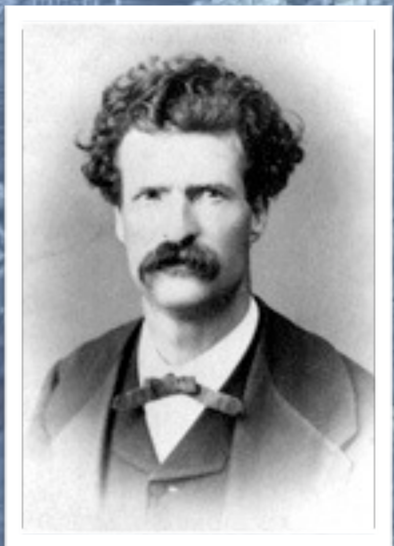
"Now, children, I want you all to sit up just as straight and pretty as you can and give me all your attention for a minute or two. There -- that is it. That is the way good little boys and girls should do ..... I want to tell you how good it makes me feel to see so many bright, clean little faces assembled in a place like this, learning to do right and be good."



Mark Twain - The adventures of Tom Sawyer
Chapter 4 **Showing off in sunday school**
(the superintendent commands attention...)

T.Brey 2013

"Sea life", PL Martin 1884. Illustrierte Naturgeschichte der Thiere. Leipzig.

Can sclerochronology facilitate our understanding of ecosystem function ?

Thomas Brey
Alfred-Wegener-Institut

T.Brey 2013

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T.Brey 2013

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“Sea life”, PL Martin 1884. Illustrierte Naturgeschichte der Thiere. Leipzig.

Ecosystem function?

"Sea life", PL Martin 1884. Illustrierte Naturgeschichte der Thiere. Leipzig.

Ecosystem function !

External Drivers

Climate & Environment

Human Impact

Biota

Biological Processes

Mechanisms: Cause & Effect

Ecological Processes

Complexity & Variability in Space & Time

Ecosystem Functions

Nutrient Recycling — N, P, Fe

Carbon Metabolization — CO_2, C_{org}, $CaCO_3$

Living Resources

Biodiversity

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“Sea life”, PL Martin 1884. Illustrierte Naturgeschichte der Thiere. Leipzig.

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The ecologist's major challenges

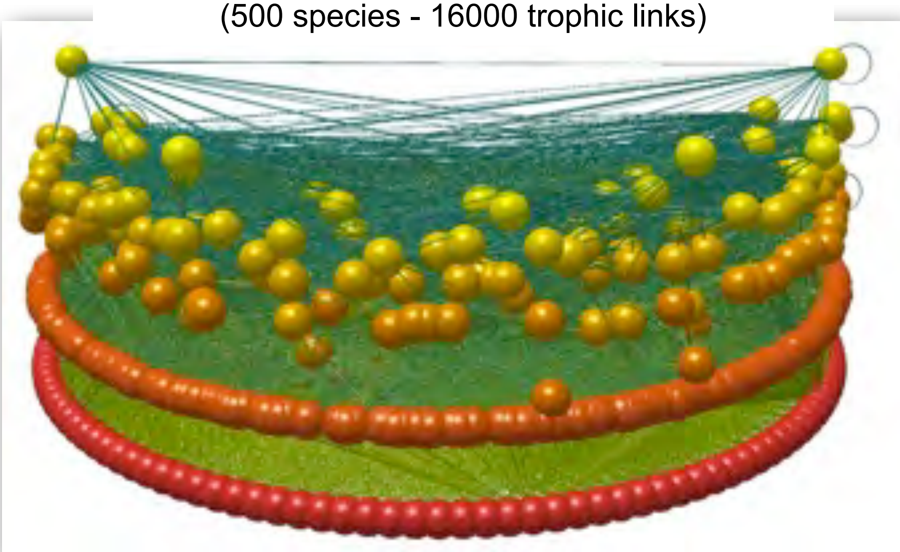
The ecologist's major challenges

- **Understanding todays aquatic ecosystems**

The ecologist's major challenges

- Understanding todays aquatic ecosystems

Always trouble with system complexity



The ecologist’s major challenges

- **Understanding todays aquatic ecosystems**

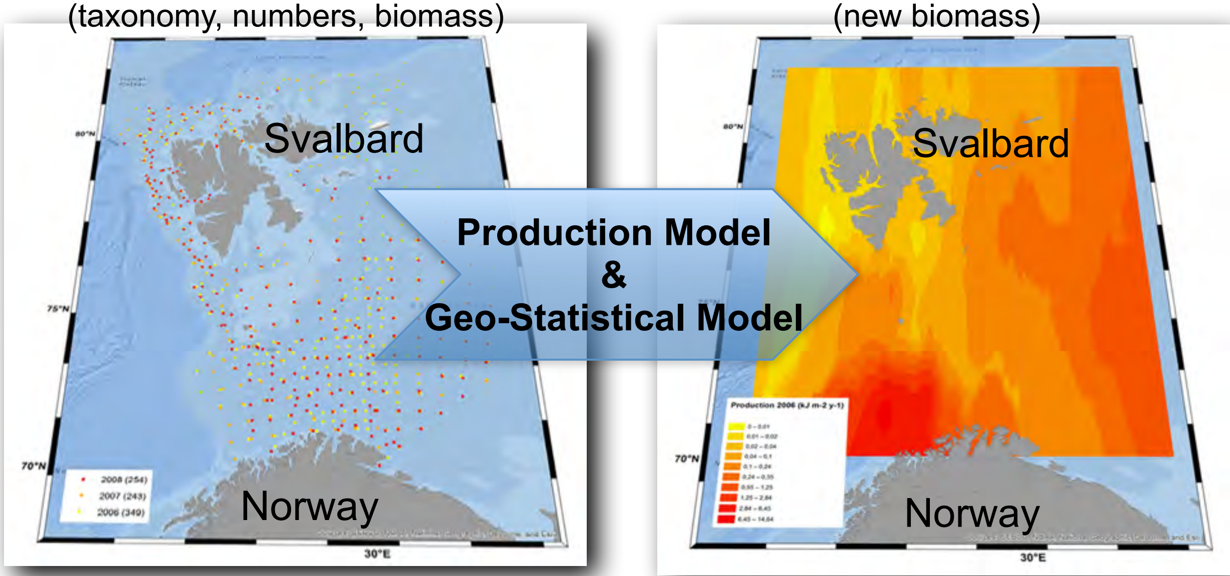
Always trouble with

system complexity

spatial heterogenity

Station Grid
(taxonomy, numbers, biomass)

Benthic Production
(new biomass)



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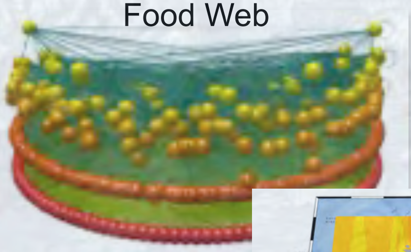
Sunday, 26 May 13

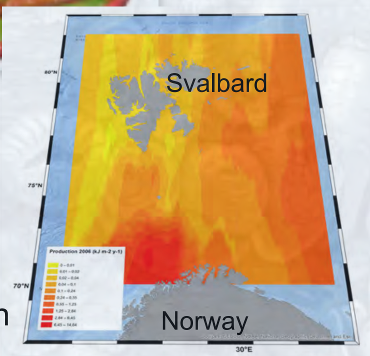
The ecologist’s major challenges

- **Understanding todays aquatic ecosystems**
- **Anticipating the future of aquatic ecosystems**

Always trouble with
system complexity
spatial heterogenity

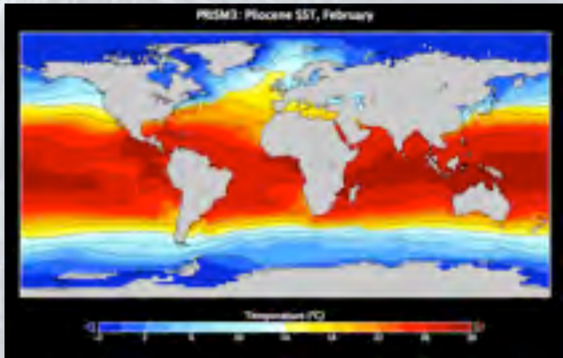
Food Web





Benthic Production

SST Today



The ecologist's major challenges

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Always trouble with
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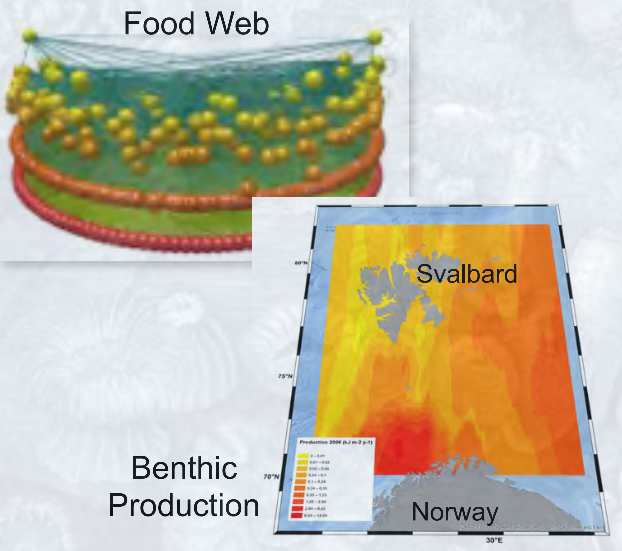
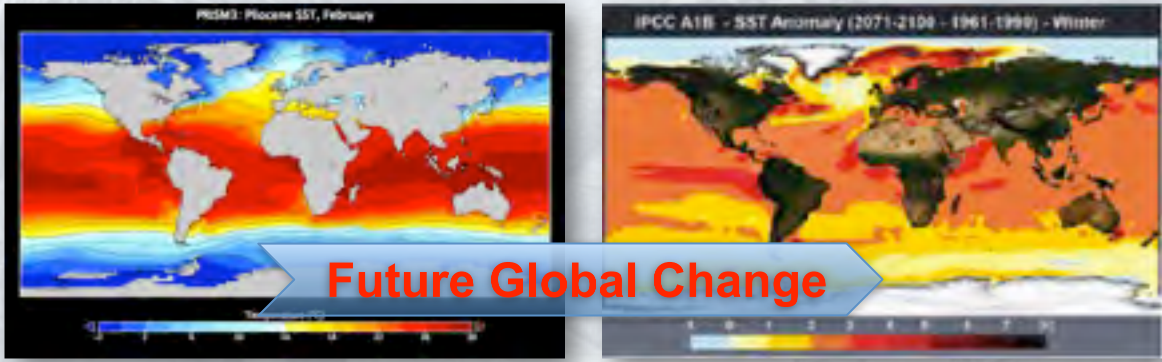


SST Today

SST Anomaly 2100 - Today



The ecologist’s major challenges

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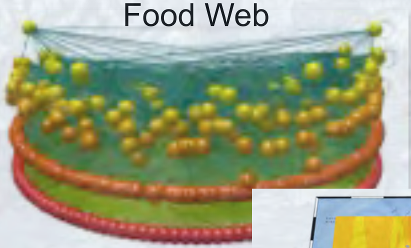

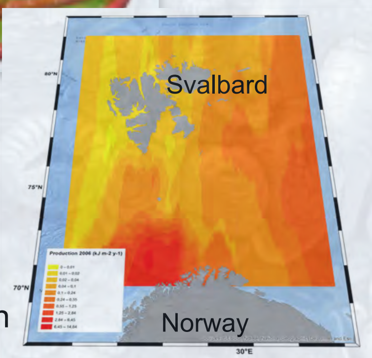

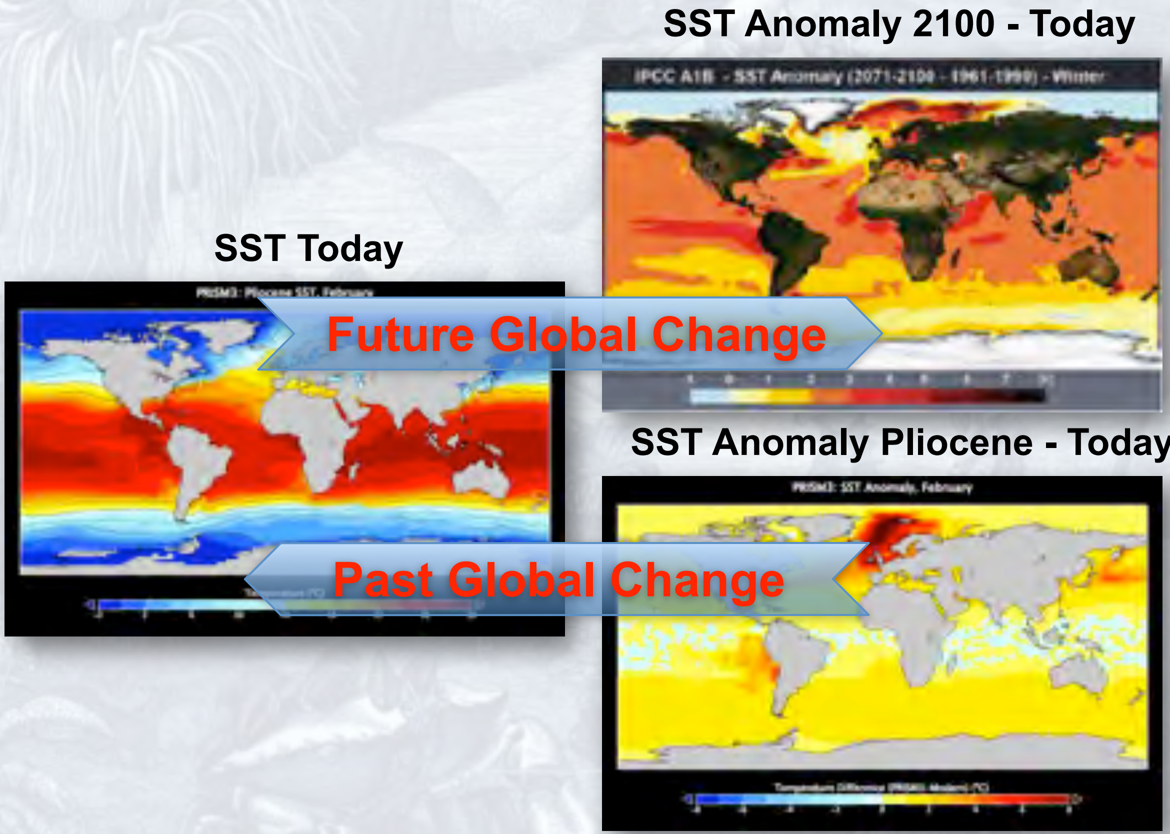

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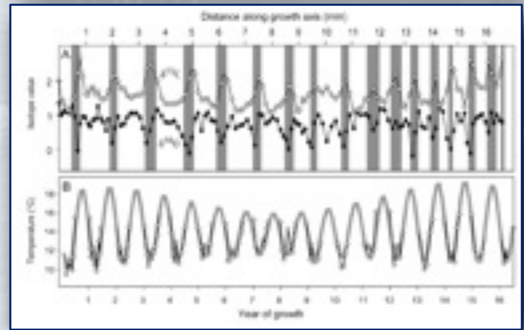
Where sclerochronology has a role:

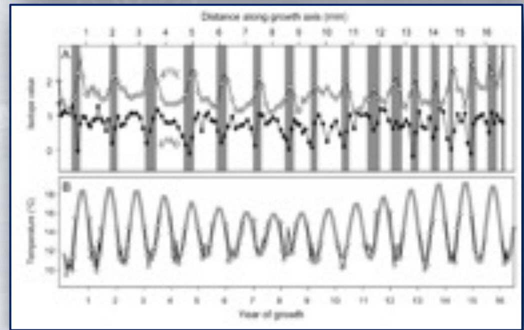
Where sclerochronology has a role:

Environmental Archive

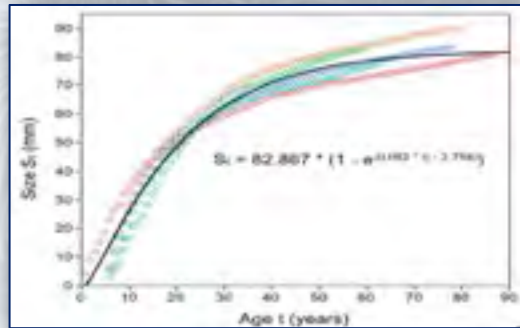


Where sclerochronology has a role:

Environmental Archive



Individual Growth



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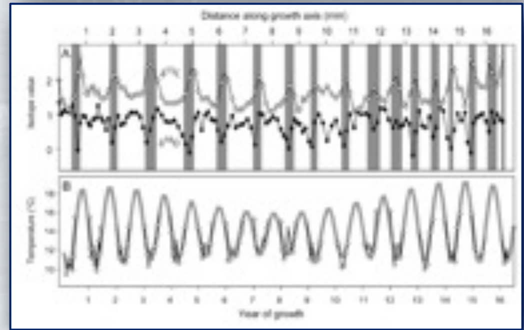

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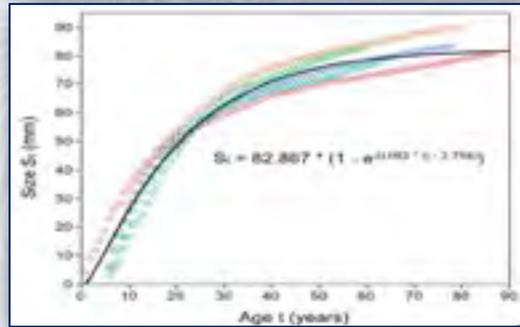
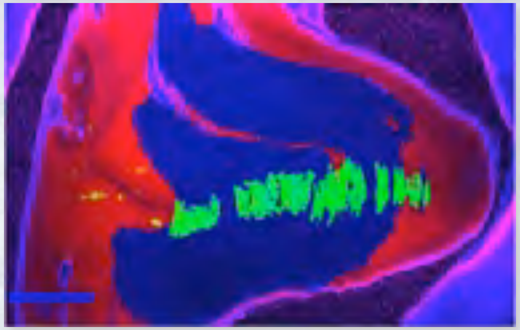


Shell Formation



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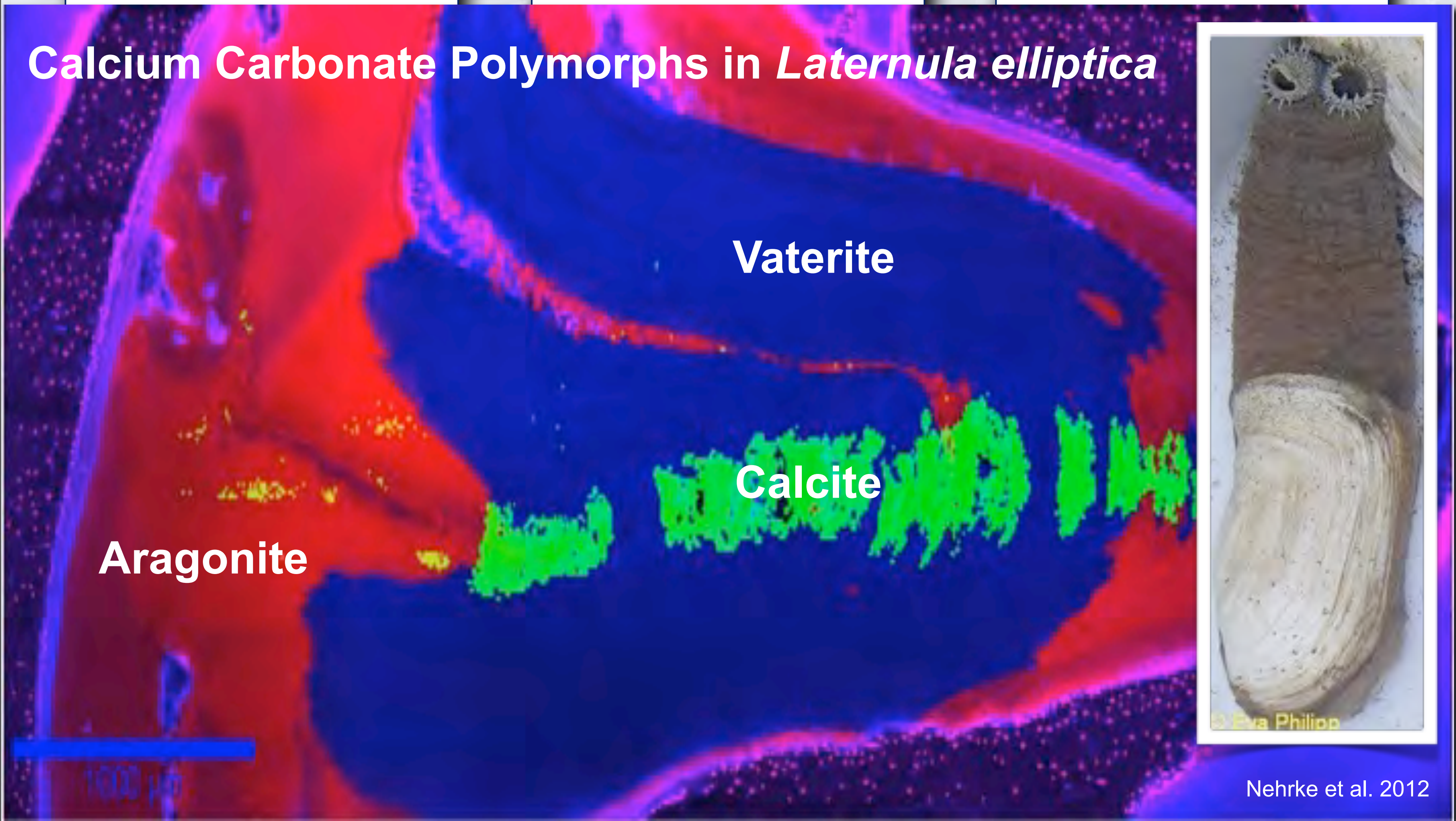
Sunday, 26 May 13

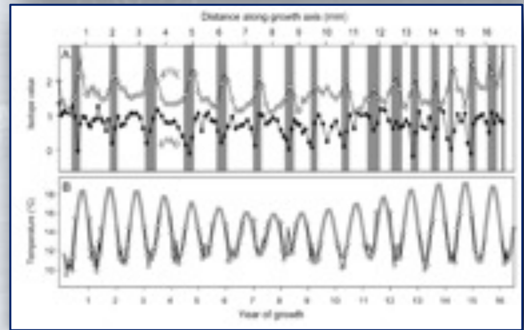
Where sclerochronology has a role:

Environmental Archive	Individual Growth	Shell Formation



Where sclerochronology has a role:

Environmental Archive



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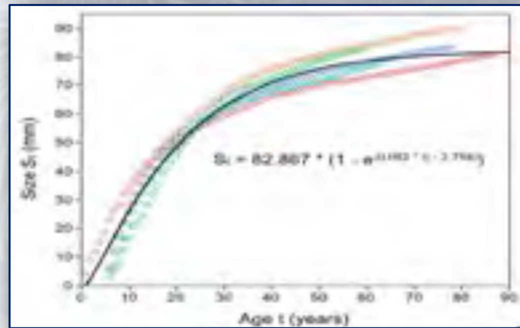
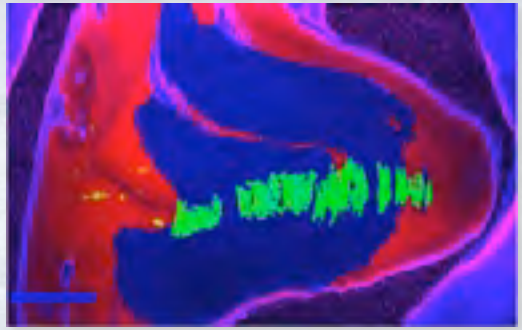


Shell Formation

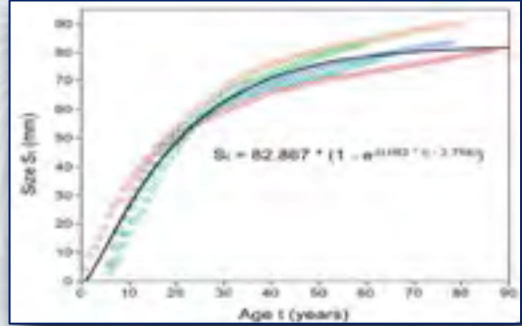


Where sclerochronology has a role:

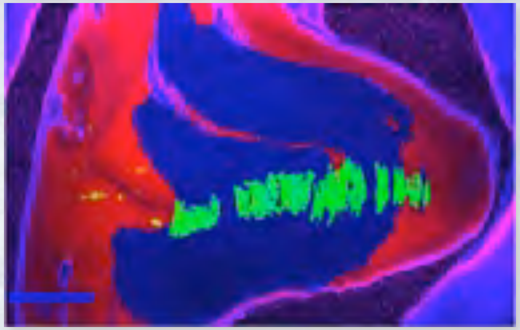
Environmental Archive

(Paleo-) Environment
- **High Resolution**
- **Archive Diversity**

Individual Growth



Shell Formation



Where sclerochronology has a role:

Environmental Archive

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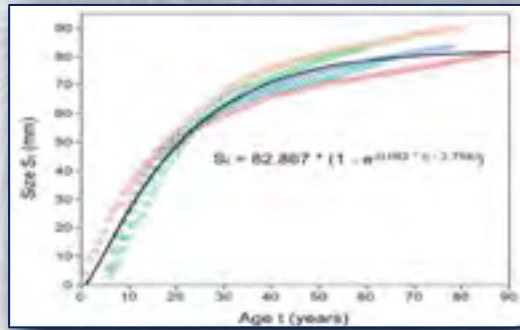
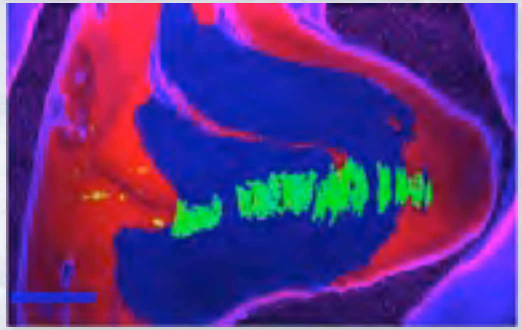
Ocean & Ecosystem Dynamics

Pollution

Individual Growth



Shell Formation



Where sclerochronology has a role:

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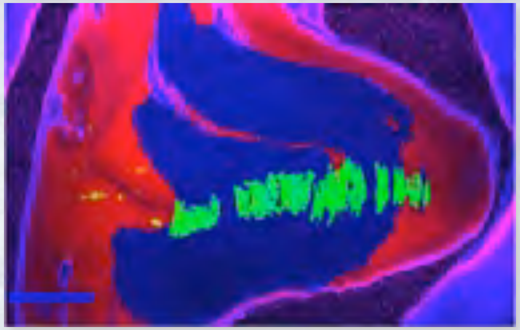
Ocean & Ecosystem Dynamics

Pollution

Individual Growth

Population Dynamics
- **Production**
- **Energy Budget**

Shell Formation



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Ocean & Ecosystem Dynamics

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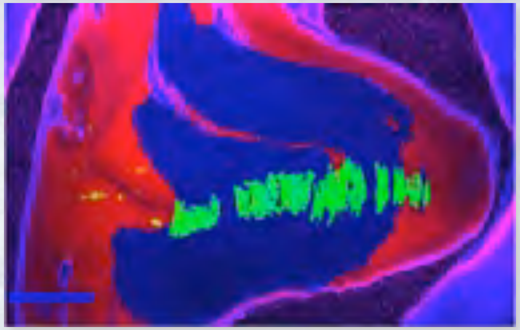
Individual Growth

Population Dynamics
- **Production**
- **Energy Budget**

Food Web
Living Resources

Shell Formation



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Ocean & Ecosystem Dynamics

Pollution

Individual Growth

Population Dynamics
- **Production**
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Food Web
Living Resources

Shell Formation

Ecophysiology
- **Calcification**
- **Energy Allocation**

Where sclerochronology has a role:

Environmental Archive

(Paleo-) Environment
- High Resolution
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Ocean & Ecosystem Dynamics

Pollution

Individual Growth

Population Dynamics
- Production
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Food Web
Living Resources

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Evolution & Biogeography

Where sclerochronology has a role:

Environmental Archive

Individual Growth

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Population Dynamics
- Production
- Energy Budget

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Ocean & Ecosystem Dynamics

Food Web Living Resources

Evolution & Biogeography

Pollution

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Case 1: Paleo - ecosystem dynamics: from growth to energy budget

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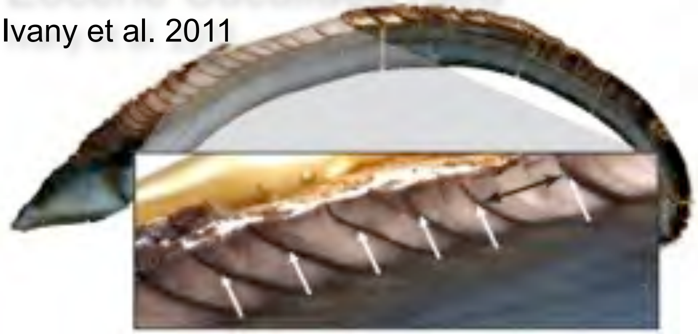
Sunday, 26 May 13

Case 1: Paleo - ecosystem dynamics: from growth to energy budget

Eocene *Cucullaea raea*

Ivany et al. 2011



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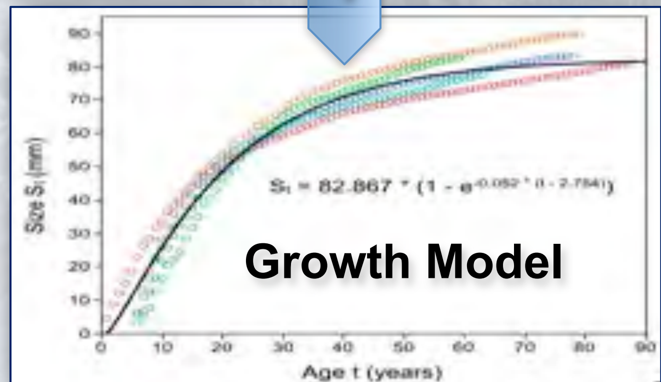
Case 1: Paleo - ecosystem dynamics: from growth to energy budget

Eocene *Cucullaea raea*
Ivany et al. 2011

1



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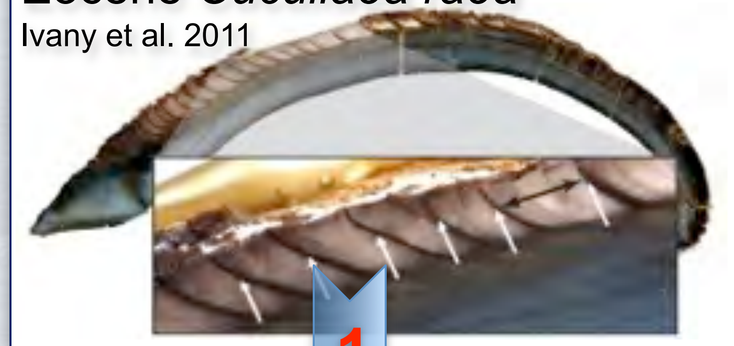

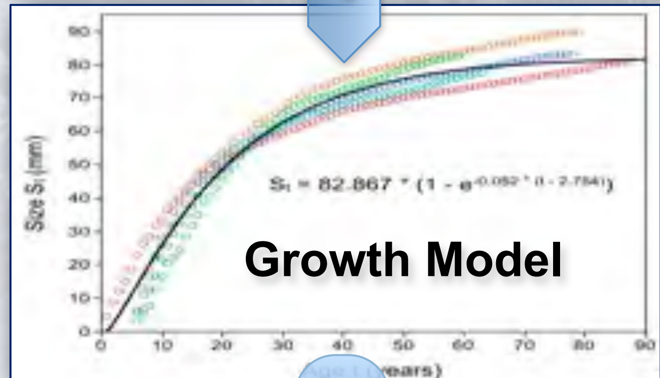

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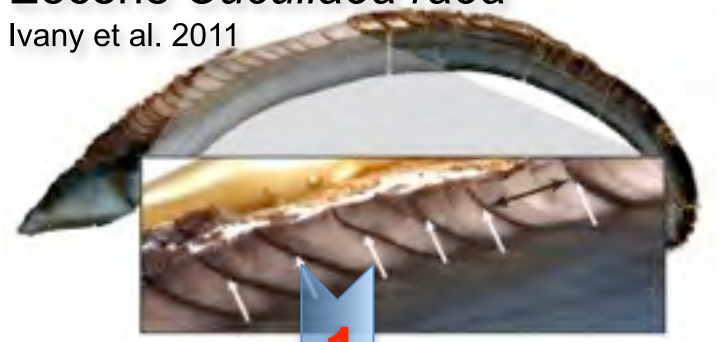
Size - Mass - Relationship

(Recent Con-Species)

Case 1: Paleo - ecosystem dynamics: from growth to energy budget

Eocene *Cucullaea raea*

Ivany et al. 2011



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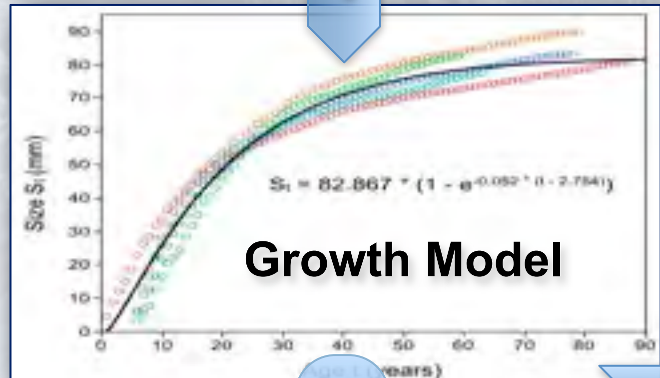

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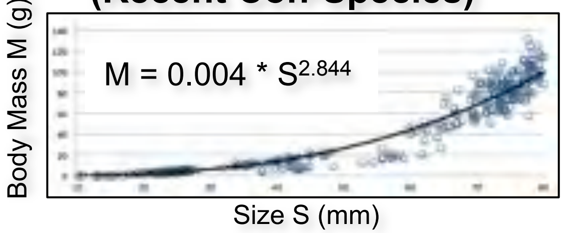
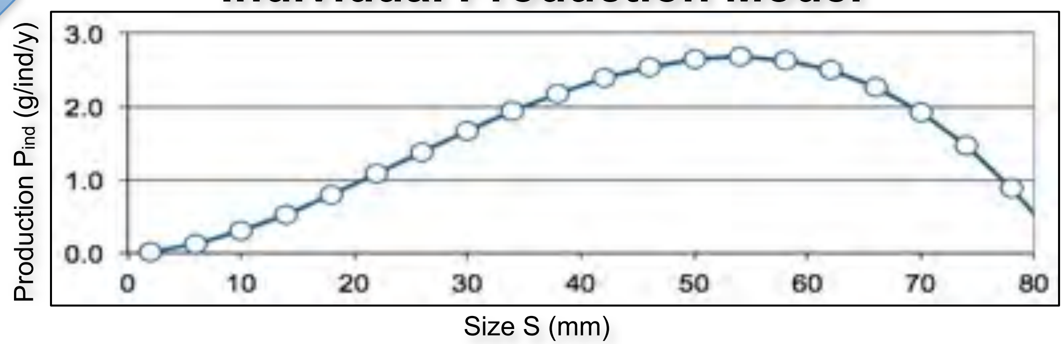
2

Size - Mass - Relationship
(Recent Con-Species)



Individual Production Model



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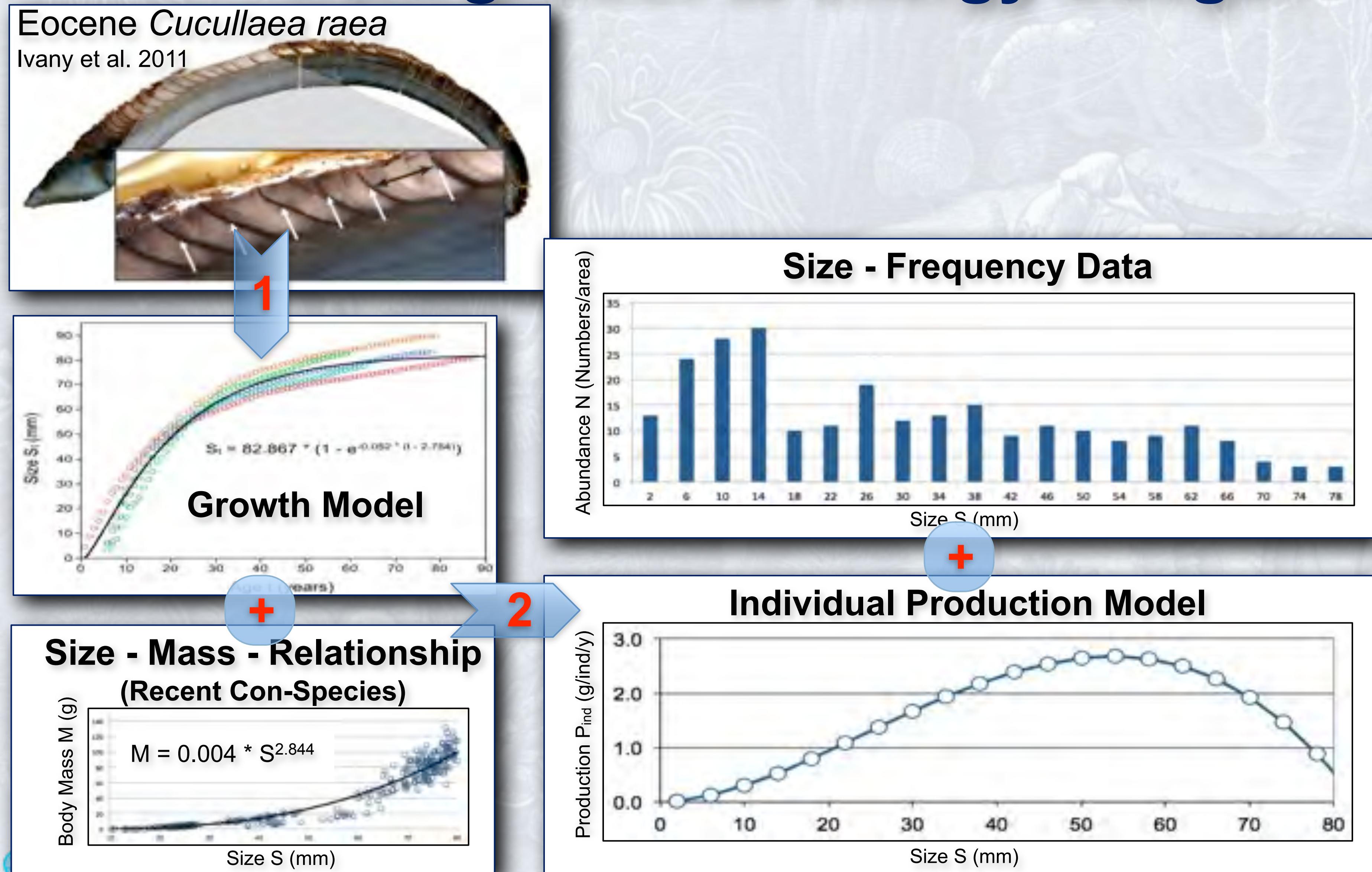

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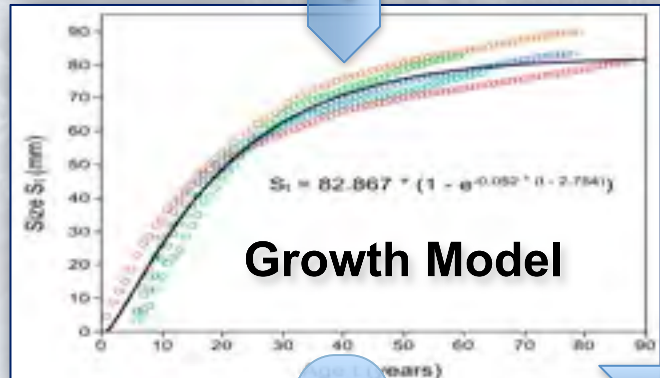

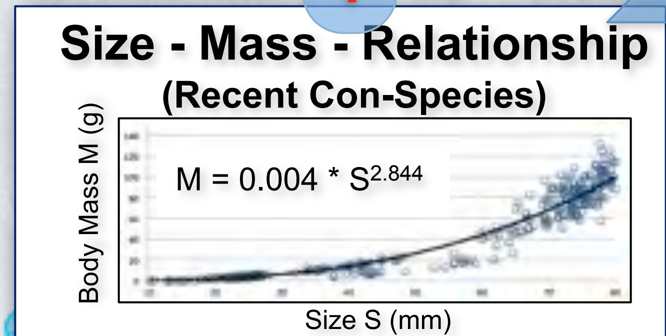

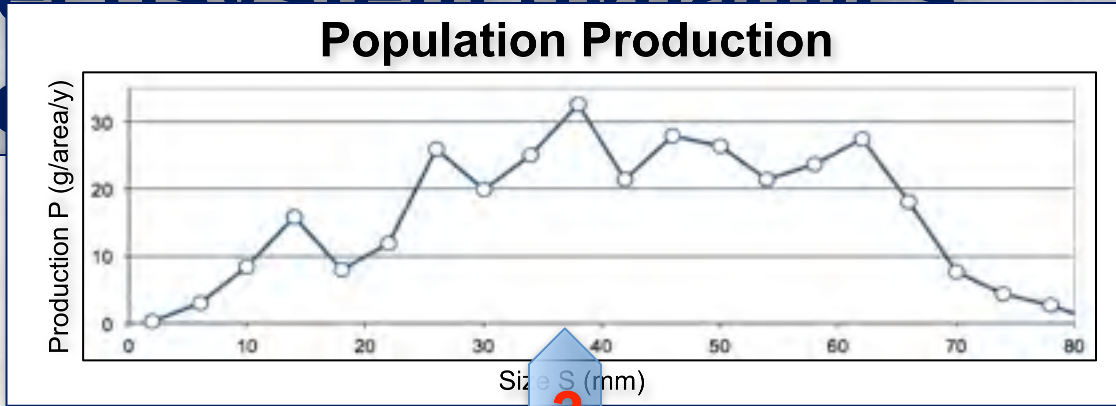

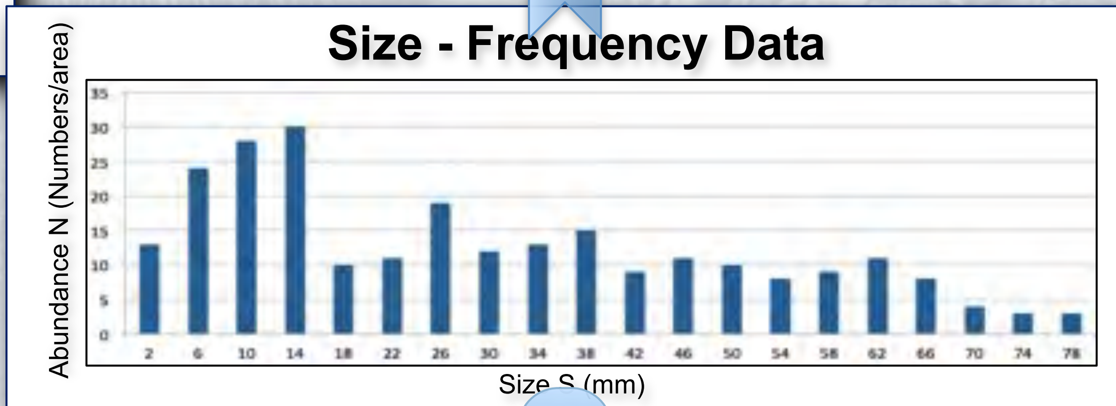

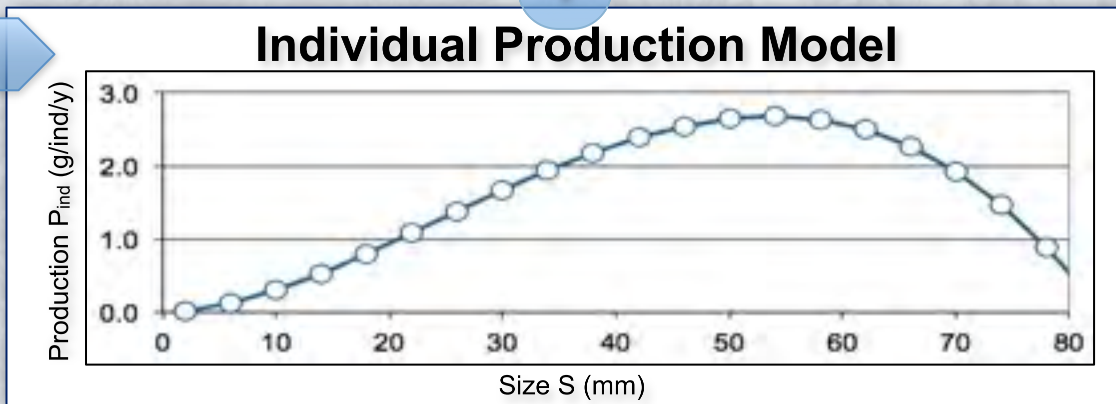

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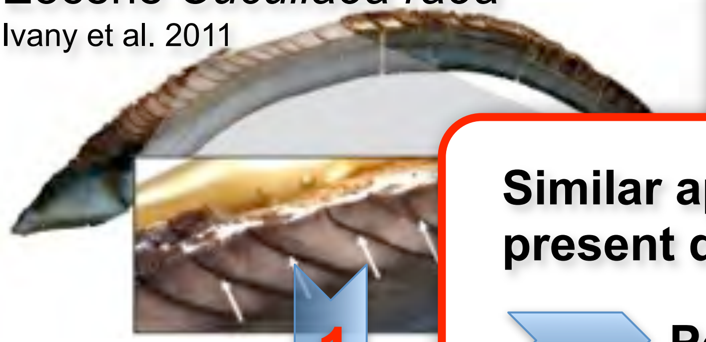

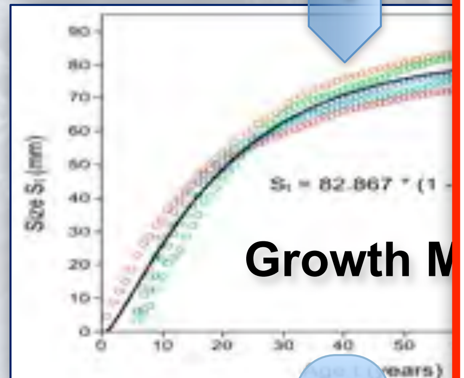

Size - Mass - Relationship

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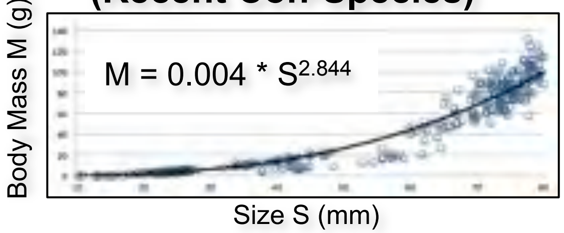
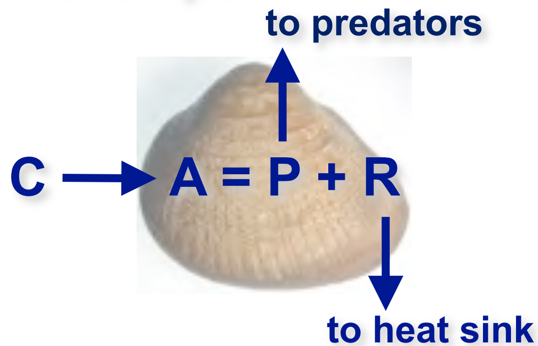
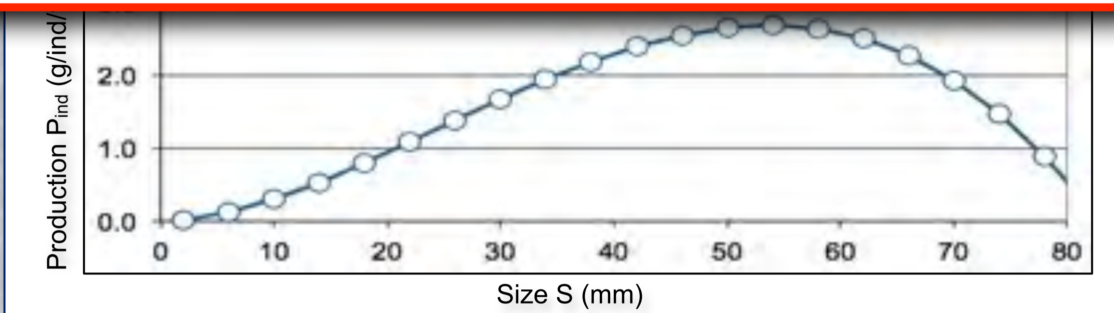


Population Production

Similar approaches using present day proxies & empirical relationships:

- Population **R**espiration
- Population **A**ssimilation
- Population **C**onsumption





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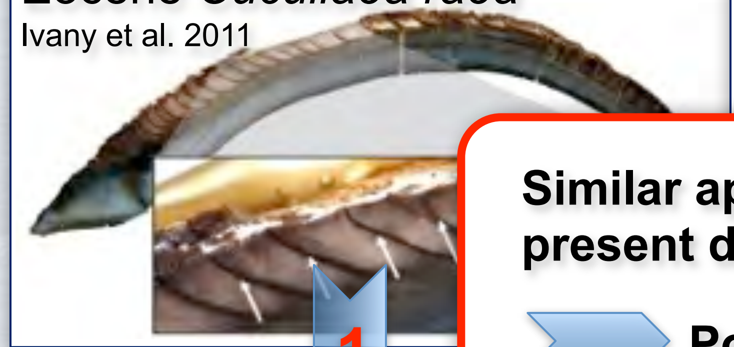
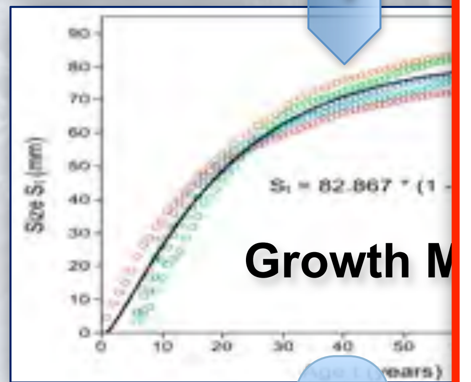
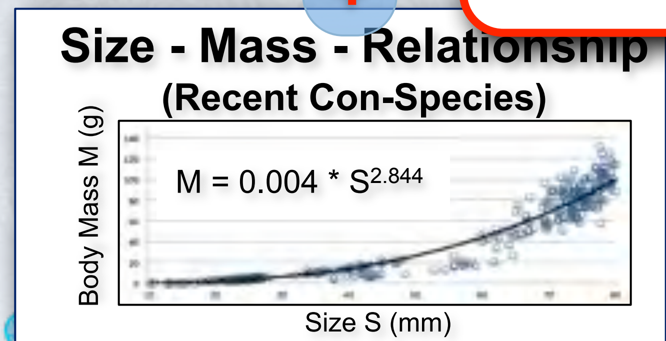
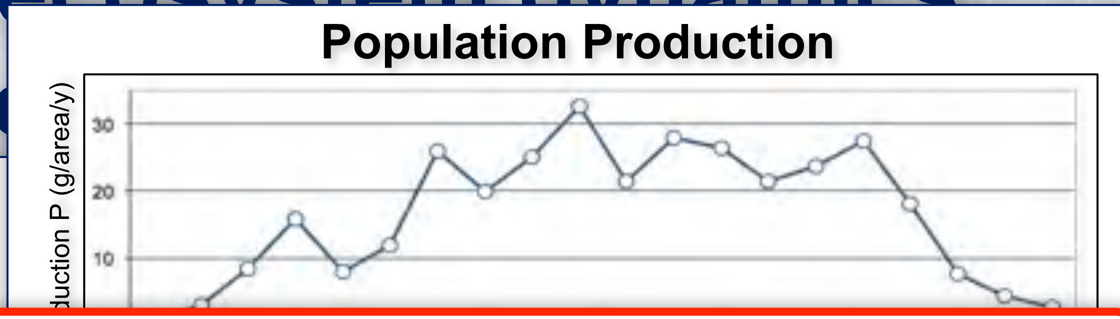


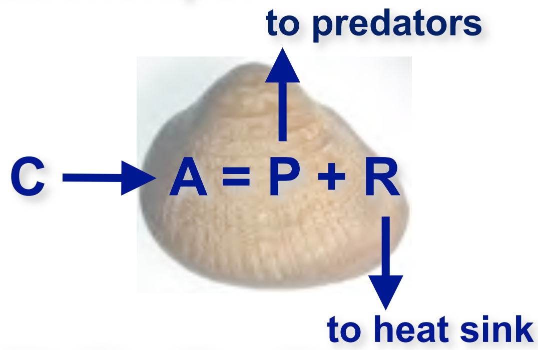




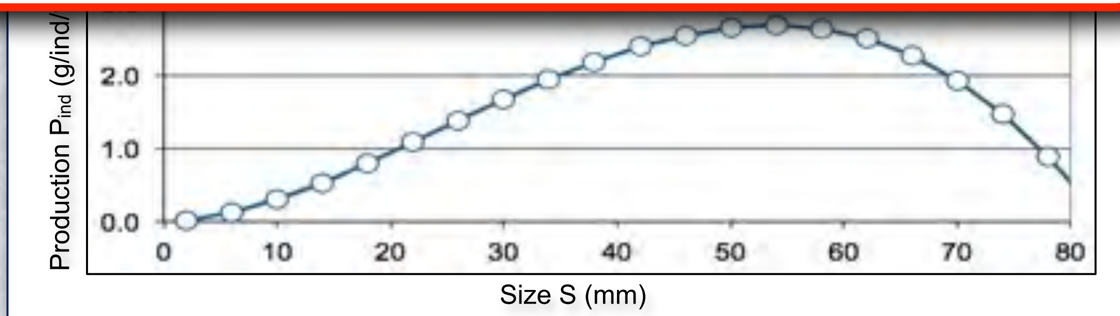


Similar approaches using
present day proxies & empirical relationships:

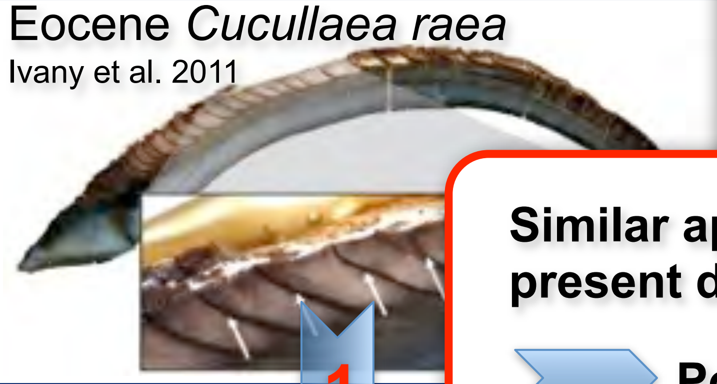
- Population **R**espiration
- Population **A**ssimilation
- Population **C**onsumption

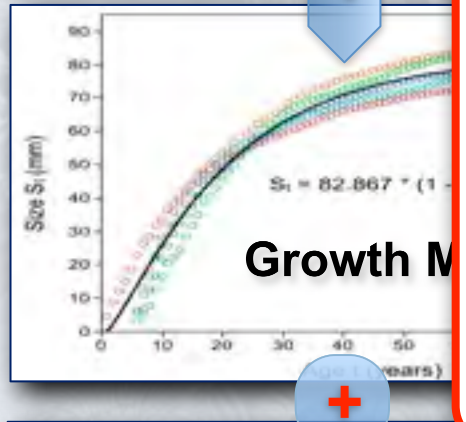


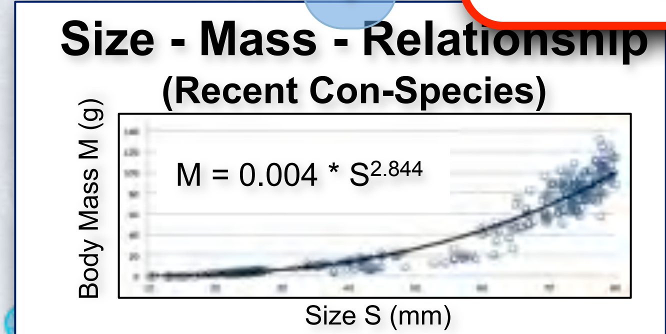
- **The role of a population in its food web**

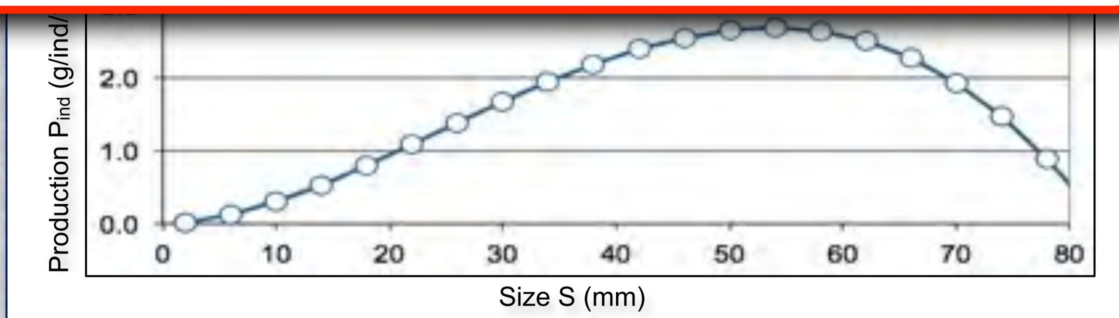


Case 1: Paleo - ecosystem dynamics: from gr



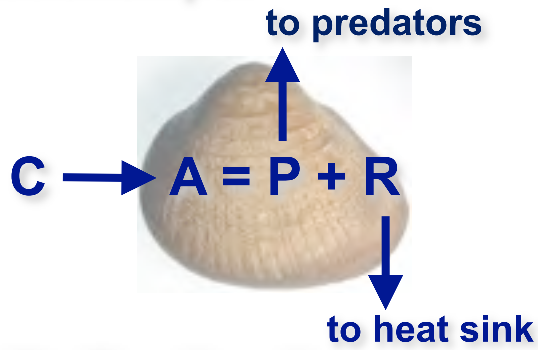






Similar approaches using
present day proxies & empirical relationships:

- **Population Respiration**
- **Population Assimilation**
- **Population Consumption**

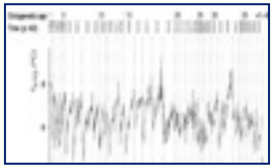


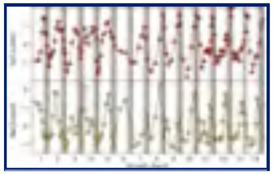
- **The role of a population in its food web**
- **Food web dynamics**

Case 2: Organism response models

Case 2: Organism response models

Biogeochemical archive



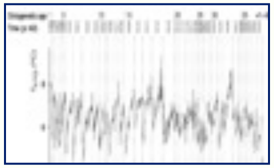


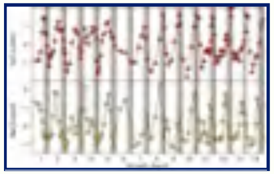
Environment

Sunday, 26 May 13

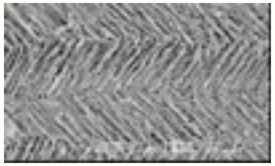
Case 2: Organism response models

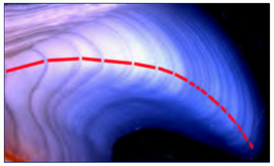
Biogeochemical archive





Environment



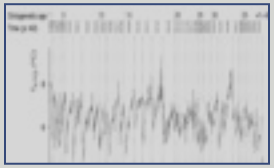


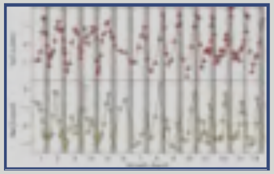
Morphological Archive

Life history

Case 2: Organism response models

Biogeochemical archive



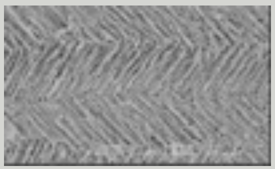


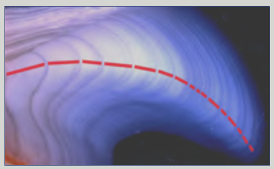
Environment

Mytilus edulis (Meyer & Möbius 1872)

Physiol. Performance
Energy budget
Biogeography

Organism-Model





Morphological Archive

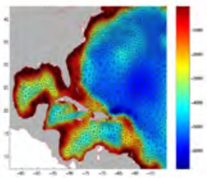
Life functions

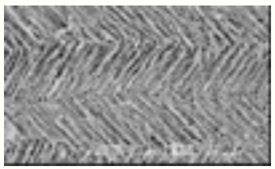
Case 2: Organism response models

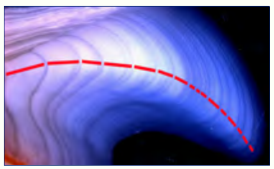
Biogeochemical archive

Climate-Ocean model

Finite Element Sea Ice Ocean Model (FESOM)







Morphological Archive

Environment

Organism-Model

Mytilus edulis (Meyer & Möbius 1872)

Physiol. Performance
Energy budget
Biogeography

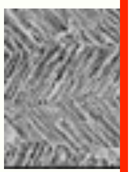
Life functions

Case 2: Organism response models

Bi

Cl

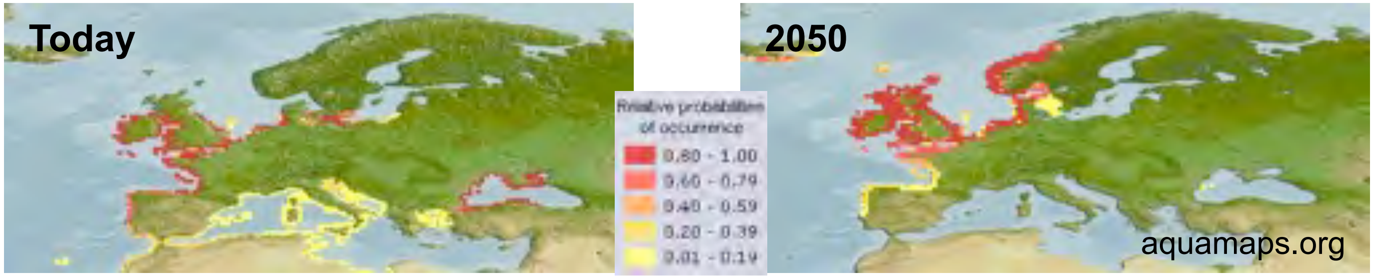
Finite El
Ocean M



M

Ecological niche - habitat dynamics in space & time

Bivalve *Cerastoderma edule*

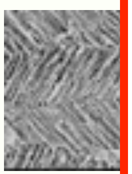


Case 2: Organism response models

Bi

Cl

Finite El
Ocean M



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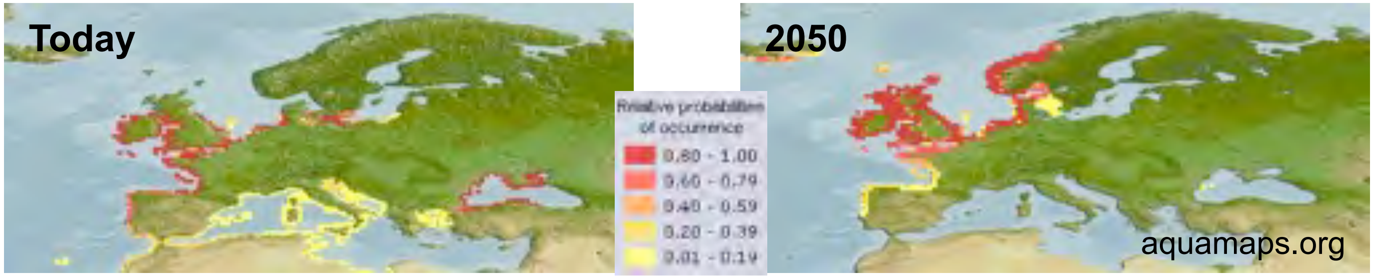
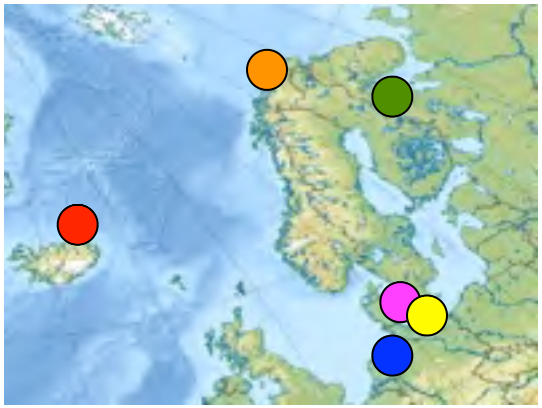
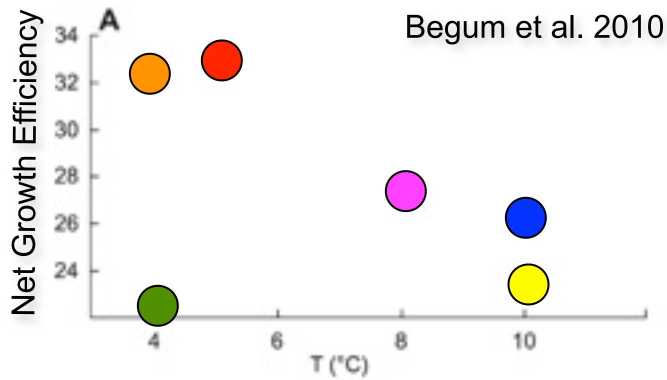


Organism performance - dynamics in space & time

Bivalve *Arctica islandica*



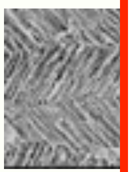


Case 2: Organism response models

Bi

Cl

Finite El
Ocean M



M

Ecological niche - habitat dynamics in space & time

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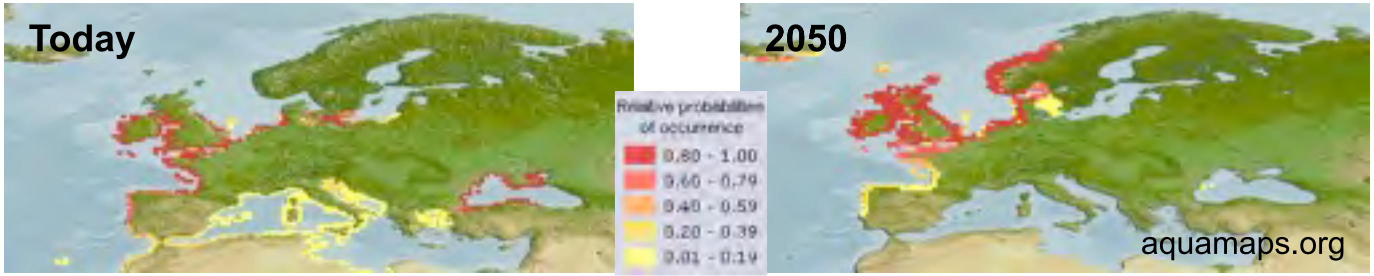
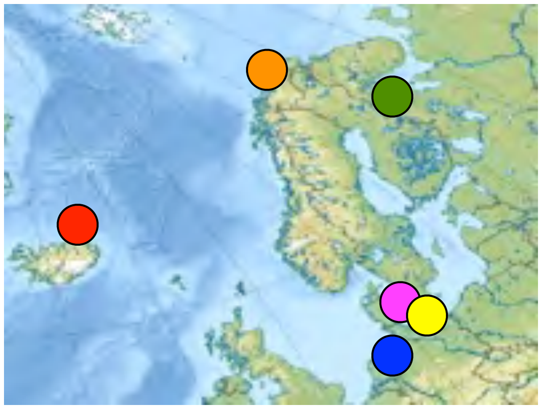
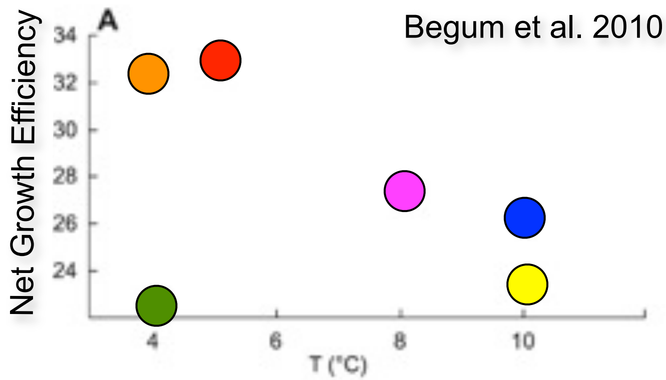


Organism performance - dynamics in space & time

Bivalve *Arctica islandica*





“Reverse” modeling -> ecosystem dynamics

Case 3: Ecosystem parameter prediction

Sunday, 26 May 13

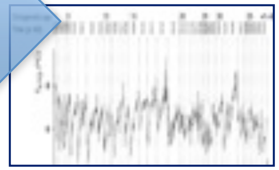
Case 3: Ecosystem parameter prediction

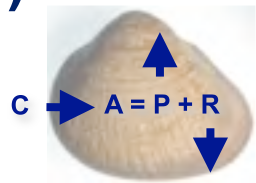
Environment

Ecosystem

Model

Bioarchive Signature
(Increment, Element,
Isotope)

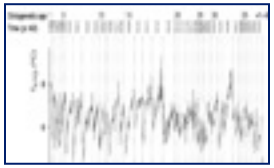


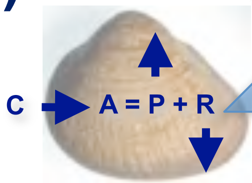


Organism Performance
(Growth, Metabolism)

Case 3: Ecosystem parameter prediction

Bioarchive Signature (Increment, Element, Isotope)





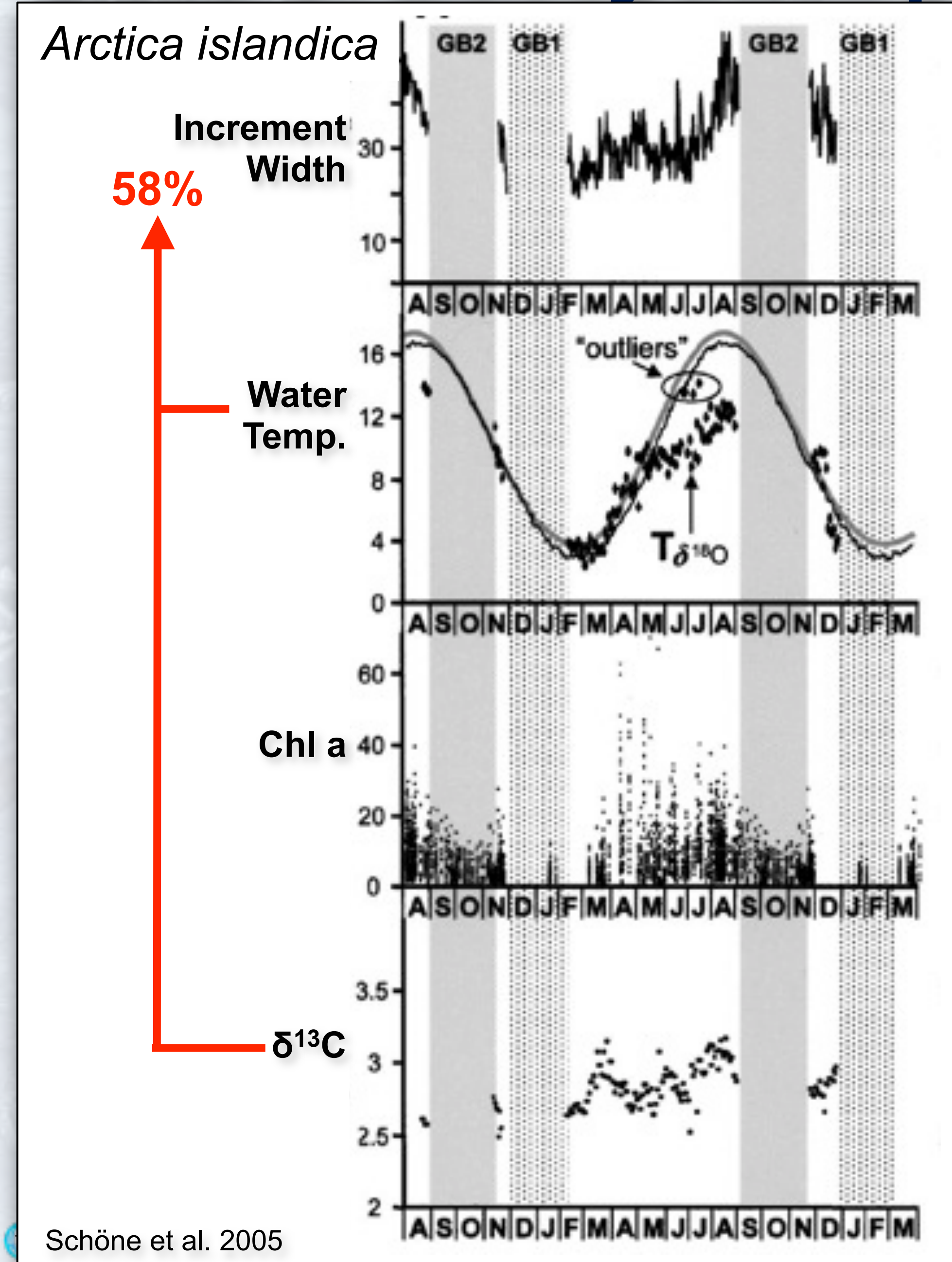
Organism Model Output (Growth, Metabolism)

Prediction

Ecosystem State

Primary Production
Zooplankton Dynamics

Case 3: Ecosystem parameter prediction



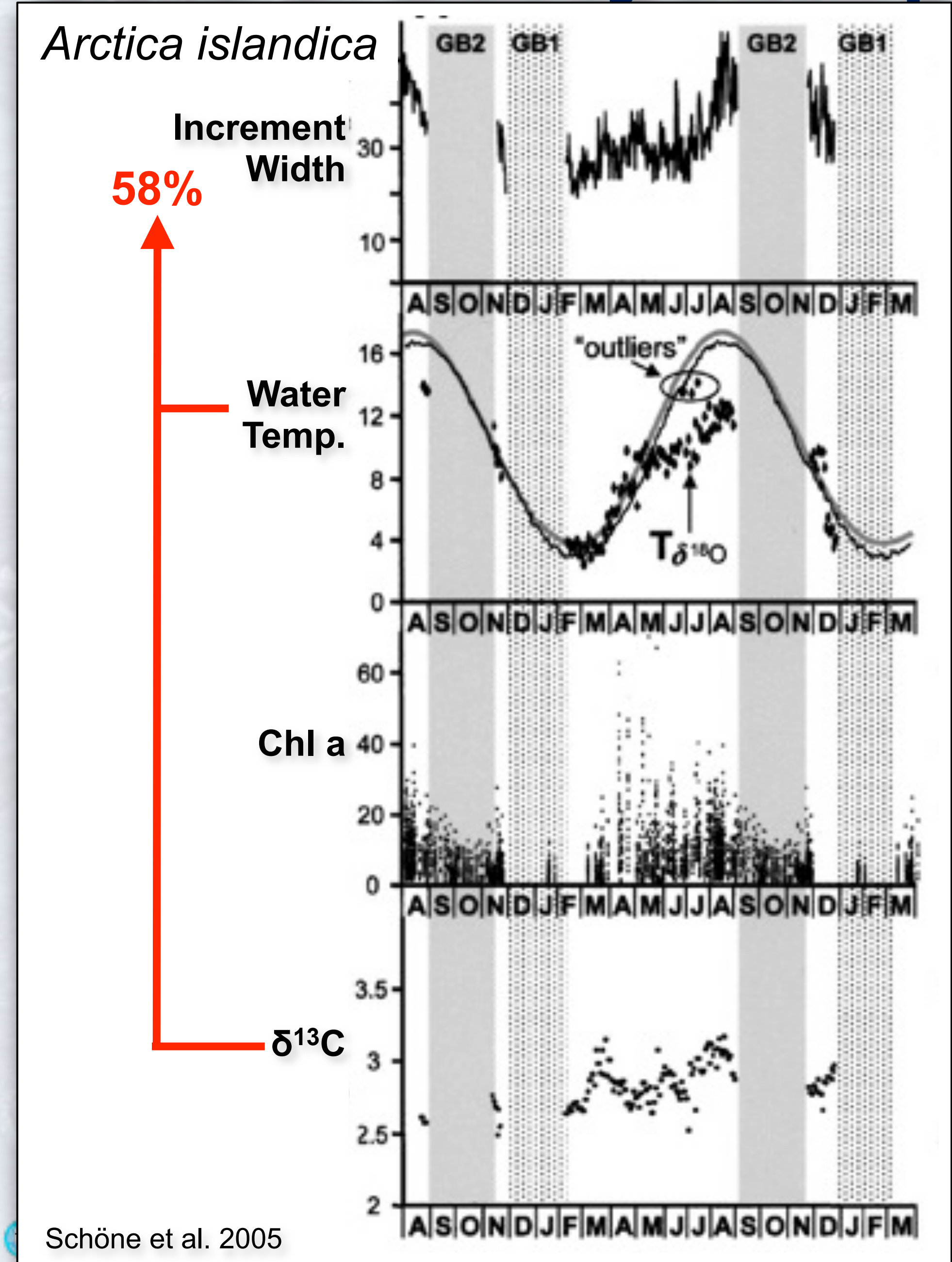
Schöne et al. 2005

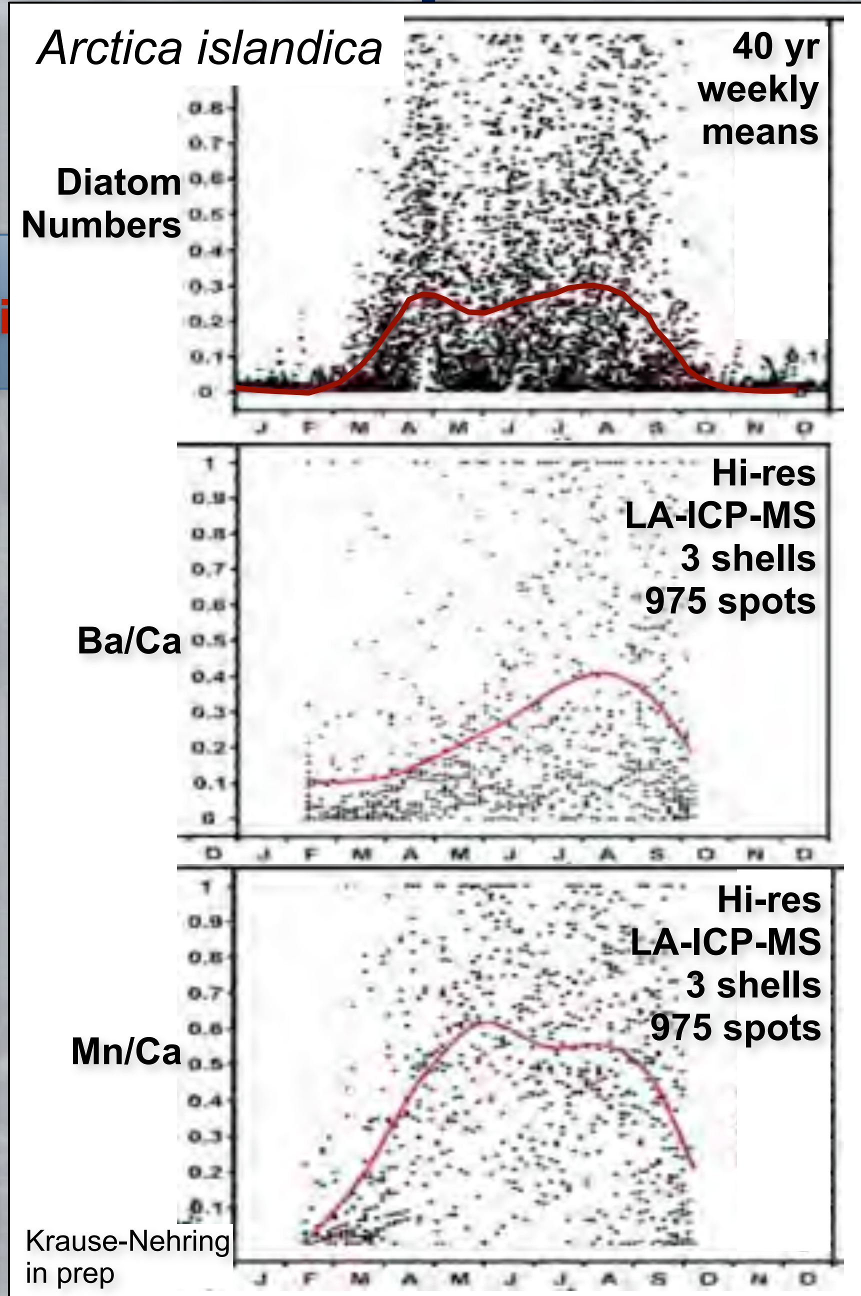
tion

Ecosystem State

Primary Production
Zooplankton Dynamics

Case 3: Ecosystem parameter prediction





Case 3: Ecosystem parameter prediction

Arctica islandica

Schöne et al. 2005

Arctica islandica

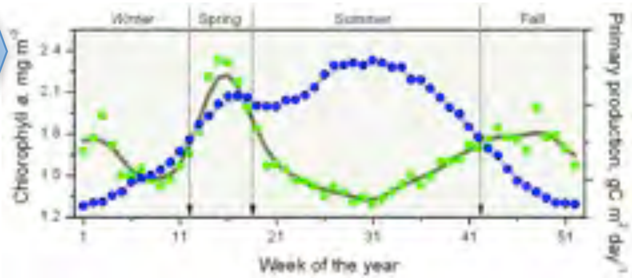
Krause-Nehring in prep

Establishment of reliable relationships

Do we need a multi-archive / multi-proxy approach ?

Prediction

Ecosystem State Parameter



Case 4: Spatial & mobility patterns

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Habitat-specific Geochemical Signature (Element, Isotope)

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Habitat-specific Geochemical Signature (Element, Isotope)

Incorporation in Bioarchive

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Habitat-specific Geochemical Signature (Element, Isotope)

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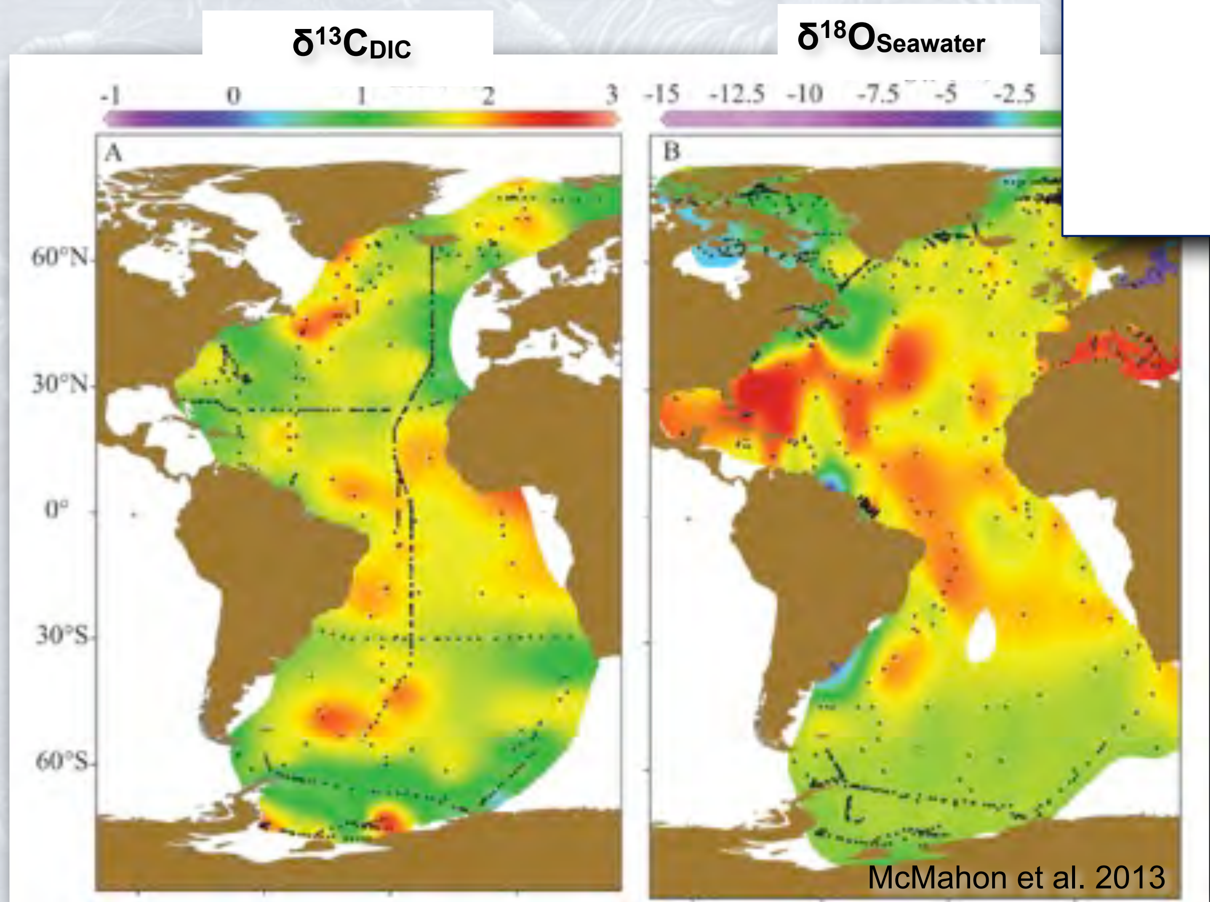


Sunday, 26 May 13

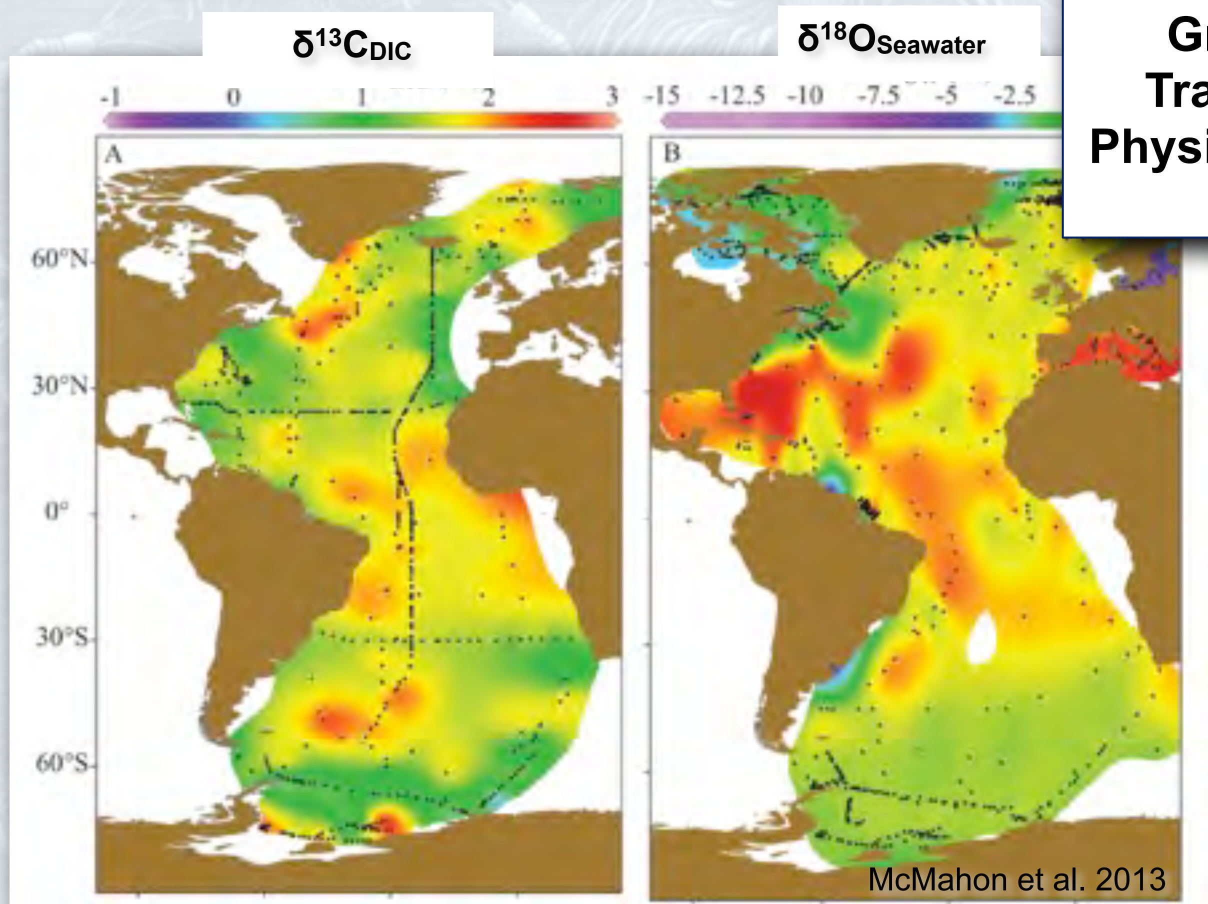
Case 4: Spatial & mobility patterns

Habitat-specific Geochemical Signature (Element, Isotope)

Incorporation in Bioarchive

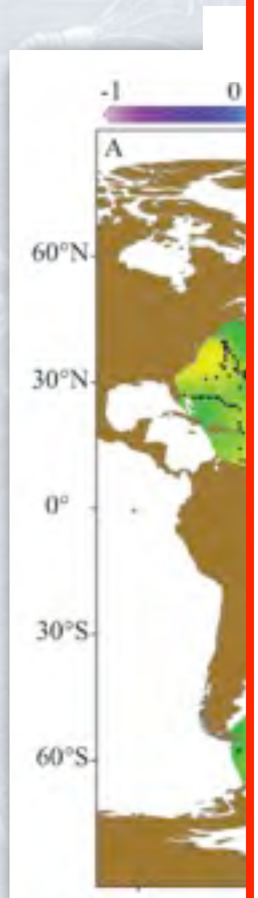
Caveats:

Growth & Turnover Rates
Tracer Fractionation Factor
Physical & Chemical Conditions
Metabolic effects



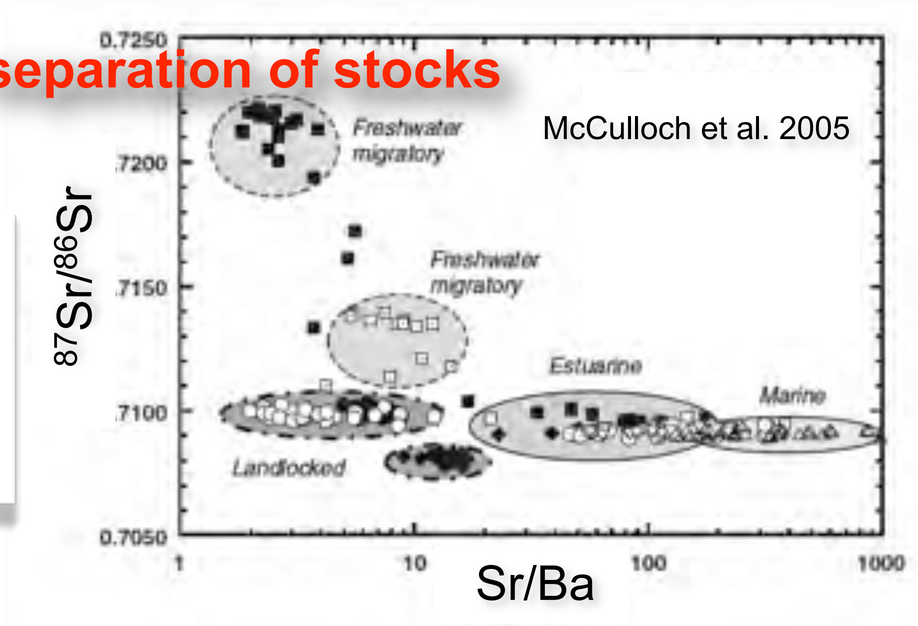
Case 4: Spatial & mobility patterns

Habitat-specific
Geoch
(Ele



Identification & separation of stocks

Lates calcarifer



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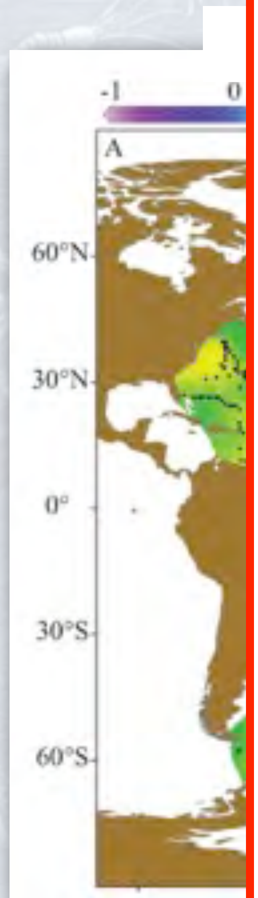

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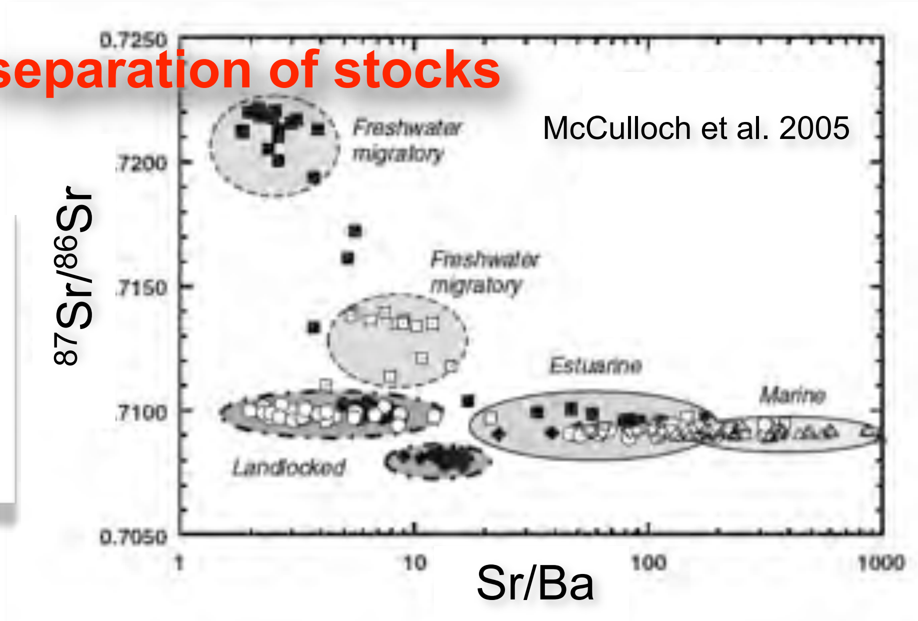

Life history of long-lived, large-distance roamers

Case 5: Ocean acidification impact

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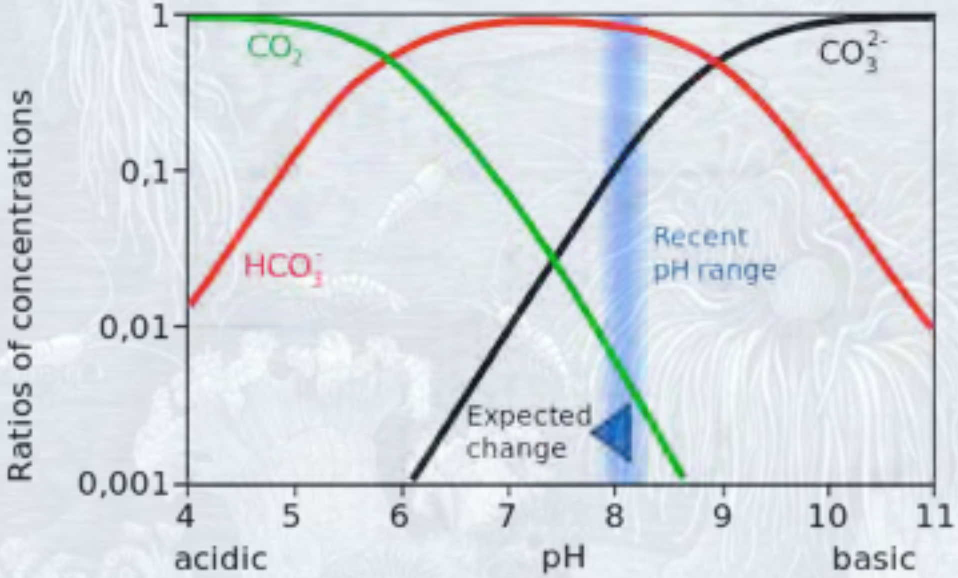
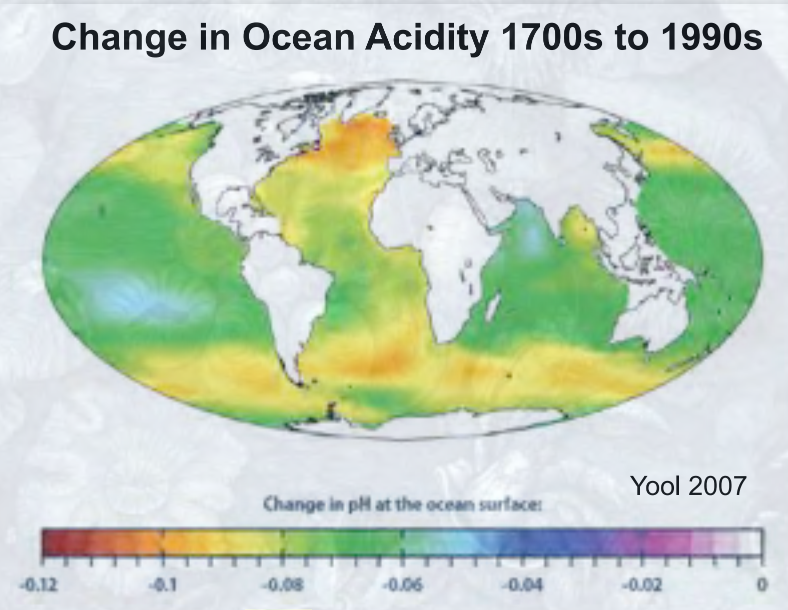
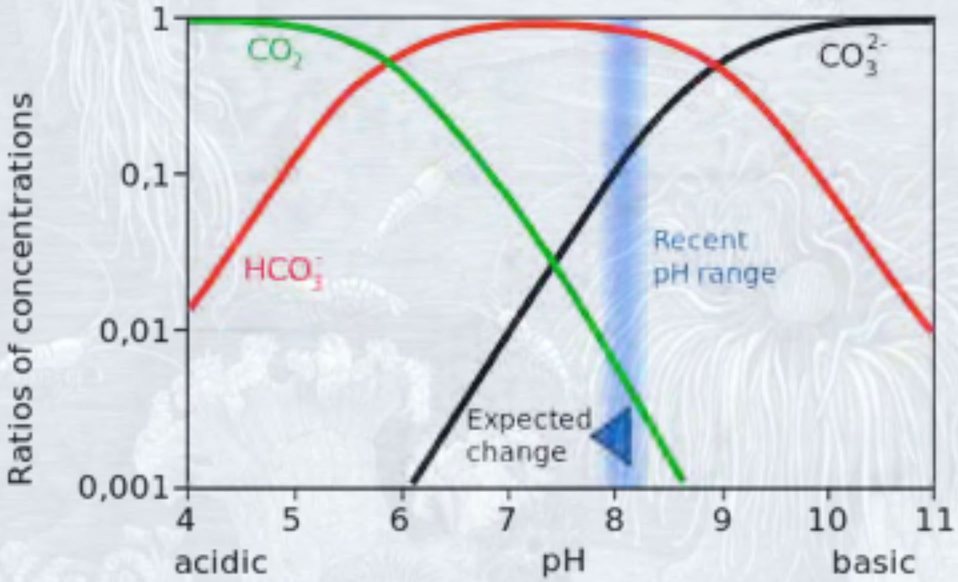
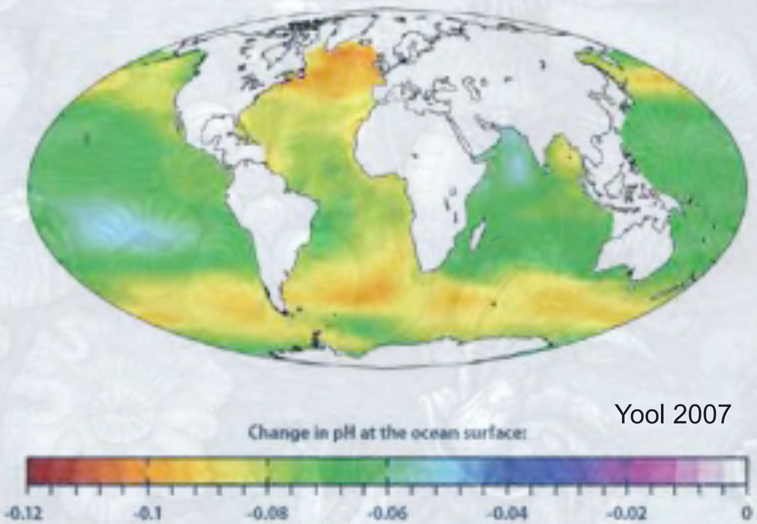




Case 5: Ocean acidification impact



Change in Ocean Acidity 1700s to 1990s

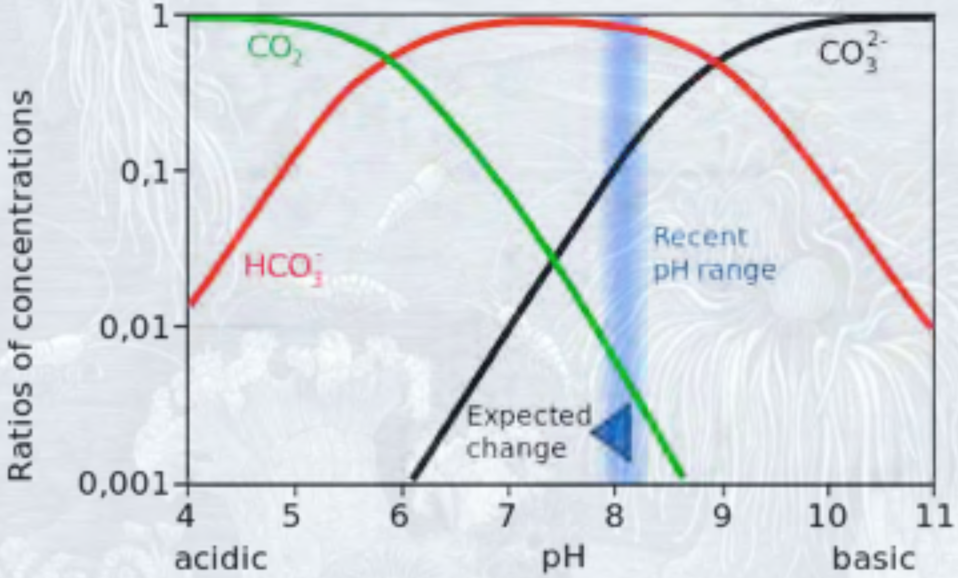


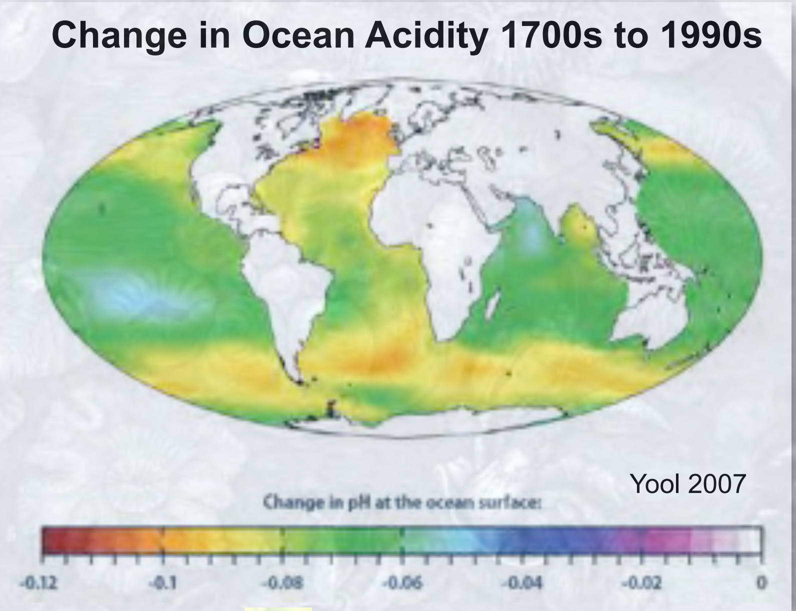
Yool 2007

Shell Growth

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

Case 5: Ocean acidification impact





Shell Growth

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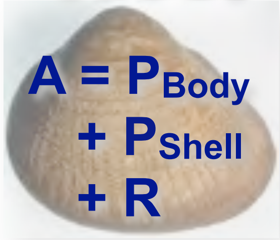
Energetic Costs ?



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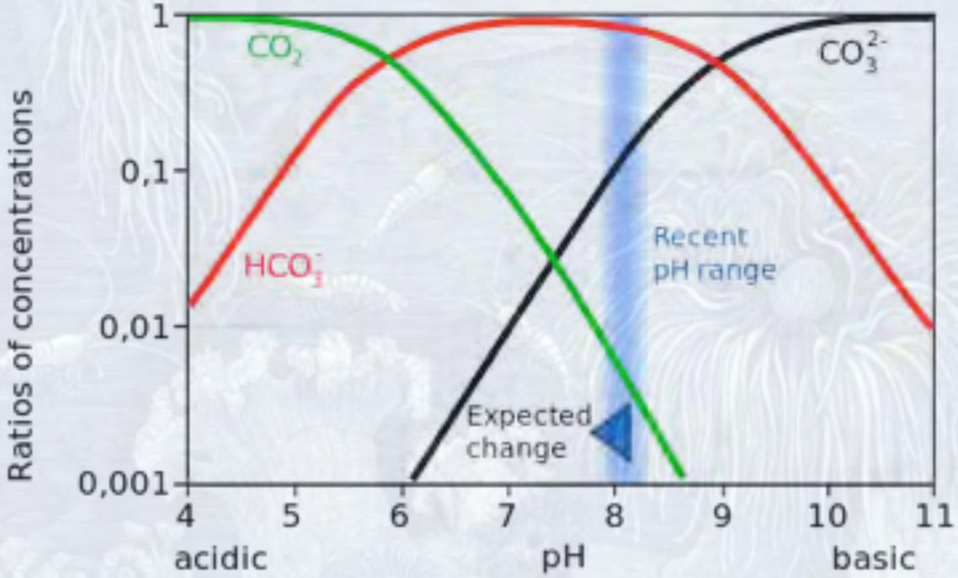

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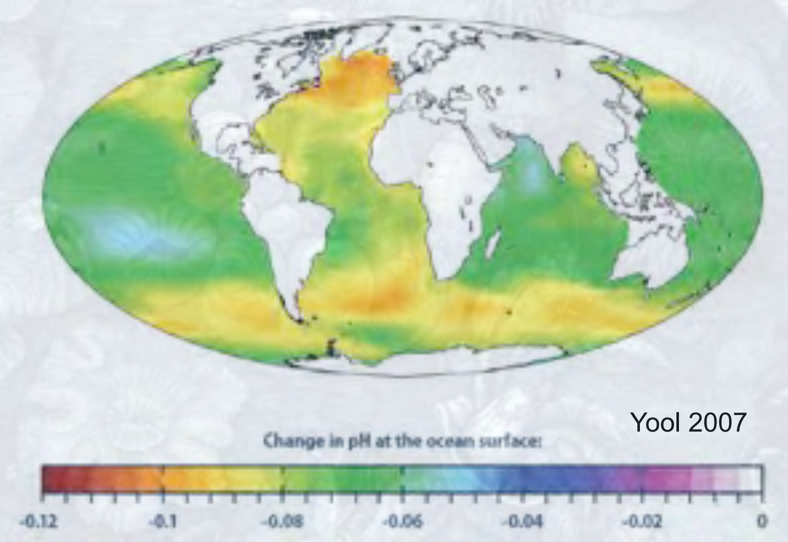

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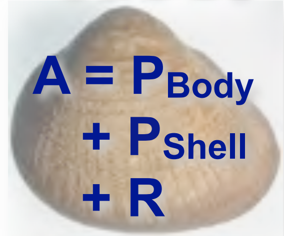
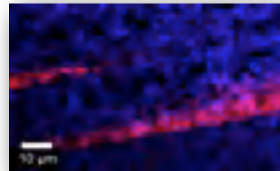


Shell Structure ?



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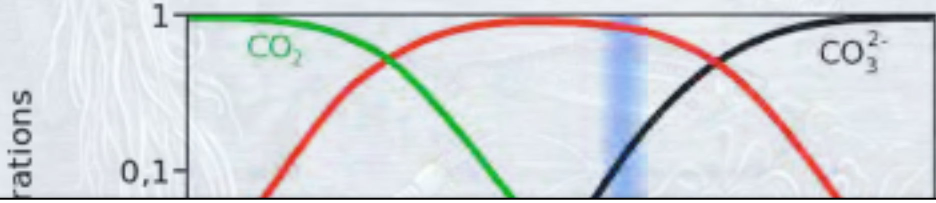
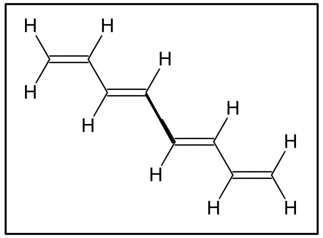
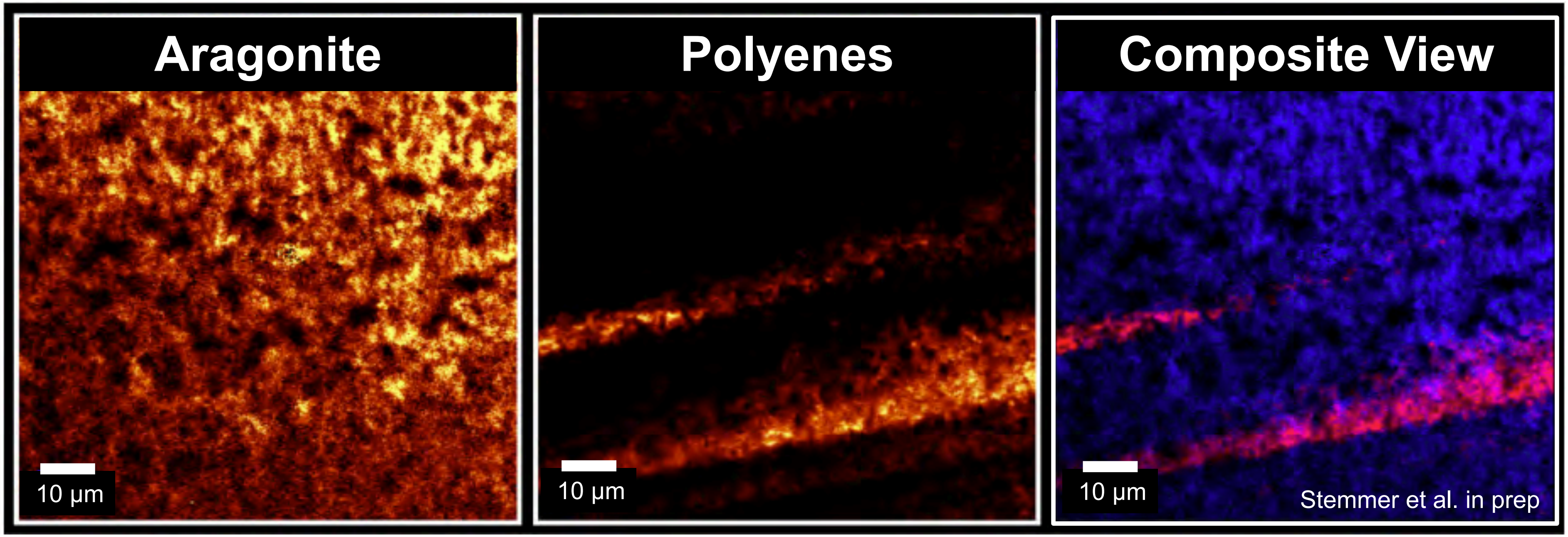


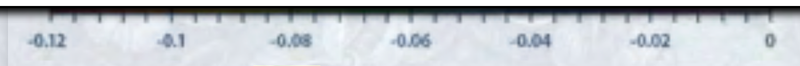
Shell Growth

$Ca^{2+} + CO_3^{2-} \Leftarrow\Rightarrow CaCO_3$

Polyenes in *Arctica islandica*







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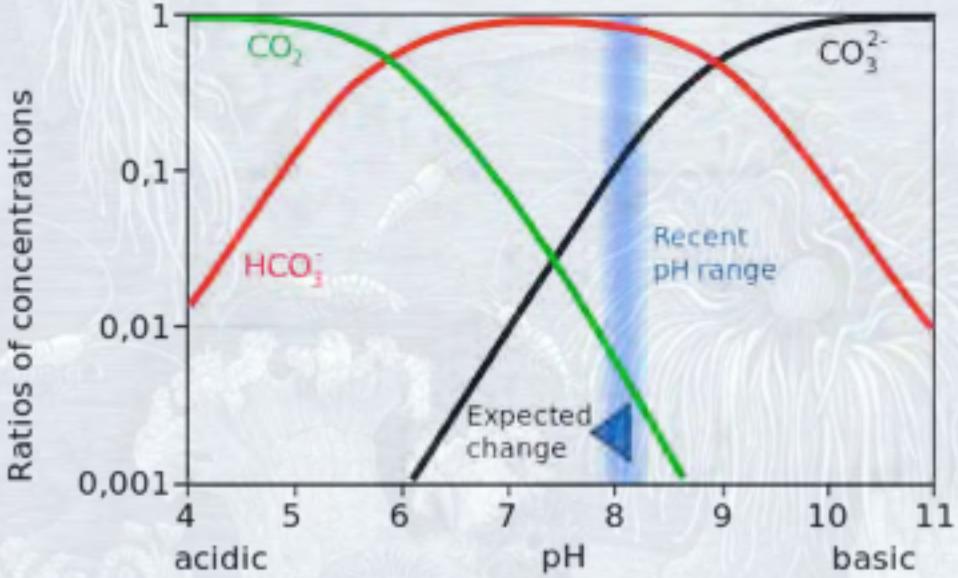

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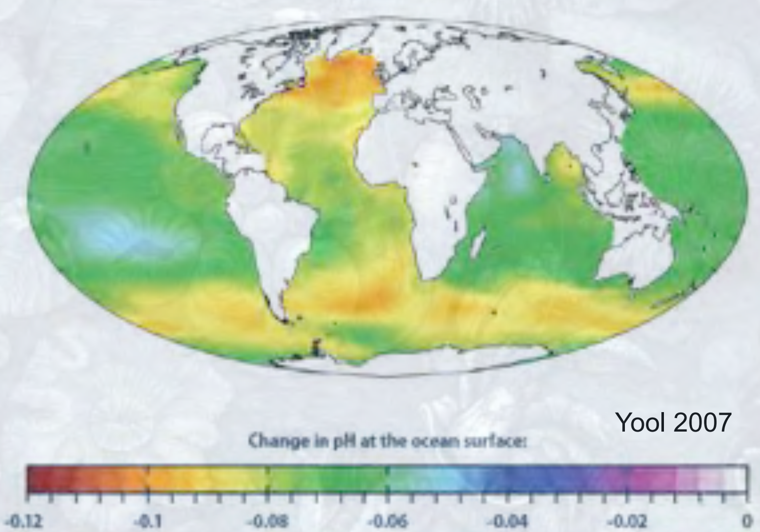

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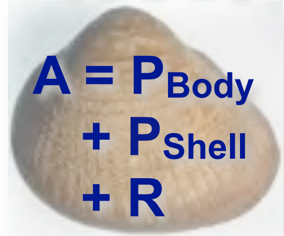
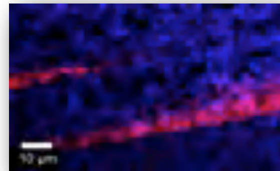
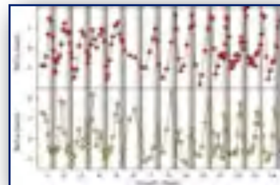


Shell Structure ?



Geochemical Properties ?



Case 5: Ocean acidification impact

An eternal evolutionary arms race

Case 5: Ocean acidification impact

An eternal evolutionary arms race

Naticid Gastropods (Moon snails) ... and their prey

Polinices sp.

drill to kill...

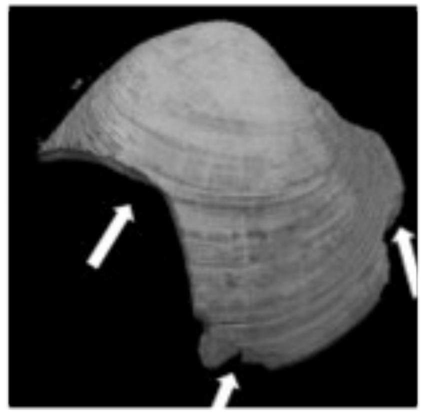
Case 5: Ocean acidification impact

An eternal evolutionary arms race

Naticid Gastropods (Moon snails) ... and their prey

drill to kill...

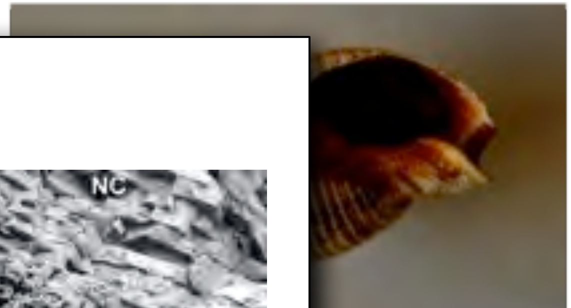
crush to nosh...



Crabs ... and their prey

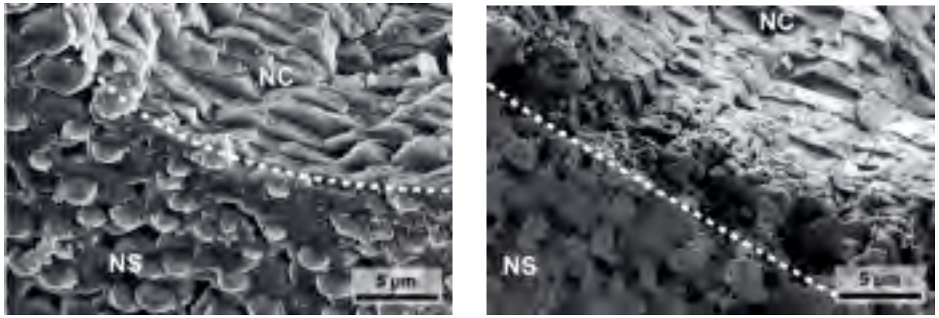
Case 5: Ocean acidification impact

An eternal evolutionary arms race



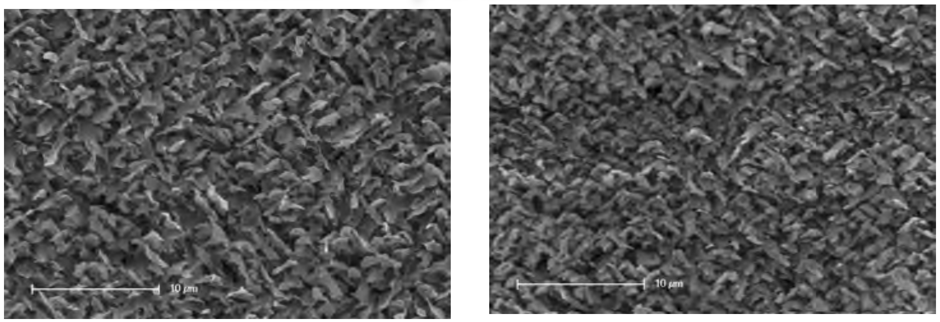
But the jury's still out ...

Shell dissolution in *Mytilus edulis*
(Melzner et al. 2011)

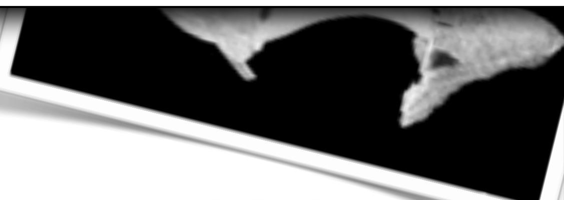


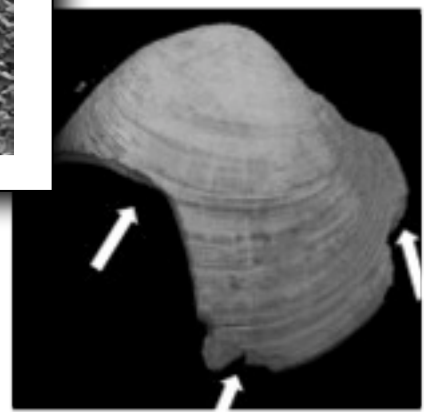
ambient pCO2 elevated

No effects in *Arctica islandica*
(Stemmer et al. in press)



Crabs



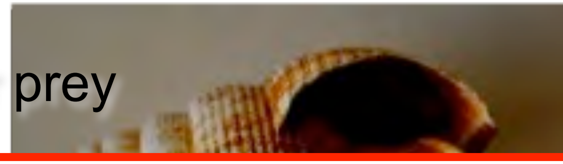


... and their prey

Case 5: Ocean acidification impact

An eternal evolutionary arms race

Naticid Gastropods (Moon snails) ... and their prey

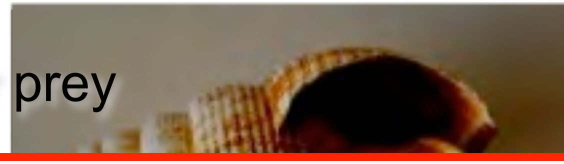


Modeling changes in predator - prey balance

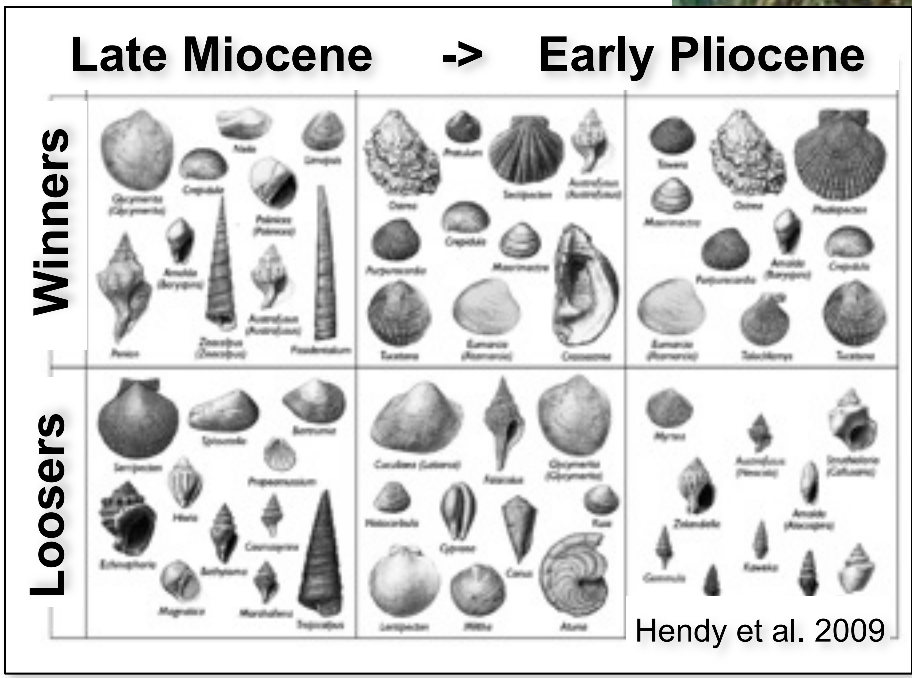
Case 5: Ocean acidification impact

An eternal evolutionary arms race

Naticid Gastropods (Moon snails) ... and their prey



Modeling changes in predator - prey balance



Hendy et al. 2009

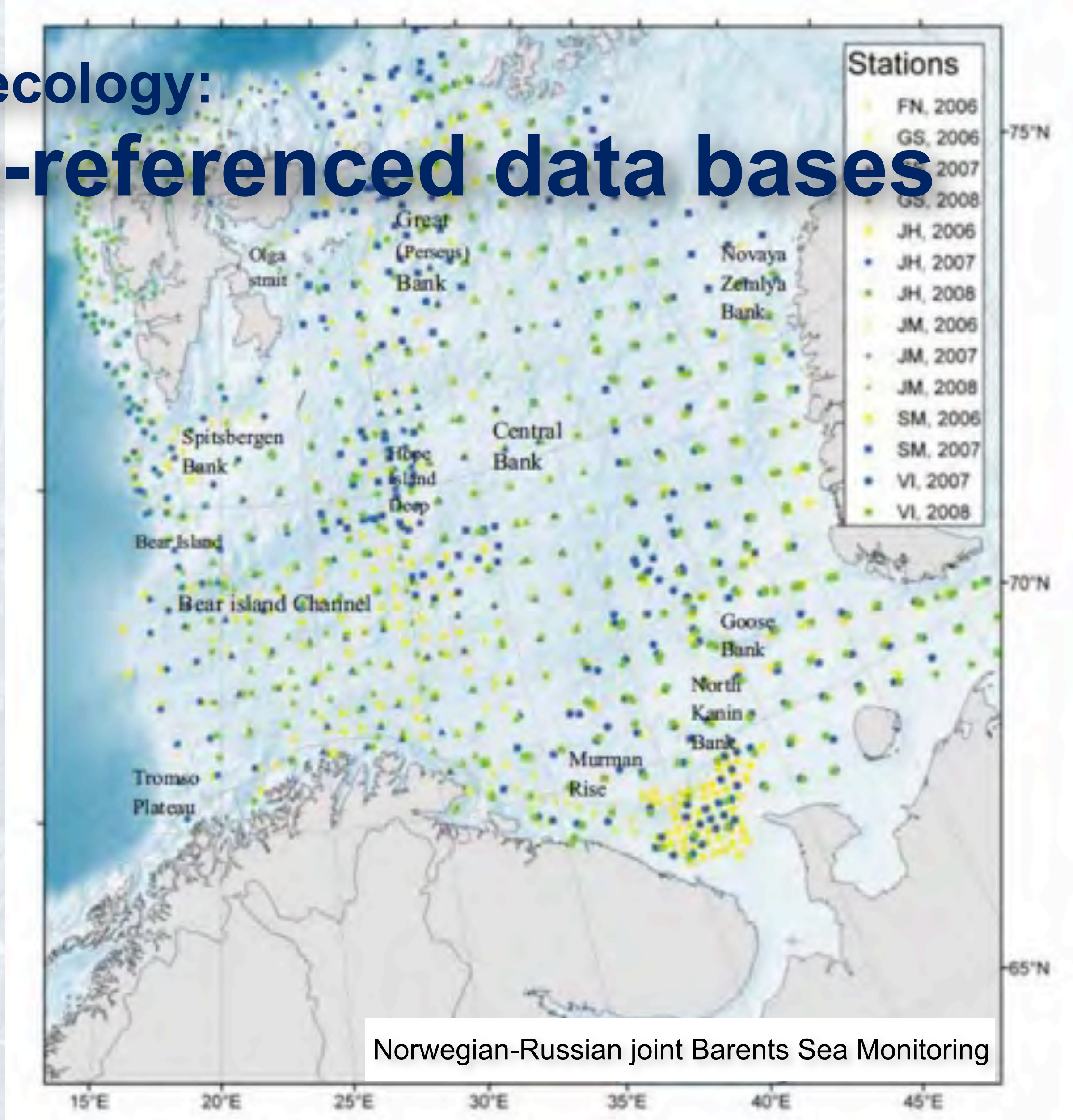
Global shifts in mollusk biodiversity

... a look ahead - what deems important

... a look ahead - what deems important

THE trend in marine ecology:

building geo-referenced data bases



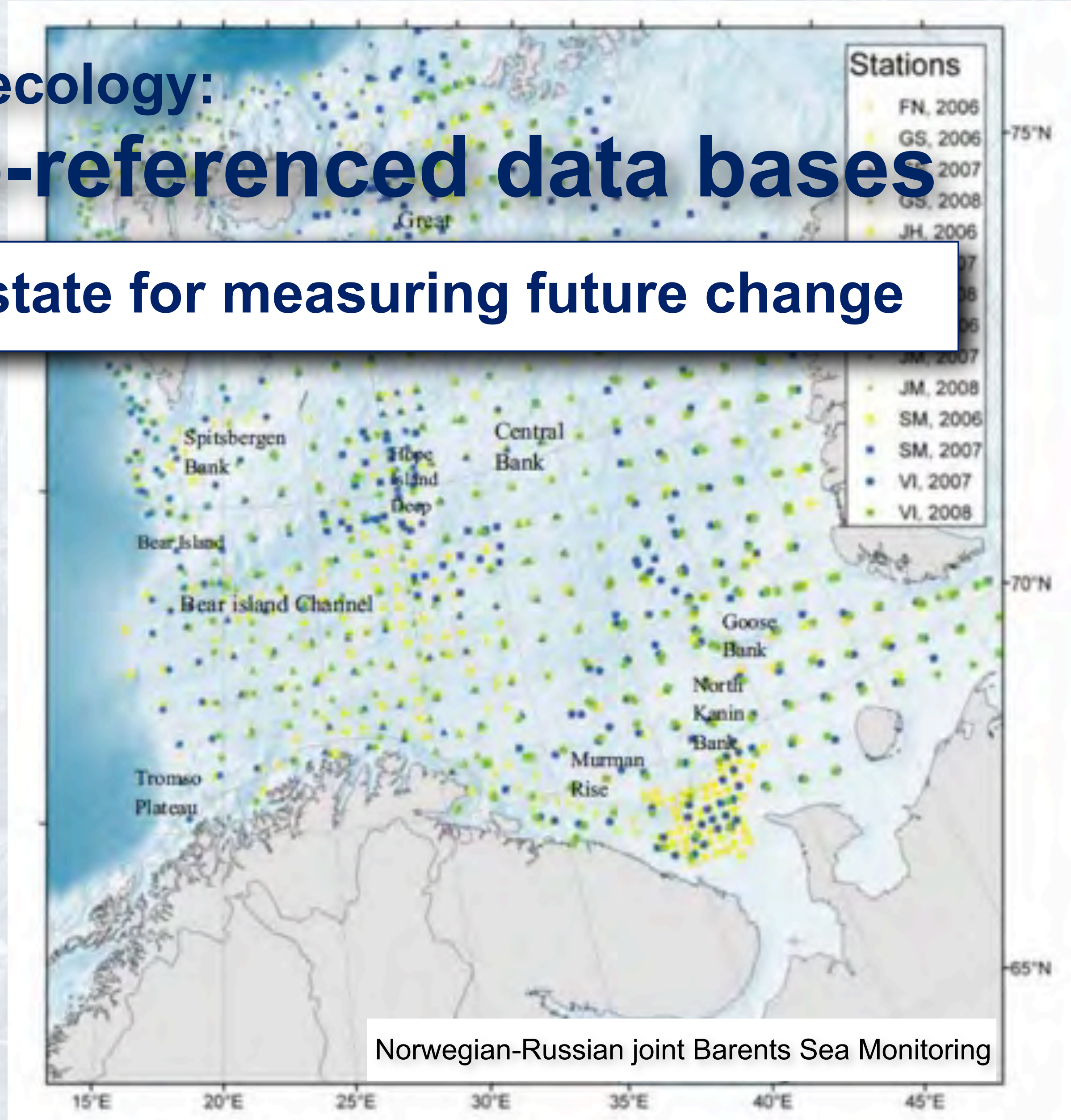
Norwegian-Russian joint Barents Sea Monitoring

... a look ahead - what deems important

THE trend in marine ecology:

building geo-referenced data bases

Reference state for measuring future change



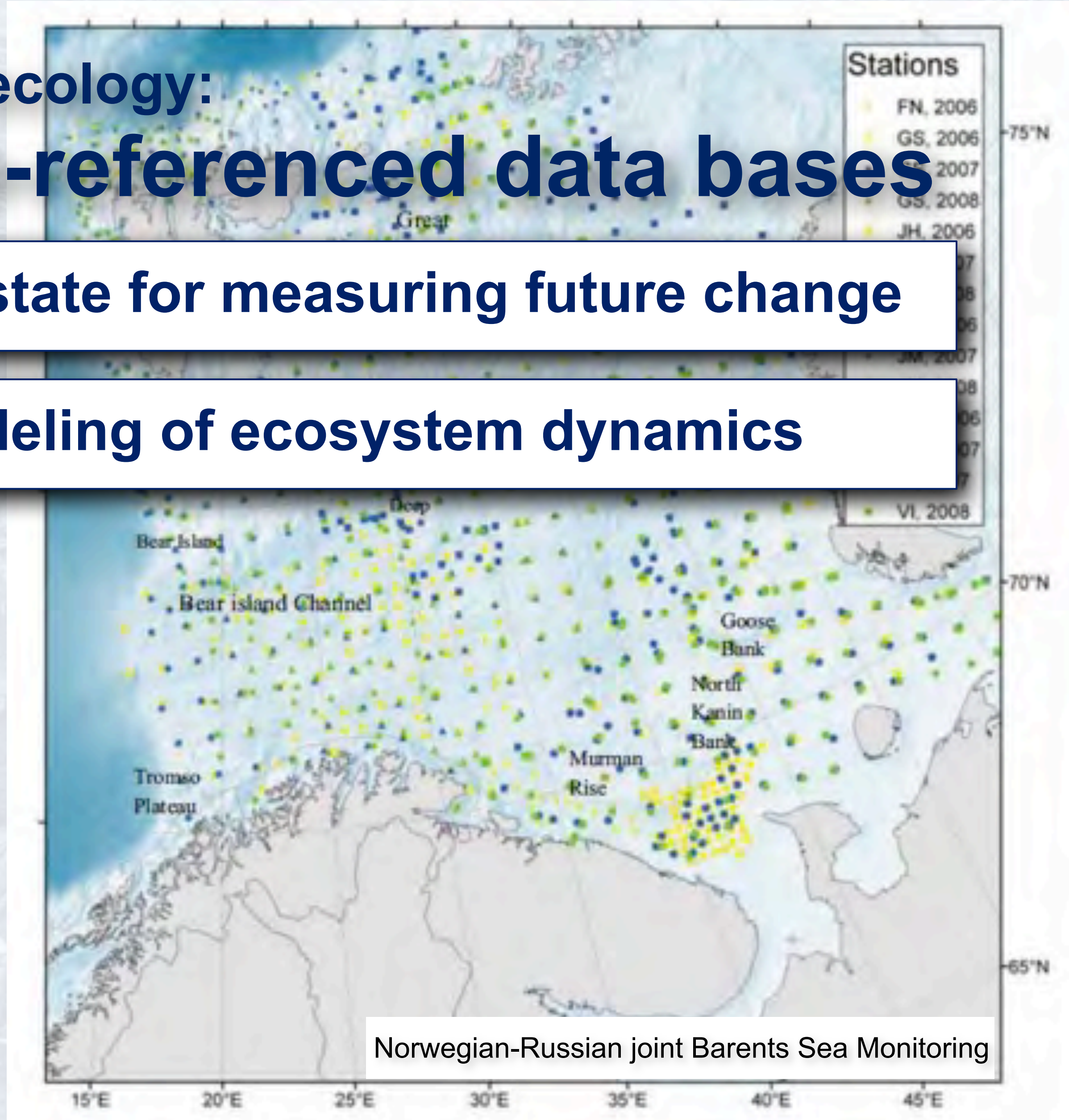
Norwegian-Russian joint Barents Sea Monitoring

... a look ahead - what deems important

THE trend in marine ecology:

building geo-referenced data bases

- Reference state for measuring future change
- Spatial modeling of ecosystem dynamics



Norwegian-Russian joint Barents Sea Monitoring

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THE trend in marine ecology:

building geo-referenced data bases

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My intention:

to make sclerochronological data a part of these initiatives

... a look ahead - what deems important

THE trend in marine ecology:

building geo-referenced data bases

- Reference state for measuring future change
- Spatial modeling of ecosystem dynamics

My intention:

to make sclerochronological data a part of these initiatives

- Enhanced spatial & temporal resolution of environmental & ecosystem processes

Can sclerochronology facilitate our understanding of ecosystem function ?

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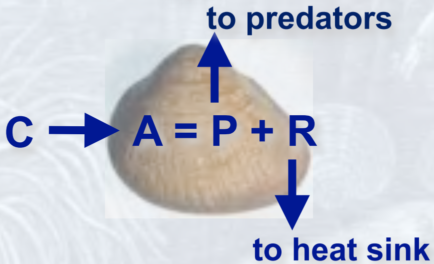
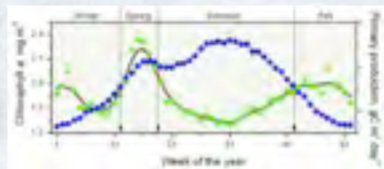
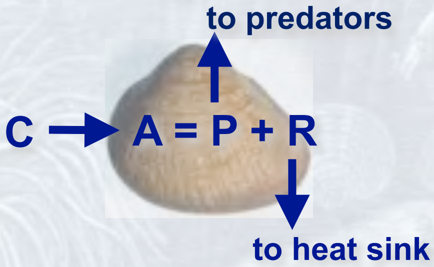


Five cases

- Paleo-ecology
- Organism response
- Ecosystem parameters
- Spatial & mobility patterns
- Ocean acidification



Can sclerochronology facilitate our understanding of ecosystem function ?



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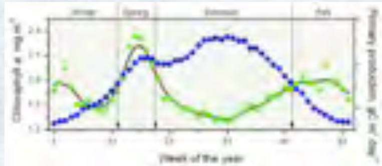

indicate: YES !

Coming soon at ISC 2013 ...

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Session 1B:	Biology, Ecology & Ecosystems (2)	Session chair: Bryan Black
10:30 – 10:50	Una Matras **Relationship between plankton characteristics and growth of the long-lived clam *Arctica islandica* on the Faroe Shelf**	
10:50 – 11:10	Julien Thébault **Sclerochronology of bathyal bivalves suggests major trophic shifts and stronger pelagic-benthic coupling in the Canadian Arctic**	
11:10 – 11:30	Michael Carroll **Bivalve growth rate and isotopic variability across the Barents Sea Polar Front**	
11:30 – 11:50	Laure Pecquerie **Understanding the impact of metabolism on $\delta^{13}C$ patterns in bivalve shells and fish otoliths in the context of Dynamic Energy Budget (DEB) theory**	
11:50 – 12:10	Roger Mann **Sclerochronology and bioenergetics: a combination to elucidate changes in growth environments at small temporal and spatial scales**	
12:10 – 12:30	Rhian Thomas **Dead shell talking: investigating the impact of flow regulation on the endangered freshwater pearl mussel (*Margaritifera margaritifera*) using conservation palaeobiology and hydrology**	

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freshwater pearl
palaeobiology an

Session 1C: Biology, Ecology & Ecosystems (3) Session chair: Rob Witbaard

14:00 – 14:20 Gretchen Grammer
Evolution of an otolith-based marine chronology for the Southern Hemisphere derived from a deep water fish species

14:20 – 14:40 Adam Rountrey
Otolith chronologies from the southeastern Indian Ocean reveal the effects of temperature and current flow on the growth of fishes in a boundary current ecosystem.

14:40 – 15:00 Alexander Arkhipkin
Annual and bi-annual life cycles in jumbo squid *Dosidicus gigas* as revealed from the statolith microstructure

15:00 – 15:20 Clémence Royer
Sclerochronological and trace element investigations in Brittany populations of the freshwater pearl mussel, *Margaritifera margaritifera*

15:20 – 15:40 Aurélie Jolivet
Is the great scallop recording upwelling events?

15:40 – 16:00 Melita Peharda
***Glycymeris bimaculata* (Poli, 1795) – a new sclerochronological archive for the Mediterranean?**

Coming soon at ISC 2013 ...

3RD INTERNATIONAL SCLEROCHRONOLOGY CONFERENCE 2013

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