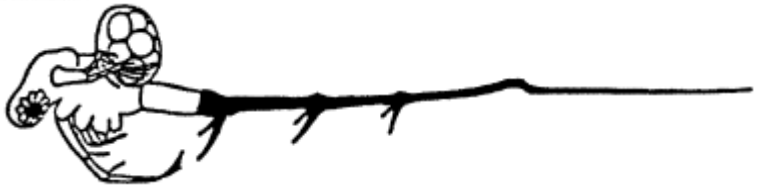
Michigan Technological University
Department of Biological Sciences



A Plague Of Water Fleas: Spiny Cladoceran Impacts On Lake Food Webs

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Background

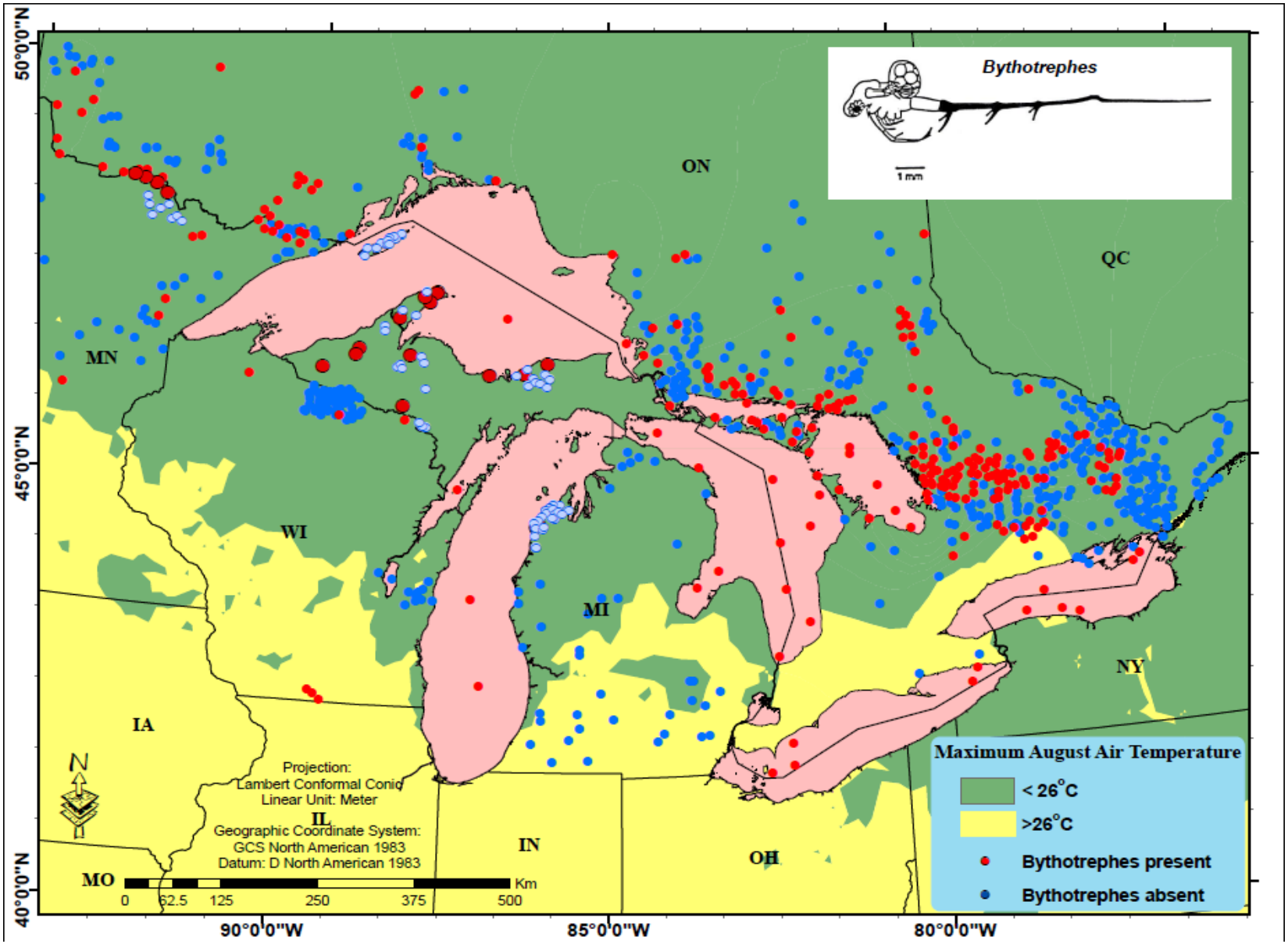
Bythotrephes longimanus

-An Invasive Zooplankter in the Great Lakes Region

- Originally from Eurasia (Baltic: Bay of Finland)
- First documented in Great Lakes in 1982, spread throughout since: Ontario in 1982, Erie 1984, Huron 1984, Michigan 1986, Superior 1987 (Lehman1987,Evans 1988, Cullis and Johnson 1988)
- Rapidly expanding into inland lakes along a temperature-related latitudinal band from Ontario and New York to Minnesota and Manitoba (Branstrator et al. 2006, Kerfoot et al. 2011)

In the Great Lakes, quagga mussels initiate collapse of alewives (planktivorous fish), which released the spiny waterflea (*Bythotrephes*) even more, causing additional loss of zooplankton species

Bythotrephes in the Great Lakes Region



Kerfoot et al. 2011

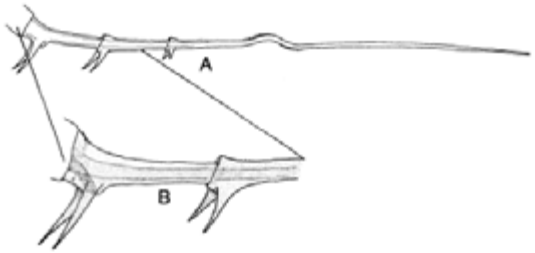
Dispersal mechanisms

- Accidental: recreational fishing
- Connection to highway conduit and accessibility (boat ramps)
- Spines can snag on anchor rope and fishing line
- Baitfish use

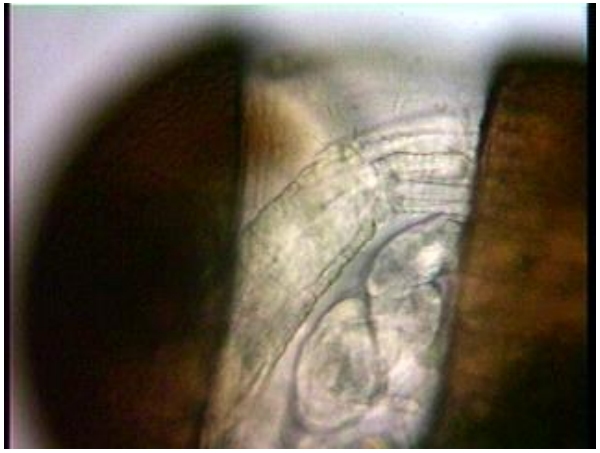
→ Resting egg transfer by fish: live well, bait bucket, anchor sediment

photo: Minnesota Sea Grant

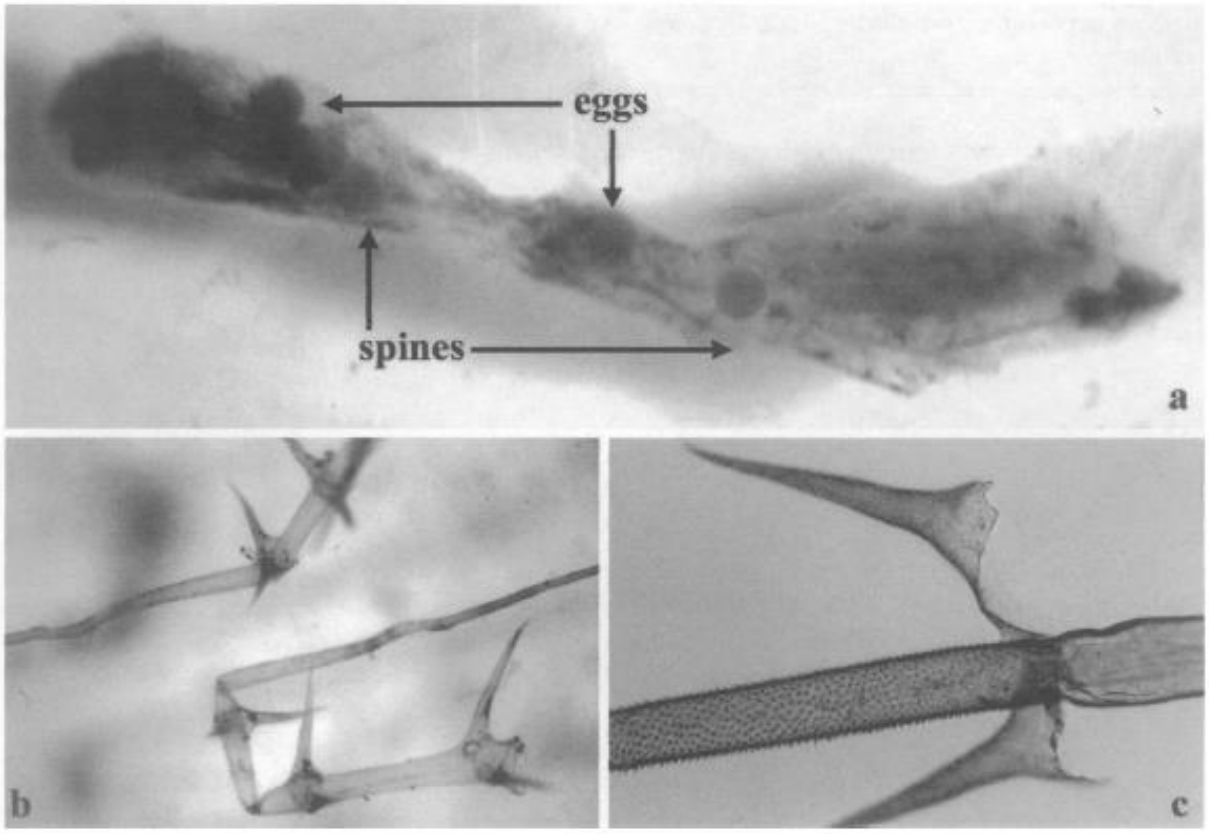
Photo credit: cabelas.com



Martin and Cash-Clark, 1995

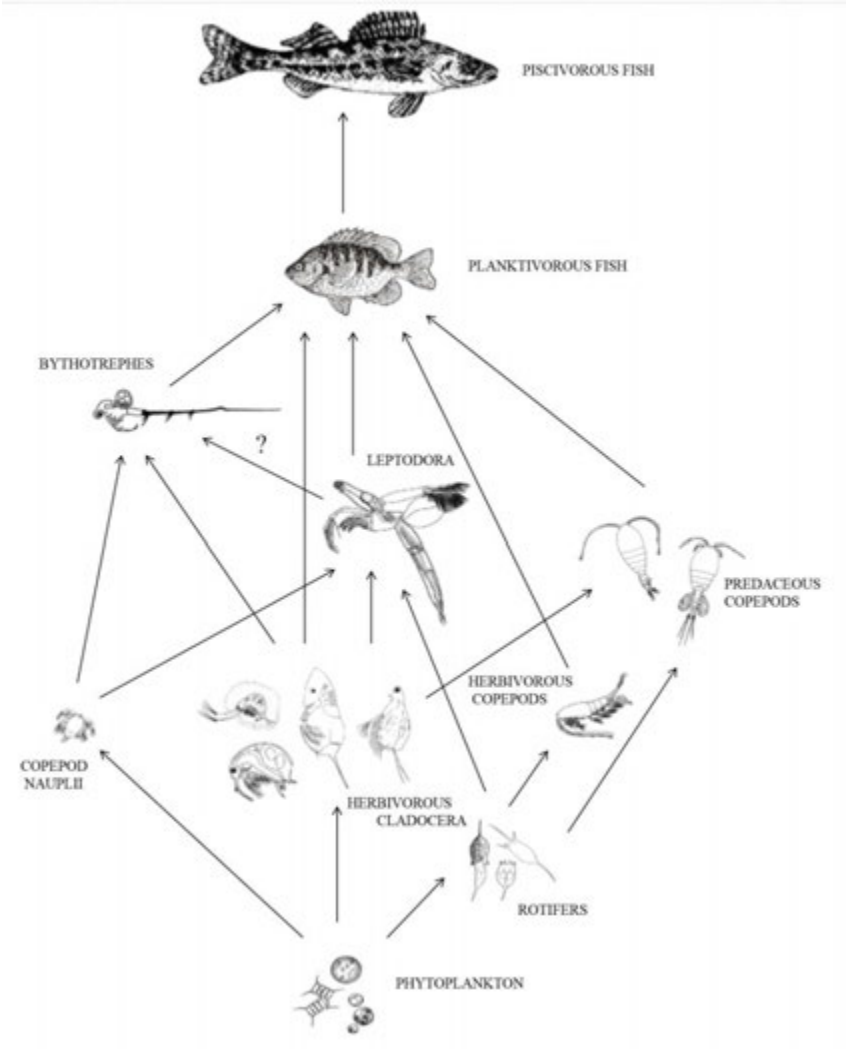


- Heavy predation by young fish lead to two adaptations:
- Spine as defense mechanism (Barnhisel 1991)
- Resting eggs pass through GI tract of most species undamaged and settle quickly

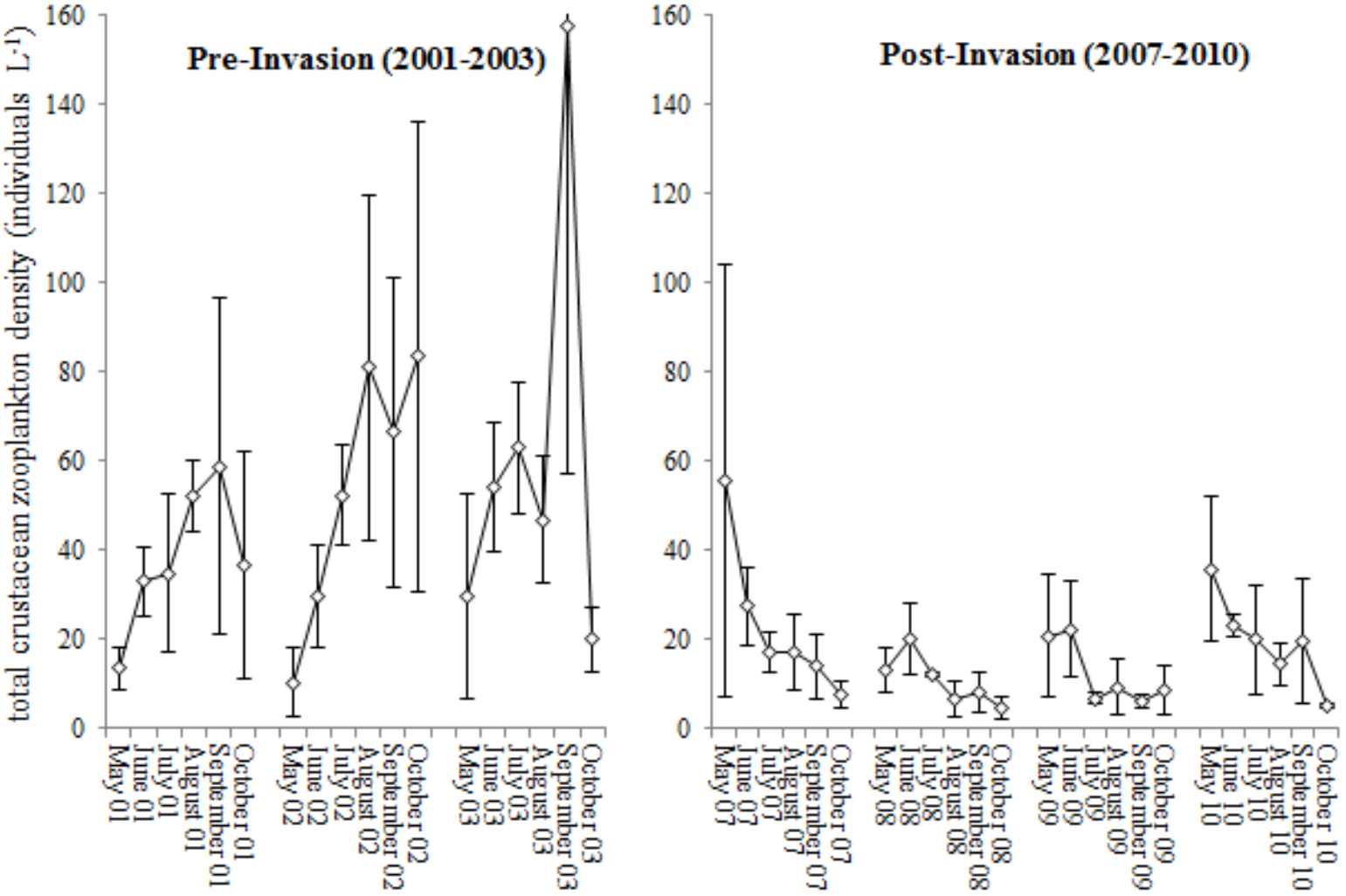


Jarnigan et al. 2004

Food Webs: Direct & Indirect Effects



Voyageurs: Seasonal Change In Zooplankton Density (Before & After *Bytho*)



Predation Impacts of *Bythotrephes*

- Smaller zooplankton vulnerable, predation can lead to shifts in the community composition, e.g. reduction in cladoceran species (Yan and Pawson 1997; Yan et al. 2002)
- Cladoceran *Holopedium* favored (protected within gelatin capsule)

Diaphanasoma birgei

Photo: unh. edu

Bosmina liederi

Photo: unh.edu

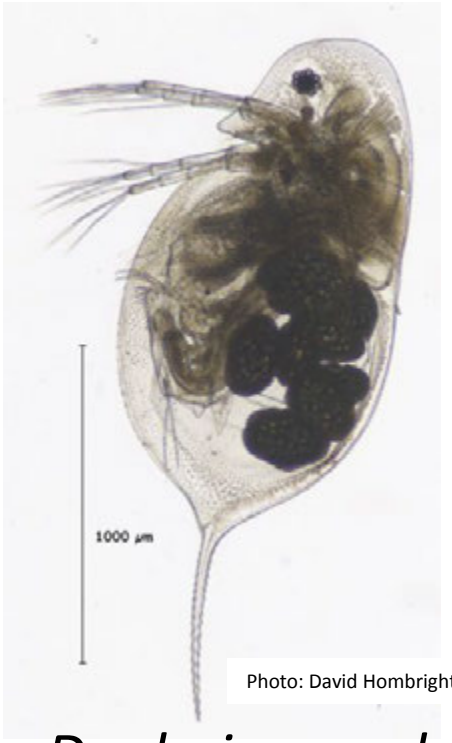
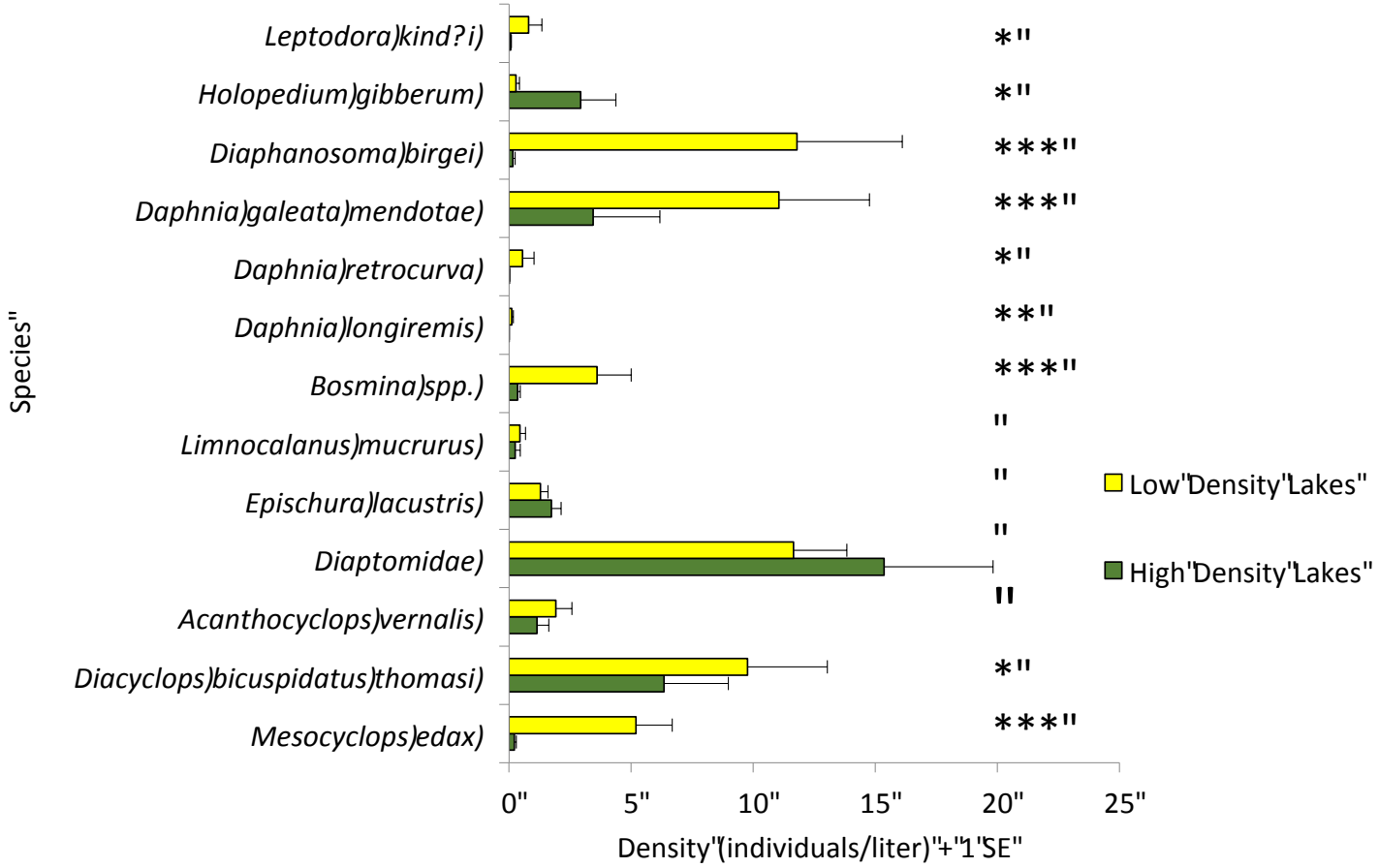


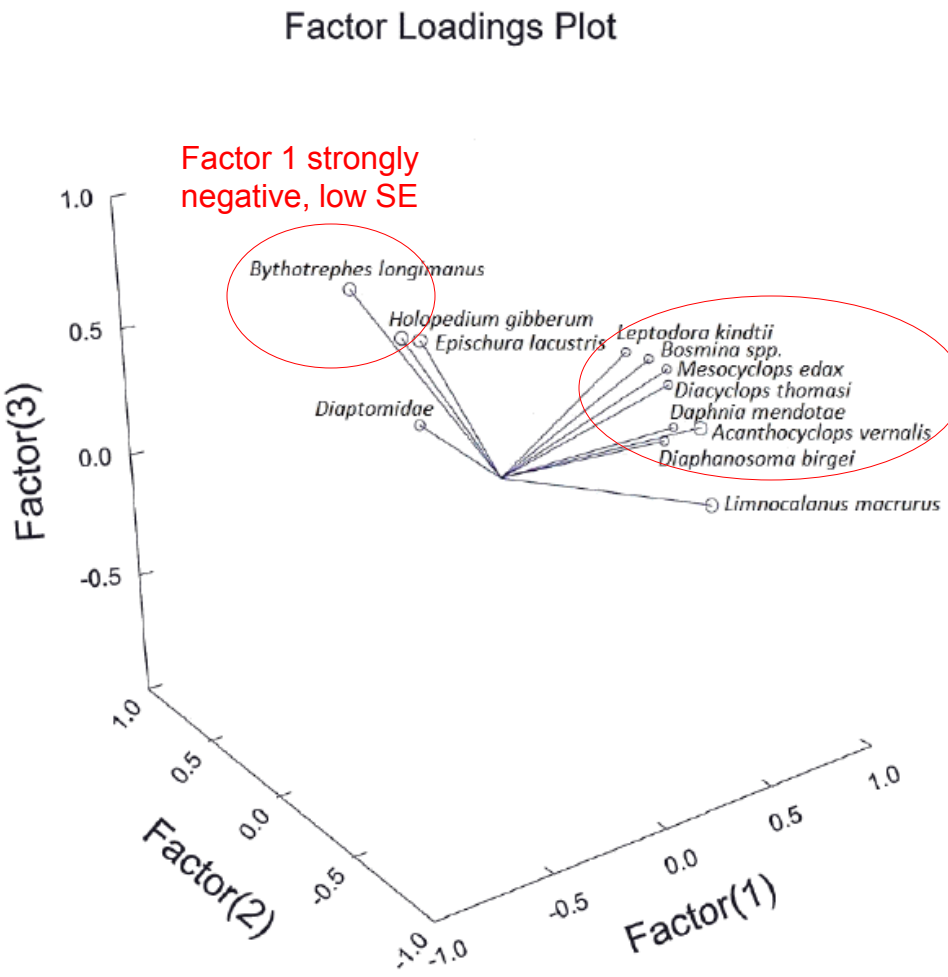
Photo: David Hombright

Daphnia mendotae

Zooplankton Community Shifts



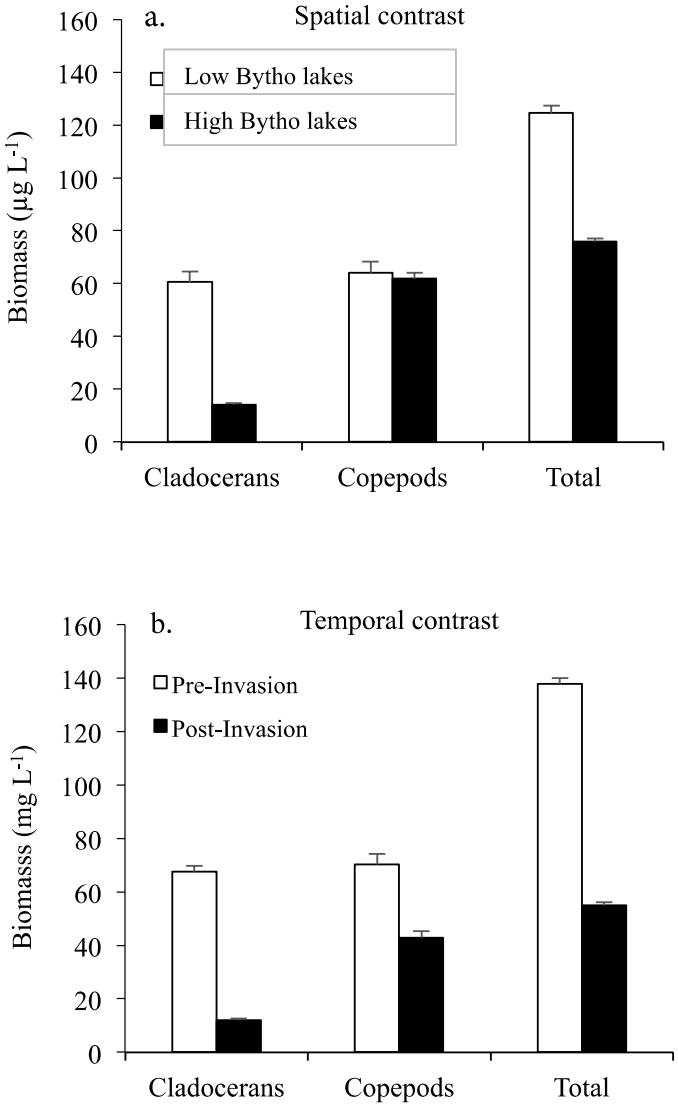
Principle Component Analysis (PCA) of Late Season Spatial Contrast Data



Factor(1) = 42.9 %
Factor(2) = 14.7 %
Factor(3) = 13.6 %
of total variation

Kerfoot Figure 11

Biomass Impacts



Conclusions

- 1*) Bytho*trephes is dispersing rapidly across the landscape; aided by recreational fishing (spines tangled on lines, seines; viable resting eggs in baitfish guts, bait buckets); spreading along temperature -related latitudinal band; primarily limited by temperature & fish predation

- 2) Spatial & temporal measures of food-web impacts in a large, multi-lake complex (Voyageurs) show severe summer depression of cladocerans and cyclopoid copepods (40-60% reduction in total biomass, 68% reduction in secondary production).

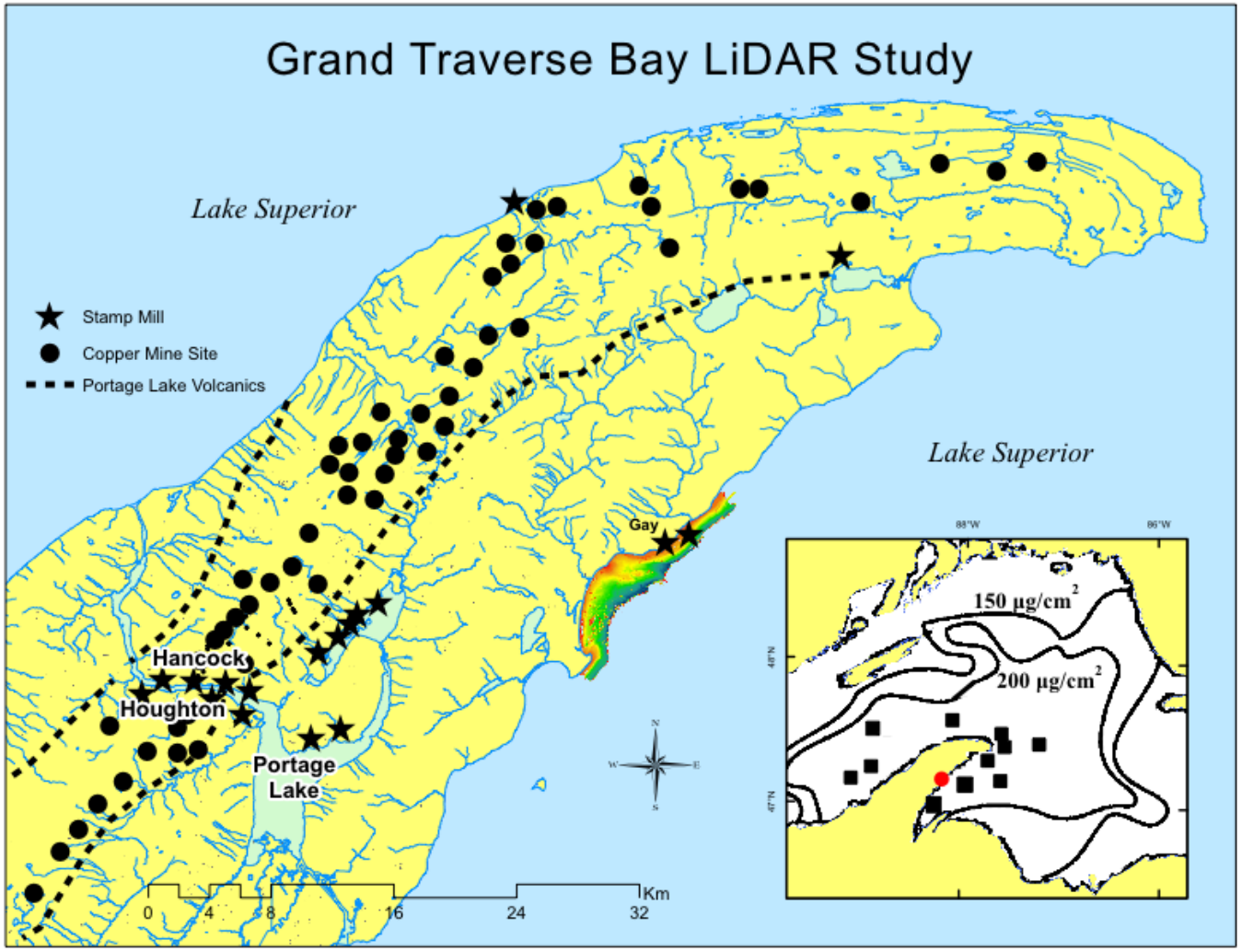
- 3) Major foodweb impacts are common-place across inland lakes and in the Great Lakes. Similar impacts are not evident in Scandanavian and lower European sites, where biodiversity is maintained. We provide evidence that native species in North America cannot sense presence of this invertebrate predator (blind-sided); prey do not deploy usual defenses (increased spines, body size; vertical migration), effecting the evolutionary fabric of communities.

Gay Stamp Sand Project: Encroachment Along Coastal Margin & Onto Buffalo Reef

- W. Charles Kerfoot, Sarah Green,
- Robert Regis, Michgan Tech, Houghton
- Joe Gallani, Earl Hayter, Molly Reif
- USACE-ERDC-EL, Vicksburg, MS
- Bob Shuchman, Colin Brooks
- Michigan Tech Research Institute, Ann Arbor

- Funding: USACE, EPA GLRI

Copper Mining On The Keweenaw Peninsula



Creation Of Stamp Sands

- Mohawk & Wolverine Mills
- 4-5 Steam-driven Norberg Stamps; Chilean Mills
- Pump House (Tobacco River)
- Michigan Smelter

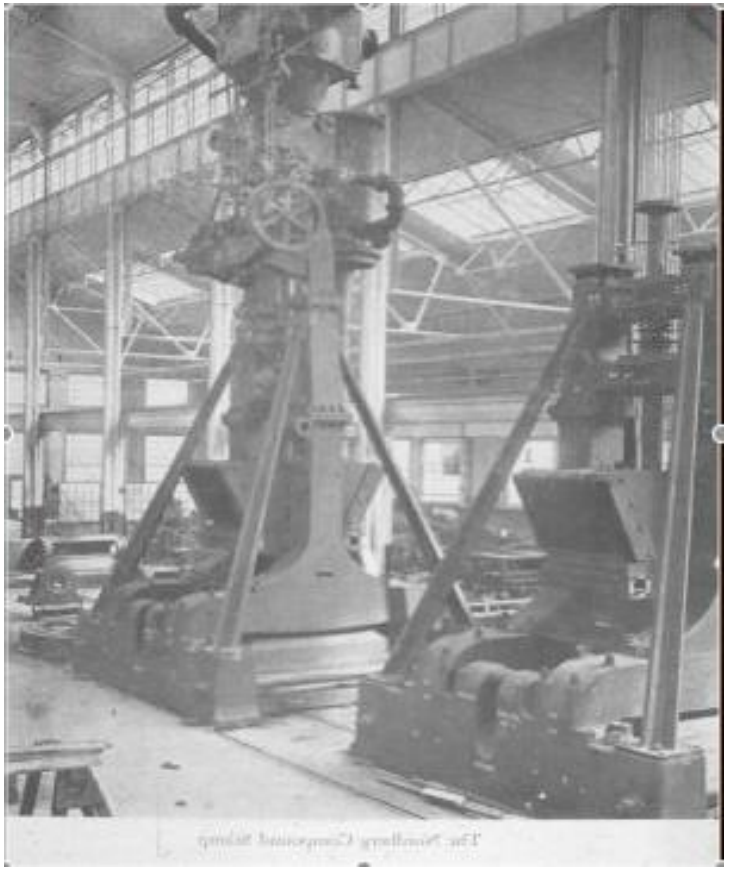
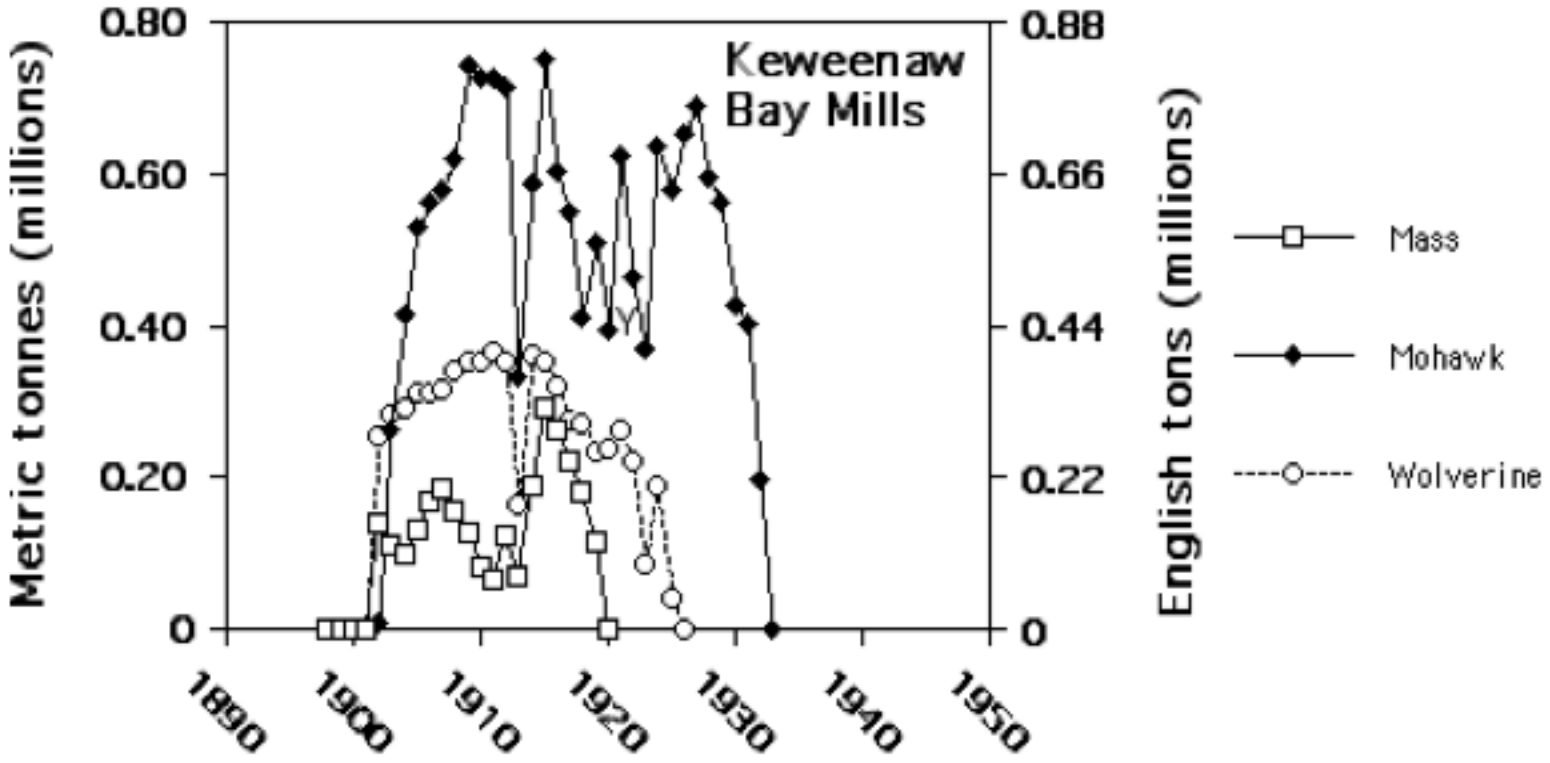


Fig. 5b. Primary and secondary sluiceways (Wolverine Mill, winter 1922?) carry stamp sands over the Gay pile. Lake Superior is on the horizon. Notice melted regions with fresh discharges.

Stamp Sands Discharged Into Keweenaw Bay (Mass 3.0Mt; Mohawk 16.2Mt; Wolverine 6.5Mt)



Buffalo Reef Outline Superimposed On Grand Traverse Bay

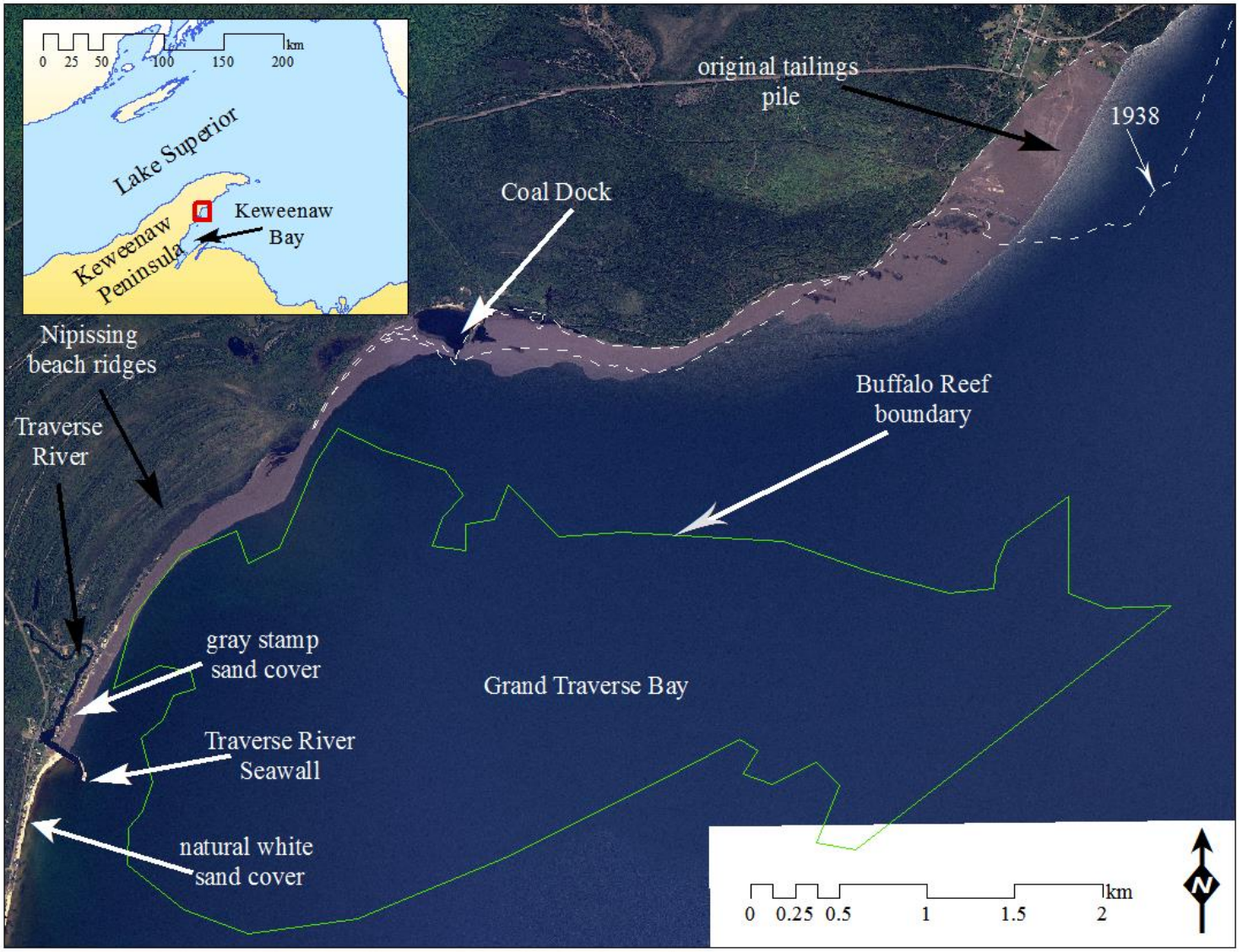
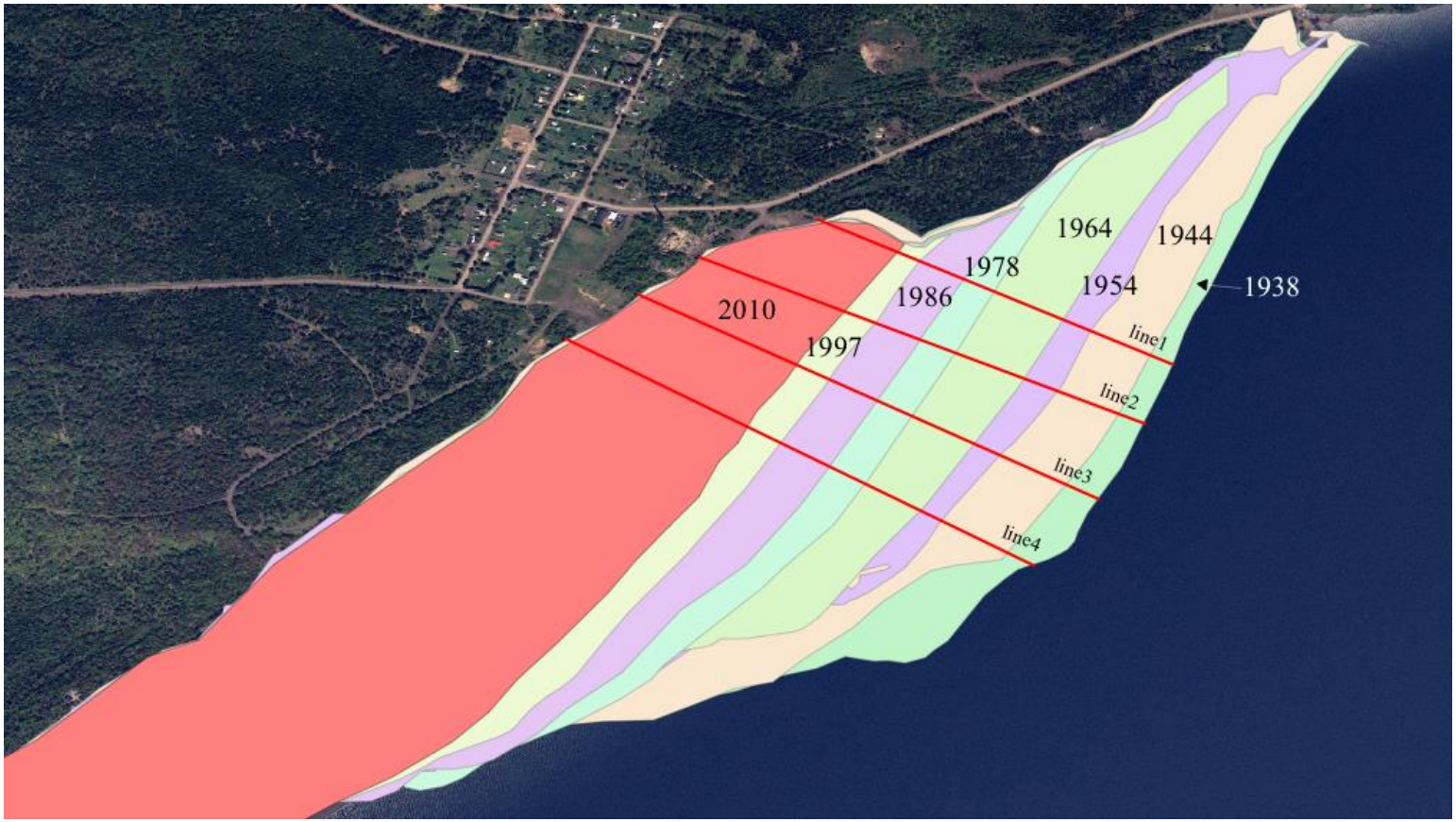


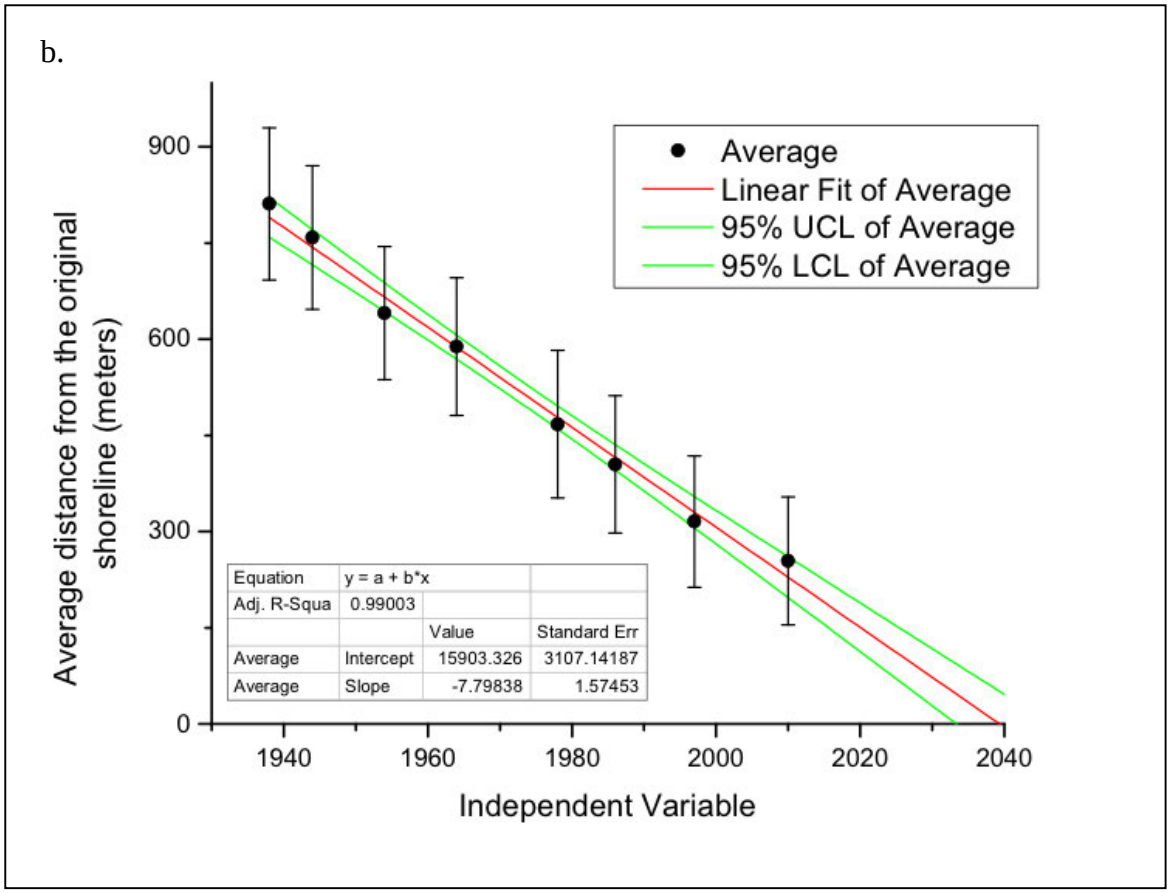
Figure 5a. Wave erosion of the Gay tailings pile. The near-vertical 7 m bluffs contain well-preserved remnants of wooden troughs that sluiced stamp sands across the pile.

Shoreline Erosion (Transects)



Shoreline Erosion (Recession)

- 1) Shoreline erosion is nearly linear
- 2) Mean intercept is around 2040

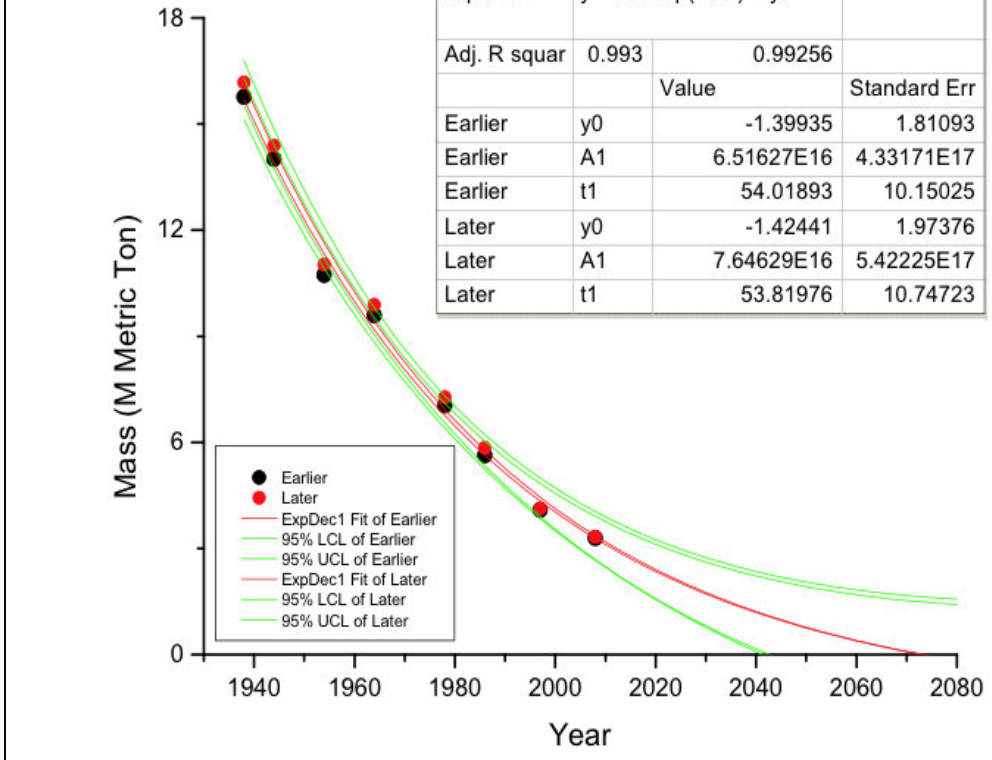


Decrease In Tailings Mass At Gay Pile

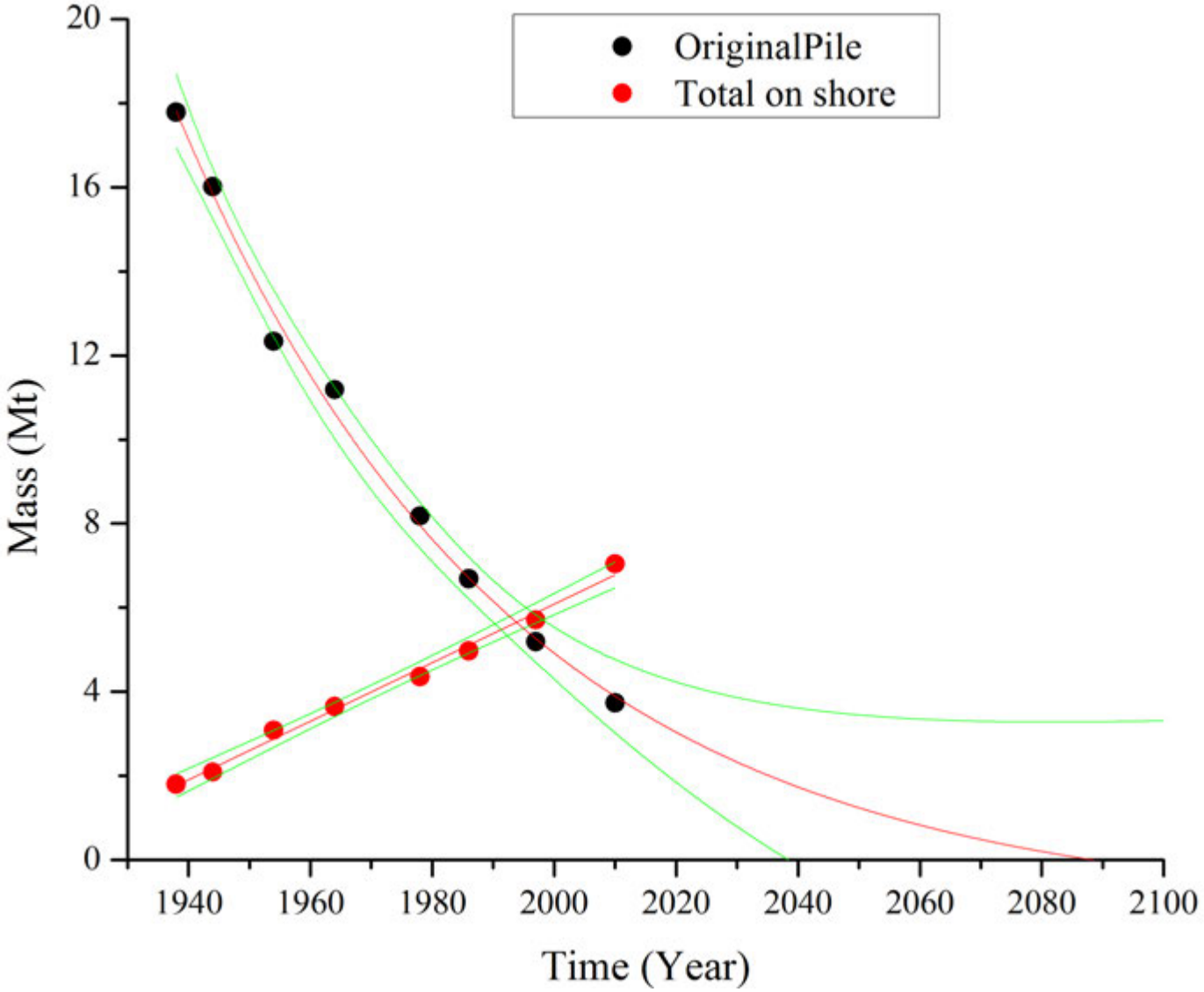
- Exponential decrease
- in mass through time
- Rate of loss declines with time
- Intercept X-axis (0) at 2073

a.

Equation	y = A1*exp(-x/t1) + y0		
Adj. R squar	0.993	0.99256	
		Value	Standard Err
Earlier	y0	-1.39935	1.81093
Earlier	A1	6.51627E16	4.33171E17
Earlier	t1	54.01893	10.15025
Later	y0	-1.42441	1.97376
Later	A1	7.64629E16	5.42225E17
Later	t1	53.81976	10.74723

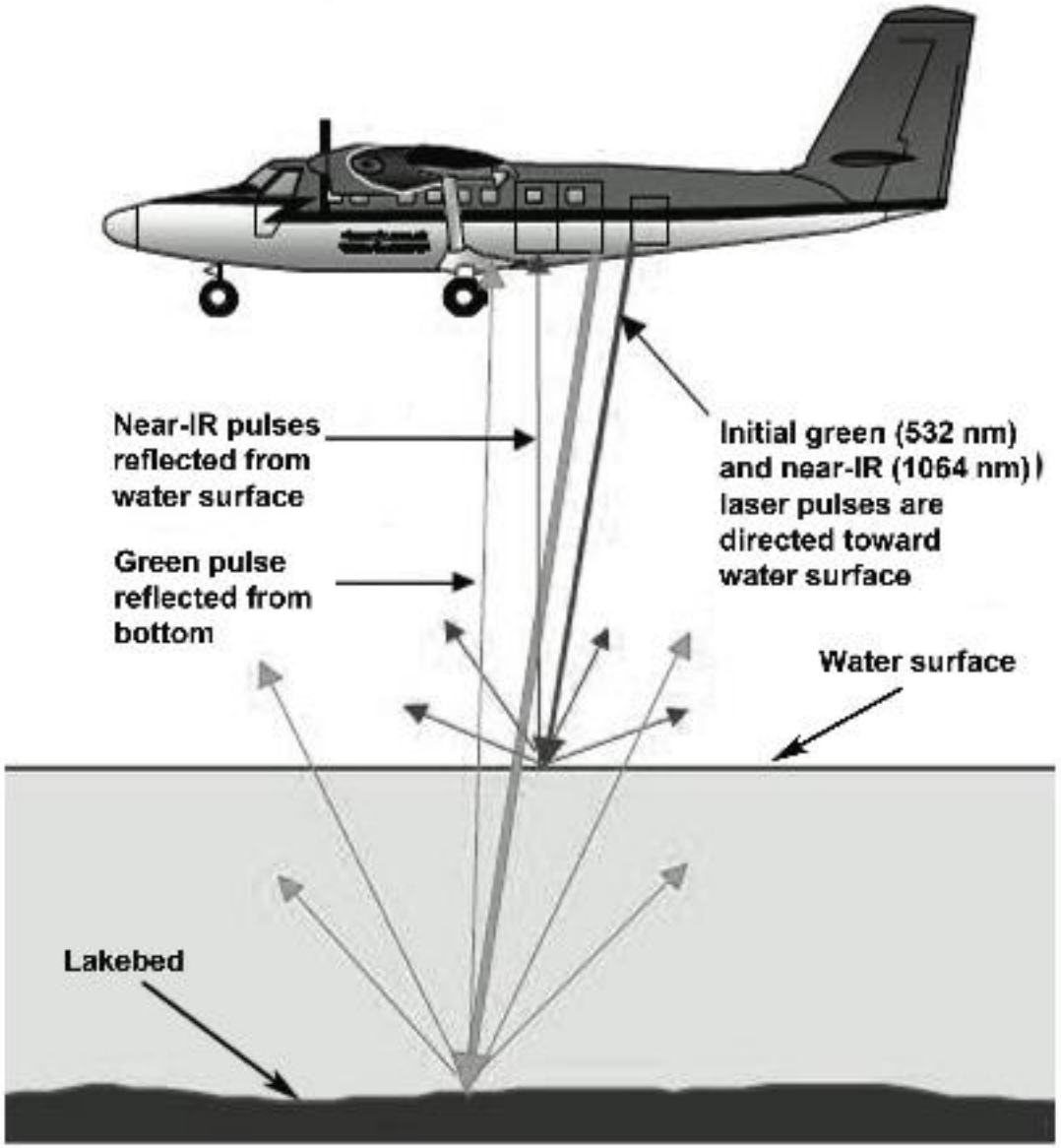


Mass Eroded From Pile & Deposited On Beach

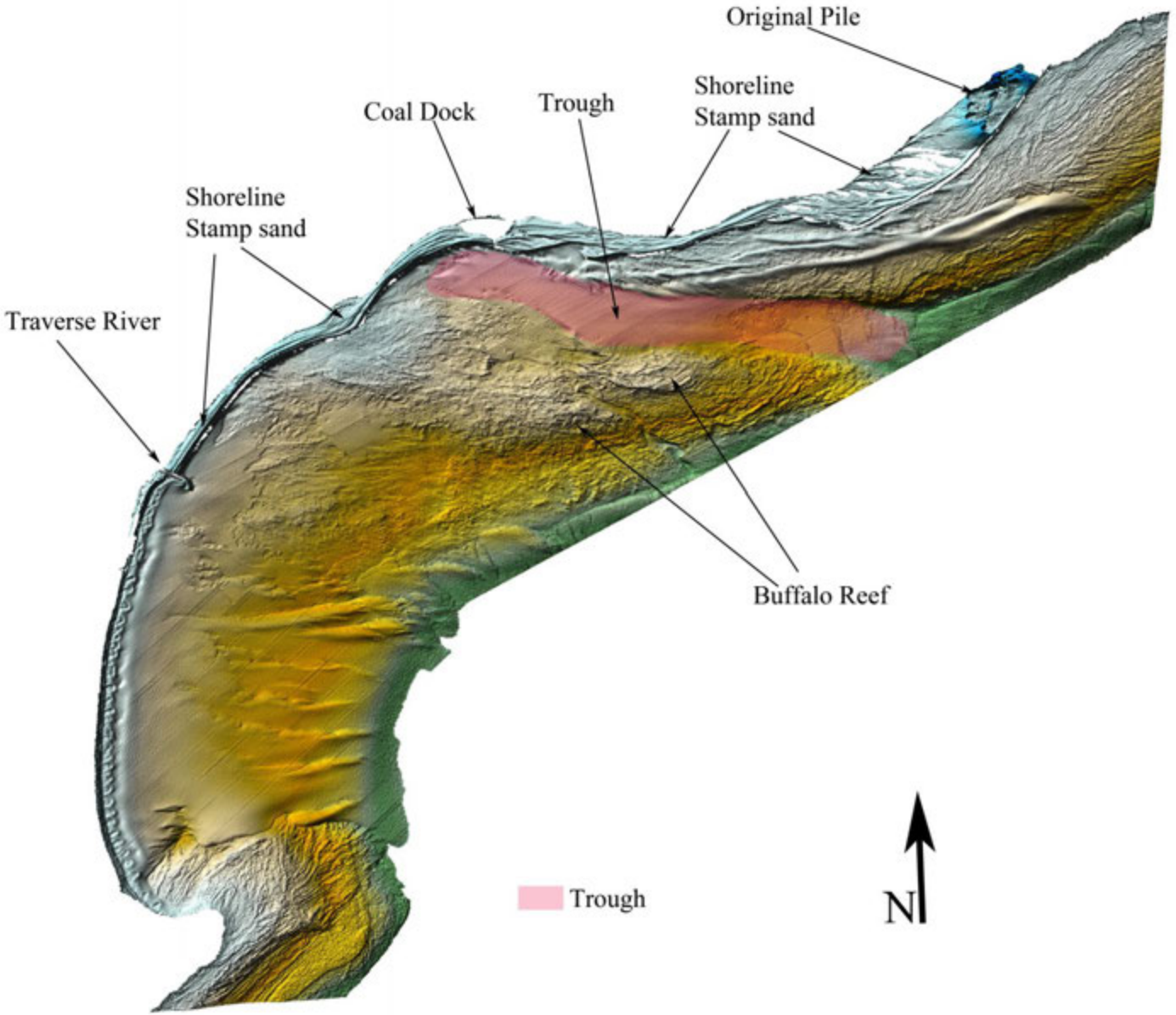


SS Overtopping: Traverse River

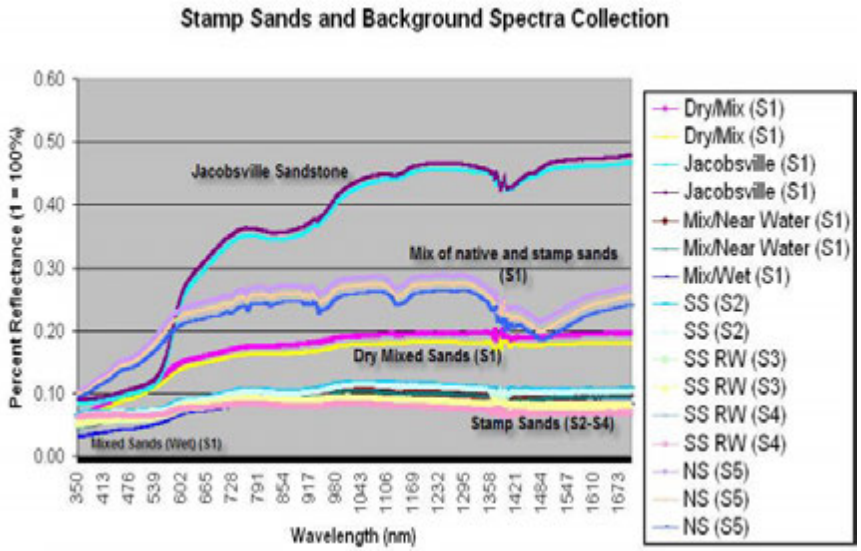
Principle of LiDAR Surveying

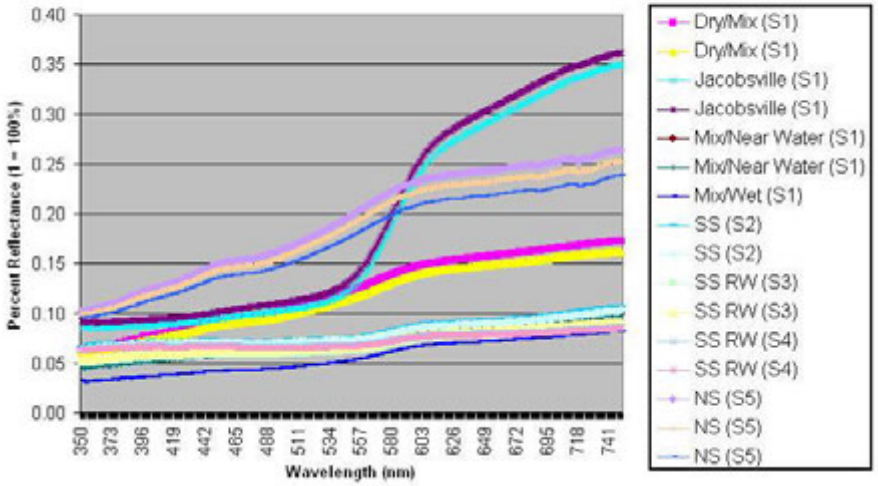


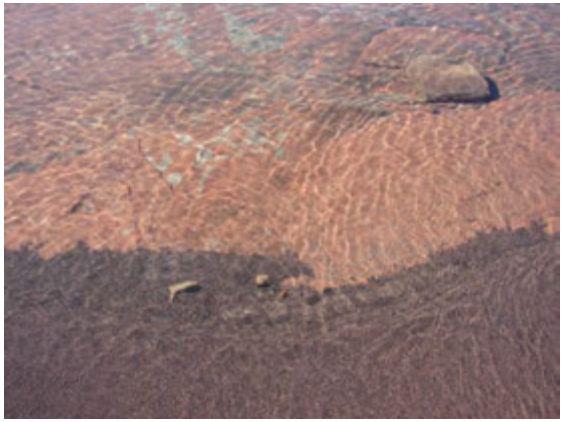
NOAA LiDAR 2010



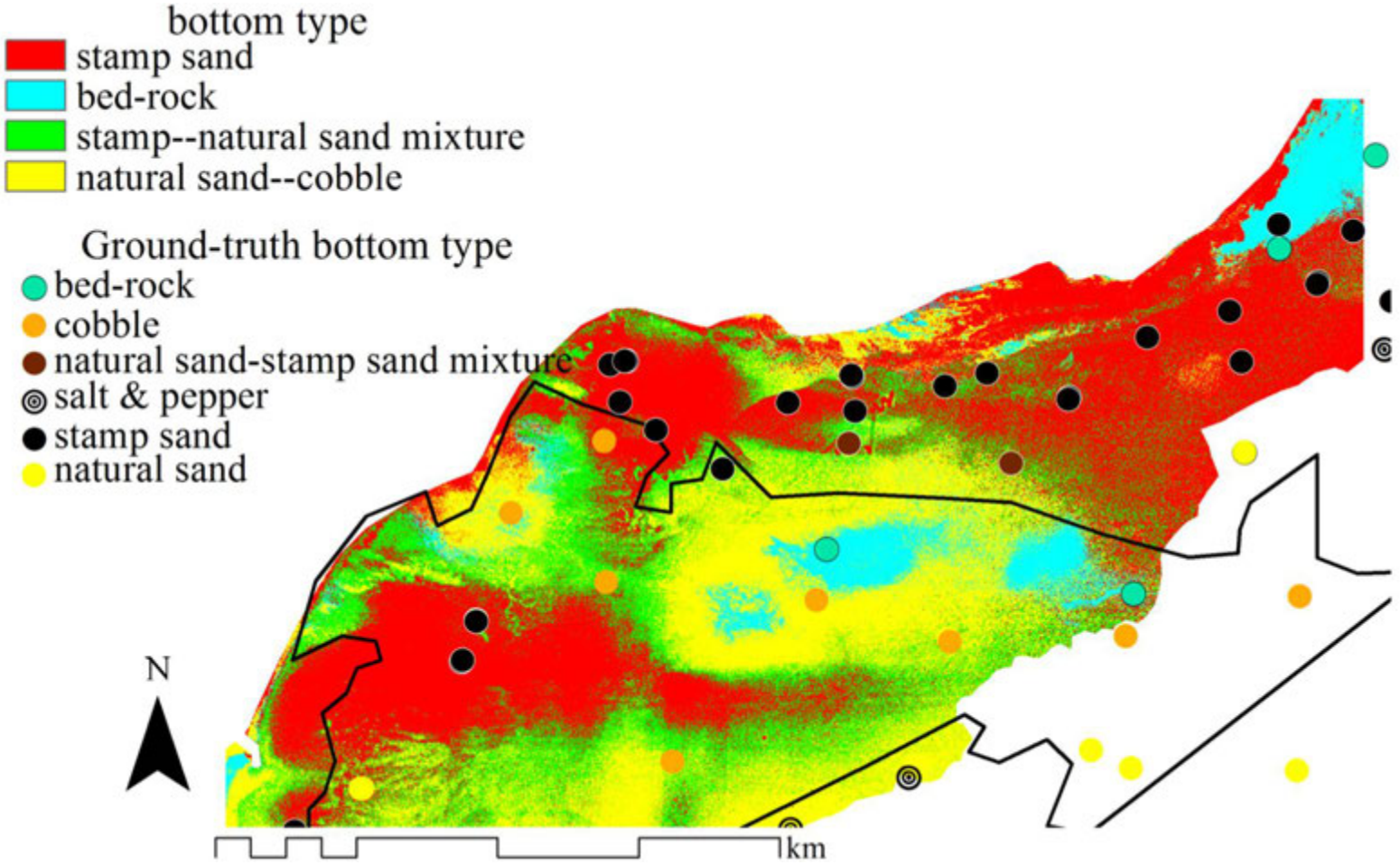
Spectral Signatures of Stamp Sands







Buffalo Reef Outline Superimposed Upon MSS Substrate Map (16% encroachment)



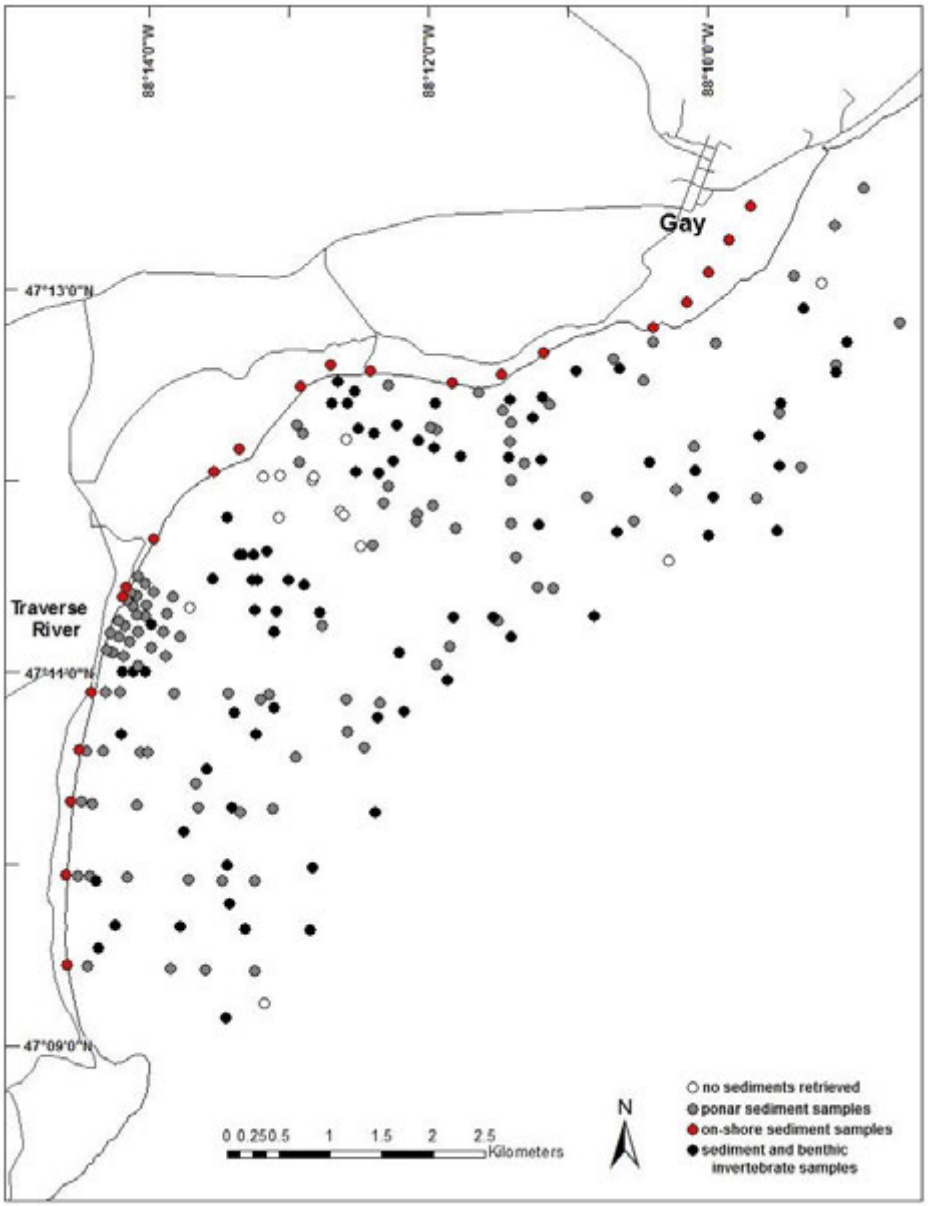
Buffalo Reef Cobble/Boulder Field

Hi-Res Side-scan Sonar (R/V Storm): Stamp Sands Moving Into Boulder Field

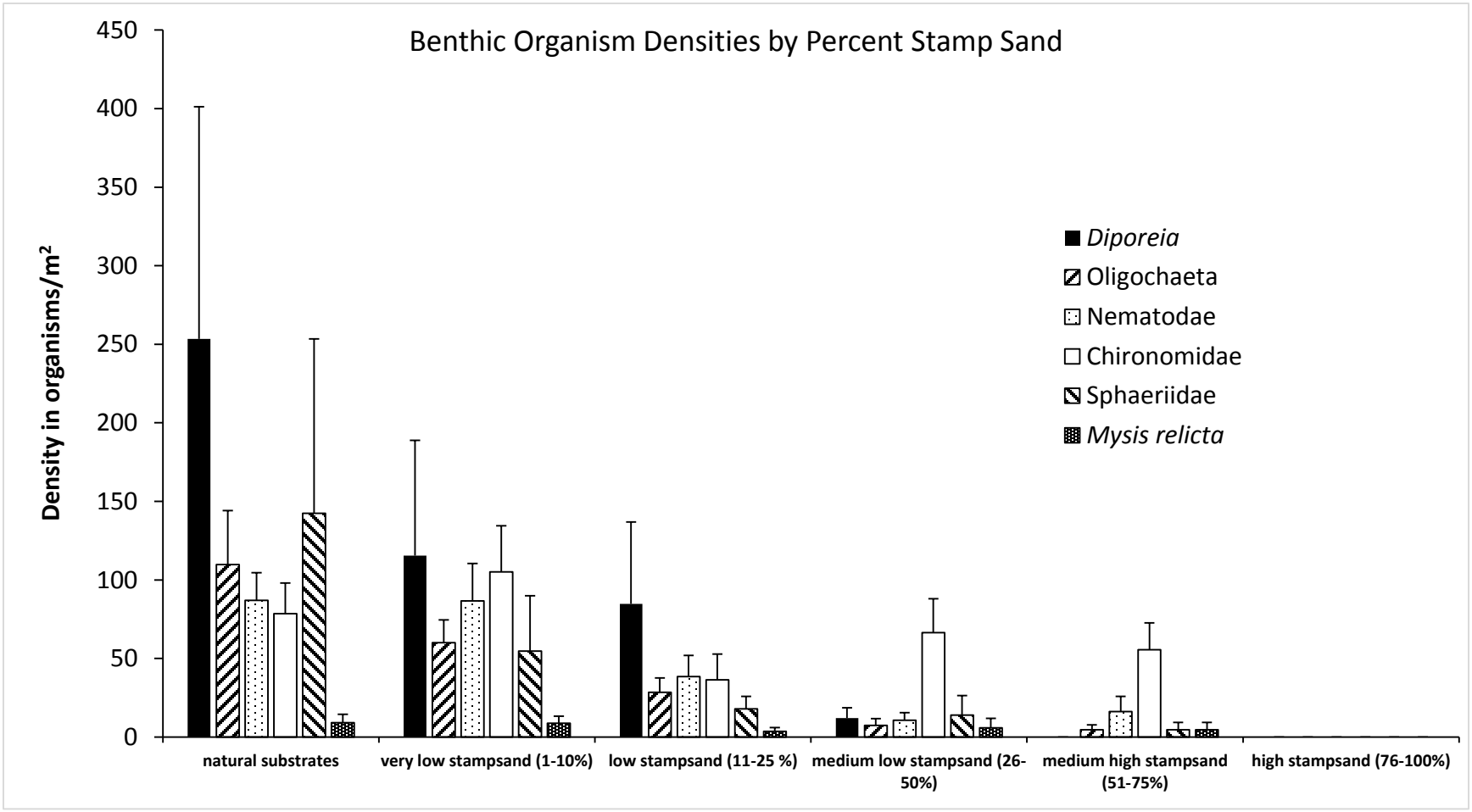
Stamp Sand Encroachment

Stamp Sand Encroachment

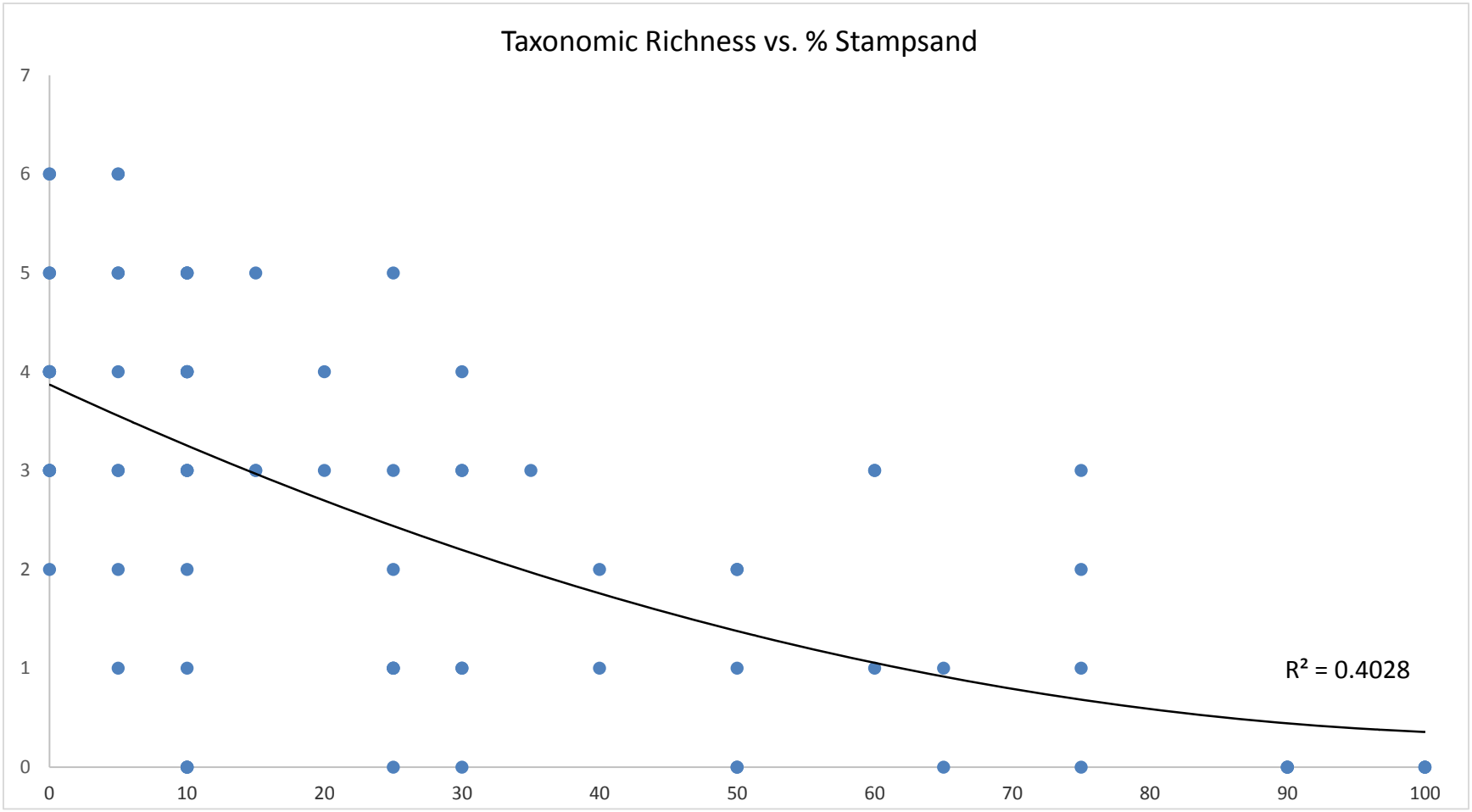
Sediment Sampling Stations (Vicksburg, MTU)



Stamp Sand Effect On Benthic Organisms



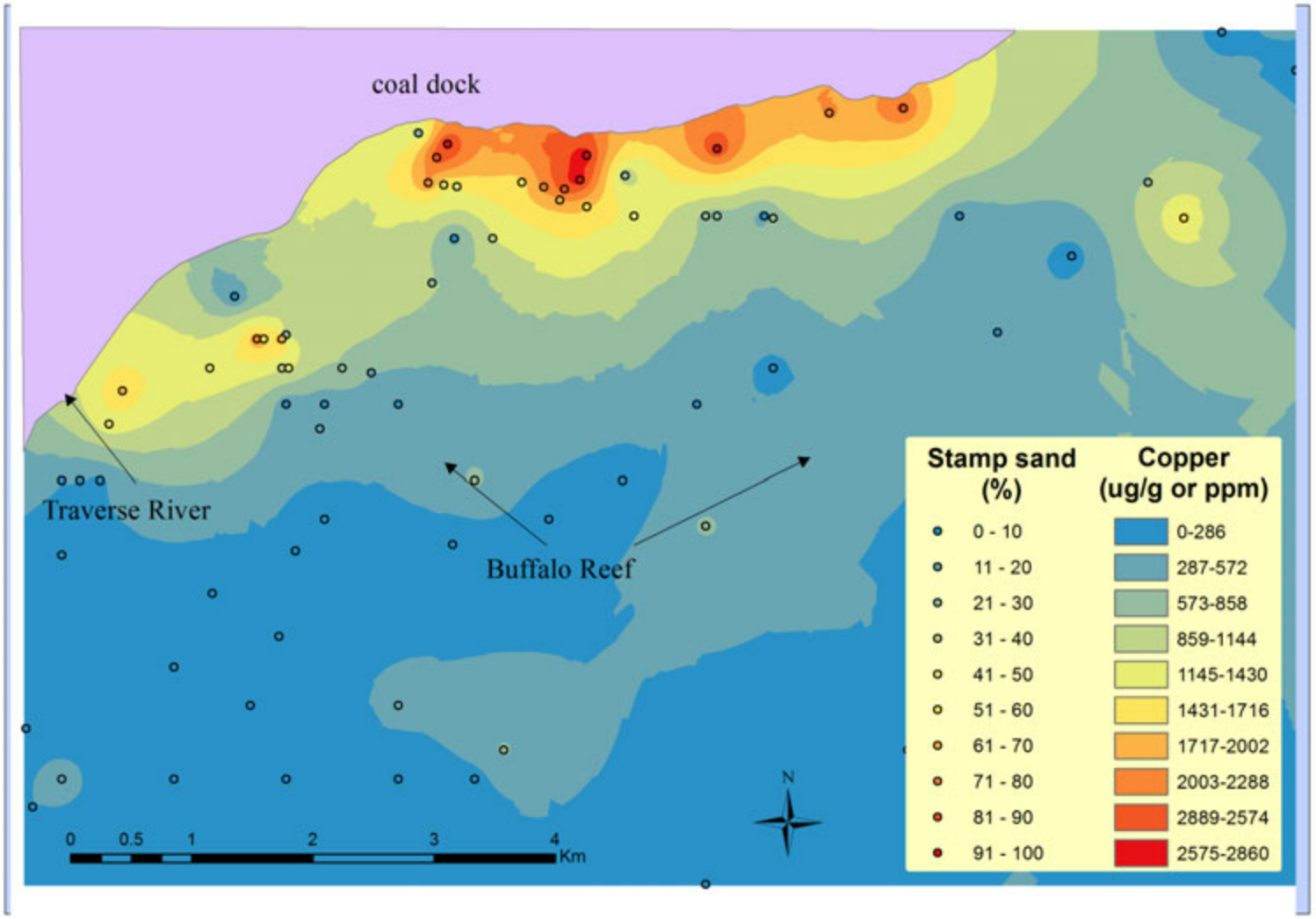
Benthic Species Richness Versus Stamp Sand %



Copper Concentrations (ug/g; ppm)

Site	N	Range	Mean	Source
Gay Pile	7	1,650-5,486	2,697	Kerfoot et al. 2002
Gay Pile	274	1,500-13,000	2,863	MDEQ 2006
Offshore Gay	5	1,400-4,400	3,020	MDEQ 2006
Redeposited SS	24	710-5,300	1,443	MDEQ 2006
Along SS Beach	6	1,500-8,500	2,967	MDEQ 2008

Conversion from % Stamp Sand To Copper Concentrations



Summary

1) In Grand (Big) Traverse Bay, Gay mine waste discharges into the coastal zone initiated a perturbation that has played out for over a century.

2) Stamp sands contain relatively high concentrations of copper and a secondary suite of elements that has detrimental environmental effects. LiDAR/MSS techniques and aerial photo images helped estimate the progressive environmental effects of migrating sands.

3) The Gay tailings pile shows exponential decay (erosion) through time, down to ca. 3.7 Mt; waves and currents have spread ca. 7 Mt of SS along coastal beaches (covering 1.6-2.3 km^2), and ca. 10 Mt into the bay (5.1 km^2). Underwater stamp sand bars are filling an ancient riverbed ("trough"). Upper reaches are full and spill-over is occurring onto Buffalo Reef breeding grounds.

4) Underwater video and high-resolution side-scan sonar verified encroachment of Cu-rich stamp sands into boulder fields. Benthic sampling suggested severe impacts on invertebrate communities and fish distribution.

Boulder With Natural Periphyton (Algae, Bacteria)

Proposed Solutions (Detroit ACE 2001)

Figure 5: Location of proposed groin, revetment and dredging at Gay study site

Dock-side (GLRC) View Of Iver 3 Base 42 (Edge Tech 2205B Side Scan)