Chemo III: Changes in Cold Seep and Hard Ground Community Structure Along a Depth Gradient on the Louisiana Slope

Chuck Fisher
Pennsylvania State University

The work summarized here is the result of the efforts of many members of the Chemo III team, including (at least): J. Brooks, B. Bernard, R. Carney, E. Cordes, S. Hourdez, I. Macdonald, and S. Schaeffer, and members of my laboratory including E. Becker, D. Cowart, S. Lessard-Pilon, M. Miglietta, and M. Porter

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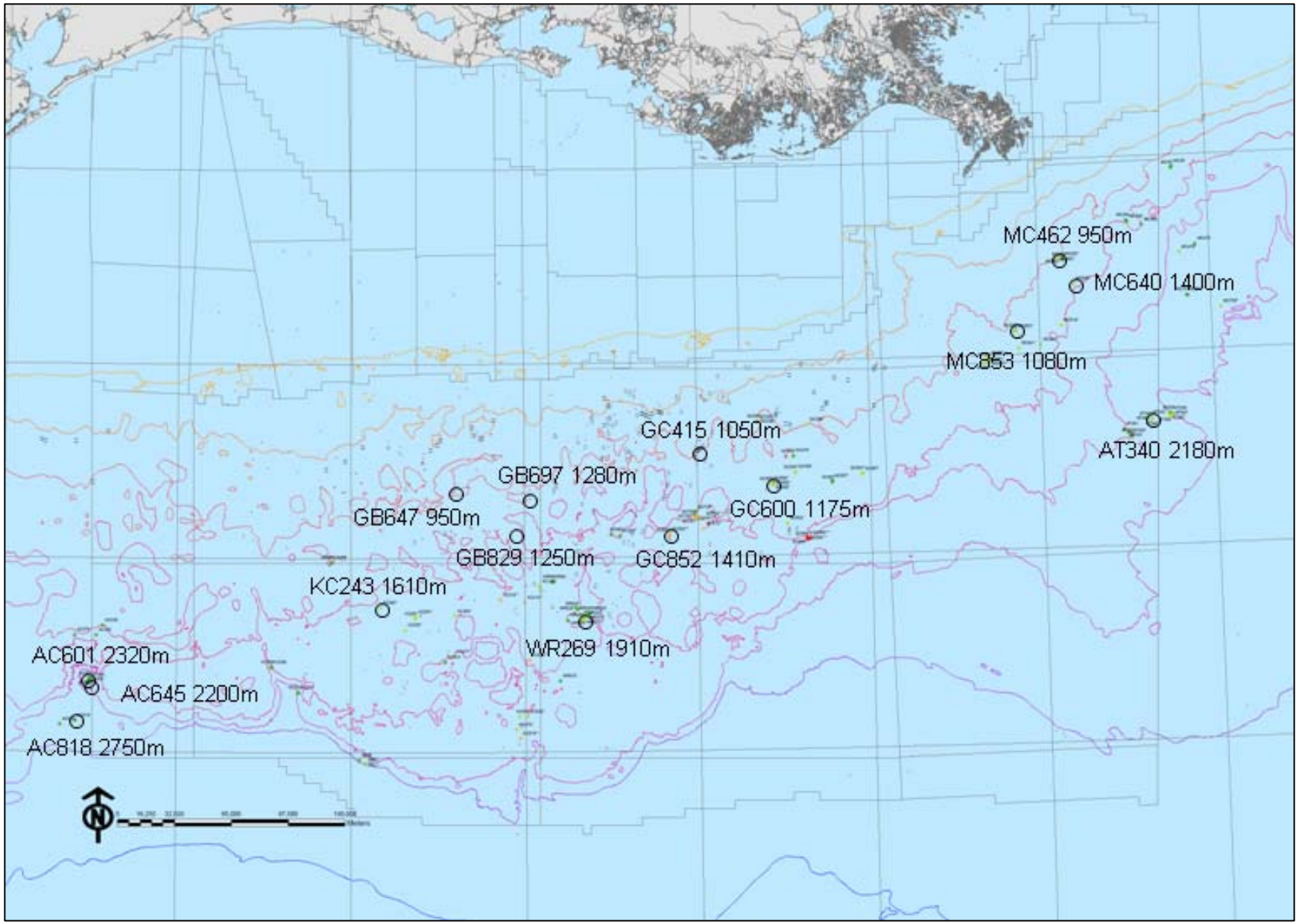
Three main objectives today:

1) Provide an overview of the distributions of the main symbiont-containing species of tubeworms and mussels.

2) Provide an overview of how the structure of the seep megafaunal communities changes with depth.

3) End with a preliminary look at some of the other new insights the study has given us with respect to the biology of the tubeworms and mussels of the lower slope.

Sites Visited in 2006 and 2007



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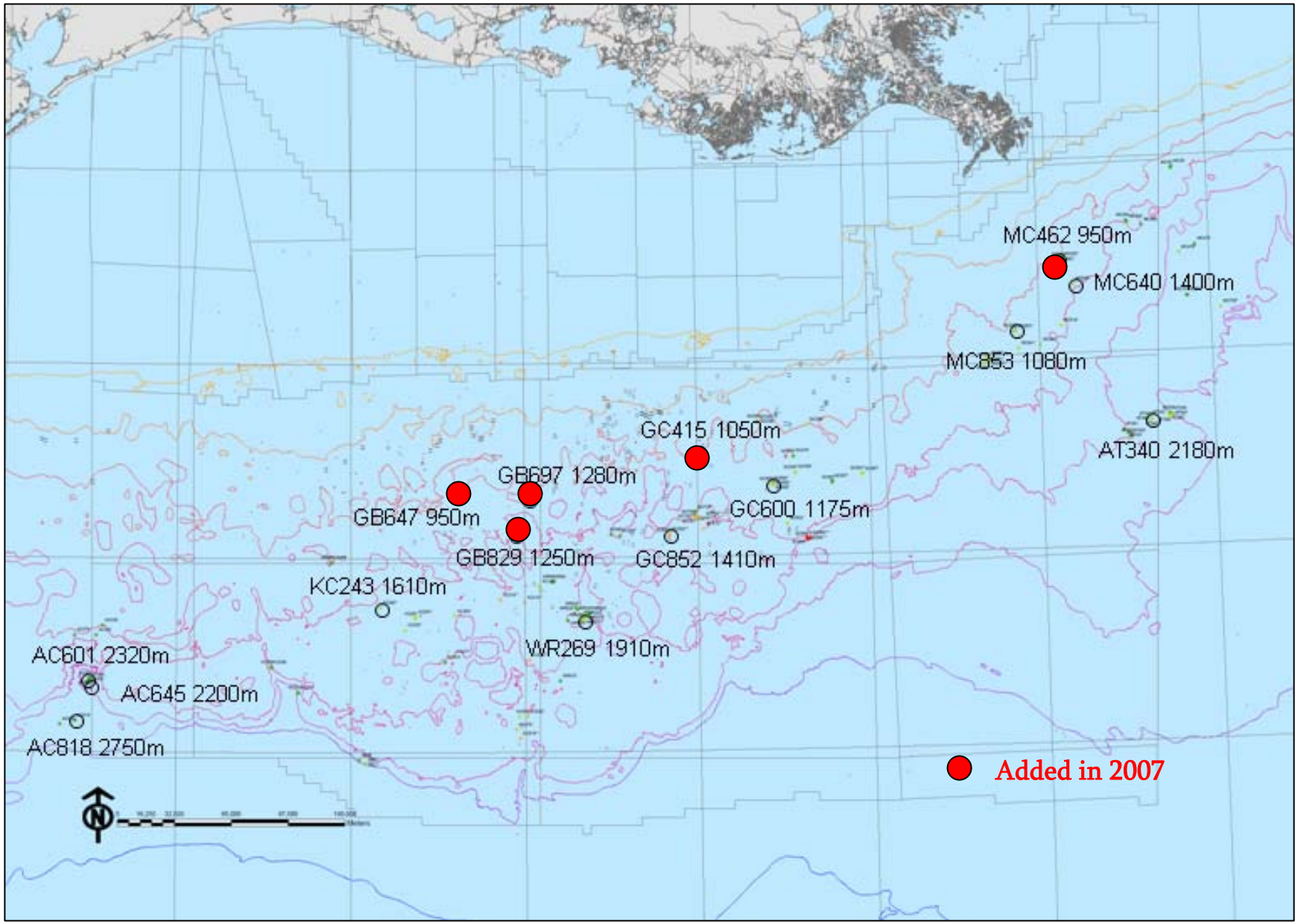
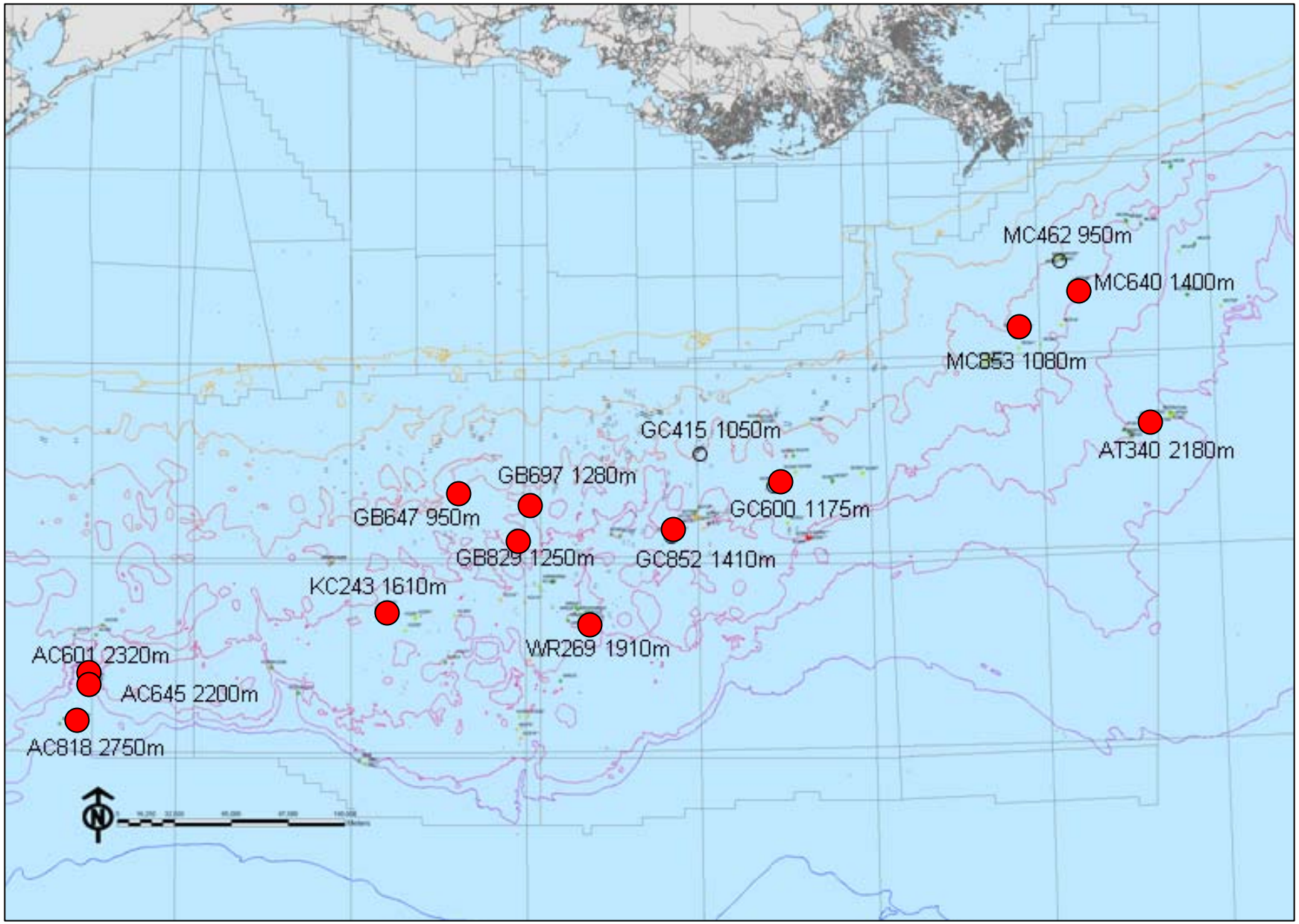
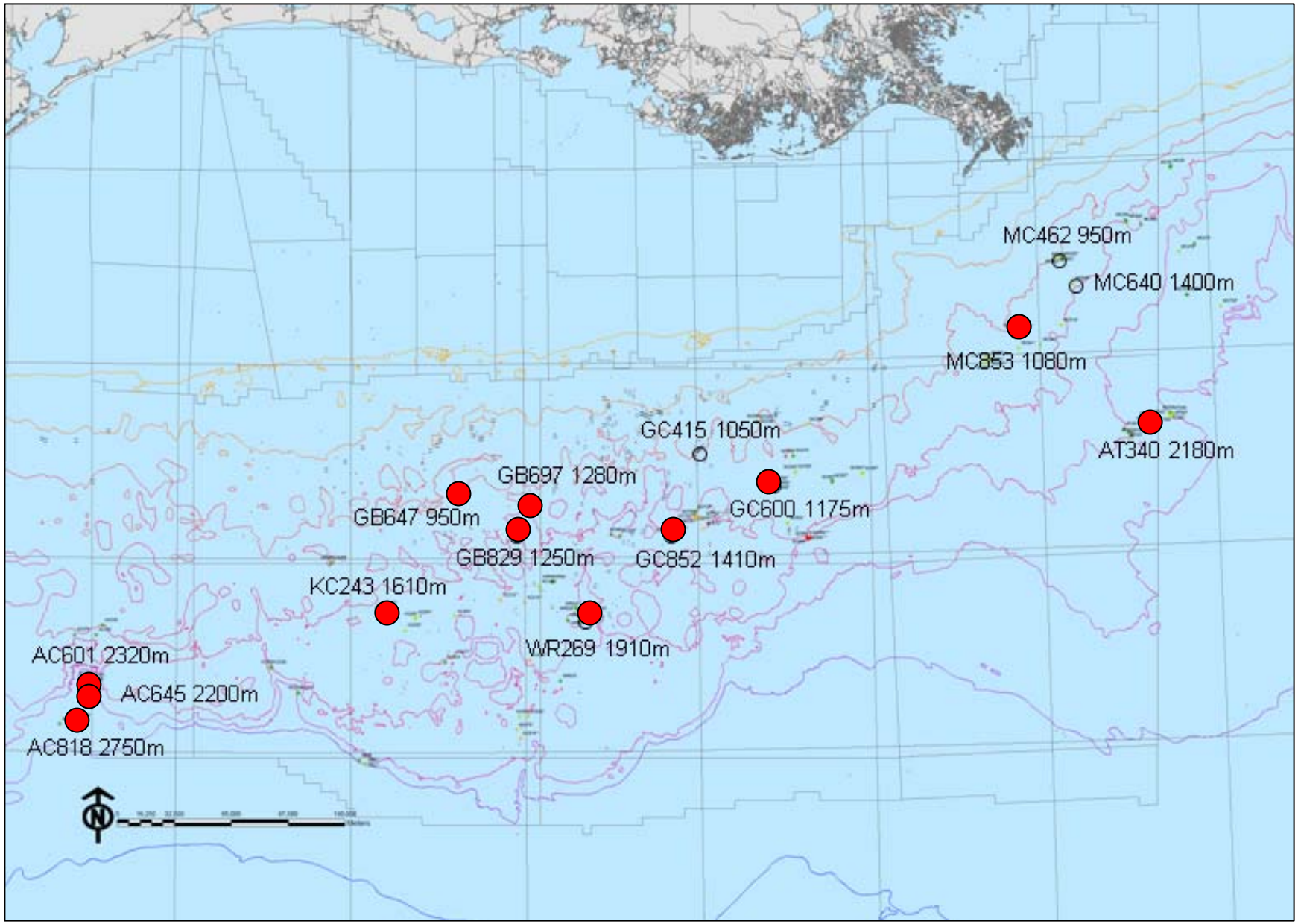


Sites with Bathymodiolid Mussels



Sites with Vestimentiferan Tubeworms



Lower slope mussels

(morphospecies, verified by CO1 genetic analysis)

Bathymodiolus brooksi
1,080–3,290 m

2 symbionts: methanotrophic and thiotrophic

Bathymodiolus childressi
525–2,220 m

1 symbiont: methanotrophic

Bathymodiolus heckerae
2,180–3,290 m
4 symbionts: 2 methanotrophic and 2 thiotrophic

Lower slope tubeworms: *All with very similar symbionts*
(morphospecies)

Seepiophila jonesi
525–1,000 m

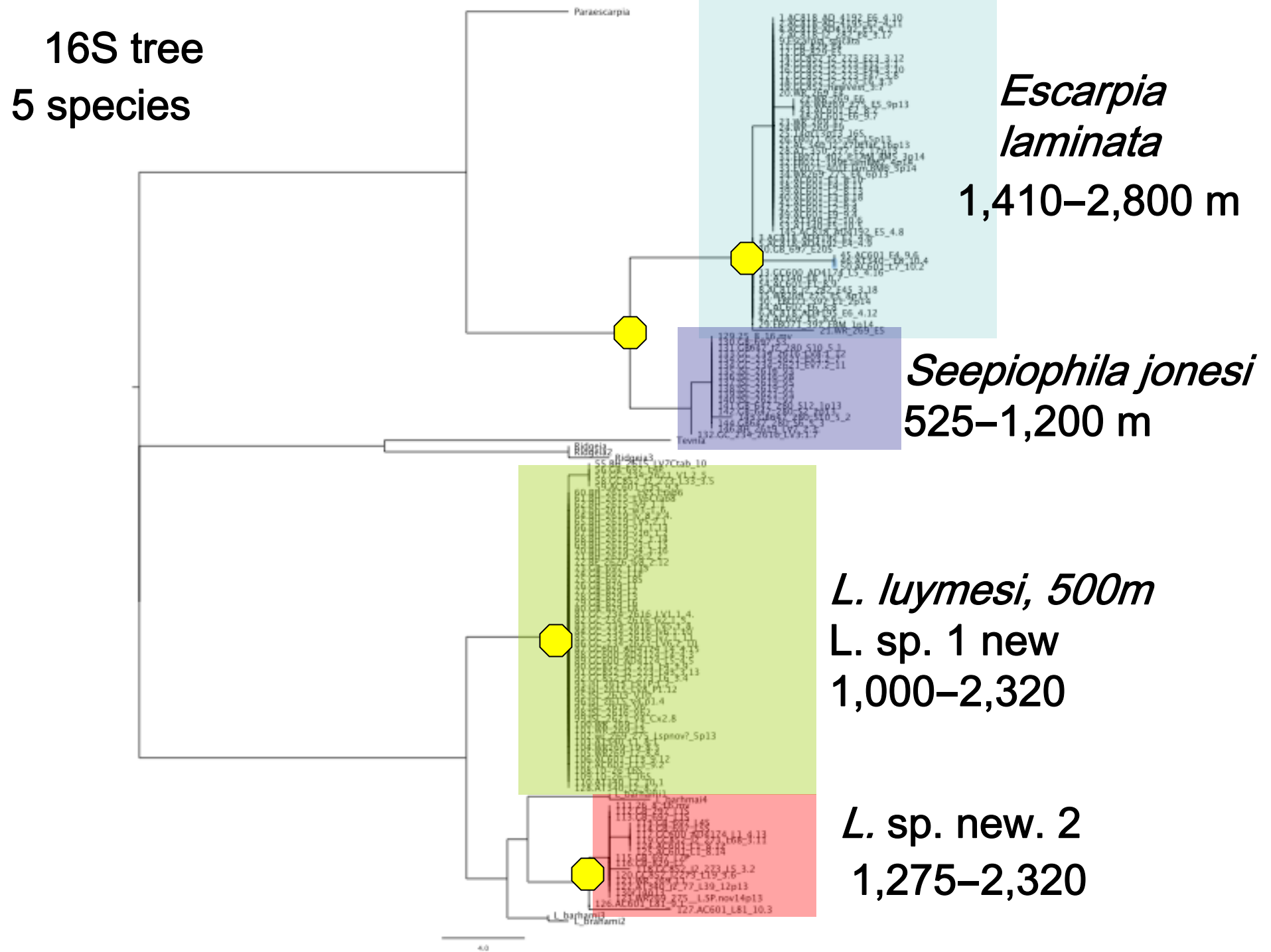
Lamellibrachia sp. nov. #1
1,000–2,320 m

Escarpia laminata
1,410–3,290 m

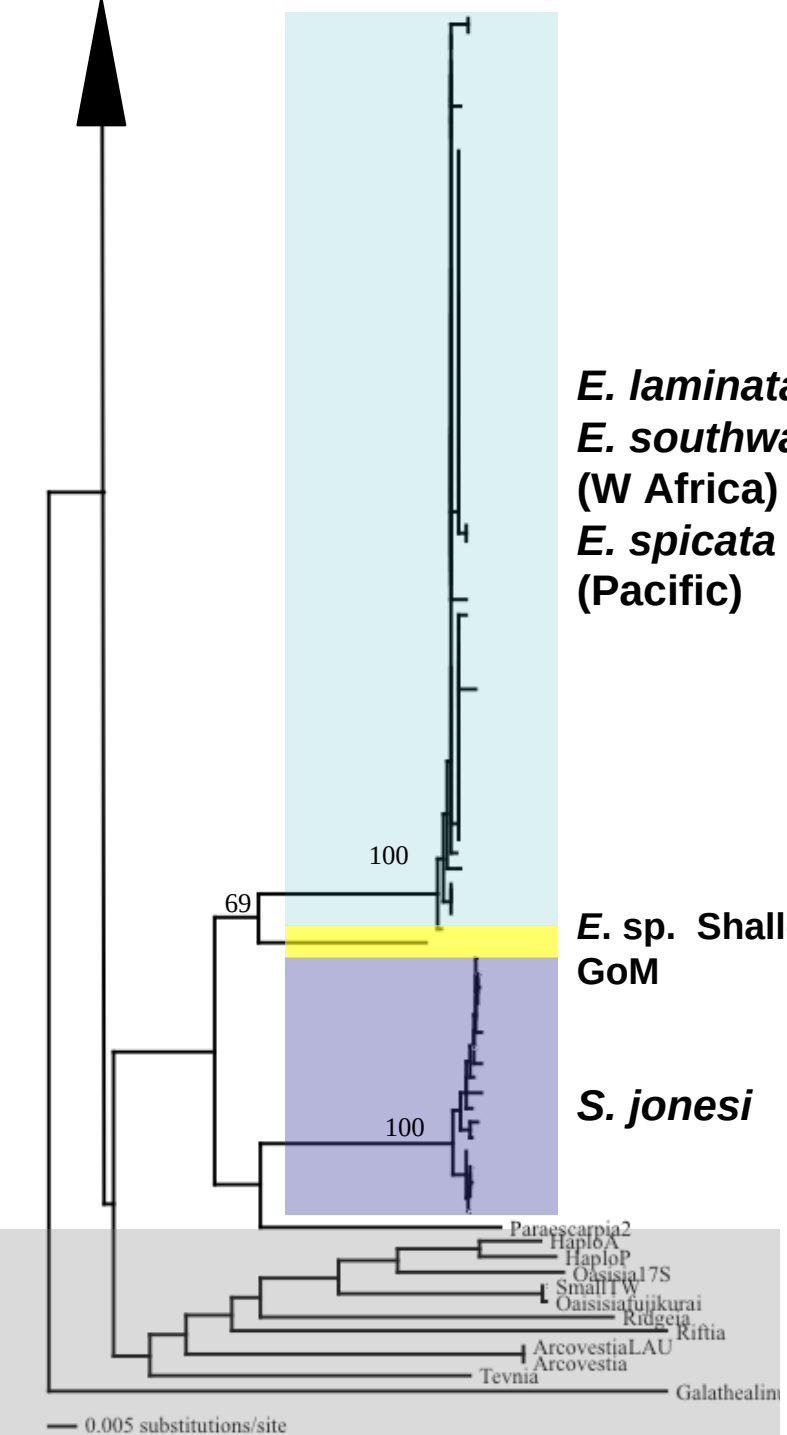
Lamellibrachia sp. nov. #2
1,275–1,420 m

But, morphospecies do not tell the whole tubeworm story…

- Molecular phylogenetic studies are underway.
- We began with two widely used mitochondrial genes:
  - CO1 (“Barcoding gene”)
    - (ran about 150 new samples)
  - 16S
    - (ran about 120 new samples)


16S tree
5 species
Paraescarpia
Escarpia laminata
1,410–2,800 m
Seepiophila jonesi
525–1,200 m
Tevnia
L. luymesi, 500m
L. sp. 1 new
1,000–2,320
L. sp. new. 2
1,275–2,320
L_bahamii3
L_bahamii2
4.0

COI tree

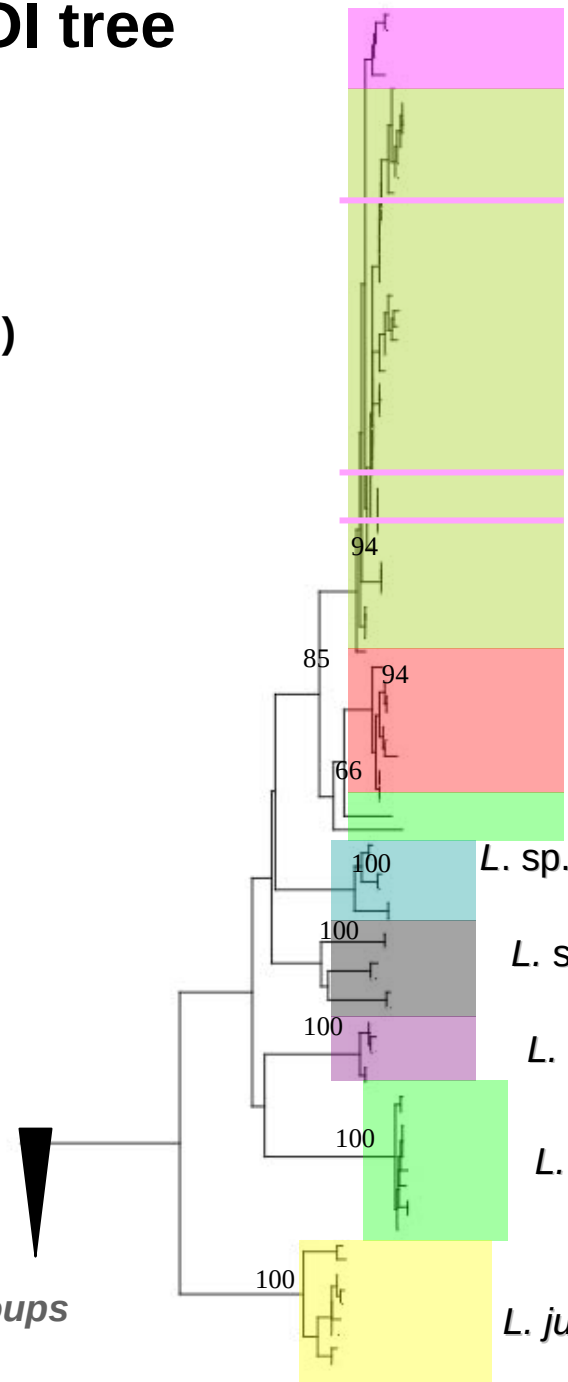


***E. laminata* (GoM)**
E. southwardae
(W Africa)
E. spicata
(Pacific)

***E*. sp. Shallow GoM**

S. jonesi

Outgroups



***L.* sp.1 (Deep GoM)**

***L. luymesi* (Shallow GoM)**

***L.* sp.2 (GoM)**

L. Chile & Med

L. sp. Japan

L. sp. WP

L. satsuma Japan

L. barhami EP

L. juni Japan

Vestimentiferans in the Gulf of Mexico
(re-consideration after molecular analyses)

1) *Seepiophila jonesi* occurs from ~500 to 1,000 m

2) *Escarpia* sp nov. is rare and only known from ~500m

3) *Escarpia laminata* occurs from 1,410 to 3,290m in the GoM

Genetically VERY similar to *E. spicata* and *E. southwardae*

4) *Lamellibrachia* sp nov 2 occurs 1,275–2,320m

Most closely related to *Lamellibrachia* spp. from Chile and the Mediterranean.

5a) *Lamellibrachia luymesi* occurs from ~500m to ???

5b) *Lamellibrachia* sp nov 1 occurs from ??? To 2,320m

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There are at least five, and likely six or more species in the Gulf of Mexico

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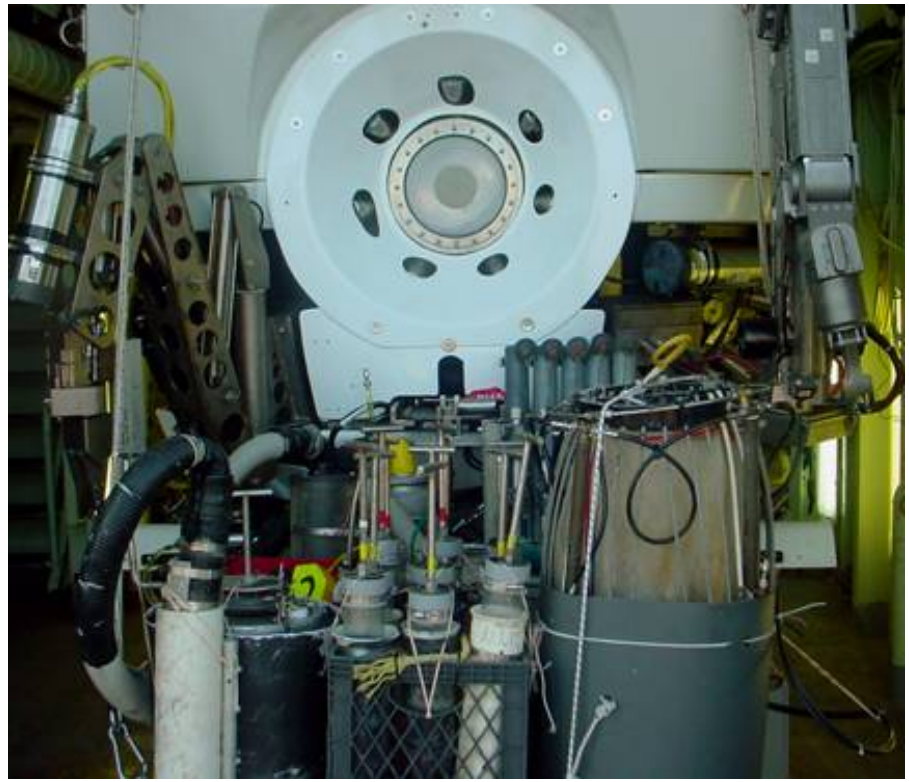
We are currently working with 2 nuclear genes (EF1 alpha and a Hb gene) and with microsatellites developed during Chemo II to resolve the *Escarpia laminata-spicata-southwardae* and GoM *Lamellibrachia luymesi sp. nov. 1* clades.

Lower Slope Community Collections

- 71 taxa in 46 quantitative collections
- Most common mussel and tubeworm associates on the Lower Slope:
  - *Alvinocaris muricola*
  - *Munidopsis* sp.
  - *Ophioctenella acies*



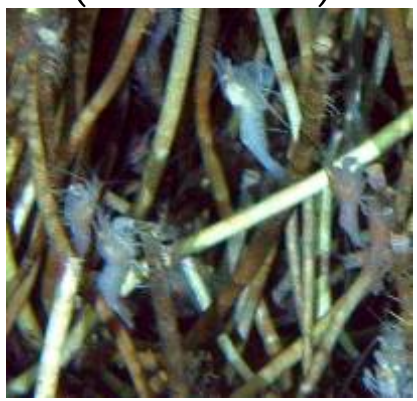
Most dominant and common species change with depth

Upper Slope
(Chemo I & II)

Alvinocaris stactophila

Species level replacement of dominant crustaceans (shrimp and galatheid crabs)

Lower Slope
(Chemo III)



Alvinocaris muricola

Bathynerita naticoidea

Phylum level shift of dominant grazer/deposit feeders from gastropods to ophiuroids

Ophioctenella acies

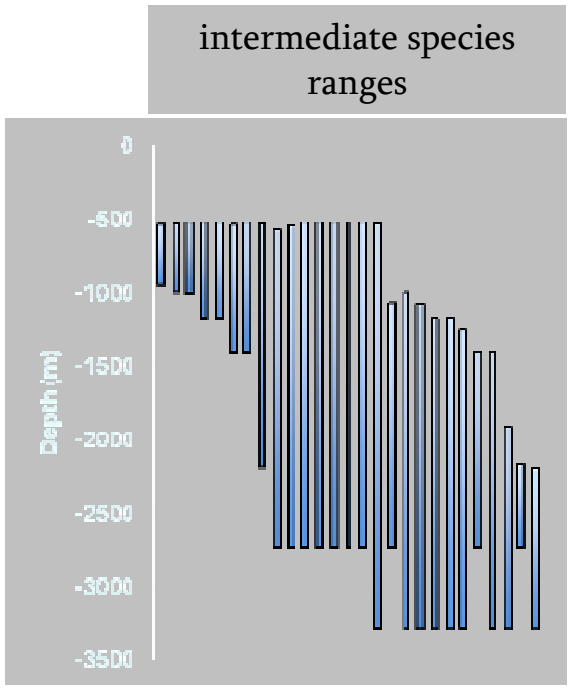
Image courtesy of Ian MacDonald

Significant changes in overall community composition occur at about 1,000m depth

Upper Slope
(Chemo I & II <800m)

Over 105 morpho-taxa collected with tubeworms and mussels that were never collected >900 m.

<800m and >900m
15 morpho-taxa



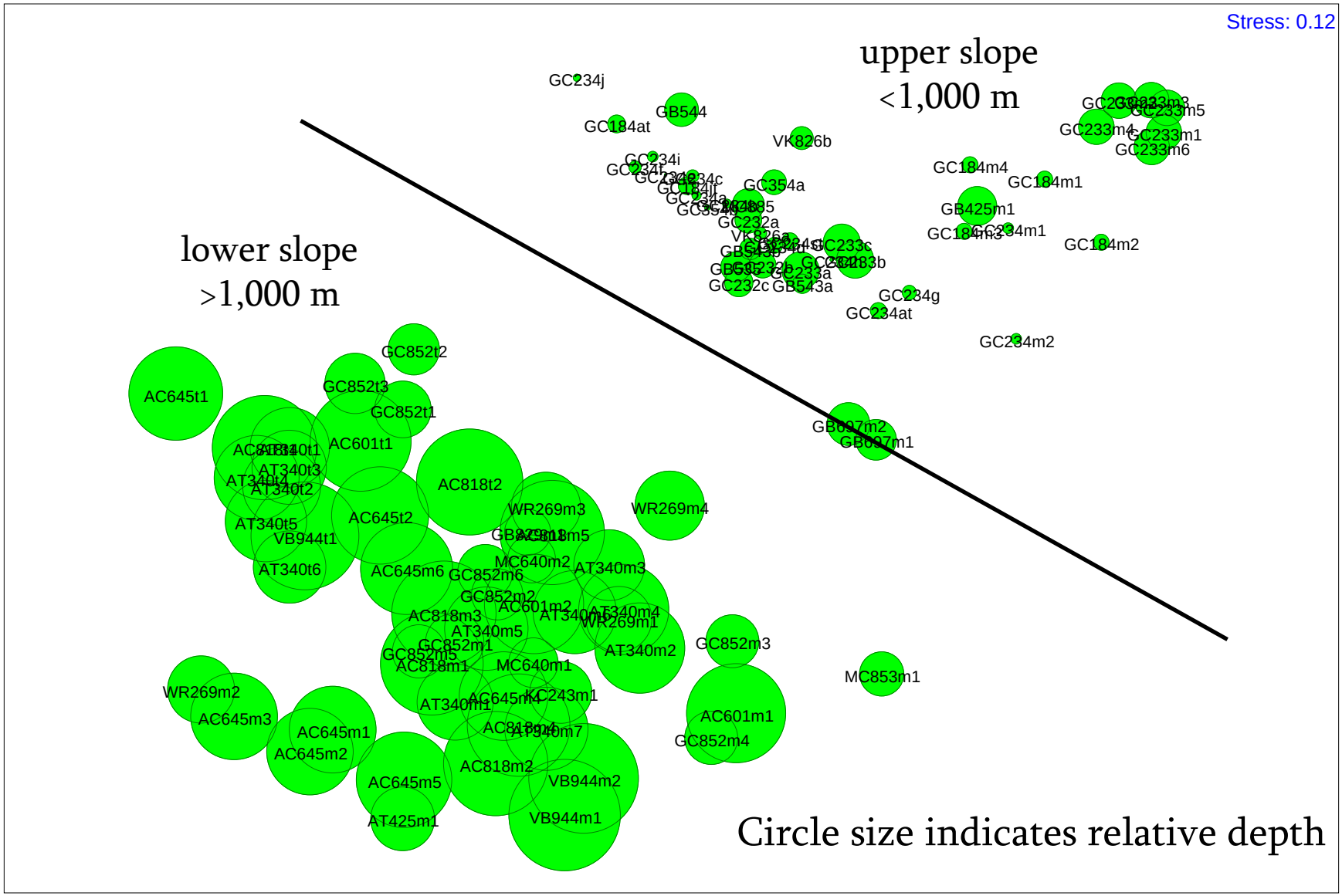
Lower Slope
(Chemo III >900m)

Over 55 morpho-taxa collected with tubeworms and mussels that were never collected <800 m.

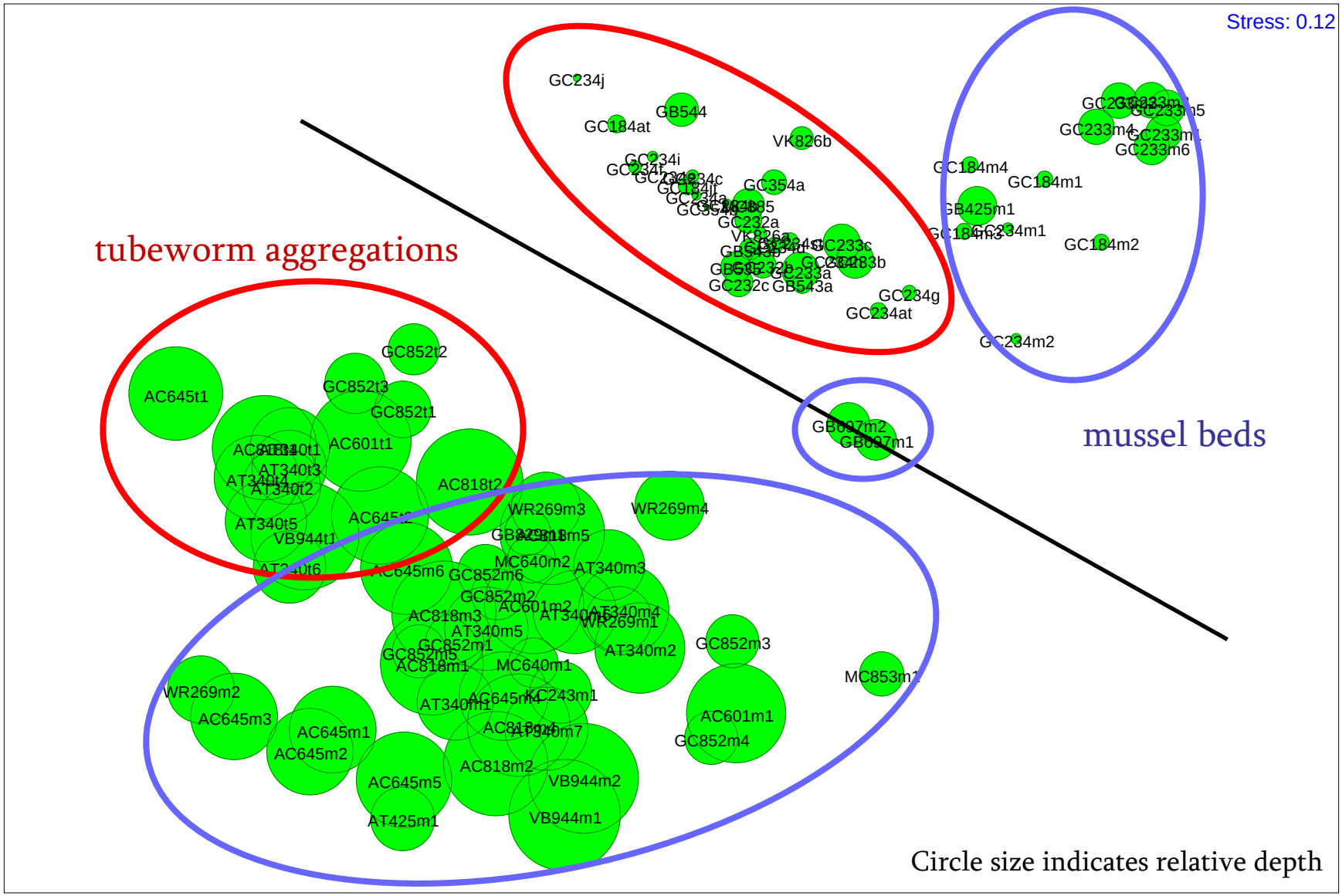
Image courtesy of Ian MacDonald

Gulf seep community similarity defined primarily by depth

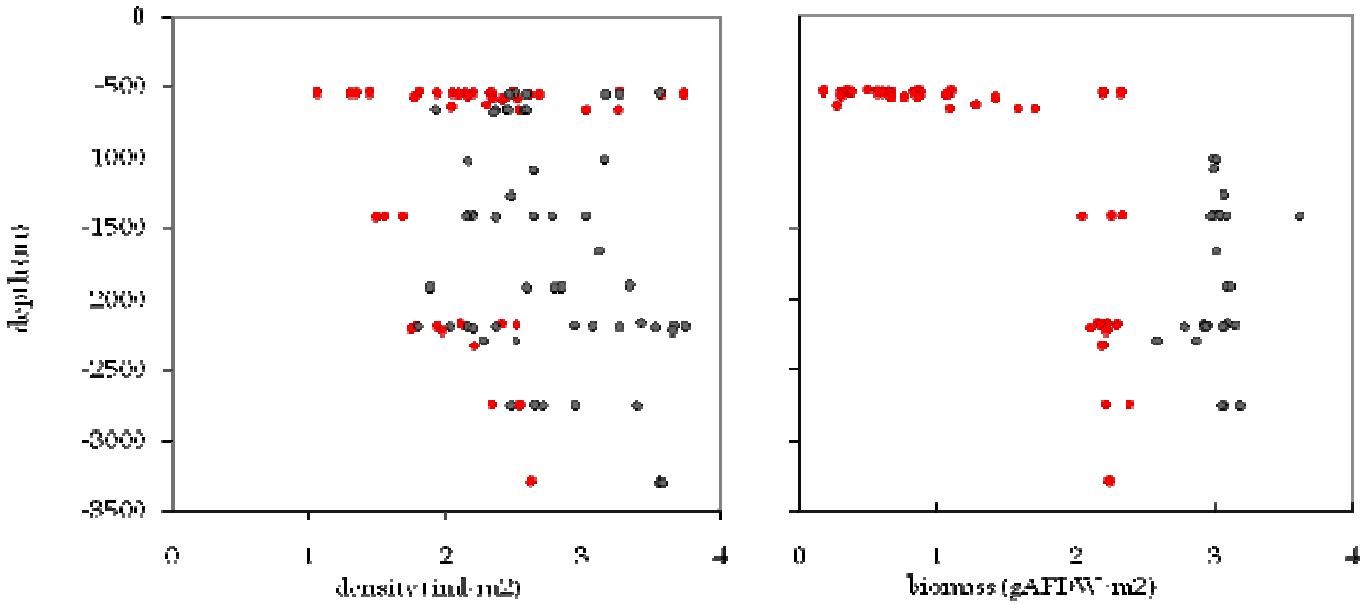
(MDS plot based on Brey-Curtis similarity indices from associated fauna density scaled to surface area of mussels or tubeworms)



Within depth range, communities group by foundation species

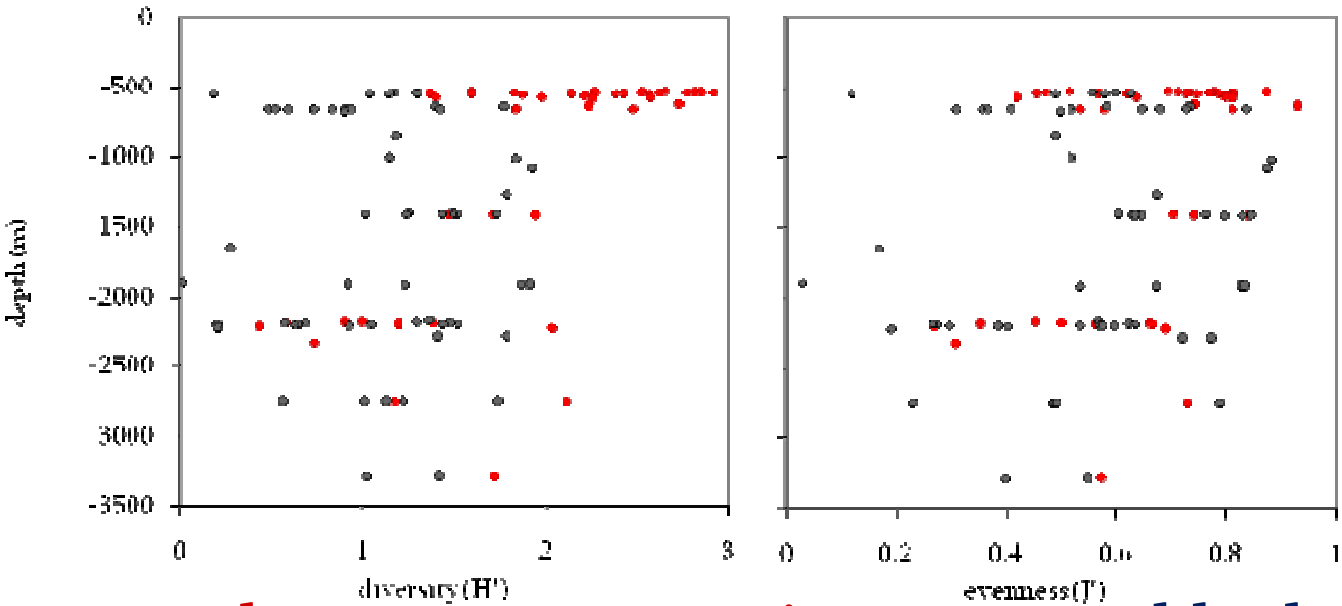


Typical deep-sea trend of decreasing abundance and biomass with increasing depth is not found in cold seep communities of the Gulf of Mexico



tubeworm aggregations mussel beds

Typical deep-sea trend of mid-depth maxima in diversity is not apparent in seep communities of the Gulf of Mexico



tubeworm aggregations mussel beds

- Diversity within mussel bed community collections does not change with depth*
- Diversity within tubeworm aggregations is generally lower at greater depths

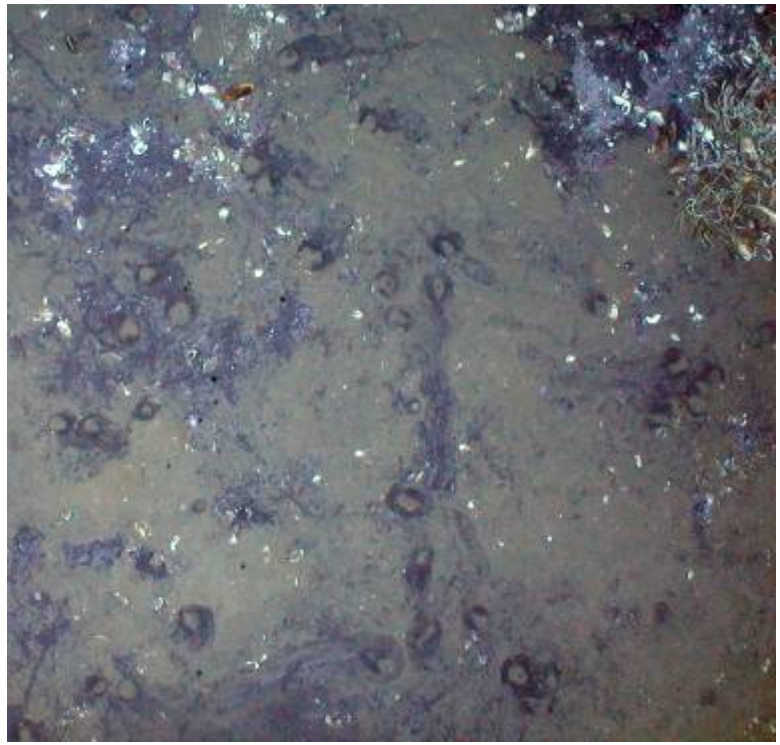
* Preliminary analyses suggest that beta diversity in mussel beds (total diversity in all mussel beds) is higher on the lower slope than on the upper slope and that it is higher than in all tubeworm communities on the lower slope.

Summary: Changes in Seep Communities with Depth

- Megafaunal chemo-communities were sampled from 13 sites during Chemo III
  - 47 quantitative collections
  - 70 morpho-species identified
    - (still going up)
- Mussel and tubeworm species change with depth, but also have considerable overlap across depths
  - May be some hybridization
- No change in density/biomass of seep communities with depth
- Community composition changes with depth
  - Significant changes at about 1,000m
  - Shift in shrimp and crab species
  - Shift from gastropods to ophiuroids
  - General increase in Echinoderms with depth

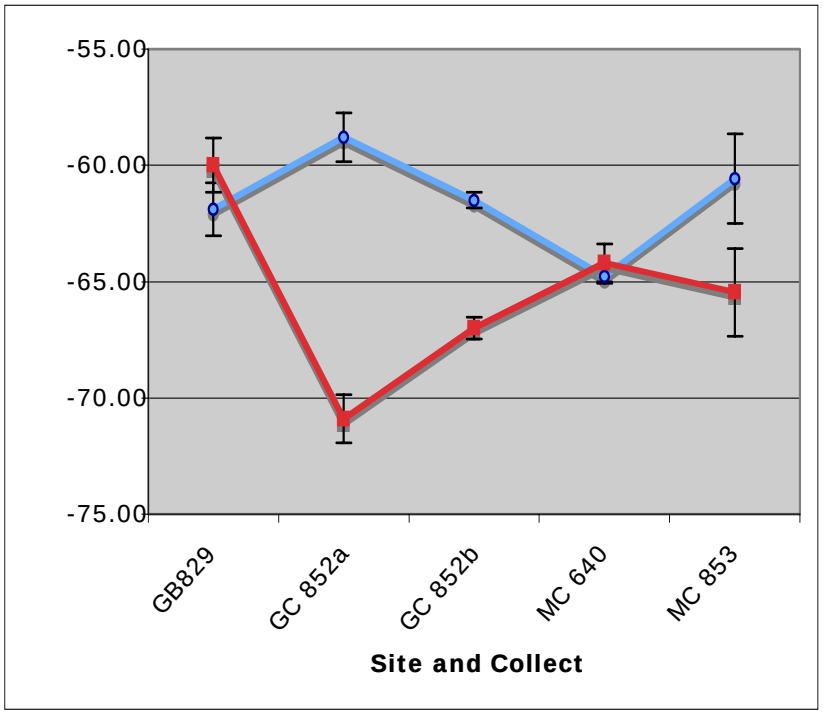
Chemo-Community Echinoderms on the Lower Slope

- Abundant heart urchins, *Sarsiaster greigi,* in some of the most reduced sediments below ~2,000m
- The holothurian, *Chirodota heheva*, was present in all chemoautotrophic megafauna community types on the lower slope (tubeworm, mussel, heart urchin, and pogonophoran/monoliferan)

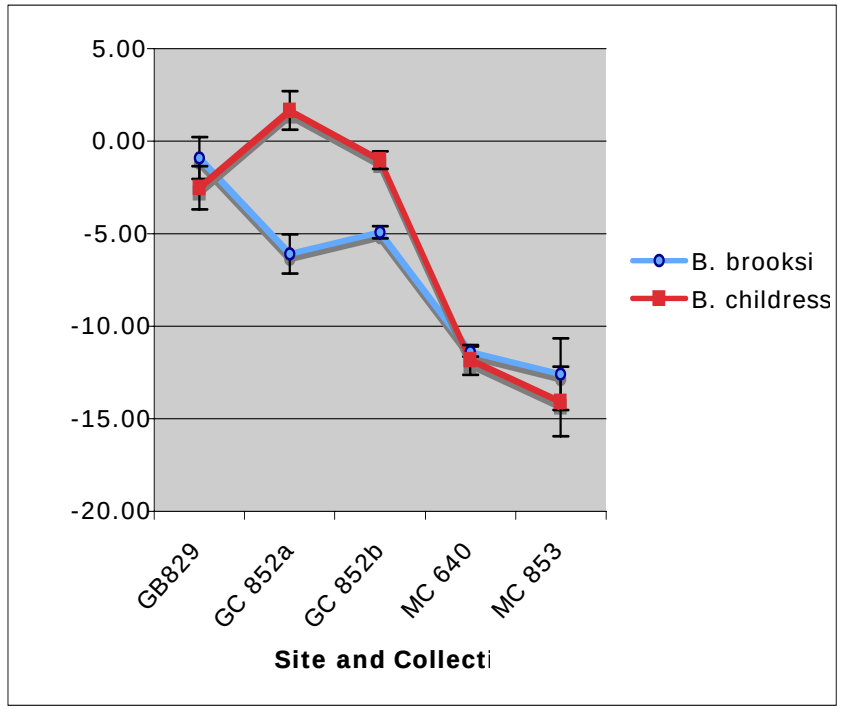


What is the difference in the niches of *Bathymodiolus childressi and B. brooksi?*

Tissue $\delta^{13}C$



Tissue $\delta^{15}N$



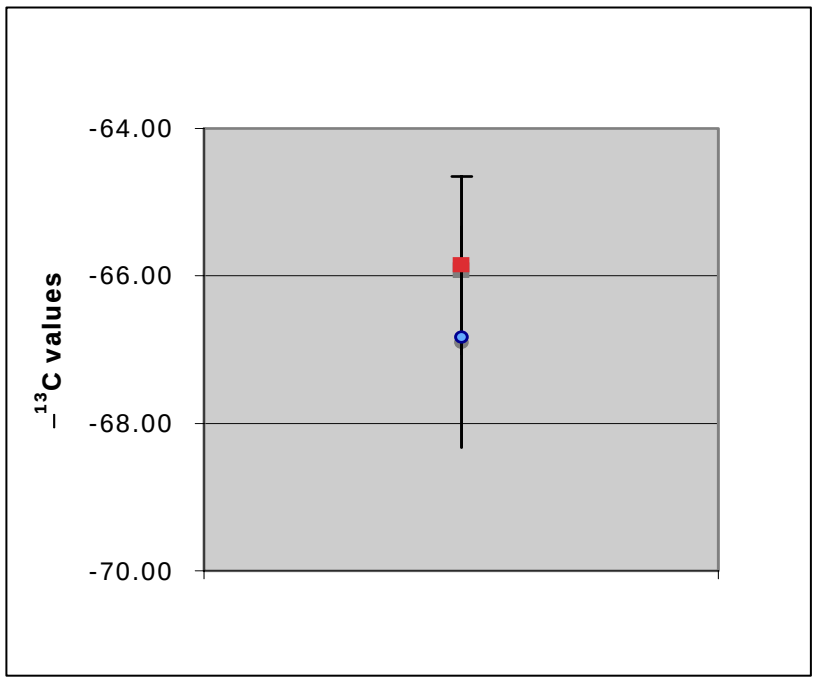
B.c. is methanotrophic
B.b. is methanotrophic and chemoautotrophic

There may also be differences in N sources or uptake mechanisms

What is the difference in the niches of *Bathymodiolus heckeri and B. brooksi?*

(only one collection with both species present)

Tissue $\delta^{13}C$



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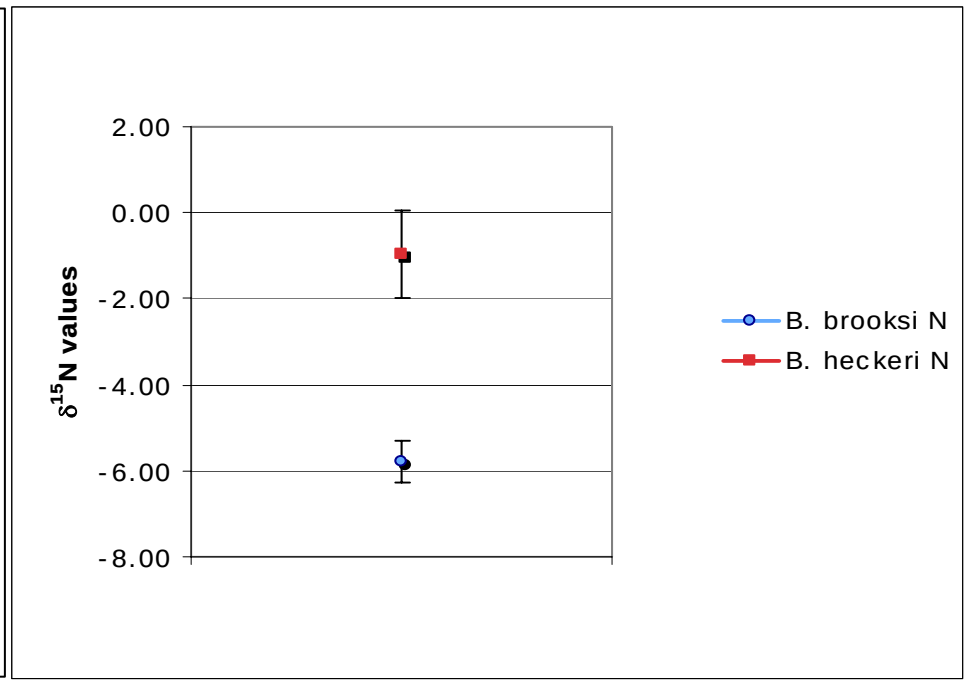
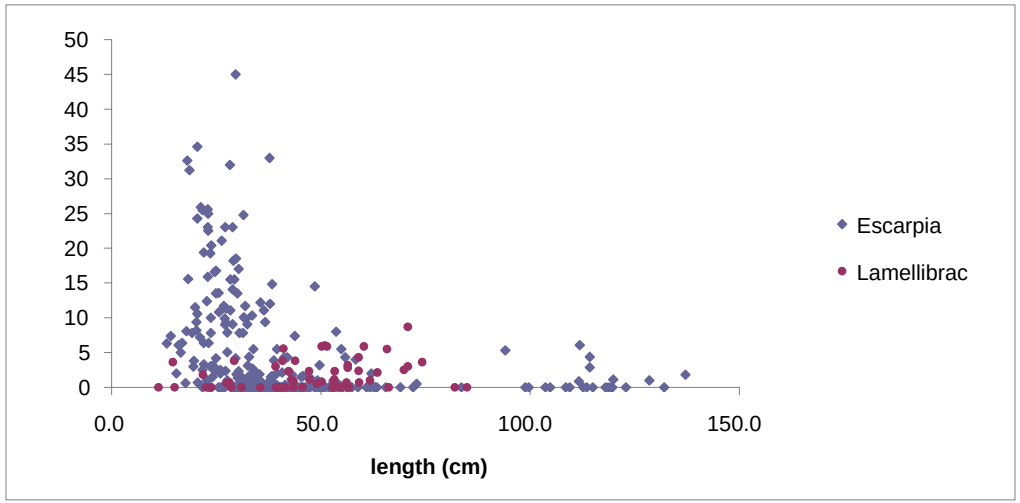


Both have methanotrophic and chemoautotrophic symbionts. *B. brooksi* has one of each and *B. heckeri* has two of each.

There appears to be differences in N sources or uptake mechanisms

Lower Slope Tubeworm Growth Rates

330 *Escarpia laminata* and
60 *Lamellibrachia* sp
stained and recovered



Four *E. laminata* banded in 1992 were re-measured in 2007

Total growth over 15 years ranged from 1–4 cm.

1992

2007

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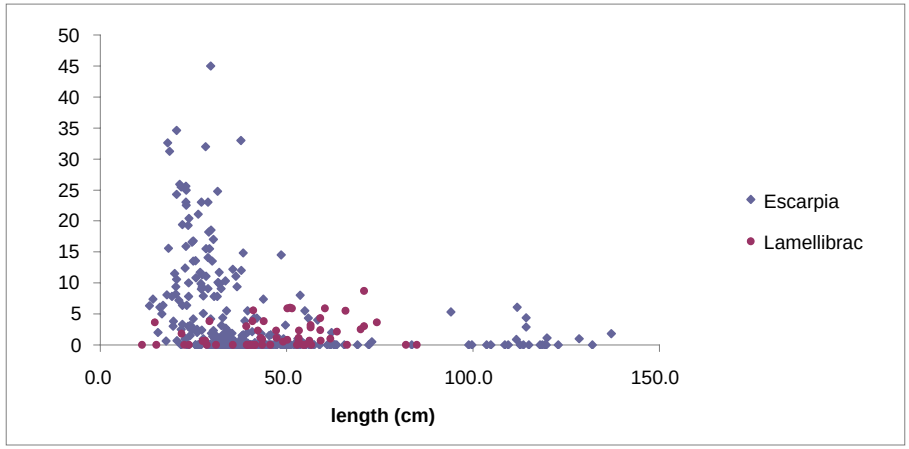


Four *E. laminata* banded in 1992 were re-measured in 2007

Total growth over 15 years ranged from 1–4 cm.

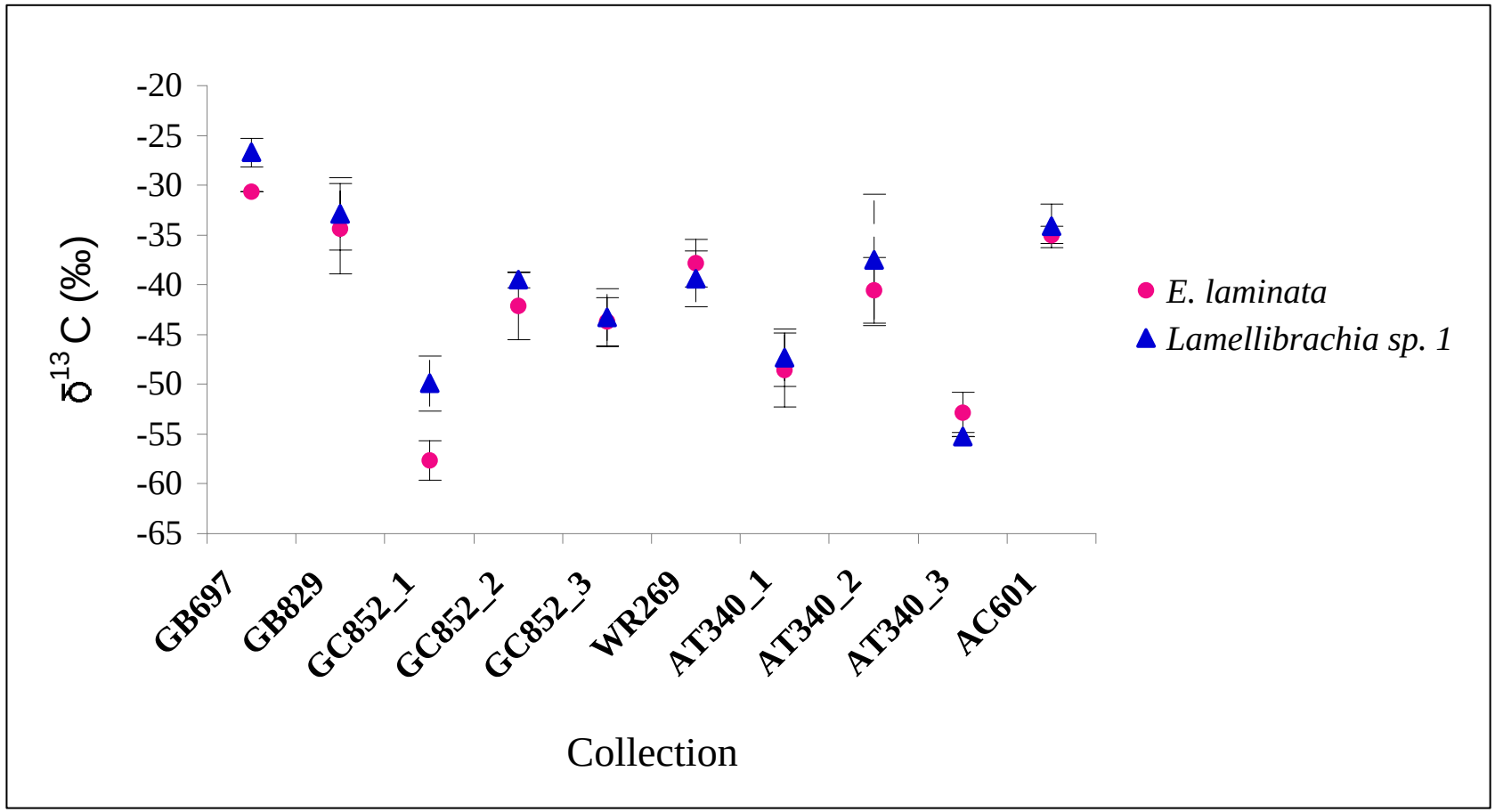
1992

2007

Tubeworms on the lower slope grow more slowly than those on the upper slope, and may live even longer than the 250+ years calculated for upper slope species. This is consistent with the almost total absence of young tubeworm aggregations found during the 2006 and 2007 dives.

What is the difference in the niches of *Escarpia laminata* and *Lamellibrachia* sp. 1?

(*Their symbionts are VERY similar or the same*)



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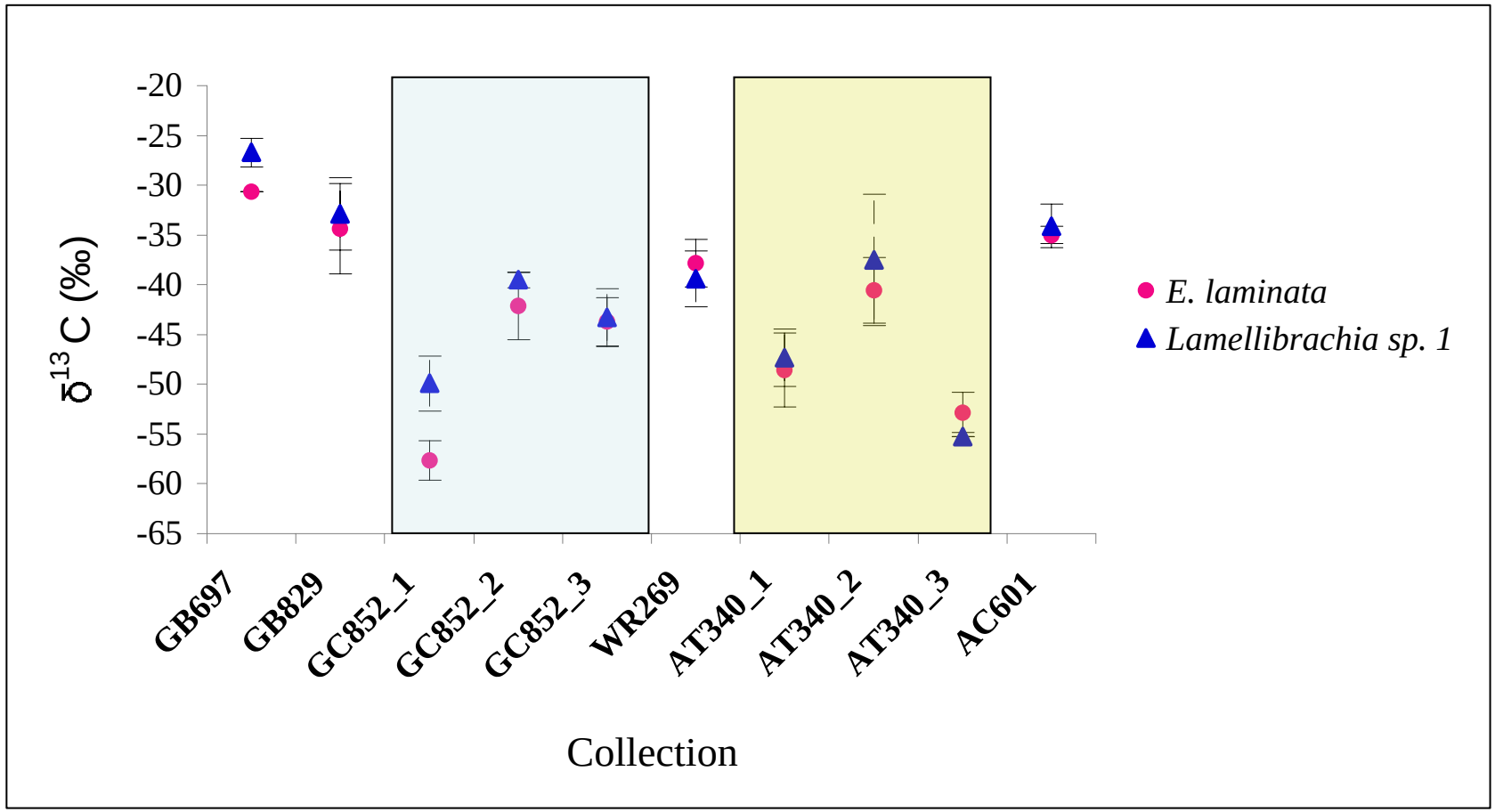

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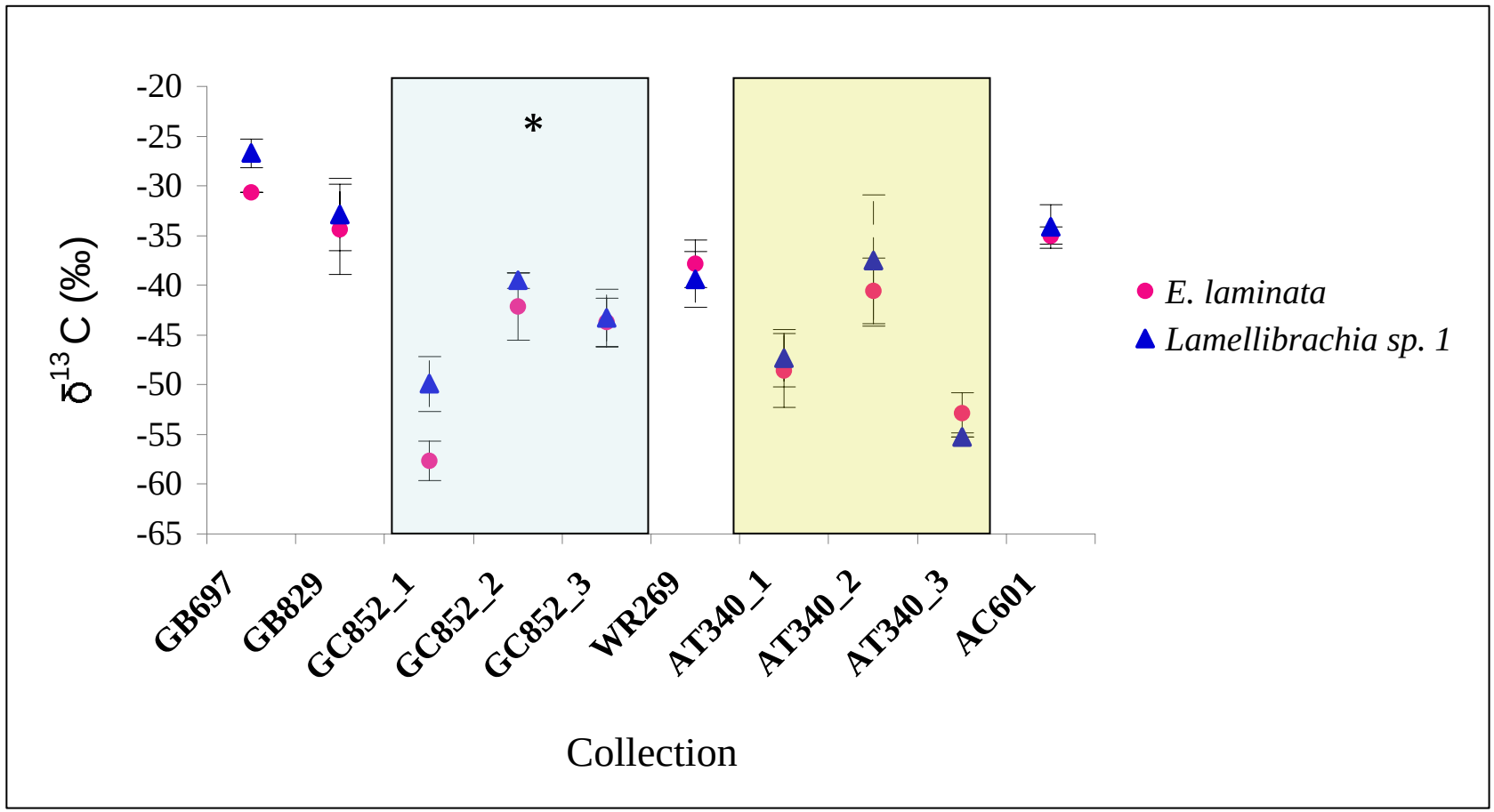

* Very small E. laminata collected with mussels at GC 852 ranged from -27 to -25‰

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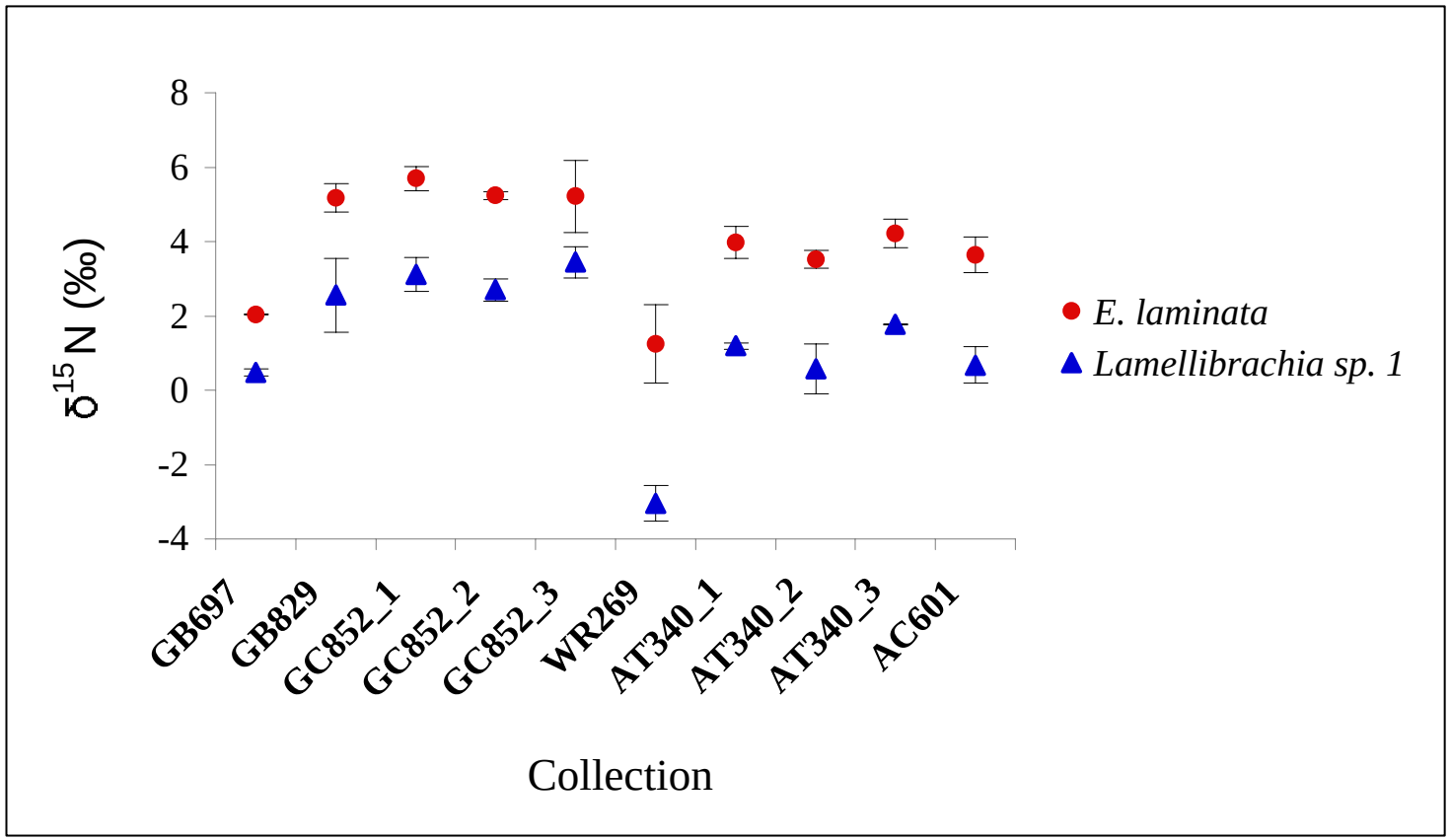

Utilizing different N sources???

Nitrate vs Ammonia ???

Shallow vs Deep roots???

What is the difference in the niches of *Escarpia laminata* and *Lamellibrachia* sp. 1?