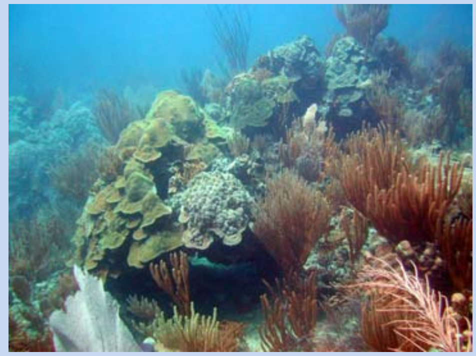
A couple points from last week

Montastrea
M.annularis complex (3 spp)
M. cavernosa

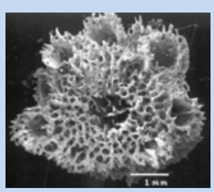


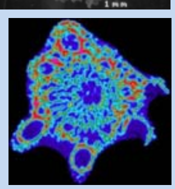
Curacao (image http://educationabroad.global.usf.edu/ index.cfm?FuseAction=programs.ViewProgram&Program_ID=23078

Porites lobata

Acropora spp. "The Protean Genus" (Wells)

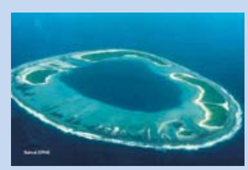
Acropora tidbit from last week

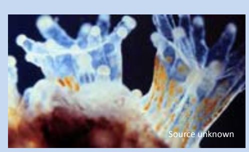




Acropora branch in cross-section
SEM and tomography (Advanced
Aquarist's online magazine

Nutrient uptake, eutrophication and coral-algal interactions





Nutrient uptake, eutrophication and coral-algal interactions

Examples of ambient seawater concentrations:

Orpheus Island, Australia 0.1 μM NH_4^+, 0.08 μM PO_4^{3-}
(Jompa and McCook 2002)

Kaneohe Bay, Hawaii (1989-1992) 0.21 μM DIN, 0.04 μM SRP
(Laws and Allen 1996)

ENCORE control patch reefs (One Tree Island, Australia)
~4 μM DIN, 0.2 μM PO_4^{3-}
(Koop et al 2001)

Waikiki Aquarium NO_3 5 μM; NH_4 2 μM, PO_4 0.6 μM
(Atkinson et al. 1995)

Proposed threshold: 1 uM DIN; 0.1 uM SRP (Bell 1992 Water Res 26:553-68; Lapointe 1997. L&O 42:1119-31).
Above which, predicted rapid phase shift to macroalgae.

Relative Dominance Model

Littler MM and Littler DS. 1984. Models of tropical reef biogenesis: the contribution of algae. Progress in Phycological Research 3: 323-364

Two important factors that mediate coral-algal interactions are nutrients and herbivory.

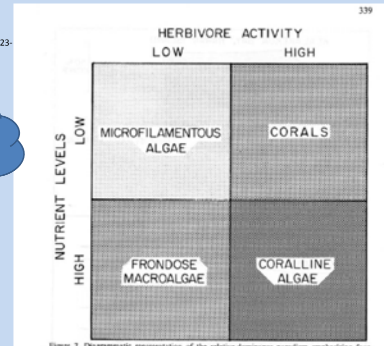


Figure 7. Diagrammatic representation of the relative-dominance paradigm emphasizing four potentially predominant space-occupying groups of sessile reef organisms as a function of long-term nutrient levels and herbivore activity. The latter is considered the more important direct controller of standing stocks on undisturbed reefs.

Case Study: Kaneohe Bay, Hawaii

Reduced coral cover and overgrowth by *Dictyosphaeria cavernosa* reported early 1970s (may have begun earlier).

Attributed to release of nutrient-rich sewage into the bay. ~75% of N & P input.

Sewage diverted offshore 1977-8 (South Bay and 1986 (North Bay).

Coral cover increased, water quality improved, macroalgae decreased. Used as an example of reef recovery.

Stimson et al. 2001. Coral Reefs 19: 343-57.

Dictyosphaeria cavernosa

Photos: University of Hawaii Botany Department

Kaneohe Bay, Hawaii (1989-1992) 0.21 uM DIN, 0.04 uM SRP
(Laws and Allen 1996)

ENCORE control patch reefs (One Tree Island, Australia)
~4 uM DIN, 0.2 uM PO_4^{3-}
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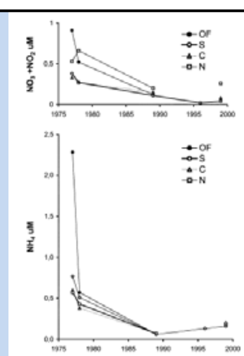
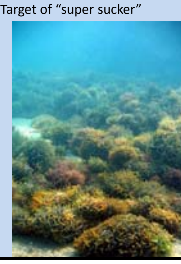


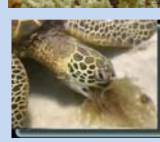
Fig. 11 Changes in DIN concentrations in three regions of Kaneohe Bay since diversion of sewage in 1977–1978. Values for 1977 are prediversion values and for 1978 are post-diversion values, both from Smith et al. (1981). Values for 1989 are from Laws and Allen (1996); values for 1996 are from Larned and Stimson (1996). Only the south bay was sampled in 1996. No samples for the outfall station were available that were contemporaneous with the 1998–1999 samples for the other three stations

Dictyosphaeria cavernosa aren't being grazed enough

H1: Reduction of herbivores
H2: Introduction of delicious invasive algae

Gracilaria salicornia "Gorilla ogo"
Target of "super sucker"

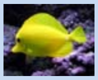




Dictyosphaeria cavernosa aren't being grazed enough

H1: Reduction of herbivorous fishes

H2: Introduction of delicious invasive algae



Summary of lab preference test for acanthurids							
Test	1	2	3	4	5	Average rank (out of 5)	Average rank (out of 4)
Number of fish tested	10	5	5	3	1		
Number of algal species offered	5	2	3	5	5		
Acanthophora spicifera	1	1	1	1	1	1	1
Dictyosphaeria cavernosa	4	4	3	4	4	4	4
Gracilaria salicornia	3	2	2	2	3	2.6	2.25
Kappaphycus alvarezii	2	3		4	2	2.6	2.75
Padina japonica	5			4	5	4.7	

Summary of lab preference tests for scarids						
Test	1	2	3	4	Average rank (out of 4)	Average rank (out of 3)
Number of fish tested	6	5	7	3		
Number of algal species offered	5	2	3	2	1	1
Acanthophora spicifera	1	1	1		3	3
Dictyosphaeria cavernosa	4	3	3		2	2
Gracilaria salicornia	3	2	2	2	4	
Kappaphycus alvarezii	5	4				
Padina japonica	2					

Stimson et al. 2001. Coral Reefs 19: 343-57.

Case Study: Kaneohe Bay, Hawaii

Removing sewage is good…now comes the hard part…

What do we do about run-off, sediment sources of nutrients, introduced algae, possible reduced herbivore loads?

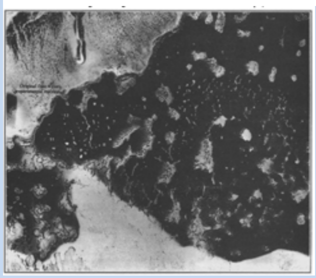
Coral-algal interactions can be complicated: not all macroalgae are equal.

ENCORE: The Effect of Nutrient Enrichment on Coral Reefs. 1. Experimental Design and Research Programme

A. W. D. LARKUM* and A. D. L. STEVENS†

*School of Biological Sciences, Macleay Building, University of Sydney, NSW 2006, Australia

†Great Barrier Reef Marine Park Authority, PO Box 1379, Townsville 4810, Australia



12 microatolls

16-25 m across

Ponded at low tide

Control, N, P, N+P

10 x background enrichment

(10 uM N, 2 uM P)

2 year experiment

Fertilization 2 x daily (low tide)

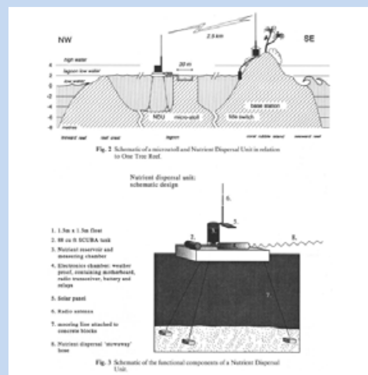


TABLE 2

Summary statistics of average initial and final nutrient concentrations (μM) of nitrogen and phosphorus in ENCORE patch reefs.[a]

Treatment	Nitrogen				Phosphorus		
	n	Mean NH_4	Mean NO_x	Mean DIN	n	Mean PO_4	Diss N:P
Initial concentration							
Control	214	0.65 (0.69)	2.94	3.59	216	0.20 (0.06)	14.70
Low-loading phase	48	11.45 (4.85)	2.94	14.39	47	2.34 (0.98)	6.15
High-loading phase	12	36.20 (21.87)	2.94	39.14	12	5.14 (2.81)	7.61
Final concentration							
Control	214	1.34 (0.57)	2.94	4.28	216	0.16 (0.04)	26.75
Low-loading phase	48	0.91 (0.79)	2.94	3.85	48	0.52 (0.32)	7.40
High-loading phase	12	11.30 (10.20)	2.94	14.24	11	2.40 (1.61)	5.93

[a] Data are calculated from all measurements of nutrients in control patch reefs and from all measurements from patch reefs to which nitrogen (i.e. +N and +N+P) and phosphorus (i.e. +P and +N+P) were added. Relevant nitrogen-to-phosphorus ratios are also shown.

Not much happened (~14 mo)….so let's try "high-loading phase" (~13 mo)

…in initial phase, pulses would reach background after 2-3 hours

…in high loading phase NH4+ was still ~11 uM by end of low tide.

TABLE 3

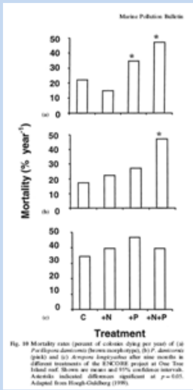
Comparison of estimated daily loadings of inorganic N and P for ambient, low-loading phase and high-loading phase of the ENCORE study.[a]

		Nutrient added			
		Nitrogen		Phosphorus	
	Duration (h)	Concentration (mmol m^{-3})	Loading (mmol m^{-2} day^{-1})	Concentration (mmol m^{-2} m^{-1})	Loading (mmol m^{-2} day^{-1})
Ambient	18	0.65	6.2	0.2	0.8
Low load	6	11.45	13.0 (2.1)	2.34	2.1 (2.6)
High load	6	36.2	41.0 (6.6)	5.12	8.0 (10.0)

[a] Numbers in parentheses in loading columns are the number of times ambient loads were exceeded. Ambient conditions were assumed to be 0.65 μM NH_4–N and 0.2 μM PO_4–P with a water velocity of 10 m s^{-1} for a period of 18 h (to take account of an average of 3 h each low tide when the One Tree Island lagoon is separated from the ocean).

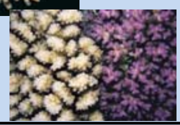
10 x the initial nitrogen concentration but only 2 x the loading.

Even with high loading experiment, didn't see big changes in algal abundance/cover.



Saw increased mortality of transplanted corals (P. damicornis…top 2 plots) with P or N+ P enrichment. (High loading phase)

Plot s show two different Pocillopora morphs and Acropora longicyathis. Mortality after 9 months.



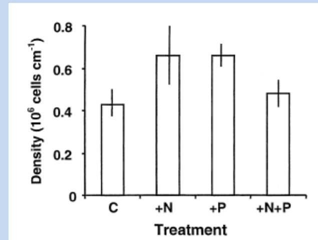
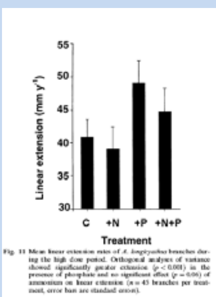
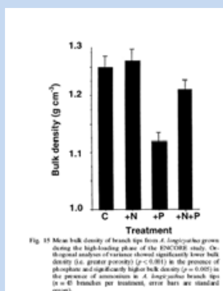


Fig. 21 Population density of zooxanthellae in *S. pistillata* after exposure to +N, +P and +N + P during the second phase of the ENCORE experiment.





Why aren't nutrient concentrations the whole story?

Proposed threshold: 1 uM DIN; 0.1 uM SRP
Above which, predicted rapid phase shift to macroalgae.

Kaneohe Bay (prediversion ~1978) **1.08 μM DIN**, 0.33 μM SRP

Kaneohe Bay, Hawaii (1989-1992) **0.21 μM DIN**, 0.04 μM SRP

Waikiki Aquarium **5 μM NO_3 ; 2 μM NH_4**, PO_4 0.6 μM;

This rule of thumb is an oversimplification! Herbivory, flow and other factors are important.

Why aren't nutrient concentrations the whole story?

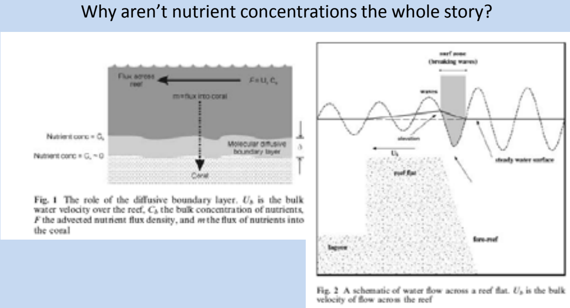
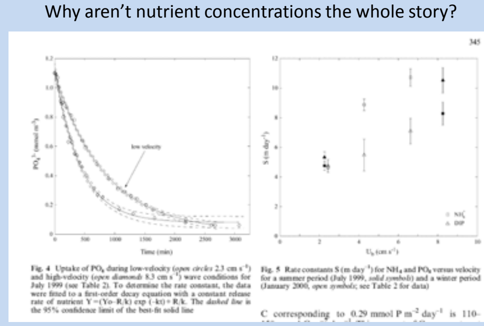


Fig. 1 The role of the diffusive boundary layer. U_b is the bulk water velocity over the reef, C_b the bulk concentration of nutrients, F the advected nutrient flux density, and m the flux of nutrients into the coral

Fig. 2 A schematic of water flow across a reef flat. U_b is the bulk velocity of flow across the reef

Hearn CJ, Atkinson MJ, Falter JL. 2001. A physical derivation of nutrient-uptake rates in coral reefs: effects of roughness and waves. Coral Reefs 20: 347-356.

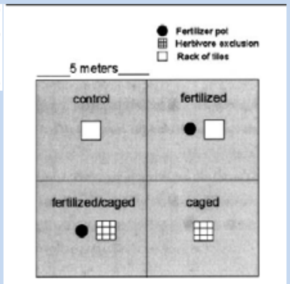
Why aren't nutrient concentrations the whole story?



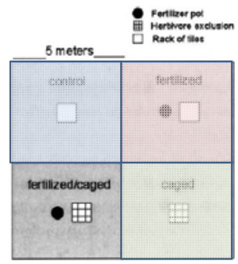
Atkinson MJ, Falter JL, Hearn CJ. 2001 Nutrient dynamics in the Biosphere 2 coral reef mesocosm: water velocity control NH4 and PO4 uptake. Coral Reefs 20: 341-6.

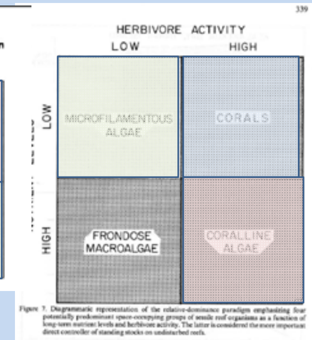
Example of Herbivore* Nutrient experiment

Distance (m)	n	NH_4	NO_3	PO_4
0.00	4	148.80 (7.51)	94.35 (19.68)	22.38 (2.06)
0.25	4	5.42 (1.23)	1.88 (0.81)	1.26 (0.29)
0.50	4	1.76 (0.87)	0.95 (0.38)	0.61 (0.23)
1.00	4	1.04 (0.56)	0.68 (0.37)	0.34 (0.16)
Ambient	4	0.713 (0.22)	0.38 (0.11)	0.24 (0.07)

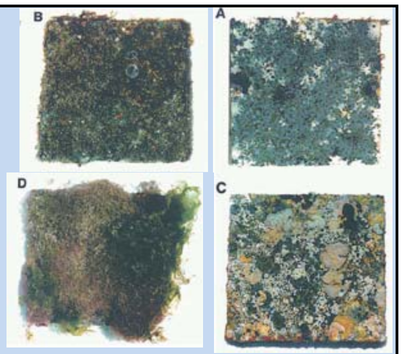


Smith JE, Smith CM, Hunter CL. 2001. An experimental analysis of the effects of herbivory and nutrient enrichment on benthic community dynamics on a Hawaiian reef. Coral Reefs 19: 332-42.





A. Control
B. Herbivore exclusion
C. Nutrients
D. Nutrients and herbivore exculsions



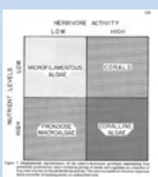
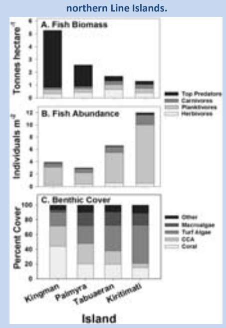


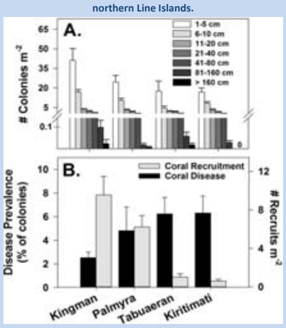
Figure 3. Fish biomass (A) and abundance (B), and cover of major benthic functional groups (C) across the northern Line Islands.



Sandin SA, Smith JE, DeMartini EE, Dinsdale EA, et al. (2008) Baselines and Degradation of Coral Reefs in the Northern Line Islands. PLoS ONE 3(2): e1548. doi:10.1371/journal.pone.0001548
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0001548

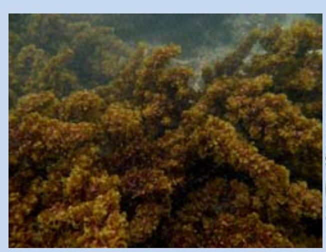
PLOS | ONE

Figure 4. Size frequency distribution of corals (A), and coral disease prevalence and recruit density (B) across the northern Line Islands.



Sandin SA, Smith JE, DeMartini EE, Dinsdale EA, et al. (2008) Baselines and Degradation of Coral Reefs in the Northern Line Islands. PLoS ONE 3(2): e1548. doi:10.1371/journal.pone.0001548
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0001548

PLOS | ONE



Bocas Algae: Sargassum polyceratium var. ovatum. By: Olga Camacho, Jimena Samper Villareal

Sargassum (Wikipedia)

Kyphosus vaigiensis
Brassy chub (Lowfin chub?)
Encyclopedia of Life

Naso unicornis
Bluespine unicornfish
(Acanthuridae)