Characterizing forage fish distribution and schooling in Maryland tributaries

Applications of high-resolution sonar imaging

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CENTER FOR ENVIRONMENTAL SCIENCE

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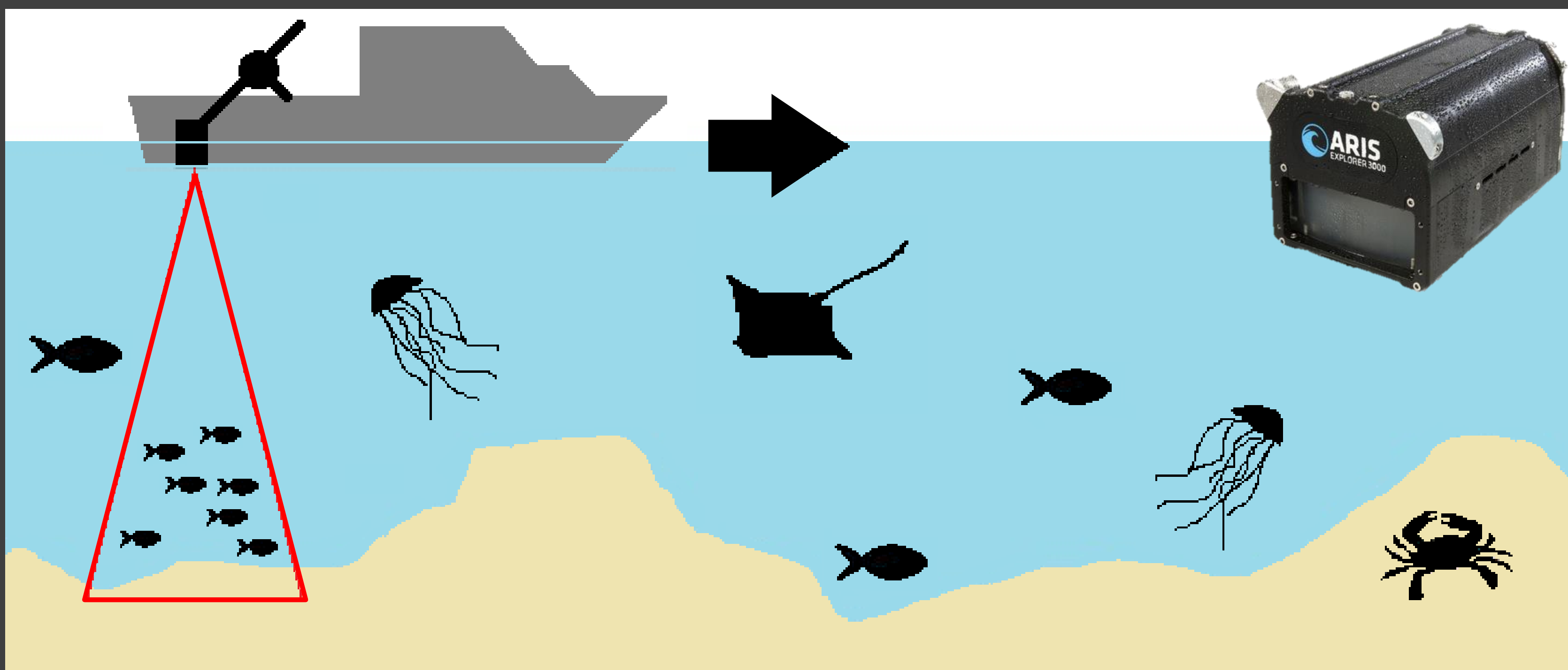
PATUXENT ENVIRONMENTAL AQUATIC RESEARCH LABORATORY PEARL

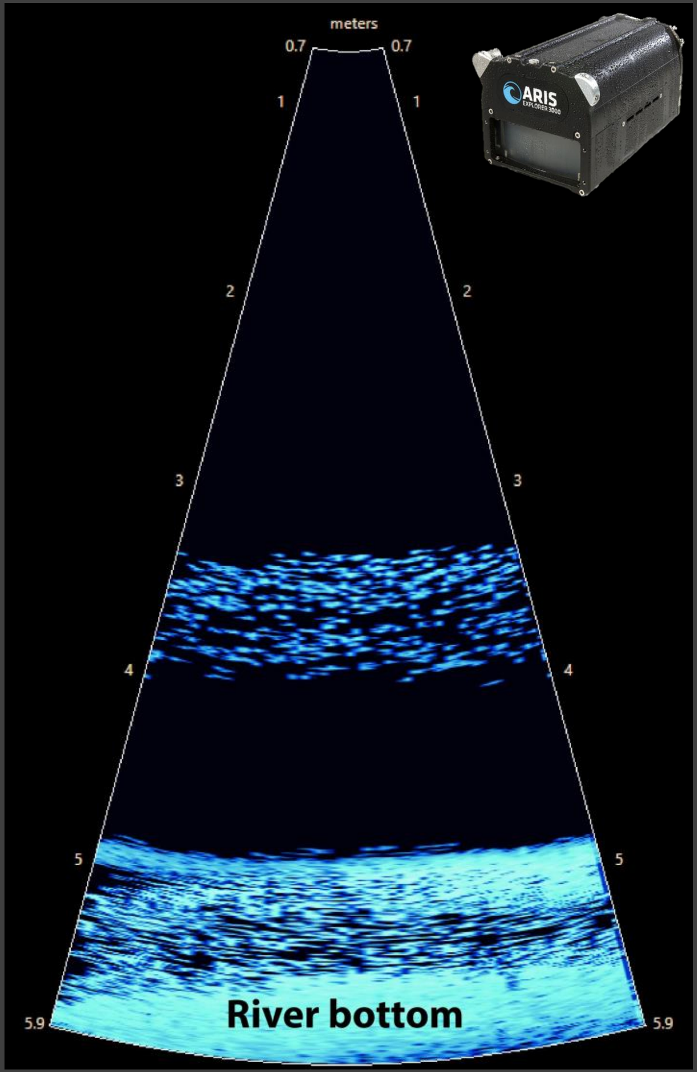
Background

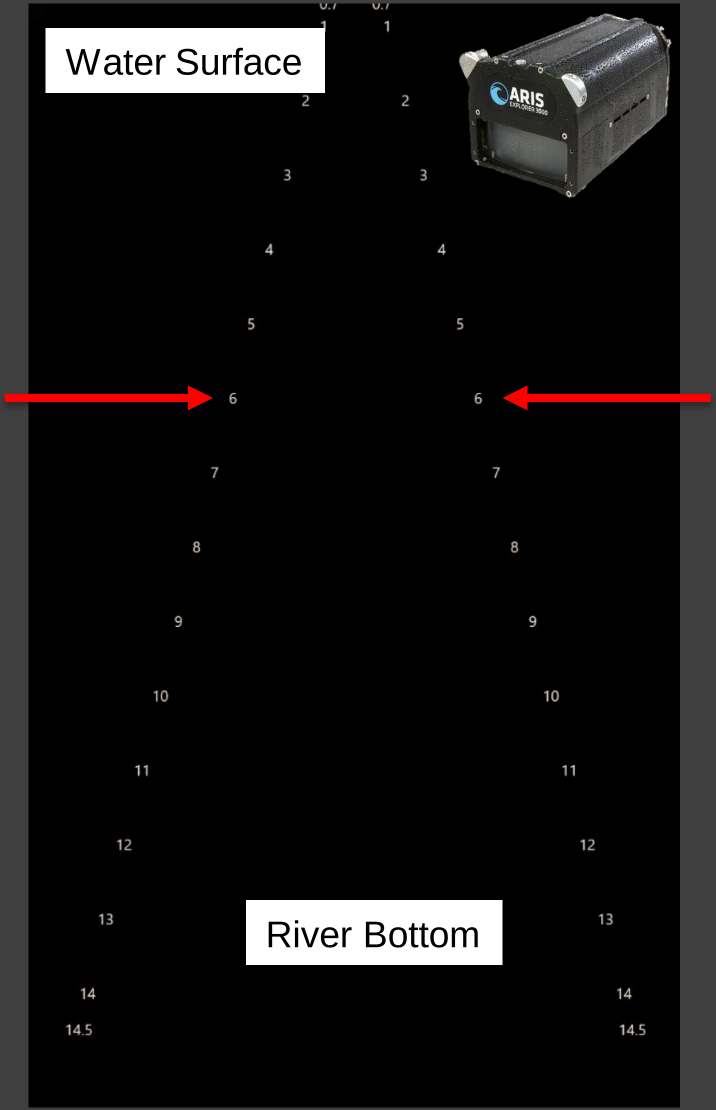
- Schooling is an important characteristic of many forage fish
- Little information available on forage fish school distribution at fine-scale spatial resolutions
- Descriptive metrics of school spatial distribution may illuminate underlying environmental and behavioral drivers of overall spatial distribution pattern
  - Addressing this gap can assist in assessing density and spatial distribution of pelagic populations

Sonar imaging

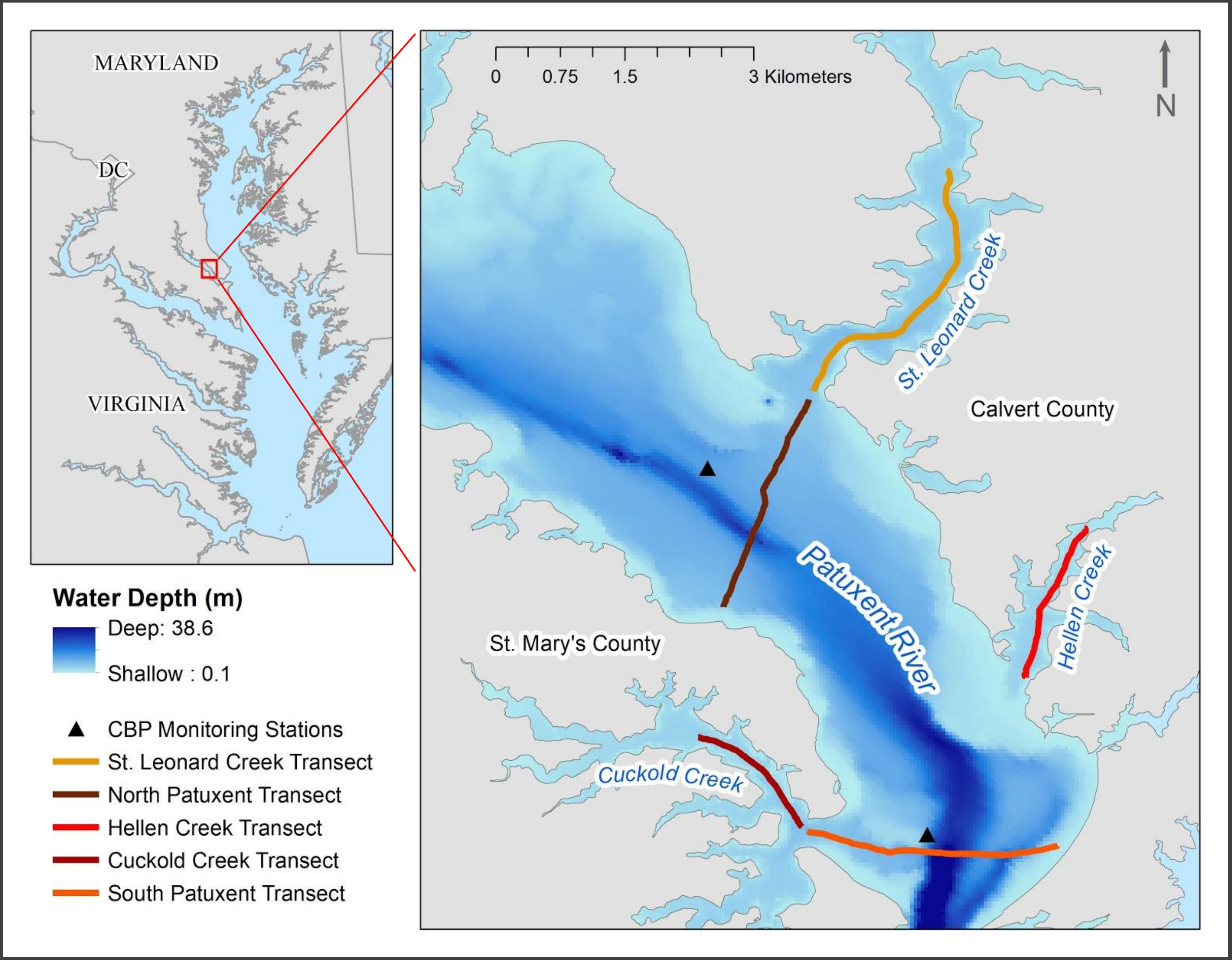


Sonar imaging





Study area



MARYLAND
DC
VIRGINIA
0
0.75
1.5
3 Kilometers
N
St. Leonard Creek
Calvert County
Patuxent River
Hellen Creek
St. Mary's County
Cuckold Creek
Water Depth (m)
Deep: 38.6
Shallow : 0.1
CBP Monitoring Stations
St. Leonard Creek Transect
North Patuxent Transect
Hellen Creek Transect
Cuckold Creek Transect
South Patuxent Transect

Previous results: density and distribution

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Sonar imaging surveys fill data gaps in forage fish populations in shallow estuarine tributaries

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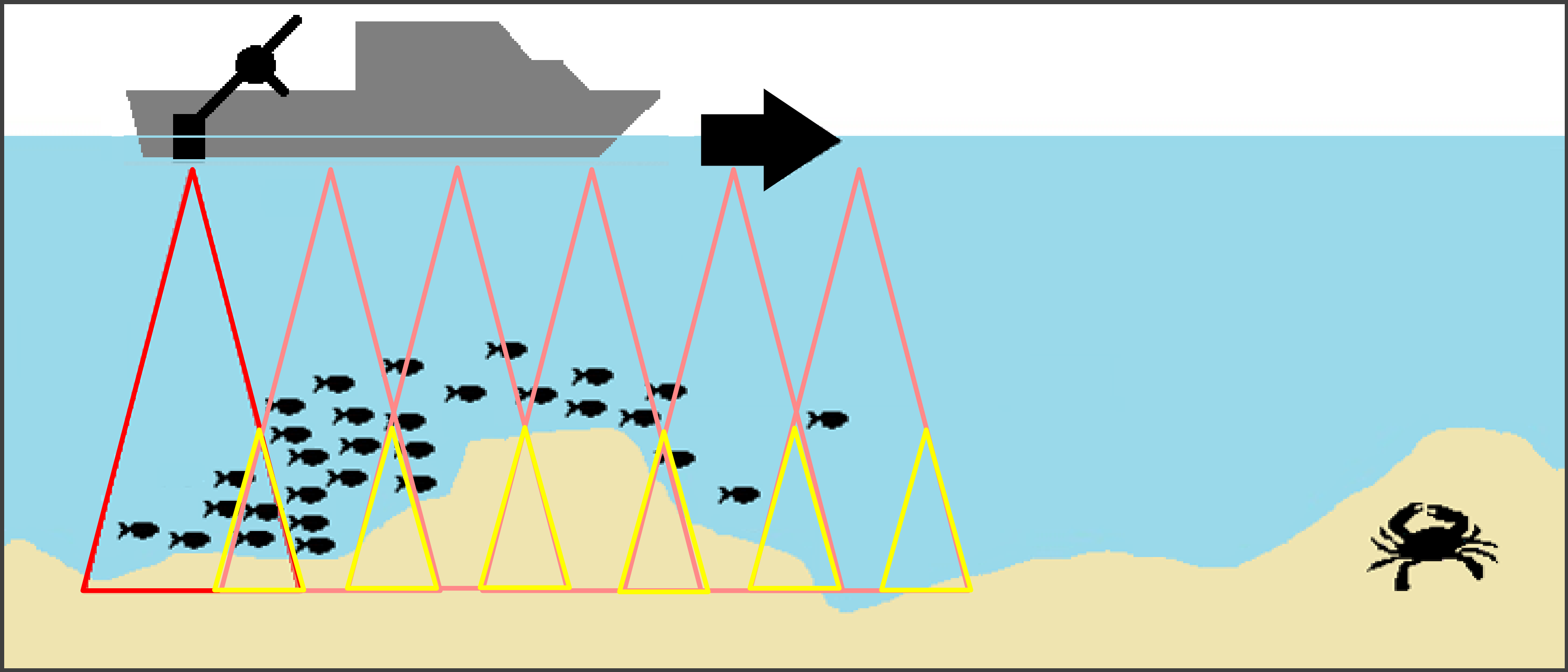
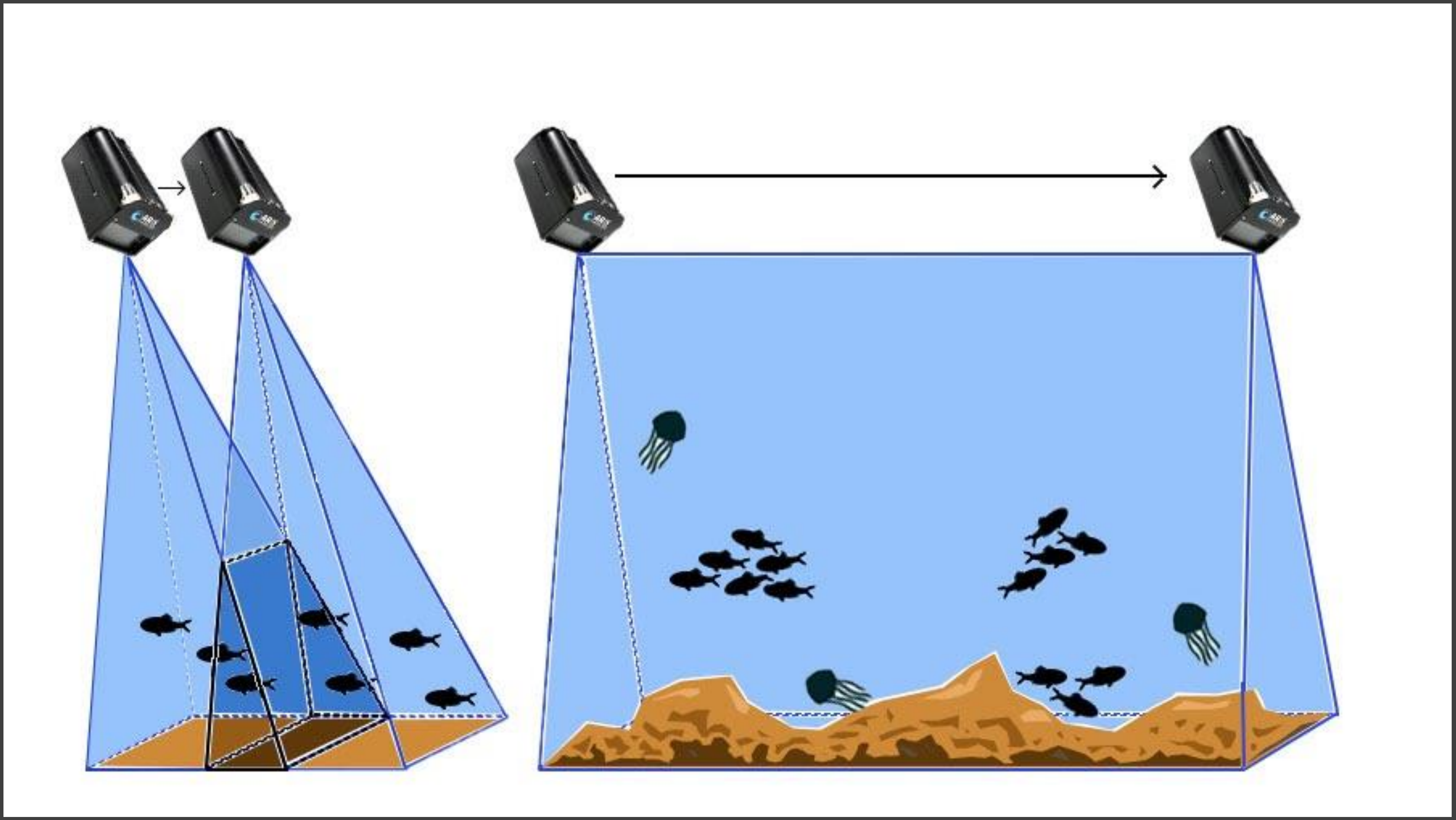
Research objectives

- Seasonal trends in forage fish school morphology
  - Number of schools and total number of fish in study area
  - Number of individual fish per school
  - Length of schools (meters)
- Comparison of school morphology and spatial distribution between river and creek habitats
  - Basic morphology (number of schools, etc.)
  - Bathymetry at point of observation
  - Proximity to nearest neighbor
- Determine clustering pattern through statistical analysis

Processing



Processing



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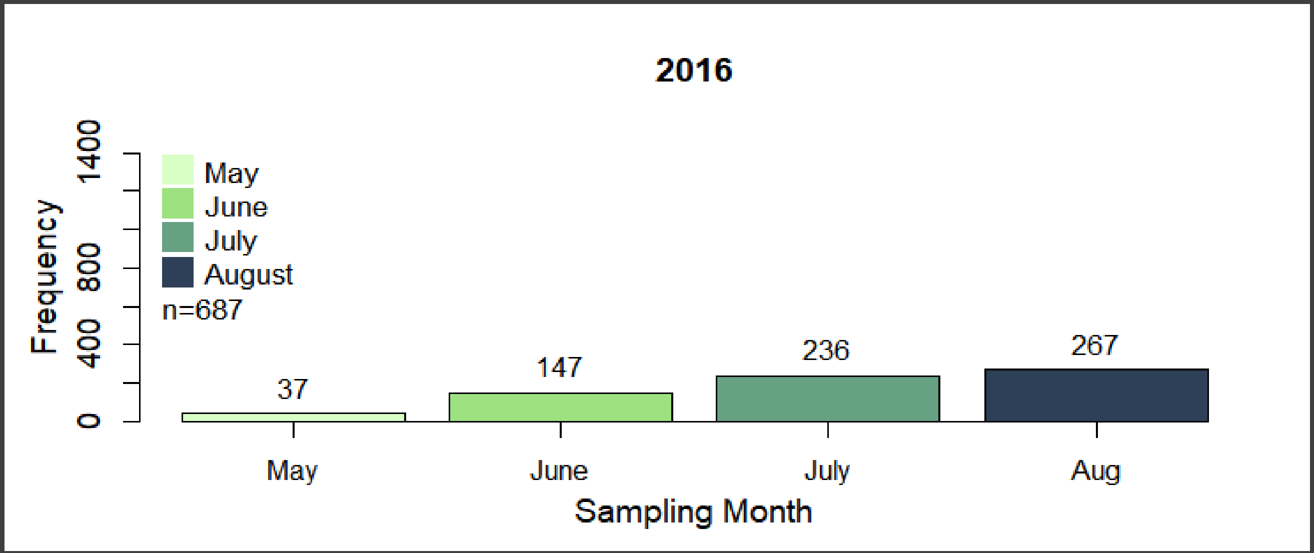
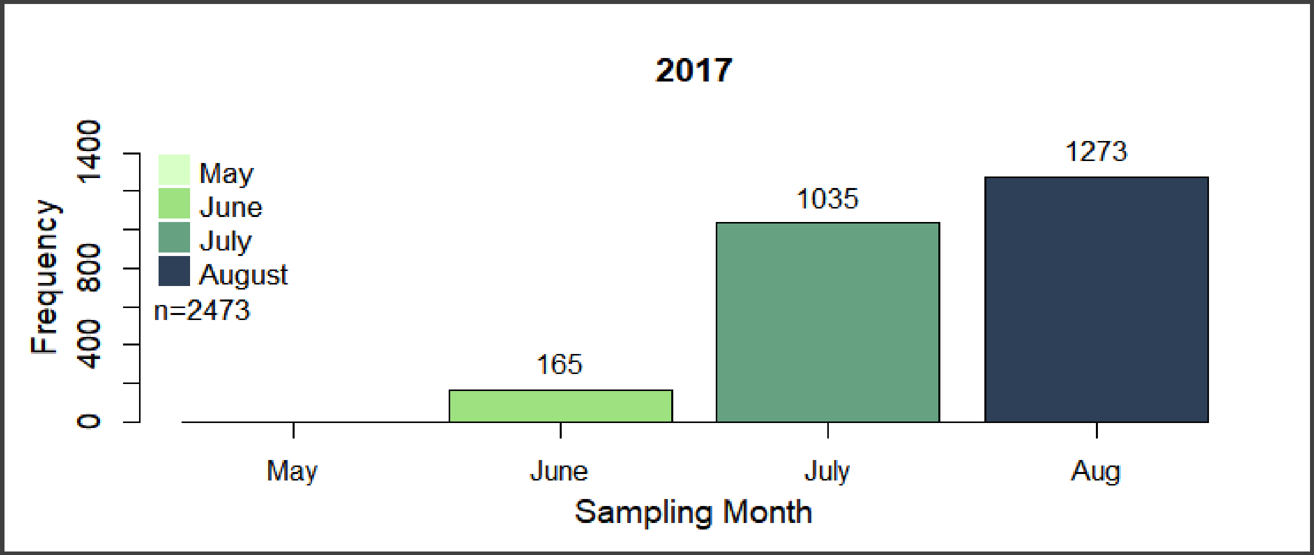
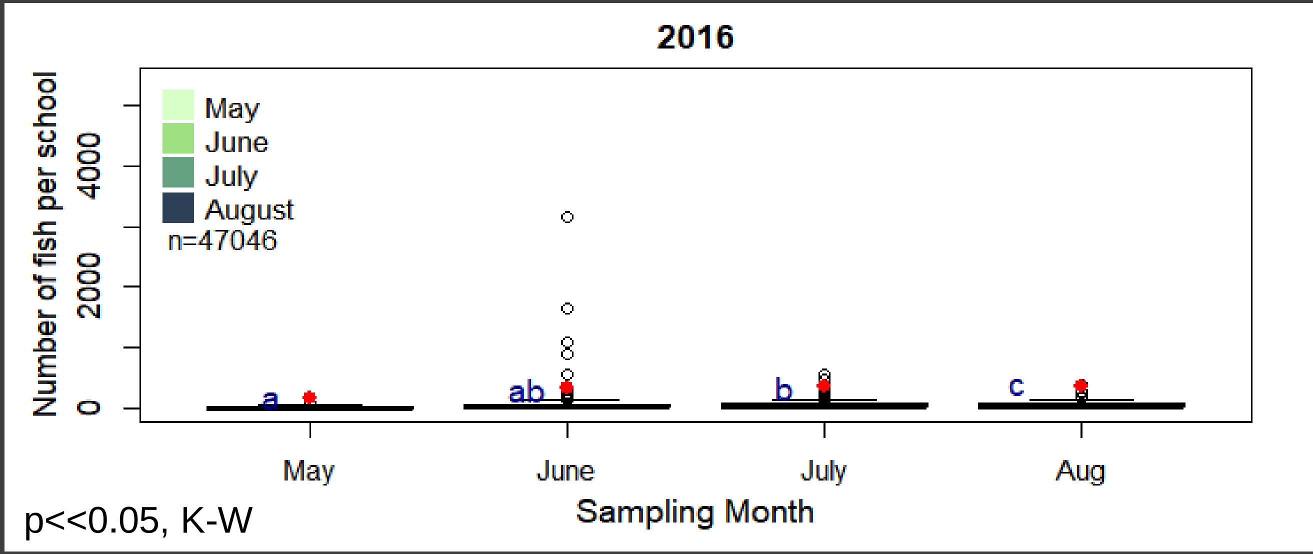
Number of schools

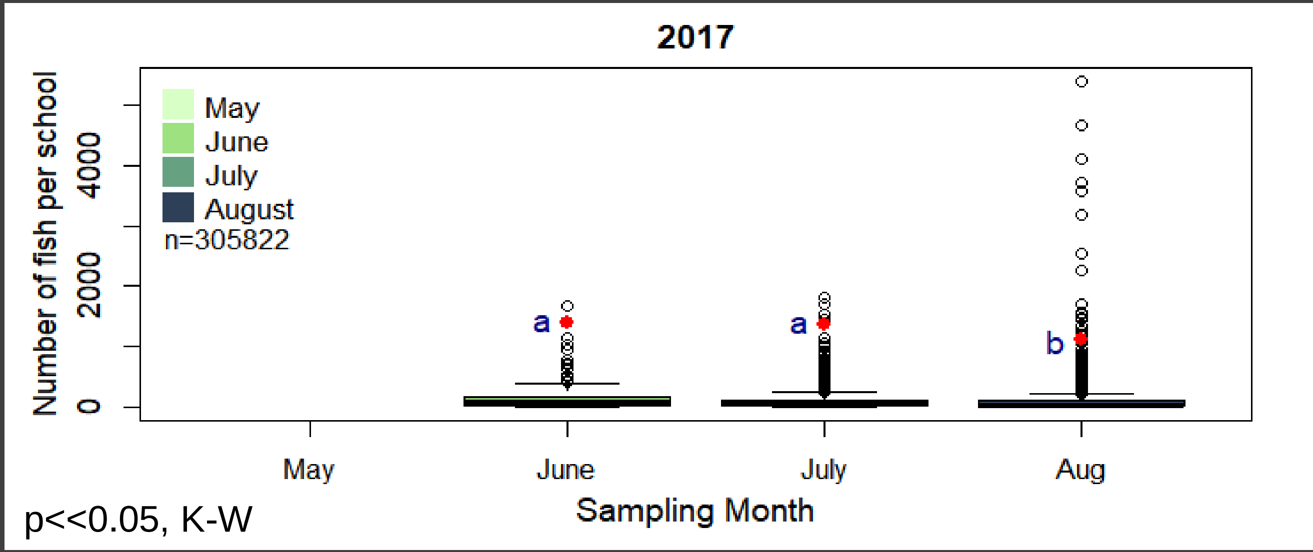




Number of individuals/ school

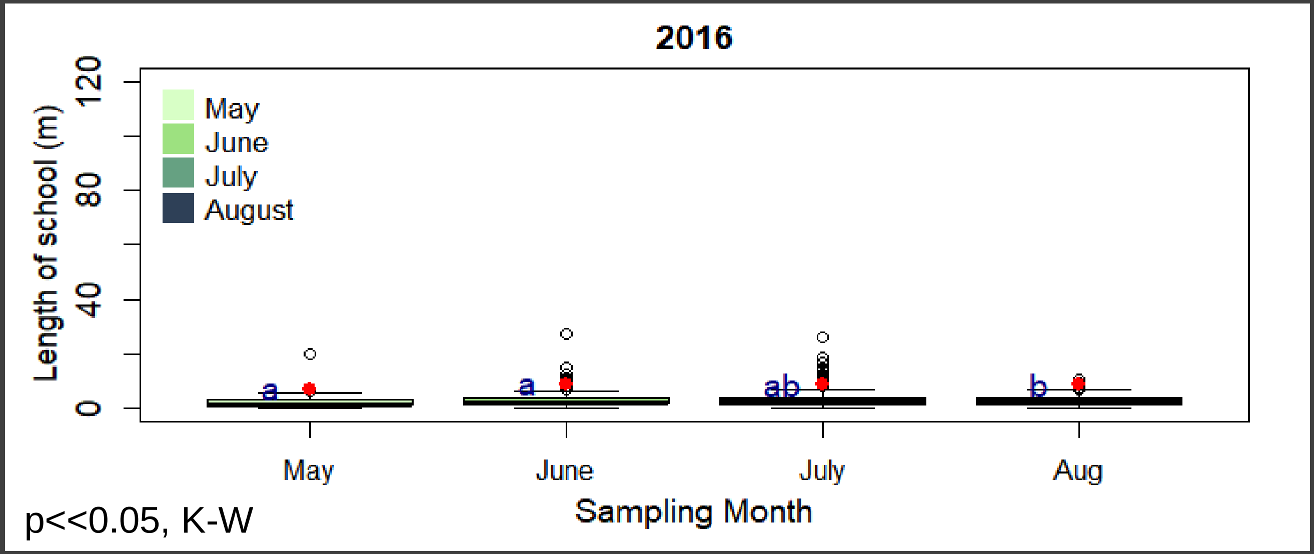


Min: 1
Median:36
Mean: 68
Max: 3157

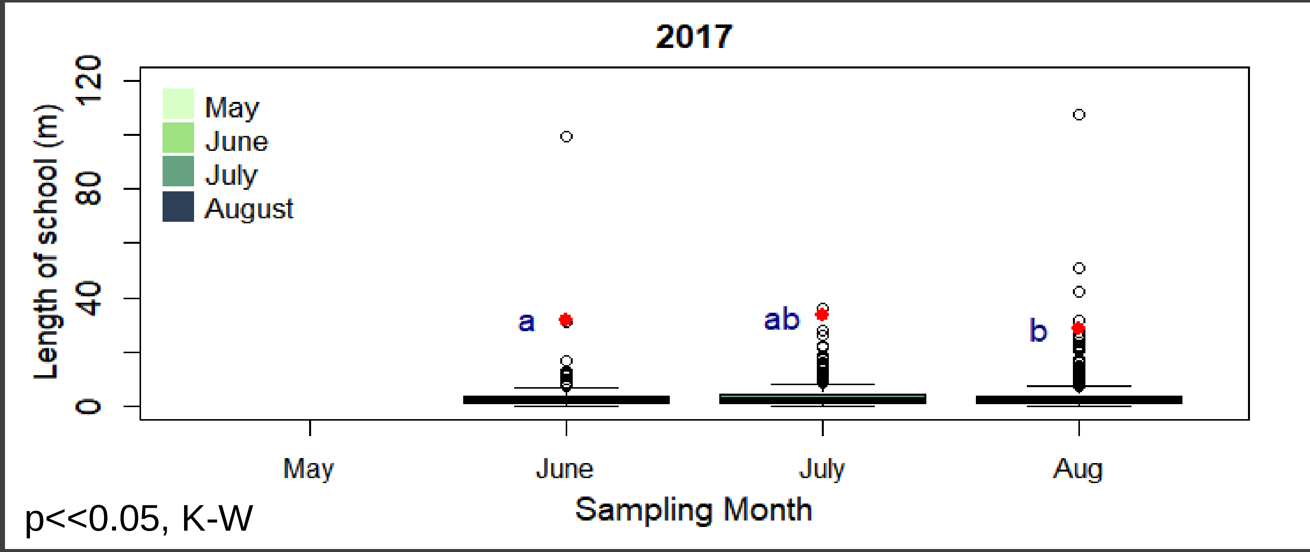


Min: 1
Median: 51
Mean: 124
Max: 5387

Length of schools



Min: < 1m
Median: 2.2m
Mean: 2.9m
Max: 27.4m



Min: < 1m
Median: 2.5m
Mean: 3.3m
Max: 107.1m

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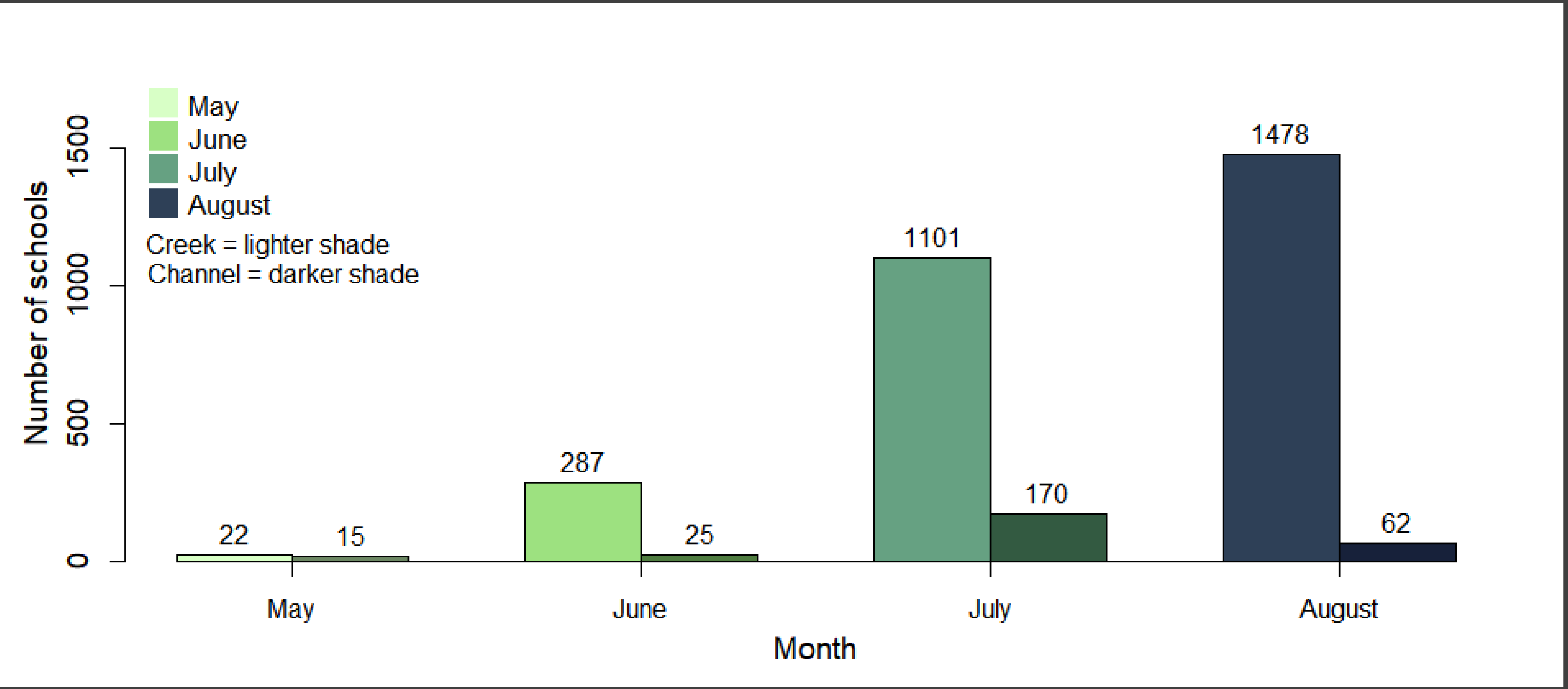
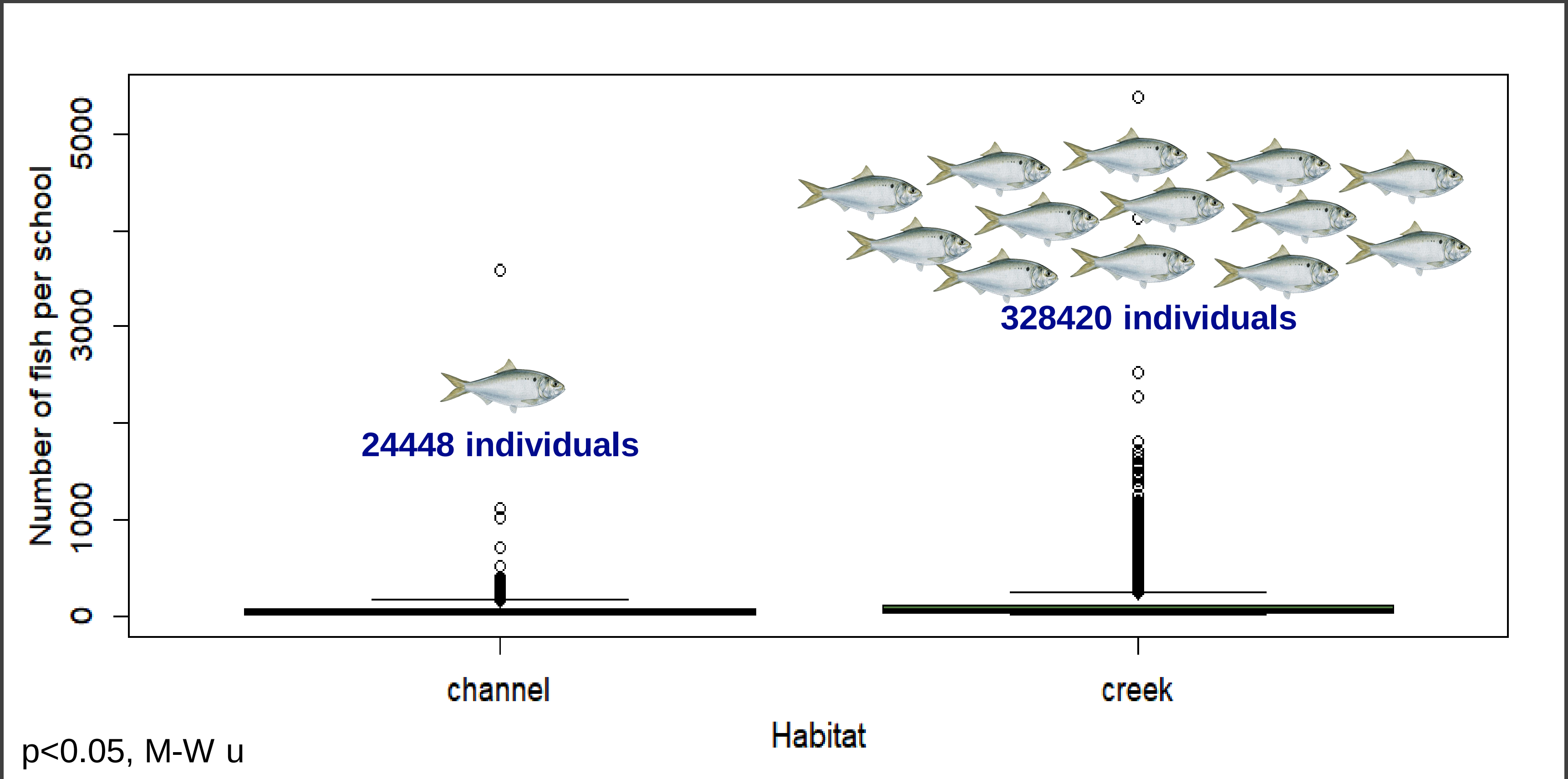
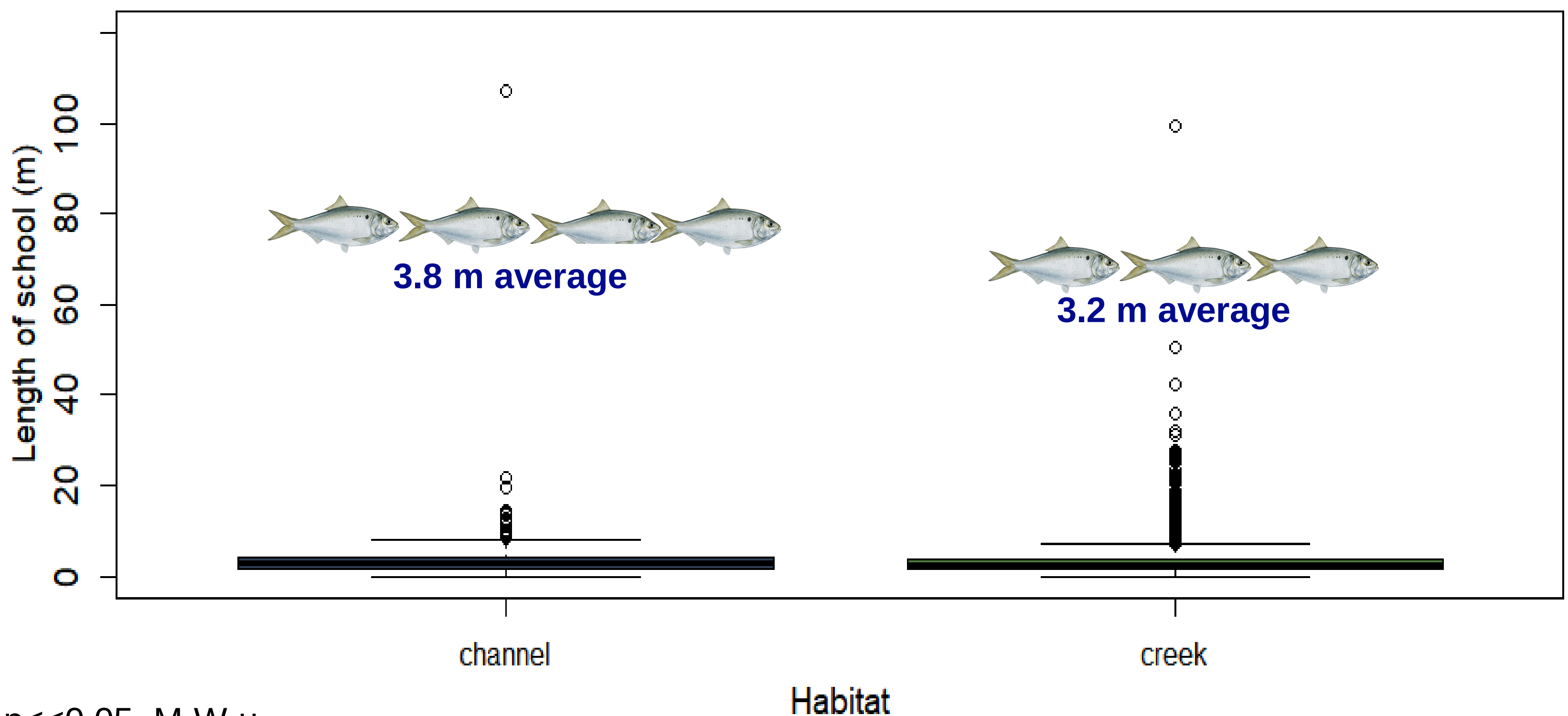
Number of schools



Number of individuals/ school

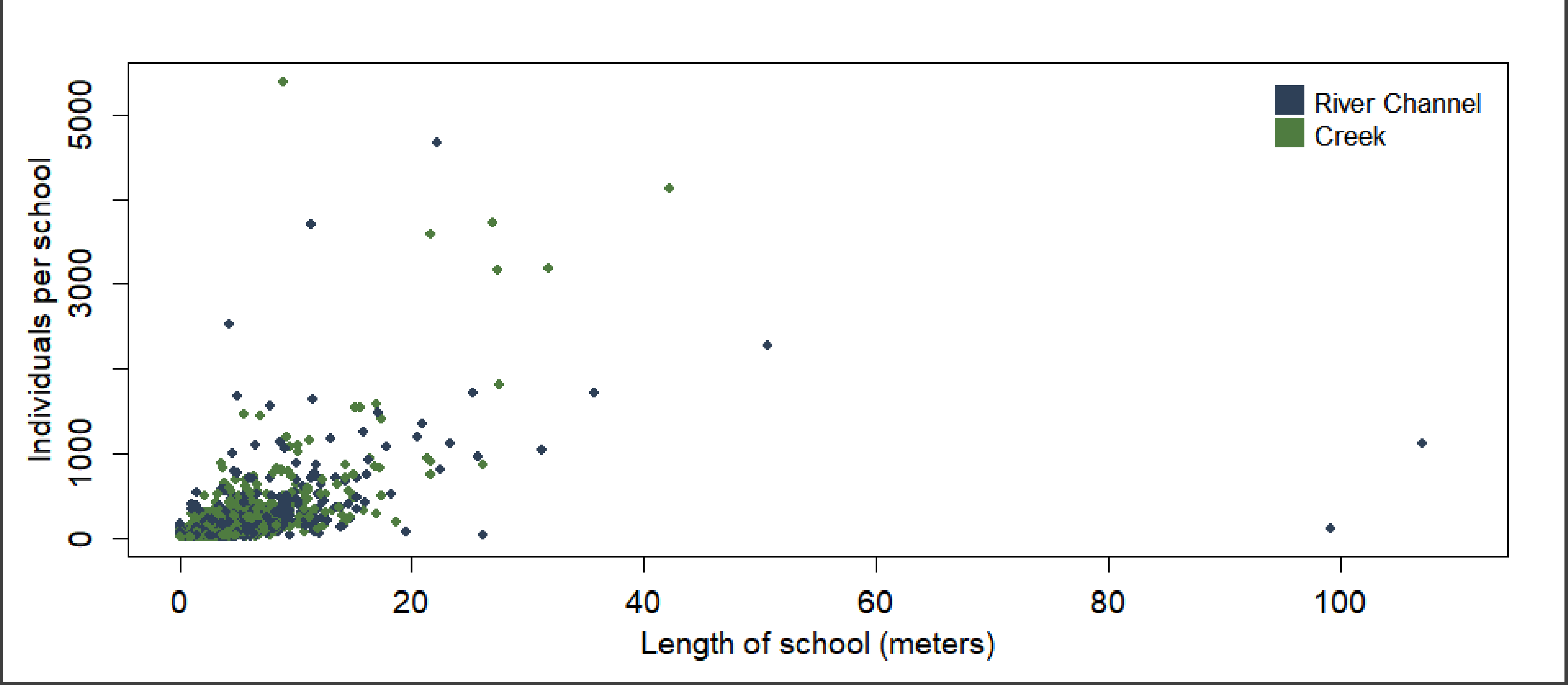


Length of schools

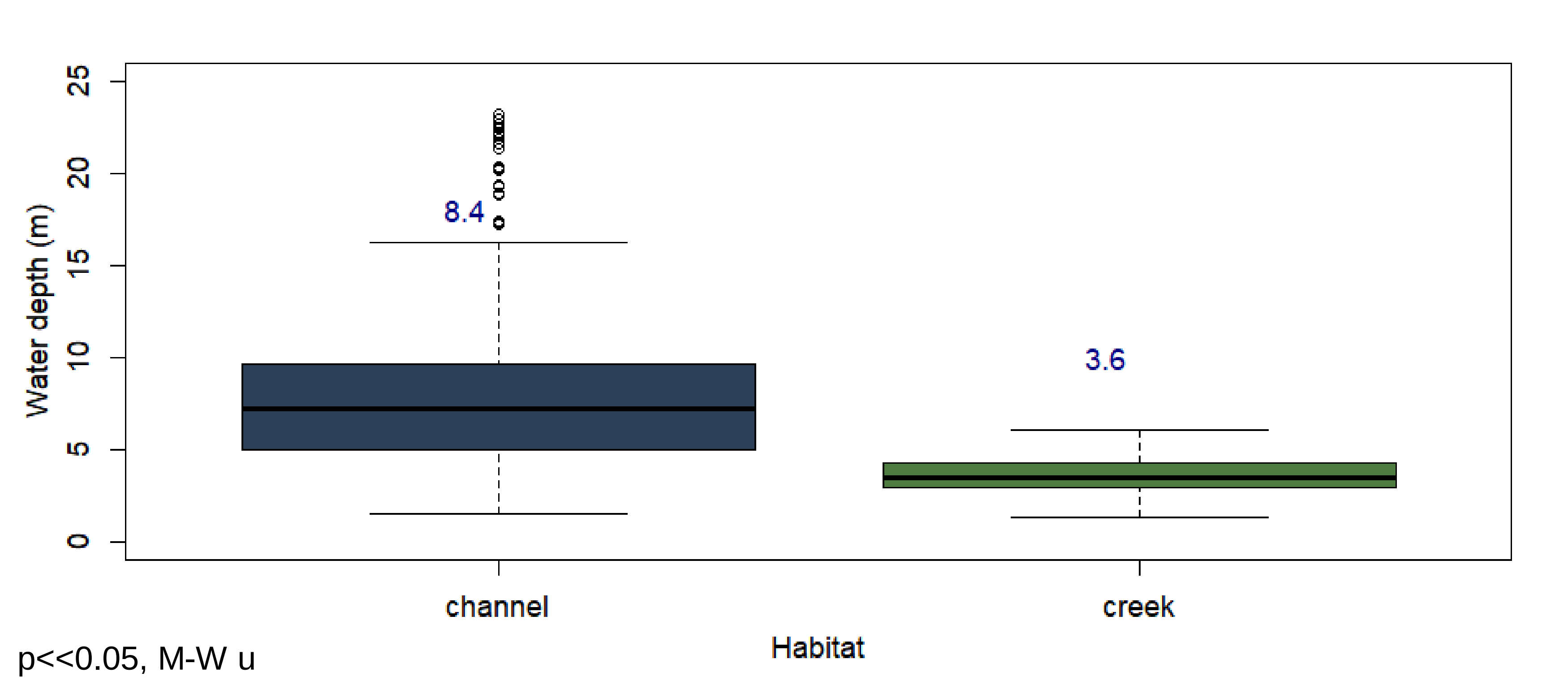


p<<0.05, M-W u

Length and size of schools

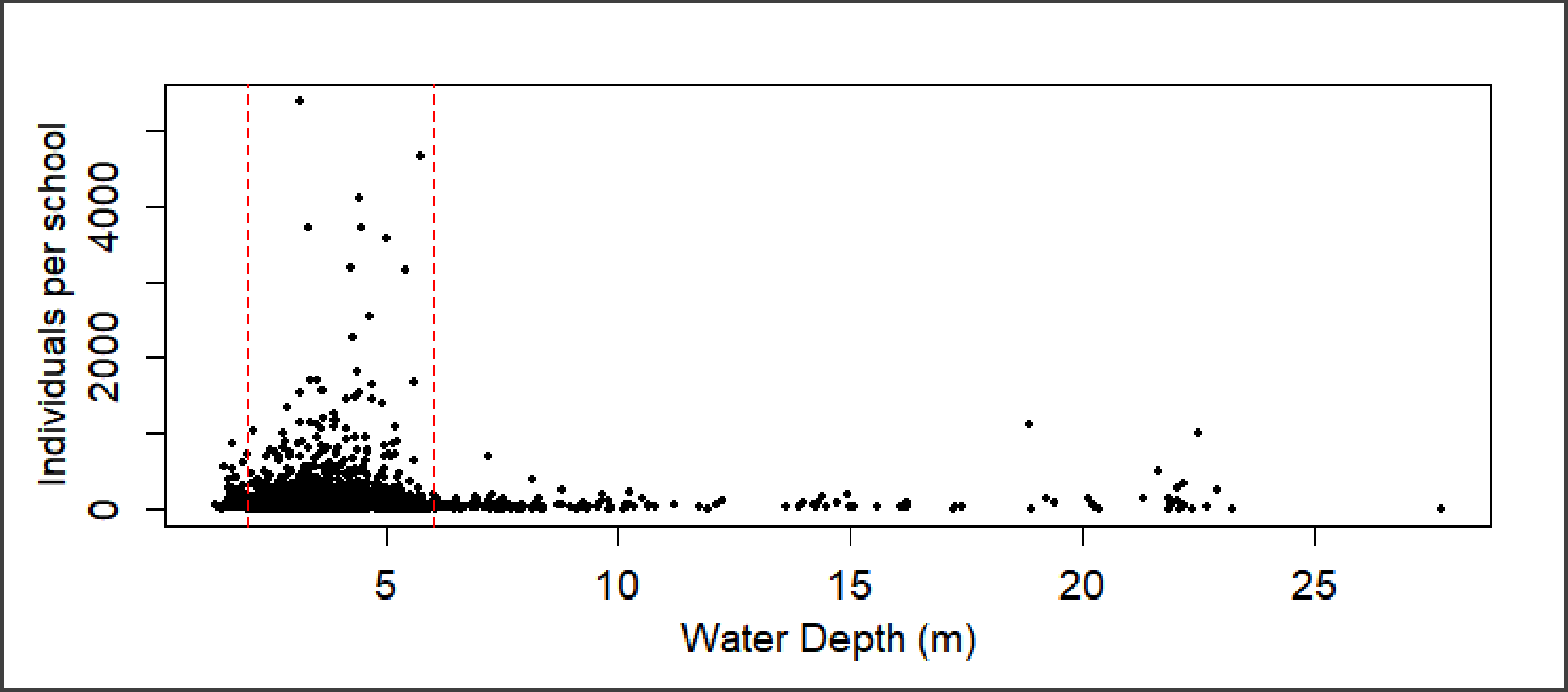


Bathymetry

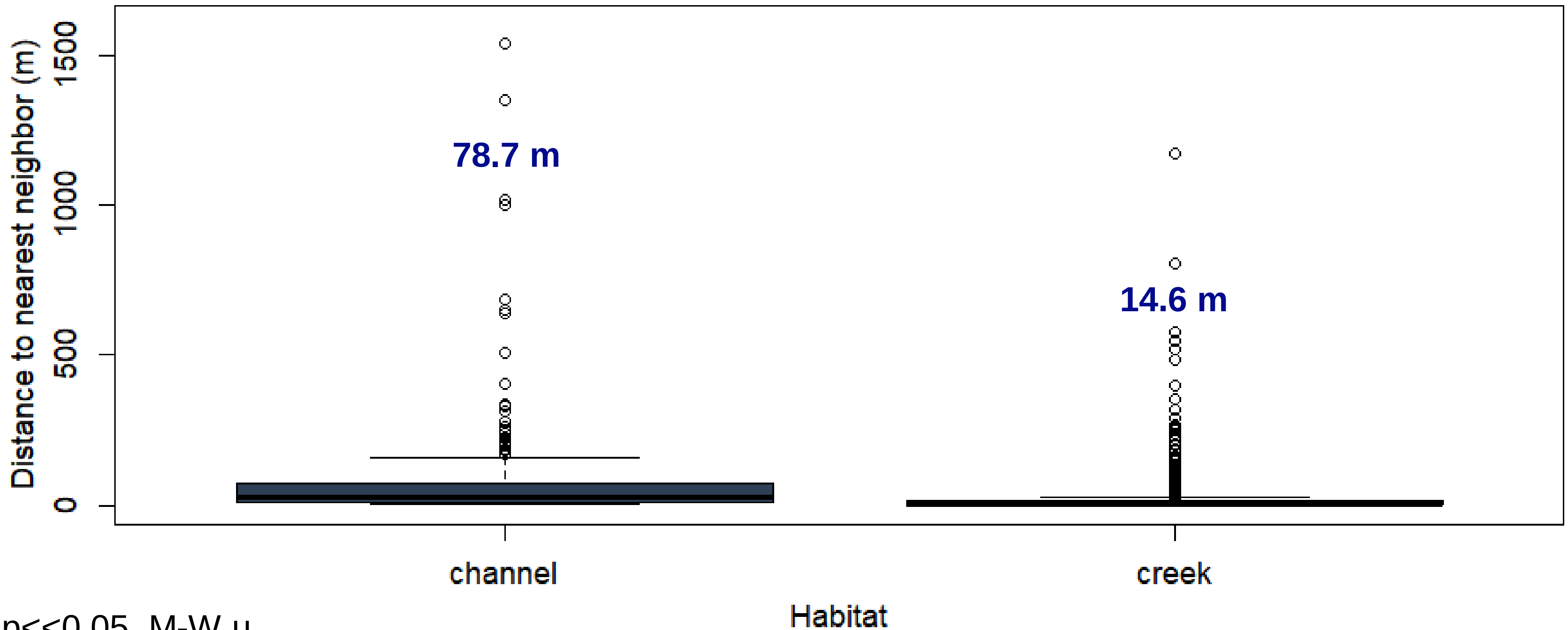


25
20
15
10
5
0
Water depth (m)
8.4
3.6
channel
creek
Habitat
p<<0.05, M-W u

Bathymetry



Proximity to nearest neighbor



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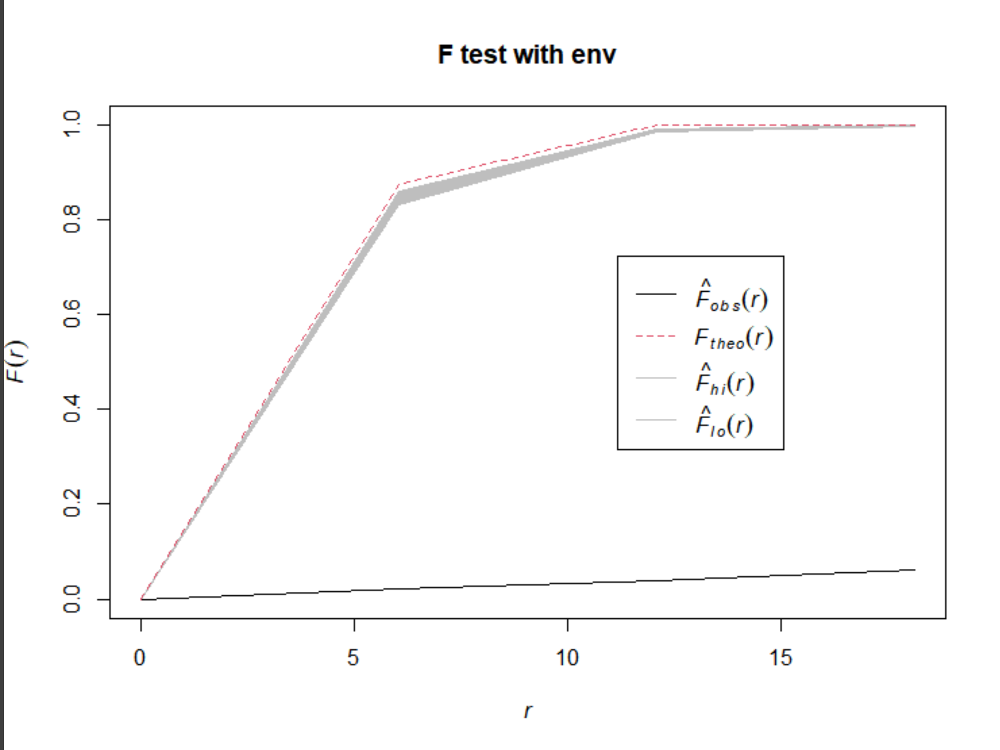
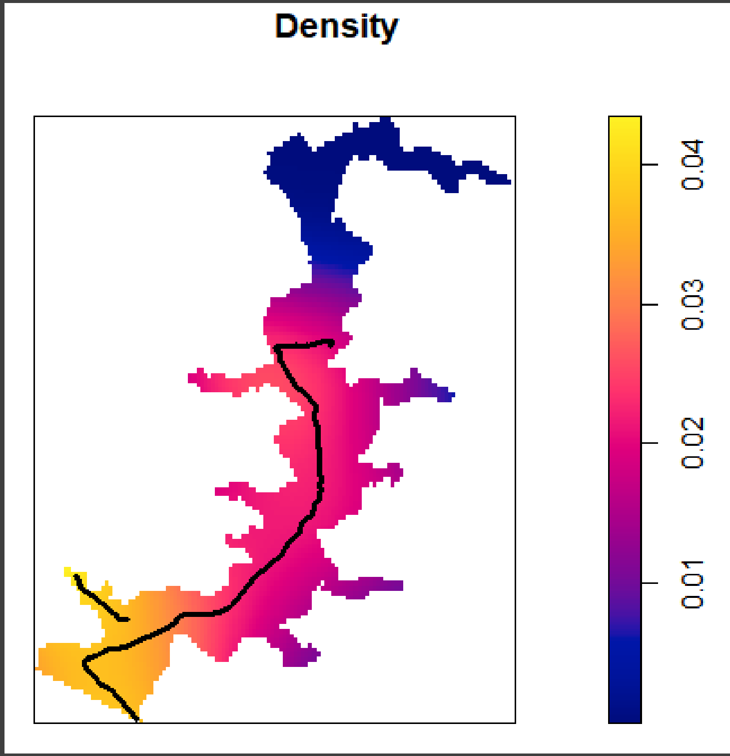
Clustering of schools





- Preliminary results indicate that schools occur in clusters; results are statistically significant for all sampling days and transects in 2016.

Conclusions

- High inter-annual variation in observed population size, trends upwards as summer season progresses
- Most observed schools had fewer than 100 fish and were found in waters 2-6m deep
- Number of forage fish observed in the three creeks was 13 times larger than the number of forage fish observed in the river channel
  - In creeks: More schools, more individuals per school, shallower water, closer spacing within and between schools
- Schools occur in clusters within habitat area and are not evenly or randomly dispersed (preliminary result)

Next steps

- Assist in developing machine learning methods to enumerate individual fish per frame, cut down on processing time
  - 4 total years of data, only 2 processed so far
- Examine patterns of spatial distribution and abundance across multiple spatial scales
- Bayesian approach – matrix variate Gaussian graphical modeling
  - Multivariate, multi-scale species distribution modeling

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Nathan Hirtle

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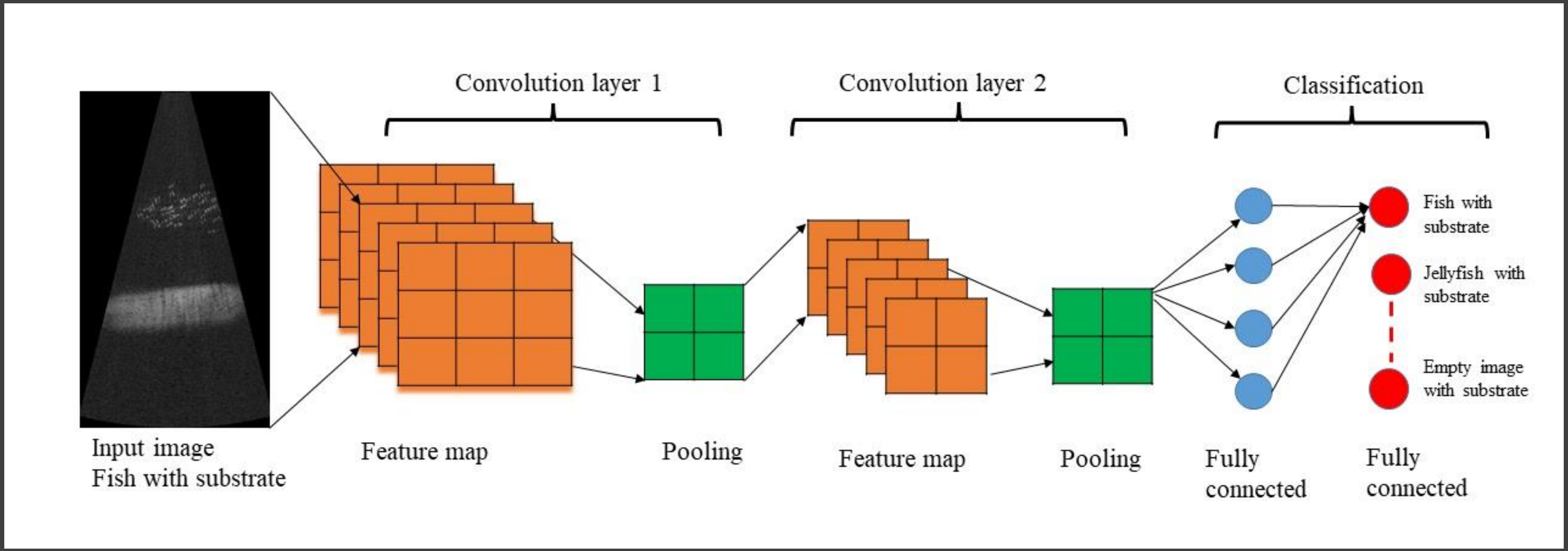
Content-based image classification



- Limited morphological detail in ARIS images, relatively weak signal, highly variable image content and structure, variation in resolution from near to far field, disjointed beam pattern
- 3-module solution:
  - Convert ARIS files to image files
  - Classify images to categories based on contents using CNN
  - Image processing and enumeration

Content-based image classification