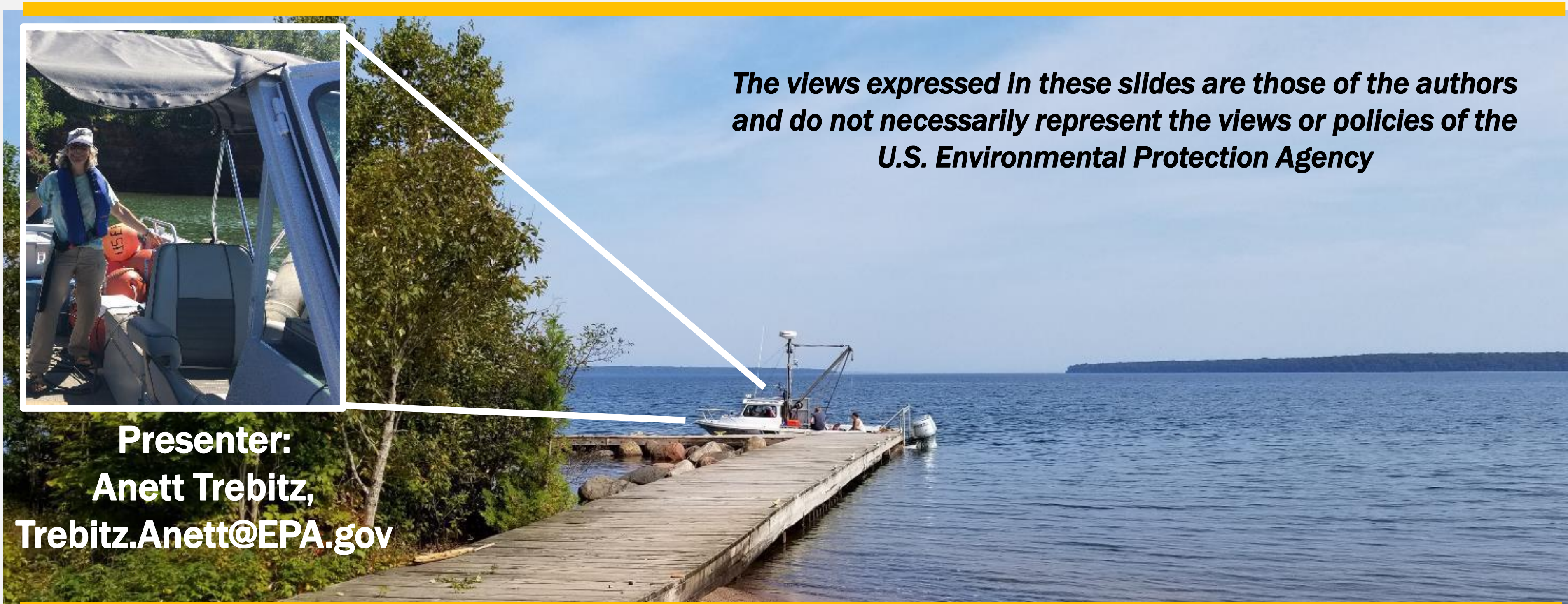
Nearshore Lake Superior invertebrate biodiversity patterns from two high-density surveys



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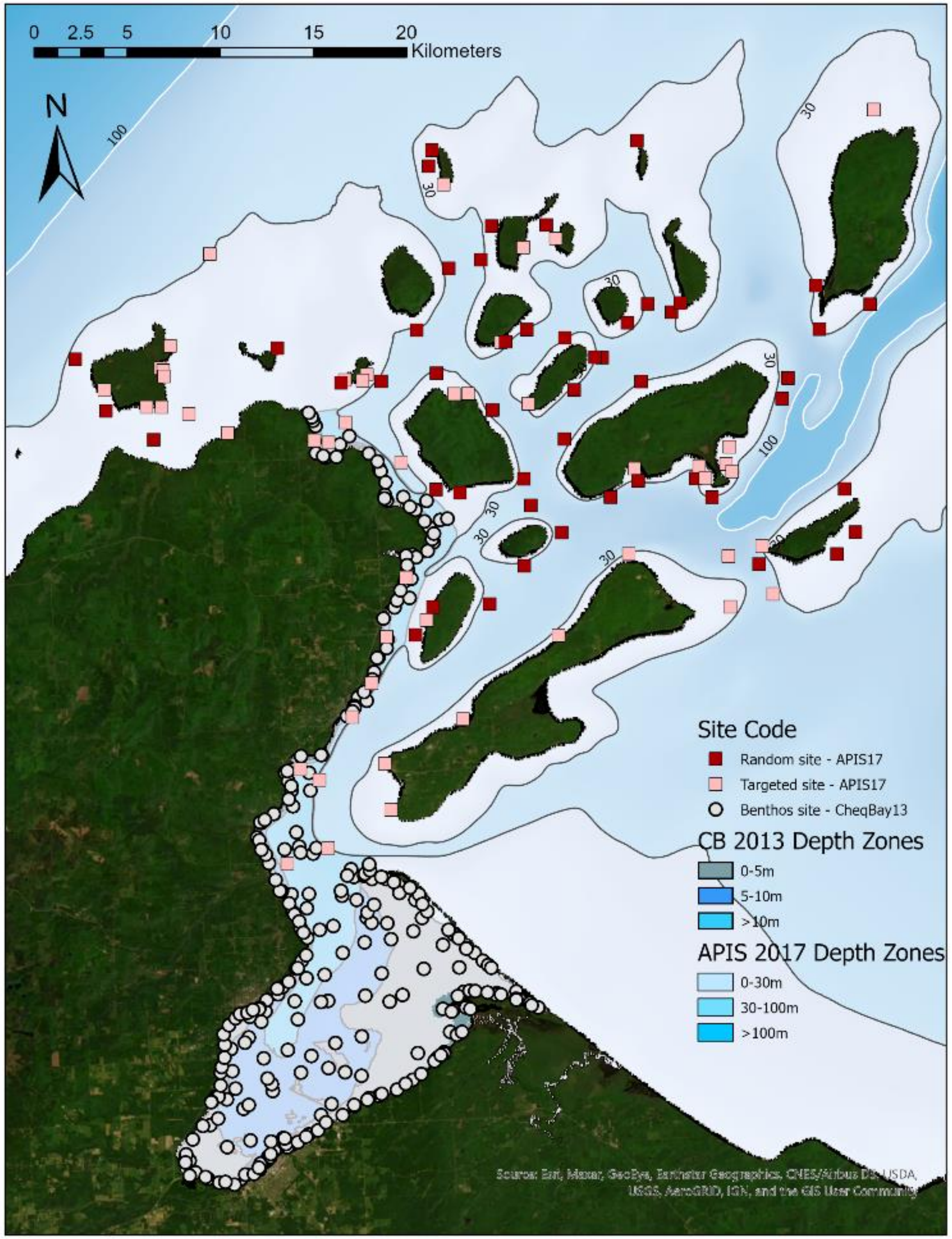
Virtual IAGLR conference, May 17 – 21, 2021

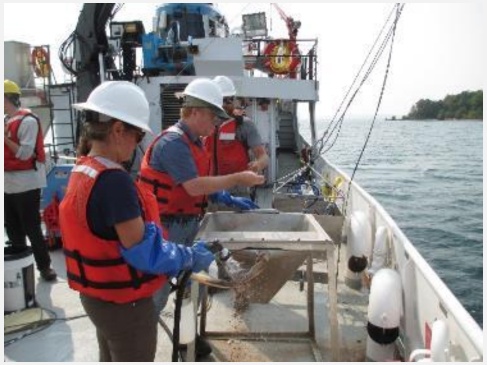
Sampling design



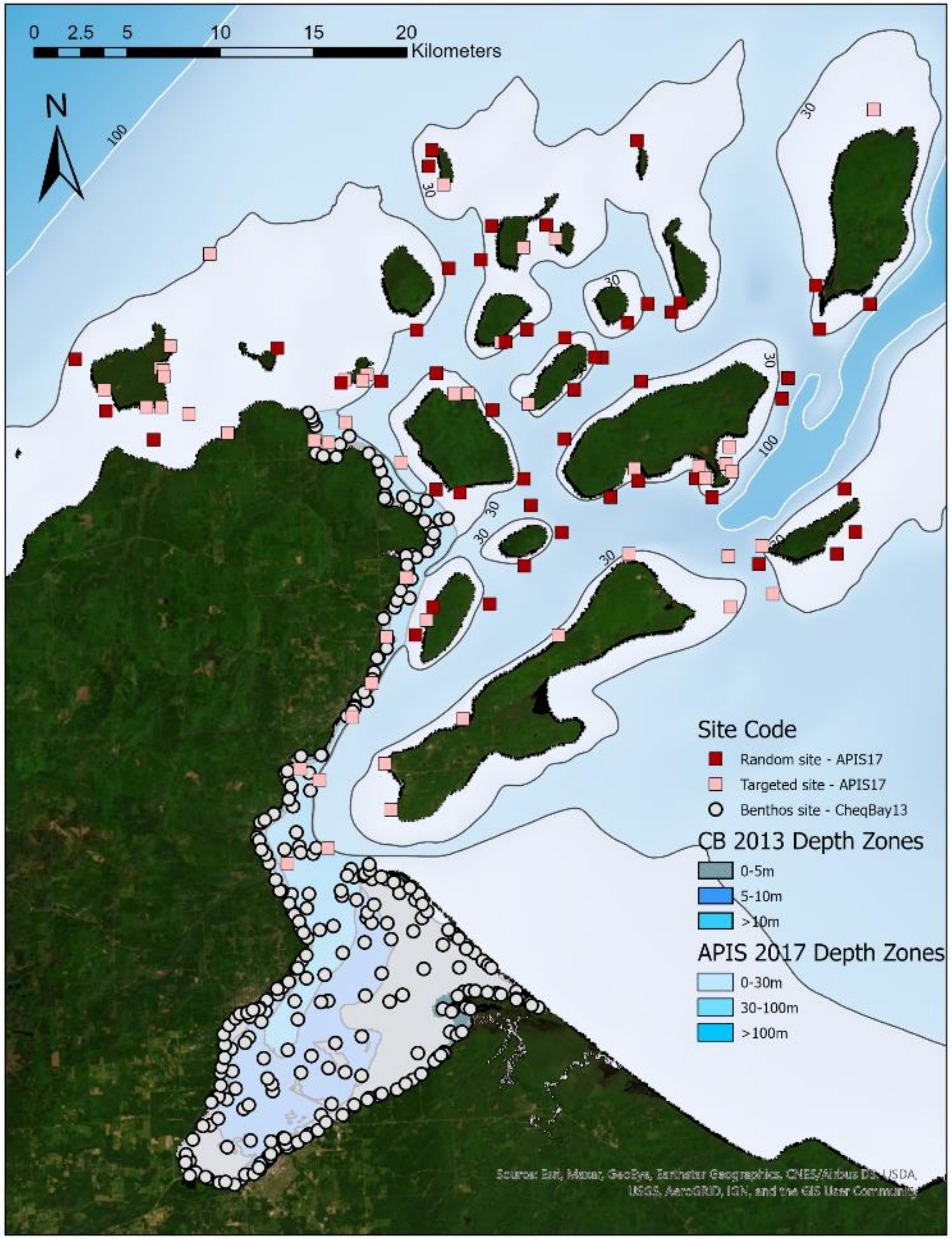
Chequamegon Bay (C-Bay), 2013:

- 288 stations:
  - Chequamegon Bay and east shoreline of Chequamegon Peninsula
  - 274 on stratified random
  - 14 at target points (marinas)
- Each sampled for:
  - Water quality (meter)
  - Benthos via ponar at random sites
  - Benthos via benthic sled at marinas

Impetus: examine sampling design strategies for early detection monitoring



Sampling design



Apostle Islands (APIS), 2017:

- **100 stations:**
  - **50 on random design (<1km from shore, <30 & 30-100m depth),**
  - **50 at target points (docks & moorings, off main rivers)**
- **Each sampled for:**
  - **Water quality (lab & meter)**
  - **Zooplankton (63 micron tows)**
  - **Benthos (ponar, hester dendy, rock bag depending on site)**

Impetus: look for Dreissena, establish baseline for potential impacts to zooplankton and benthos

Taxonomic Analysis

Species-resolution as goal (always attainable)

Zooplankton:

- Enumerated via GLNPO method
  - Sequential splits, two 200-400 organism splits counted in full, higher splits scanned for large/rare
  - Veligers treated as macro-zoops
  - Taxonomy by Heidi Schaefer & Lana Fanberg (UW-Superior)
- Mixed resolution addressed manually
  - Copepodites (immatures) primary cause of mixed resolution
  - Richness: finest level retained
  - Abundance: aggregated to genus or family for analyses

Benthos:

- Enumerated via full counts
  - Except subsampling to ID chironomids and oligochaetes (via slide mounting)
  - Taxonomy by Gerald Shepard, Adam Frankiewicz, Brent Gilbertson (BTS)
- Mixed resolution addressed via R-script (see ms below)
  - Combo of immatures, damaged specimens, unmounted chiros/oligos cause mixed resolution
  - Richness: finest level retained
  - Abundance: distribute parents across children at site, then study area

Contents lists available at ScienceDirect

Ecological Indicators

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Original Articles

Resolving taxonomic ambiguities: Effects on rarity, projected richness, and indices in macroinvertebrate datasets

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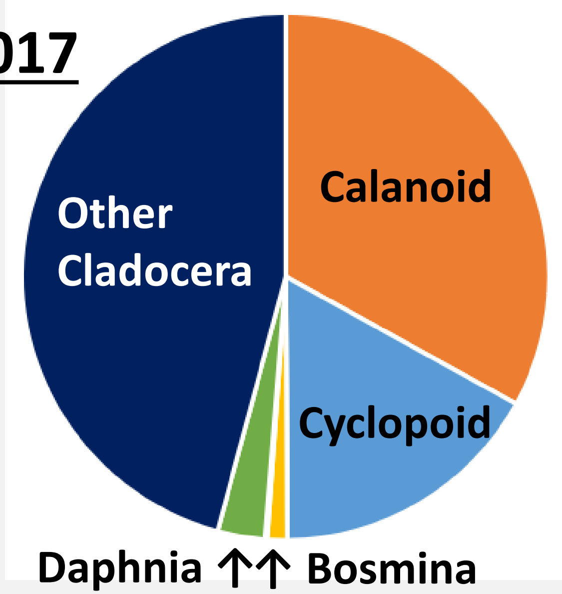
Results: zoop & benthos composition overview

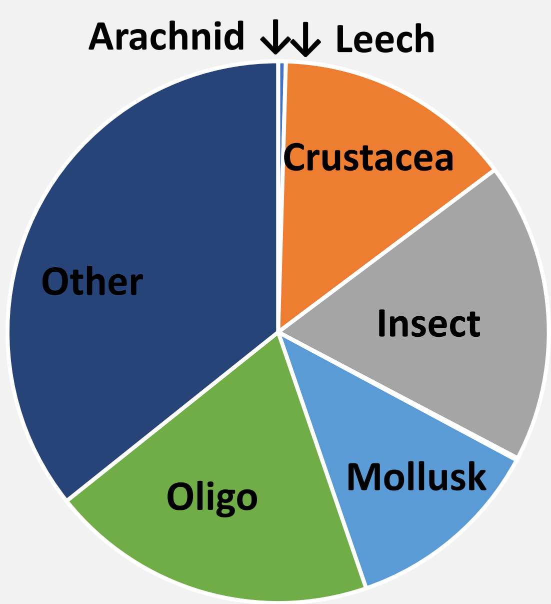
APIS 2017



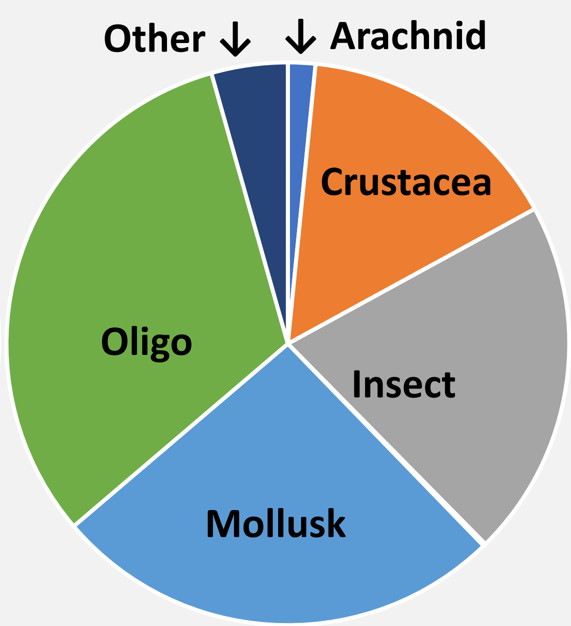
Zooplankton: 27 unique taxa →

- 6 genera of calanoid copepods
- 5 genera of cyclopoid copepods
- 10 genera of cladocerans
- 2 other taxonomic groups

APIS 2017



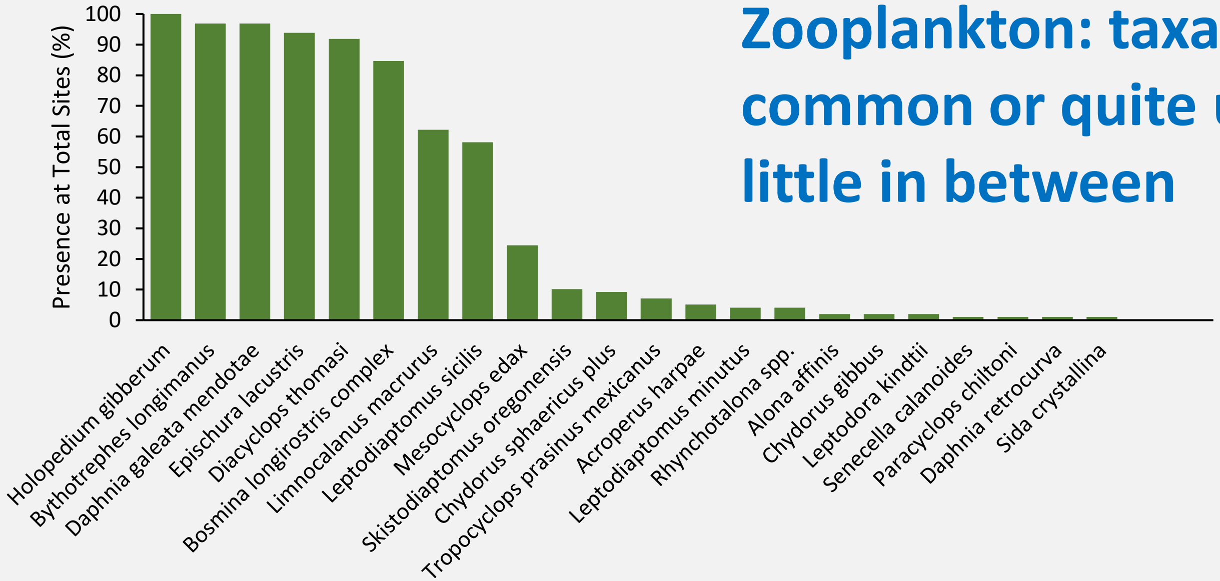
C-Bay 2013



← Benthos: 291 unique taxa

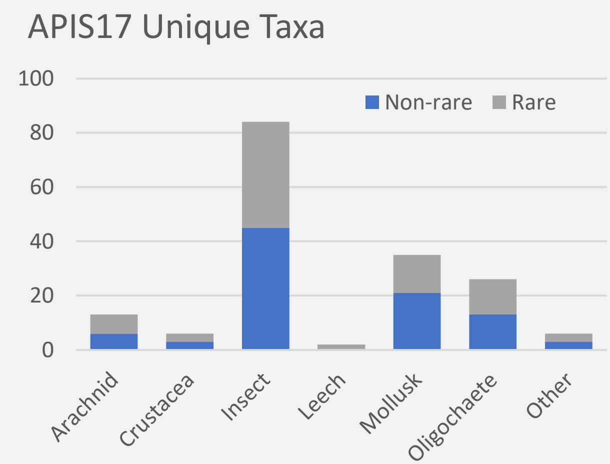
- 25 genera of mollusks
- 19 genera of arachnids
- 18 genera of oligochaetes
- 8 genera of leeches
- 104 genera of insects
- 5 genera of crustacea
- 8 other phyla

Results: rare species



Zooplankton: taxa either very common or quite uncommon; little in between

Benthos: many taxa are numerically rare (<2% of sites)

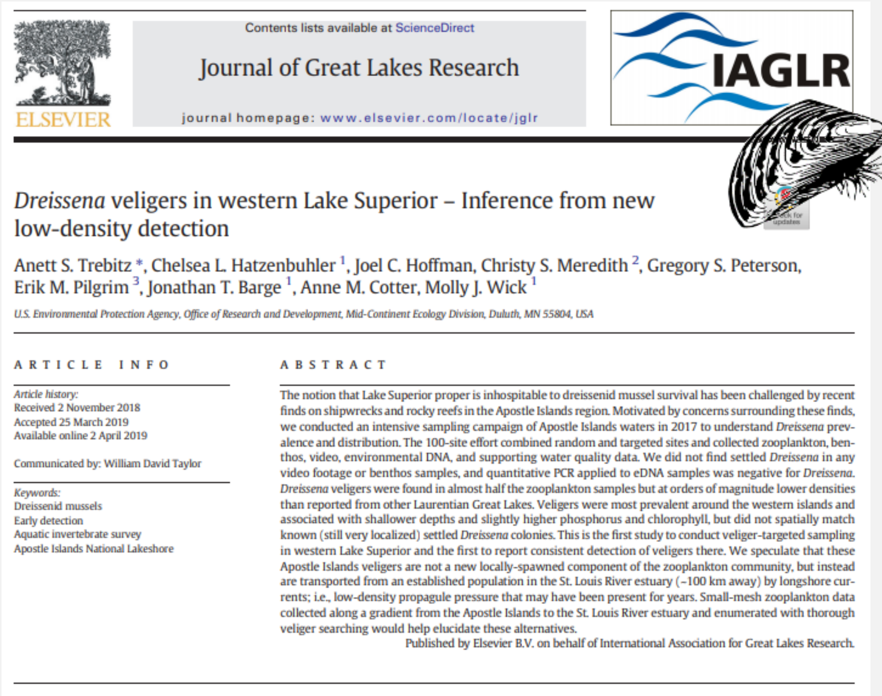


Benthos on state "special concern" lists

- **Gastropods *Cincinnatia cincinnatiensis* & *C. integra* – MI**
- **Unionid *Elliptio complanta* – MN/WI/MI**
- **Gastropod *Helisoma anceps* – MI**
- **Peaclams *Pisidium idahoense* & *P. punctatum* – MI**
- **Trichoptera *Triaenodes flavescens* – MN**

Results: non-native species

***Dreissena*: veligers in 44%**
of APIS zoop tows →
but no settled mussels



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Dreissena veligers in western Lake Superior – Inference from new low-density detection

Anett S. Trebitz *, Chelsea L. Hatzenbuhler [1], Joel C. Hoffman, Christy S. Meredith [2], Gregory S. Peterson, Erik M. Pilgrim [3], Jonathan T. Barge [1], Anne M. Cotter, Molly J. Wick [1]

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ABSTRACT

The notion that Lake Superior proper is inhospitable to dreissenid mussel survival has been challenged by recent finds on shipwrecks and rocky reefs in the Apostle Islands region. Motivated by concerns surrounding these finds, we conducted an intensive sampling campaign of Apostle Islands waters in 2017 to understand *Dreissena* prevalence and distribution. The 100-site effort combined random and targeted sites and collected zooplankton, benthos, video, environmental DNA, and supporting water quality data. We did not find settled *Dreissena* in any video footage or benthos samples, and quantitative PCR applied to eDNA samples was negative for *Dreissena*. *Dreissena* veligers were found in almost half the zooplankton samples but at orders of magnitude lower densities than reported from other Laurentian Great Lakes. Veligers were most prevalent around the western islands and associated with shallower depths and slightly higher phosphorus and chlorophyll, but did not spatially match known (still very localized) settled *Dreissena* colonies. This is the first study to conduct veliger-targeted sampling in western Lake Superior and the first to report consistent detection of veligers there. We speculate that these Apostle Islands veligers are not a new locally-spawned component of the zooplankton community, but instead are transported from an established population in the St. Louis River estuary (~100 km away) by longshore currents; i.e., low-density propagule pressure that may have been present for years. Small-mesh zooplankton data collected along a gradient from the Apostle Islands to the St. Louis River estuary and enumerated with thorough veliger searching would help elucidate these alternatives.

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Zooplankton (APIS %):

- ***Bythotrephes longimanus*** **(97%),** **(also in ~50% of benthos samples)**
- ***Daphnia galeata mendotae*** **(97%)**
- ***?? Eurytemora*** **(3%) -- 1 native, 1 NIS spp**
- **?? Harpacticoid (3%) – 4 of 30+ possible spp**

Benthic inverts (APIS/Cbay %):

- **Amphipod *Gammarus fasciatus* (12/41%)**
- **Peaclams *Pisidium amnicum* (<1/8%), *P. henslowanum* (<1/5%),** ***P. moitessierianum*** **(0/<1%),** ***P. supinum*** **(0/<1%)**
- **Oligochaetes *Potamothrix moldaviensis* (0/<1%), *P. vejdovskyi* (0/<1%)**
- **Oligochaete *Ripistes parasita* (19/4%)**

Results: zoop nearshore vs offshore (by species)

More unique zoop taxa nearshore than offshore

Offshore (2 unique, +4 maybe)

Calanoids

[1]Diaptomus minutus
[1]Diaptomus oregonensis
[1]Diaptomus sicilis

Cyclopoids

[3]Cyclops bicuspidatus thomasi

Diplostracans

Ceriodaphnia lacustris
Diaphanosoma birgei

Shared (9+ taxa)

Calanoids

([1]*Diaptomidae copepodites]*
[1]Leptodiaptomus sicilis
[[2]Senecella copepodites]
Epischura lacustris
[Epischura copepodites]
Limnocalanus macrurus

Cyclopoids

[[3]Cyclopoid copepodites]
[3]Diacyclops thomasi
[[4]Mesocyclops copepodites]
Tropocyclops prasinus mexicanus
[Tropocyclops copepodites]

Diplostracans

Bosmina longirostris
Bythotrephes longimanus
Daphnia galeata mendotae
Daphnia retrocurva
Holopedium gibberum
Leptodora kindtii

Nearshore (8 unique, +6 maybe)

Calanoids

[1]Leptodiaptomus minutus
[1]Skistodiaptomus oregonensis
[2]Senecella calanoides
Eurytemora copepodites

Cyclopoids

[3]Eucyclops spp.
[4]Mesocyclops edax
[3]Paracyclops chiltoni

Harpacticoids

Bryocamptus minutus

Diplostracans

Acroperus harpae
Alona affinis
Alona costata/guttata/rectangula
Chydorus gibbus
Chydorus sphaericus
Rhynchotalona spp.
Sida crystallina

Superscript #'s = not necessarily unique (copepodites)

Pawlowski & Sierszen 2020 (JGLR 46:1015-1027) for CSMI offshore data (excluding <30m)

Results: benthos nearshore vs offshore (by family)

MANY more unique taxa nearshore than offshore

Offshore (12 unique)

Leeches
Piscicolidae (1 genus; 2 spp)
Worms (Annelida)
Naididae (6 genera, 8 spp)
Crustacea
Mysis (1 sp)
Insects
Chironomidae (1 genus/sp)

Shared (21 taxa)

Worms (Annelida)
Enchytraeidae (family ID)
Lumbriculidae (1 genus/sp)
Naididae (5 genera, 6 spp)
Bivalves
Pisidiidae (2 genera)
Crustacea
Diporeia (1 sp)
Assorted phyla
Hydra
Platyhelminthes
Insects
Chironomidae (7 genera)

Nearshore (254 unique)*

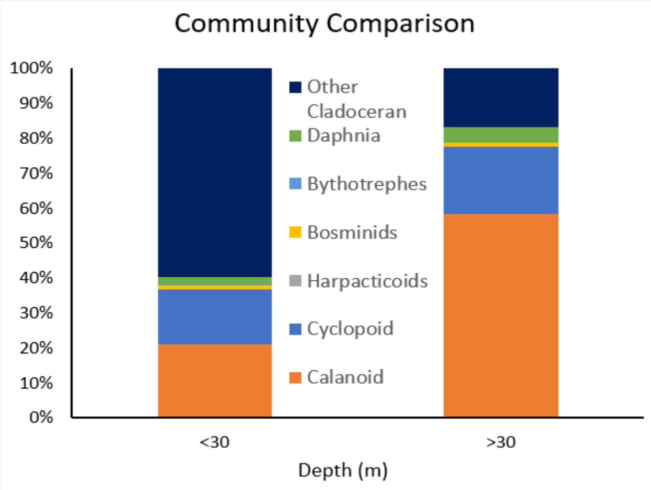
Leeches
Erpobdellidae (1 genus/sp)
Glossiphoniidae (6 genera, 9 spp)
Piscicolidae (1 genus/sp)
Worms (Annelida)
Lumbricidae (1 genus)
Naididae (11 genera,1 6 spp)
Sabellidae (1 genus/sp)
Sparganophilidae (1 genus)
Bivalves
Pisidiidae (3 genera, 27 spp)
Unionidae (4 genera, 3 spp)
Snails
Ancylidae (1 genus/sp)
Hydrobiidae (5 genera, 6 spp)
Lymnaeidae (3 genera, 3 spp)
Physidae (1 genera/sp)
Planorbidae (5 genera, 8 spp)
Succineidae (1 genus/sp)
Valvatidae (1 genus/sp)
Viviparidae (1 genus/sp)
Crustacea
Asellidae (1 genus, 2 spp)
Cambaridae (1 genus)
Crangonyctidae (1 genus)
Gammaridae (1 genus, 3 spp)
Assorted phyla
Collembola
Nematoda
Nematomorpha
Tardigrada
Tetrastemmatidae

Insects
Coleoptera
Chrysomelidae (1 genus)
Dytiscidae (1 genus)
Elmidae (2 genera, 2 spp)
Haliplidae (1 genus/sp)
Scirtidae (1 genus)
Diptera
Ceratopogonidae (4 genera)
Chironomidae (46 genera, 72 spp)
Empididae (2 genera)
Muscidae (2 genera)
Tipulidae (3 genera)
Ephemeroptera
Baetidae (1 genus/sp)
Baetiscidae (1 genus/sp)
Caenidae (2 genera, 7 spp)
Ephemeridae (2 genera, 2 spp)
Heptageniidae (1 genus/sp)
Leptohyphidae (1 genus)\
Hemiptera -- Corixidae (2 genera, 5 spp)
Hymenoptera -- Trichogrammatidae (1 genus)
Lepidoptera
Crambidae (1 genus)
Pyralidae (1 genus)
Megaloptera -- Sialidae (1 genus)
Nueroptera -- Sisyrida (1 genus/sp)
Odonata -- Coenagrionidae (2 genera, 1 spp)
Plecoptera
Capniidae (1 genus)
Perlodidae (1 genus)
Trichoptera
Dipseudopsidae (1 genus/sp)
Helicopsychidae (1 genus/sp)

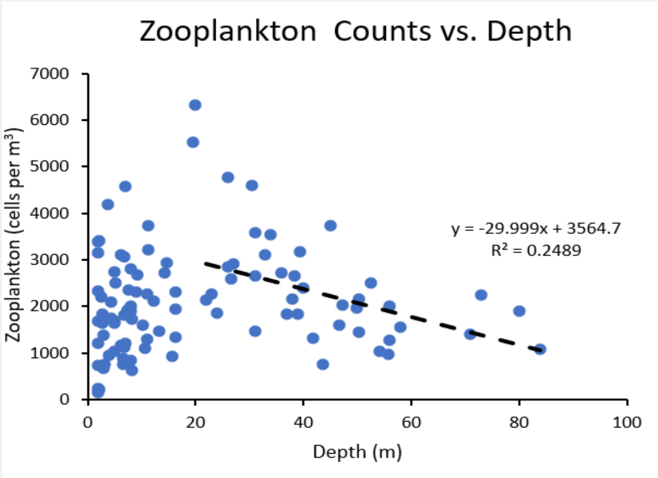
* Excludes 21 mite genera (unclear if Burlakova et al enumerated)

Burlakova et al. 2018 (JGLR 44:600-617) for GLNPO offshore data

Results: zoop environmental associations

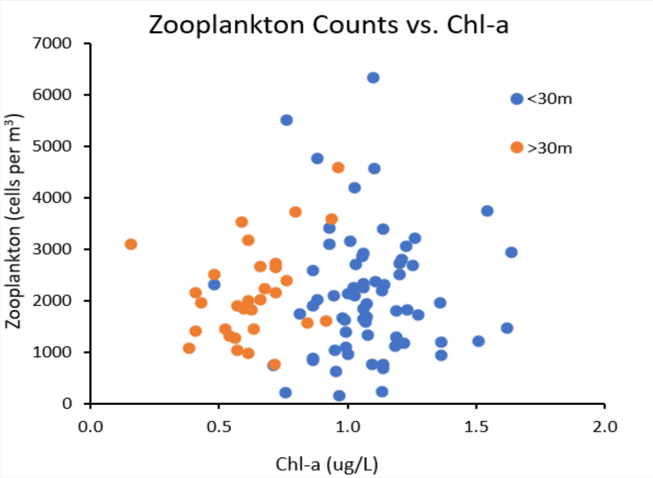


Depth: shift from cladocera (shallow) to calanoid copepods (deep) →

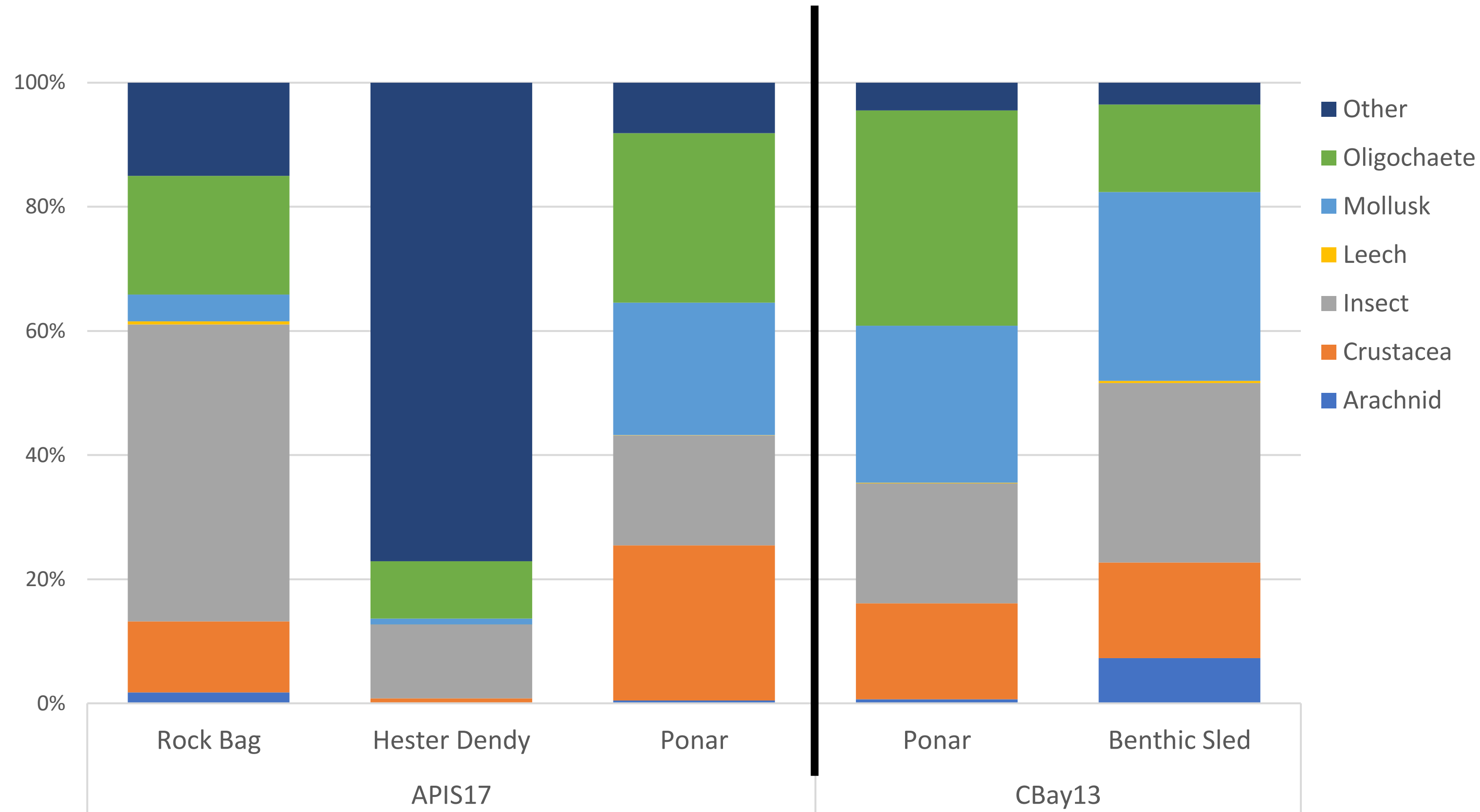


Depth: abundance declines ← with depth above ~20m

Chlorophyll: higher shallow than deep, but NOT driving zoop abundance →

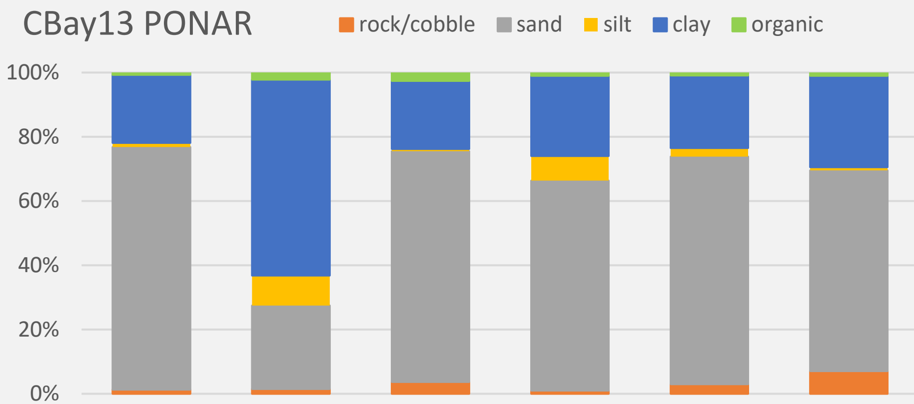


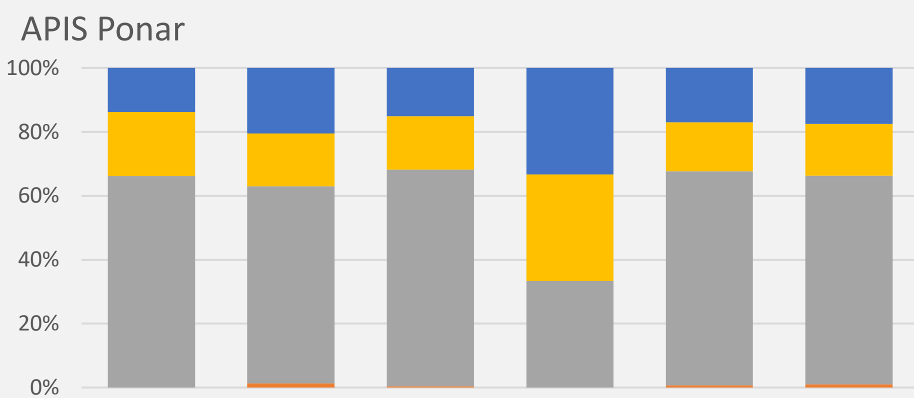
Results: benthos gear type comparisons

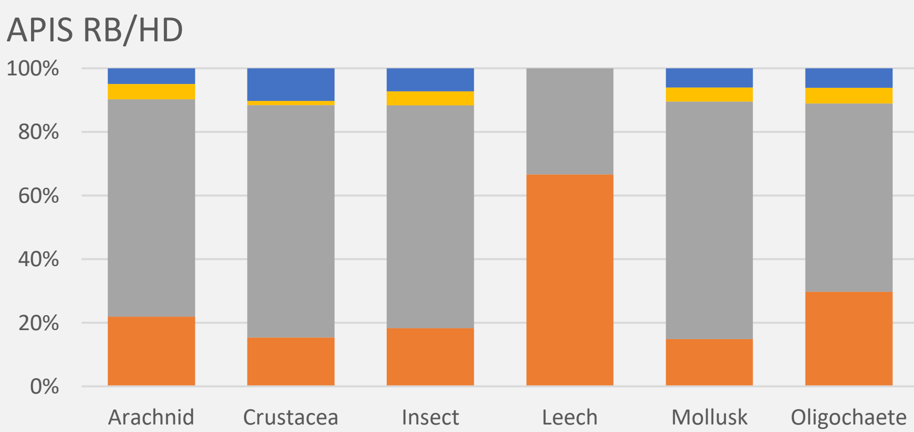


- **Ponar very similar between APIS & C-Bay**
- **Hester Dendy very different from other APIS gear**
- **Benthic sled *distribution* similar to Ponar despite much higher area sampled and total catch**
- **Substrate dictates gear & complicates resolving envi drivers**

Results: benthos envi assoc’s – sediment & depth

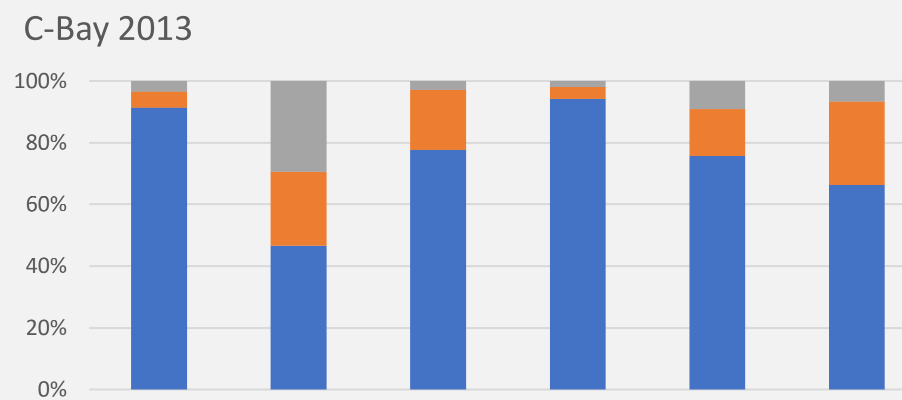


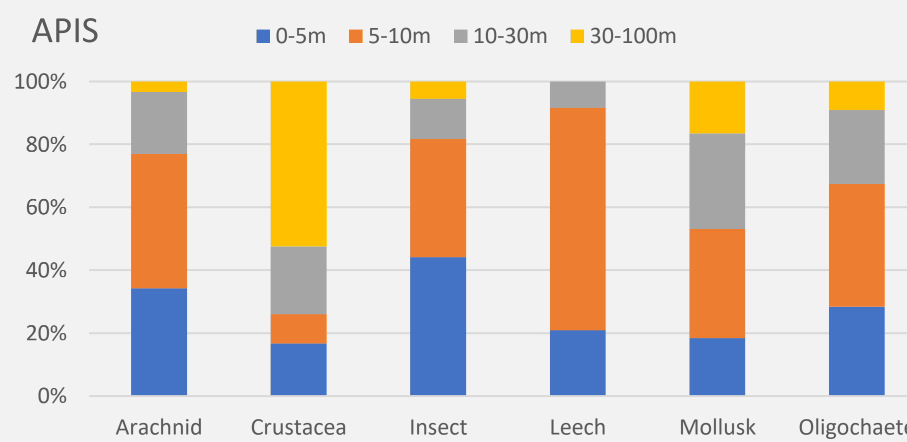




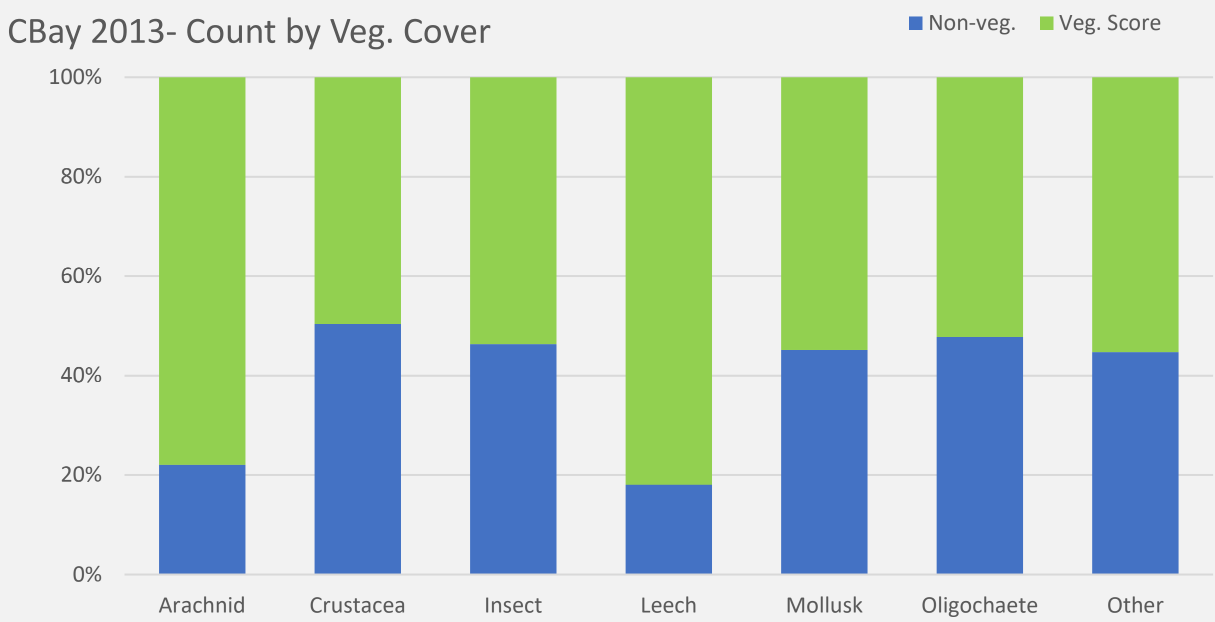
Taxa distribution mirrors envi distribution in many cases. Exceptions:

- **Crustacea biased to deep and clay (Bytho effect)**
- **Arachnids (mites) biased to shallow**
- **Leeches biased to shallow and non-sand**





Results: benthos envi associations -- vegetation



← 32% of sites vegetated

← 68% of sites NOT vegetated

Although vegetated sites are the minority, all taxa counts are biased towards vegetation. Especially arachnids (mites) and leeches.

Summary

Hi-resolution near-shore invertebrate surveys yield many interesting taxa & valuable baselines for future conditions and impacts

- **Benthos & zoop far more diverse nearshore than offshore**
- **Lake Superior nearshore hosts some rare & state-listed species**
- **Also hosts some non-natives (Bytho, D. galeata, amphipods, peaclams, oligochaetes)**
- **Depth-related shifts in zoop composition despite close spatial proximity**
- **Multiple gear for benthos complicate envi associations**
- **Clear depth and substrate assoc's only for some taxa (e.g., mites, leeches)**
- **Vegetation vs lack thereof is strong drive of patterns**

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- BTS & UW-Superior taxonomists
- National Park Service
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United States Environmental Protection Agency

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Nearshore Lake Superior invertebrate biodiversity patterns from two high-density surveys

Abstract: Despite recognition that invertebrate fauna in nearshore regions of the Great Lakes can differ substantially from offshore regions, datasets amenable to exploring nearshore biodiversity patterns remain limited. Here, we use two spatially intensive Lake Superior nearshore invertebrate surveys to explore taxa prevalence patterns, differences from offshore communities, non-native taxa occurrence, spatial covariance, and environmental factors. Data come from ~290 benthos samples from the Bayfield Peninsula coastline (year 2013) and ~100 zooplankton and ~150 benthos samples from the Apostle Islands (year 2017) that collectively contain 25+ crustacean zooplankton taxa and ~400 benthos taxa. Over 30% of zooplankton and 60% of benthos taxa were numerically rare (at <2% of stations) and several appeared on state rare-species lists. Besides Bythotrephes, non-native species came primarily from benthic oligochaetes, amphipods, and mollusks. Within the 30m depth cutoff typically used to define 'nearshore', we found considerable variability in community composition related to depth, exposure, and substrate.