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

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Dreissena (zebra and quagga mussels) represent novel ecological type in the freshwater ecosystems

- 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:

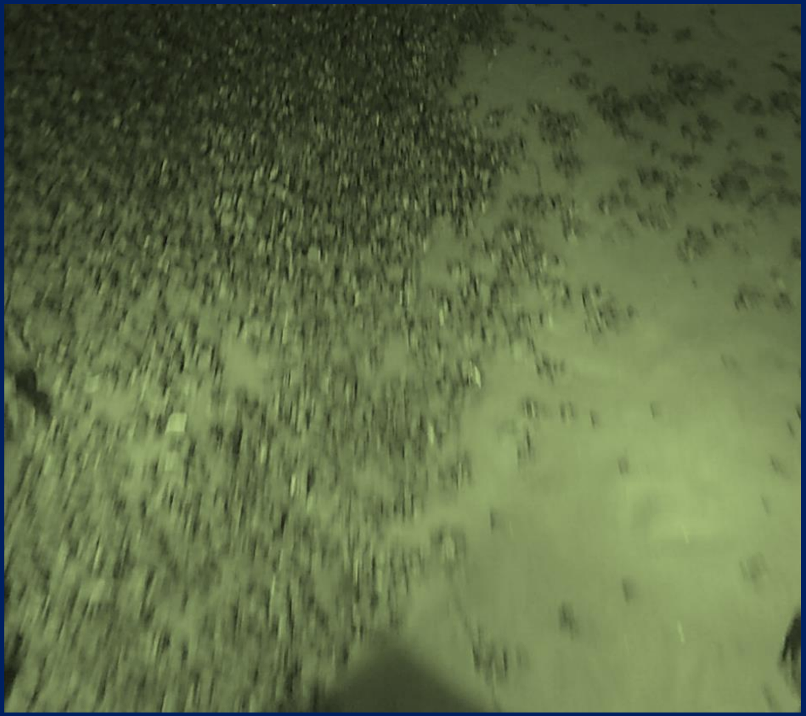
- population size
- population dynamics
- distribution within a waterbody

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

- How many of them are there?
- Where they are?
- Are their increasing or decreasing?

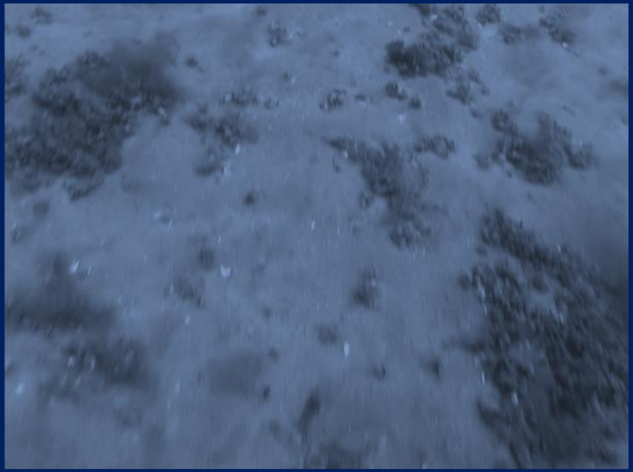
Population size and distribution

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



Population size and distribution

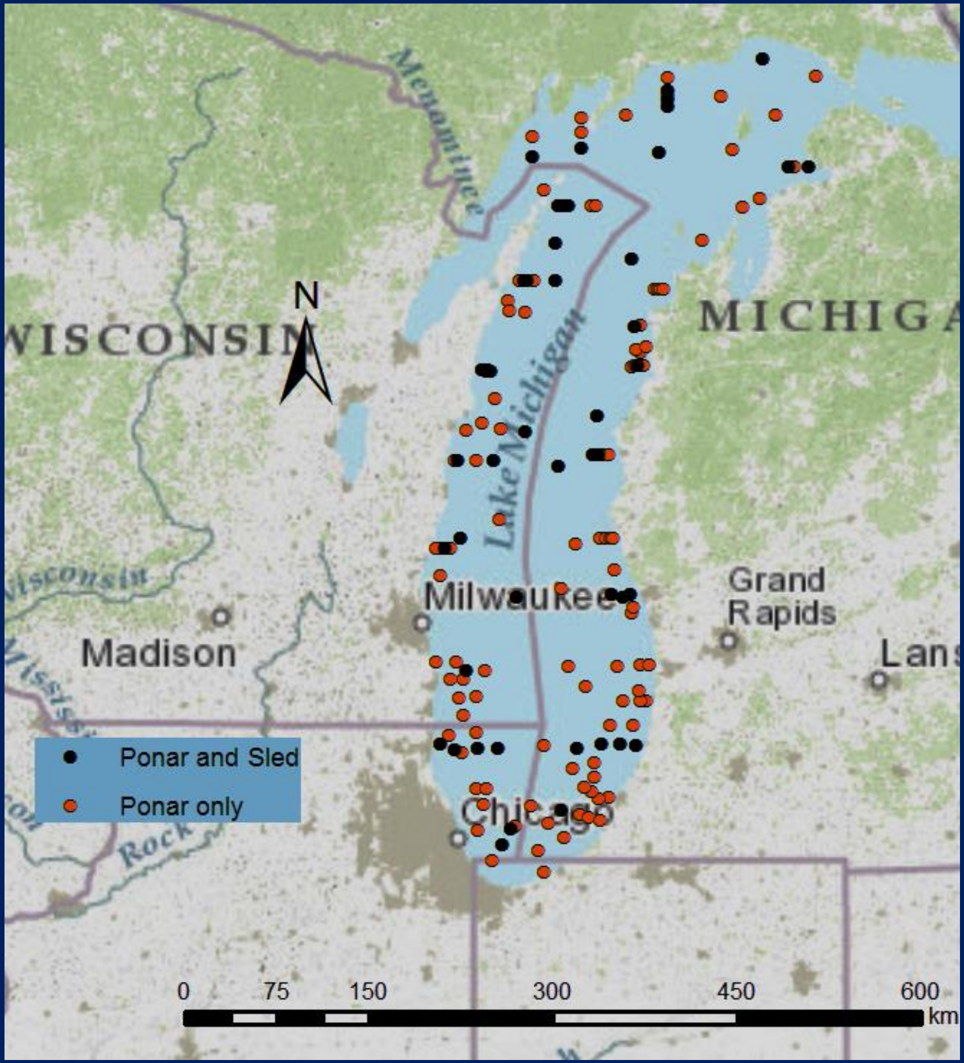
Almost every study of *Dreissena* in the Great Lakes has relied on bottom grabs with a small sampling area limiting our ability to understand the scale of the spatial variability



To understand large scale distribution and estimate population size with a greater confidence we need to overcome local patchiness

Lake Michigan 2015 CSMI (158 sites sampled)

- 469 ponar samples
- 616 videos taken from GoPro on ponar
- 44 videos taken from benthic sled tows



Dreissena coverage in still images

Ponar:

calculated from **5** randomly chosen still images within the larger still image for each Ponar

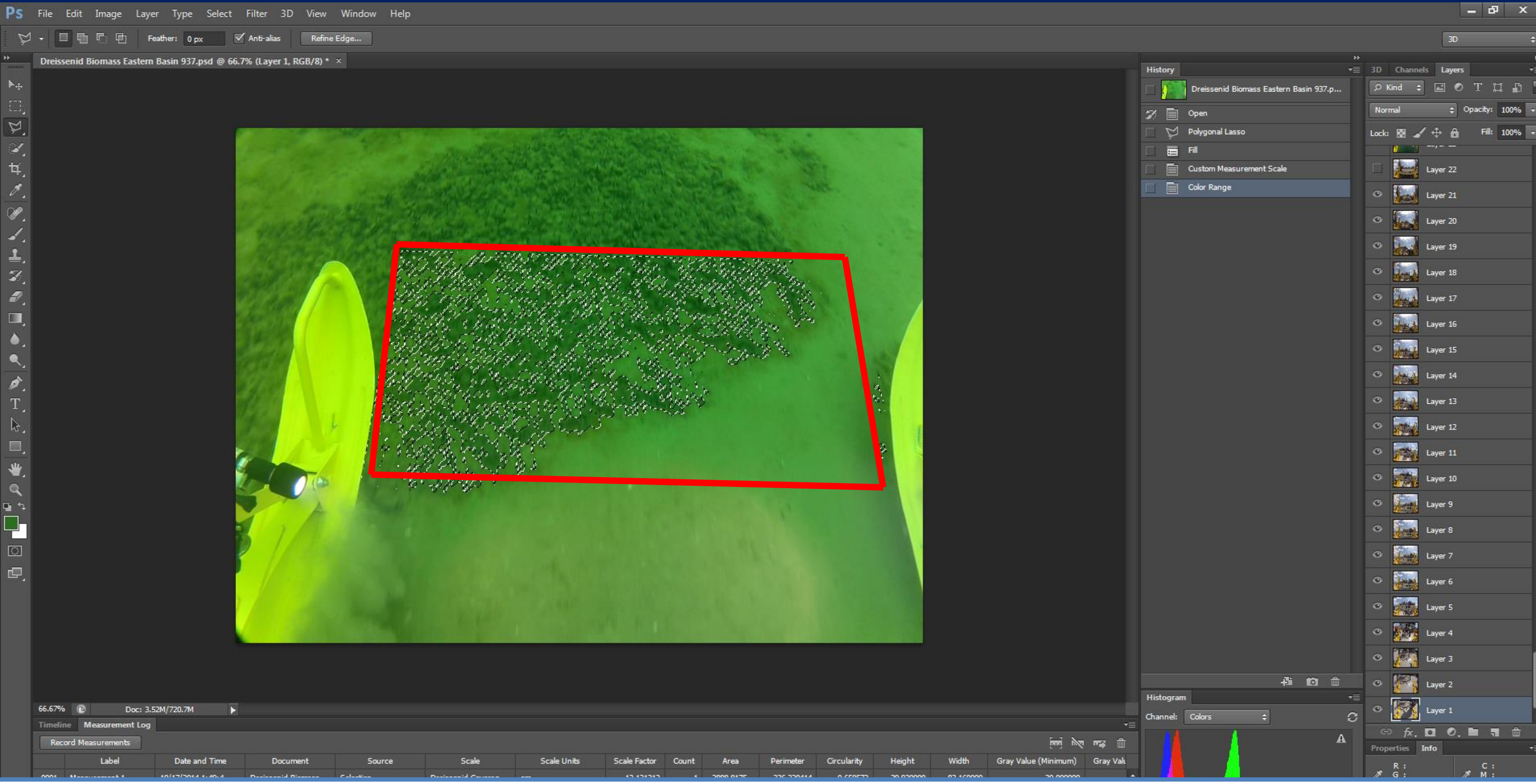
Benthic sled:

video from 500 m transects clipped into individual images

coverage from **100** randomly distributed still images

Estimating *Dreissena* coverage from a sled tow

Dreissena coverage was calculated based on **100 frames** randomly distributed along 500 m of benthic sled video transects using semi-automatic method



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Anti-alias
Refine Edge...
Dreissenid Biomass Eastern Basin 937.psd @ 66.7% (Layer 1, RGB/8) *
History
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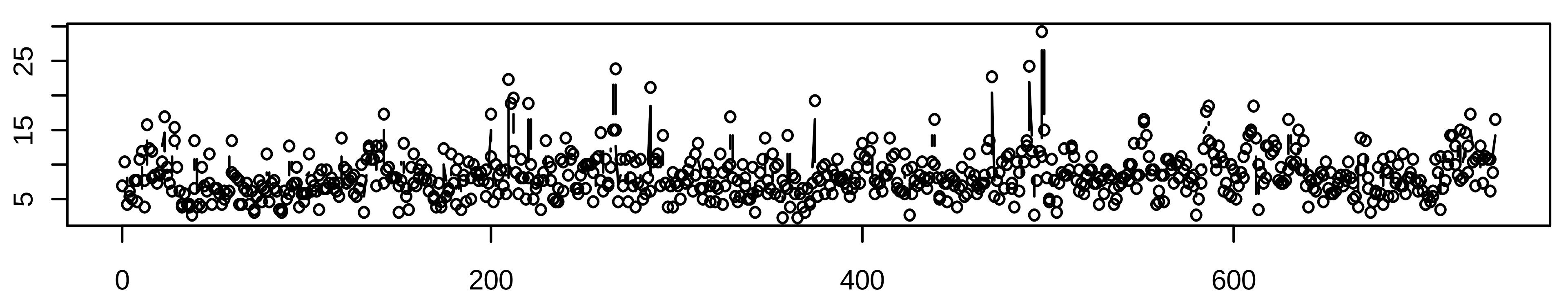


5
15
25
0
200
400
600

Sampling area

Because of the patchy distribution of *Dreissena*, larger sampling area and more replicates should provide better estimation of the bottom coverage

- Ponar sampling area - **0.053** m^2
- Go Pro attached to a ponar ($0.046 m^2$ x 4 Ponars x 5 frames = **0.92** m^2)
- Go Pro attached to a benthic sled 100 frames ($0.16\ m^2$ x 100 = **16** m^2)
- **The whole transect** ($0.16\ m^2$ x 800 frames = **128** m^2)
- **1 Video from a sled tow = 300 ponars**

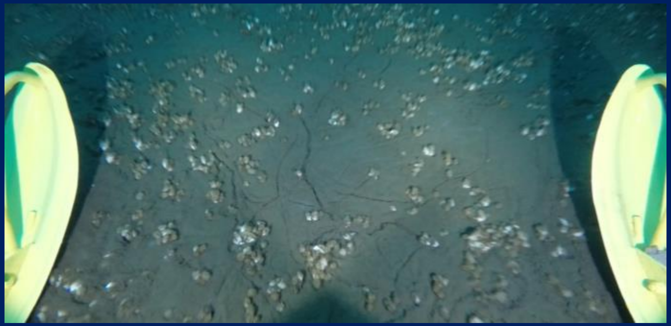
Lake Michigan 2015: Video image analysis

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

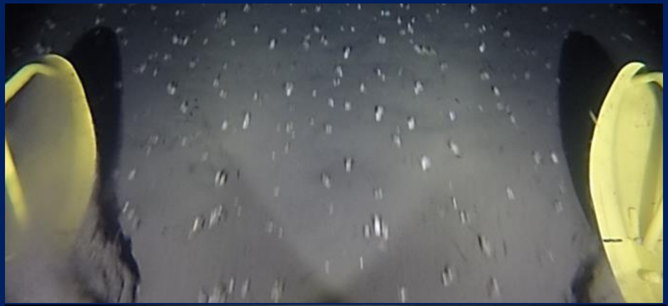
- 88% are usable (70% great, 18 OK)
- 5% not usable due to uncontrollable events (algae cover)
- 7% not usable due to technical problems (cable, light, wrong angle)

45 m

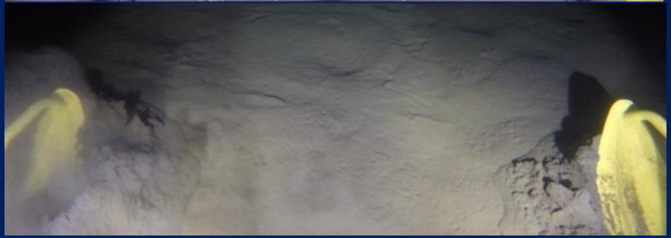
50 m



54 m



139 m



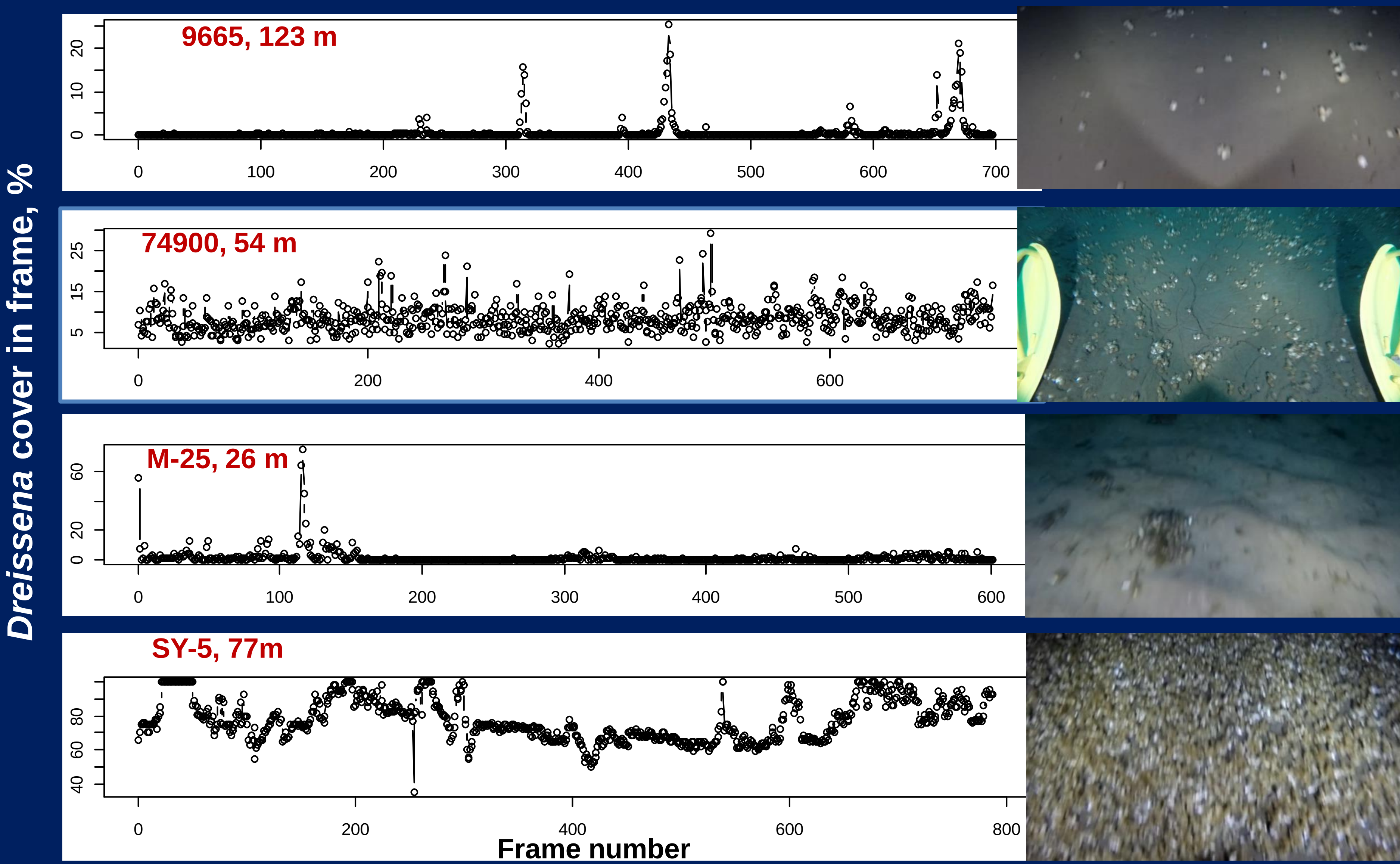
165 m

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

Video clip (80 m depth, lots of *Dreissena*):

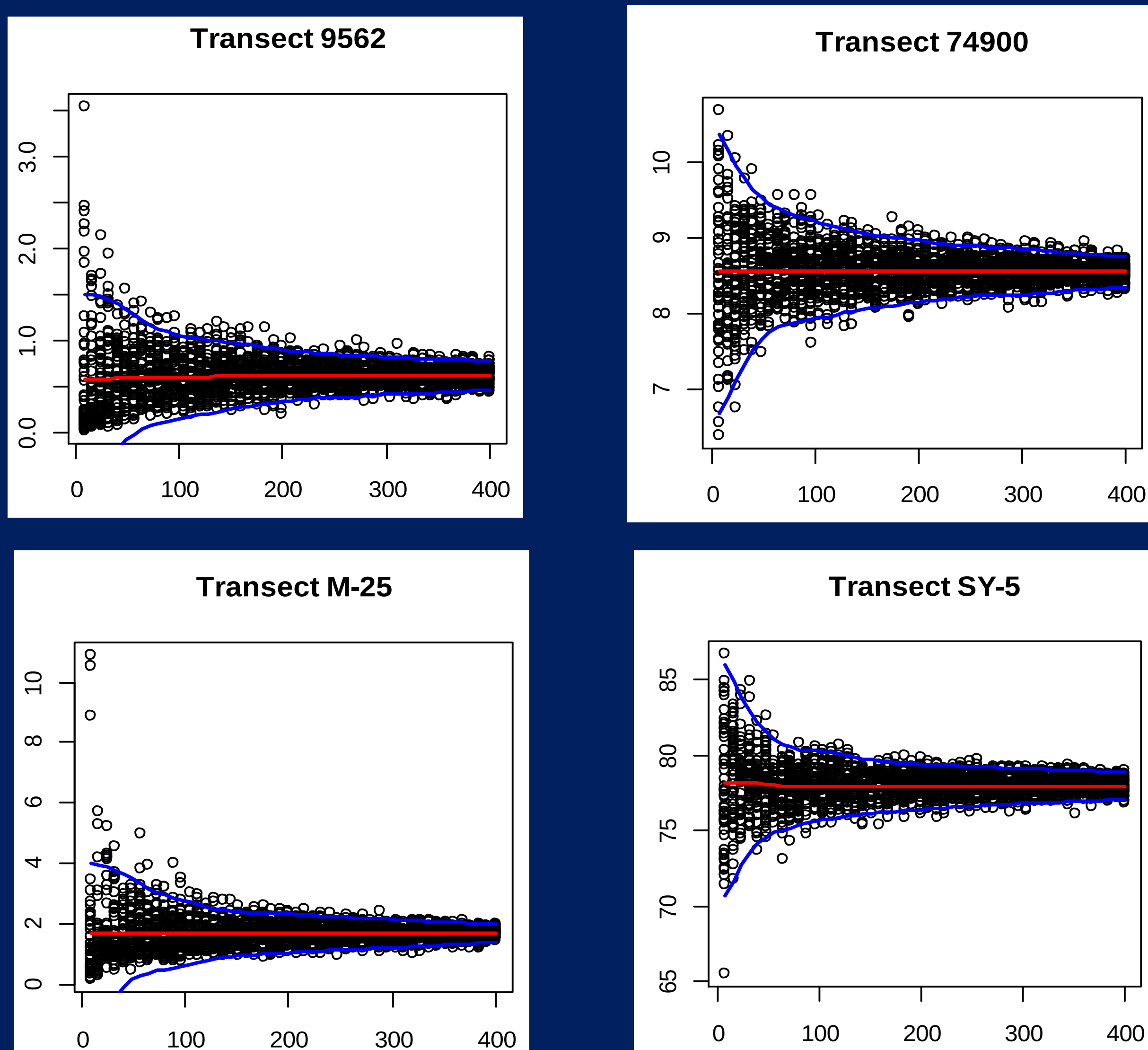
Video clip (120 m depth, few *Dreissena*):

The whole *Dreissena* coverage was counted at 4 transects with different degree of coverage (2800 images total)



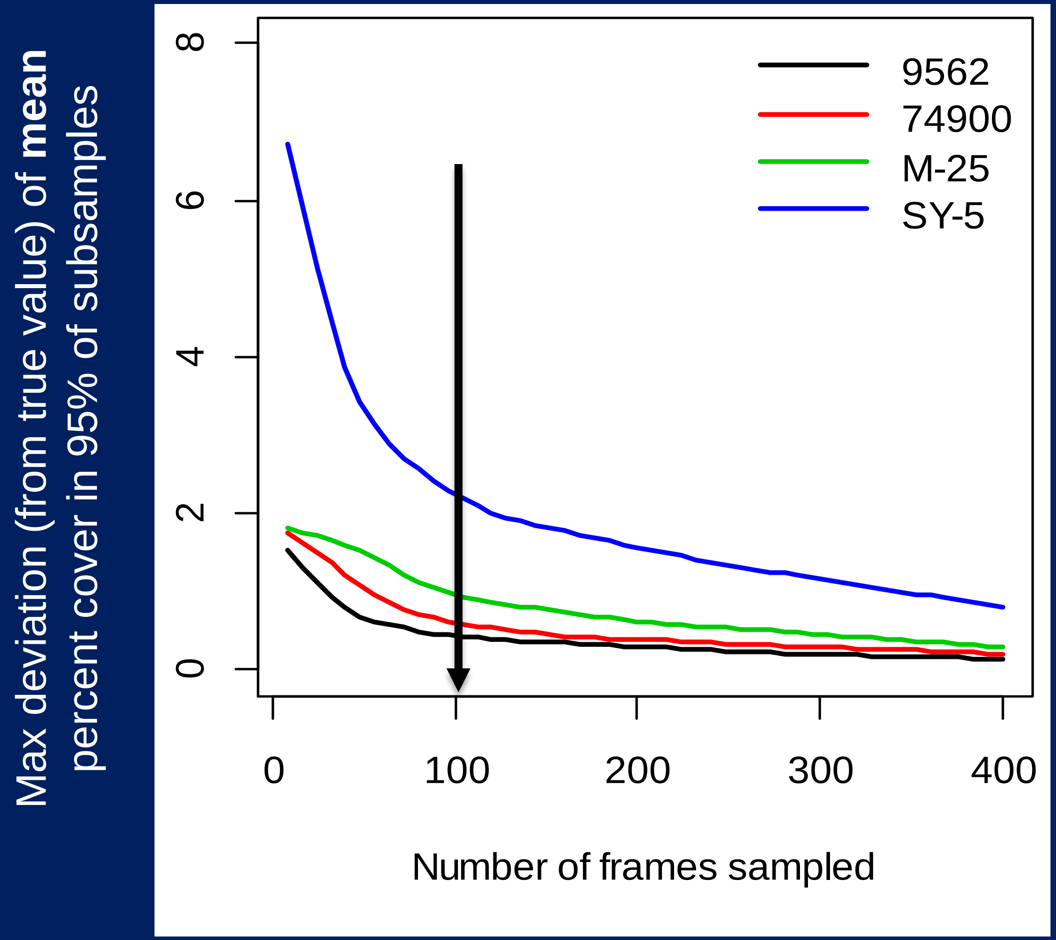
Relationship between number of frames sampled and estimated *Dreissena* coverage (bootstrapping)

Average percent cover in sampled frames



Number of frames sampled (blue line 95% confidence interval)

100 randomly selected frames from each transect appeared to be an appropriate number

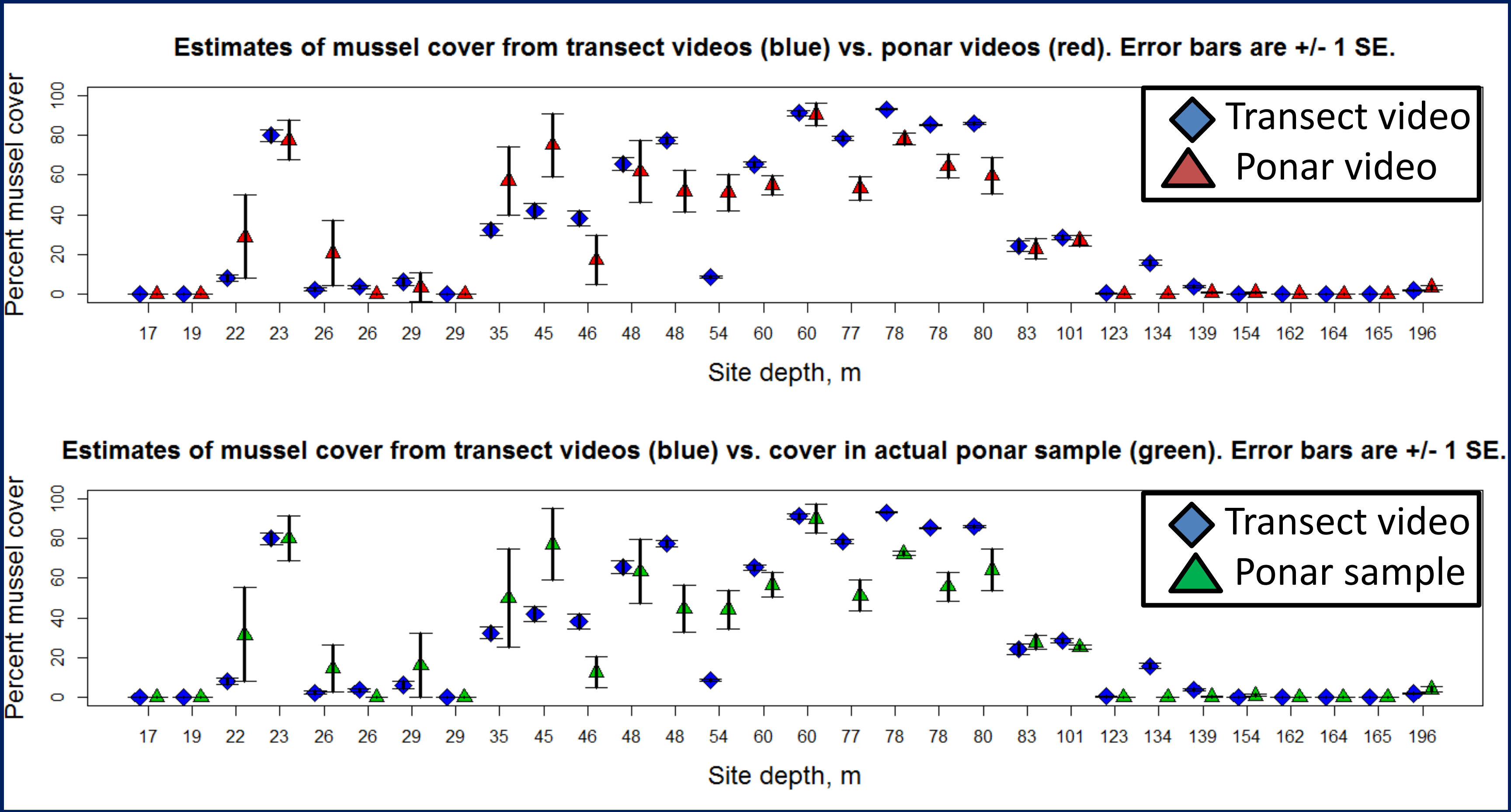


Estimating *Dreissena* coverage (%)

Site (depth)	Whole Transect (# of frames)	100 Frames ±SE	20 Ponars ±SE	4 Ponars ±SE
74900 (45m)	**8.6** (741)	8.0±0.3	51.1±4.2	44.0±9.7
9562 (123m)	**0.6** (582)	0.5±0.2	0	0
SY-5 (77m)	**77.9** (787)	76.0±1.1	53.4±2.6	51.0±7.8
M-5 (26)	**1.7** (601)	2.0±0.7	32.1±9.3	37.0±21.0

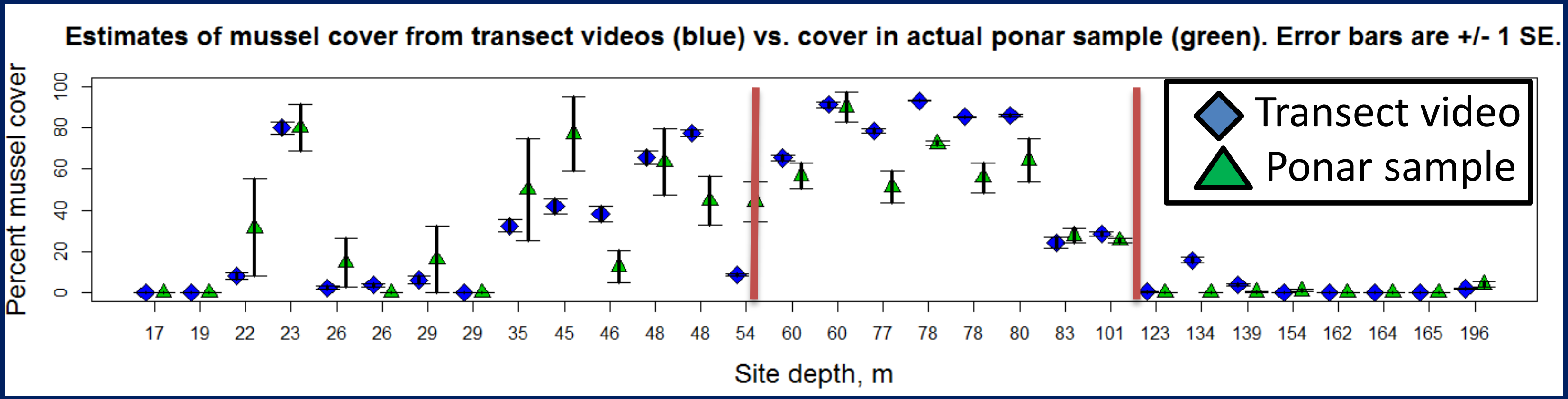
- There was a significant difference between coverage estimated from transects and ponars in 2 cases
- Ponars missed *Dreissena* on low density transects
- Mean coverage estimated from 100 frames randomly distributed along a transect was much closer to the "true value" than coverage estimations from ponars
- Mean coverage estimated from 4 and 20 ponars did not differ, suggesting that addition of more replicate ponars will not increase precision of our estimation

Estimating *Dreissena* coverage from transects, 20 ponars (upper graph), and 4 ponars (lower graph)



- **> 60% sites differed significantly between transect and ponars**
- Transects did not record *Dreissena* at 6 sites
- Ponars (20 reps) did not record *Dreissena* at 7 sites
- Ponars (4 reps) did not record *Dreissena* at 9 sites

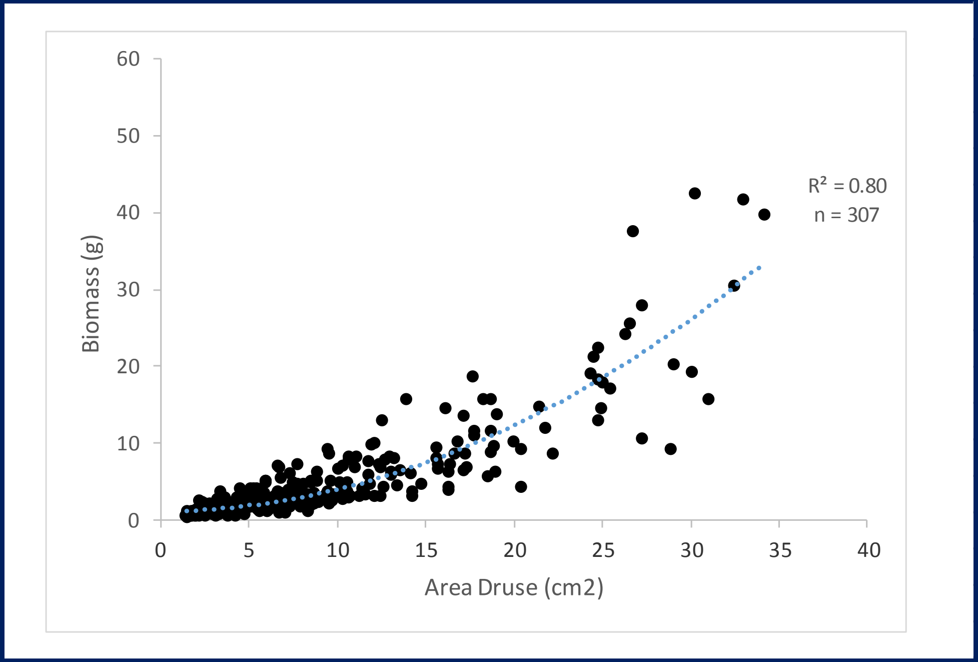
Preliminary findings:



- In shallow areas (<50 m) large patches of *Dreissena* likely due to large scale environmental factors (e.g. substrate, hydrology, etc.)
- At intermediate depths (50 – 110 m) virtually all bottom is often covered with *Dreissena*
- At >110 m *Dreissena* forms very small druses evenly distributed on the bottom (intraspecific competition for food?)

Converting Coverage into Biomass

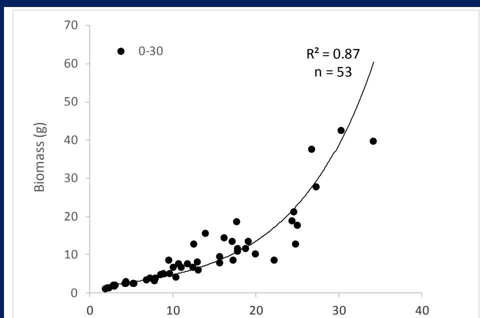
To convert coverage into biomass, we calculated surface area/biomass relationship for 307 *Dreissena* druses collected from different depths

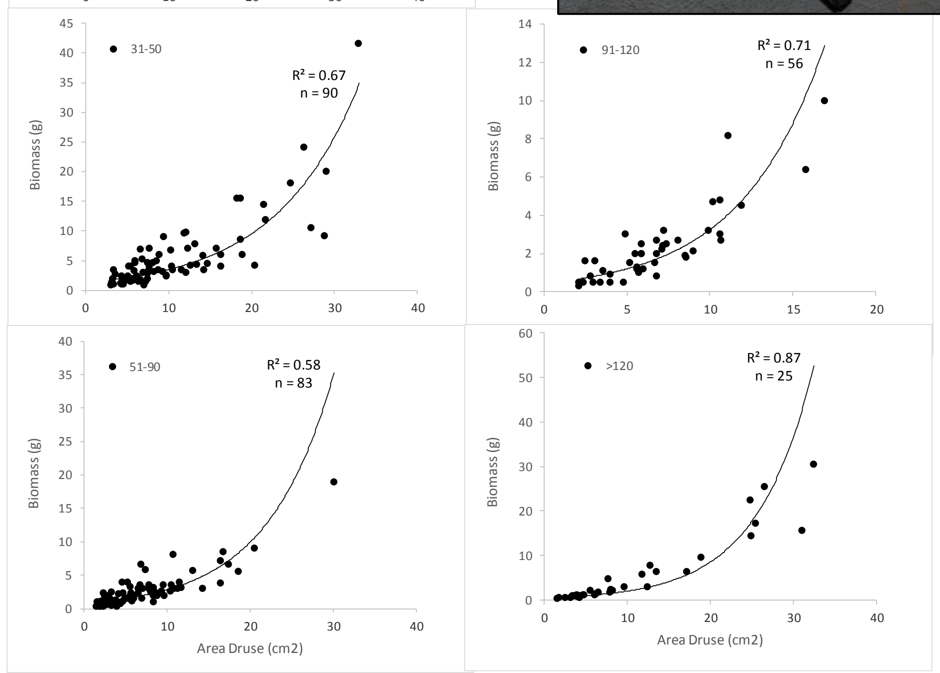


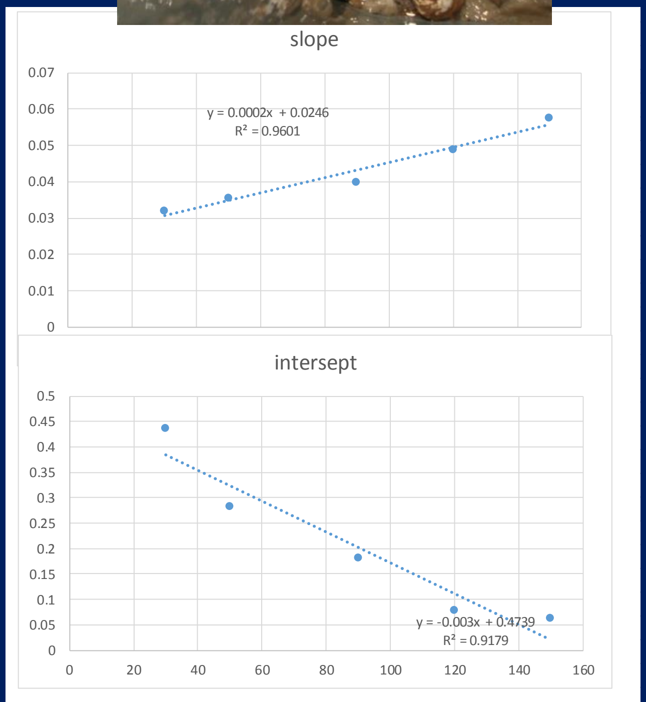
Surface area of each druse was determined in Photoshop

Coverage vs. biomass

- Relationship between druse surface area and wet biomass differed among depths
- *Dreissena* biomass per surface area **declined with depth**
- In deep areas *Dreissena* does not form multilayer aggregations







Cost-Benefit Analysis:
Video transect vs. ponar grab (a hypothetical example)

2015 Lake Michigan sampling (158 sites, 469 ponars collected x 0.053 m^2 sampling area = **24.9 m^2 of total area sampled**):

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

total 2.4 years of technician time

Suggested design (79 sites, 79 ponars + 79 sled tows = **1,268 m^2 of total area sampled**):

- Sorting of 79 samples – ca. 80 days
- counting and measuring – ca. 20 days
- Analysis of 79 video transects – 60 days
- + time for data analysis.

total 7 months

Suggested total sampled area is equal to 23,925 ponars, which will require > 90 years of technician time to process and > 20,000 L of formalin on board of R/V *Lake Guardian*

*Note: suggested design for *Dreissena* only, other benthos may be analyzed from 79 ponars (requires additional time)

Video transect vs. ponar grab

60 days of watching movies and eating popcorn

or

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

Conclusions

- *Dreissena* is the only freshwater invertebrate that, due to their large body size and high density, can be detected using remote sensing, allowing for rapid collection and processing of information
- Underwater video could be a very efficient tool and a great supplement to a traditional sampling for monitoring of *Dreissena* distribution, coverage, and biomass in Great Lakes (1 video from a sled tow = 300 ponars)
- Underwater video could also be used to estimate macrophyte coverage (e.g., Cladophora)

Acknowledgments

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