FOOD-WEB STRUCTURE IN BIG CYPRESS SWAMP WETLANDS BASED ON STABLE-ISOTOPE RESULTS

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INTRODUCTION

Southern Florida wetlands have been modified by drainage. A major restoration plan, CERP, is attempting to reestablish natural hydrology. CERP success implies aquatic food webs will be restored to support important predator populations. That premise is difficult to measure without data on those webs. From 2005-07, we collected biotic samples to map pathways of energy flow and trophic status of biota in freshwater wetlands of Big Cypress National Preserve (BCNP) (Fig. 1). Food webs in cypress wetlands have been relatively unstudied throughout their range.

Food webs provide maps of their biotic constituents, their roles, and interactions. We used stable-isotope analysis to trace the movement of carbon ($\delta^{13}C$) from primary producers to fishes, and to determine the trophic positions of animals by using nitrogen ($\delta^{15}N$).

Basic questions included:

What are the major primary producers?
How long are food chains?
Is there spatio-temporal variability in the web?
What roles do non-native fishes play?

Figure 1. Cypress Forest.

METHODS AND STUDY LOCATIONS

Primary producer, invertebrate, and fish samples of common species (Table 1) were taken three times per year: wet season, transitional season, and dry season. Sampling was at three sites within BCNP cypress habitats: L-28, Bear Island (BI), and Raccoon Point (RP) (Figure 2). Site descriptions, sampling techniques, and physico-chemical data were reported in Liston et al. (2008) (Fig. 3). Three to five individuals or sub-samples were collected for each taxon from each sub-habitat (marsh & dome).

Samples were field-frozen, then measured in the lab prior to drying appropriate tissues at 50 C. Plant material was acid-treated to remove carbonate. Dried tissue was pulverized, weighed, and prepared for analysis by mass spectrometer at FIU (see Williams & Trexler, 2006).

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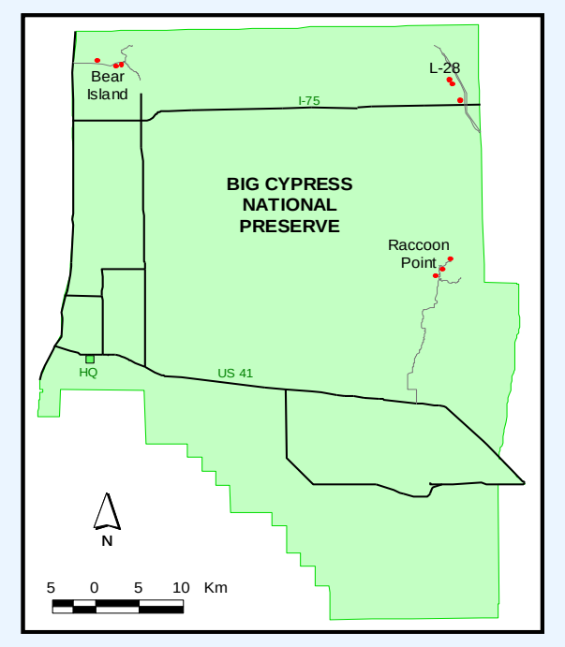


Figure 2. Maps of study locations

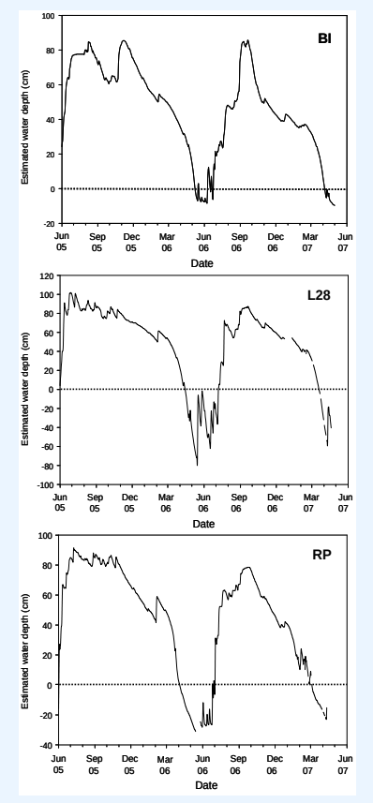


Figure 3. BCNP water depths showing strong seasonal patterns at the three study sites: Bear Island (BI), L-28, and Raccoon Point (RP).

Ea. mosquitofish
(Gambusia holbrooki)

Sailfin molly
(*Poecilia latipinna*)

Least killifish
(*Heterandria formosa*)

a) Fishes

Scientific Name	Common Name	% RA	% I
Gambusia holbrooki	Eastern mosquitofish	56.7	84.5
Jordanella floridae	Flagfish	20.8	40.8
Heterandria formosa	Least killifish	10.2	43.7
Lepomis marginatus	Dollar sunfish	2.8	29.6
Lucania goodei	Bluefin killifish	2.6	46.5
Lepomis gulosus	Warmouth	2.1	30.3
Labidesthes sicculus	Brook silverside	1.6	15.5
Ameiurus natalis	Yellow bullhead	1.3	4.2
Poecilia latipinna	Sailfin molly	0.8	11.3
Cichlasoma bimaculatum	Black acara	0.7	22.5
Elassoma evergladei	Everglades pygmy sunfish	0.6	16.9
Fundulus chrysotus	Golden topminnow	0.4	15.5
Clarias batrachus	Walking catfish	0.3	1.4
Hoplosternum littorale	Brown hoplo catfish	0.2	7.7
Enneacanthus gloriosus	Bluespotted sunfish	0.2	9.2
Cichlasoma urophthalmus	Mayan cichlid	0.2	8.5
Notemigonus crysoleucas	Golden shiner	0.1	4.2
Tilapia mariae	Spotted tilapia	0.1	4.2
Lepomis punctatus	Spotted sunfish	0.1	2.1
Lepisosteus platyrhincus	Florida gar	0.01	1.4
Belonesox belizanus	Pike killifish	0.01	0.7

b) Invertebrates

Scientific Name	Common Name	% RA	% I
Palaemonetes paludosus	Grass shrimp	46.2	62
Procambarus alleni	Everglades crayfish	12.4	62.7
Procambarus fallax	Slough crayfish	5.6	54.9
Gyrinus spp.	Whirligig water beetle	4.4	13.4
Anisoptera	Dragonfly	3.6	63.4
Coleoptera	Aquatic beetle	2.4	20.4
Coenagrionidae	Damselfly	0.7	14.8
Planorbella spp.	Planorbid snail	0.7	21.8
Corixidae	Water boatman	0.4	9.2
Pelocoris femoratus	Alligator flea	0.4	16.2
Dytiscidae	Predaceous diving beetle	0.3	5.6
Lethocerus spp.	Toe biter	0.3	11.3
Physella spp.	Physid snail	0.3	8.5
Belostoma spp.	Giant water bug	0.1	7.7
Ephemeroptera	Mayfly	0.01	1.4
Ranatra spp.	Water scorpion	0.01	3.5

Table 1. Relative abundance (%RA) and % Incidence in samples of a) common fishes and b) common invertebrates collected at the study sites (Liston et al., 2008). All taxa were analyzed for stable-isotope values.

RESULTS: We analyzed 777 individual fishes of 24 taxa; 7 were non-native. We also analyzed 751 invertebrate samples of 24 taxa and 733 vegetation samples of 24 taxa. Fish species names are in Table 1. Stoichiometric data for C:N showed that as $\delta^{15}N$ values increased, C:N ratios decreased (Fig. 4). Most vegetation taxa had $\delta^{13}C$ values within $\pm 2\ ^0/_{00}$ of $-30\ ^0/_{00}$, except algae and moss. Values from BCNP biota were remarkably similar to those from Everglades marshes (Fig. 5).

General Patterns

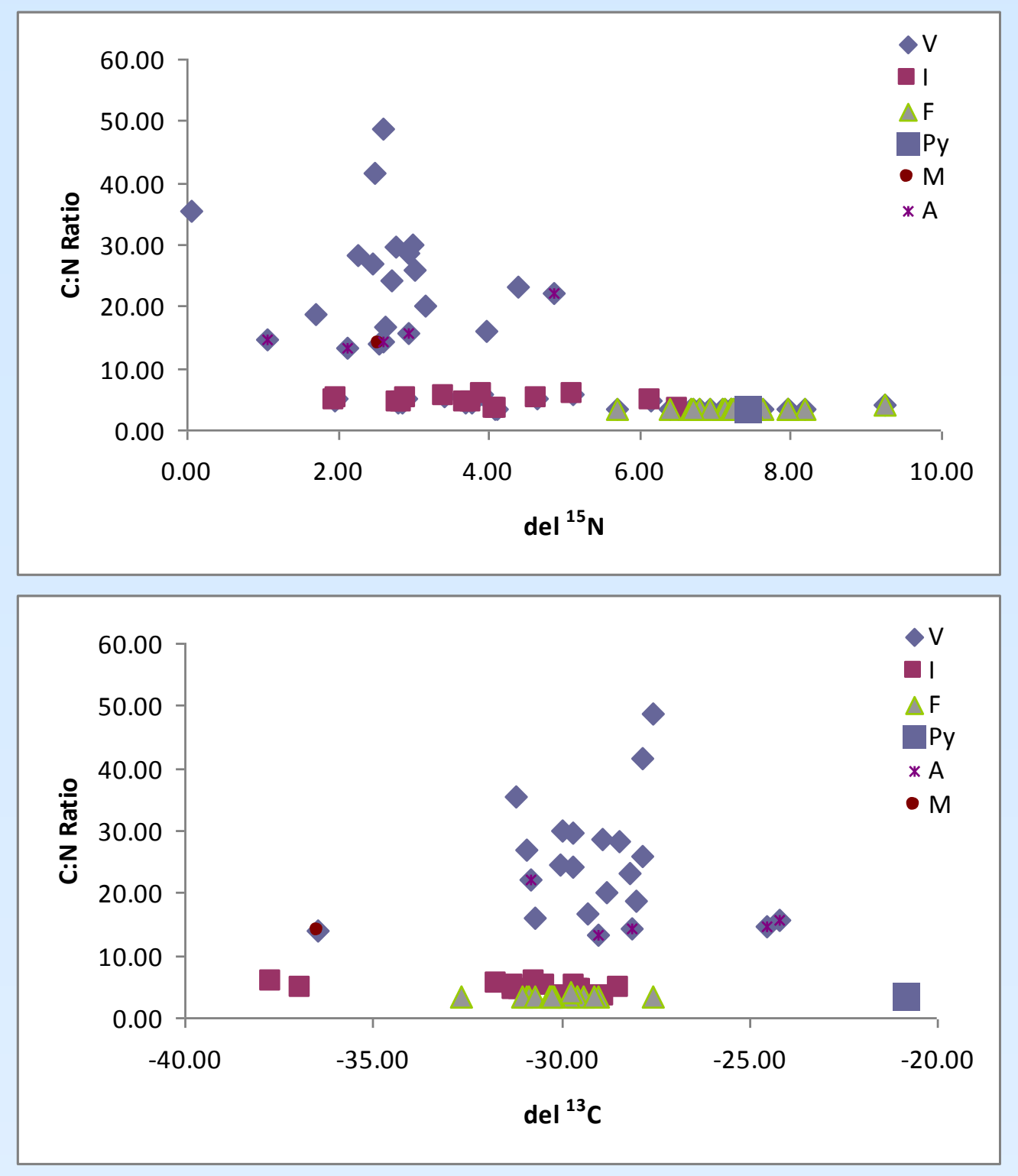


Fig. 4. Bi-plots of $\delta^{13}C$ and $\delta^{15}N$ with C:N ratios for groups of biota. V=Vascular Plants, I=Insects, F=Fish, Py=Python, A=Algae, and M=Moss.

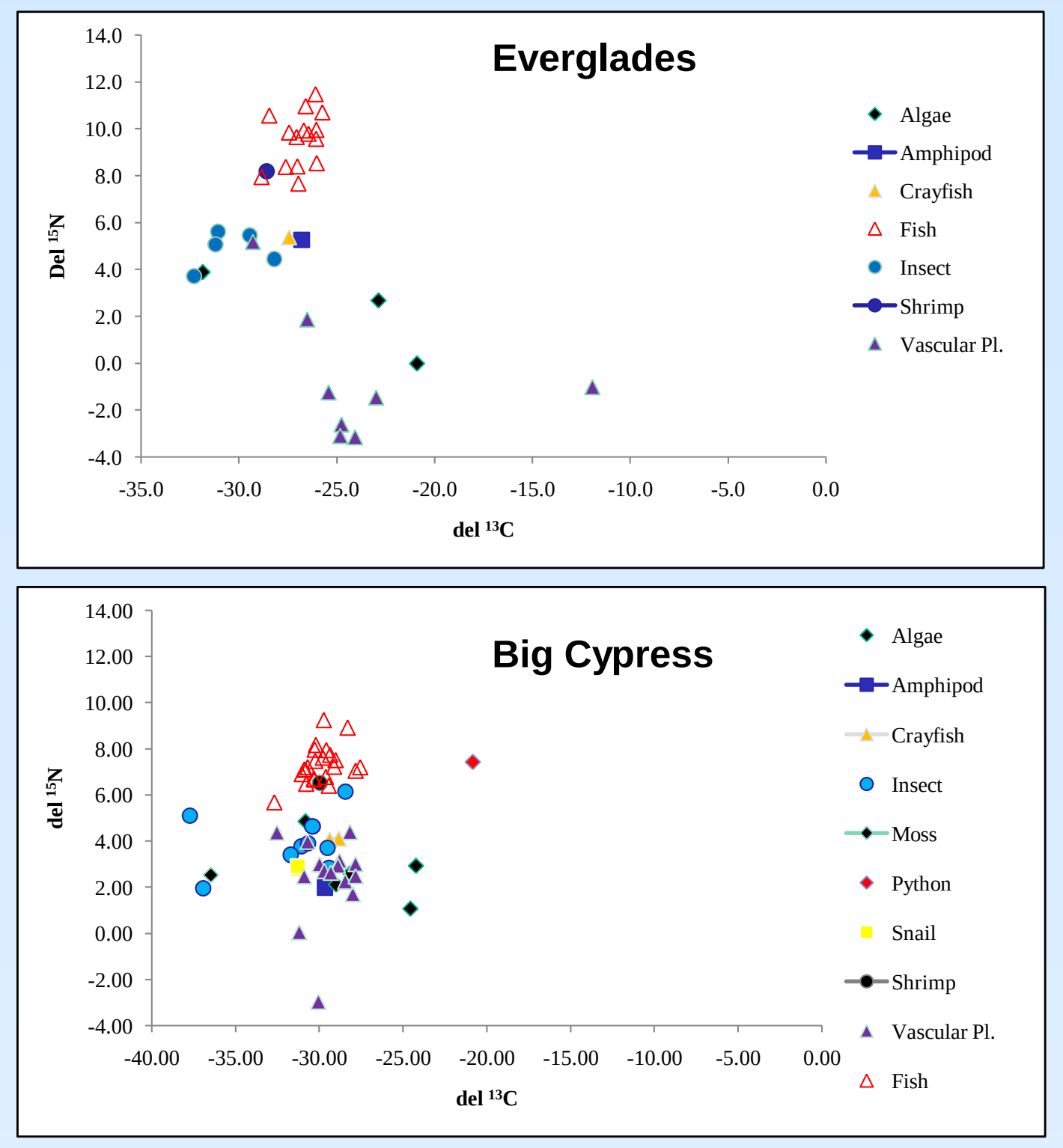


Fig. 5. Comparison bi-plots for taxa with all data combined from the Everglades (Loftus 2000) and BCNP (this study).

$\delta^{15}N$ values from Everglades animals appear enriched compared to BCNP values. Myriad factors influence $\delta^{15}N$ values. For example, enrichment may indicate Everglades organisms function at higher trophic levels than conspecifics in BCNP, or it may imply differences in source, fractionation, or assimilation processes in primary producers at the base of the food web.

Spatial/ Temporal Comparisons By Year

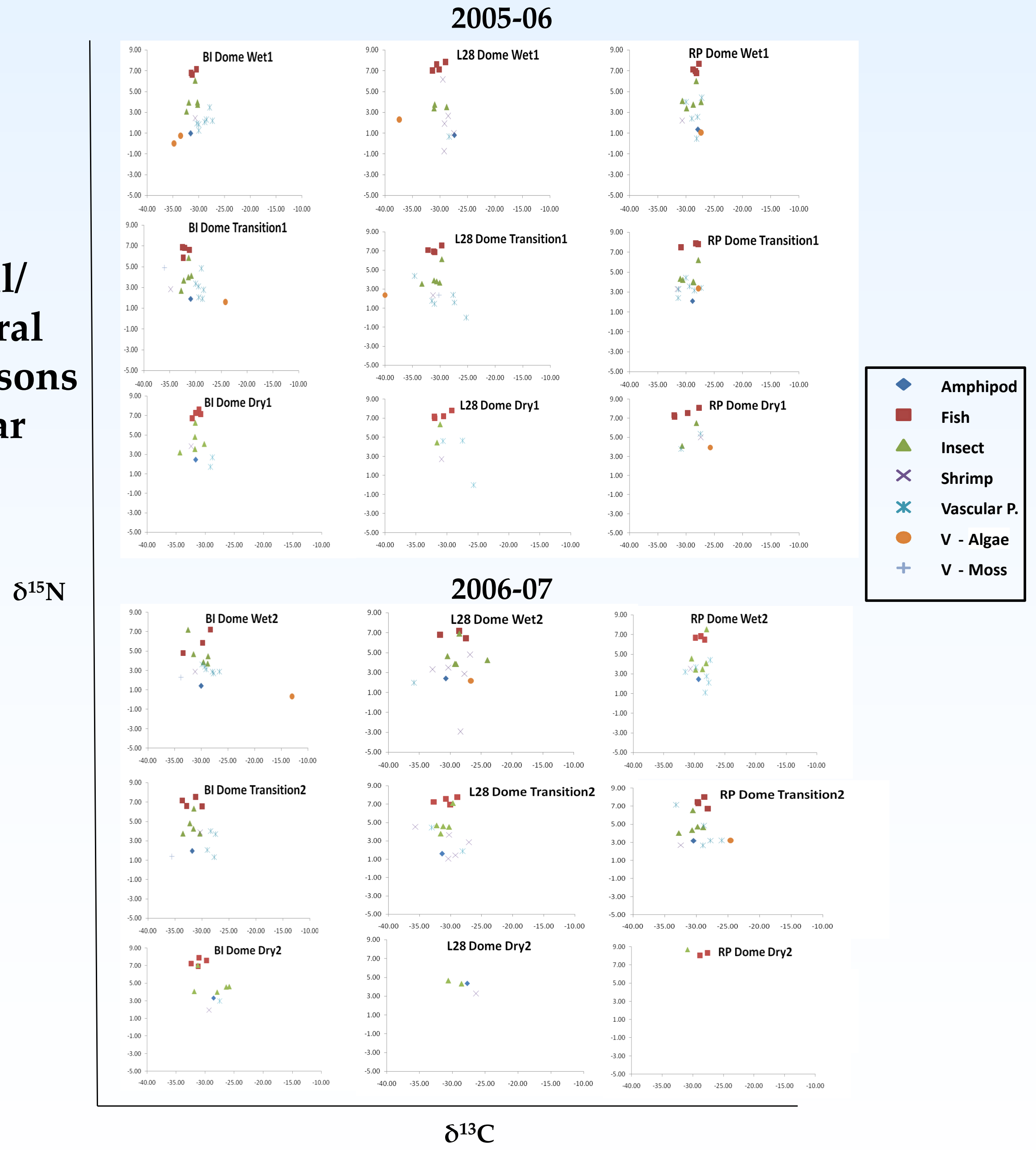


Fig. 6. Stable-isotope values for taxa consistent among locations & seasons. The three locations had very similar isotope values, though fish/shrimp seemed more enriched at L-28. Most fish and insects were omnivores/carnivores. The web seems to have but three levels: producers, 1° consumers, and 2° consumers, with both algal and detrital bases important. By the dry season, domes had few species surviving. L-28 and RP were sites with contiguous marshes.

Seasonal Comparisons: As animals move from marsh to dome from wet to transition (Liston Et al, 2008), do isotope values reflect those movements?

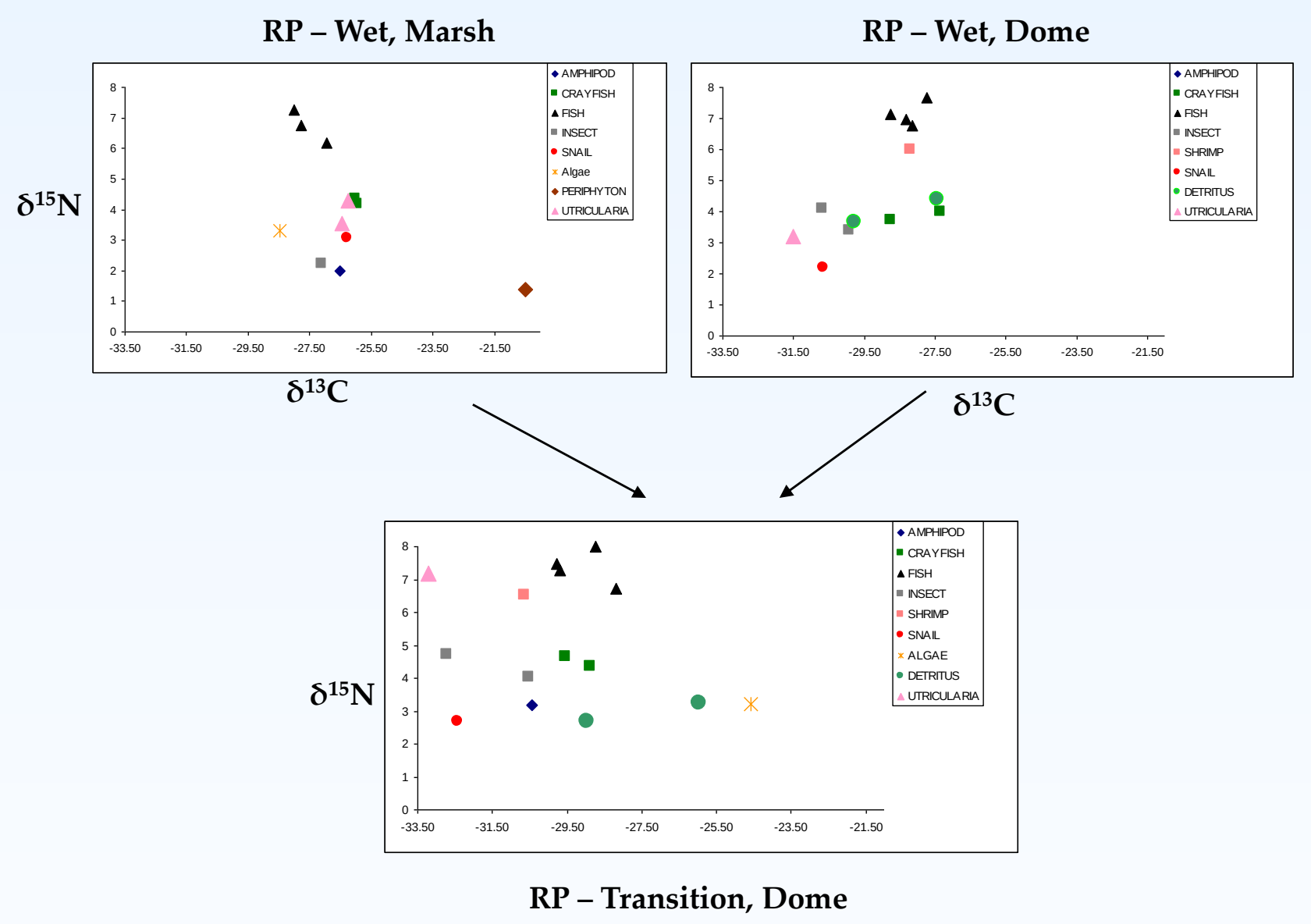


Figure 7. Values in wet-season marshes are enriched compared to domes. We see little evidence of enrichment signal in the transition-season domes, 1.5 months later, that we would expect as animals enter the domes for dry-season shelter. We will continue to examine these data.

Non-native Fishes

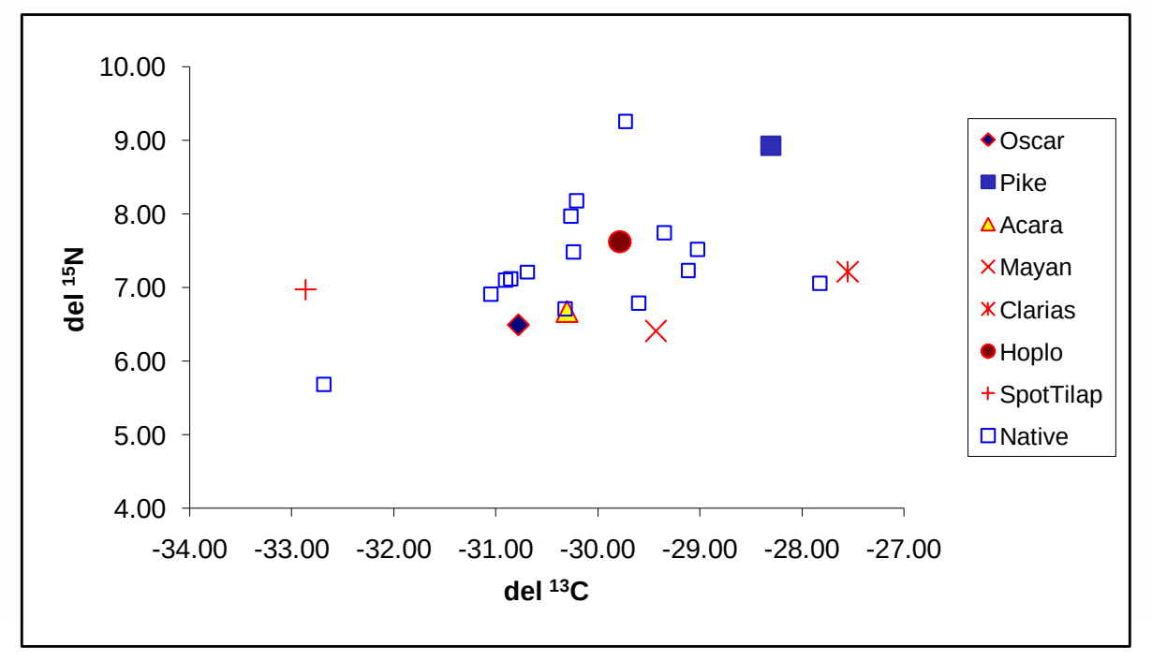
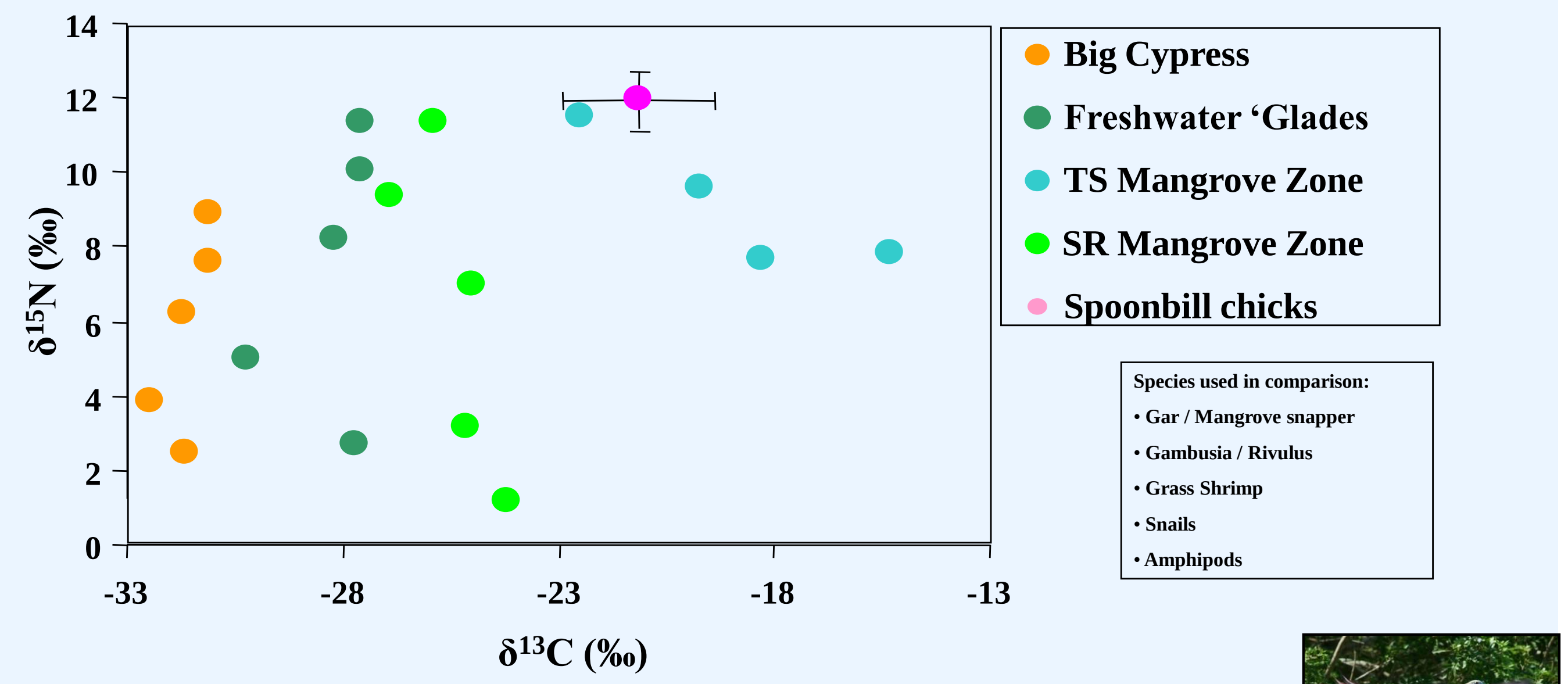


Fig. 8. Introduced fish values overlapped those of native species. Piscivorous Pike killifish had highest trophic position, as expected.

CROSS-LANDSCAPE COMPARISONS



Species used in comparison:
- Gar / Mangrove snapper
- Gambusia / Rivulus
- Grass Shrimp
- Snails
- Amphipods

Distinct food webs are evident in south Florida studies; data may serve to relate spatial data to key indicator species. For example, Roseate Spoonbills (pink circle; mean ± 1 SE; N=8) receive energetic inputs from Taylor Slough mangroves, near nesting locations and flight paths to foraging grounds (Lorenz data).

CONCLUSIONS

Isotope values varied temporally and spatially, and were similar to those from the Everglades. Cypress dome $\delta^{13}C$ values tended to be more depleted compared with other south Florida systems. Both detritus and algae were food base end-members. Snails, crayfishes, and amphipods were major 1° consumers, while fishes, shrimp, and most insects were mainly carnivorous. As prairies dried in fall, animals moved into cypress domes but food-web plots showed little evidence for movement. Piscivorous Florida gar had the highest $\delta^{15}N$ values and highest relative trophic positions. Non-native fishes functioned at similar trophic levels to native species and used a similar range of primary producers.

FUTURE WORK

We will explore the dataset with analytical tools such as the IsoSource (Phillips and Gregg 2003) and circular statistical models (Schmidt et al. 2007) to examine mixing of primary producers in the cypress. We will investigate effects of lipids on values, and will also compare data quantitatively to food webs from other systems.

APPLICATIONS

Hydrological restoration should restore aquatic food webs supporting populations of higher vertebrates. Our data can help test that premise by defining spatio-temporal patterns in cypress-wetland food webs as a baseline for post-restoration comparisons.

Hydrologic restoration will affect aquatic plant communities at the food-web base. We hypothesize that changes at the base will affect key invertebrate groups, with consequences resonating through the web. Stable-isotope analyses will permit tracing of food-web changes at both local and landscape scales. Our data will complement other south Florida food-web studies to provide a more comprehensive understanding of the entire ecosystem.

LITERATURE CITED

Liston, S. et al. 2008. Development and testing of protocols for sampling fishes in forested wetlands in southern Florida. Draft report to USACOE and USGS-PES.

Loftus, W.F. 2000. Mercury bioaccumulation through an Everglades aquatic food web. Ph.D. Dissert., Florida International University, Miami.

Phillips, D.L., and J.W. Gregg. 2003. Source partitioning with stable isotopes: coping with too many sources. Oecologia 136:261-269.

Post et al. 2007. Getting to the fat of the matter: models, methods, and assumptions for dealing with lipids in stable isotope analysis. Oecologia 152: 179-189.

Schmidt, S.N. et al. 2007. Quantitative approaches to the analysis of stable isotope food web data. Ecology 88:2793-2802.

Williams, A.J. and J.C. Trexler. 2006. A preliminary analysis of the correlation of food-web characteristics with hydrology and nutrient gradients in the southern Everglades. Hydrobiologia 569:494-503.

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