Underwater video is an effective tool to reveal *Dreissena* spatial distribution

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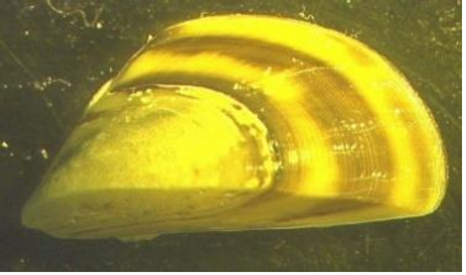
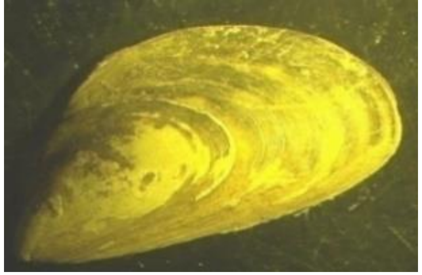


Zebra mussel

Dreissena represent novel ecological type in freshwaters of North America



Quagga mussel

- Both species have high fecundity, planktonic larvae and an attached benthic adult stage, and they are highly efficient filter feeders
- Their life history allowed them to spread rapidly across landscapes, and become **enormously abundant** when introduced into a new waterbody
- Being powerful ecosystem engineers they deeply modify freshwater ecosystems *(Karatayev et al., 1997, 2002, 2007, 2015; Pimentel et al. 2005; Keller et al. 2007; Higgins & Vander Zanden 2010)*

Dreissena ecological impacts depends on:

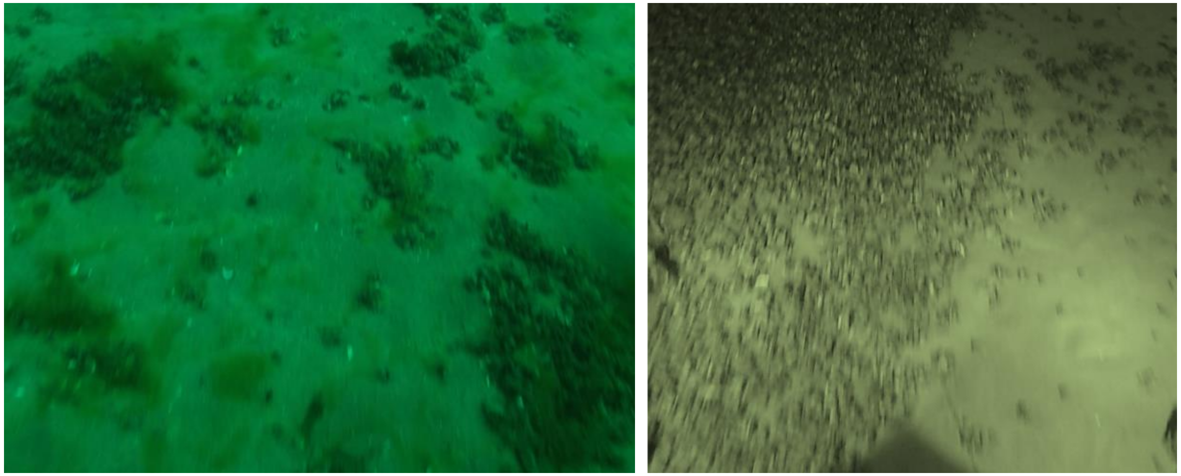
- population size
- population dynamics
- distribution within a waterbody

In order to accurately predict *Dreissena* ecological impacts we need to know:

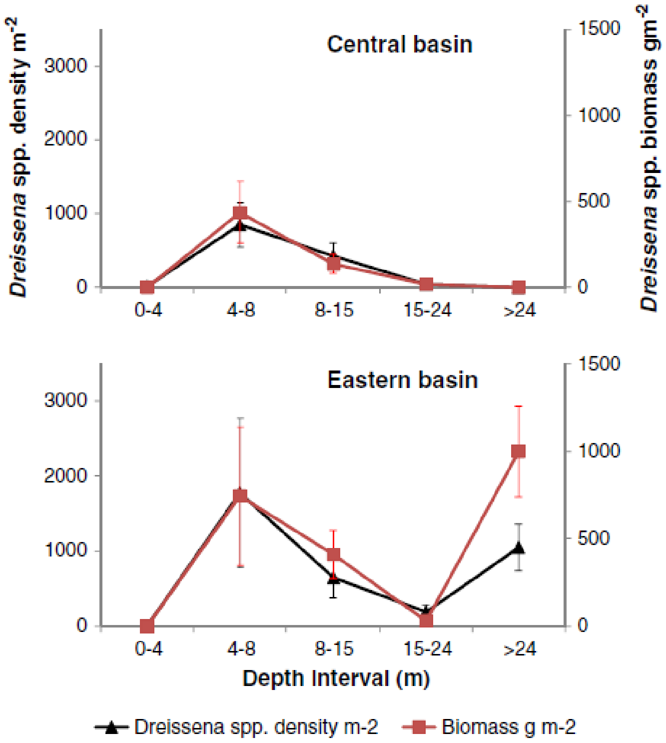
- where they are
- how many of them are there
- are their populations increasing or decreasing

Population size and distribution

- However *Dreissena* distribution **fluctuates widely** at all spatial scales



Local scale patchiness
(up to 3 orders of magnitude)



Lake-wide patchiness
(up to 3 orders of magnitude)

Video *vs.* bottom grabs

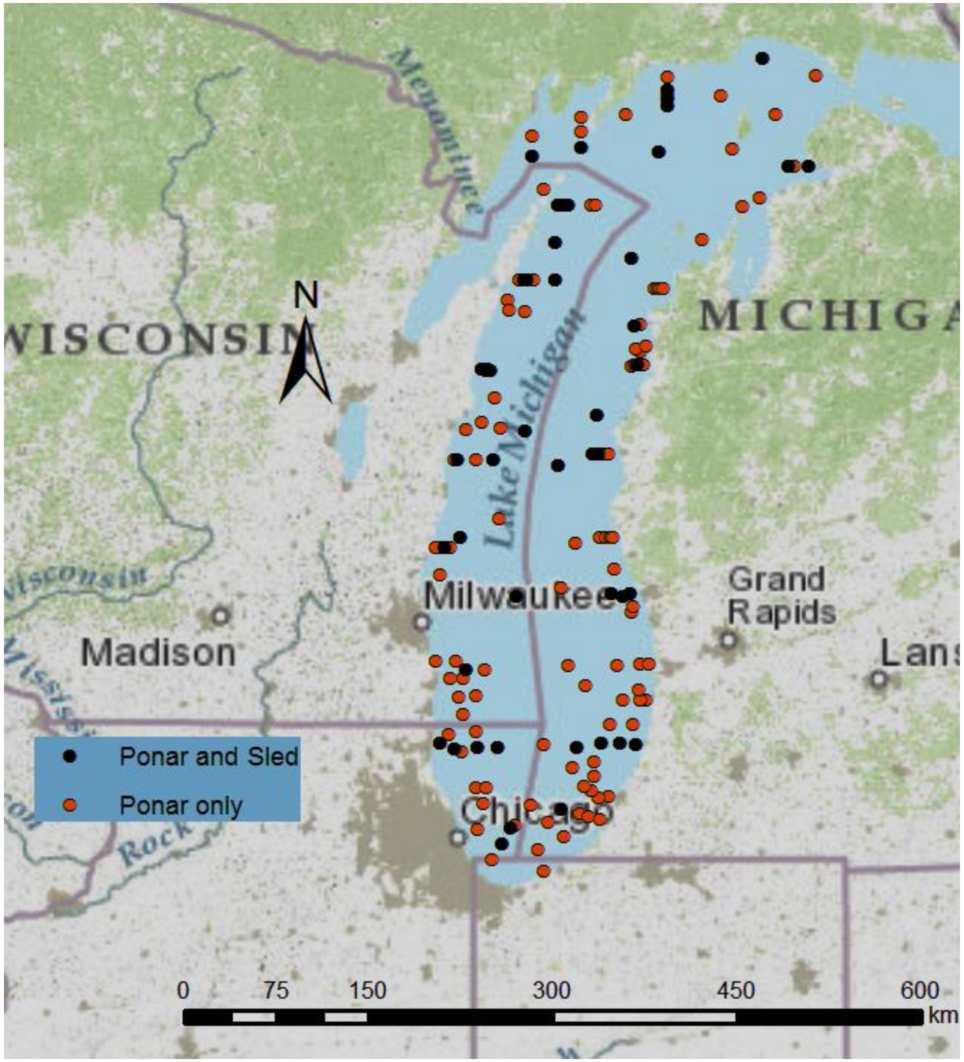
- Almost every historical study of *Dreissena* in the Great Lakes has relied on bottom grabs with a small sampling area and small number of replicates
- The introduction of dreissenids, that create large well visible aggregations on lake bottom, made it possible to imply underwater remote sensing methods, commonly used in marine systems to study benthic sessile organisms

Implementation of remote sensing methods allows to:

- survey much larger bottom areas than traditional bottom grabs or SCUBA
- study distribution patterns of *Dreissena* at various spatial scales
- improve the accuracy of estimation of mussels density

Lake Michigan 2015 CSMI

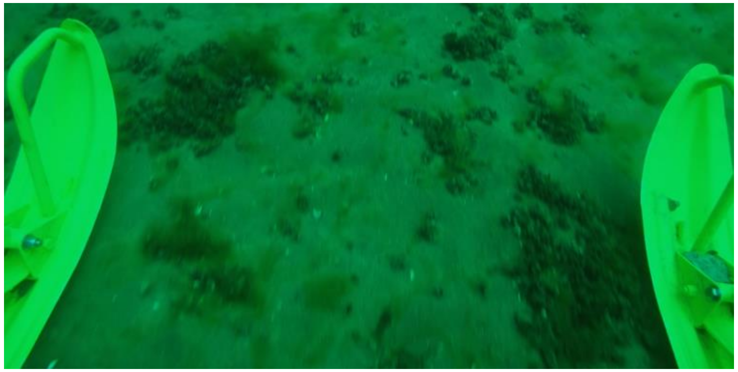
- 143 stations sampled
- 429 Ponar samples
- 616 video images attached to Ponar
- 47 benthic tows with Go pro camera



Lake Michigan 2015: Video image analysis

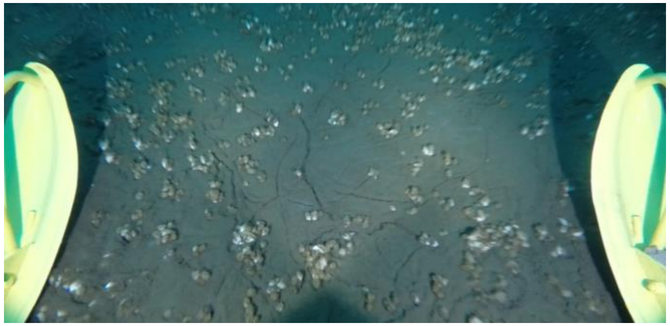
47 video transects were recorded with a Go Pro camera mounted on a benthic sled towed behind the boat for 500 m

- 43 (92%) were used for analyses
- 4% not usable due to high turbidity and algae cover
- 4% not usable due to equipment malfunction

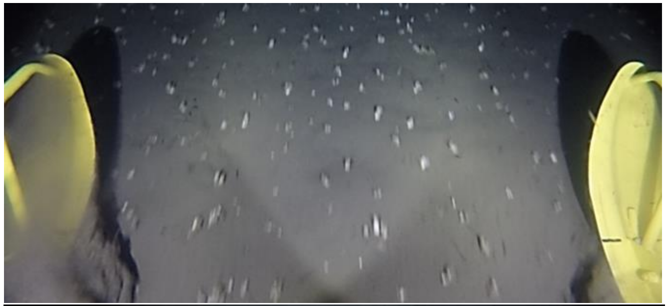


45 m

50 m



54 m



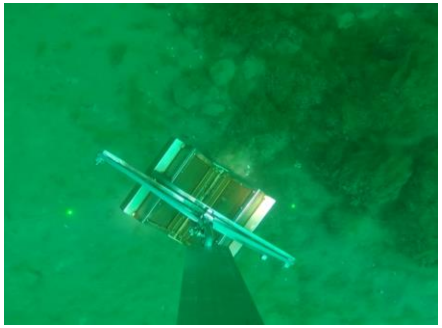
139 m

165 m

Lake Michigan 2015 sampling

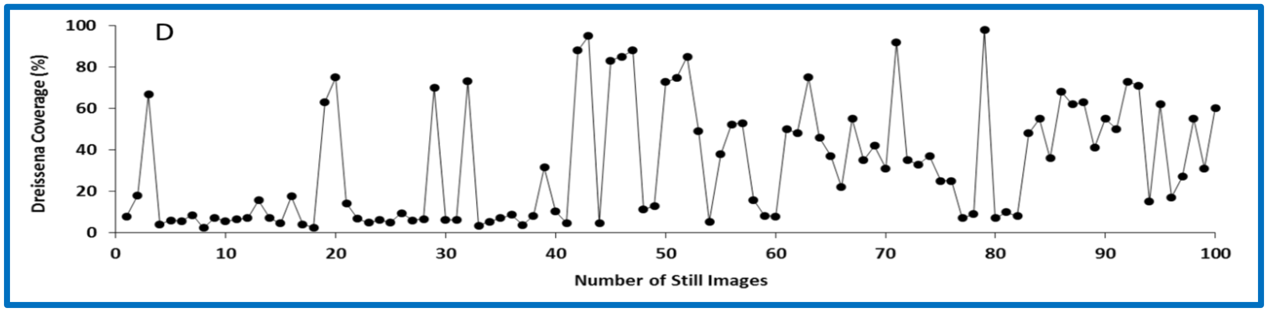
From each of 143 stations:

1. Three Ponars were processed for *Dreissena* density, biomass and size

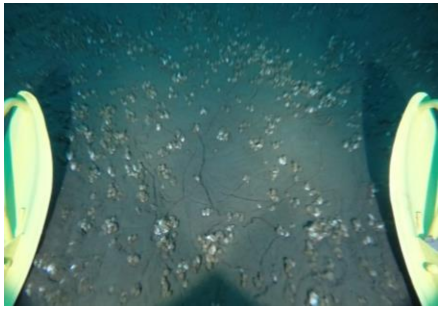


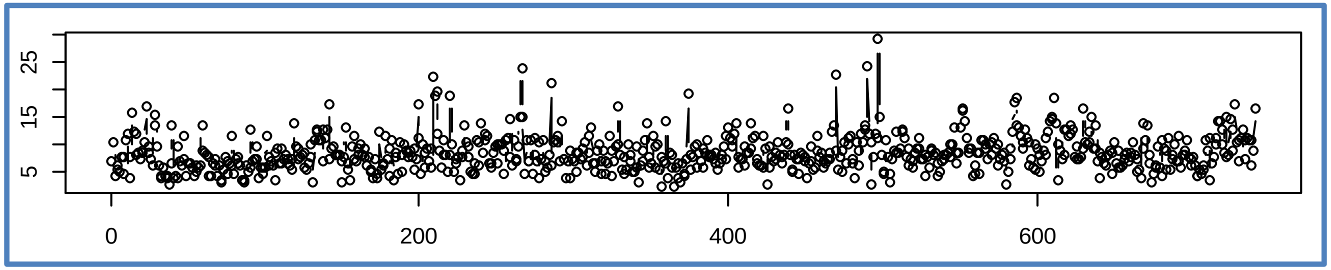
2. *Dreissena* coverage was calculated using Go Pro camera mounted on a Ponar grab

3. At 43 stations coverage was calculated from **100 frames** randomly distributed along 500 m benthic sled transects



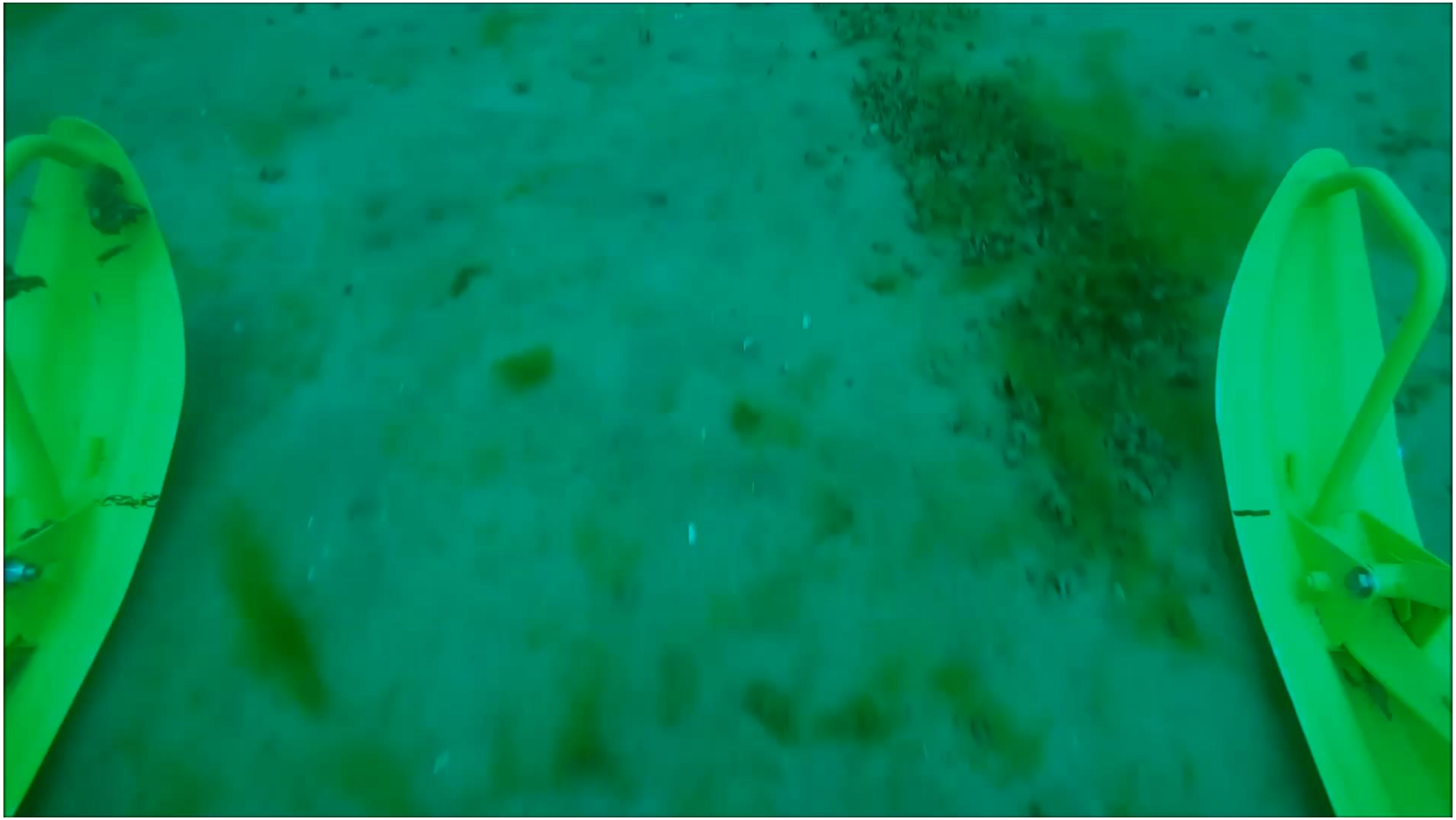
4. At 5 transects *Dreissena* coverage was calculated from the entire transect (**600 – 800 frames**, “true average”)





Video clip (160 m depth no *Dreissena*):

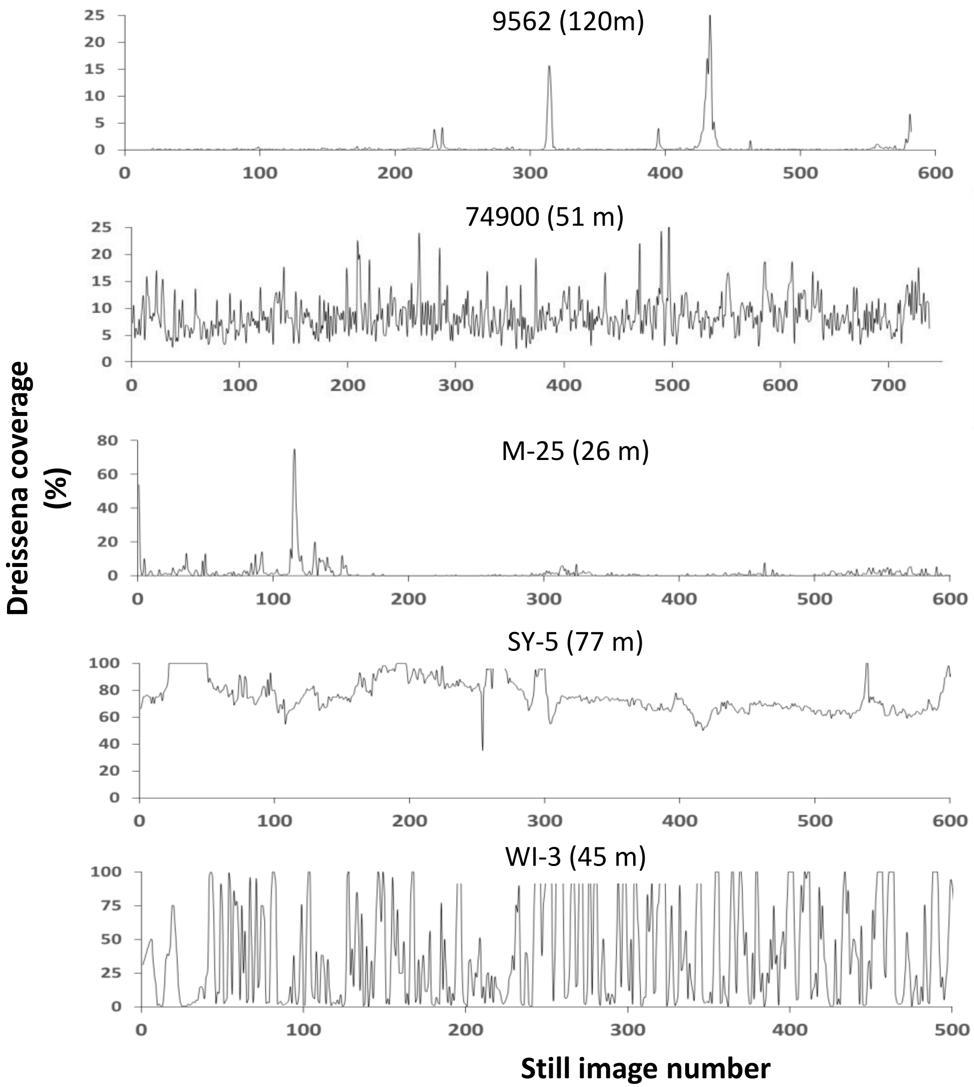
< 30 m zone - highly heterogenic aggregations (22 m):

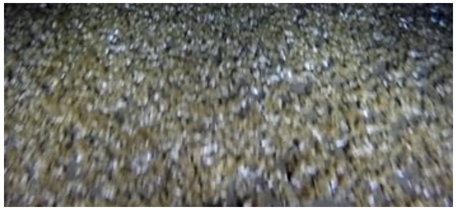


30 – 100 m zone, almost complete coverage (80 m depth):

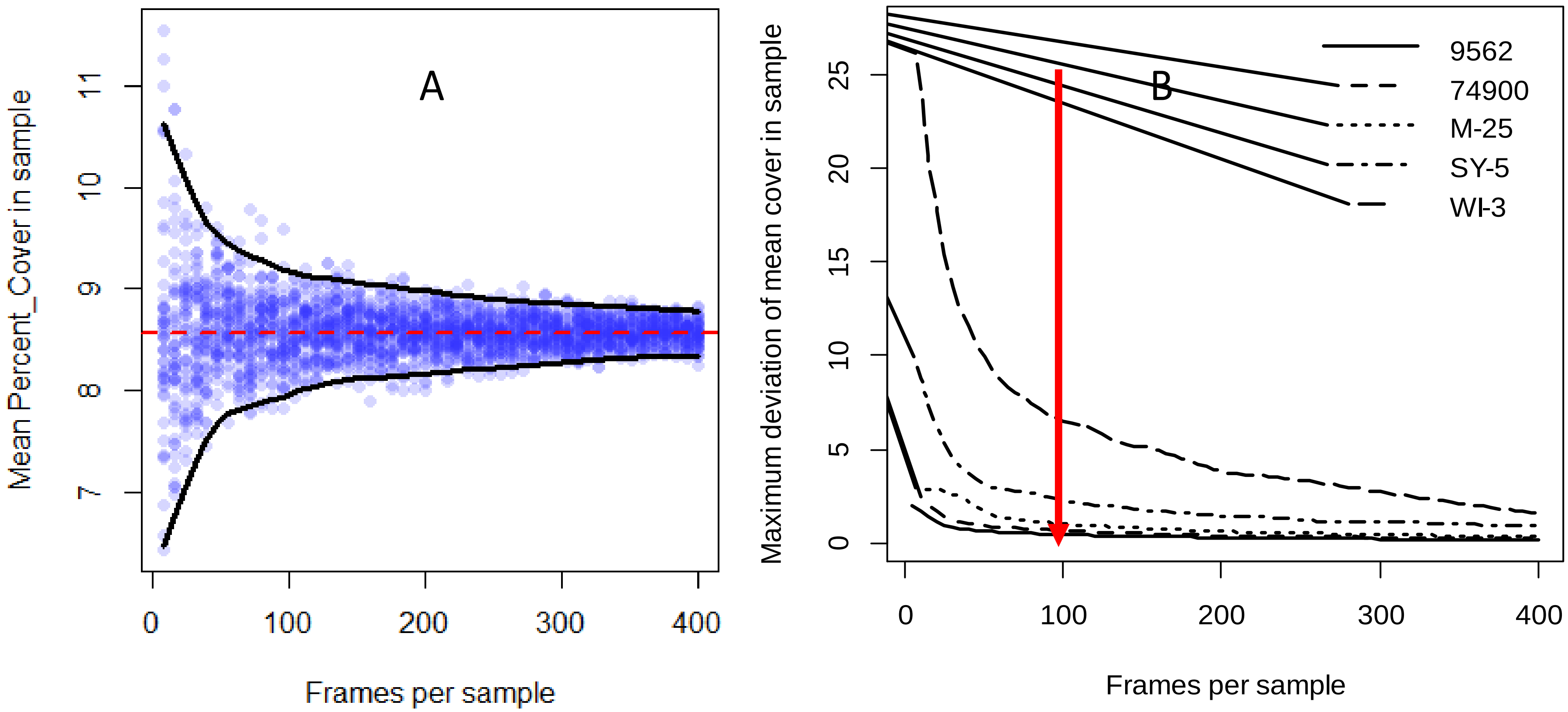
> 100 m zone, small druses evenly distributed (120 m):

The whole *Dreissena* coverage was counted at 5 transects with different degree of coverage (> 3000 non-overlapping still images) to obtain "true transect average"





Relationship between number of still images sampled and estimated *Dreissena* coverage (bootstrapping)



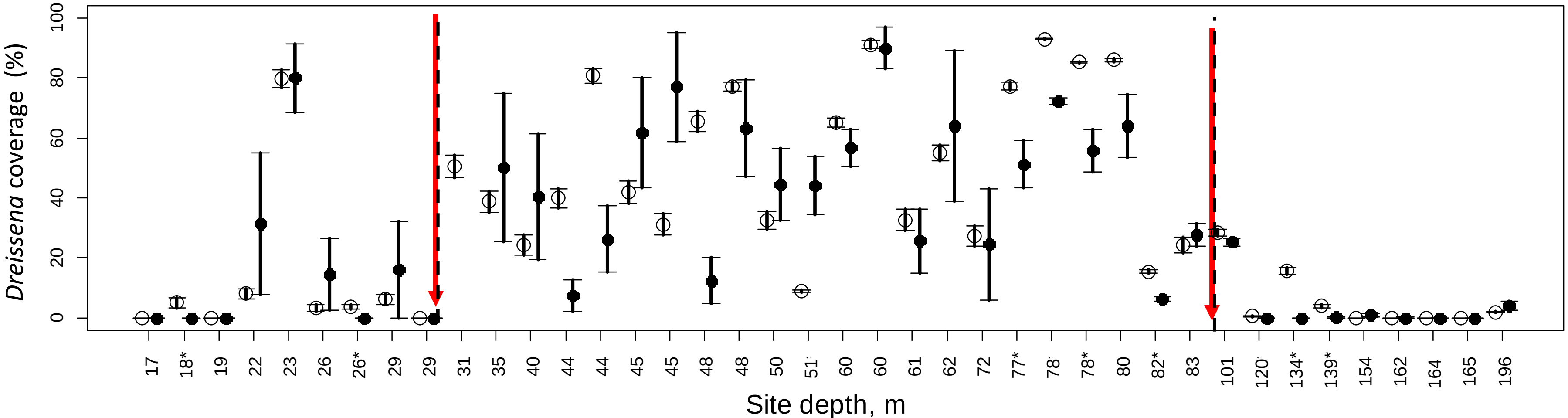
Estimating *Dreissena* coverage (%)

Station number (depth, m)	Benthic sled		Ponar grab, 4 still images
	Entire transect (total number of still images)	100 still images	
74900 (45)	**8.6 (741)**	**8.0 ± 0.3***	44.0 ± 9.7
9562 (123)	**0.6 (582)**	**0.5 ± 0.2**	0
SY-5 (77)	**77.9 (787)**	**76.0 ± 1.1***	51.0 ± 7.8
M-25 (26)	**1.7 (601)**	**2.0 ± 0.7**	37.0 ± 21.0
WI-3 (45)	**38.7(509)**	**31.2 ± 3.6**	12.5 ± 7.3

- Mean coverage estimated from 100 images randomly distributed along a transect was much closer to the “true average” than coverage estimations from Ponar grabs
- There was a significant difference between coverage estimated from transects and Ponar grabs in 2 cases
- Ponar missed *Dreissena* on a low density transect

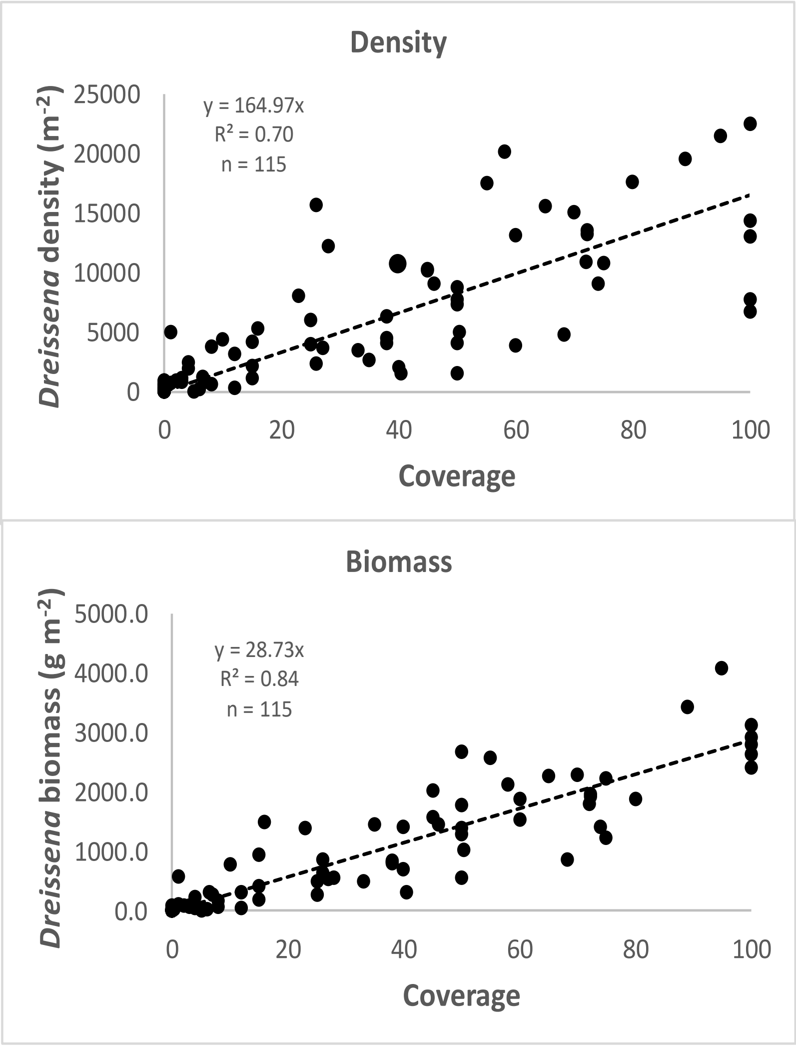
Dreissena cover from video transects (white circles) vs. Ponar (black circles)

*significant difference



- <30m: largest heterogeneity in coverage, likely due to large-scale environmental factors
- 30 – 100m: virtually all bottom is often covered with *Dreissena*
- >100m: *Dreissena* forms very small evenly distributed druses
- Average values from video transects and Ponars did not differ in any of the three depth intervals
- However, when we compared data station by station, for 18% stations bottom coverage differ significantly between video transects and Ponar videos

Converting coverage into density and biomass



Correlation between *Dreissena* bottom coverage in Ponar grabs and density and biomass obtained from same grabs in Lake Michigan in 2015

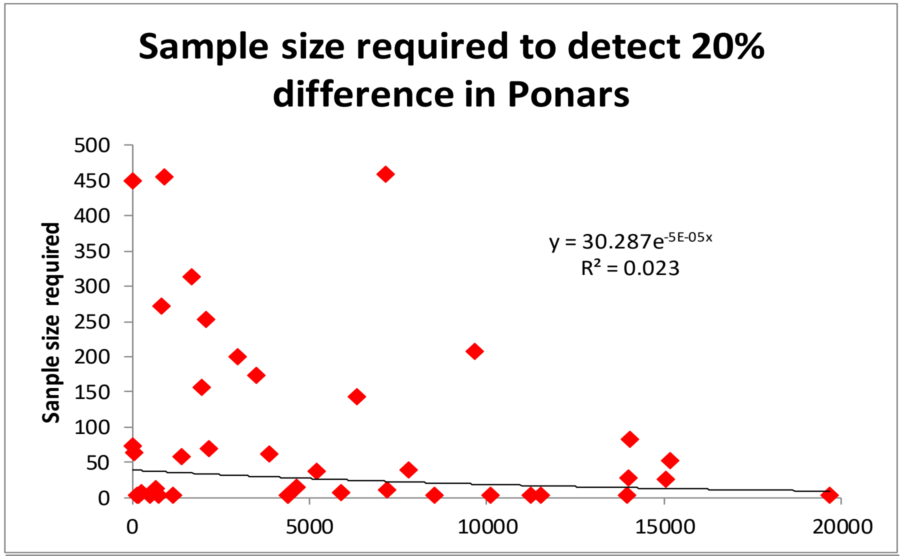
Video transects vs. Ponar grabs

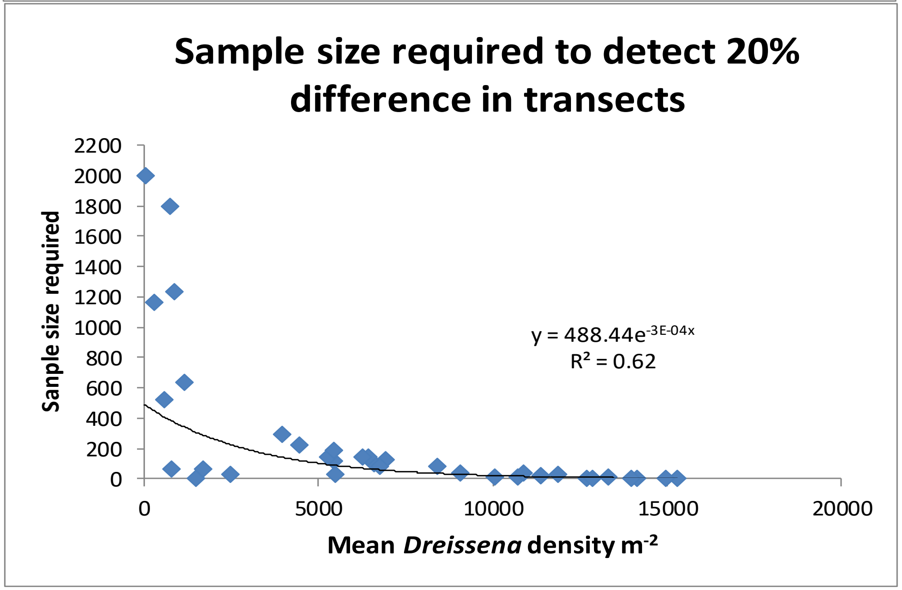
Depths (m)	N	Coverage (%)		Density (m^2)		Biomass ($g\ m^{-2}$)	
		Video	Ponar	Video	Ponar	Video	Ponar
<30	9	11.7±8.6	15.6±8.6	1930±1418	2034±931	336±247	543±281
30-100	23	53.8±5.1	45.3±5.4	8867±849	7201±1105	1544±148	1232±140
>100	10	6.3±3.0	3.4±2.5	1045±500	1544±1091	182±87	90±46
Average	42	33.9±4.8	28.1±4.5	5996±798	4804±800	974±139	822±122

- All differences in coverage, density and biomass estimates between methods (tested with Wilcoxon Matched Pairs test) were not significant after Bonferroni corrections.
- **However** …

Accuracy of density estimation

- Accuracy for video transects was higher than that for Ponars at a station scale
- For Ponar grabs only 31% of stations sampled satisfied EPA requirement *(detect a change of 20% in Dreissena densities at the 90% confidence level at a power of 0.80)*
- For transects with 100 images processed, 84% stations met 20% requirement
- If 600 images analyzed, ALL stations will meet 20% requirement
- For video transects there was a significant negative relationship between density and sample size
- Stations with higher density require less replicates, suggesting that areas with high density were sampled with higher accuracy





Pros and cons of underwater video vs. Ponar in *Dreissena* sampling

Activity	Video transect (100 still images)	Ponar (3 grabs)
Sampling (Ship) time	45 min	20 min
Lab analysis	4 hours	21 hours
Number of replicates	100 (flexible)	3 (fixed)
Sampling area, m^{-2}	15.0	0.14
Advantages	• Allows large scale observations • Successful on most substrate types • Utilizes computer software to calculate mussel coverage across large areas	• Not limited by turbidity and macrophytes • Could be used for *Dreissena* ID and size determination
Disadvantages	• Limited by turbidity and macrophytes • Cannot be used for size and species ID • Can overlook small mussels	• Cannot be used on hard substrates • Does not allow large scale observations

- *Dreissena* analysis from a station using Ponar (3 reps.) - **21 hrs. vs. 4 hrs.** Video (100 reps.)
- Video sampling area two orders of magnitude greater than Ponar
- To sample equivalent to video bottom area would require 300 Ponars per station

Given the unique strengths of both methods, a combined approach using video transects and bottom grabs may be extremely productive in *Dreissena* monitoring, and will yield valuable information not obtainable by either method alone.

2015 Lake Michigan video transect vs. Ponar grab

Traditional sampling (143 stations, 469 Ponars, total sampling area = **22.5 m^2**):

- Sorting of 469 samples – ca. 470 days,
- counting and measuring – ca. 130 days **total 2.4 years of technician time**
- + time for data analysis.

Video transects (43 tows,100 images/transect analyzed) = **645 m^2 of bottom area**

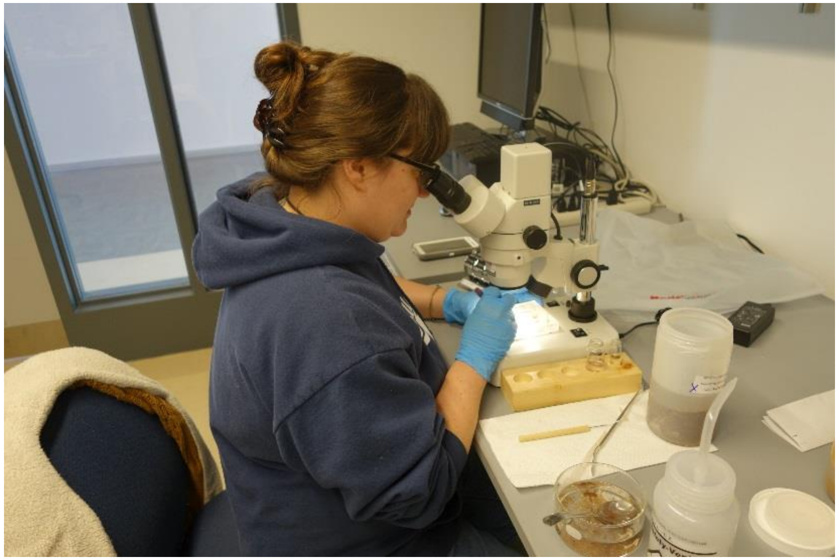
- **2 month of technician time**

Video transects (43 tows, entire transects analyzed) = **3,225 m^2 of bottom area**

- **4 month of technician time**

Suggested total sampled area is equal to **67,187 Ponars,** which will require **> 200** years of technician time to process and **> 60,000** L of formalin on board R/V Lake Guardian

Video transects vs. Ponar grabs



4 months of watching movies and eating popcorn

or

200 years of sorting dead *Dreissena* and smelling formalin?

Conclusions

- Underwater video image analysis allows large scale observation of *Dreissena* and greatly increases precision of density estimation
- By substantially increasing the ability to detect relatively small (<20%) changes between years within a particular station, this method could be a useful and cost effective addition for monitoring *Dreissena* populations
- Given the unique strengths of both methods, a combined approach using video transects and bottom grabs may be extremely productive in *Dreissena* monitoring, and will yield valuable information not obtainable by either method alone.

Acknowledgments

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