

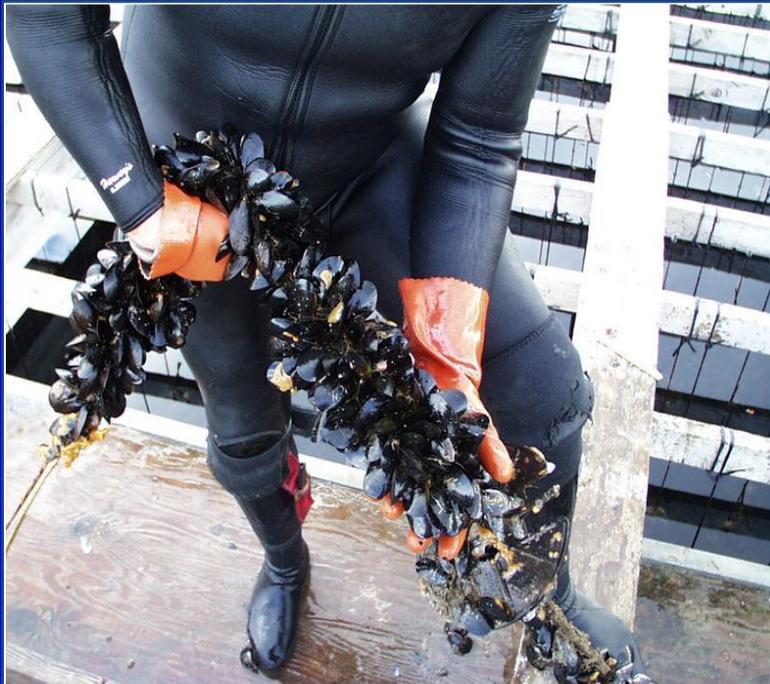
EVALUATION OF MUSSEL-OYSTER-SALMON IMTA IN PUGET SOUND USING STABLE ISOTOPE TRACING

World Aquaculture Society February 2013 Nashville
Integrated Multitrophic Aquaculture Session

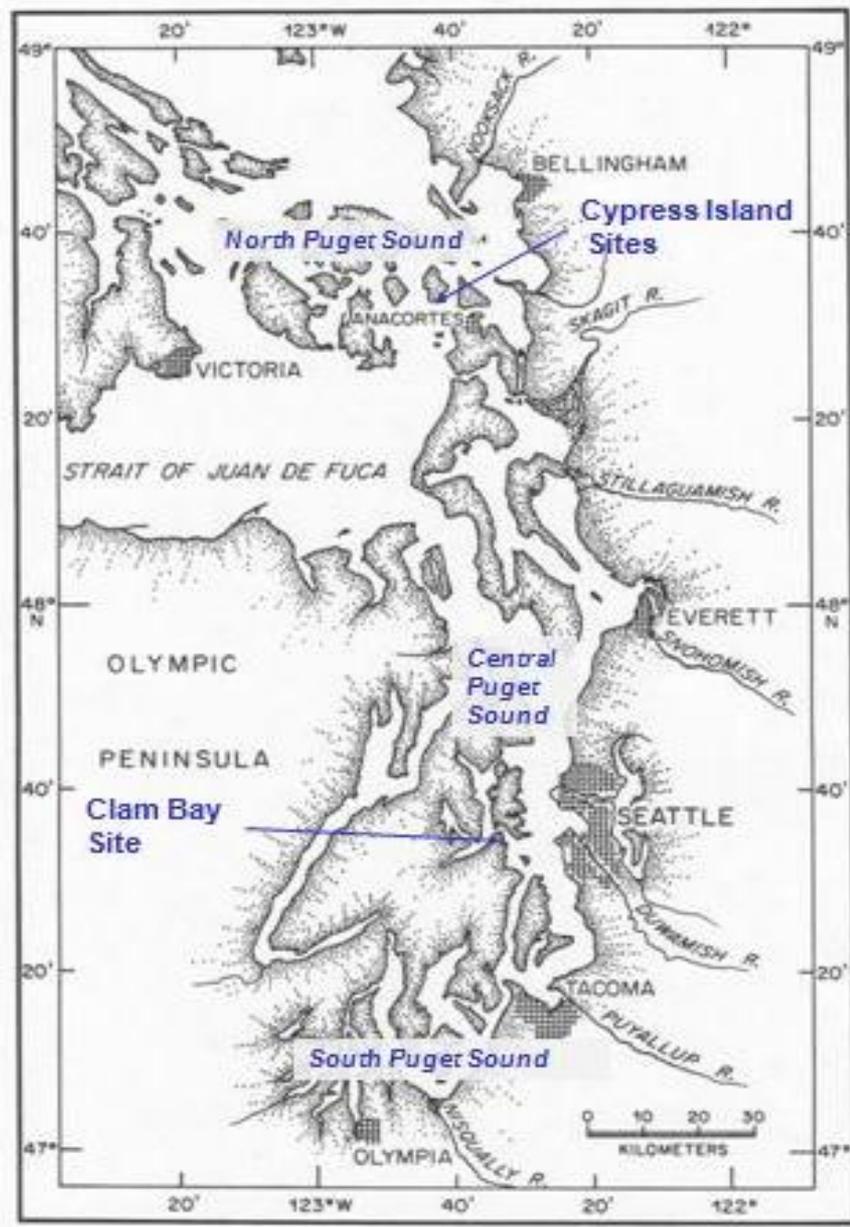
Jack Rensel*, Kevin Bright**, Zachary Siegrist*

*Rensel Associates Aquatic Sciences

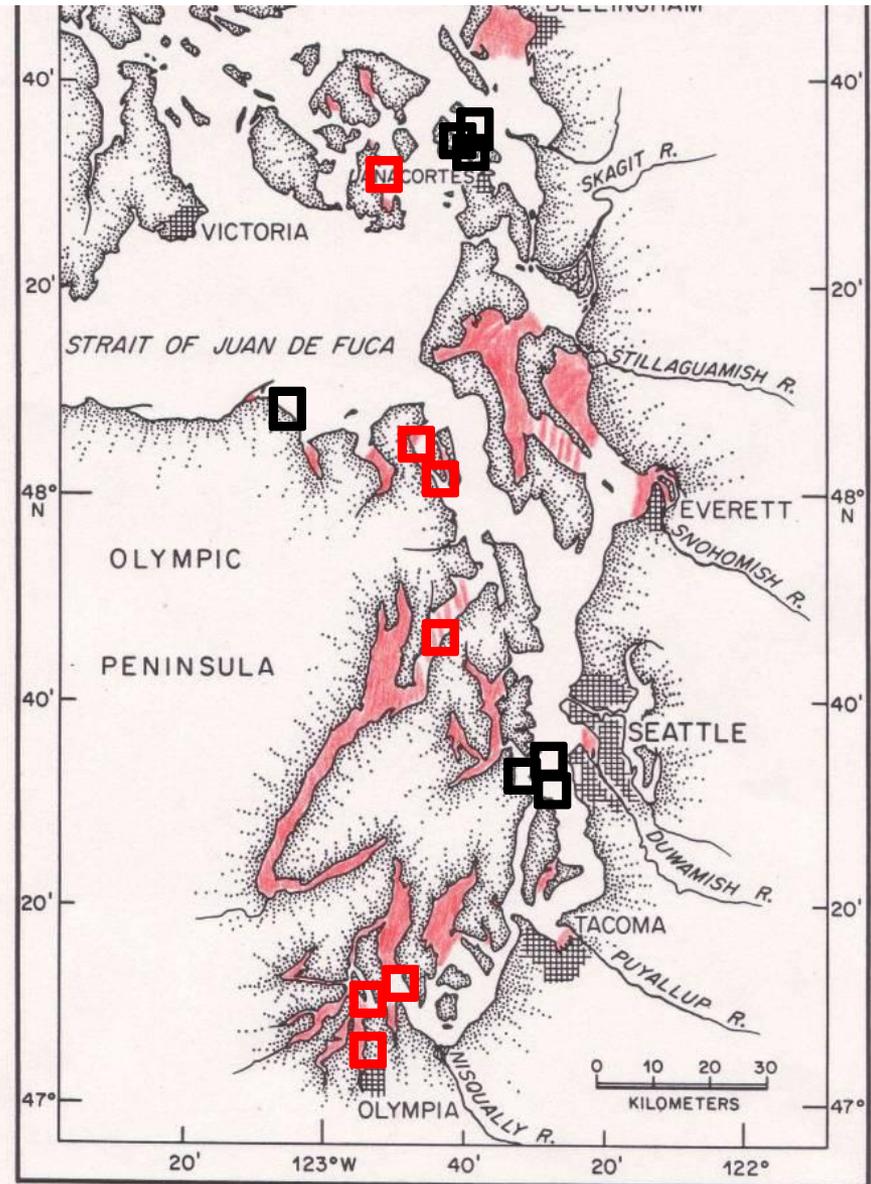
**American Gold Seafoods – Icicle Seafoods Inc.



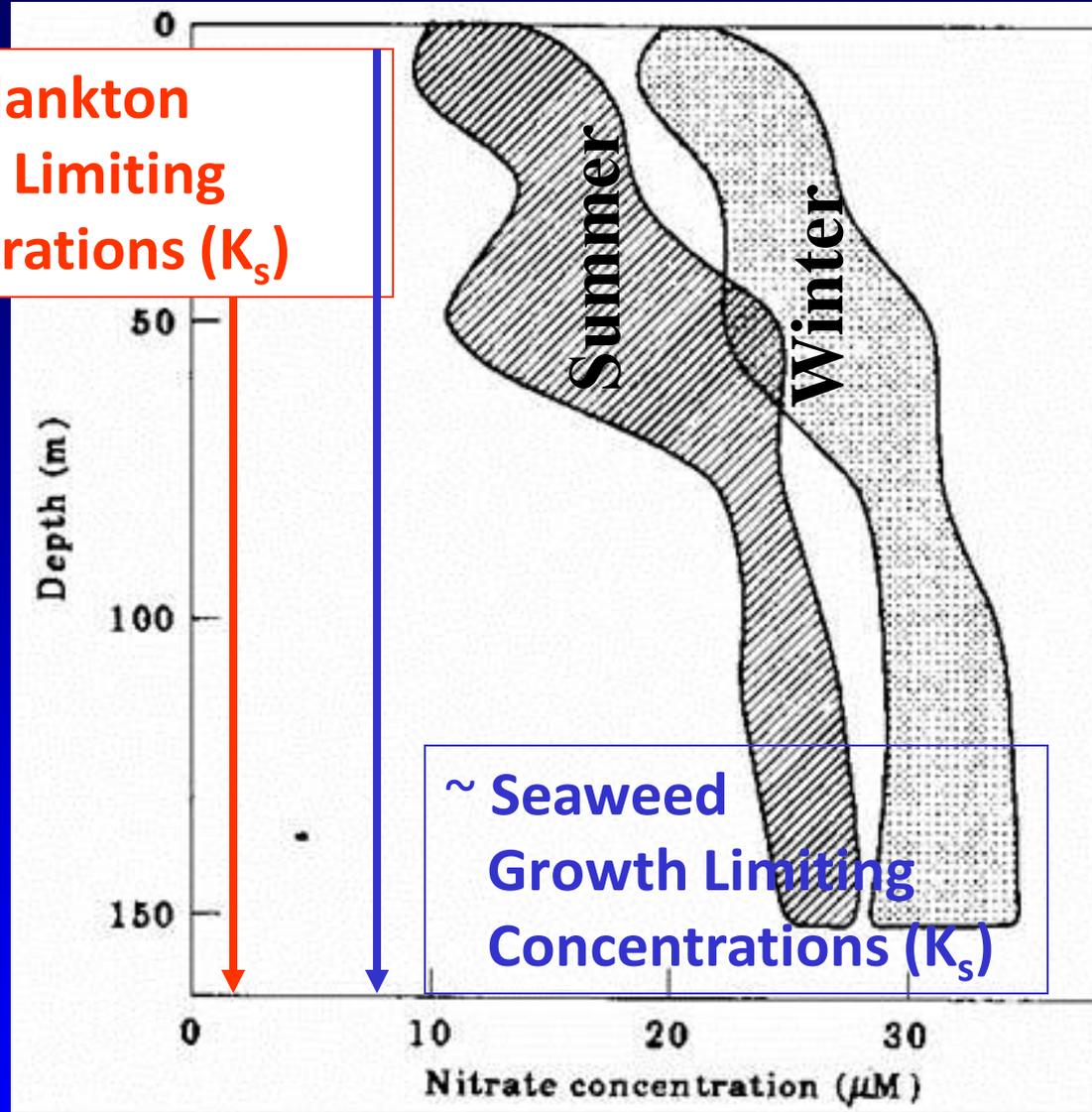
Nutrient Sensitive, Historical Pen Locations
Non-Nutrient Sensitive Siting 2013
Rensel et al. (EPA) 1991



North Basin: Cypress Island
Central Basin: Clam Bay

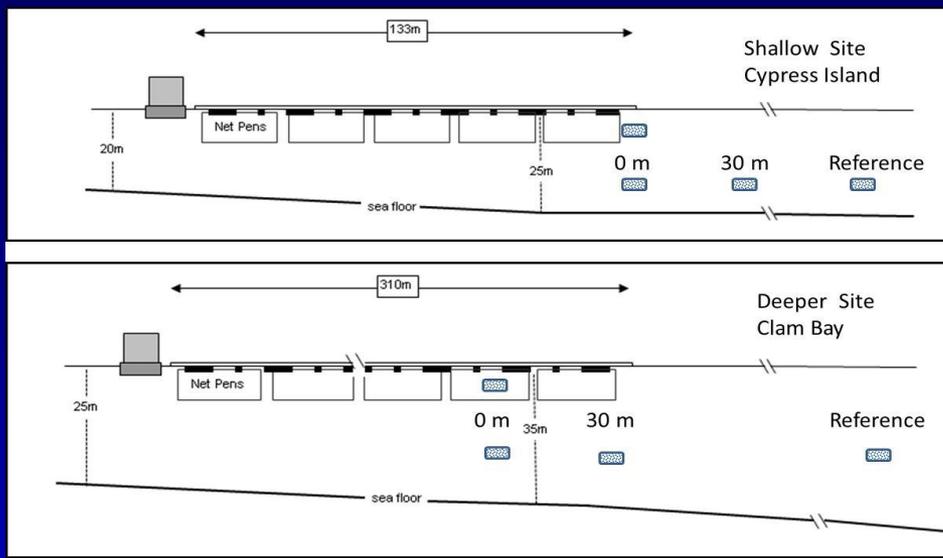


~ Phytoplankton
Growth Limiting
Concentrations (K_s)



~ Seaweed
Growth Limiting
Concentrations (K_s)

Sunlight & vertical mixing limit algal growth, not nutrient supply, in main basins of Puget Sound and the Strait of Juan de Fuca. (after P. Harrison, UBC)

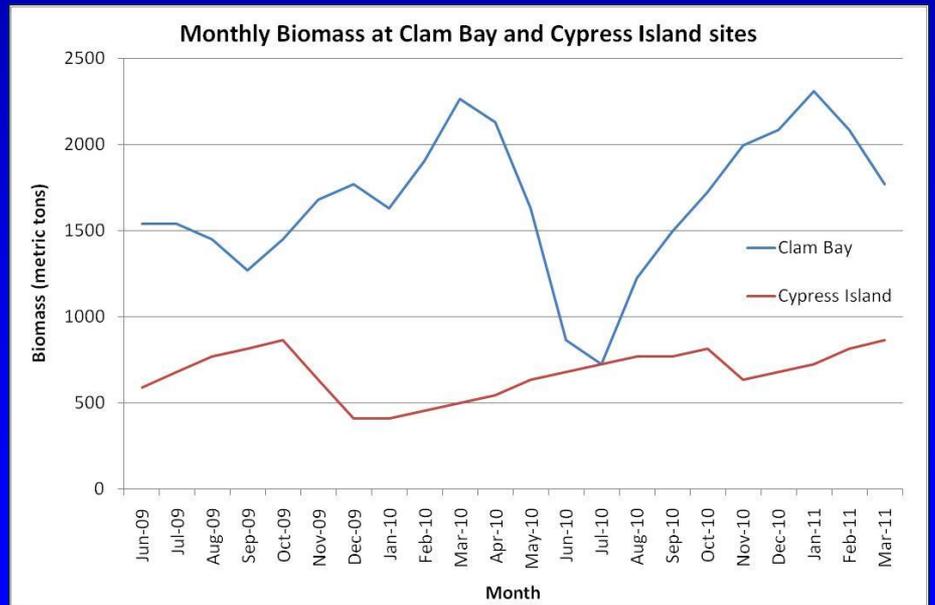
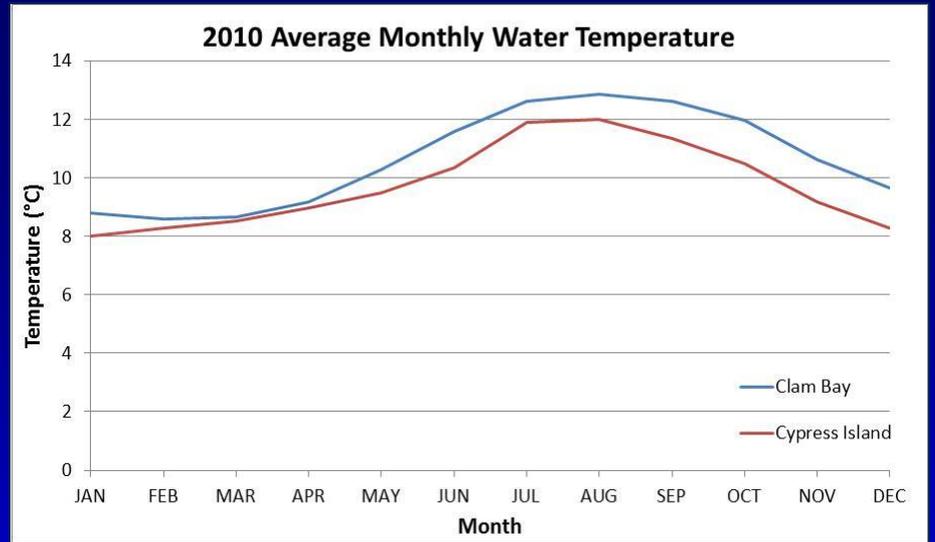


Exp. 1 Mussels and Oysters
Sept – June

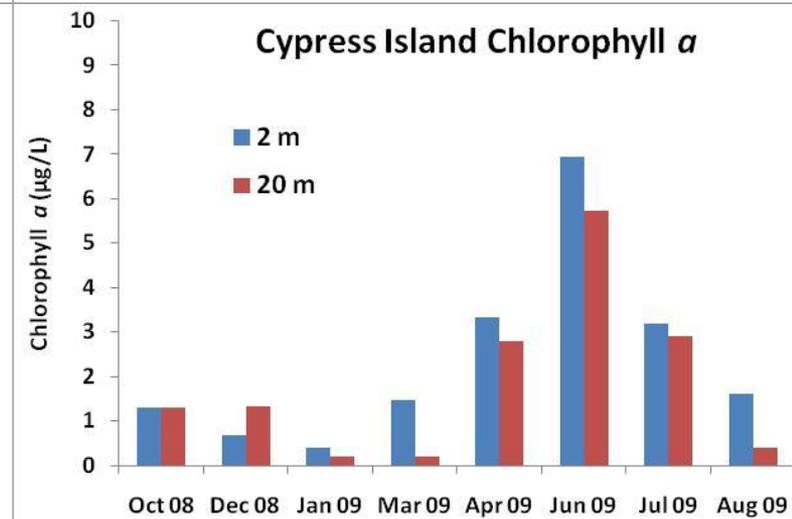
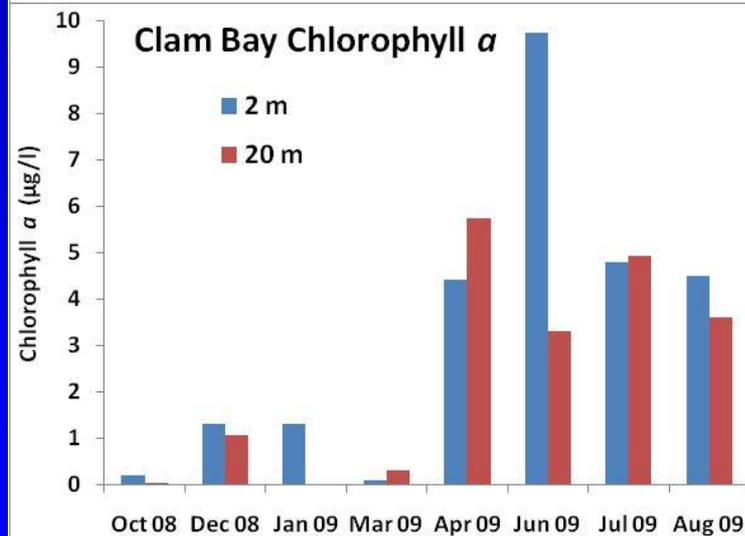
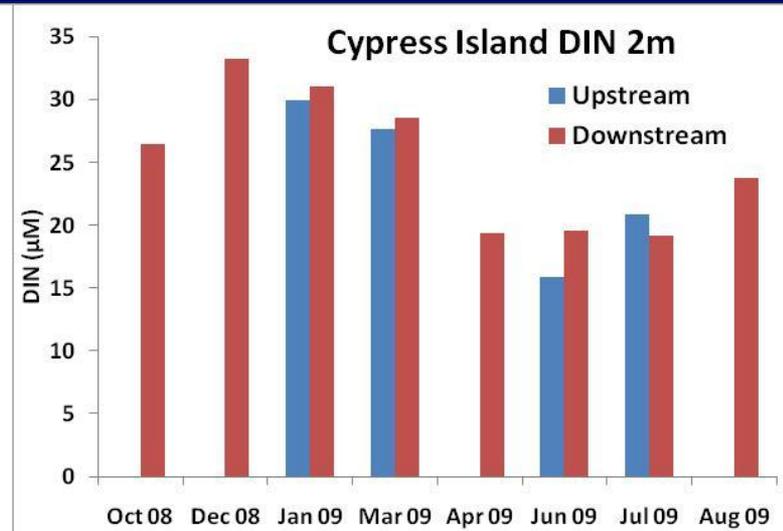
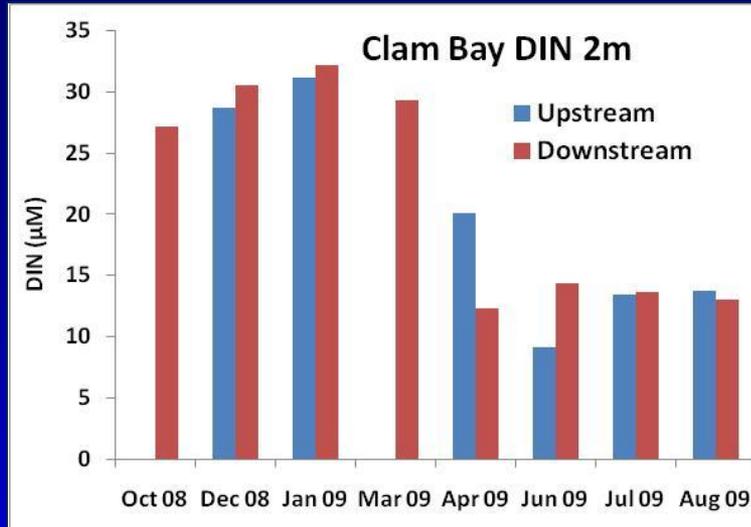
Exp. 2 (2nd Year) Mussels
April – March

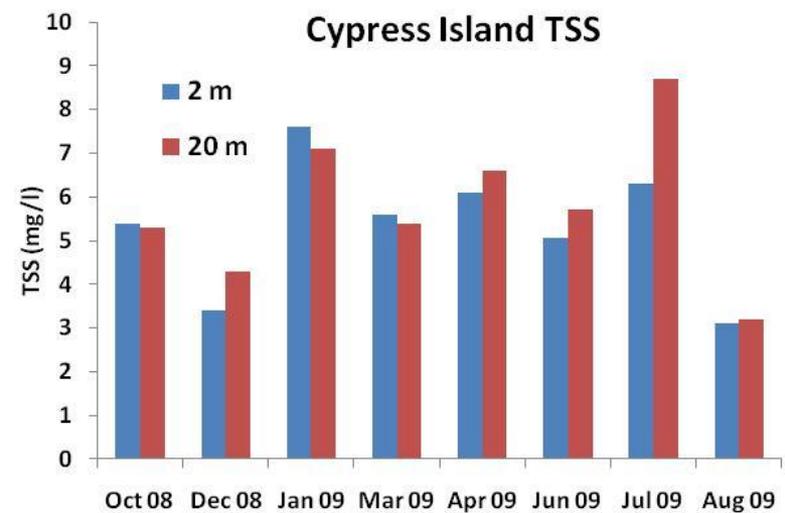
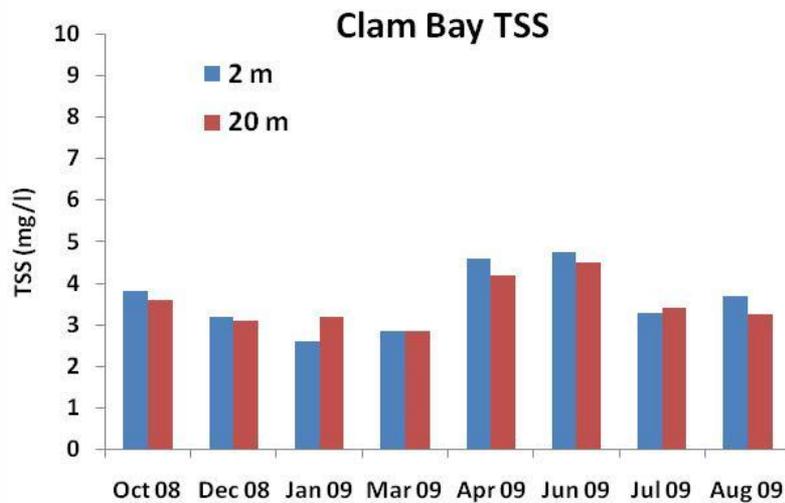
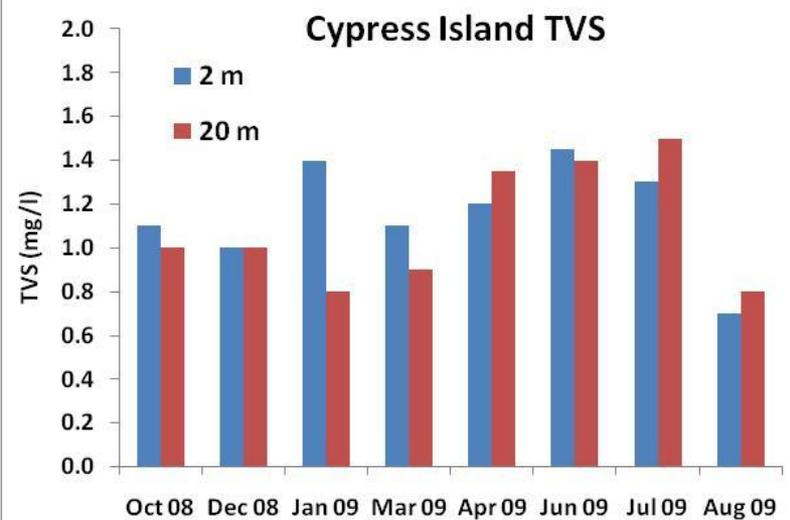
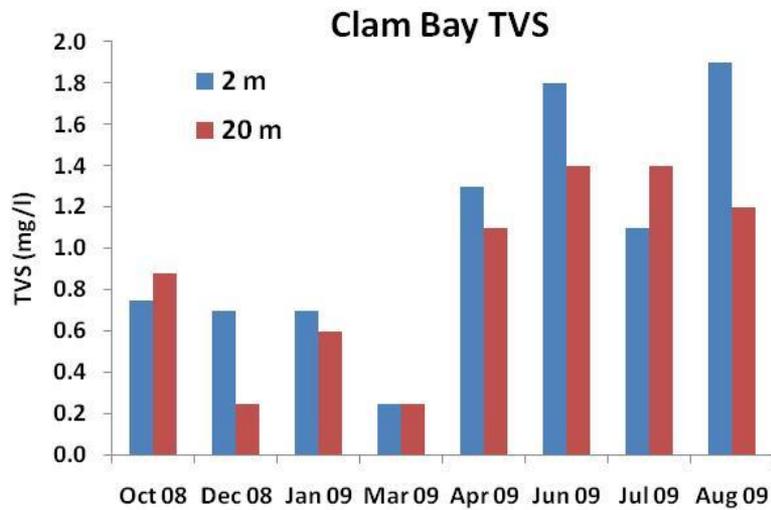
- Gallo mussels
- Pacific oysters
- Fast currents
- No stratification
- Sand sea-bottoms
- Upwelling D.O. a limiting factor



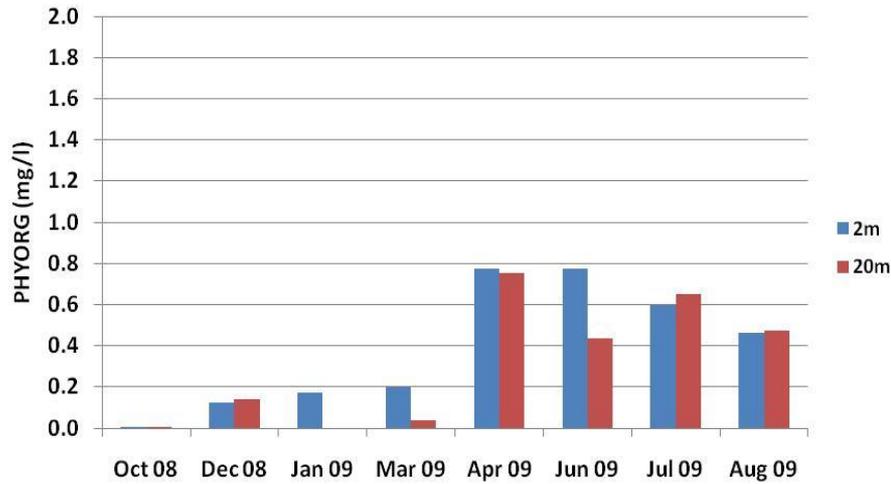


Conditions: Up/Downstream of Pens

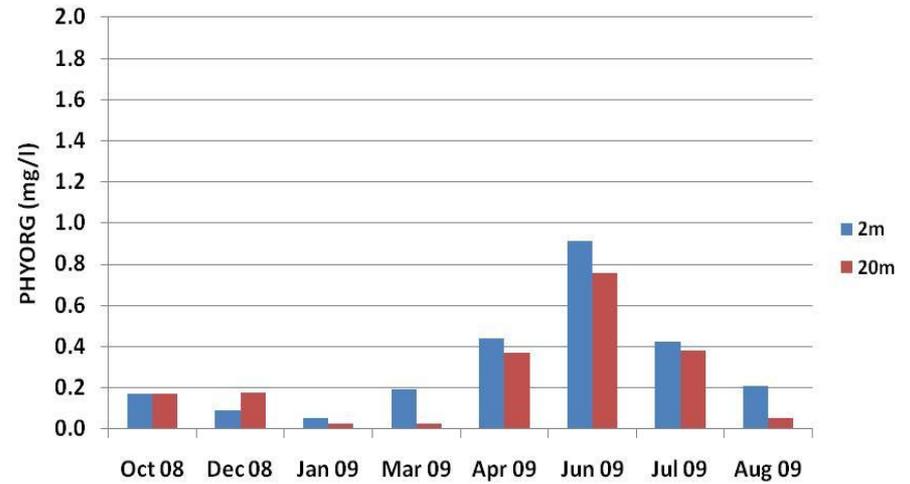




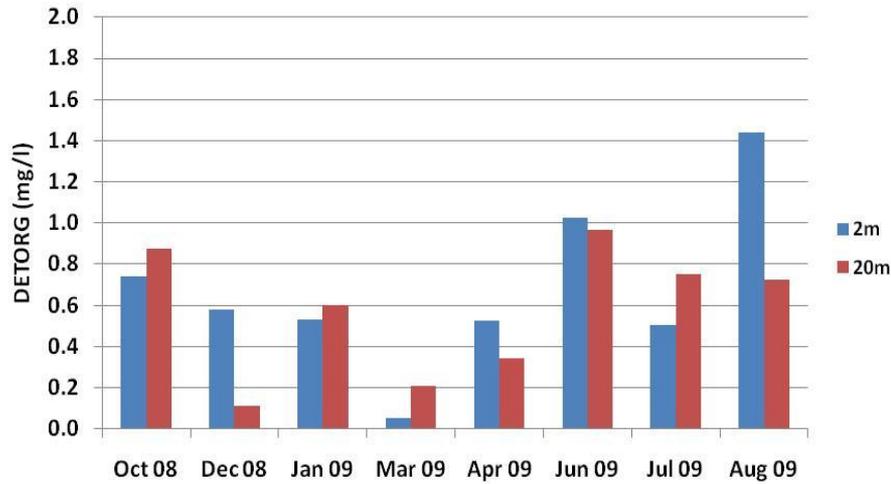
Clam Bay Phytoplankton Organics (mg/l)



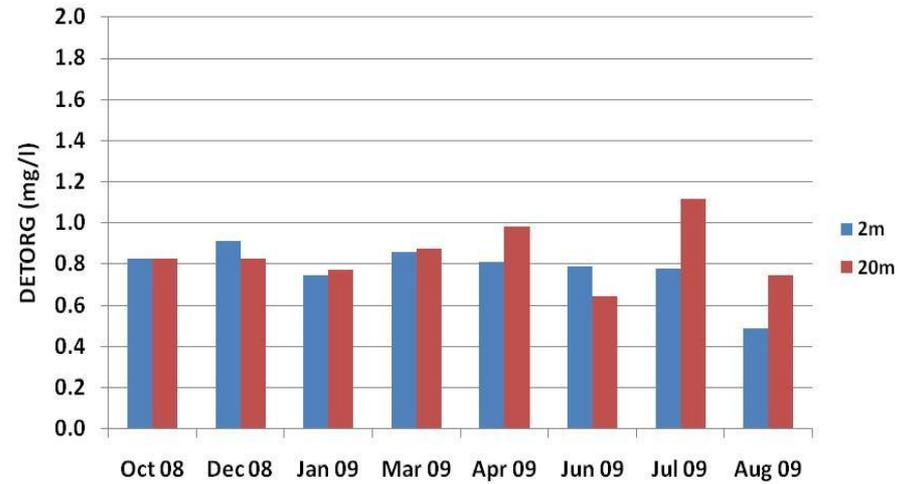
Cypress Island Phytoplankton Organics (mg/l)



Clam Bay Non-Phytoplankton Organics (mg/l)

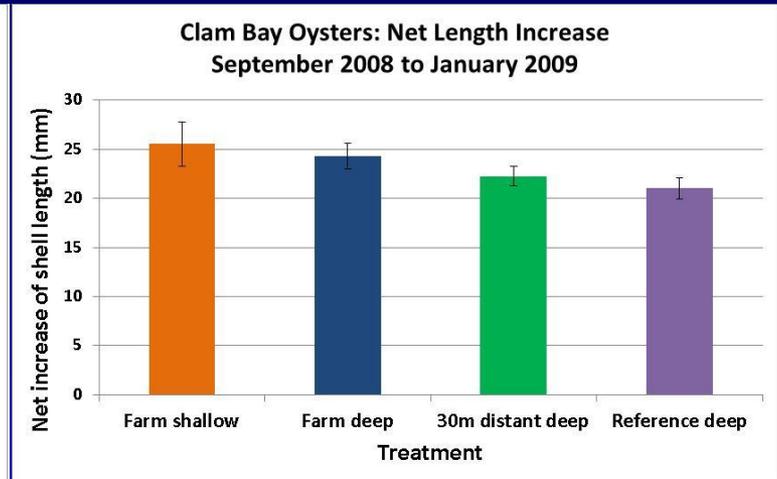
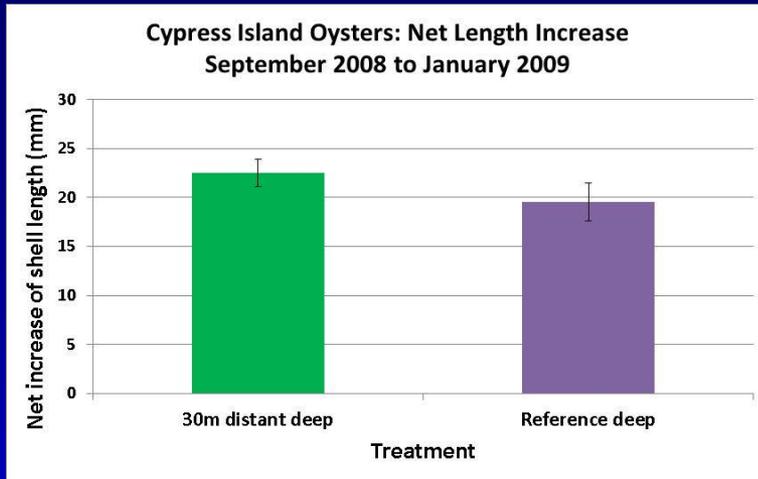


Cypress Island Non-Phytoplankton Organics (mg/l)

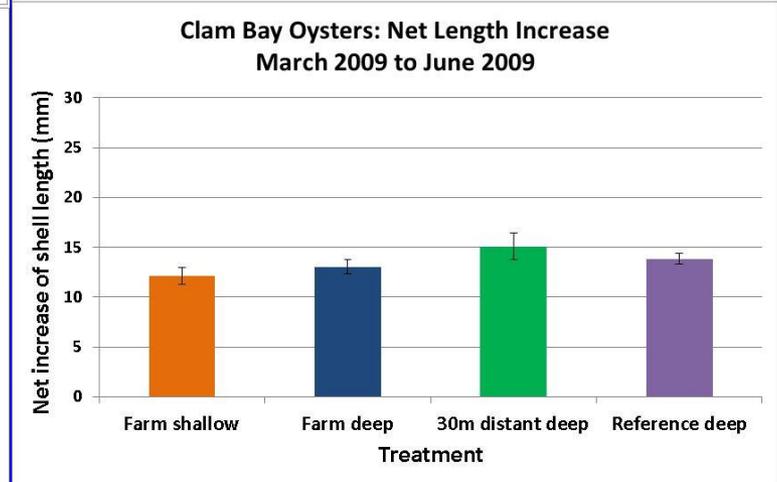
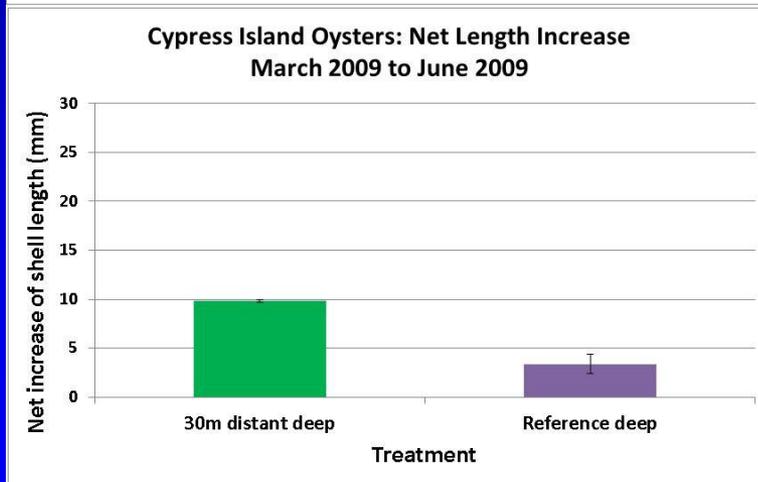


Pacific Oyster Growth

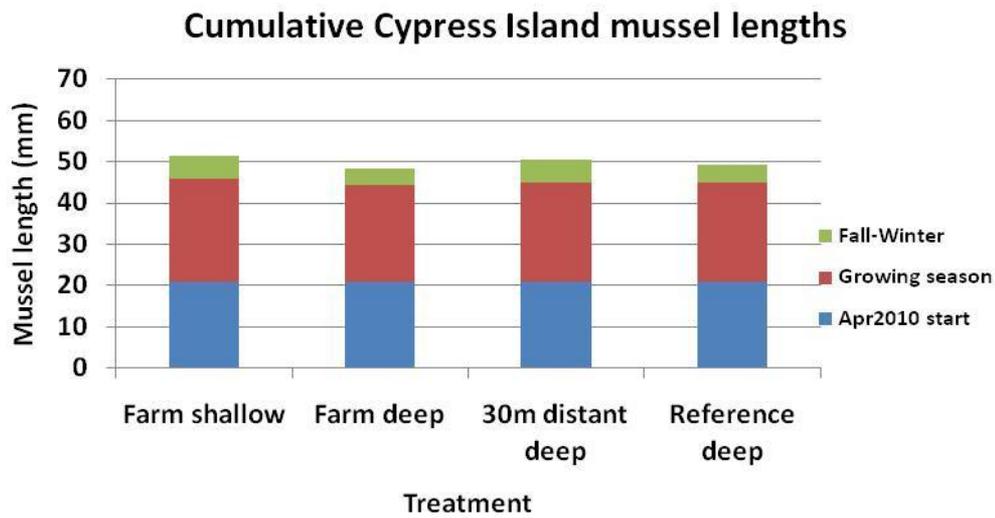
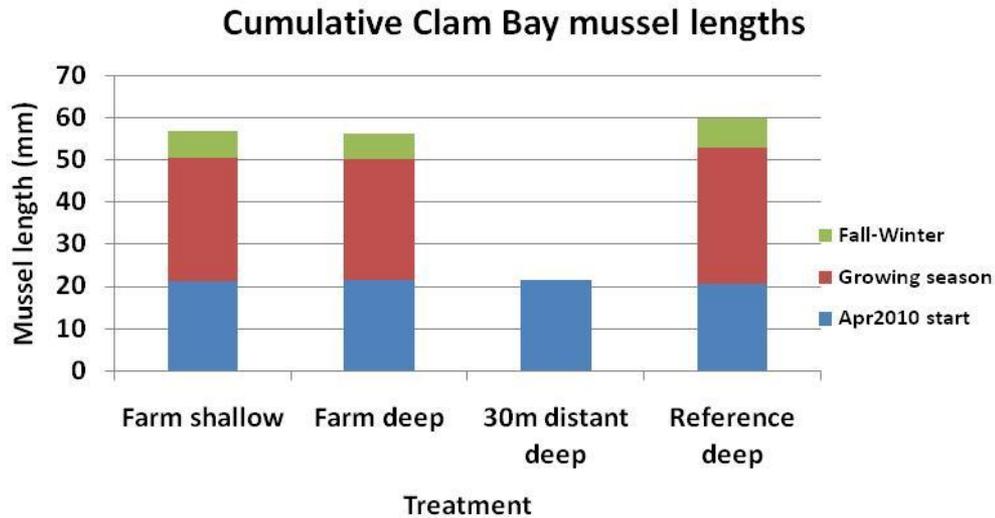
Fall &
Early
Winter



Spring

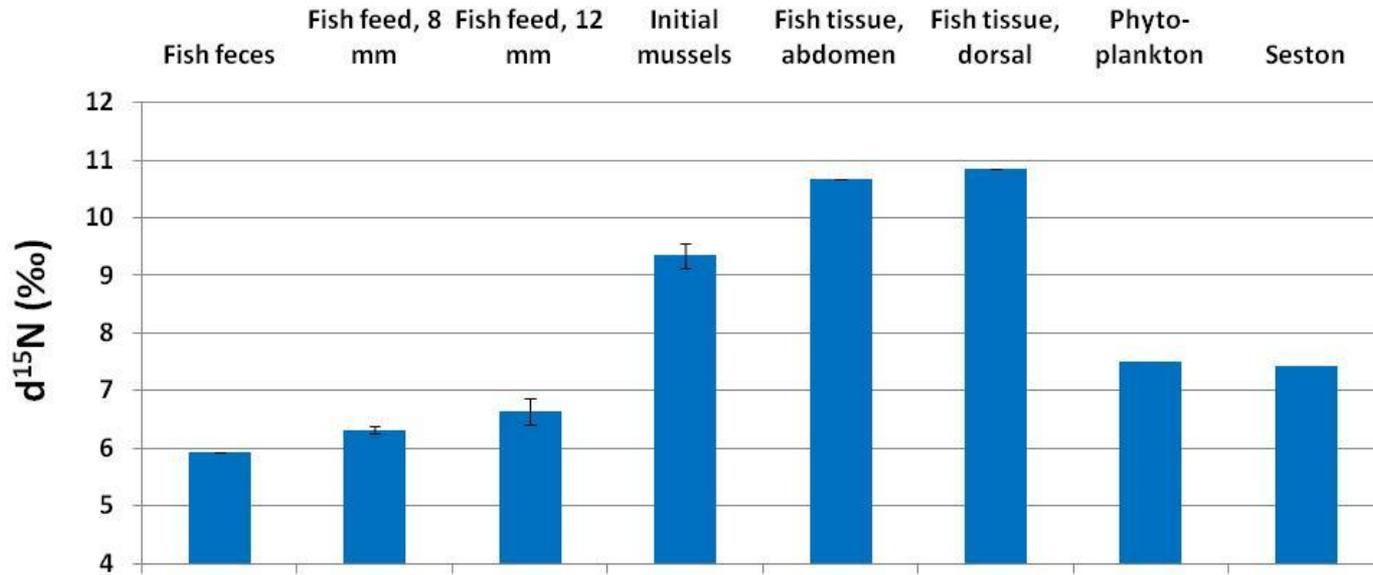


IMTA oyster growth ↑ in fall & early winter in 3 of 4 periods/locations shown above, or 3 of 6 counting winter

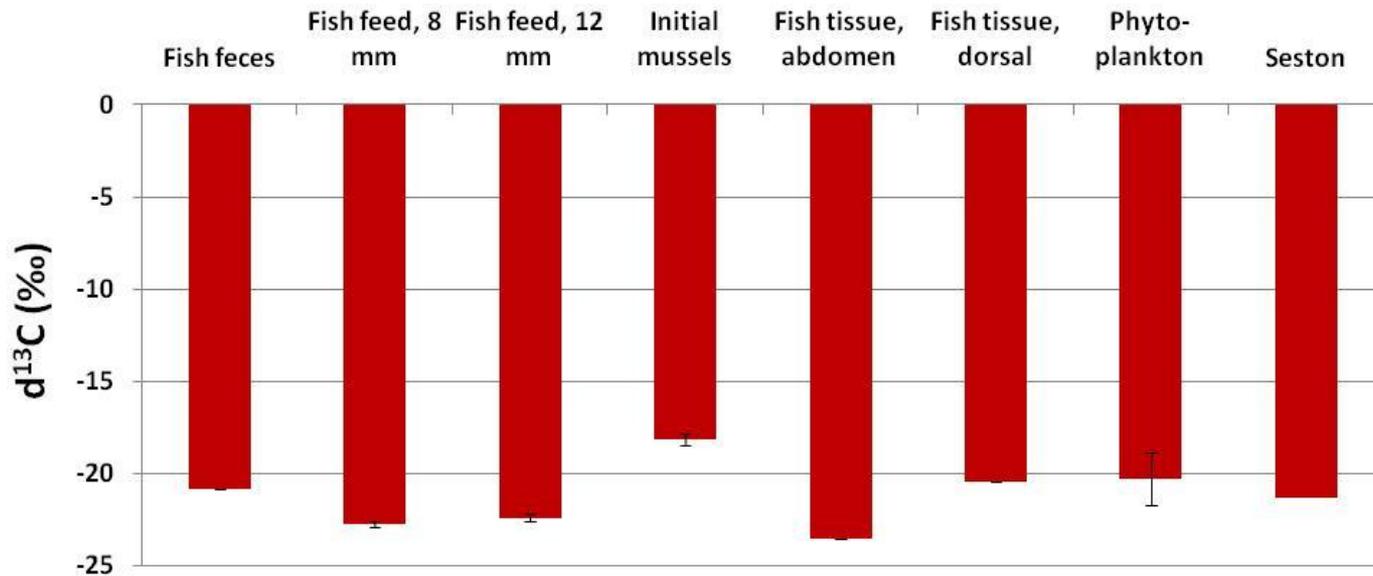


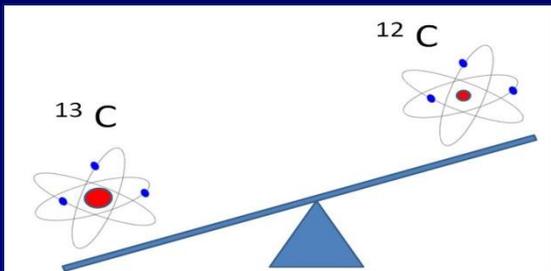
Year 1 mussel growth not accelerated
 Year 2 also no growth effect

Nitrogen Stable Isotope Signatures

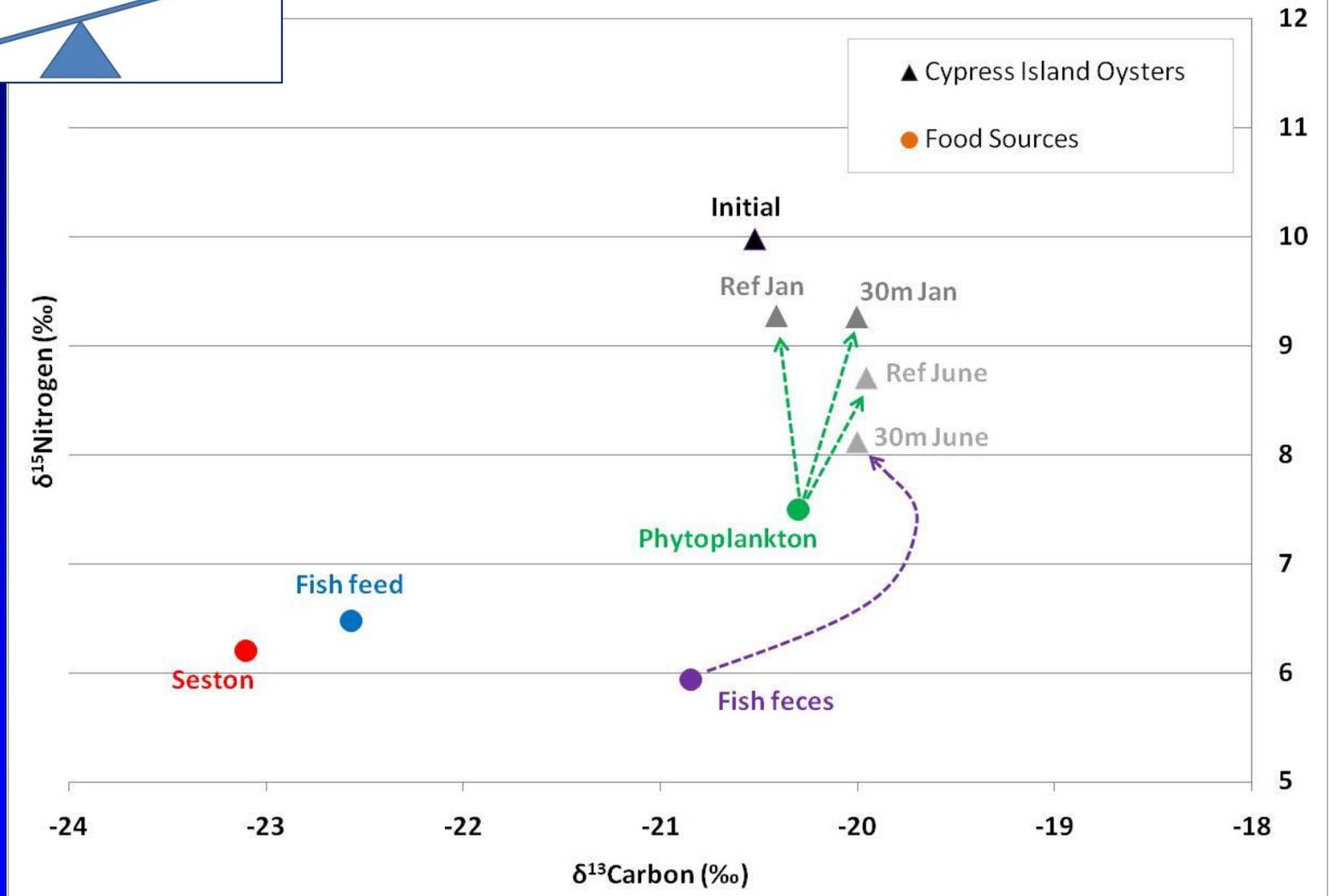


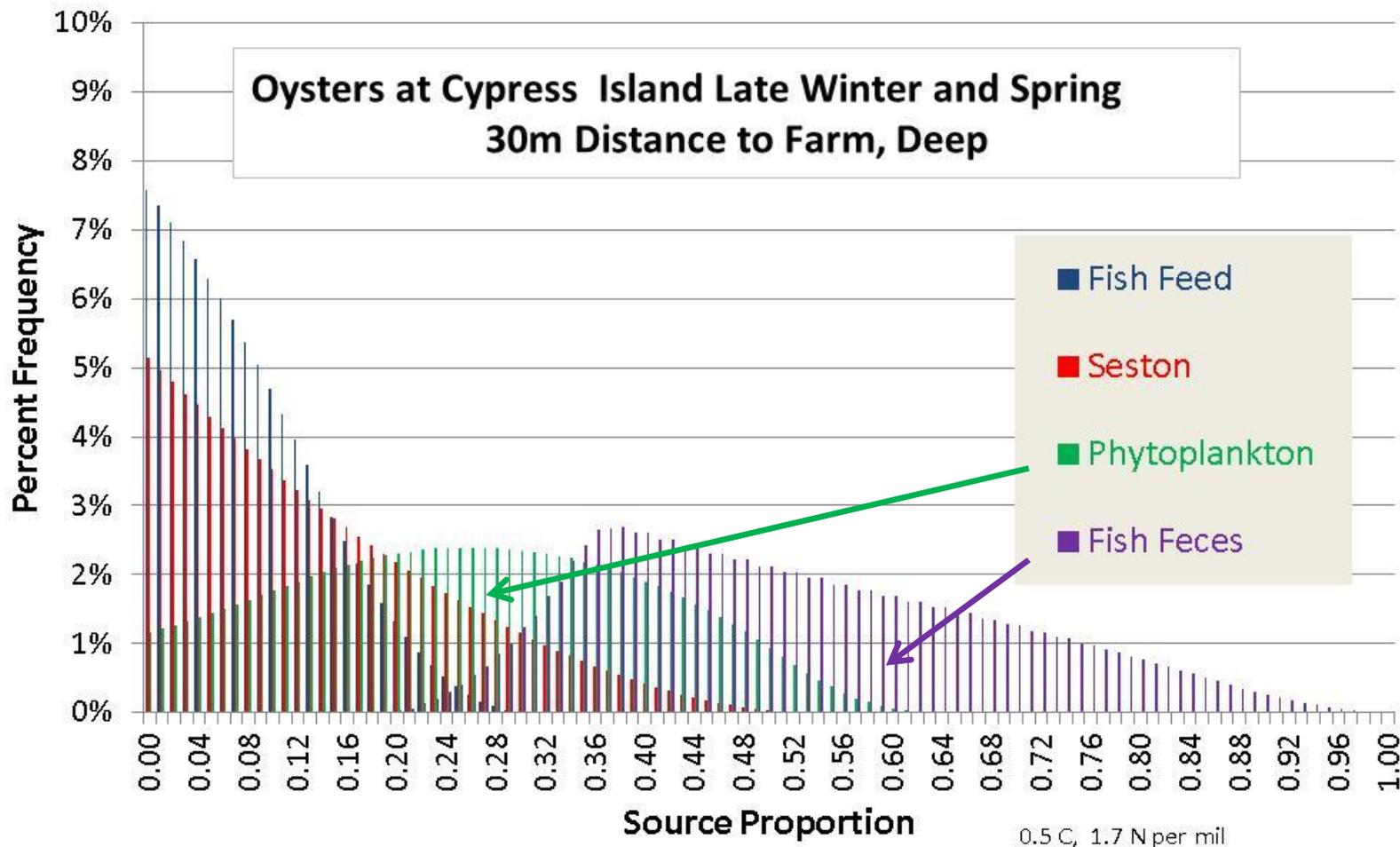
Carbon Stable Isotope Signatures





Cypress Island oysters: dual stable isotope plot

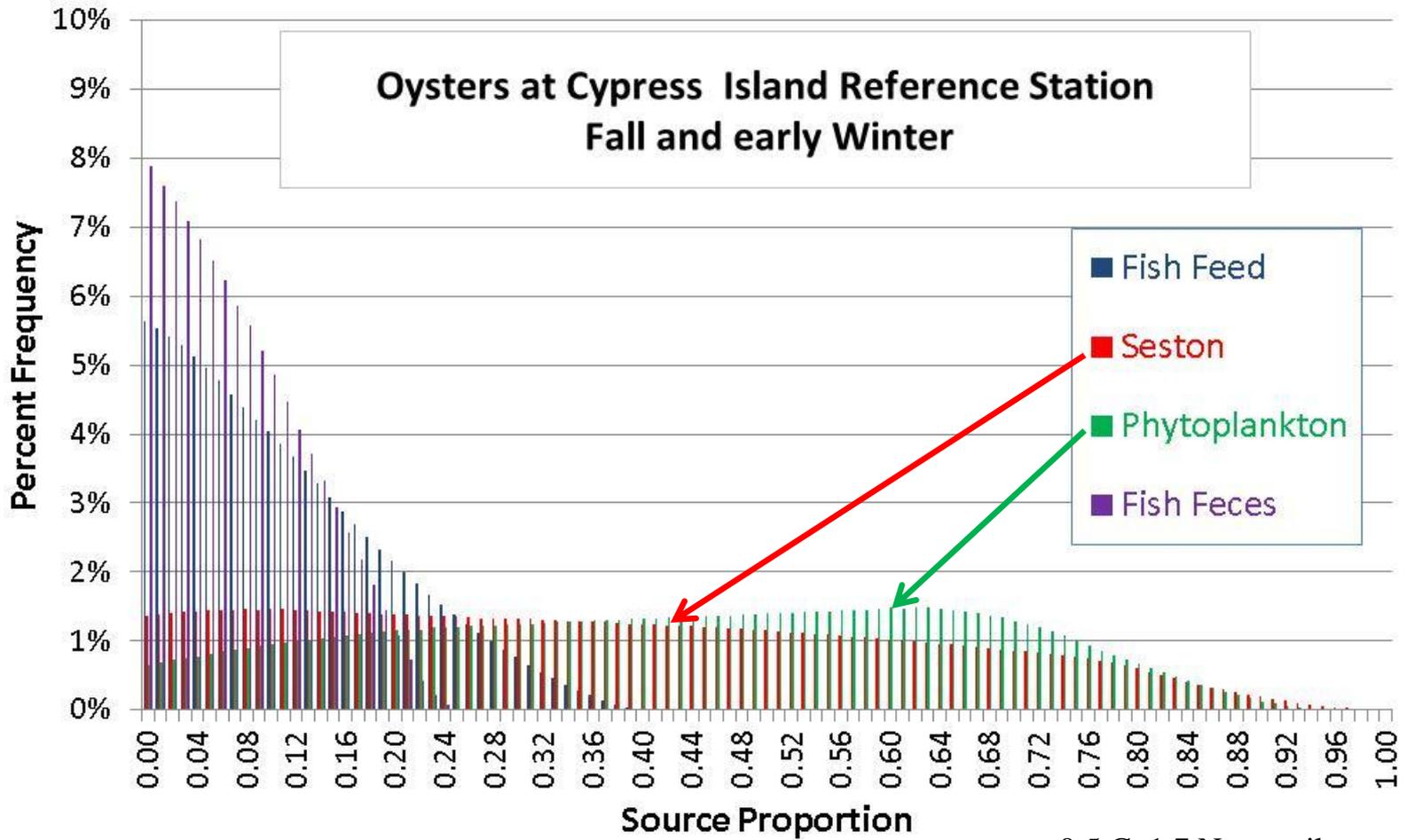




**IsoSource mixing model
probability calculations →
January = Fall and early winter,
June = Winter and Spring.**

Treatment	Fish Feed	Seston	Phyto-plankton	Fish Feces
30m Jan	9%	7%	77%	7%
30m June	8%	5%	36%	51%
Ref Jan	10%	8%	76%	6%
Ref June	10%	7%	61%	23%

Oysters at Cypress Island Reference Station Fall and early Winter



0.5 C, 1.7 N per mil

Experiment 1: 2009-2010												
Oysters							Mussels					
Clam Bay			Cypress Island				Clam Bay			Cypress Island		
Fall	Winter	Spring	Fall	Winter	Spring	Fall	Winter	Spring	Fall	Winter	Spring	
Growth	+	+	-	+	-	+	-	-	-	-	-	-
SIA Nitrogen	-	-	+	-	-	+	+	-	-	-	-	-
SIA Carbon	-	-	-	-	-	-	-	-	-	-	-	-
IsoSource C&N Mixing Model	Phyto.	-	-	Farm	-	Farm	-	-	-	-	-	-
Fish Farm Cummulative Effect?	No	No	No	Yes	No	Maybe	No	No	No	No	No	No
Survival	-	-	-	-	-	-	+	-	+	-	-	-

Results Matrix

Experiment 2 2010-2011				
Mussels				
Clam Bay		Cypress Island		
Spr-Sum	Fall-Wint	Spr-Sum	Fall-Wint	
Growth	-	-	-	-
SIA Nitrogen	-	+	+	-
SIA Carbon	-	-	+	-
IsoSource C&N Mixing Model	-	-	-	-
Fish Farm Cummulative Effect?	No	No	Maybe	No
Survival	-	-	-	-

Higher Food Web Effects

Sport & Commercial Species
Abundant Near PS Net Pens



Dungeness Crab



Spot Prawns &
Side Striped Shrimp



Rockfish



Juvenile Forage Fish



Pacific Spiny Dogfish

Higher Food Web Effects

Seabirds in Net Pen Areas





Few
Ducks &
No Farm

Cypress Island Preserve

Few
Ducks &
No Farm

Few
Ducks &
No Farm

Diving
Ducks
& Farm

Same Pattern
at Other Sites



Summary

- Natural productivity & high dispersion rates appear to limit shellfish sequestration of fish farm wastes in Puget Sound. Oysters appeared to benefit, Gallo mussels did not (maybe too cold for normal metabolism).
- Net pens & shellfish culture sites in Washington historically located separately. Net pen sites a bit cool for Gallo mussels.
- Fish wastes are being used by food web at these pen sites
- Strong evidence of localized enrichment of food web, 1000's of seabirds reside near fish farms, much less in reference areas
- Beneficial ecosystem services of properly sited fish aquaculture in such settings not widely recognized, important PR
- IMTA of oysters maybe technically feasible in Puget Sound. Mussel culture at pen sites might require *M. trossulus* or hybrid seed.

Acknowledgements

American Gold Seafoods - Icicle Seafoods Inc.

Taylor Shellfish Inc.: Gordon King

National Oceanic and Atmospheric Administration

Kevin Bright: American Gold Seafoods

Zach Siegrist: Rensel Associates



For more information Google:
“IMTA Rensel” for separate
Fish/Shellfish IMTA &
Beneficial Effects of Net Pens
reports