How wastewater discharge is structuring communities in the urban Santa Ana River headwaters

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Background

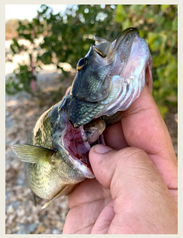
A Santa Ana Sucker collected during the 2018 Santa Ana Sucker surveys below the Rialto/RIX confluence.

- Ecological communities and trophic interactions can be studied using stable isotope compositions[1]
- Assessing a consumer population's isotopic composition can show if they are consuming material across all basal resources or are feeding from specific resources[1,2]
- The relationship between basal and consumer isotopic compositions has given rise to the isotopic niche space concept
- Characterizing variability in the $d^{13}C$ and $d^{15}N$ of populations provides a quantitative framework to compare populations' and communities' isotopic niches[3,4]
- This framework can be used to assess trophic interactions[5,6]
- Are wastewater discharge and novel urban habitat altering invasive populations' trophic role in the Santa Ana River?
- Our first hypothesis is that the three invasive species we assessed will have different isotopic niches in two separate wastewater discharge regimes.
- Our second hypothesis is that the complexity of these species' trophic niches will increase from the most disturbed wastewater discharge point.
- We predict that more complex food webs will develop as distance from wastewater discharge points increases due to lessened alterations to historic river heterogeneity.

The Rialto/RIX confluence demonstrating habitat differences caused by differential effluent outflows

Conclusions

- Increased occupied niche space within the lower reach supports our hypothesis that increases in trophic niche complexity occurred as distance from wastewater discharge points increased
- A compressed isotopic niche in the Rialto channel suggests a local extinction of intermediary food web members
- Differences in species' isotopic niches between channels provide evidence for significant differences in community composition and trophic webs



A largemouth bass that was caught immediately after consuming a Santa Ana sucker

Santa Ana River Study Sites

Rialto Wastewater Facility (Rialto) Channel :

- re-wets the the Santa Ana River after it goes dry
- shaded by riparian canopy cover
- composed predominantly of runs and riffles over cobble substrates.
- **Upper Channel**

Rapid Infiltration and Exfiltration Facility (RIX) and Rialto confluence:

- The majority of flow in the Santa Ana River urban headwaters is provided by the RIX wastewater facility
- This river reach has a mix of riparian cover and open canopy
- This channel contains more fine substrates (i.e. sand) and an invasive benthic alga (*Compsopogon caeruleus*) is common
- **Lower Channel**

Freshwater Community

Native Fish

Santa Ana sucker

Arroyo Chub

Invasive Fish

Largemouth bass

Mosquitofish

Green Sunfish

Yellow bullhead catfish

Discussion

- *G. affinis*, *A. natalis*, and *M. salmoides* have measurable differences in their populations' isotopic niches between wastewater channels.
- Extremely elevated $d^{15}N$ values provide evidence of nutrient enrichment throughout the urban headwaters of the Santa Ana River.
- Macroinvertebrates, aquatic plants, and benthic detritus all demonstrated the same patterns of elevated $d^{15}N$ values within the lower and upper reaches of the Santa Ana River
- Despite close proximity and a lack of physical barriers between the two reaches, our results support hypothesized differences in the isotopic niche of invasive fishes between the lower and upper reaches of the Santa Ana River.

Left: Dr. Kurt Anderson holding the invasive alga common below the Rialto/RIX confluence common to the Lower Channel

Right: The Santa Ana River following the November wastewater release shutdown during which samples were collected

- The role of wastewater discharge within novel urban habitats is an important contemporary topic in urban ecology
- Once invasive populations become naturalized, we do not understand what enables the coexistence of intermediate food web species, often native species, within urban aquatic systems
- Assessments of where and how these species coexist can help us to understand what factors enable the survival of native species in effluent-dominated systems containing high densities of predatory invasive fish
- Exploring spatially explicit food webs along urban disturbance gradients can help explain what mechanisms alter biotic and abiotic filters forming communities in invasive and effluent dominated freshwater systems

Results

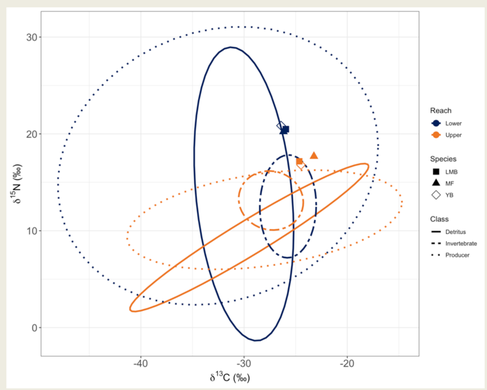
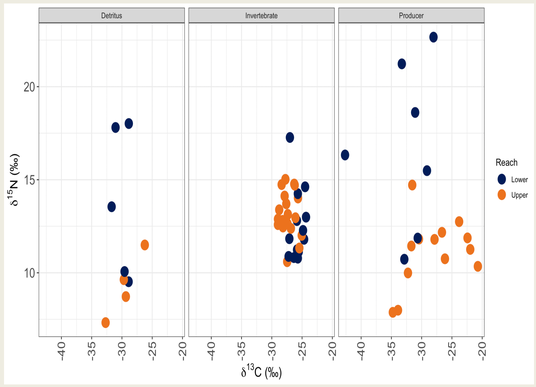


Figure 1 : Centroids for fish populations and 95% confidence ellipses of lower trophic level organic matter sources

- Organic matter in the Upper reach is a condensed isotopic niche space
- Species codes: LMB: Largemouth Bass (*M. salmoides*); YB: Yellow Bullhead (*A. natalis*); MF: Mosquitofish (*G. affinis*).

Figure 2: Carbon and nitrogen isotope composition for lower trophic level organic matter sources in the Santa Ana River.

- Invertebrate group was comprised of (Odonates, Mayfly, Caddisfly, and Damselfly larvae)
- Detrital samples were decomposing terrestrial material collected along the banks
- Producer samples were a mix of macrophytes, algae, and riparian plants



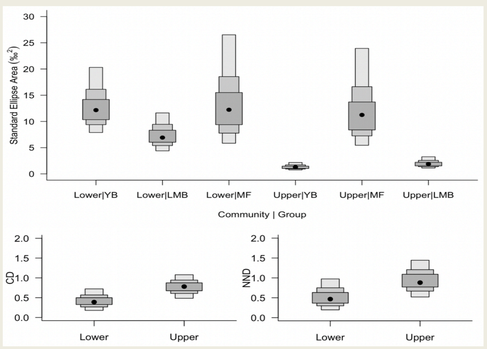
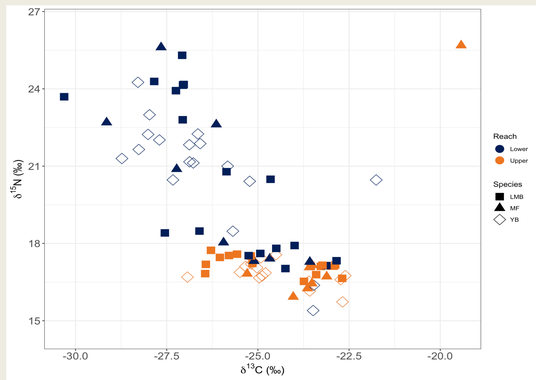


Figure 3: High density region boxplots of model output for: Bayesian standard ellipse area; Centroid distance (CD); Nearest neighbor distance (NND)

- Increased NND and CD in the upper reach was driven by the mosquitofish population present in the lower extreme of the Upper (Rialto) Channel

Figure 4 : Nitrogen and Carbon stable isotope composition of fishes collected in the Santa Ana River

- separated by river reach (N=83)
- Species codes: LMB: Largemouth Bass (*M. salmoides*); YB: Yellow Bullhead (*A. natalis*); MF: Mosquitofish (*G. affinis*).



Acknowledgements and References

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