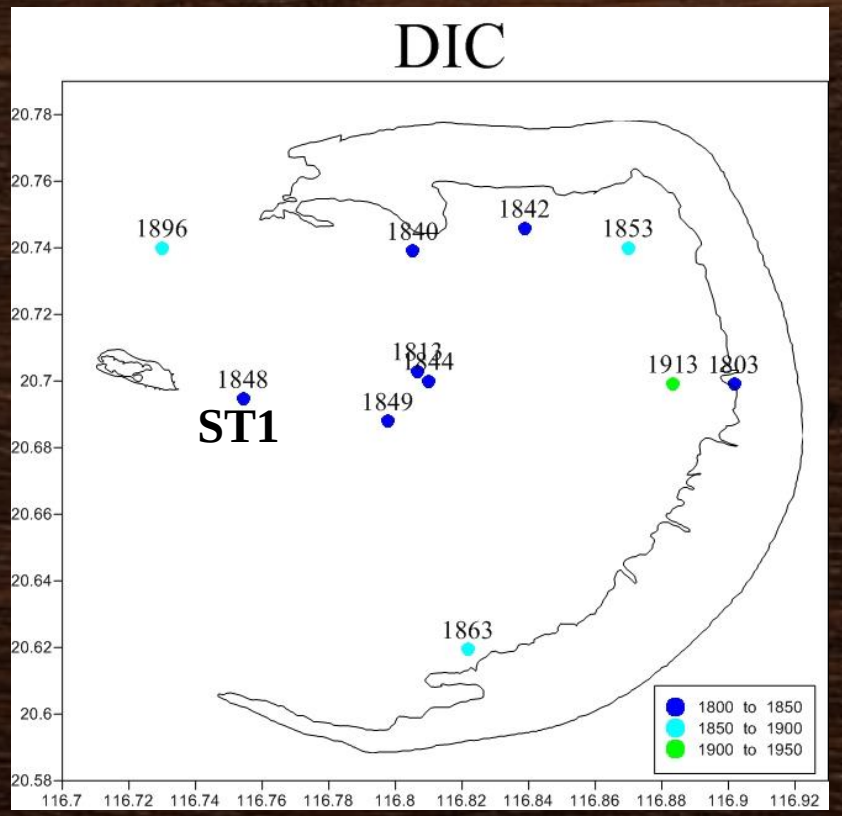
南海及東沙碳化學參數比較

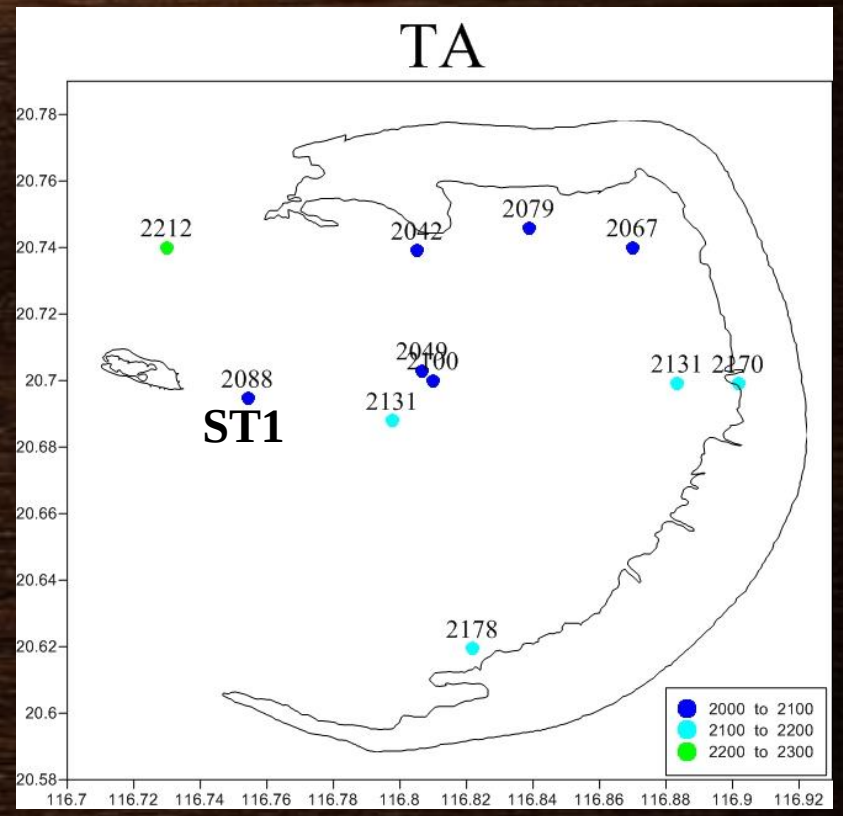


Location	Longitude	Latitude	pH	DIC	TA
OR5 ST4	117.1223	20.41386	8.061	1929	2234
OR5 ST9	116.5833	20.08334	8.050	1941	2229
OR5 ST12	116.0525	20.18124	8.051	1939	2224
Dongsha atoll(ST1)	116.8100	20.7000	8.010	1943	2207

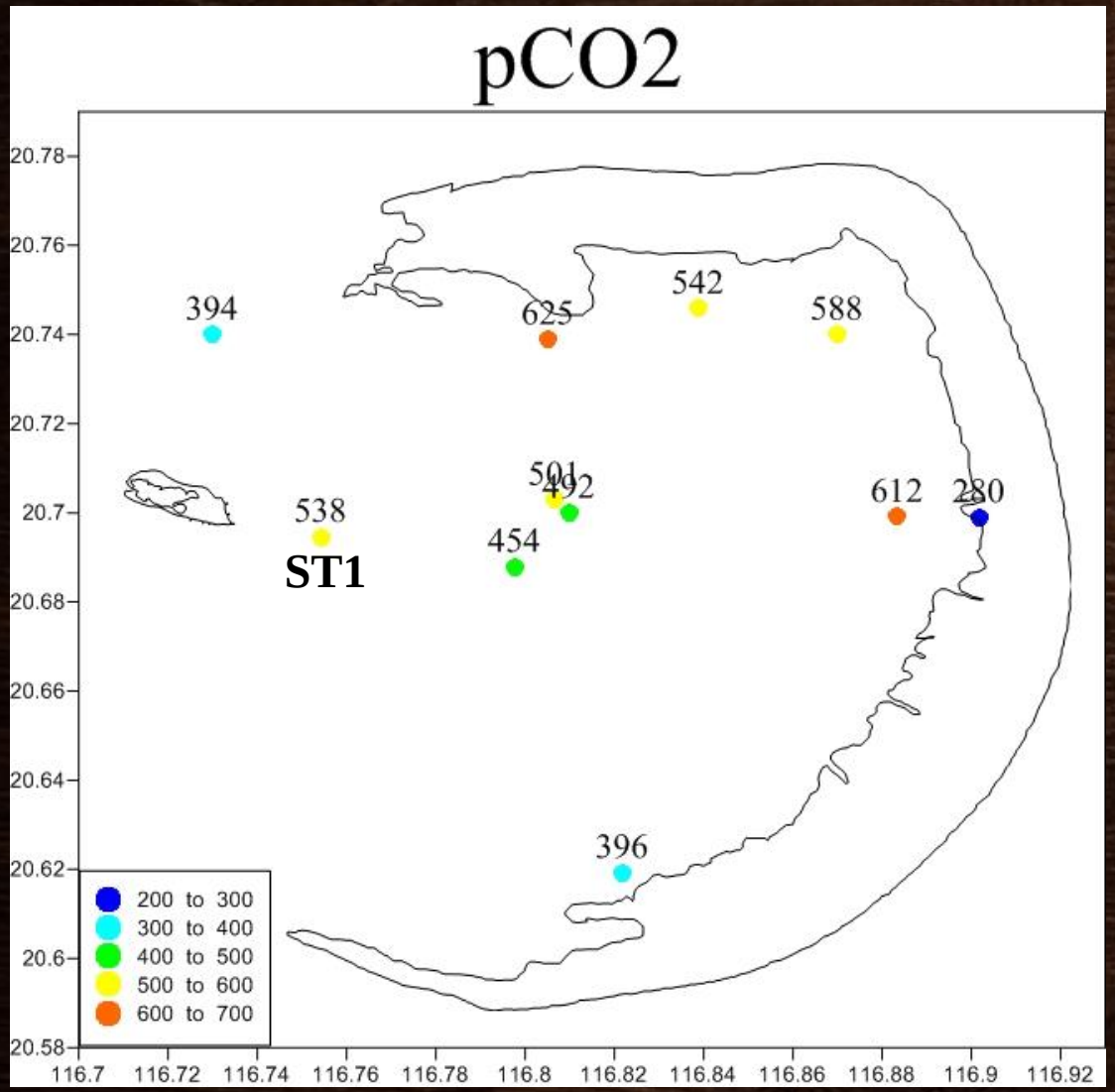
東沙環礁潟湖pH、DIC、TA空間分布圖

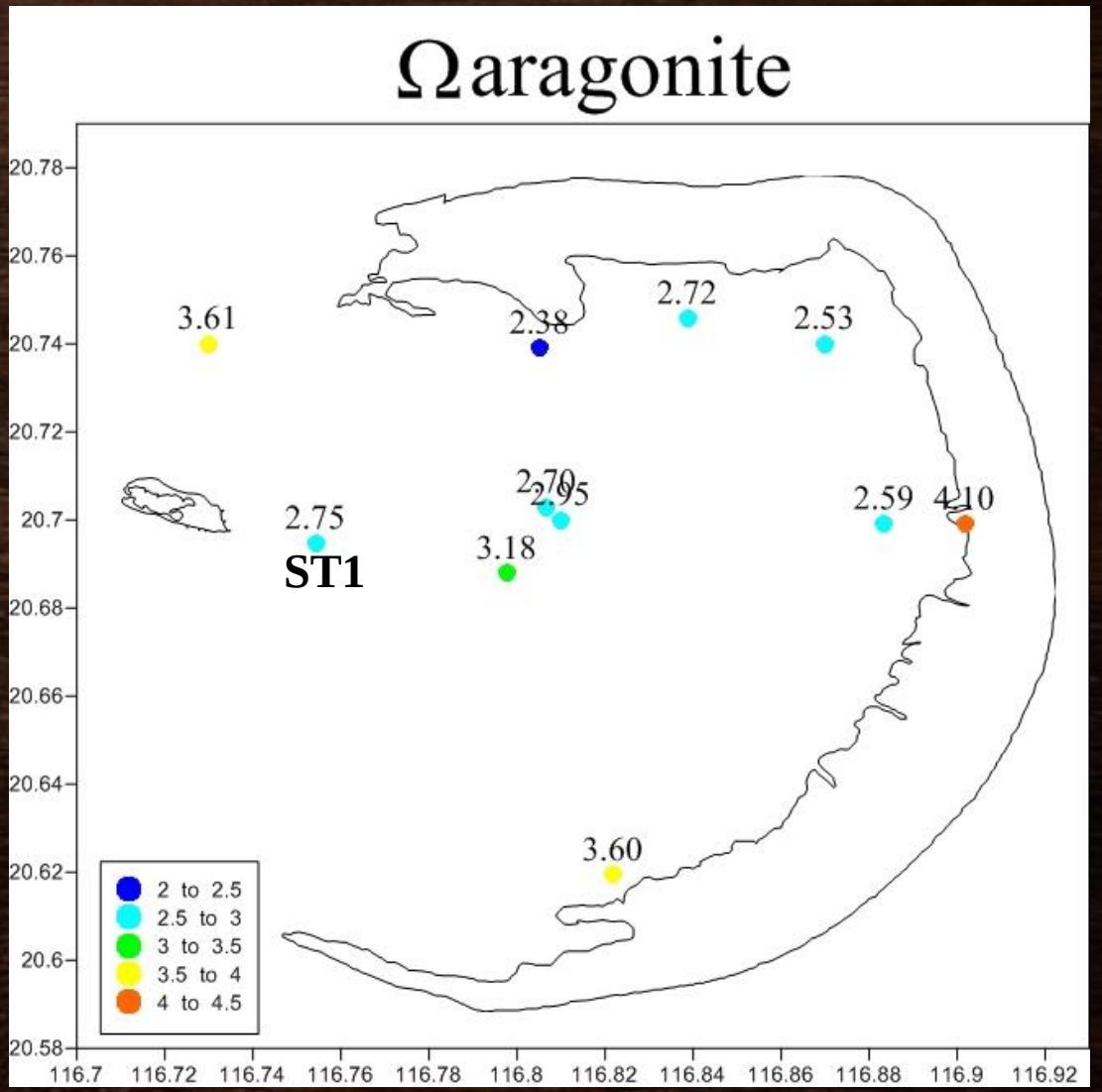






東沙環礁潟湖pCO2、Ω_{ara}空間分布圖



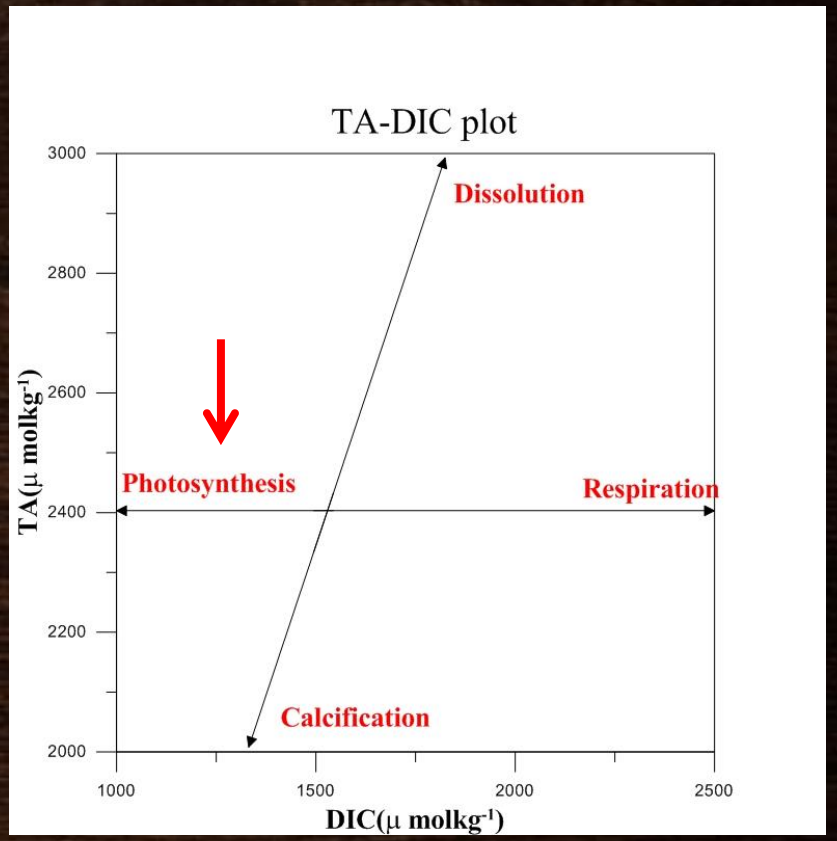


光合作用與TA、DIC之關係變化

Photosynthesis $6CO_2 + 12H_2O \longrightarrow C_6H_{12}O_6 + 6H_2O + 6O_2$

$DIC = [CO_2^*] + [HCO_3^-] + [CO_3^{2-}]$

$TA = [HCO_3^-] + 2[CO_3^{2-}] + [B(OH)_4^-] + [OH^-] + [HPO_4^{2-}] + 2[PO_4^{3-}] + [SiO(OH)_3^-] + [NH_3] + [HS^-] - [H^+]_F - [HSO_4^-] - [HF] - [H_3PO_4]$



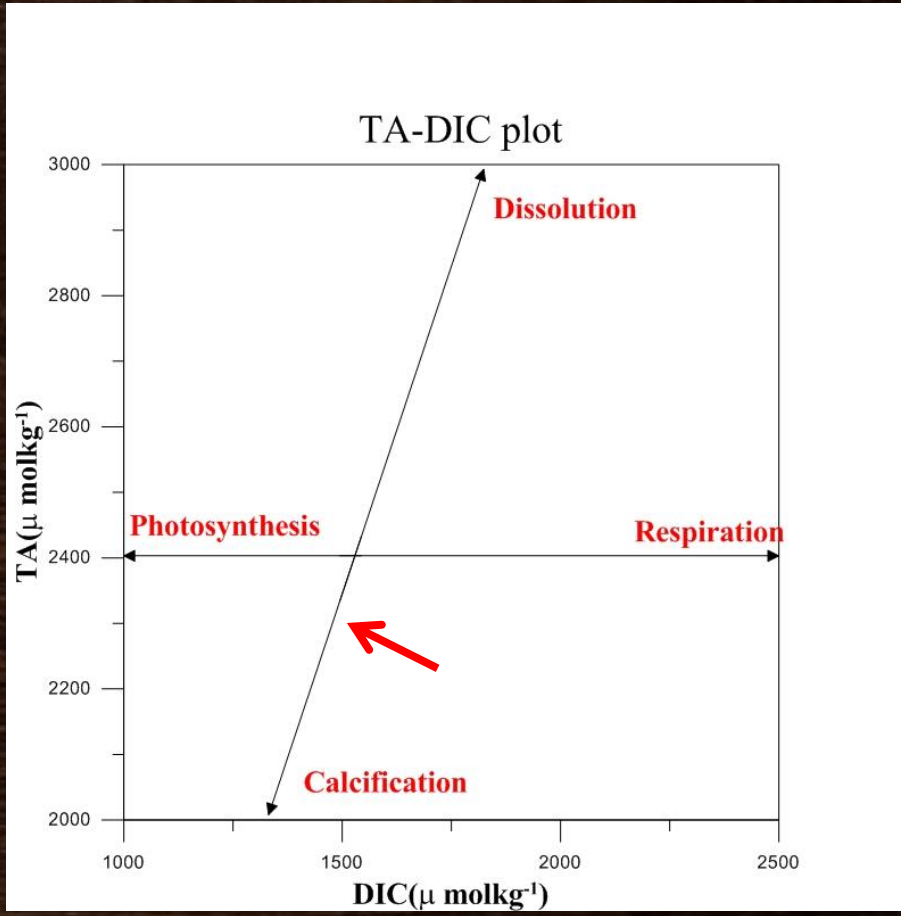
Gattuso et al., 1993

鈣化作用與TA、DIC之關係變化

Calcification: $Ca^{2+} + CO_3^{2-} \rightarrow CaCO_3$

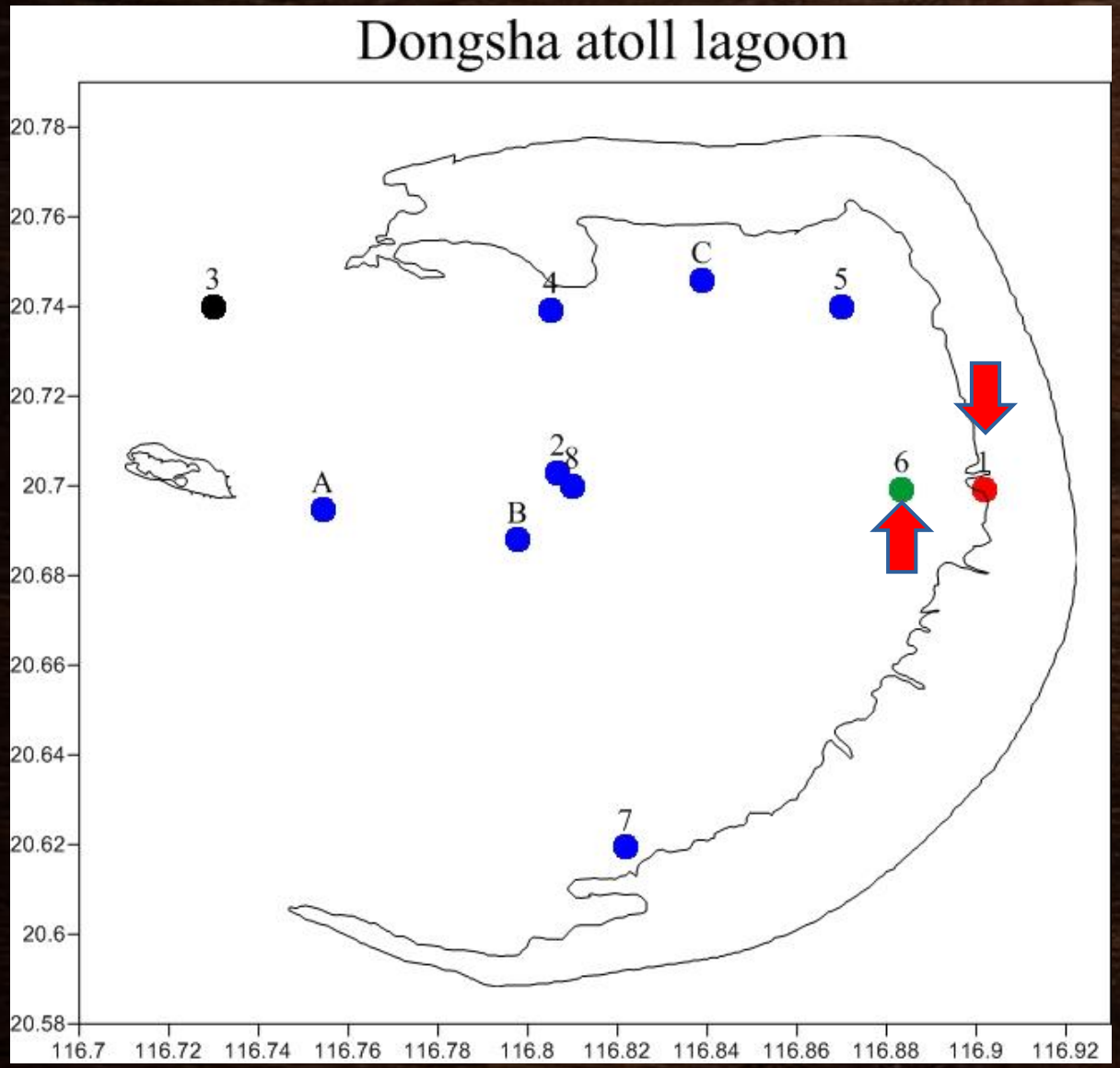
$$DIC = [CO_2^*] + [HCO_3^-] + [CO_3^{2-}]$$

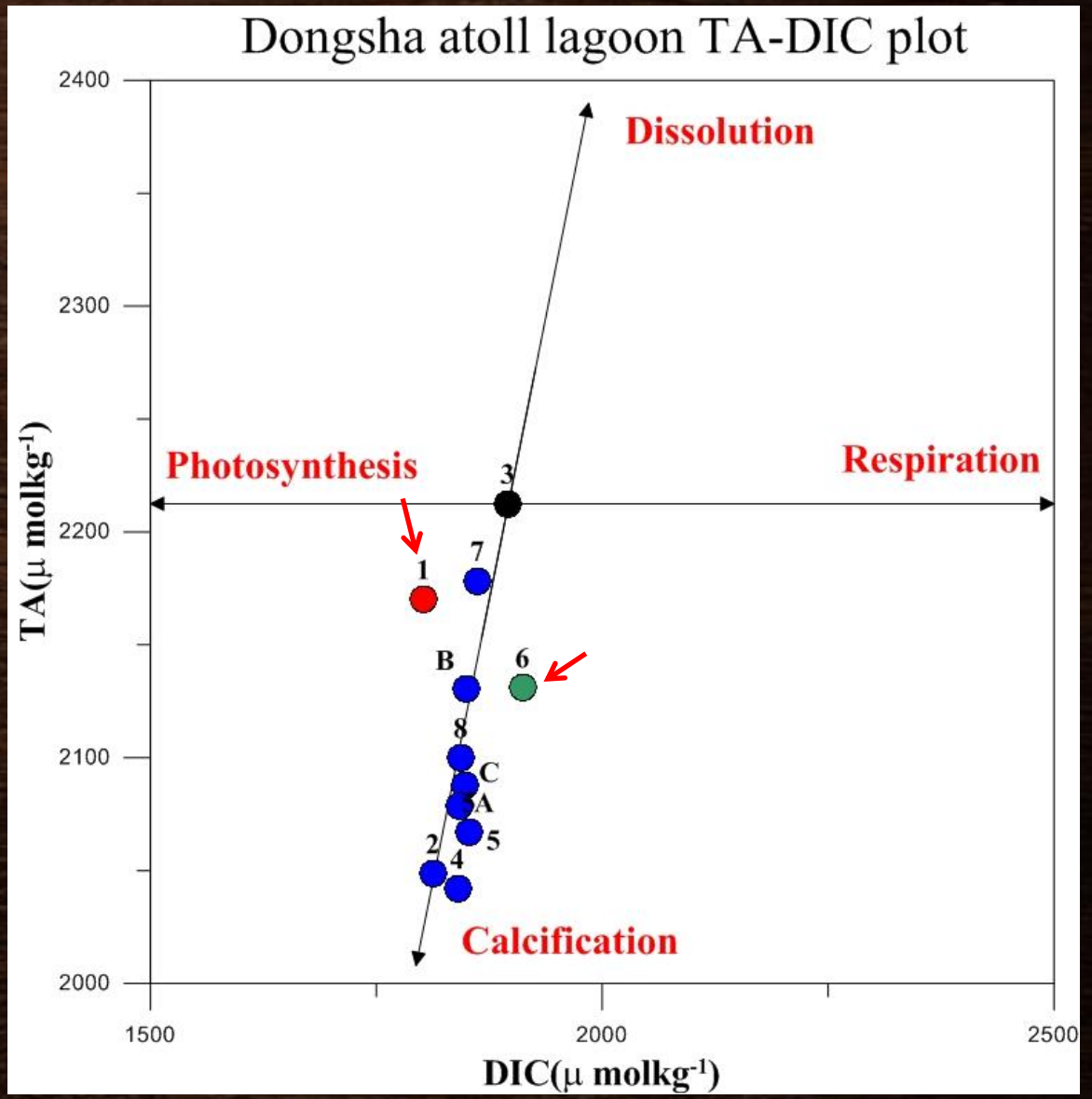
$$TA = [HCO_3^-] + 2[CO_3^{2-}] + [B(OH)_4^-] + [OH^-] + [HPO_4^{2-}] + 2[PO_4^{3-}] + [SiO(OH)_3^-] + [NH_3] + [HS^-] - [H^+]_F - [HSO_4^-] - [HF] - [H_3PO_4]$$



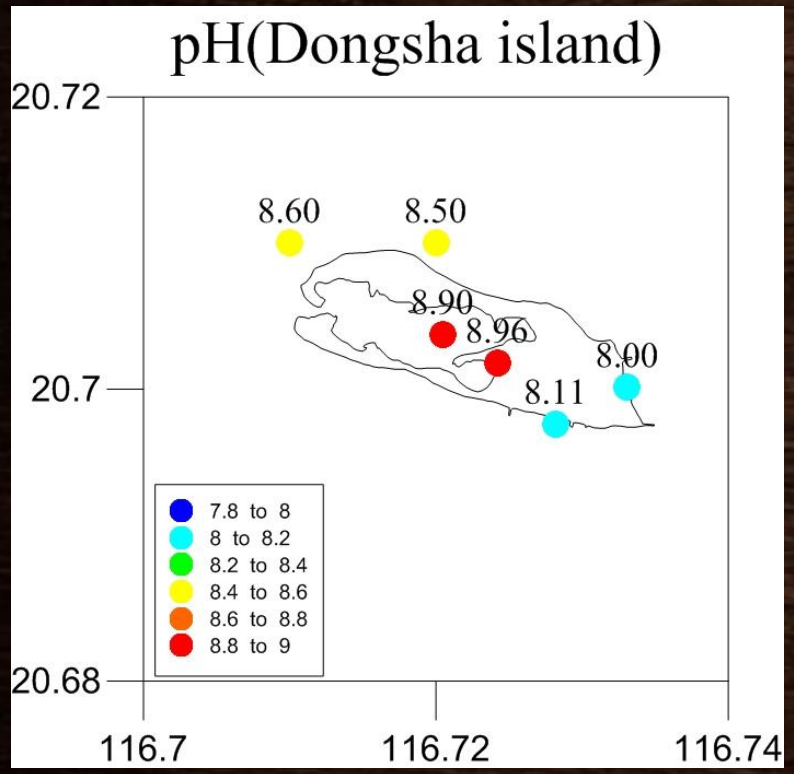
Gattuso et al., 1993

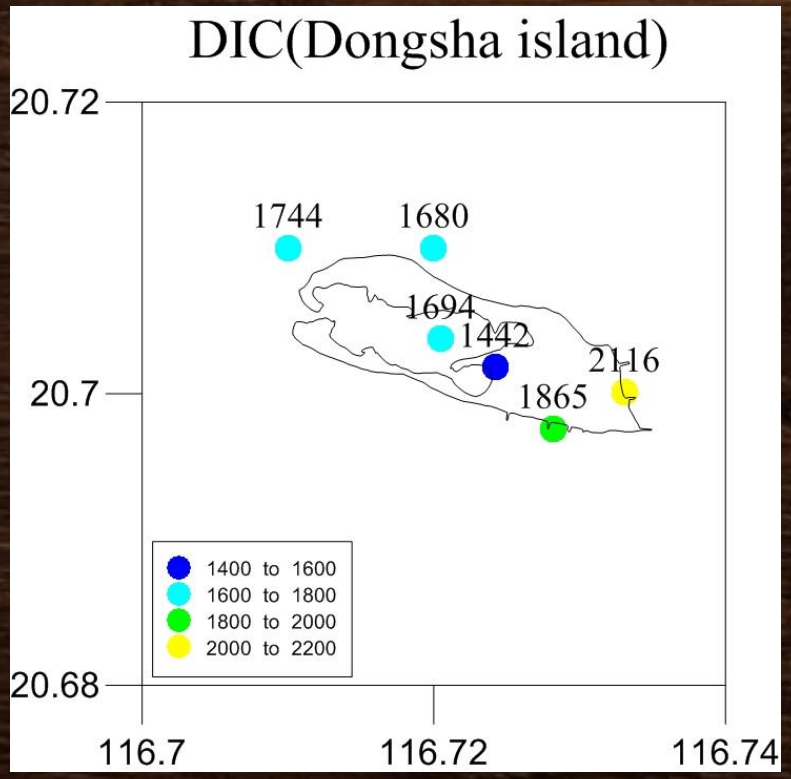
東沙環礁潟湖TA-DIC plot圖

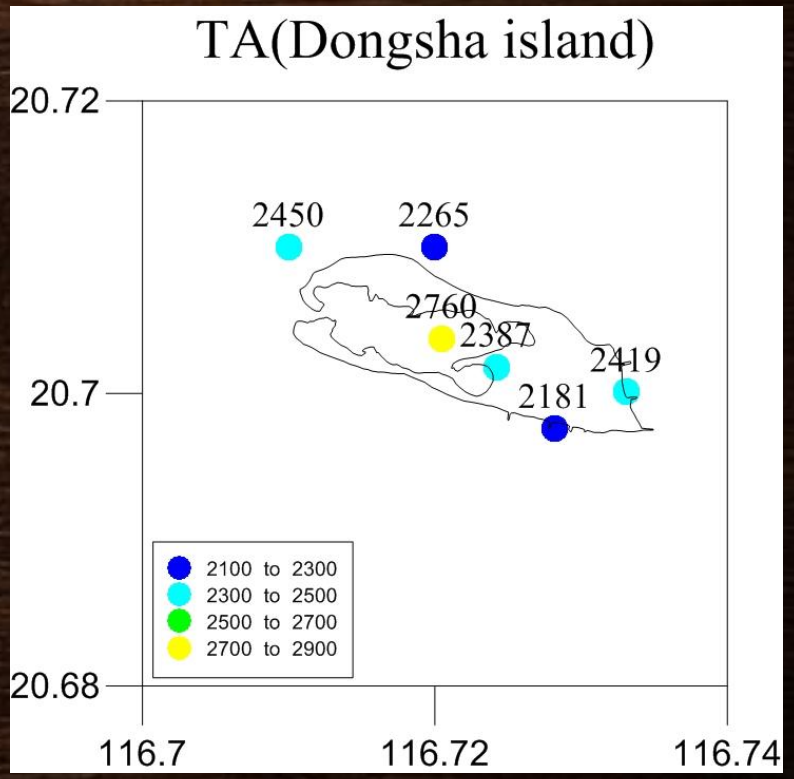




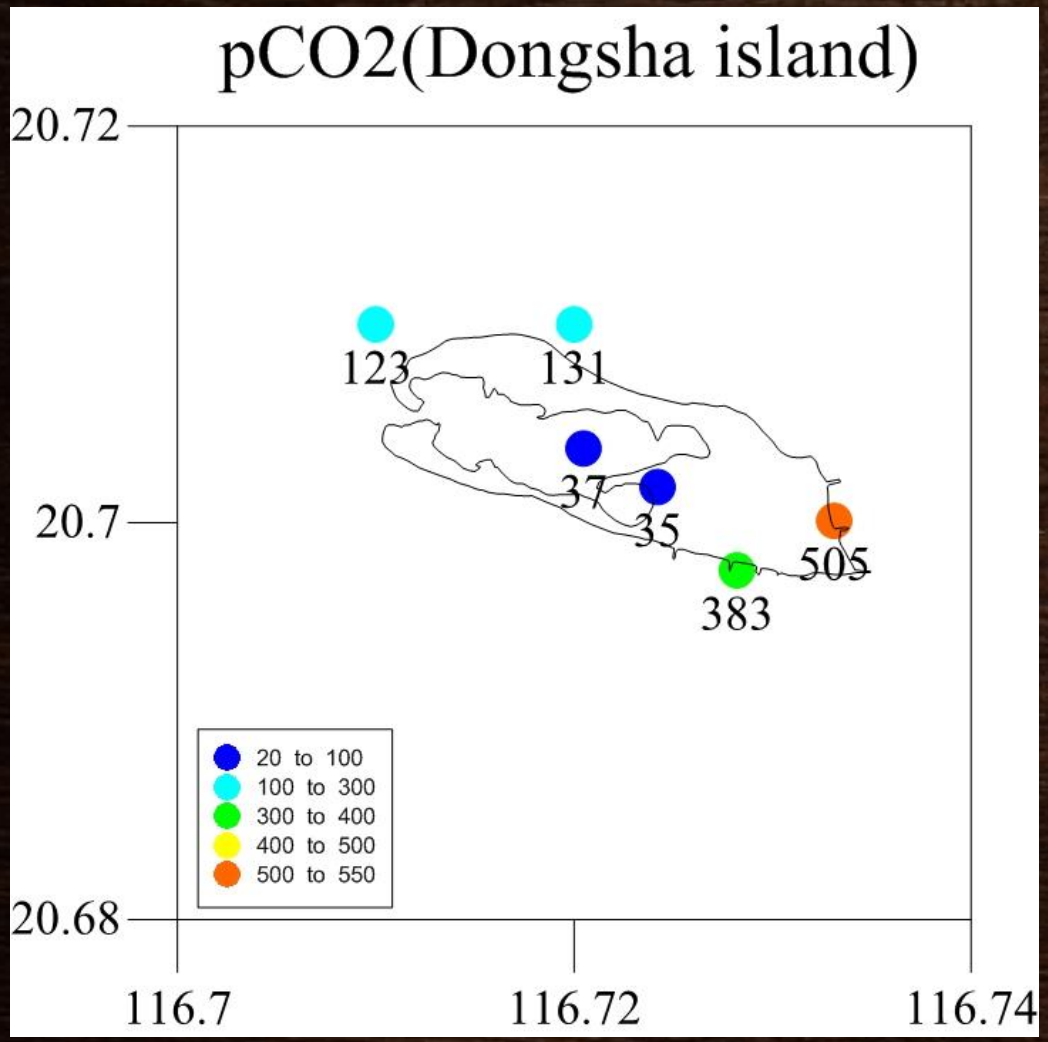
東沙島邊pH、DIC、TA空間分布圖

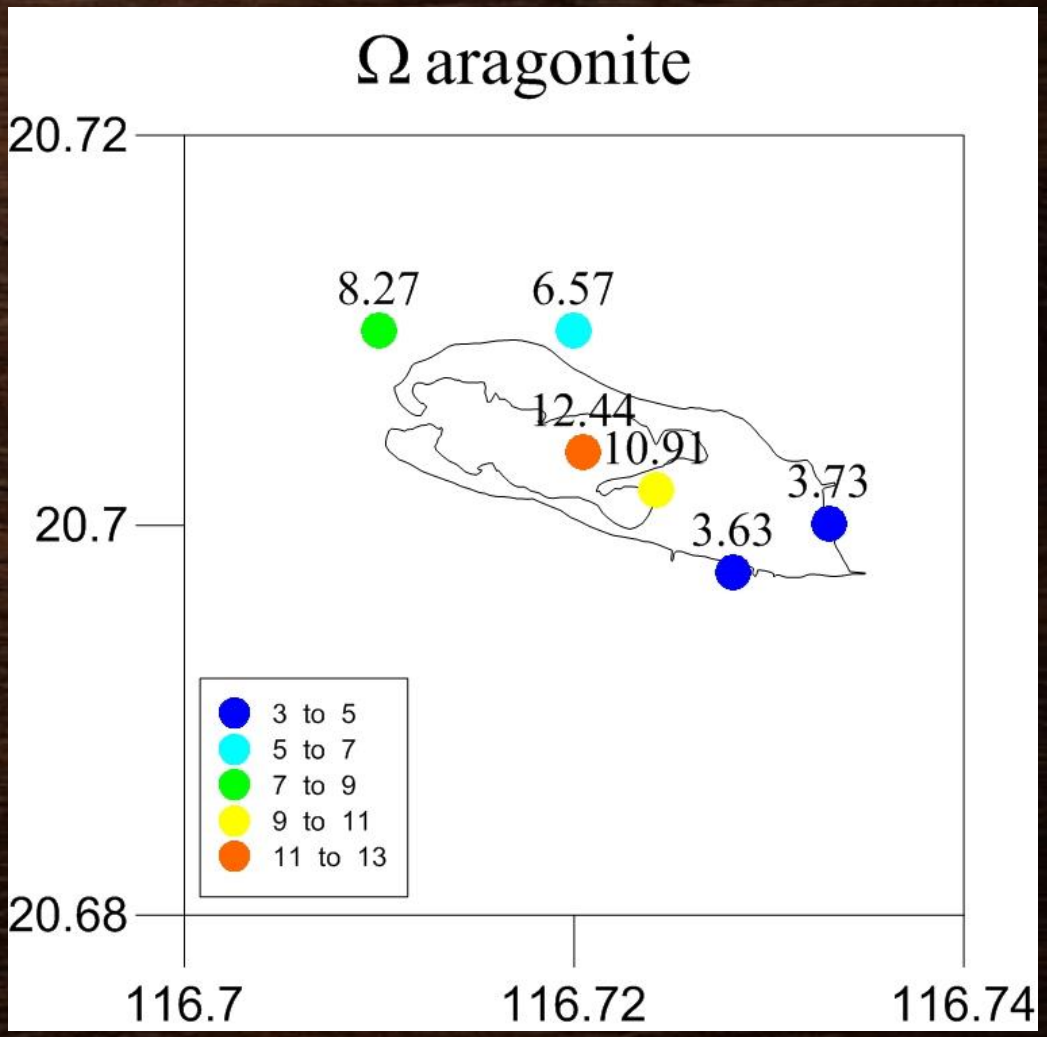






東沙島邊pCO2、Ω_{ara}空間分布圖





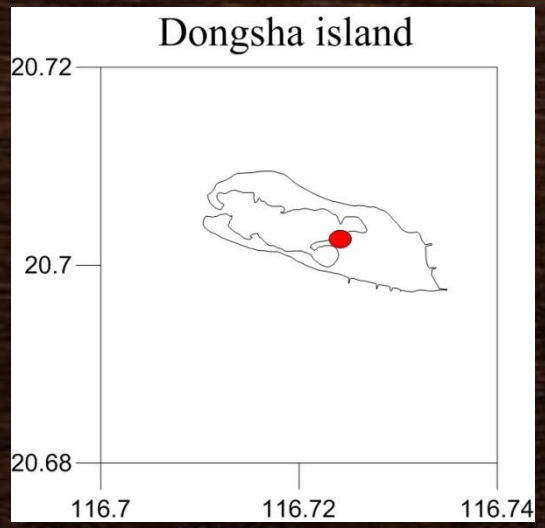
東沙島小潟湖岸邊日夜實測值

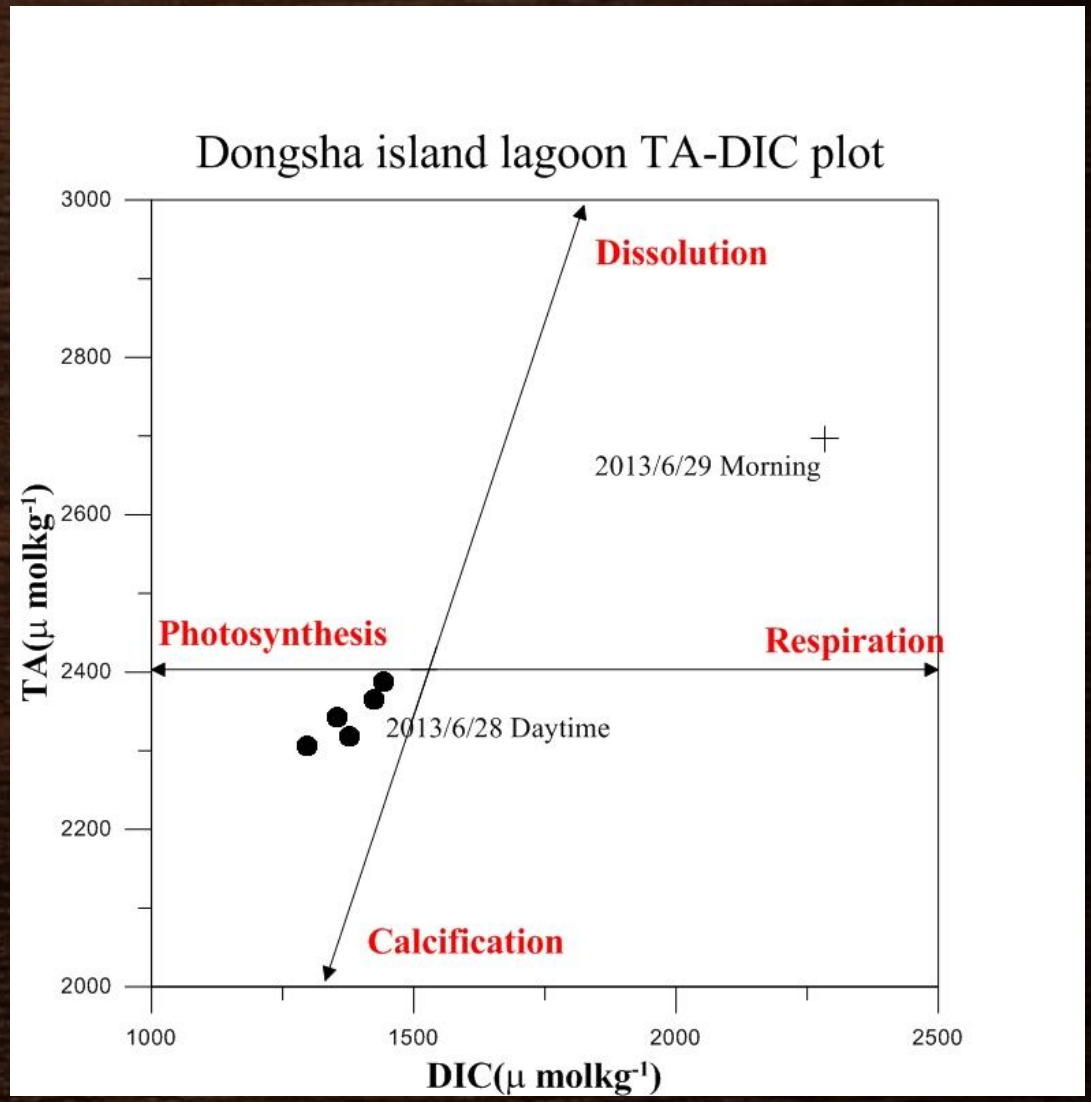
小潟湖內日夜	Time	Longitude	Latitude	Salinity	Ttemperature	pH	DIC	TA
ST4	2013/6/28 11:00	116.7242	20.7018	30.36	33.2	8.95739	1442	2387
ST4	2013/6/28 13:00	116.7242	20.7018	29.35	34.4	8.92331	1425	2365
ST4	2013/6/28 15:00	116.7242	20.7018	29.42	36.6	8.97607	1354	2343
ST4	2013/6/28 17:00	116.7242	20.7018	29.49	36.4	9.06362	1296	2307
ST4	2013/6/28 19:00	116.7242	20.7018	29.63	34.1	8.94678	1377	2319
ST4	2013/6/29 07:00	116.7242	20.7018	29.56	29.6	8.22383	2283	2697

Normalize:

Salinity 29.63 PSU

Temperature 25 ◦ C





東沙島樣區海草相關研究

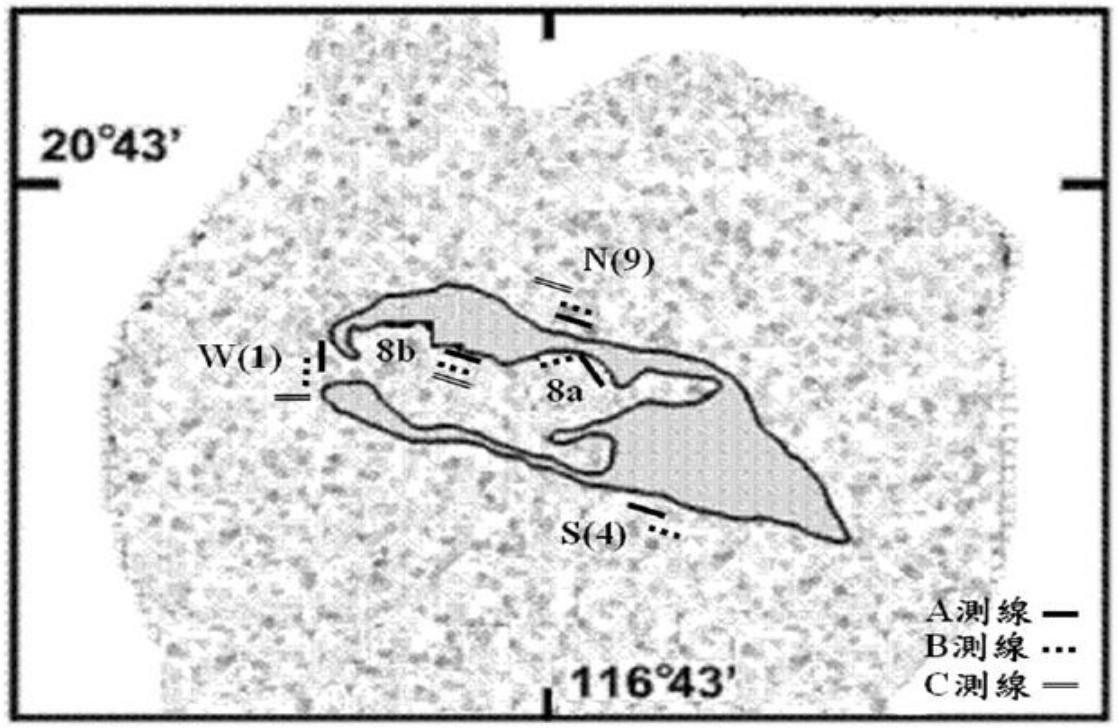


圖 2-1. 本計畫之 5 個樣區位置圖，分別爲北岸(N(9))、南岸(S(4))、西岸(W(1))、小潟湖內部(8a)與小潟湖外部(8b)，以 Lin et al. (2005)之樣區編號爲基礎設定。

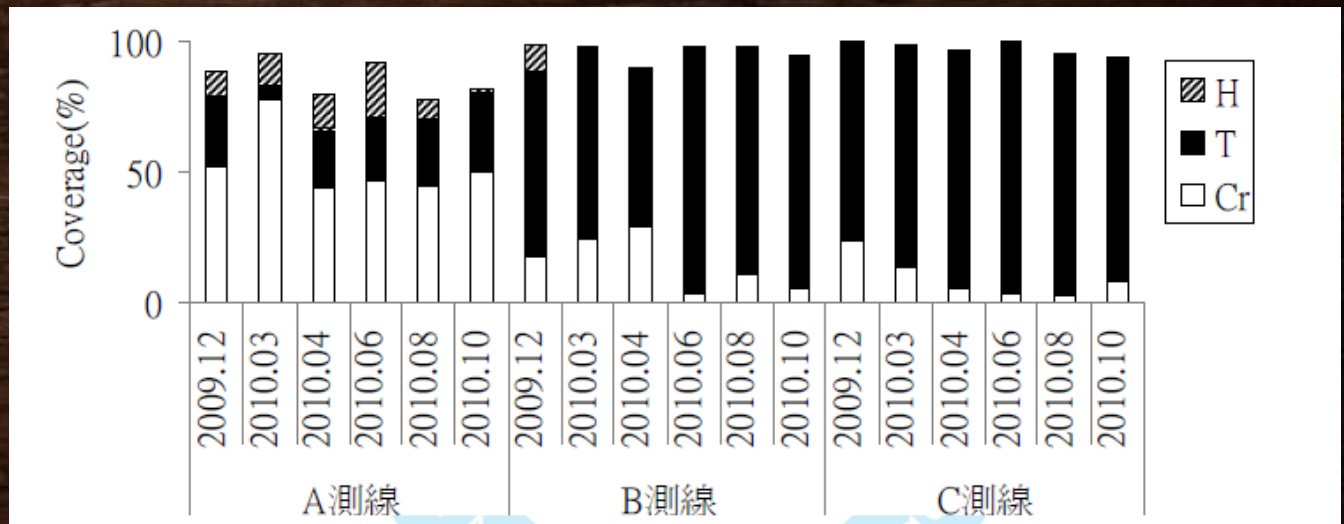


圖 3-28. 小潟湖外部各測線海草覆蓋度變化。**Cr**：圓葉水絲草；**H**：單脈二藥草；**T**：泰來草。

所有樣區海草平均覆蓋度都在75%以上，其中小潟湖外的海草覆蓋度之年平均高達93.25%，其優勢組成為泰來草。其次為西岸和北岸，分別為81.94到81.1%，其優勢組成為圓葉水絲草。

林幸助 等 2010

東沙與全球珊瑚礁系統參數比較

Reference	Study site	pH value	pCO2(matm)	Ωara
Kayanne et al.2005	Japan, Ishigaki(石垣) and Palau(帛琉) Island	7.9-8.4(NBS scale)	280-400	—
Gray et al.2012	Puerto Rico(波多黎各), Media Luna reef	7.89-8.17(total scale)	176-613	2.7-4.7
Manzello et al.2012	America,Florida Reef Tract	—	257-452	3.4-4.7
Santos et al.2011	Australia,Great Barrier Reef	7.7-8.4(total scale)	—	—
本研究	東沙Station 4測站(夏季)	8.22-9.06(total)	24-90	5.2-11.5


THANKS FOR YOUR ATTENTION !