Potential effects of ocean acidification on Salish Sea planktonic food webs

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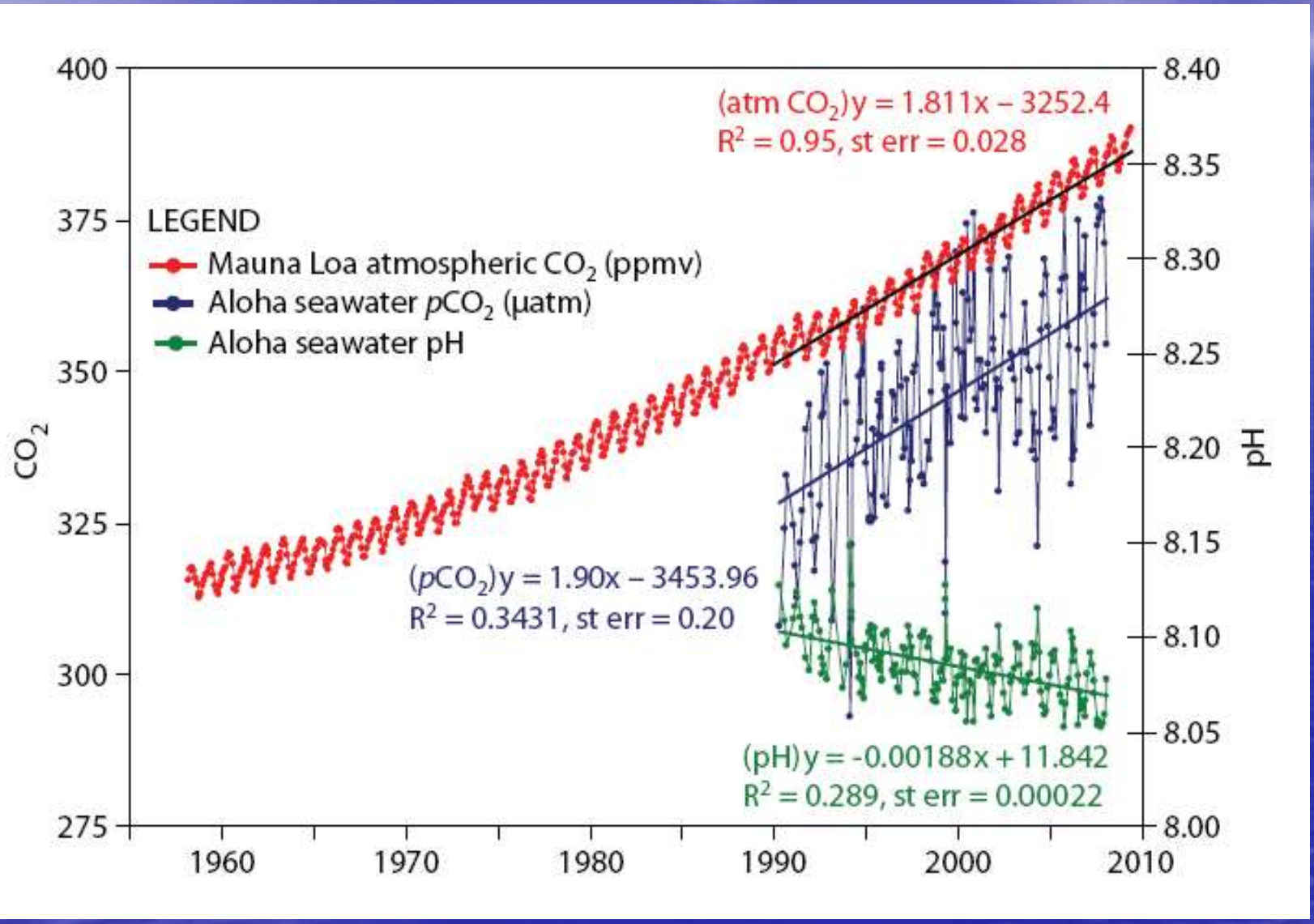
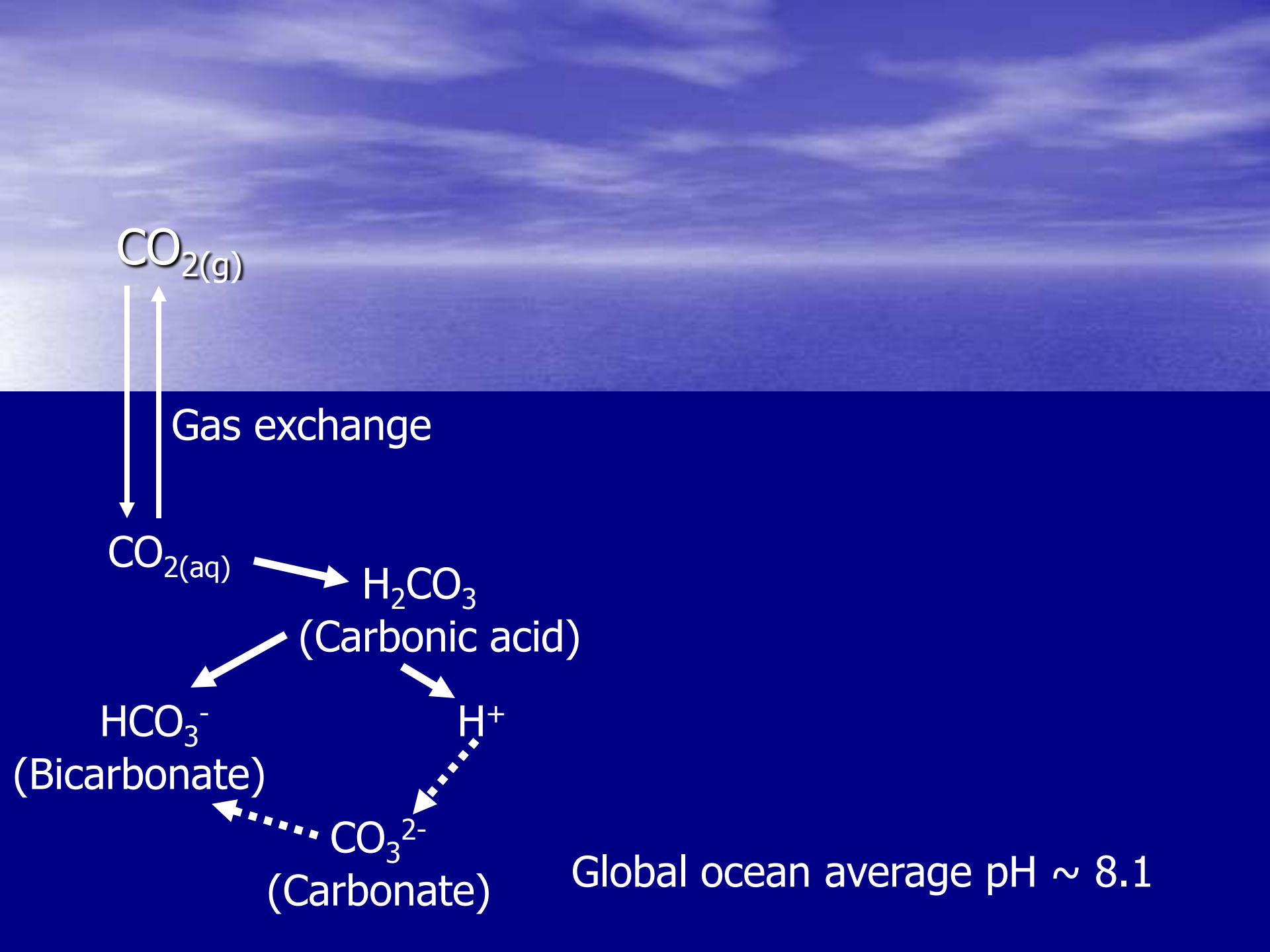
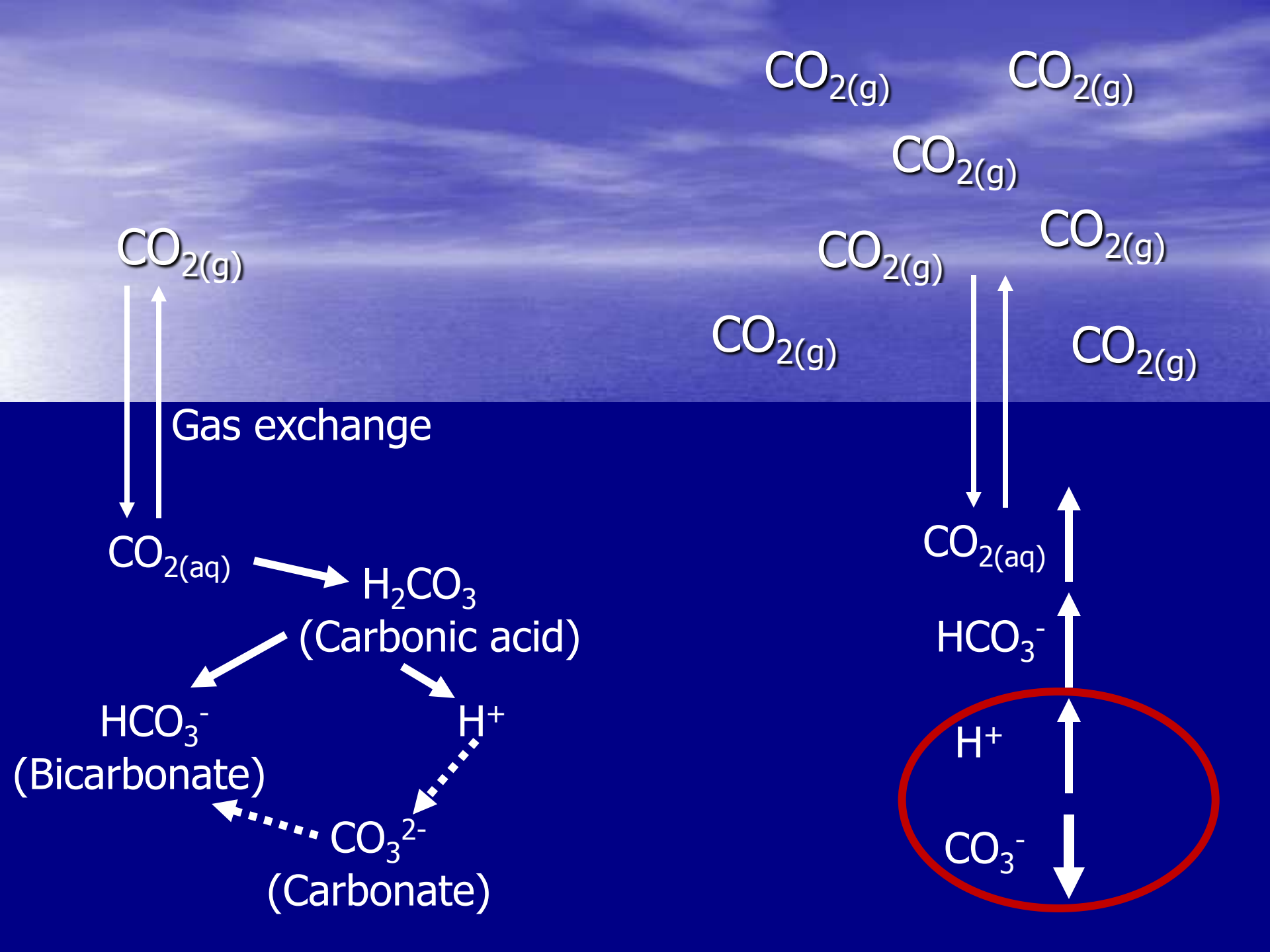


Feely et al. 2009


$CO_{2(g)}$
Gas exchange
$CO_{2(aq)}$
H_2CO_3
(Carbonic acid)
HCO_3^-
(Bicarbonate)
H^+
CO_3^{2-}
(Carbonate)
Global ocean average pH ~ 8.1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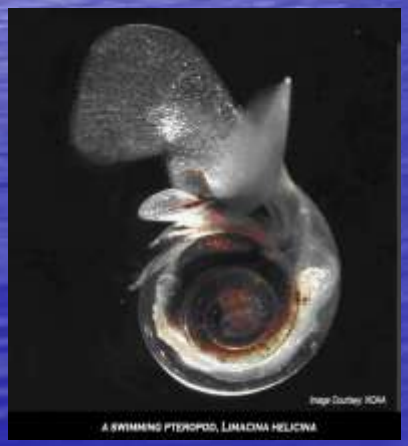
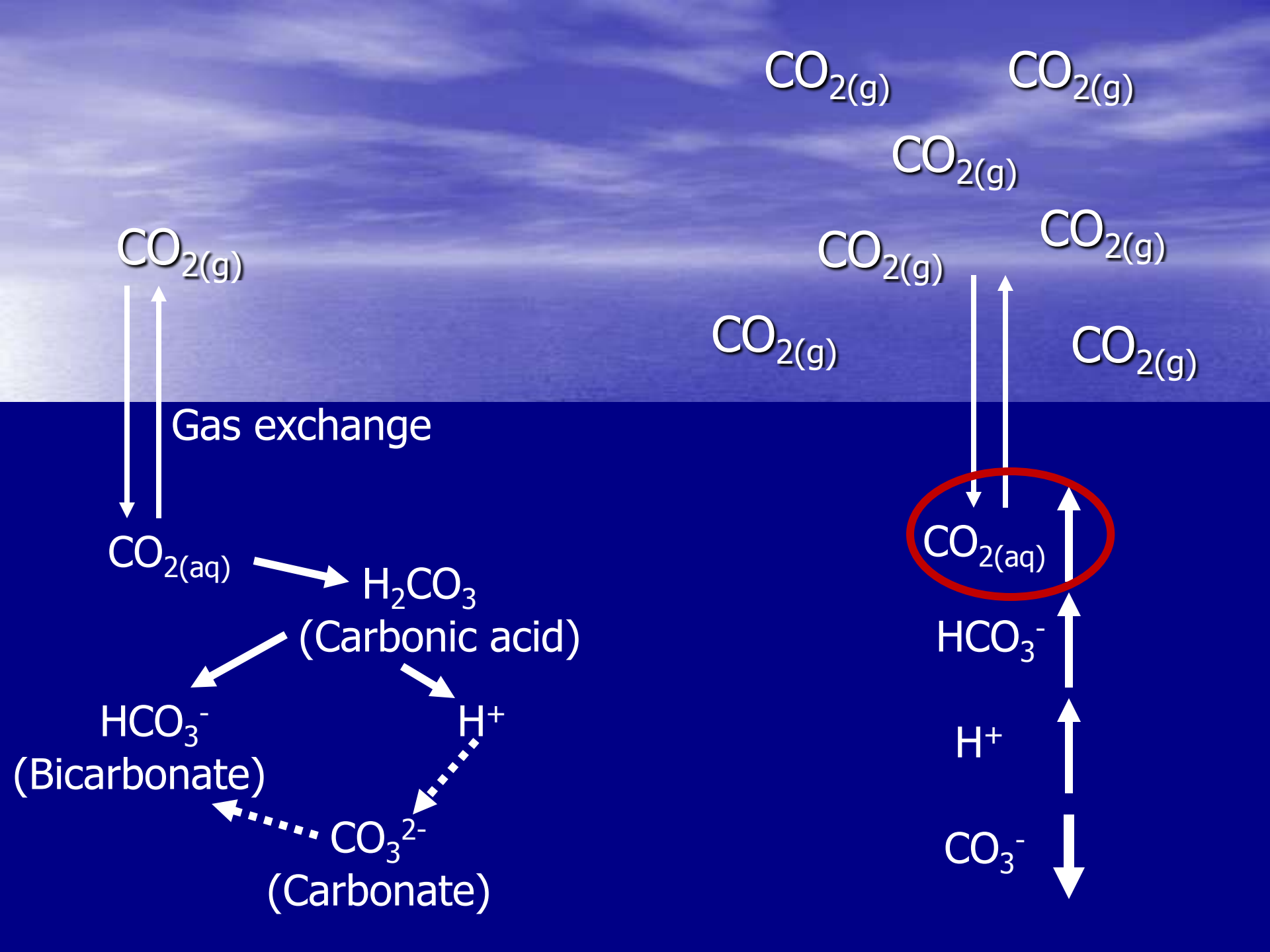
HCO_3^-
H^+
CO_3^-

Formation and dissolution of calcium carbonate

$$Ca^{2+} + CO_3^{2-} \rightleftharpoons CaCO_3$$

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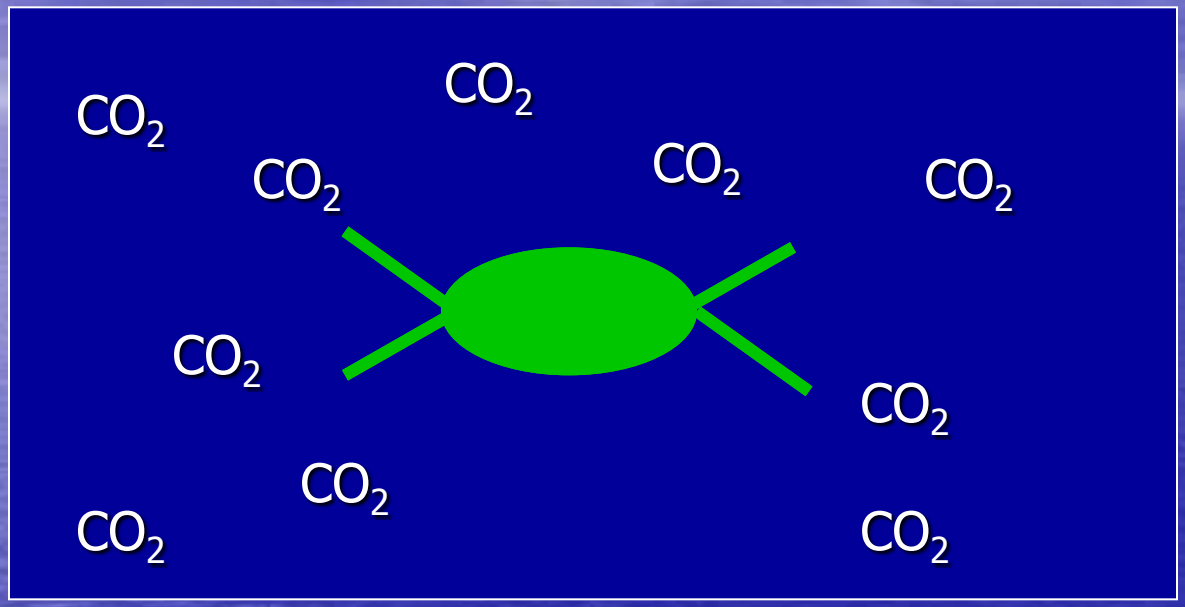
Photosynthesis

$+ \ CO_2 + H_2O \rightleftharpoons CH_2O + O_2$



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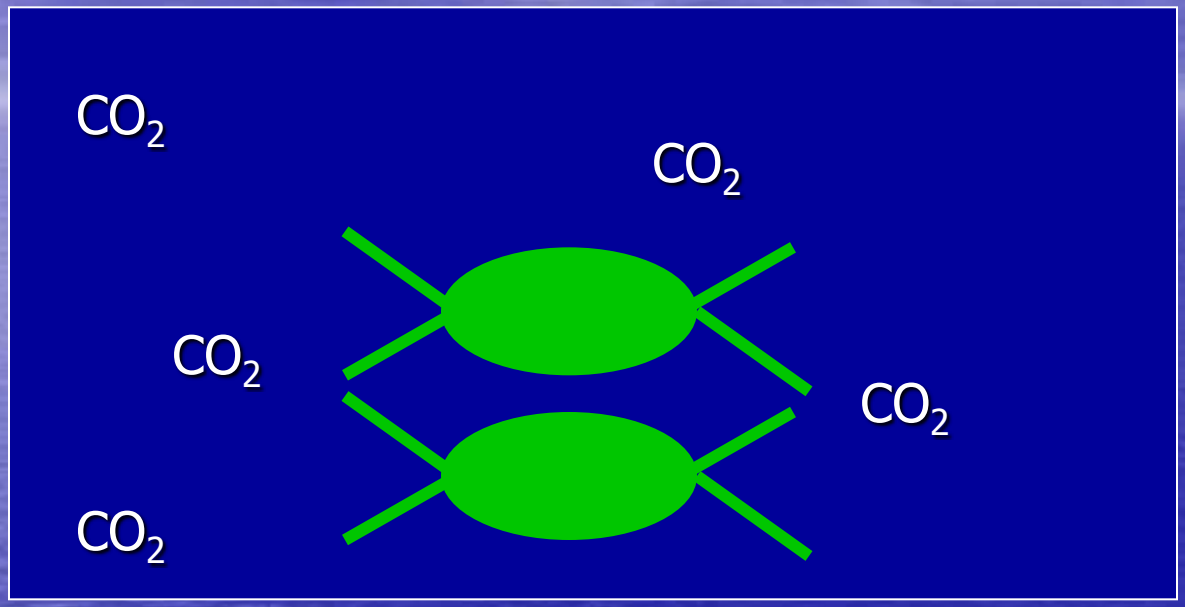


At pH 8.1 dissolved inorganic carbon exists as:

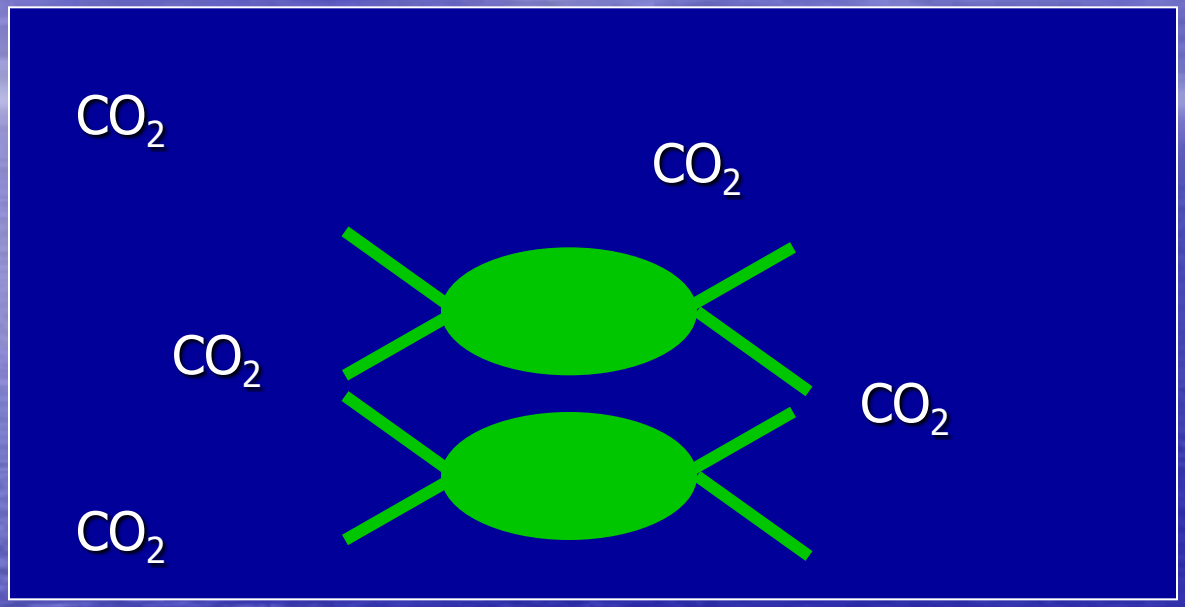
~ 90% HCO_3^-

~ 9% CO_3^{2-}

<1% dissolved inorganic carbon is CO_2

Photosynthesis

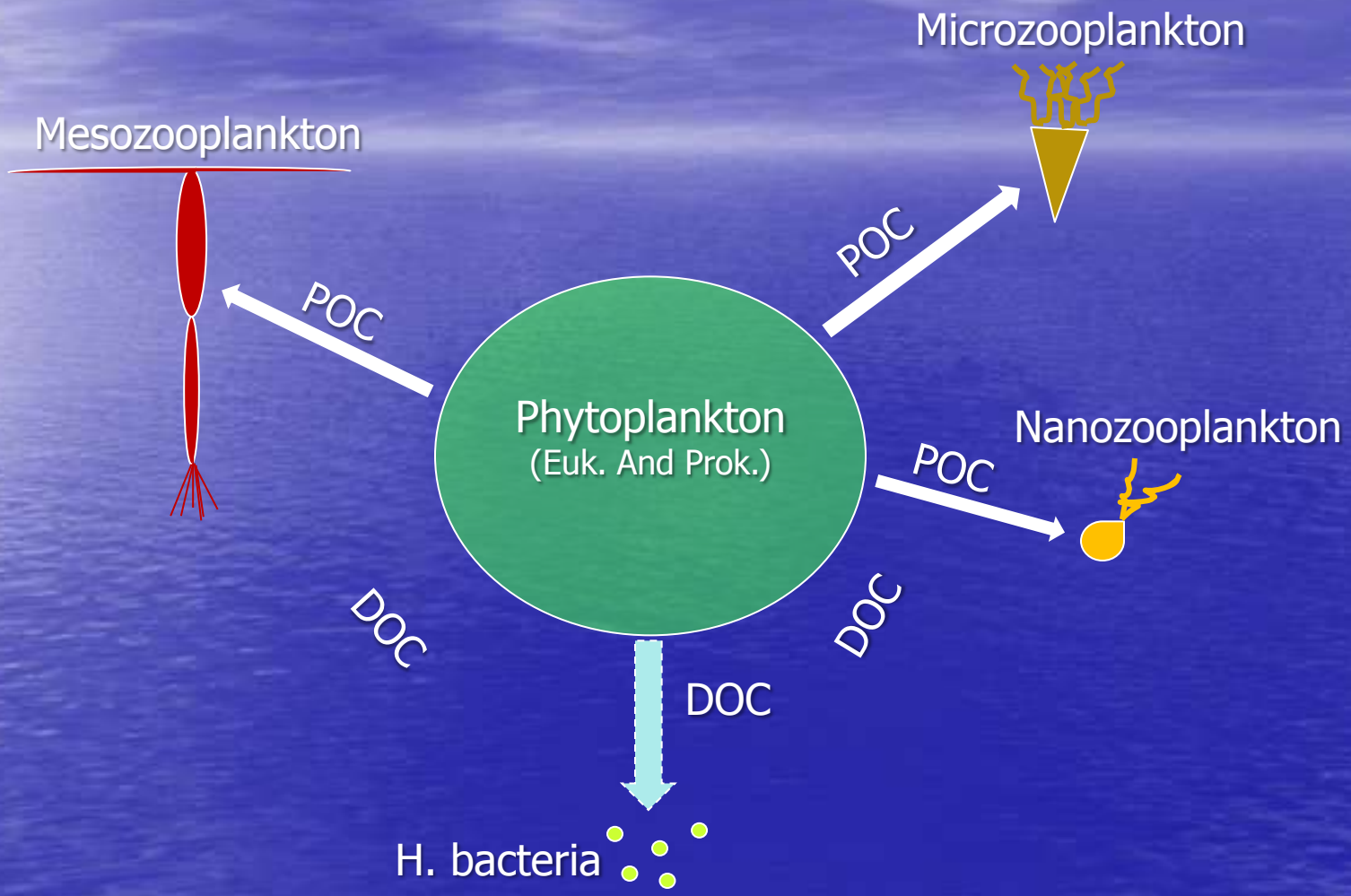
$+ \ CO_2 + H_2O \rightleftharpoons CH_2O + O_2$

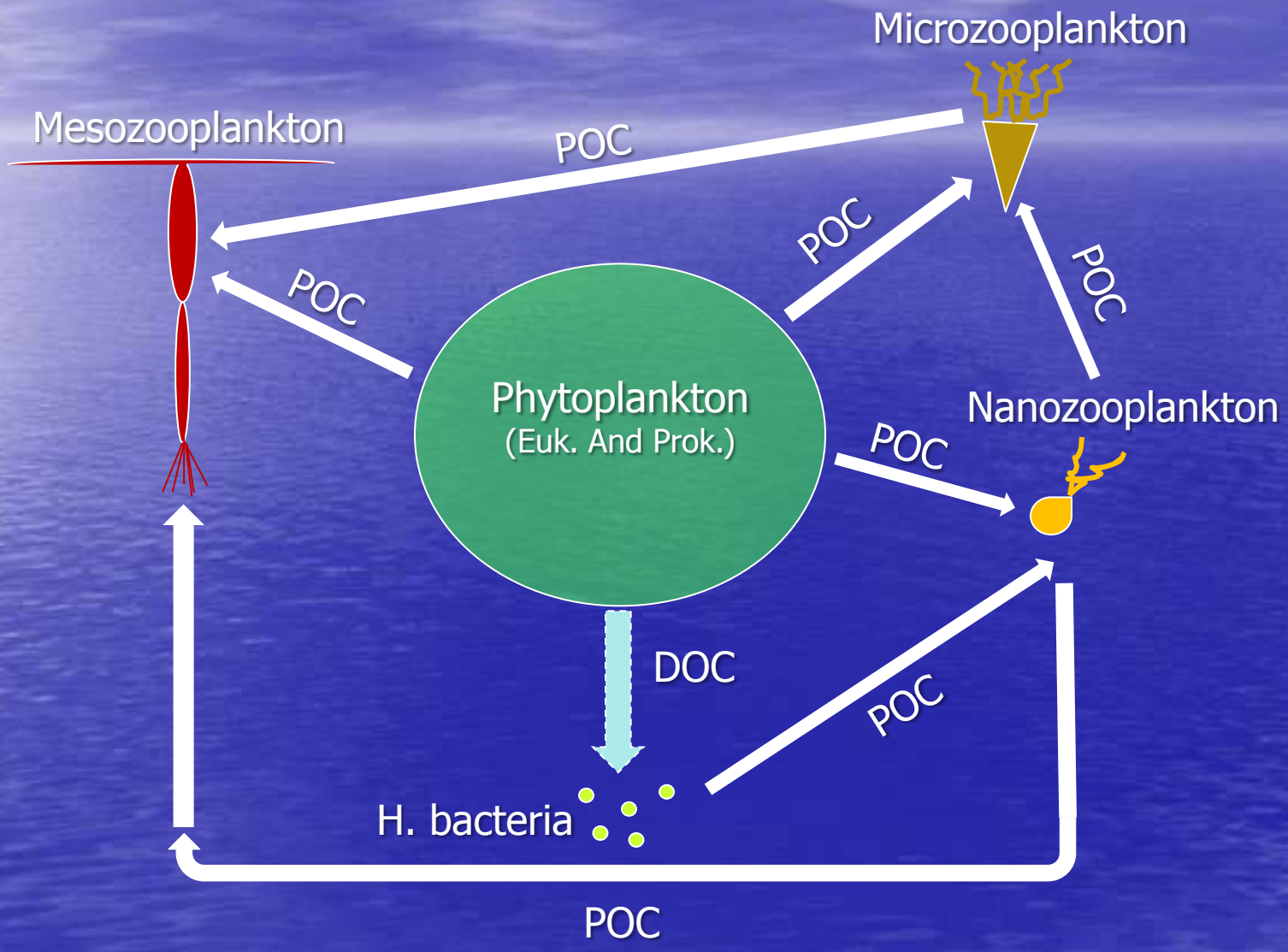


Cellular machinery that 'fixes' CO_2 into simple sugars is typically undersaturated with respect to modern day CO_2 concentrations

Ocean Acidification

Carbon Fertilization


Microzooplankton
Mesozooplankton
POC
POC
Phytoplankton
(Euk. And Prok.)
Nanozooplankton
POC
DOC
DOC
DOC
H. bacteria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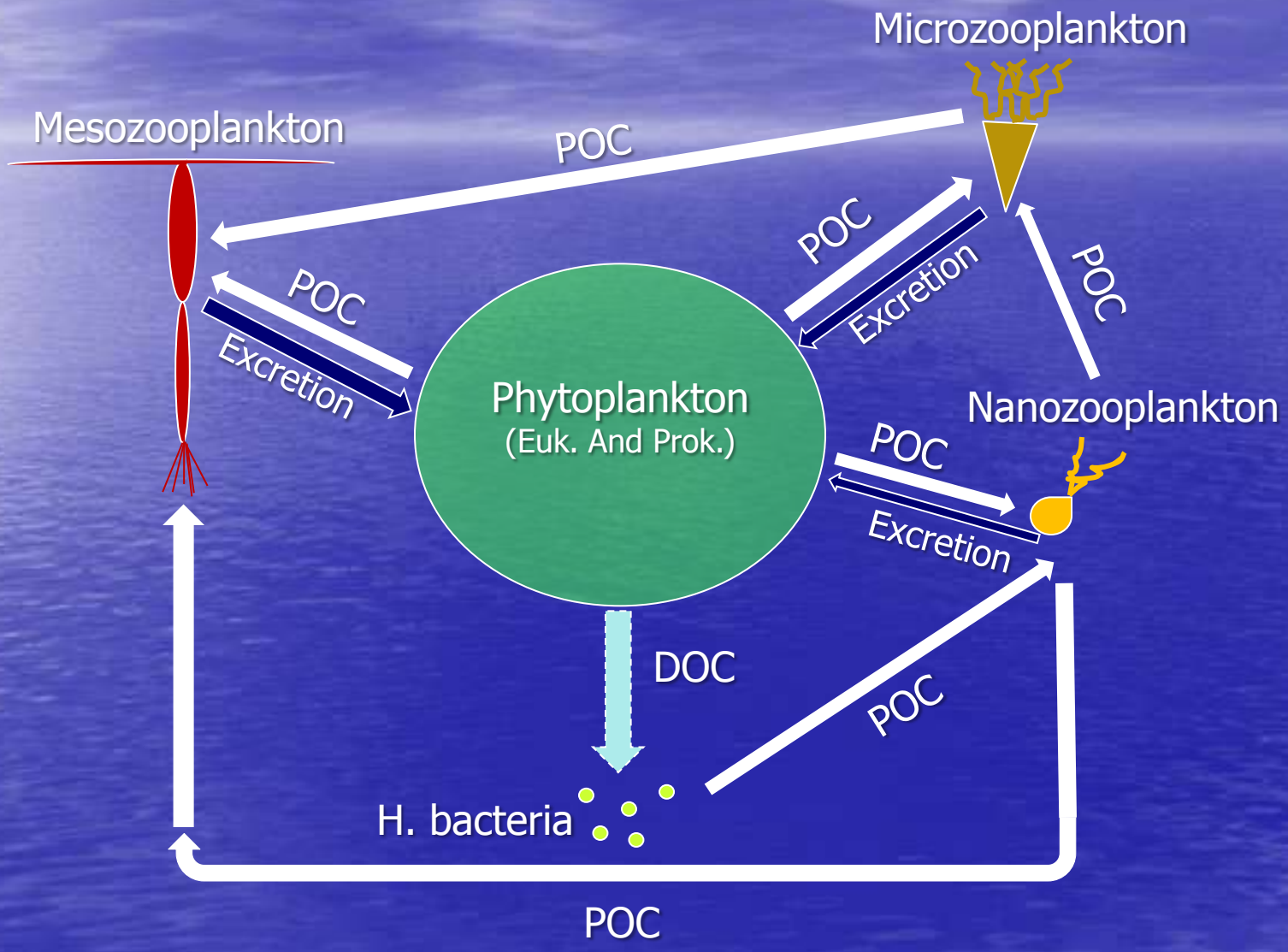
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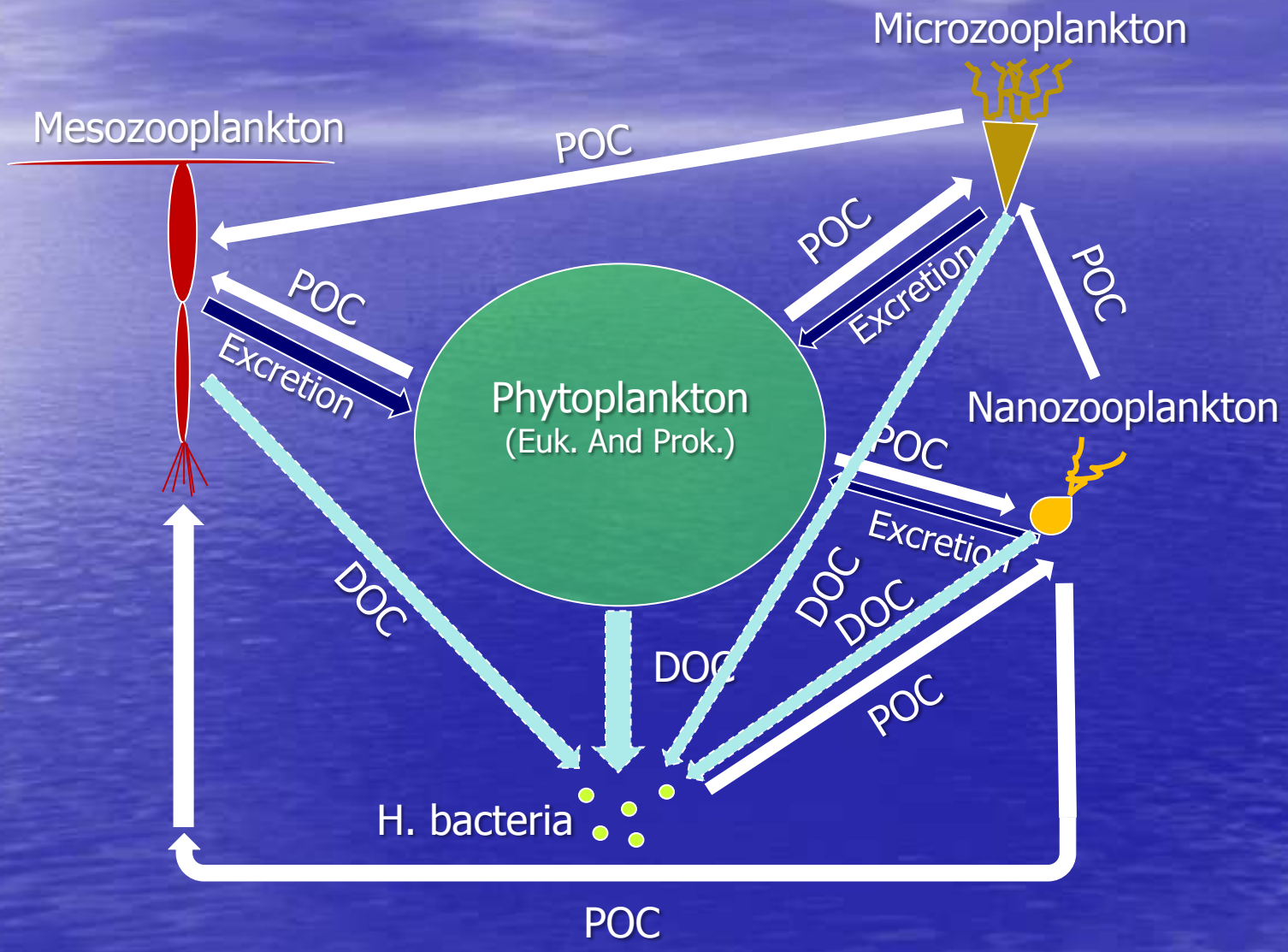
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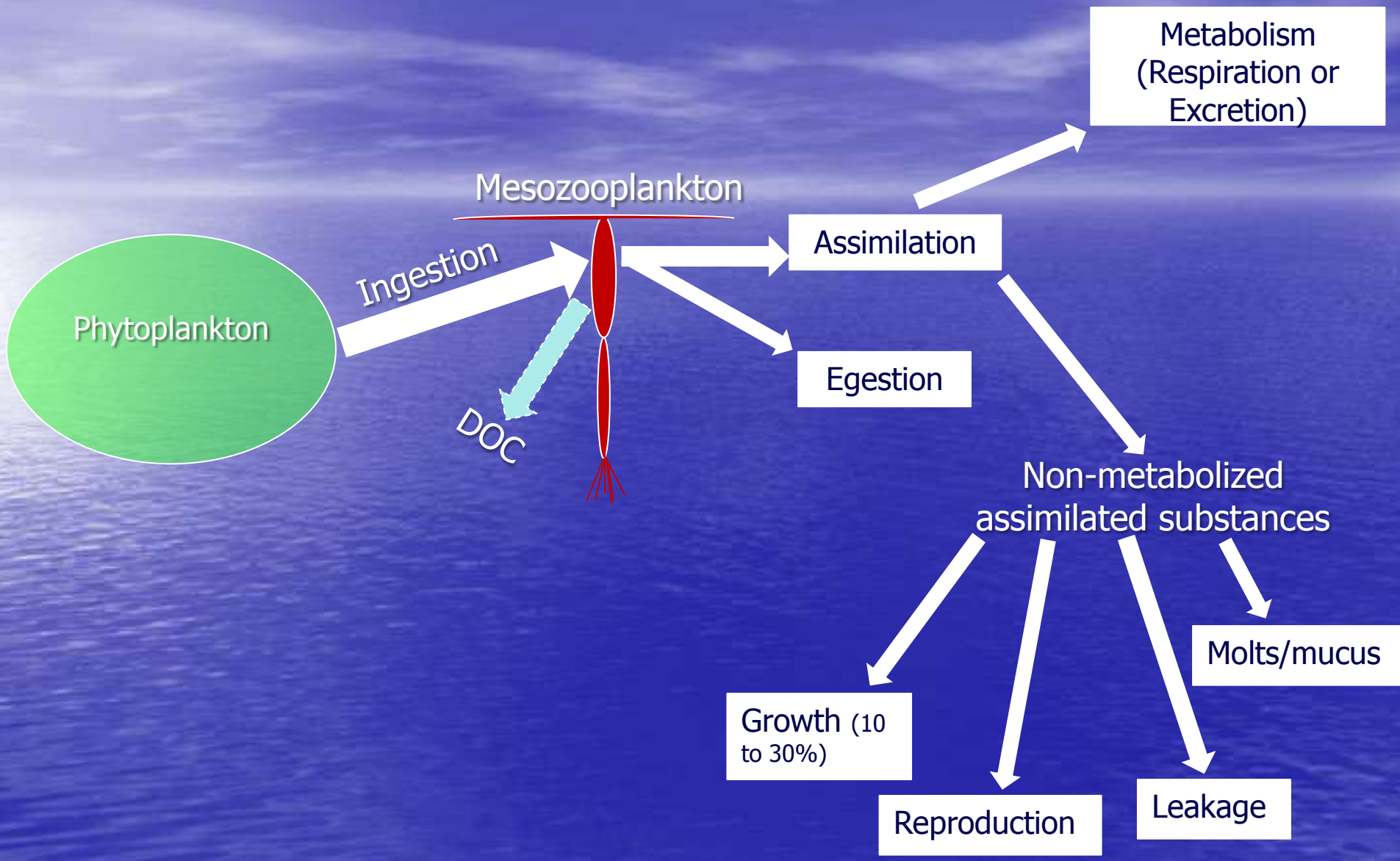
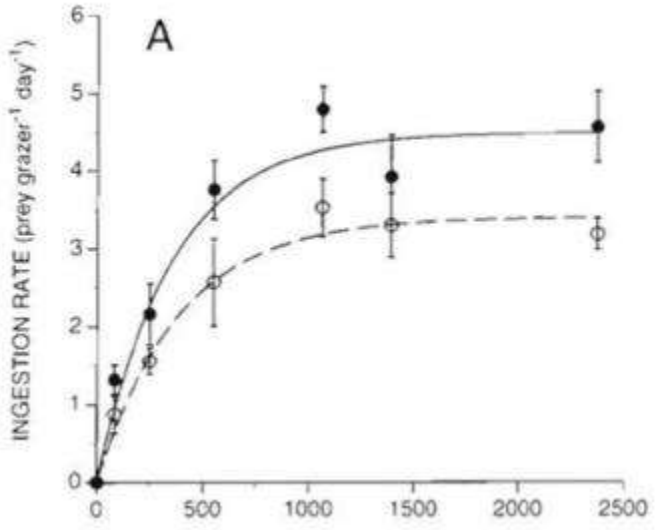
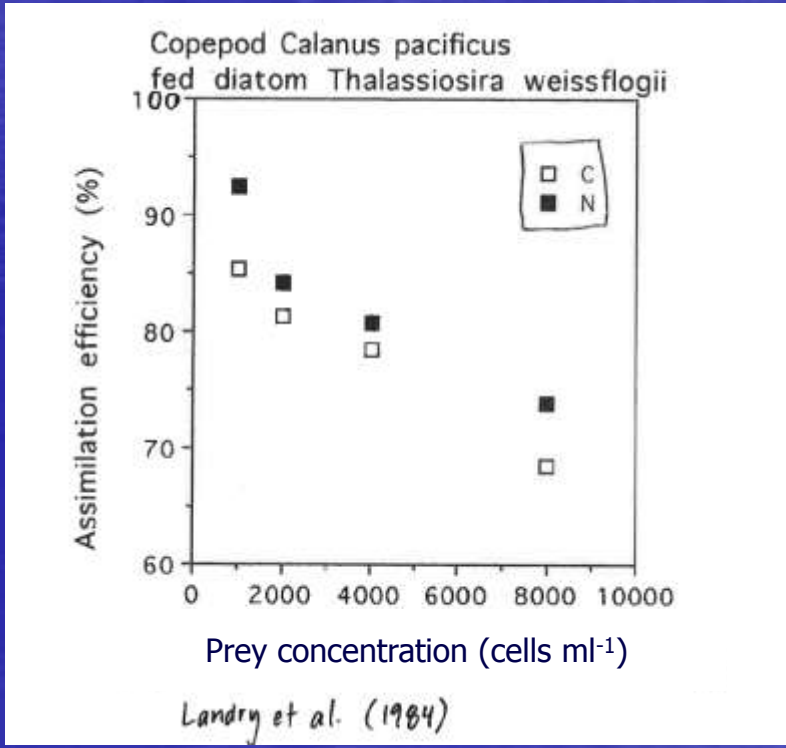

Metabolism (Respiration or Excretion)
Mesozooplankton
Assimilation
Phytoplankton
Ingestion
Egestion
DOC
Non-metabolized assimilated substances
Molts/mucus
Growth (10 to 30%)
Reproduction
Leakage

- Ingestion
  - Prey abundance
  - Prey nutritional quality (C:N:P)
  - Prey growth rate
  - Prey size
  - Prey defense mechanisms

- Assimilation
  - Prey abundance (high or low)
  - Prey nutritional quality (C:N:P)





Planktonic food web structure and function will be affected by ocean acidification

I. Alterations in physiology, rate processes and biochemistry of phytoplankton
    i. Photosynthetic rate
    ii. C:N:P stoichiometry
    iii. Size, cell division rate, defense properties
    iv. Dissolved organic carbon release

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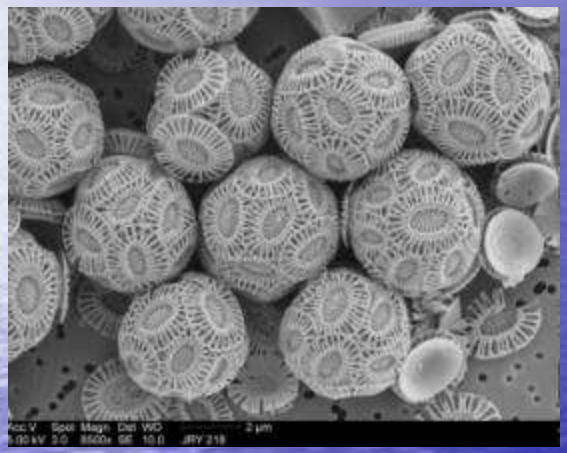
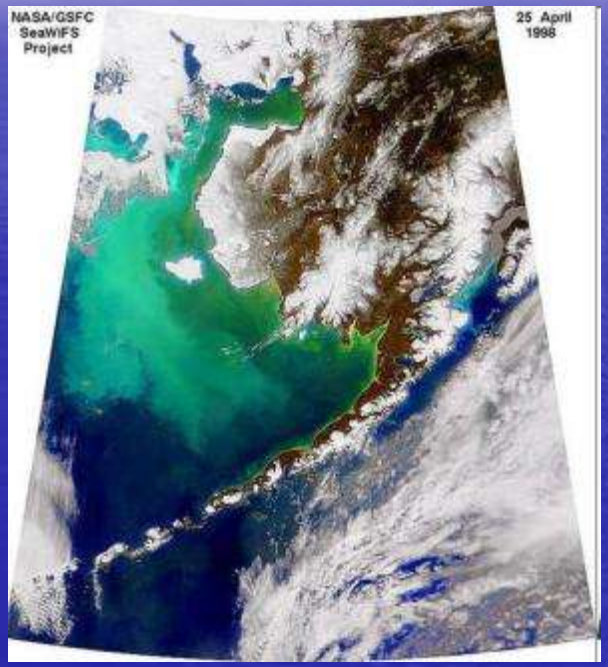
II. Alterations in zooplankton ecology
    i. Feeding and growth rates, assimilation
    ii. Excretion rate, products, stoichiometry

Experiments underway:

- Characterizing physiology and biochemistry of the globally important haptophyte *Emiliania huxleyi* at elevated pCO_2





- Globally abundant, blooms
- Produces $CaCO_3$ as coccoliths
- Chemically defends itself (DMSP)

Experiments underway:

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  - Growth rate
  - C:N
  - Particulate organic carbon (POC) production
  - Particulate inorganic carbon (PIC) production
  - DMSP production
  - Cell size, coccolith structure

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- Feed *E. huxleyi* cultured in different pCO_2 regimes to zooplankton
  - Measure zooplankton grazing and ingestion rate
  - Measure zooplankton growth rate

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- Expose Salish Sea water to elevated pCO_2
  - Measure chlorophyll *a*, pCO_2 and nutrient drawdown daily
  - Measure C:N, community composition and transparent exopolymers at select time points

Mass flow controller

1000 ppm CO_2

Mass flow controller

750 ppm CO_2

Mass flow controller

395 ppm CO_2

CO_2

Air compressor

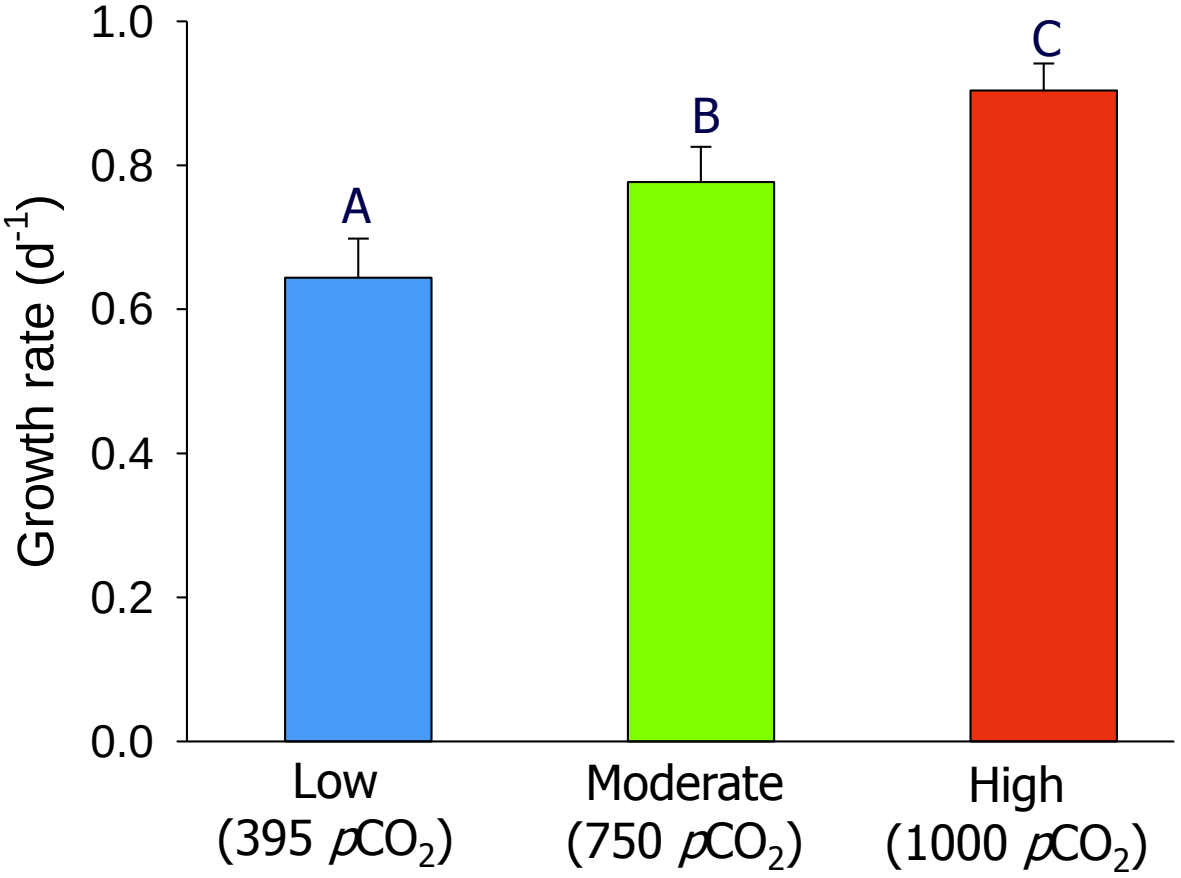
LI-COR CO_2 sensor

Seawater measurements:

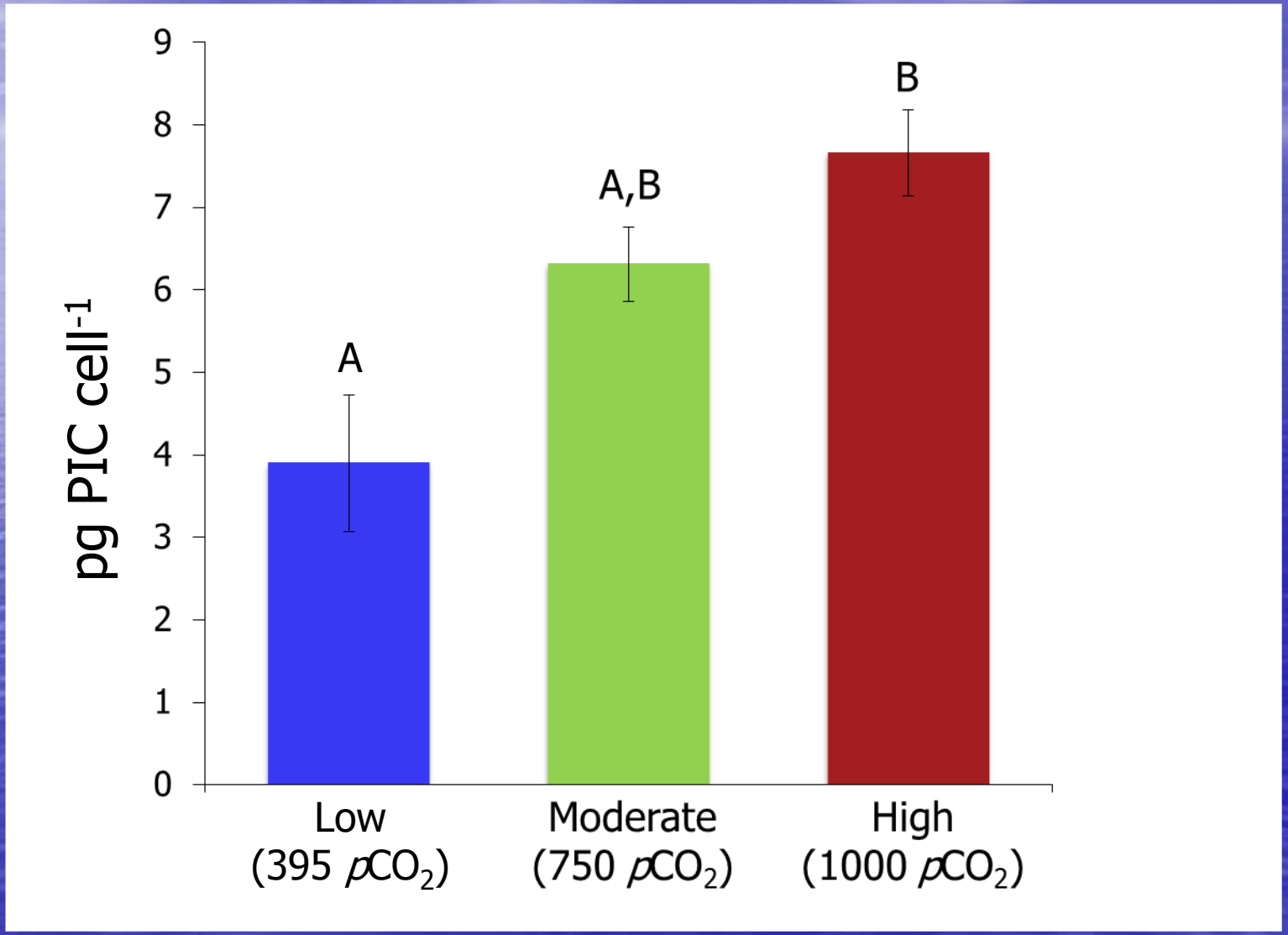
1. Total alkalinity
2. pH

pCO_2

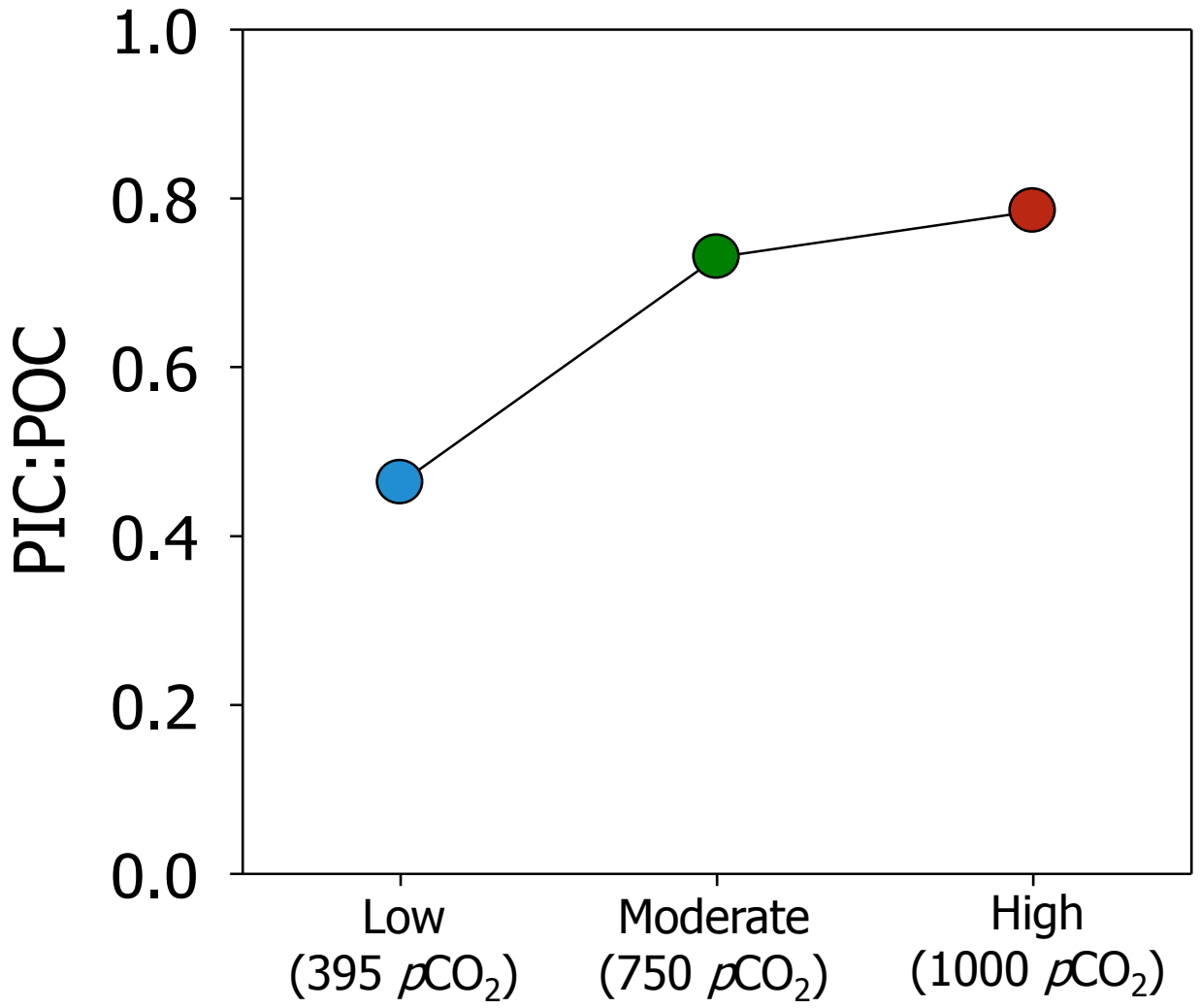
E. Huxleyi grew faster with increasing pCO_2



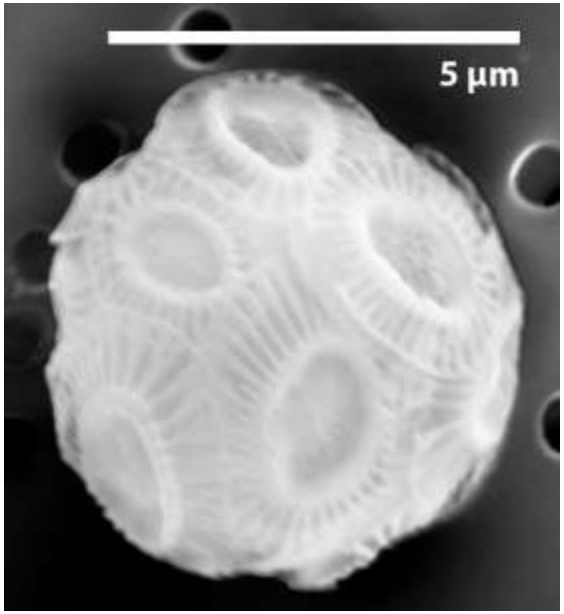
PIC cell^{-1} increased with increasing pCO_2



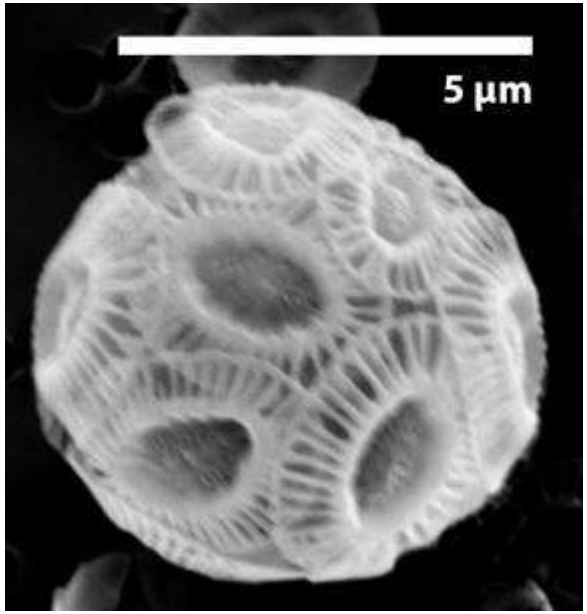
Elevated PIC:POC with elevated pCO_2



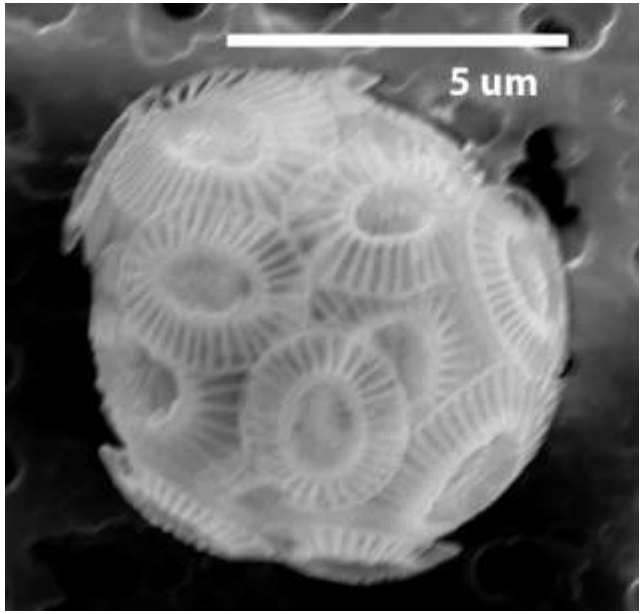
Increasing coccoliths cell^{-1}, cell diameter



Ambient
(395 pCO_2)

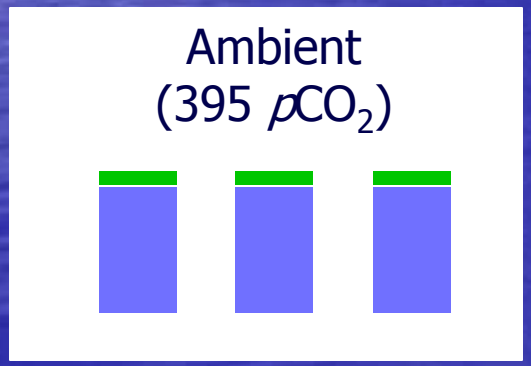


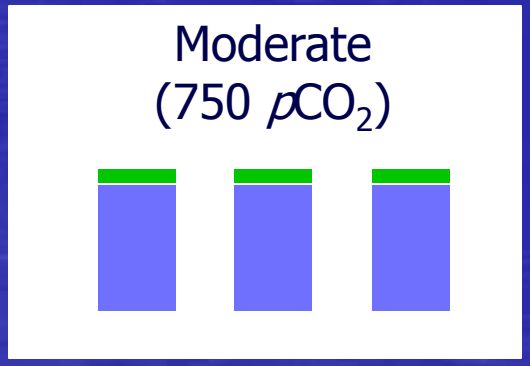
Moderate
(750 pCO_2)

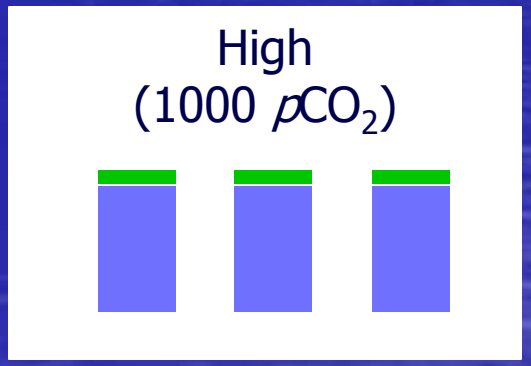


High
(1000 pCO_2)

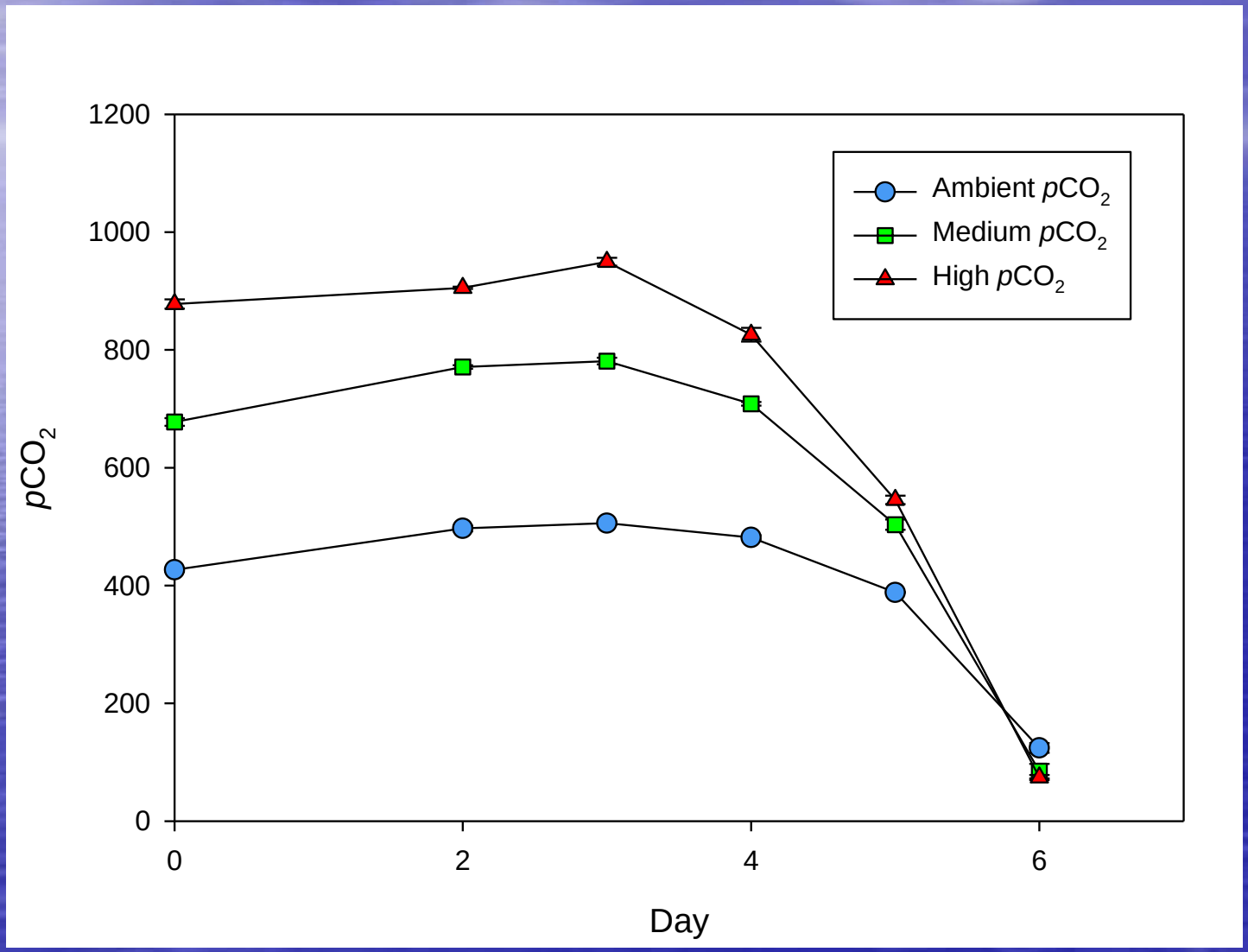
Natural Salish Sea planktonic community experiment



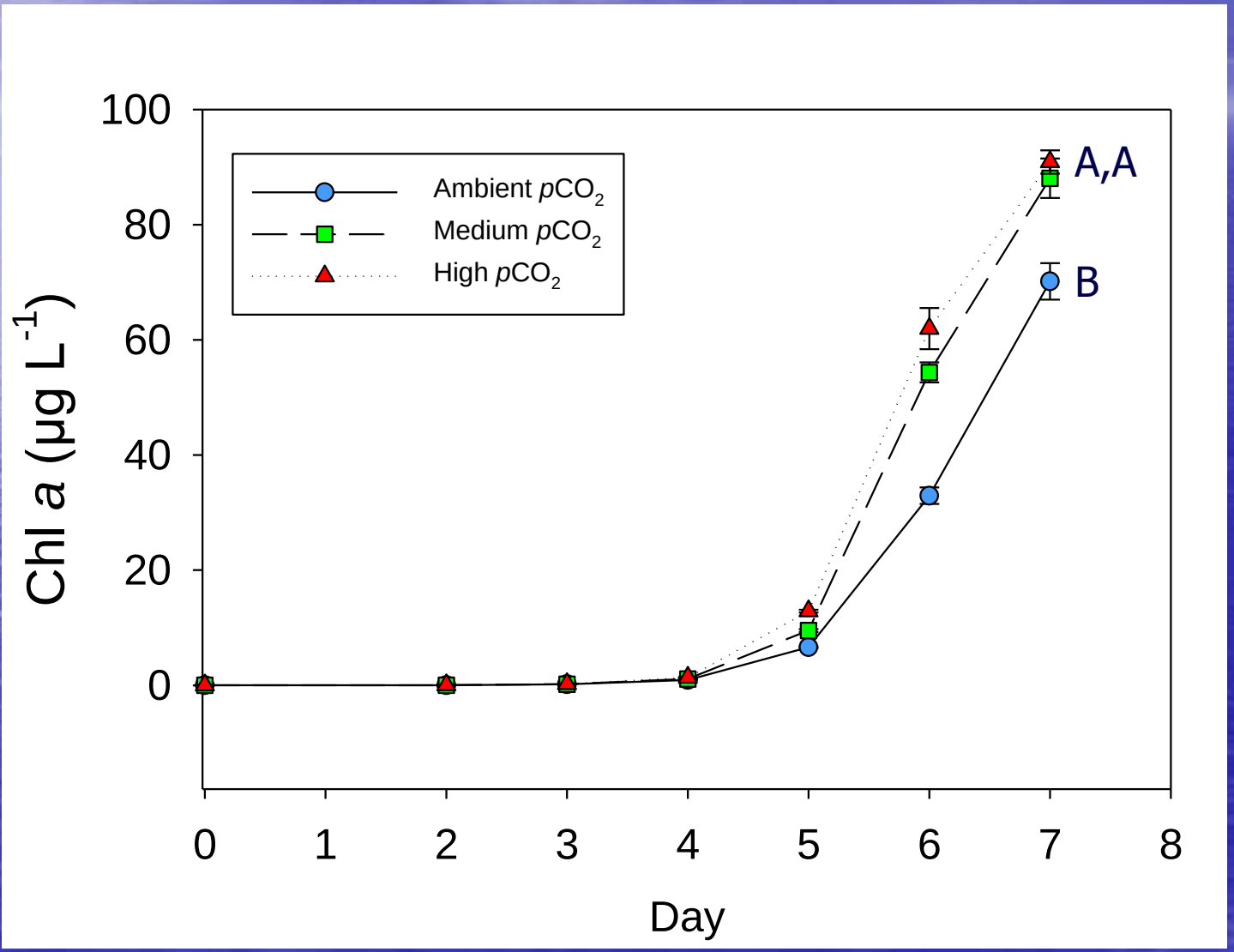




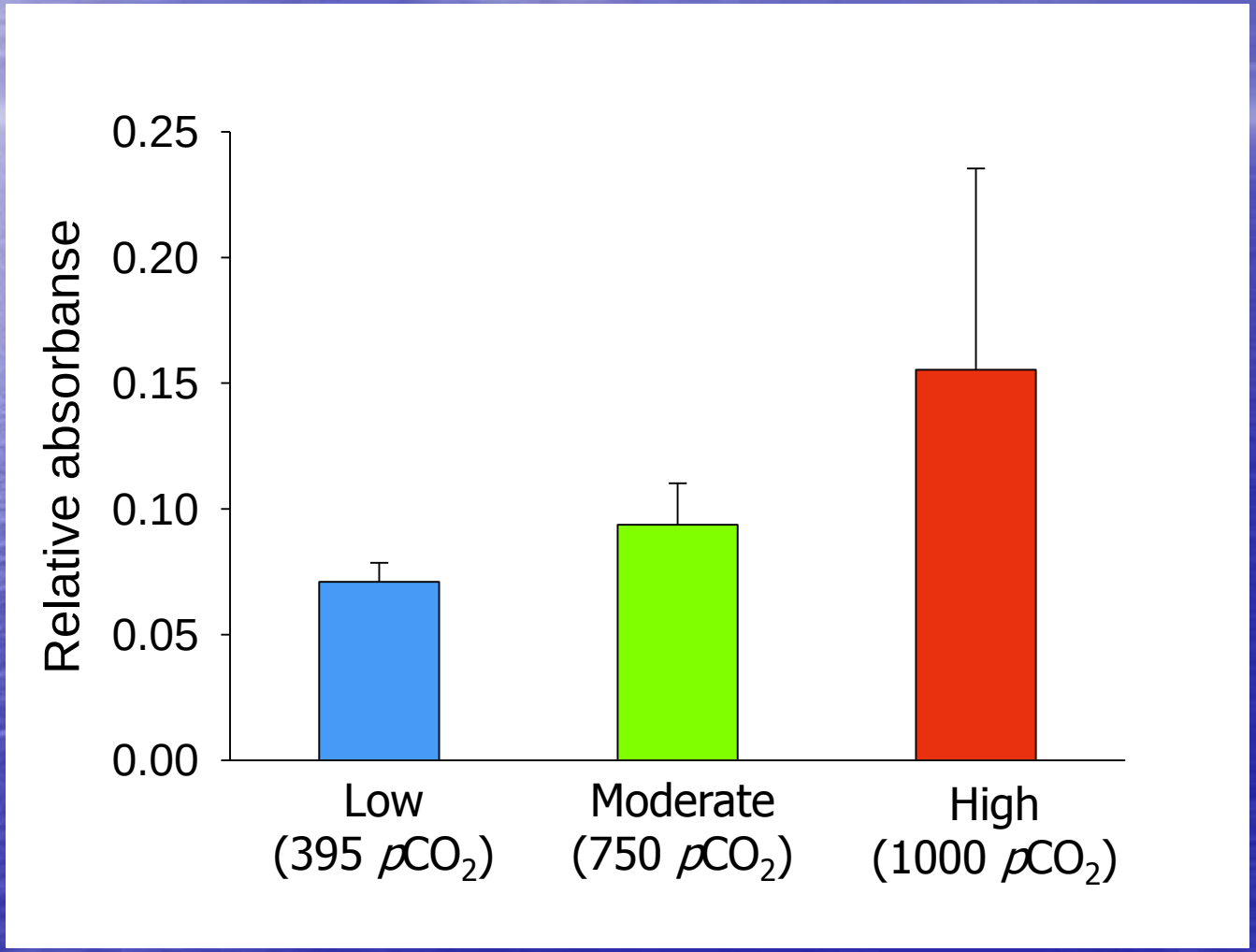
More inorganic carbon drawn down under elevated pCO_2



Significantly more chlorophyll *a* was produced under elevated pCO_2



Plankton community produced more extracellular transparent polymers (TEP) with increasing pCO_2



Conclusions:

- Changes in phytoplankton physiology and biochemistry were/are observed under elevated pCO_2
  - *E. huxleyi*
    - Growth rate, PIC, size, calcification
  - Salish Sea community
    - Higher chlorophyll *a* concentrations, more dissolved inorganic carbon consumed, TEP

- These changes in phytoplankton state are known to induce change in zooplankton grazing and growth rate, and assimilation

- Changes in zooplankton feeding, growth and assimlation, in turn, will affect secondary production and bacterial production

Thanks to my colleagues Brooke Love and Suzanne Strom, many students, NSF and the Shannon Point Marine Center
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