Examination of the seasonal variation in the abundance of *Crangon* shrimp and its relationship to the presence of the green sturgeon (*Acipenser medirostris*)

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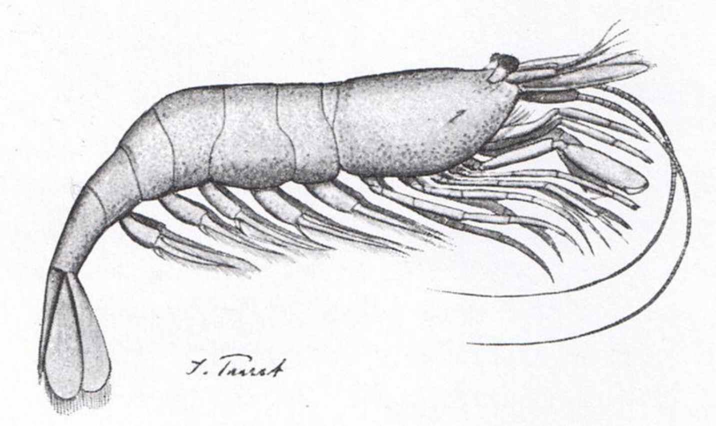

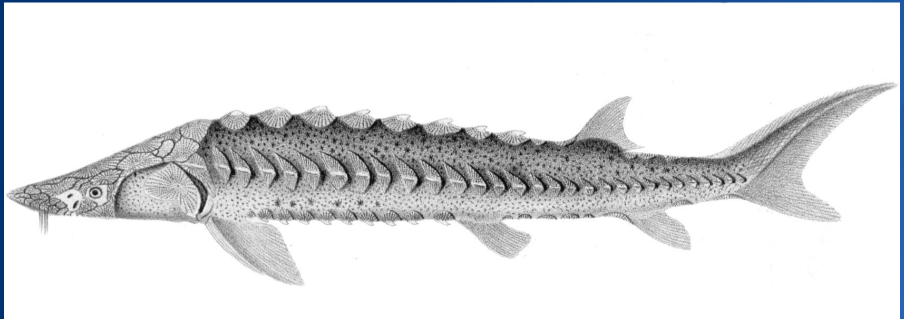

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Overview:

- Ecology and behavior of benthic species are important in understanding food webs

- Little is known about the habits of many common benthic invertebrates such as *Crangon* shrimp

- This study examines how *Crangon* are distributed spatially and temporally, and how those patterns relate to the modeled distribution of their predator, the green sturgeon (*Acipenser medirostris*)

Background: *Crangon* spp.

- Caridean decapods found in the northern hemisphere in both the Atlantic and Pacific oceans (Campos et al. 2012)

- Few studies have examined the ecology, phenology, and reproductive behaviors of the genus, apart from one Atlantic species, *Crangon crangon* (d. Linnaeus 1758)

Image: Wikimedia commons

Background: *Crangon* spp. (Linnaeus 1758)

Four species commonly found off the central Oregon coast:

Crangon alaskensis (Lockington 1877)

Crangon stylirostris (Holmes 1900)

Crangon franciscorum (Stimpson 1856)

Crangon alba (Holmes 1900)

Images: www.wallawalla.edu, linnet.geog.ubc.ca, ahslibrary.
com

Background: *Acipenser medirostris* (Ayres 1854)

- Anadromous fish found in the north Pacific Ocean
- Listed as vulnerable under the IUCN (IUCN 2014)
- Feeds on small fish and invertebrates, including *Crangon* (Kelly et al. 2006, Israel & Klimley 2008)

Image: bigfishmidwest.forumotion.com

Background: *Acipenser medirostris* (Ayres 1854)

- Economic importance: a strictly controlled fishery

- A better understanding of the how these sturgeon interact with trophic systems will be vital in devising effective conservation strategies

Image: mthsecology.wikispaces.com

Objectives:

- Determine how the distribution of various *Crangon* species differs between months and at different depths

- Determine if the caloric content of Crangon varies between months and at different depths

- Determine whether *A. medirostris* follows similar patterns in time and space

Questions & hypotheses:

1) Question: Are the abundance and caloric density of *Crangon* shrimp different between different months?

- Hypothesis: abundance and caloric density of *Crangon* will be higher in the summer and early than the winter

- Mechanism: chemical energy in the trophic system is elevated in the summer months due to seasonal upwelling, so *Crangon* will be found in greater abundance and energy density (Whitney et al. 2005)

Questions & hypotheses:

2) Question: Is caloric density of *Crangon* shrimp different between different depths?

- Hypothesis: caloric density of *Crangon* will be higher at deeper depths

- Mechanism: because it is thought that *Crangon* migrate outward from shore in order to spawn, and must reach a certain minimum size in order to produce eggs, large calorically dense gravid females would be expected to cause higher calorimetry further from shore

Questions & hypotheses:

3) Question: Is the seasonal and distribution of *A. medirostris* explained by variations in caloric density of *Crangon*?

- Hypothesis: *A. medirostris* will be found in greater abundance during months and at depths in which *Crangon* abundance is also greater

- Mechanism: *A. medirostris* are attracted to areas where their prey are more abundant

Methods:

- Invertebrate samples taken as part of baseline sampling of Northwest Marine Renewable Energy Test Center's North Energy Test Site

- 3 transects, each with 3 stations, arranged roughly perpendicular to shore at 30, 40, and 50 meter depths

- Sampling took place from June 2010 to August 2013, covering 15 months

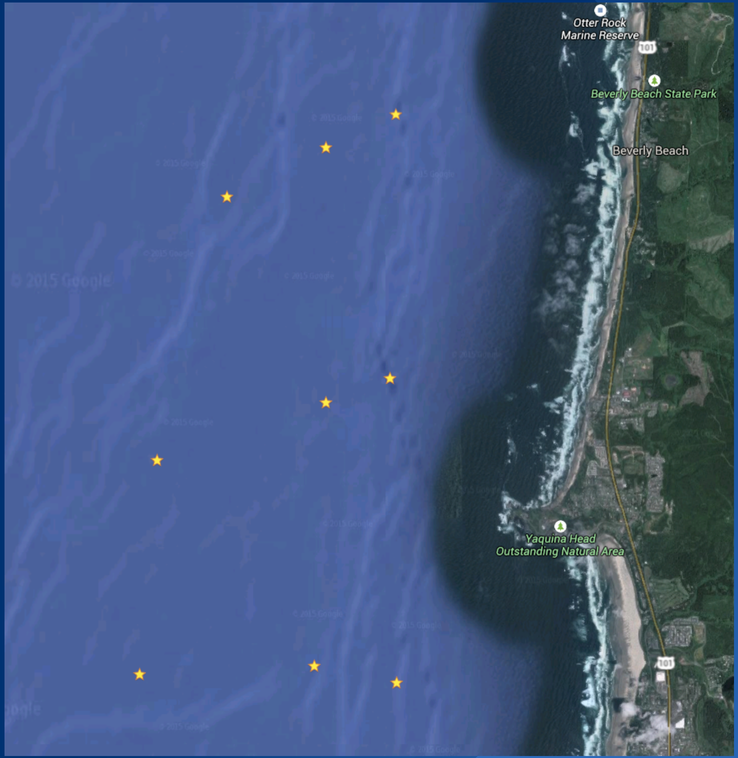


Image: © Google

Methods:

- *Crangon* sorted to species

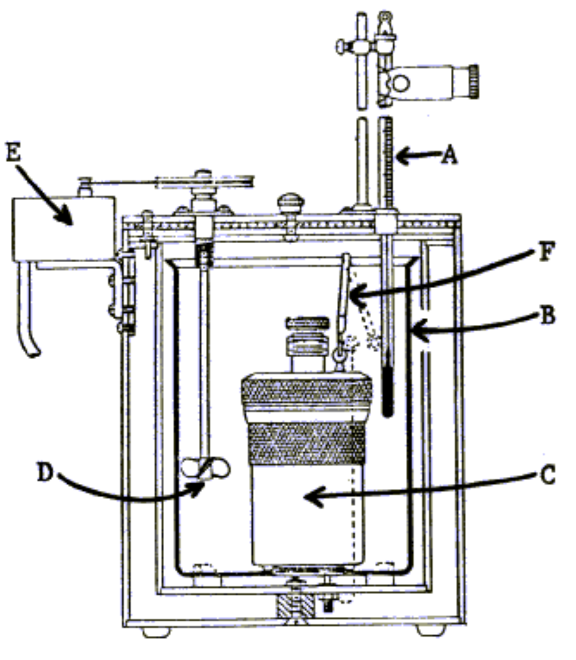
- Only *C. alaskensis* and *C. stylirostris* found in sufficient numbers for reliable results; the other two species were eliminated due to largely having <20 individuals per tow

Methods:

- Samples placed in drying oven for 48-72 hours at 65°C and then dry weighed to obtain biomass

- Dry samples then ground to a fine powder and ~1g sub sample placed in Parr model 1341 oxygen bomb calorimeter

- Joules/gram determined by rate of temperature change in the calorimeter



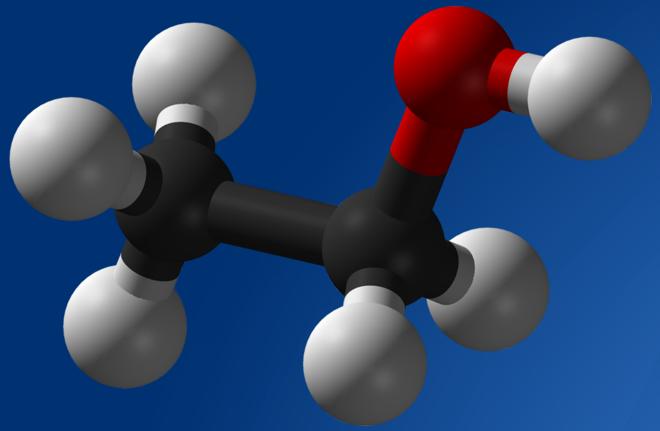
Cross Section of Series 1300 Plain Calorimeter

Image: ntweb.deltashare.edu

Methods:

- Some samples had previously been preserved in 70% EtOH

- Recorded dry mass for these samples was adjusted in accordance with a predicted rate of mass loss



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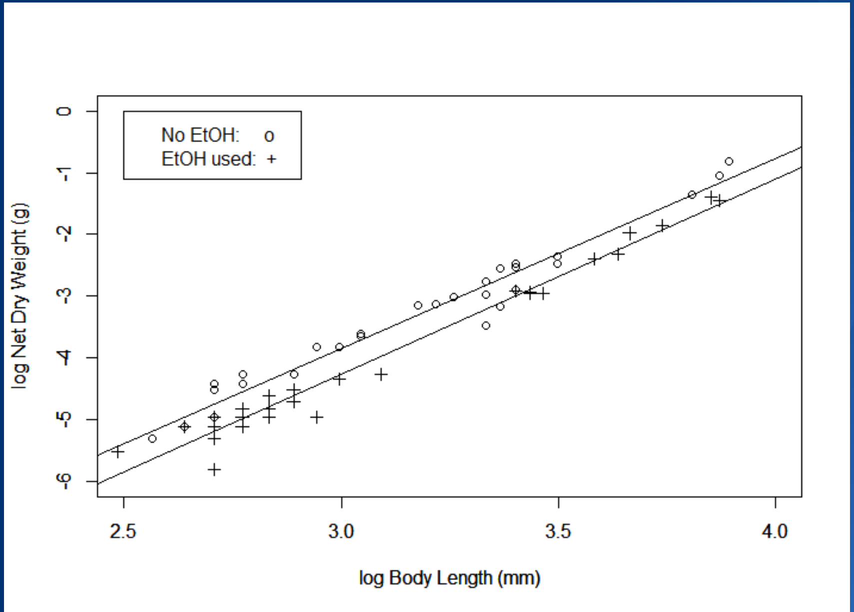
Methods:

● Predicted rate of mass loss of chemically preserved samples was determined using 30 individual *C. alaskensis* that were preserved in ethanol for 1 month and 30 sampled during the same month that had not (Qureshi et al. 2008)

● Regression lines of the natural logs of body length and dry mass for both groups were compared, showing an average weight loss of 33% at all lengths for the preserved sample

● This amount was used to adjust the recorded dry masses of all preserved samples



Methods:

- Many calorimetry samples of the same depth and month but different stations had previously been combined

- When this potential source of error was realized, all of these samples were eliminated from any subsequent data analysis that dealt with calorimetry, necessitating the elimination of all replicates up to the end of August 2011

- Full time series used for all other analyses

Methods:

- A model to predict the probability of *A. medirostris* presence for each date and station was used (Huff et al. 2012, Chai et al. 2002)

- The model was based on data from coastal hydrophone arrays tracking acoustically tagged sturgeon, that included a number of physical covariates

Statistical analyses:

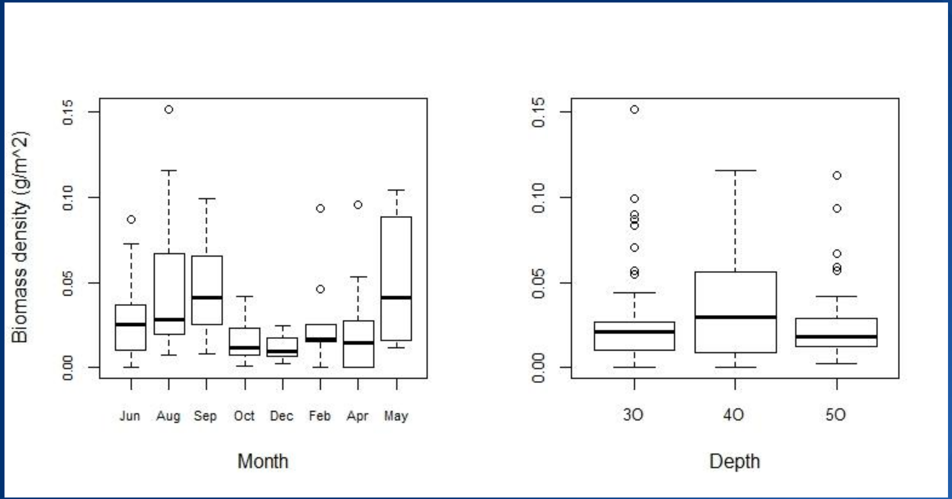
- For most tests, a 2-way ANOVA involving month and depth as explanatory variables was run

- For factors that showed significance, a Tukey's Honestly Significant Difference test was run, which looked at all the pairwise comparisons of the means of each level of the relevant factor, to see which ones were significantly different

- For the tests involving *A. medirostris*, a simple linear regression was used

Results:

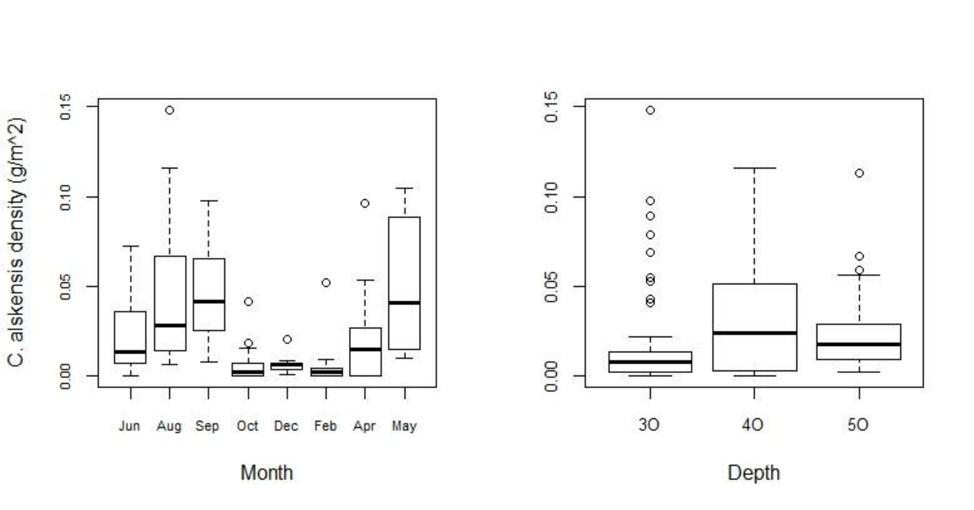
● For total biomass density of *Crangon* (both species combined): October and December had less grams of *Crangon* per square meter than August, and depth was not significant



Biomass density of *Crangon* (both species pooled) by month and depth, from June 2010 to August 2013

Results:

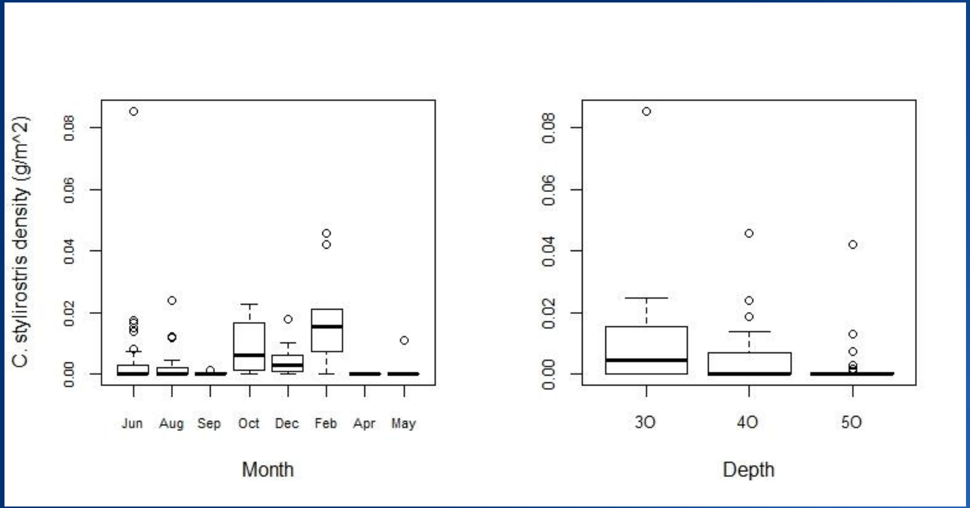
- For biomass density of *C. alaskensis*: winter months tended to have lower means than summer, fall, and spring months. Depth was not significant.



Biomass density of *C. alaskensis* by month and depth, from June 2010 to August 2013

Results:

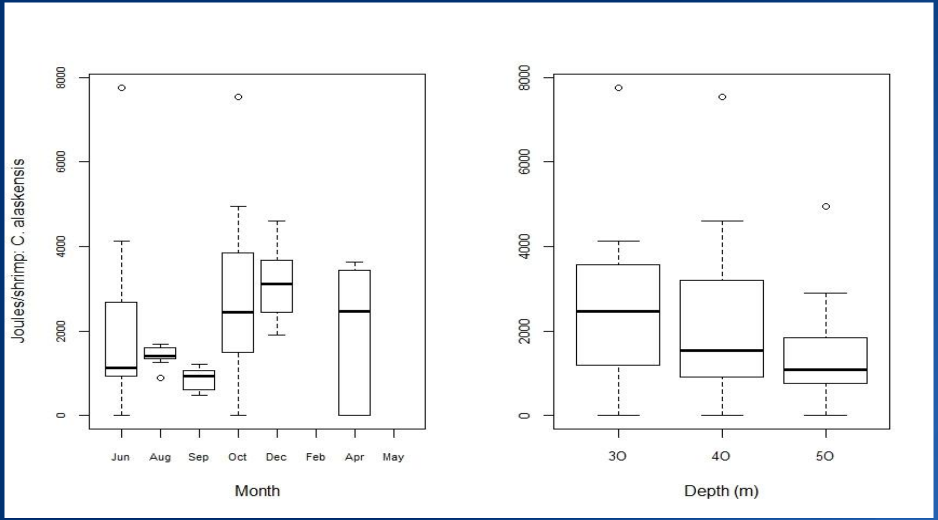
For biomass density of *C. stylirostris*, February was found to have a higher mean than other months. 30 meters depth was found to have significantly greater biomass density than 40 and 50 meters



Biomass density of *C. stylirostris* by month and depth, from June 2010 to August 2013

Results:

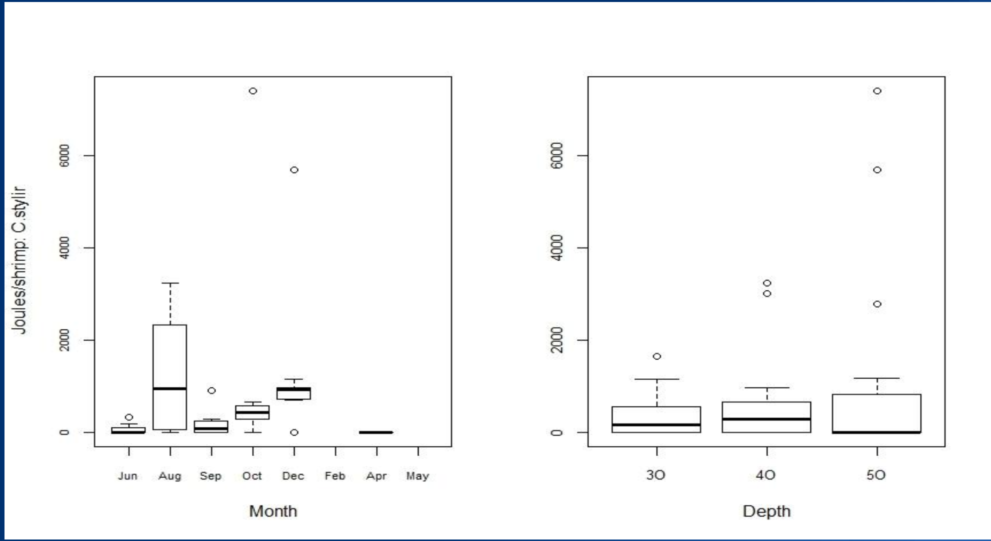
Joules per individual *C. alaskensis* was greater at 30 meters than at 50 meters, and greater in December and October than in September



Mean Joules of individual *C. alaskensis* by month and depth, from August 2011 to August 2013

Results:

Joules per individual *C. stylirostris* showed no significance with month or depth

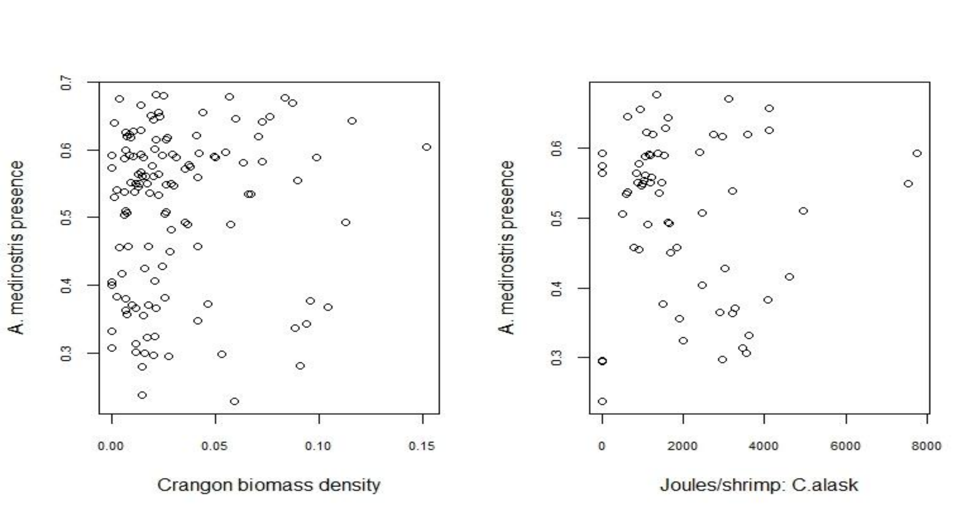


Mean Joules of individual *C. stylirostris* by month and depth, from August 2011 to August 2013

Results:

- Linear regression with *A. medirostris* presence and biomass density of *Crangon* showed no correlation

- Linear regression with *A. medirostris* presence and Joules per individual *C. alaskensis* showed no correlation



Modeled probability of *A. medirostris* presence compared with *Crangon* biomass density and mean individual Joules of *C. alaskensis*

Summary of results:

- *C. alaskensis* tended to have lower biomass density in winter months, while *C. stylirostris* was more abundant in February

- Both species responded to depth differently: *C. alaskensis* showed no abundance pattern with depth but had more Joules per individual at 30 meters; and *C. stylirostris* had greater abundance at 30 meters but showed no response in calorimetery

- *A. medirostris* showed no response to *Crangon* abundance, nor to patterns in calorimetry of *C. alaskensis*

Discussion:

- General trend of biomass density appears to be higher in summer and early fall and lower in winter (except for *C. stylirostris*)

- This supports Hypothesis 1 (higher abundance caused by more nutrients from upwelling), but is inconclusive because some *Crangon* are known to migrate from estuaries and onto the continental shelf during summer and fall in order to spawn (Jarrin & Shanks 2008)

- Results are consistent with the action of either mechanism

Discussion:

- February being significantly higher for *C. stylirostris* biomass should be considered with caution because February was only sampled once, and thus only 9 replicates were available

Discussion:

- *C. alaskensis* shows higher calorimetry in October and December than September, which is almost the reverse of the hypothesis that it would be greater in summer and fall than winter

- *C. alaskensis* having greater mean Joules per individual at 30 meters depth than at the other depths is inconsistent with hypothesis 2, which predicted higher Joules at a 50 meter depth. This could indicate a different mechanism.

Discussion:

- Undersampling of some months represents one methodological flaw

- Another possible source of error is the smaller data set used for calorimetry, which could skew the results

- Biomass density is potentially problematic in that it ignores patchiness of distribution

- More useful results could have been gained by looking at two factors together, i.e. depth-by-month

Conclusion:

- The hypothesis that abundance of *Crangon* would be higher in summer and fall was partially supported

- No relationship between *A. medirostris* and any measurement of *Crangon* could be found

- Many aspects of *Crangon* behavior and trophic relationships remain to be discovered; further research will be needed to elucidate these questions

Acknowledgements:

Sarah K. Henkel
David D. Huff
Kevin McDonnell
A. Jason Phillips
Kristin Politano
Pieter Waldenmaier

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Questions?

Image: columbiariverimages.com