Ancient fish and recent invaders: white sturgeon (*Acipenser transmontanus*) diet response to invasive species-mediated changes in a benthic prey assemblage

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The ancient fish

- Popular native game fish in the SFE.
- May be in a period of decline.
- Long lived
- Delayed maturation
- Irregular reproduction/recruitment
- Special requirements for reproduction.

White sturgeon

The recent invader

- Discovered in 1986.
- Rapidly spread through the estuary.
- Exists in high densities.
- Resulted in significant and lasting change to the benthic community.

Overbite clam (*Potamocorbula amurensis*)

Invasions and food webs

- Direct effects – Predation, direct competition, habitat alteration.
- Indirect effects- alteration of benthic community = change in available prey items.

1. Nichols et al. 1990
2. Peterson and Vayssieres 2010
3. Feyrer et al. 2003

Project goals

1. Compare white sturgeon diet composition and prey importance in the pre- and post-invasion period.
2. Use stable isotopes of white sturgeon and prey to model the assimilation of prey into sturgeon tissues. (i.e. Do gut contents match assimilation).

Methodology

- **Gut contents**

1. Only provides a snap shot of prey consumed.
2. Biased by hard to digest prey items.
3. Good taxonomic resolution.

- **Stable isotopes**

1. Taxonomic resolution can be poor.
2. Provides a measure of what is actually assimilated.
3. Integrates feeding over longer time periods.

The data (gut contents)

- **Pre-invasion**
- McKechnie and Fenner (CDFW 1971).
- Collections from recreational catches 1965-1967 in Suisun and San Pablo bays.

- **Post-invasion**
- Kogut (CDFW).
- Collections from recreational catches. 2001-2003 in Suisun and San Pablo bays.
- USFWS/CFS 2012-2013.
- Collections from Super bowl Sturgeon Derby.

The data (cont.)

- **Stable isotopes**
- Stewart et al. (2004) USGS.
- Collection of tissues between 1999 and 2001.

- **Data reduction**.
- Esophagus and stomach.
- Analysis limited to fish 117-168 cm to avoid bias from changing slot limit.
- All prey items measured by displacement

Analysis (gut contents)

- Volumetric proportions of prey compared between pre- and post-invasion periods.
- Prey frequency of occurrence compared between periods.
- Niche breadth compared in each period with Levin's measure *B*

Analysis (stable isotopes)

- Carbon $^{13}C/^{12}C$ and Nitrogen $^{15}N/^{14}N$
- Bayesian mixing model (MixSIR) used to estimate contributions.
- Tissue diet fractionation from Post (2002)
- Carbon 0.4 (SD=1.3)
- Nitrogen 3.4 (SD=1.0)

Prey

- Crangon spp./Dungeness
- Ampelisca
- Corophium
- Isopods
- Yellowfin goby
- Starry flounder
- Overbite clams

Results (gut contents)

- **Pre-invasion**

1. 22 prey taxa in 254 guts.
2. 14% of guts empty.
3. Individual taxa combined into 9 prey categories because many taxa were rare.

- Clams = 30%
- Herring eggs = 27%
- Barnacles = 13%
- Fish = 12%
- No other item >5%

Results (gut contents)

- **Post-invasion**

1. 13 prey taxa in 81 guts.
2. 10% empty
3. Individual taxa placed into 8 categories.

- Clams = 82-93%
- Crayfish = 11% (2012-2013)
- No other item >5%.

Niche breadth

Pre-invasion = 4.8

2001-2003 = 1.2

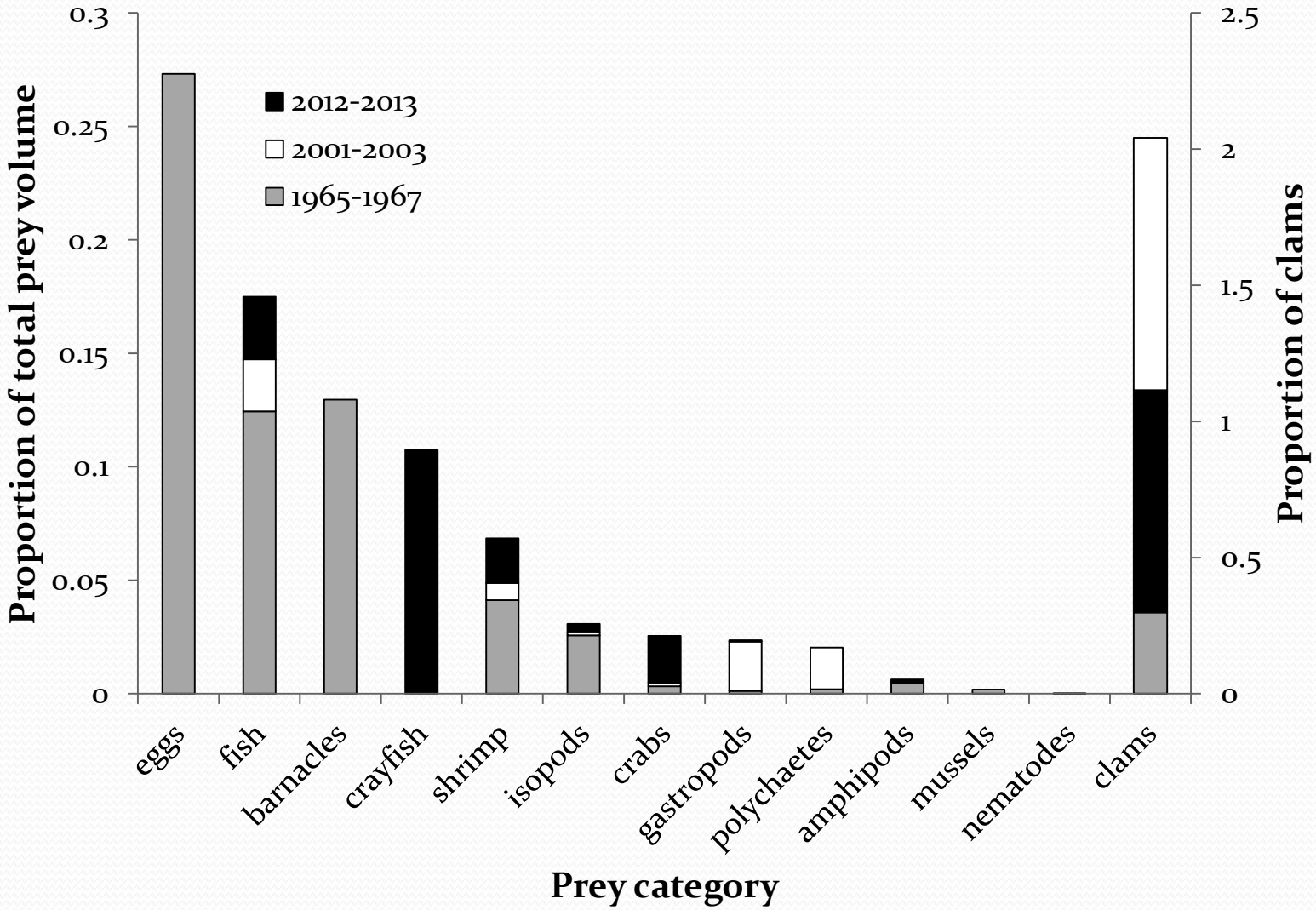
2012-2013 = 1.5

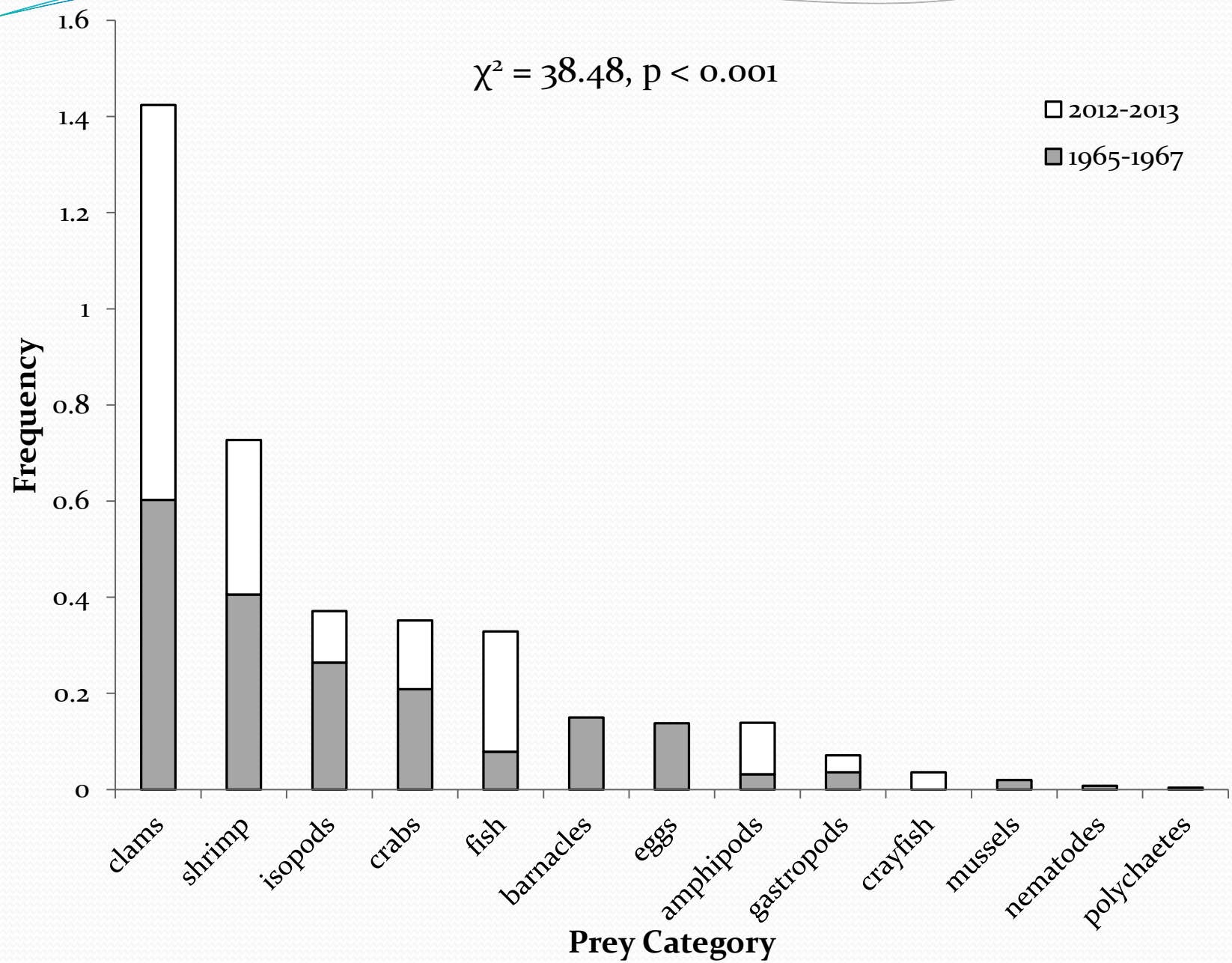
Table 1. List of all taxa identified from each prey category during the pre- and post-invasion periods. Categories are listed in order of their rank in total volumetric proportions.

Prey category	Taxa identified	Pre-invasion period	Post-invasion period
Clams	*Gemma gemma*[2]	X	
	Macoma sp.[1]	X	
	Tapes semidecussata[2]	X	
	Potamocorbula amurensis[2]		X
	Corbicula fluminea[2]		X
Fish eggs	*Clupea pallasi* (eggs)[1]	X	
Fish	*Morone saxatilis*[2]	X	
	Platichthys stellatus[1]	X	
	Clupea pallasi (eggs)[1]	X	
	Engraulis mordax[1]	X	
	Porichthys notatus[1]	X	
	Leptocottus armatus[1]	X	
	Menidia beryllina[2]		X
	Gobidae[2]	X	X
	Cottidae	X	X
Barnacles	*Balanus spp.*[2]	X	
Crabs	*Rhithropanopeus harrisii*[2]	X	X
	Metacarcinus magister[1]	X	
Shrimp	*Palaemon macrodactylus*[2]	X	X
	Crangon spp.[1]	X	X
	Neomysis spp.[3]	X	
Crayfish	Astacidae		X
Isopods	*Synidotea sp.*[2]	X	
Gastropods	Opisthobranchia		X
	Physidae		X
Polychaetes	*Nereis* sp.[3]	X	
Mussels	Mytilus sp.[3]	X	
Amphipods	Gammaridae		X
Nematodes	Unidentified	X	

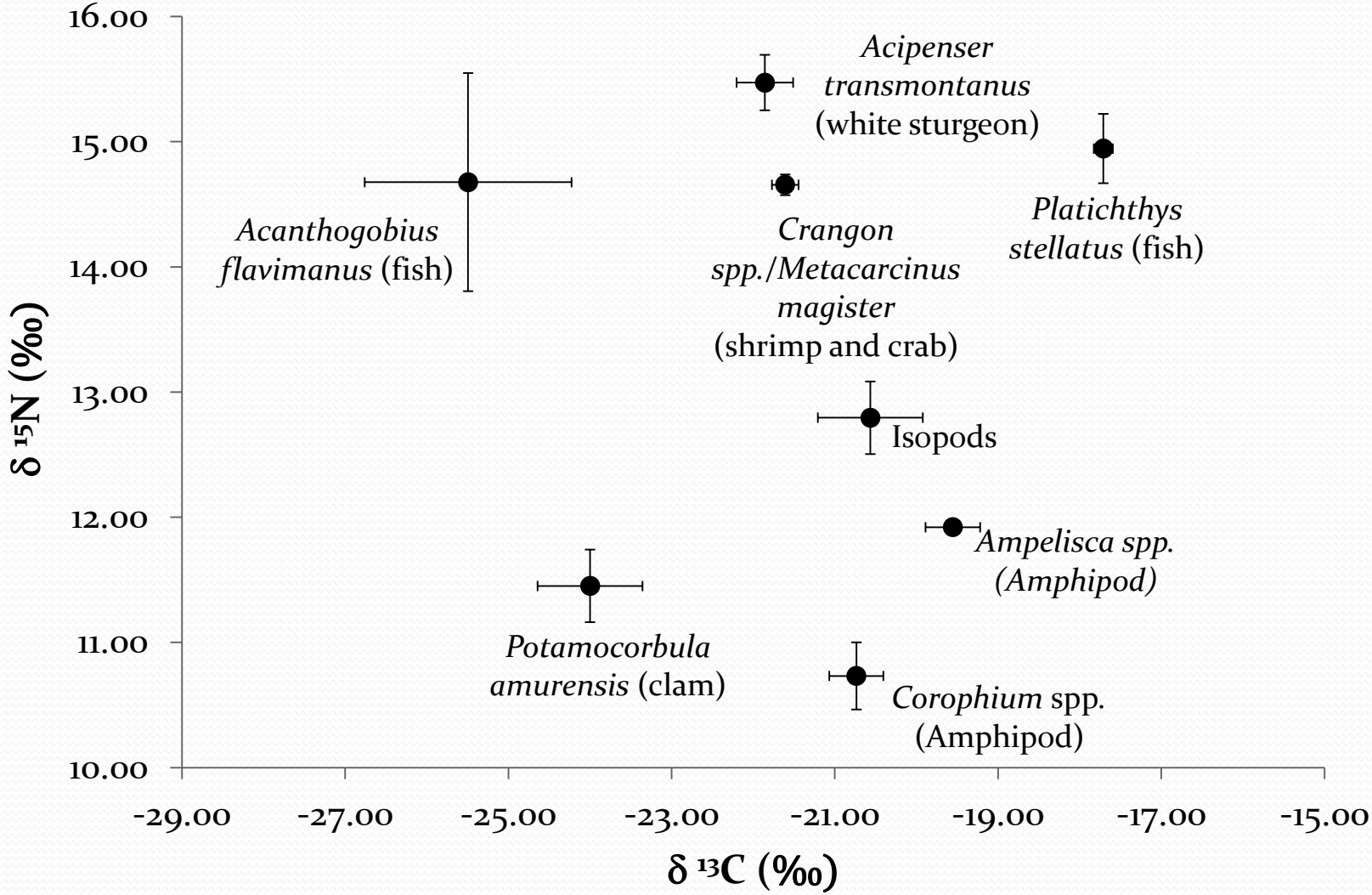
[1] native, [2] introduced, [3] native and introduced species within this taxonomic classification

Pre vs. 2001-2003 $\chi^2 = 3162$, $p < 0.001$
Pre vs. 2012-2013 $\chi^2 = 1495$, $p < 0.001$




$\chi^2 = 38.48$, $p < 0.001$
2012-2013
1965-1967
Frequency
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
clams
shrimp
isopods
crabs
fish
barnacles
eggs
amphipods
gastropods
crayfish
mussels
nematodes
polychaetes
Prey Category

Results (stable isotopes)



Results (stable isotopes)

Table 2. Proportional contribution of each prey item to sturgeon biomass at five cumulative probability levels from the stable isotope mixing model.

Prey item	**0.05**	**0.25**	**0.5**	**0.75**	**0.95**
Crangon spp./Metacarcinus magister	0.001	0.006	0.013	0.026	0.055
Ampelisca spp.	0.001	0.009	0.020	0.039	0.080
Corophium spp.	0.001	0.006	0.014	0.027	0.071
Isopods	0.001	0.007	0.016	0.033	0.076
Potamocorbula amurensis	0.703	0.746	0.770	0.796	0.830
Acanthogobius flavimanus	0.001	0.003	0.008	0.016	0.037
Platichthys stellatus	0.037	0.097	0.127	0.152	0.190

Results

- Clam contributions (post invasion)

1. Gut contents 82-93%
2. Stable isotope estimates 70.3 – 83.0%

- Fish contributions (post invasion)

1. Gut contents 2.3-2.8%
2. Stable isotope estimates 3.7-19.0%

- Variation reflects biases of each analysis and differences in prey type.

Conclusions

- White sturgeon readily consume *Potamocorbula*.
- Significant change in diet composition following the invasion of *Potamocorbula*.
- Significant change in diet diversity.
- Contributions from overbite clams are large but not as large as indicated but gut contents.
- Fish make larger contributions than indicated by gut contents.

Implications

- Increased potential for trophic transfer of toxins.
- Reliance on a single prey item = potential web instability.
- Poor energy transfer efficiency.

Future directions

- Better size distribution of white sturgeon.
- Increased spatial resolution of feeding activity
- Diet-contaminant relationships

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Questions?