Food-web Structure of Seep Macrobenthos from the Gulf of Mexico

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Introduction

Charismatic megafauna

Charismatic meiofauna/macrofauna?

Nutrition at seeps

- Most data from large fauna that host endosymbiotic chemoautotrophic bacteria
  - Via SIA, autotrophic enzyme analysis, electron microscopic studies, molecular sequencing of symbionts
  - Both methane and sulphur-based symbioses fuel tubeworms, mussels and clams (e.g., Childress et al. 1986; Brooks et al. 1987; Fisher et al. 1993; Peek et al. 1998)
- SIA reported for larger, megafaunal heterotrophic species from GOM seeps (Brooks et al. 1987; Fisher 1996; MacAvoy et al. 2002, 2005, 2008)
- Nutritional relations of smaller macro/meiofaunal seep associates not well understood

Nutrition for infauna

- Food-limited deep sea: what are they eating?
- Major options include
  - Organic matter derived from chemosynthetic endo/ectosymbionts
  - Heterotrophic consumption of free-living chemosynthetic bacteria/archaea
  - Consumption of photosynthetically-fixed material deposited from above

Nutrition for infauna

- SIA revealed different food resources utilized
  - Symbioses (nematodes: Dando et al. 1991, Jensen et al. 1992)
  - Local chemosynthetic production (Levin and Michener 2002; Van Dover et al. 2003)
- Macrofaunal reliance on chemo-derived sources may be depth dependent
- Nutritional relations for seep associates (infauna) in the lower slope GOM remain unknown

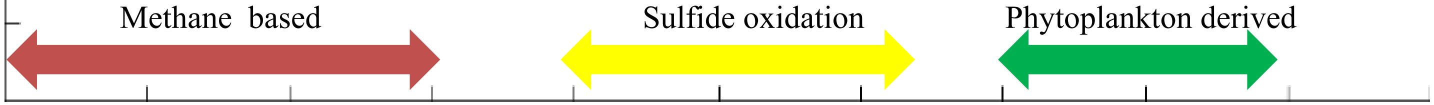
(see reviews by Conway et al. 1994; Levin 2005; Van Dover 2007)

Objectives

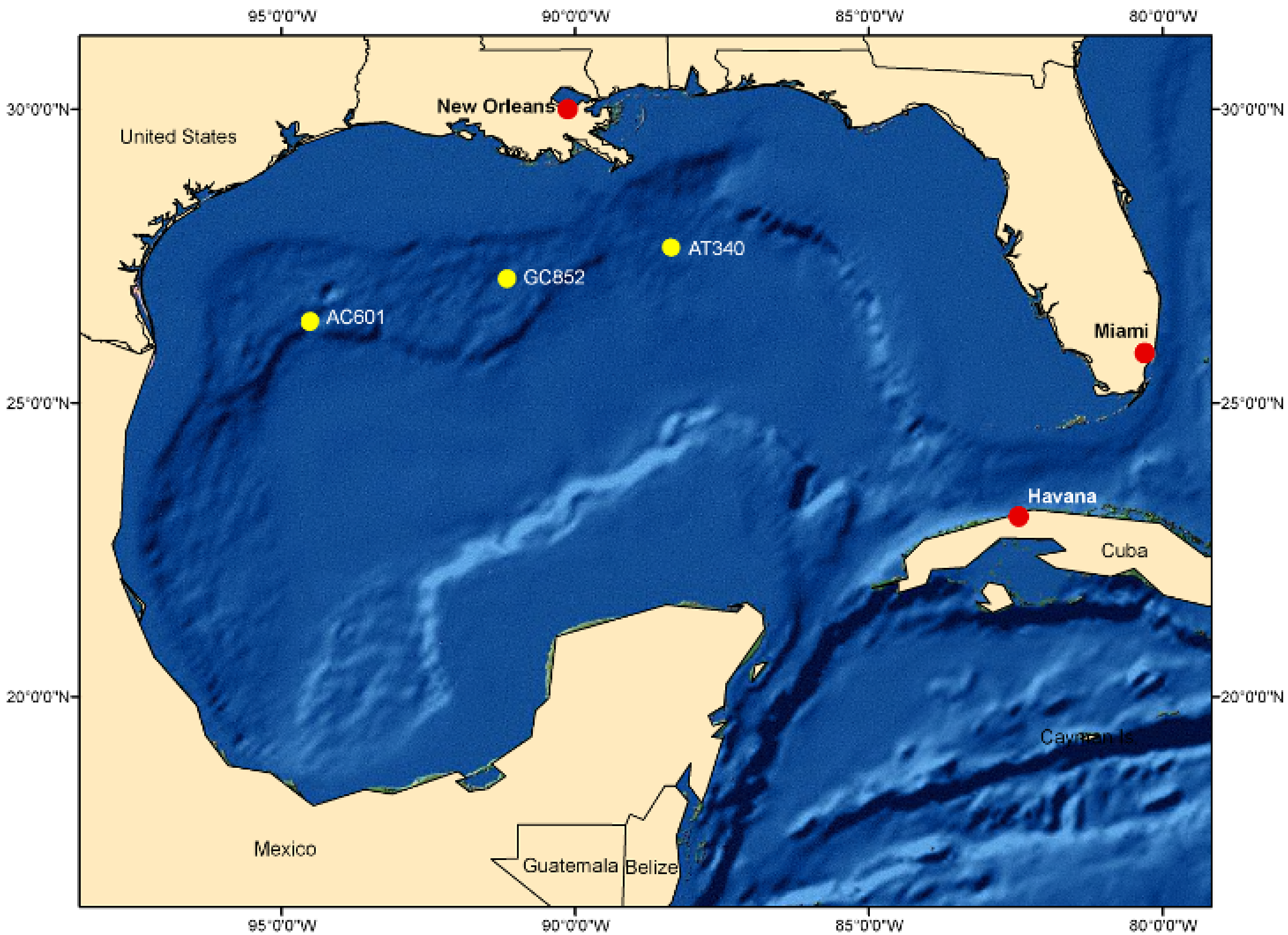
- To determine which, if any, infauna derive their nutrition from chemosynthetic production
  - $\delta^{13}C$, $\delta^{15}N$ analyses were used to investigate trophic linkages among the macrofauna (infauna) closely associated with seep environments

Chemosynthetic Habitats

- Very negative tissue carbon values ($\delta^{13}C < -45$ ‰): methane derived carbon
- Carbon fixation fueled by energy derived from sulfide oxidation: $\delta^{13}C = -27$ to -40‰.
- Phytoplankton derived organic matter: $\delta^{13}C = -15$ to -25 ‰



cf. Kennicutt et al. 1992; Levin and Michener 2002, references therein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90°0'0"W
85°0'0"W
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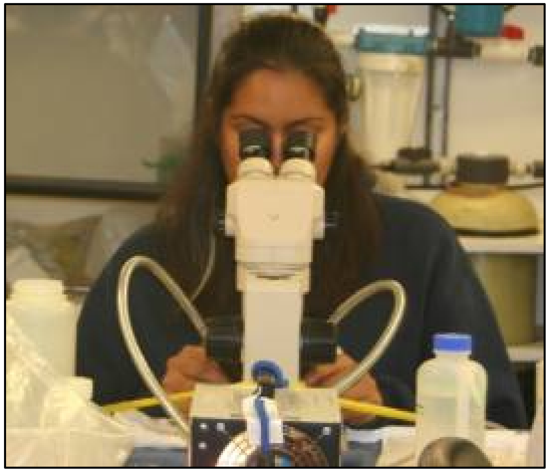
30°0'0"N
25°0'0"N
20°0'0"N
United States
New Orleans
AT340
GC852
AC601
Miami
Havana
Cuba
Mexico
Guatemala
Belize

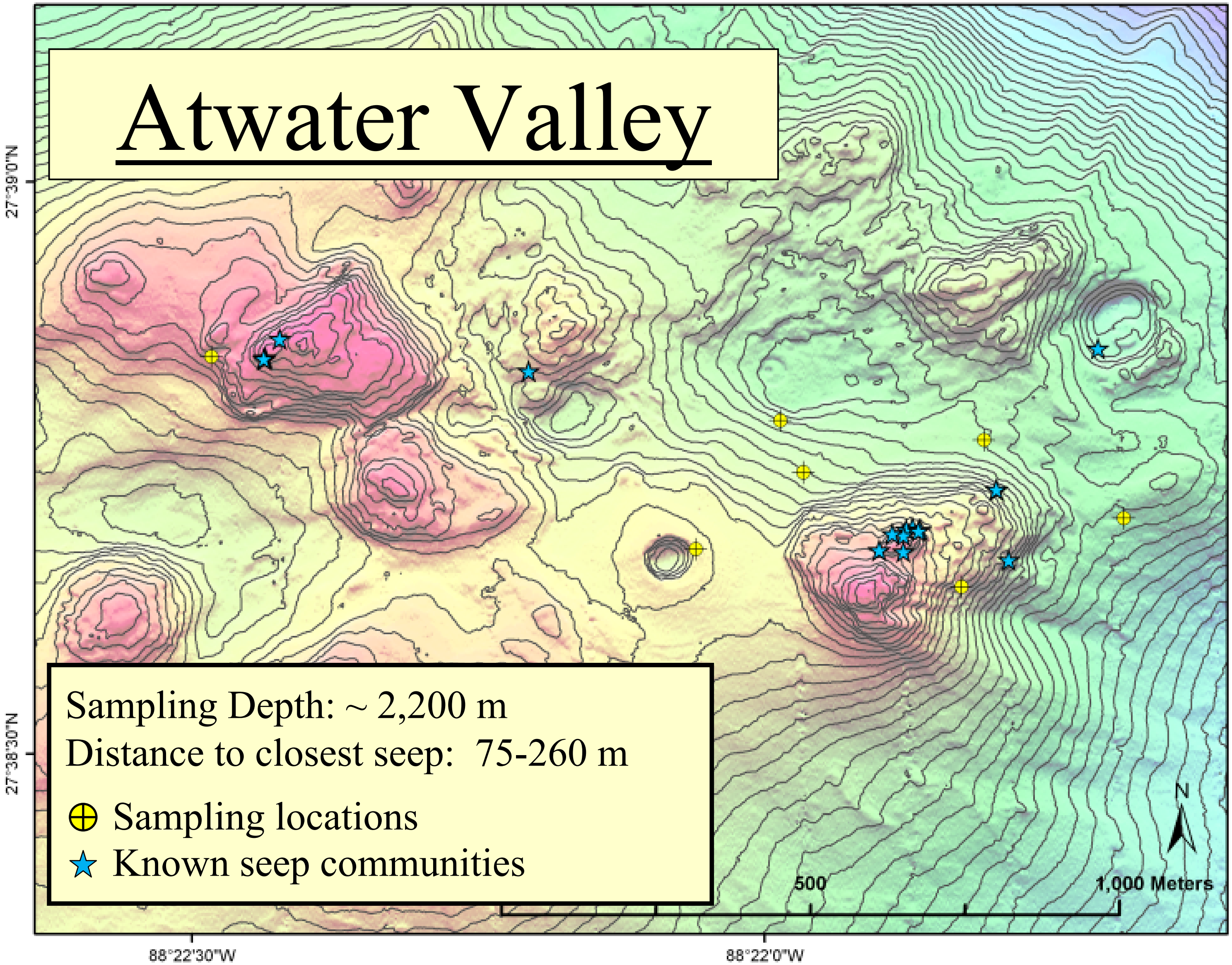
Methods

- Box core samples
- 33 cm^2 push cores
  - Infaunal community analysis
  - Stable isotopes
  - Sediment porewater chemistry, particle size and organic c/n

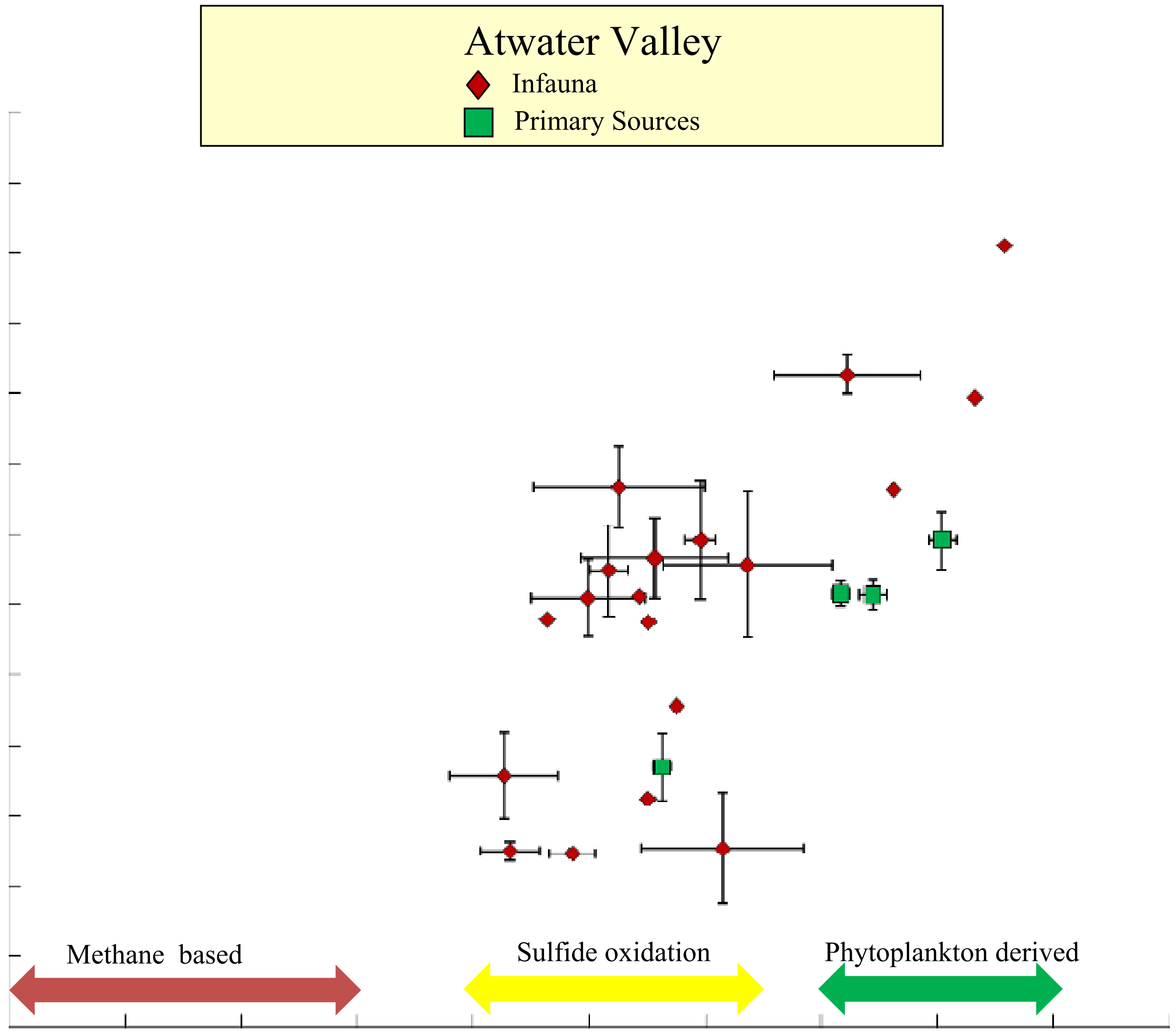
Photo: nicholas.duke.edu

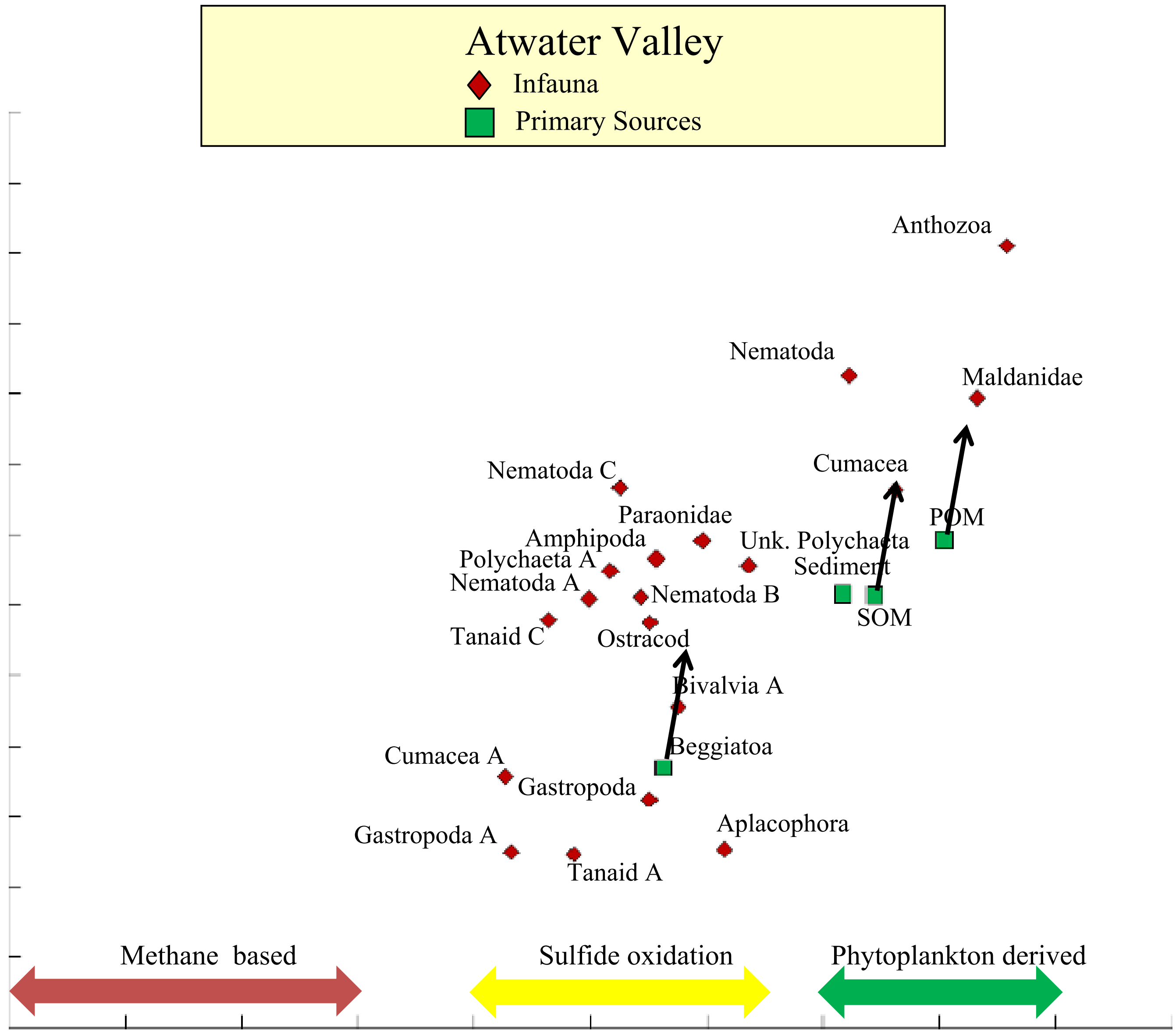


Photos: S. Ross, A. Roa-Varon



Multibeam courtesy of MMS/OE Chemo III Study P.I.s
Seep locations from TDI-Brooks 2006


Atwater Valley
Infauna
Primary Sources
Methane based
Sulfide oxidation
Phytoplankton derived

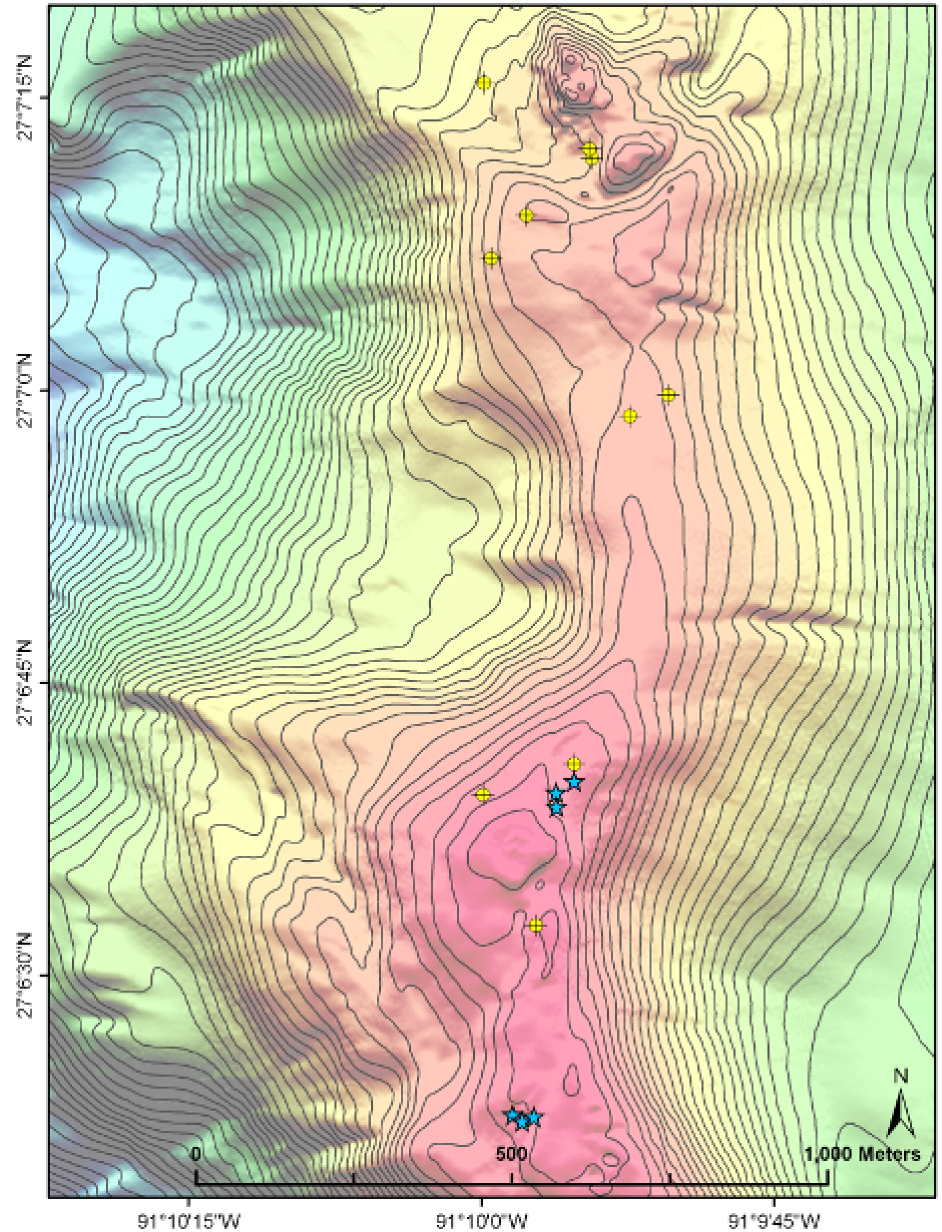


Atwater Valley
Infauna
Primary Sources
Anthozoa
Nematoda
Maldanidae
Nematoda C
Cumacea
Paraonidae
POM
Amphipoda
Unk. Polychaeta
Polychaeta A
Sediment
Nematoda A
Nematoda B
SOM
Tanaid C
Ostracod
Bivalvia A
Beggiatoa
Cumacea A
Gastropoda
Aplacophora
Gastropoda A
Tanaid A
Methane based
Sulfide oxidation
Phytoplankton derived

Green Canyon

Sampling Depth: ~ 1,400 m
Distance to seeps: 27–1,000 m

⊕ Sampling locations
★ Known seep communities



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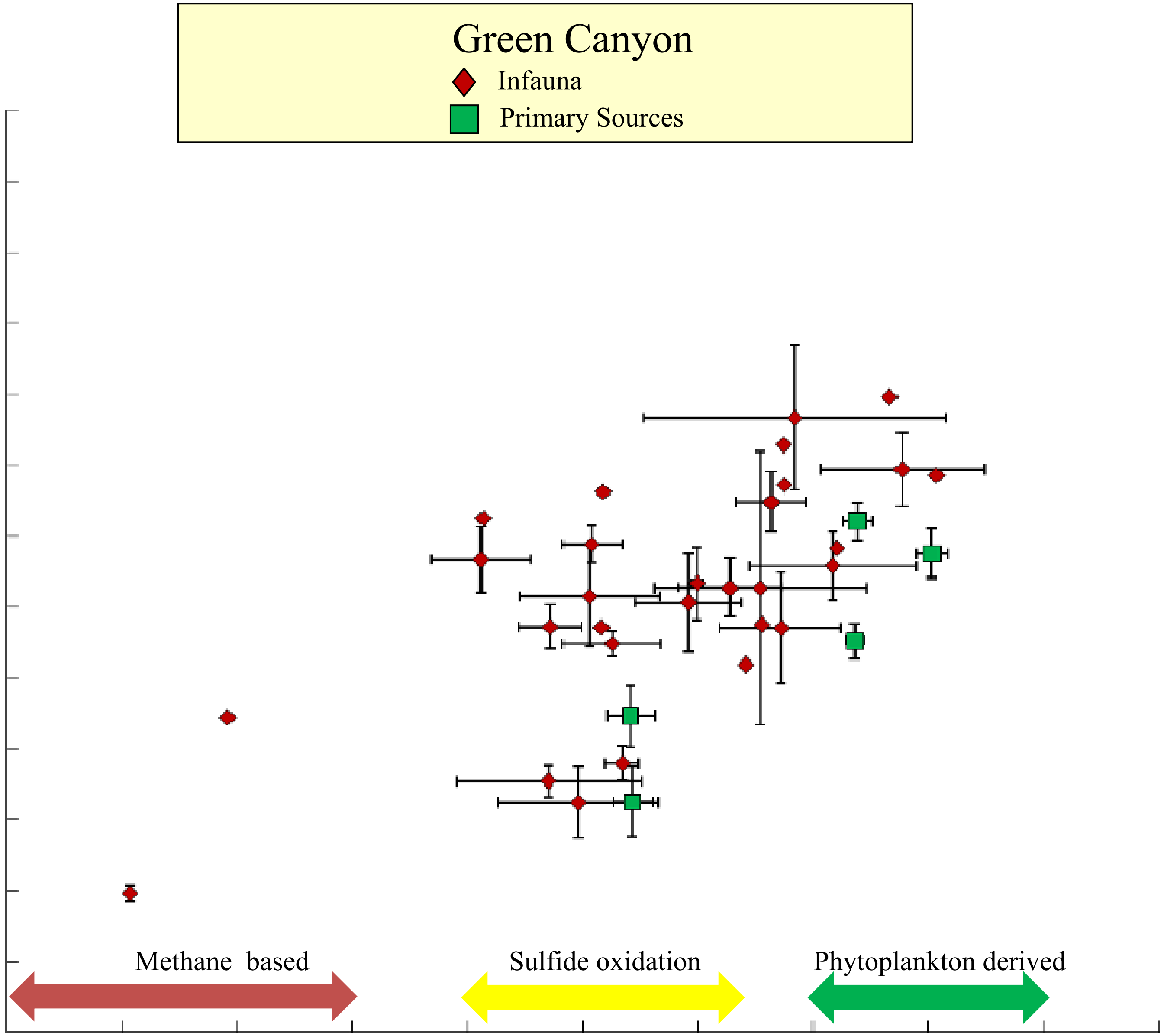
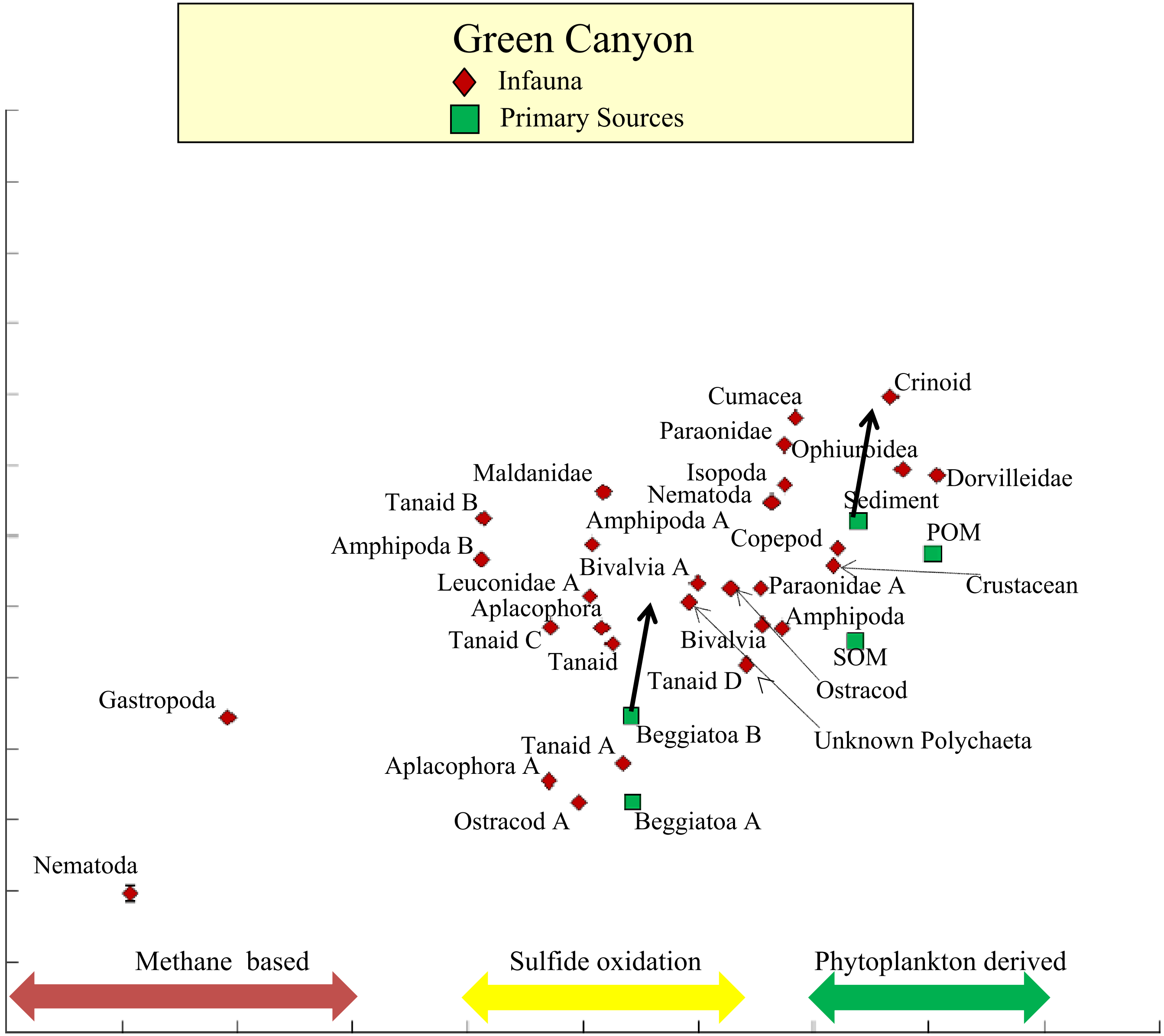
Seep locations from TDI-Brooks 2006


Green Canyon
Infauna
Primary Sources
Methane based
Sulfide oxidation
Phytoplankton derived

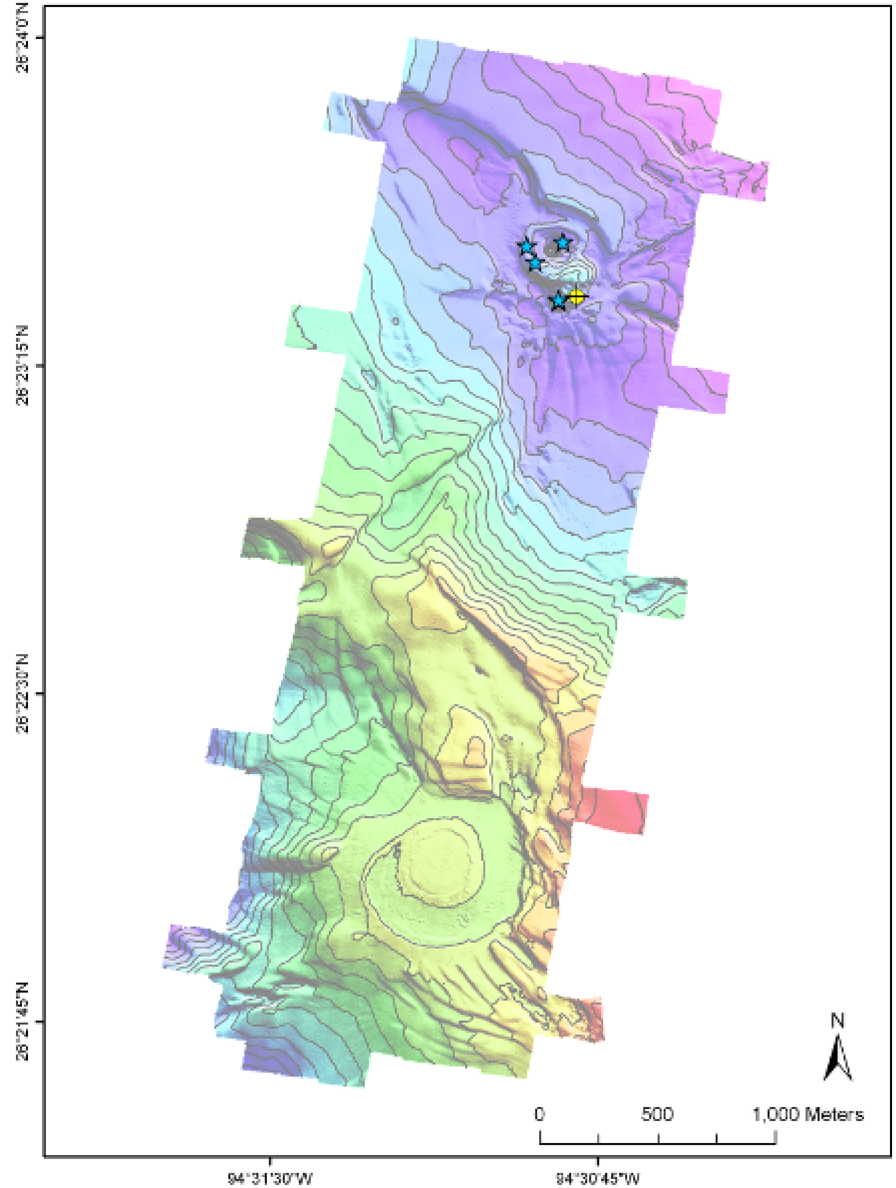


Green Canyon
Infauna
Primary Sources
Crinoid
Cumacea
Paraonidae
Ophiuroidea
Dorvilleidae
Maldanidae
Isopoda
Nematoda
Sediment
Tanaid B
Amphipoda A
POM
Copepod
Amphipoda B
Crustacean
Bivalvia A
Paraonidae A
Leuconidae A
Aplacophora
Amphipoda
Tanaid C
Bivalvia
Tanaid
SOM
Tanaid D
Ostracod
Gastropoda
Beggiatoa B
Unknown Polychaeta
Tanaid A
Aplacophora A
Ostracod A
Beggiatoa A
Nematoda
Methane based
Sulfide oxidation
Phytoplankton derived

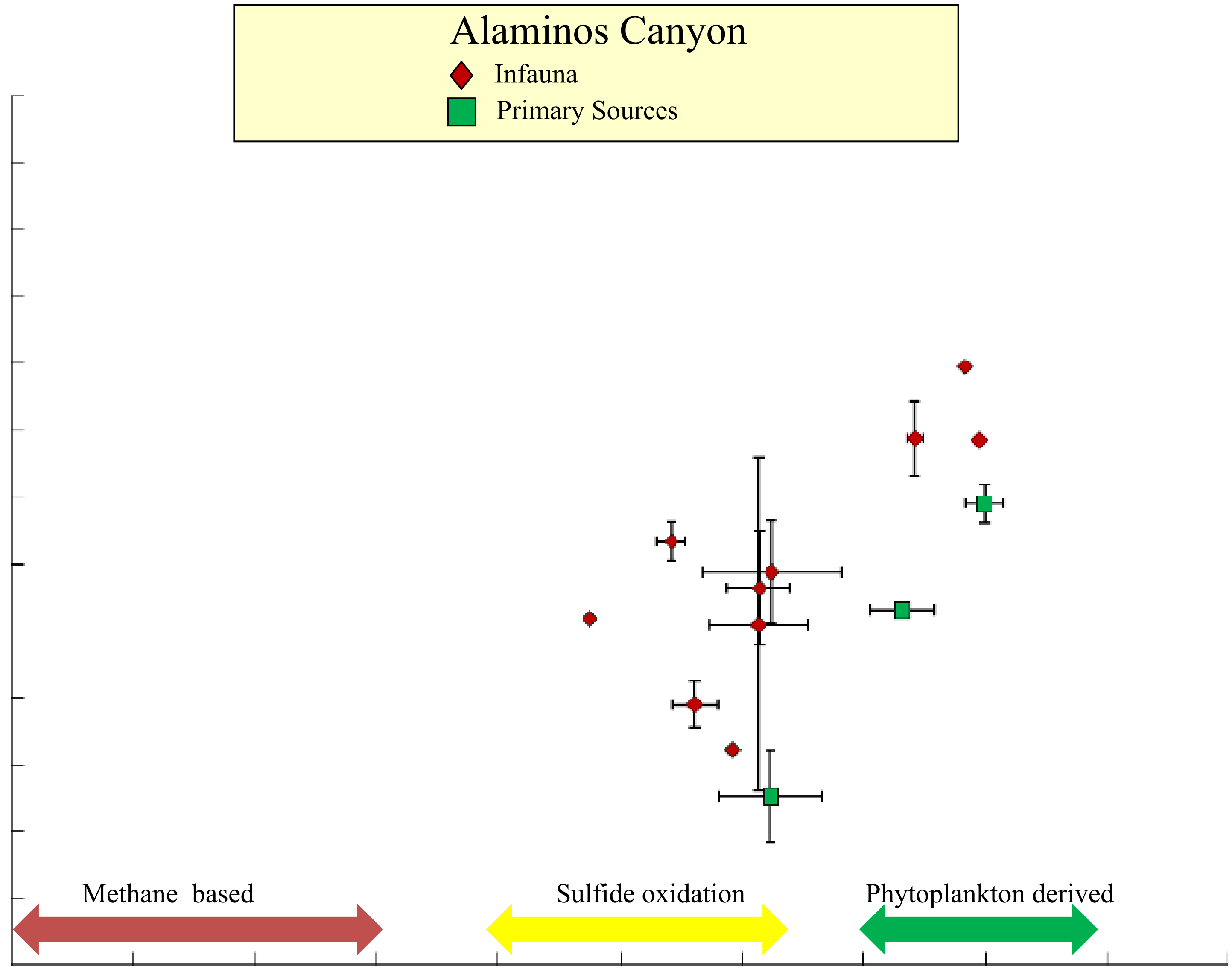
Alaminos Canyon

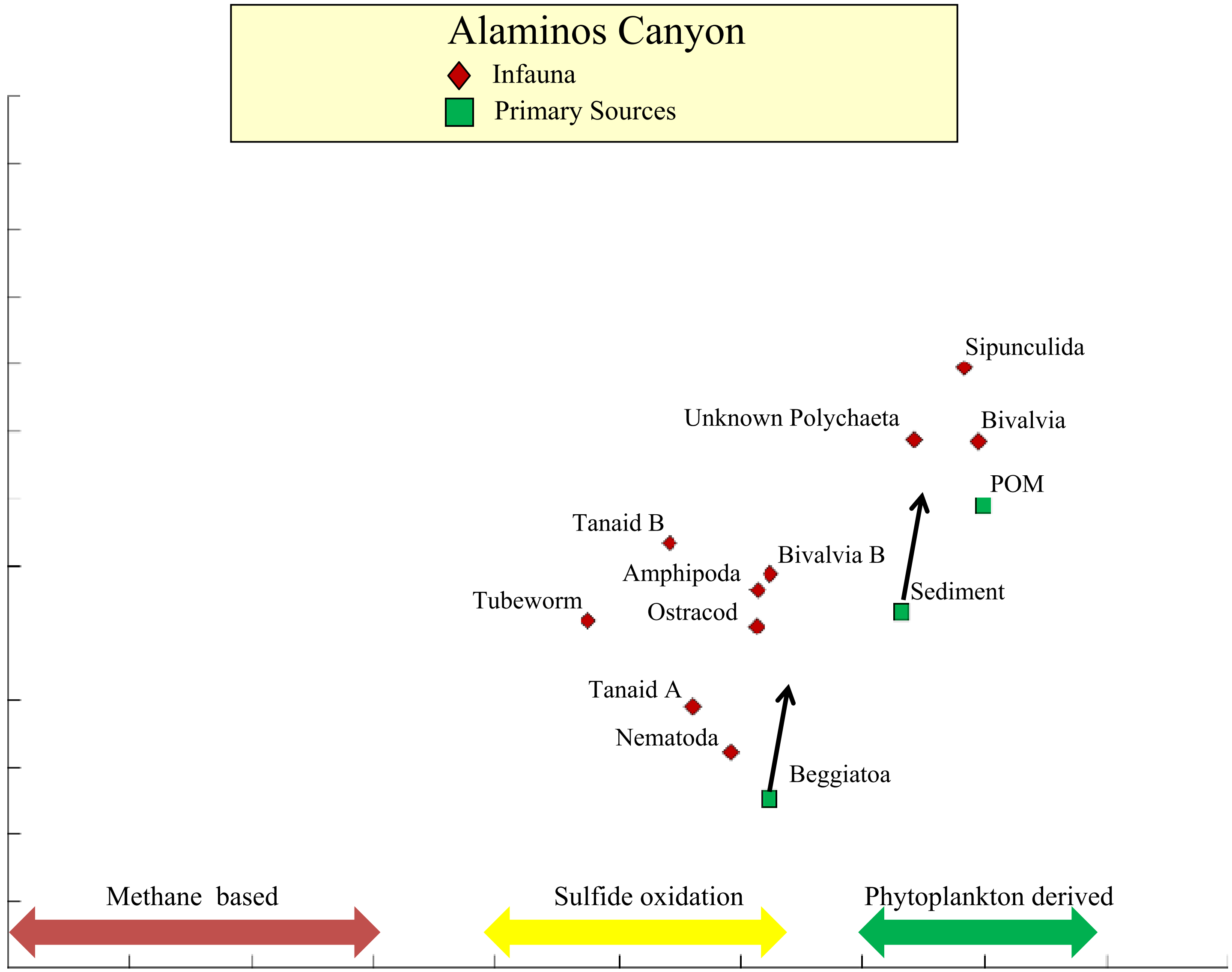
Sampling Depth: ~ 2,400 m
Distance to closest seep: 78 m

⊕ Sampling locations
★ Known seep communities

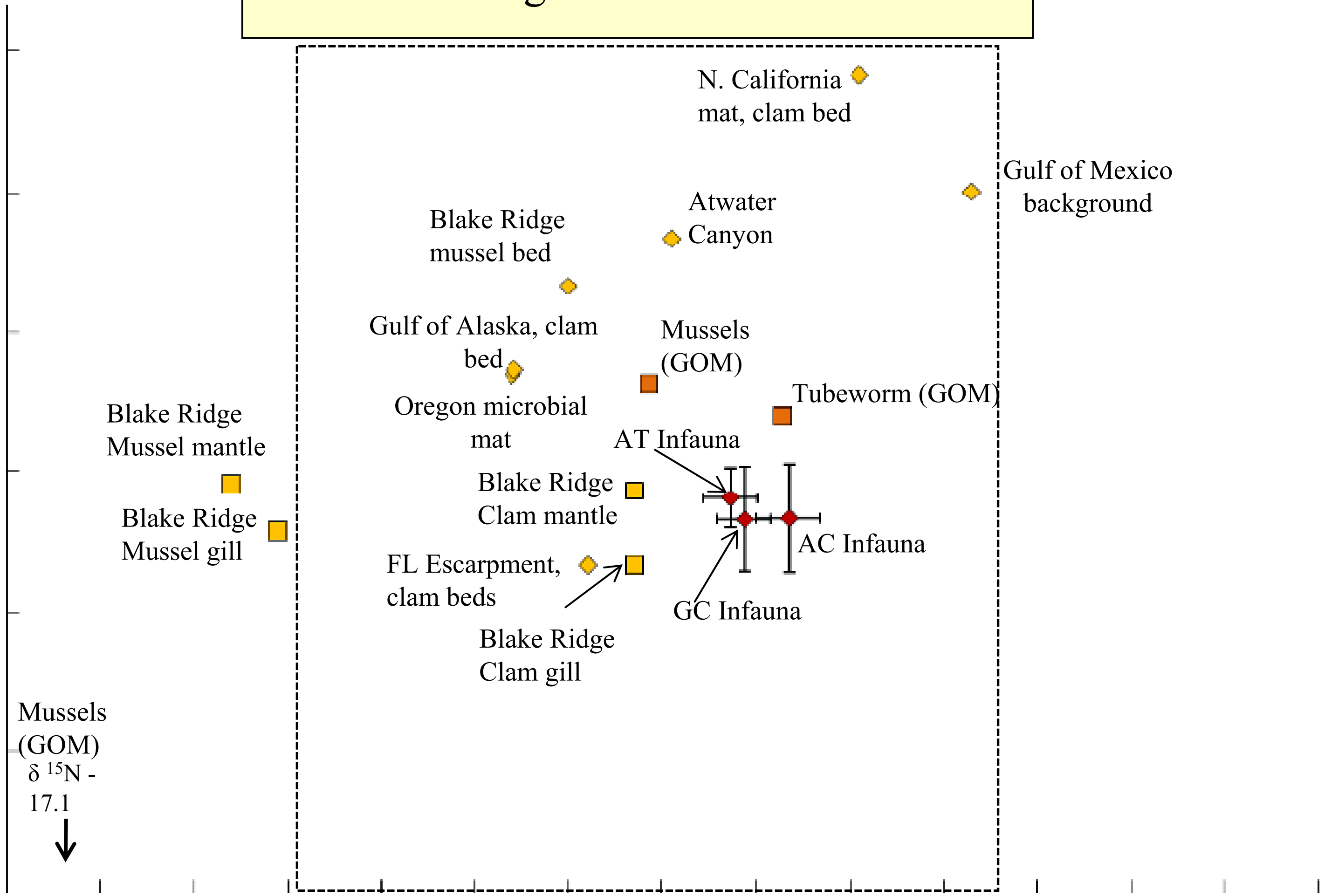


Multibeam courtesy of MMS/OE Chemo III Study P.I.s
Seep locations from TDI-Brooks 2006


Alaminos Canyon
Infauna
Primary Sources
Methane based
Sulfide oxidation
Phytoplankton derived


Alaminos Canyon
Infauna
Primary Sources
Sipunculida
Unknown Polychaeta
Bivalvia
POM
Tanaid B
Bivalvia B
Amphipoda
Sediment
Tubeworm
Ostracod
Tanaid A
Nematoda
Beggiatoa
Methane based
Sulfide oxidation
Phytoplankton derived

Infauna and epifauna from seeps and background sediments



Seep Data: Florida Escarpment (Levin 2005; Levin and Mendoza 2007)
GOM seep mussels and tubeworms (MacAvoy et al. 2008)
Non-GOM seeps (Van Dover et al. 2003; Levin 2005)

Results and Discussion

- SI values of heterotrophic macroinfauna exhibited a large range in $\delta^{13}C$ and $\delta^{15}N$ values
  - Lightest ^{13}C values likely reflect input from methane-derived carbon
  - Most infauna had intermediate isotope values (maybe mixed diet)
  - Few taxa exhibited values consistent with phytoplankton-derived diets
- Three lower slope sites yielded similar average isotope values
- Results consistent with other seep ecosystems

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Discussion: Macrofaunal Nutrition

- Large range in isotope values may reflect species-specific differences in the importance of chemosynthesis
- Light $\delta^{13}C$ values have been reported for nematodes (Levin and Mendoza 2007)
- Light $\delta^{15}N$ values reported for several seep-associated taxa (MacAvoy et al. 2002, 2005, 2008; Carney 2008)
- Majority of macrofauna at deep seeps exhibit stable isotopic evidence of chemosynthesis-based nutrition

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Conclusions

- Surprising how spatially widespread these chemosynthetic signals are among infaunal communities
- Chemosynthetic bacterial mats can be extensive (Sassen et al. 1993), potentially fueling these communities (cf. Kelley et al. 1998, Gilhooly et al. 2007)
- Future work includes
  - Community comparisons, sediment and porewater characteristics
  - Linking infauna to higher trophic levels

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