Seasonally migrating round goby in Lake Ontario: a case of missing adults?

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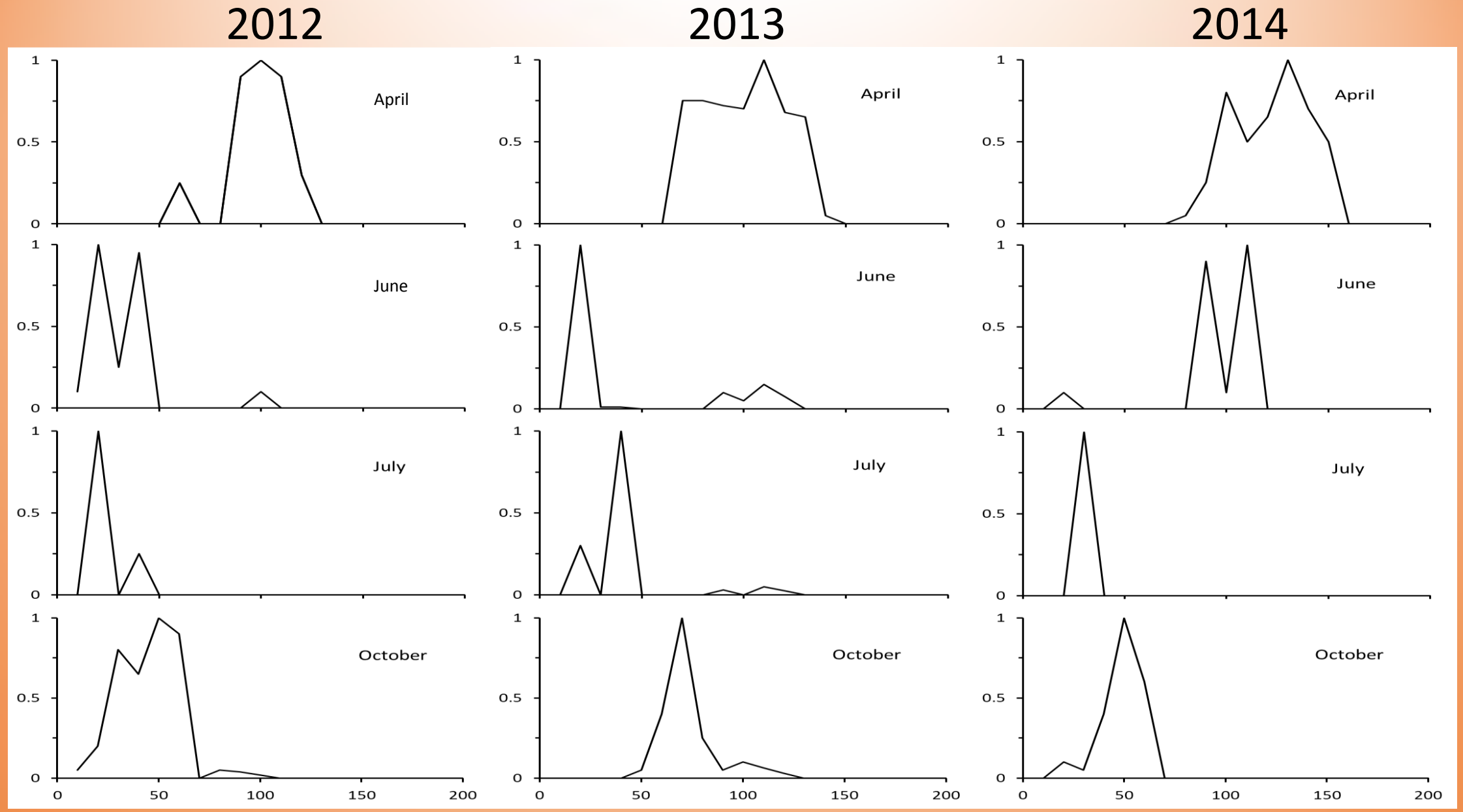
Animal migrations can have significant ecosystem impacts

- landscape changes via browsing or physical restructuring
- nutrient translocations
- prey subsidies
- etc.

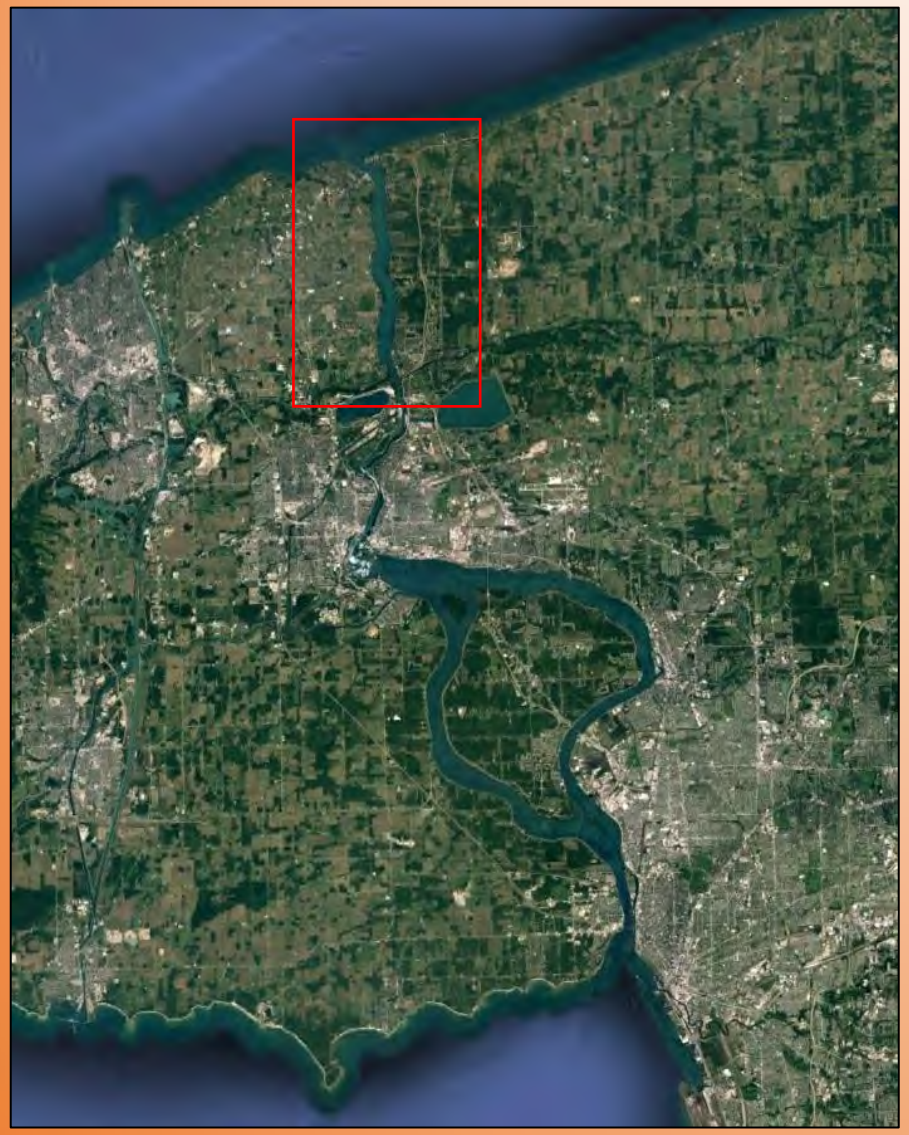
Do non-native species continue migratory behaviors in new ranges?
If so, how do they perform migrations (cues, destinations, etc)?
Can this behavior afford a management strategy?

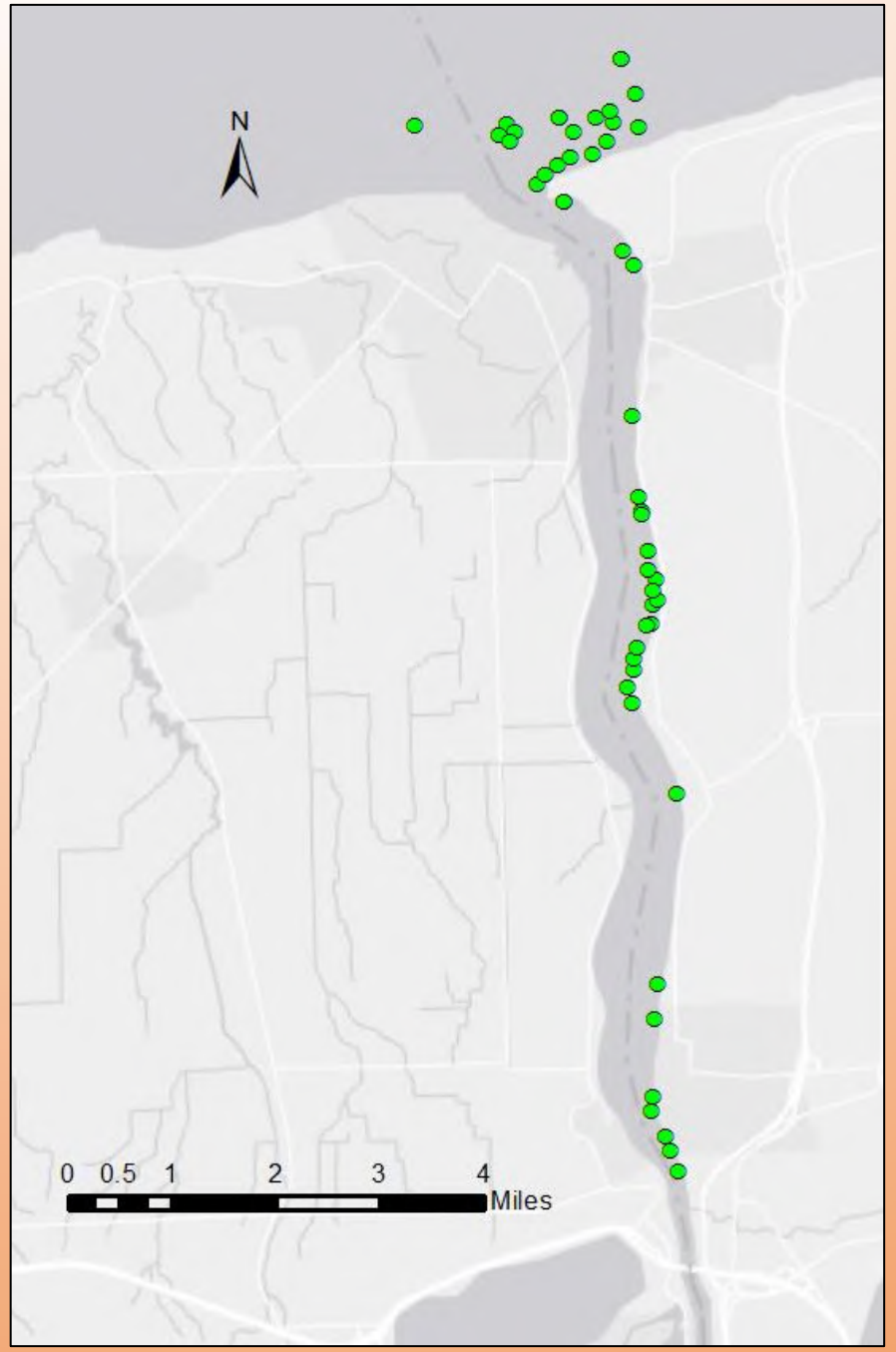
- Native to Caspian & Black Sea region
- First arrival 1990, St. Clair River
- Fused pelvic fin
- Nest guarding males, females can spawn multiple/year
- Planktonic larval stage
- Invertivore as juvenile, molluscivore as adults (*Dreissena*)
- Many populations engage in **annual OFS/ONS migrations** (Skaskina & Kostyuchenko 1968, Sapota & Skóra 2005, Walsh *et al.* 2007, Pennuto *et al.* 2010, Pennuto *et al.* 2012, Blair *et al.* 2018, Pennuto *et al.* in review)

Size structure implications


2012
2013
2014
April
June
July
October
Relative biomass
Depth (m)
0
0.5
1
0
50
100
150
200

Study Site





50 sites (Niagara River or Lake Ontario)

~1 – 20 m deep

Nearshore

6 sample dates (Aug, Nov, Feb, Jun, Sep, Dec)

Video-capture

Equipment and Field Survey

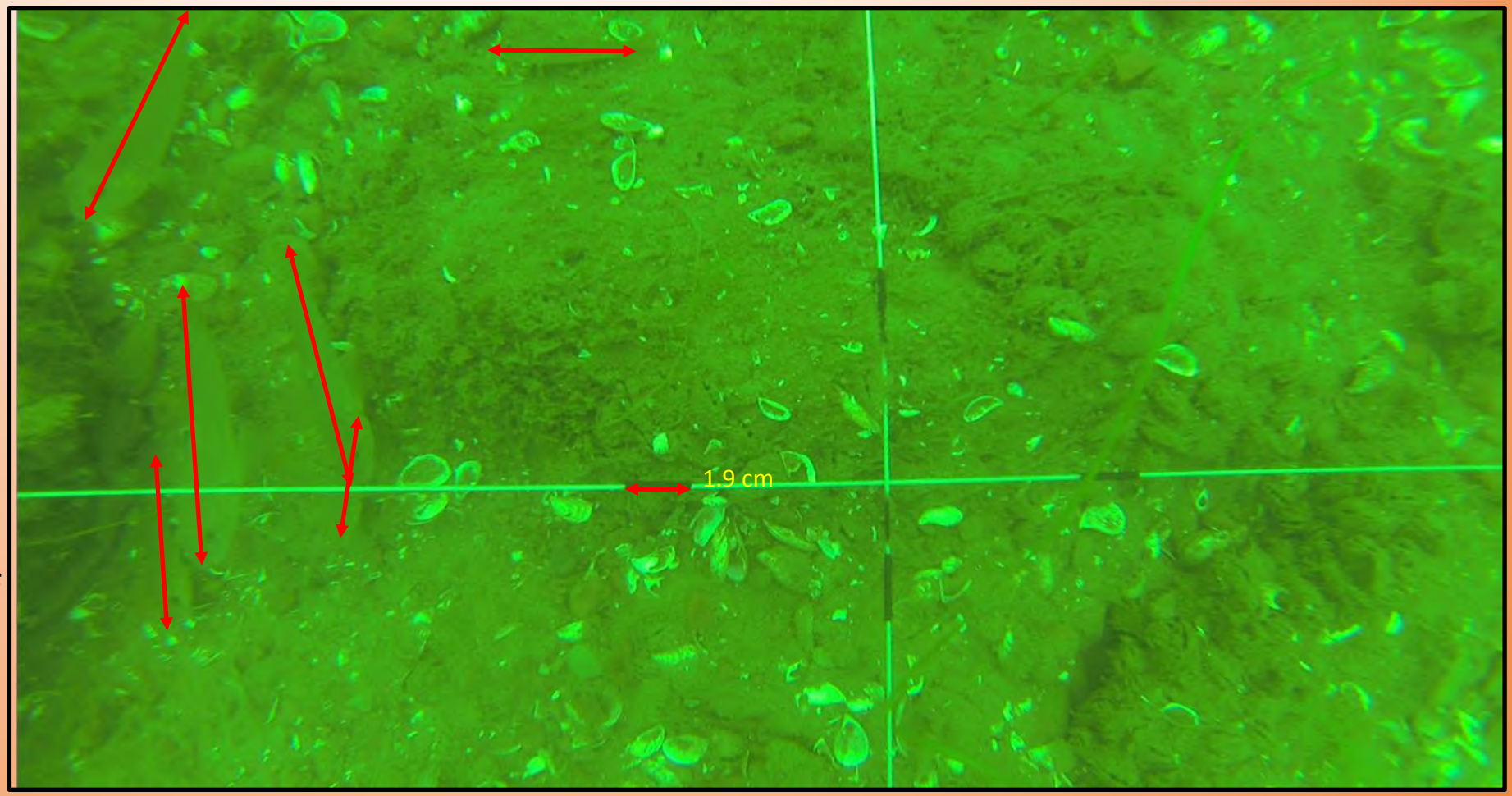
- GoPro Camera attached to frame, viewed 0.2 m^2
- At each site underwater video was recorded for 10 min, 5-min acclimation, then 5-min sample
- Surface temp from depth finder, long-term data from NOAA website

Methodology

Video was clipped into 5 still images at 1-min intervals

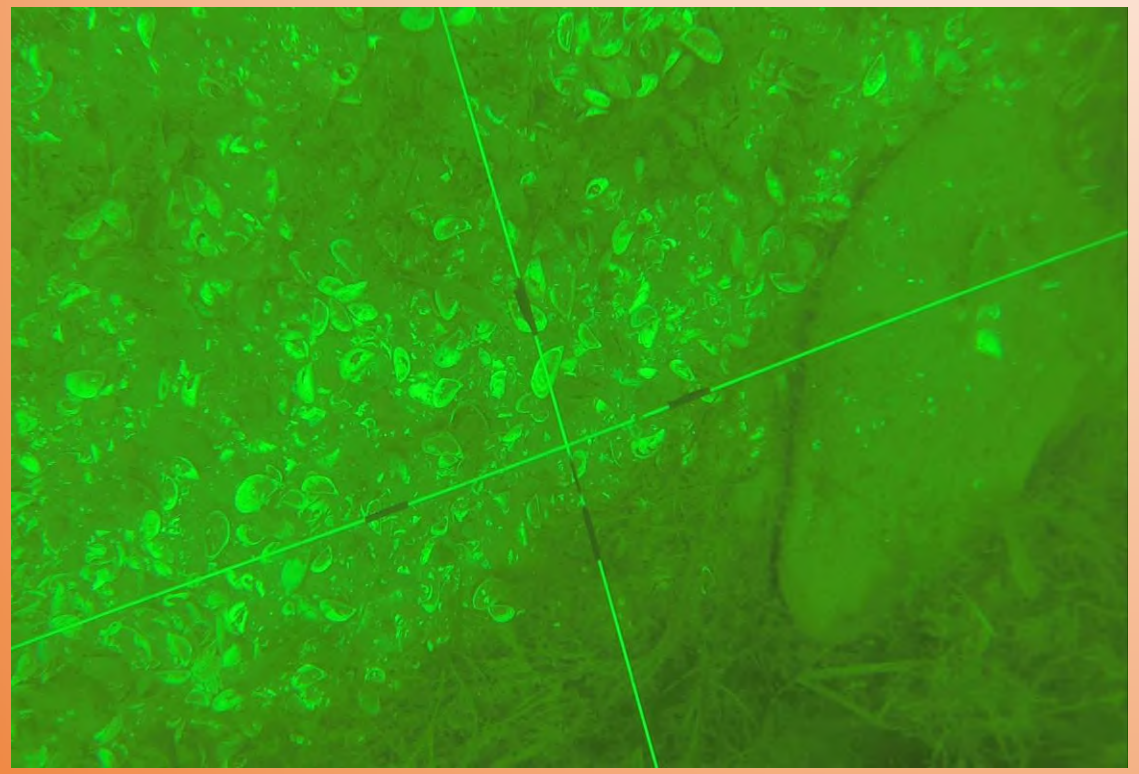
First five minutes were used as acclimation

At minute 6 thru minute 10, all gobies within frame were counted (n = 5) and measured (only if whole animal visible)

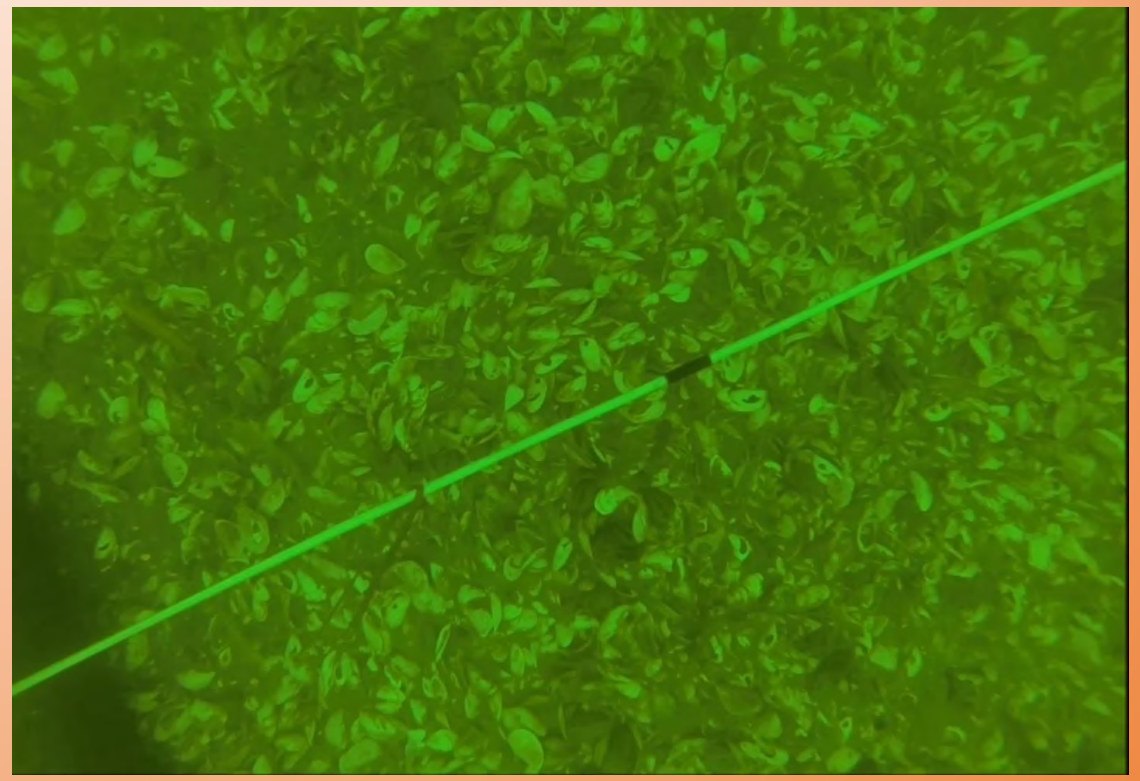


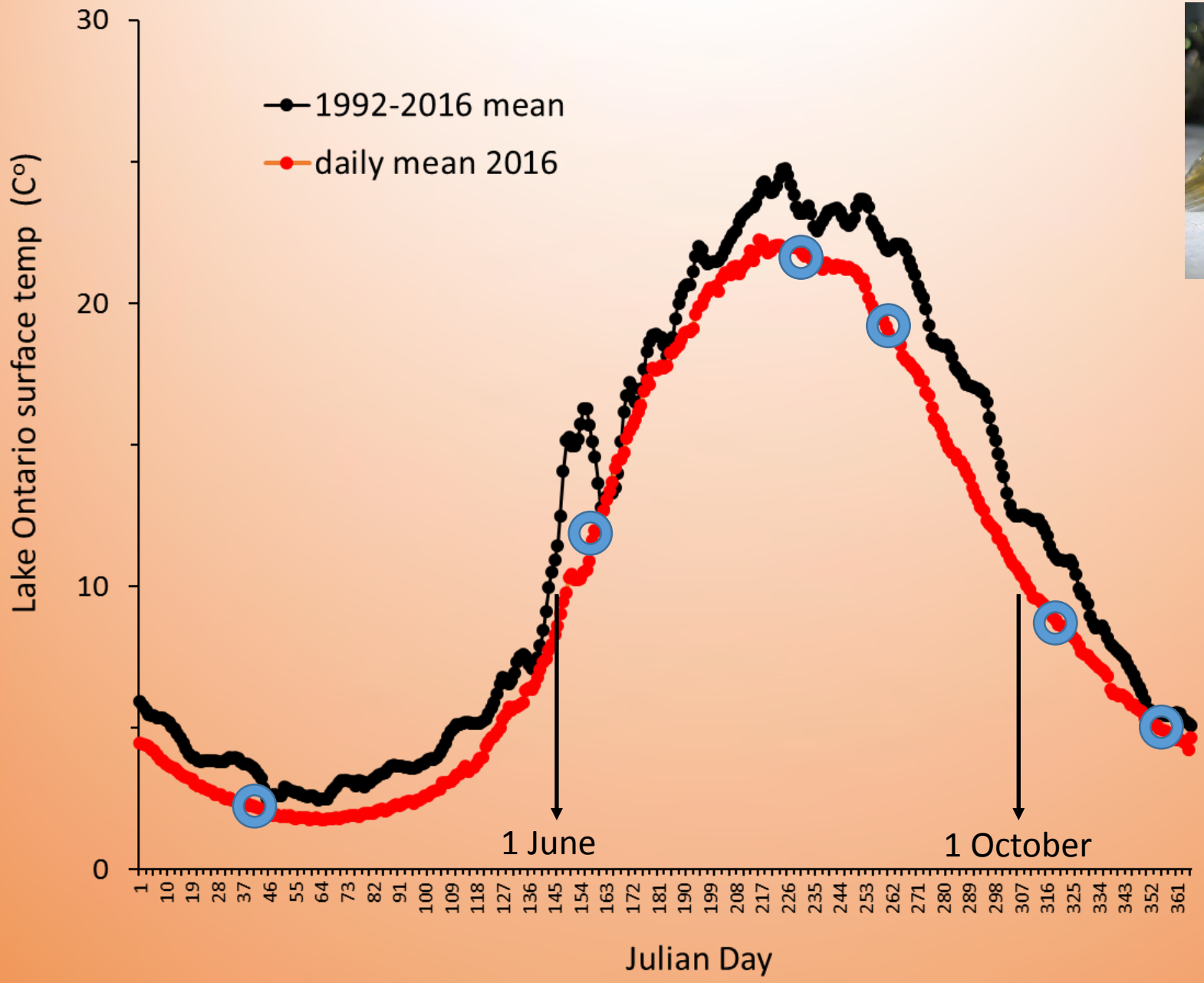
Results...tremendous reduction in nearshore goby density in winter

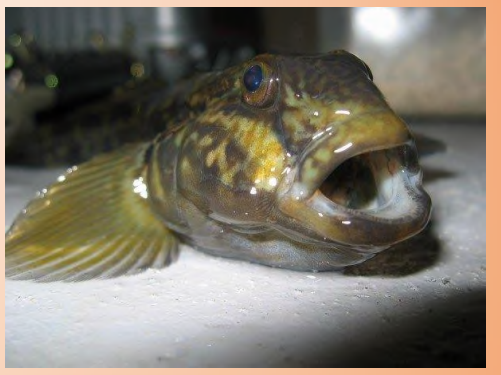
August 2016



December 2016







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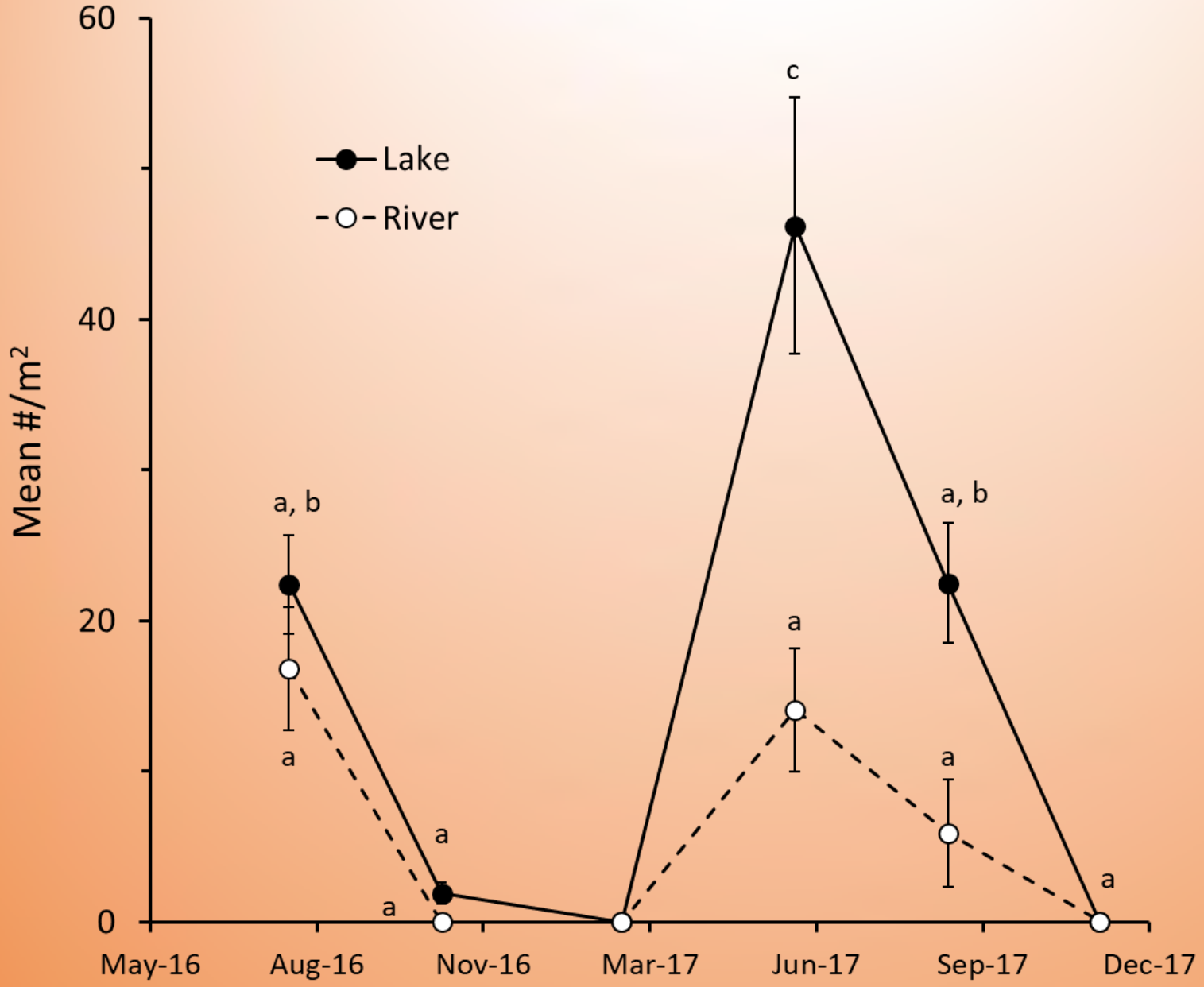
= sample date


60
40
20
0
Mean #/m²
Lake
River
c
a, b
a, b
a
a
a
a
a
May-16
Aug-16
Nov-16
Mar-17
Jun-17
Sep-17
Dec-17

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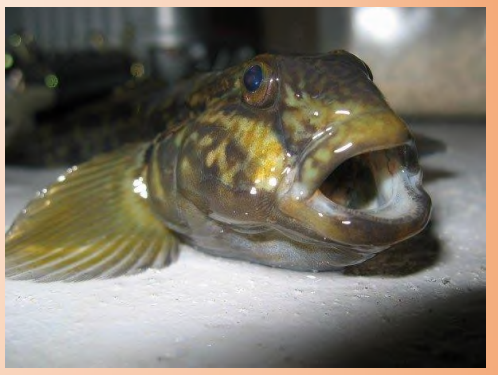
Running mean goby TL with 95% C.I.



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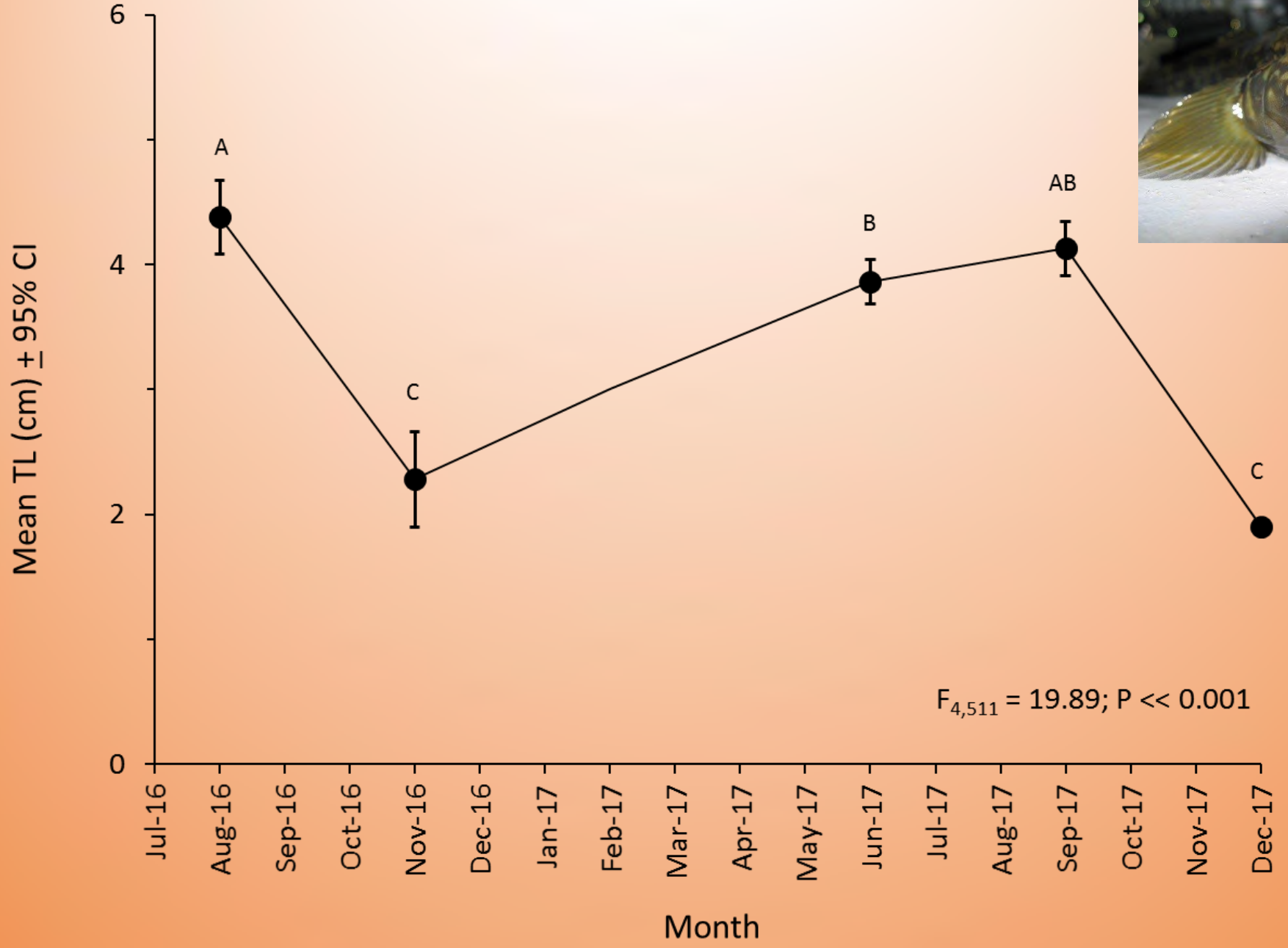

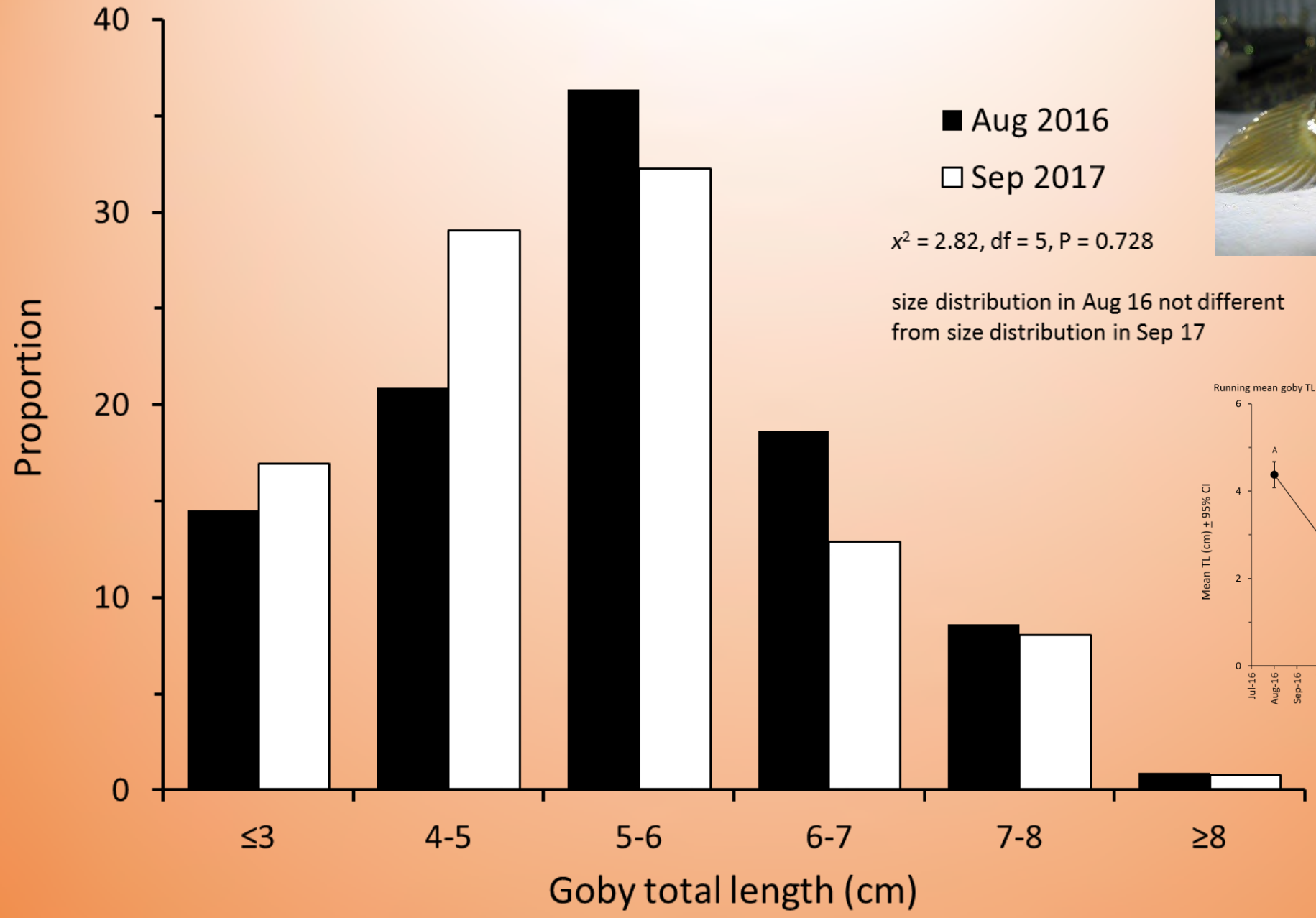

$x^2 = 2.82$, df = 5, P = 0.728

size distribution in Aug 16 not different from size distribution in Sep 17

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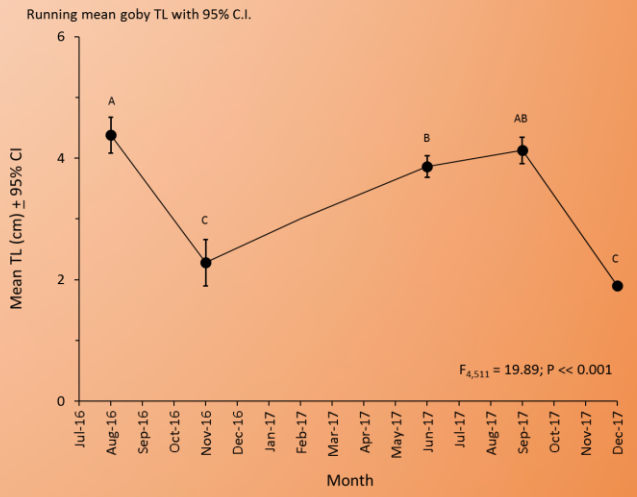

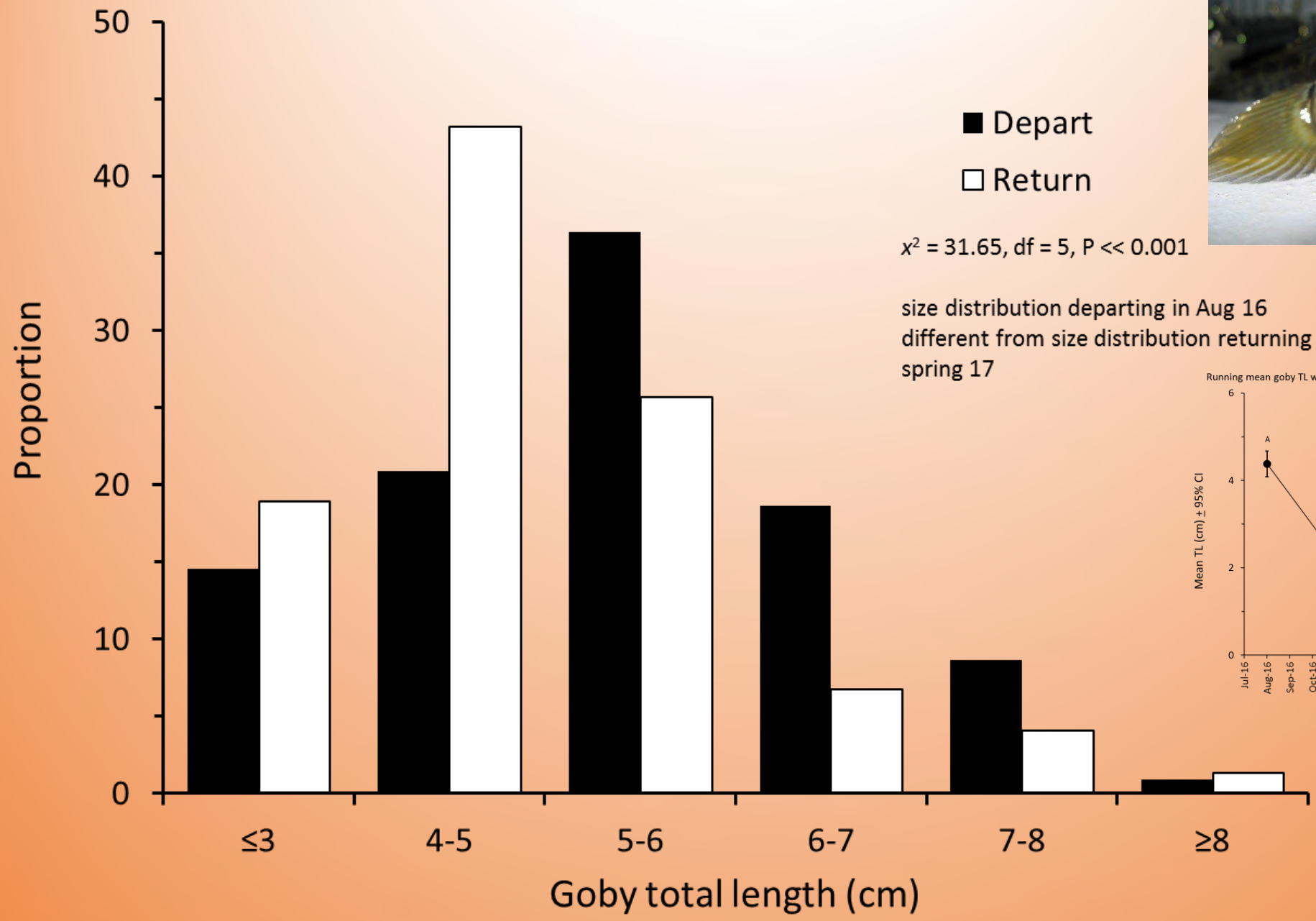

$x^2 = 31.65$, df = 5, P << 0.001

size distribution departing in Aug 16 different from size distribution returning in spring 17

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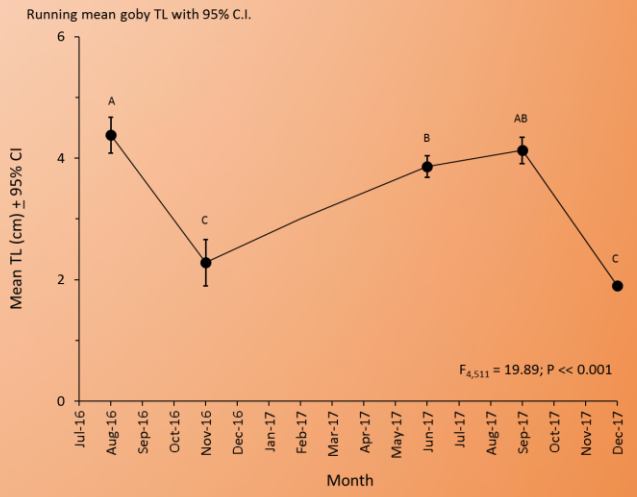

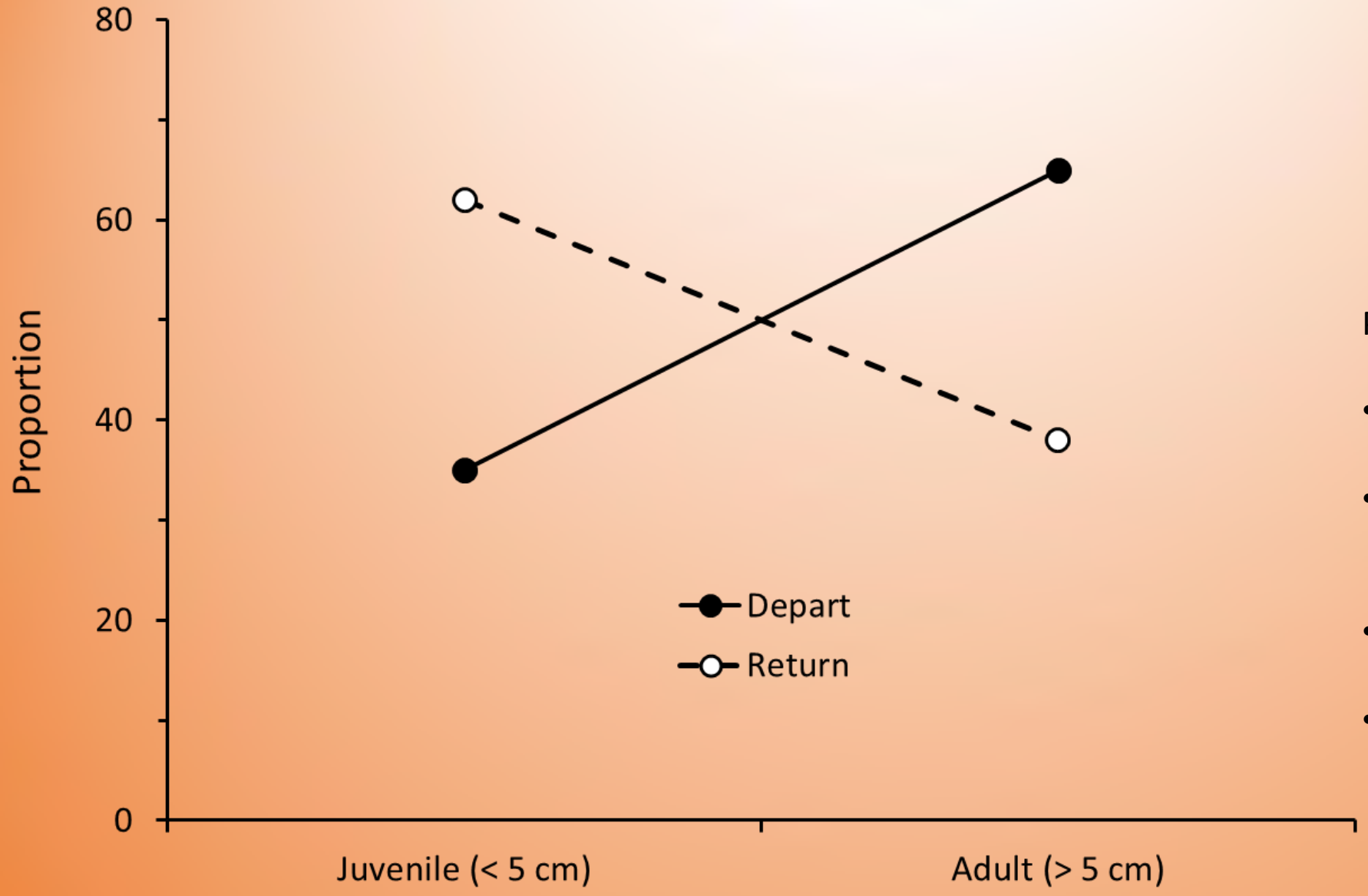

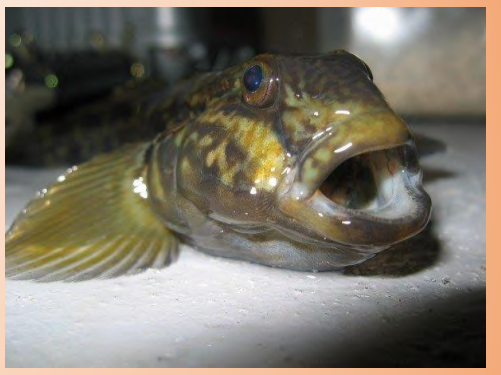

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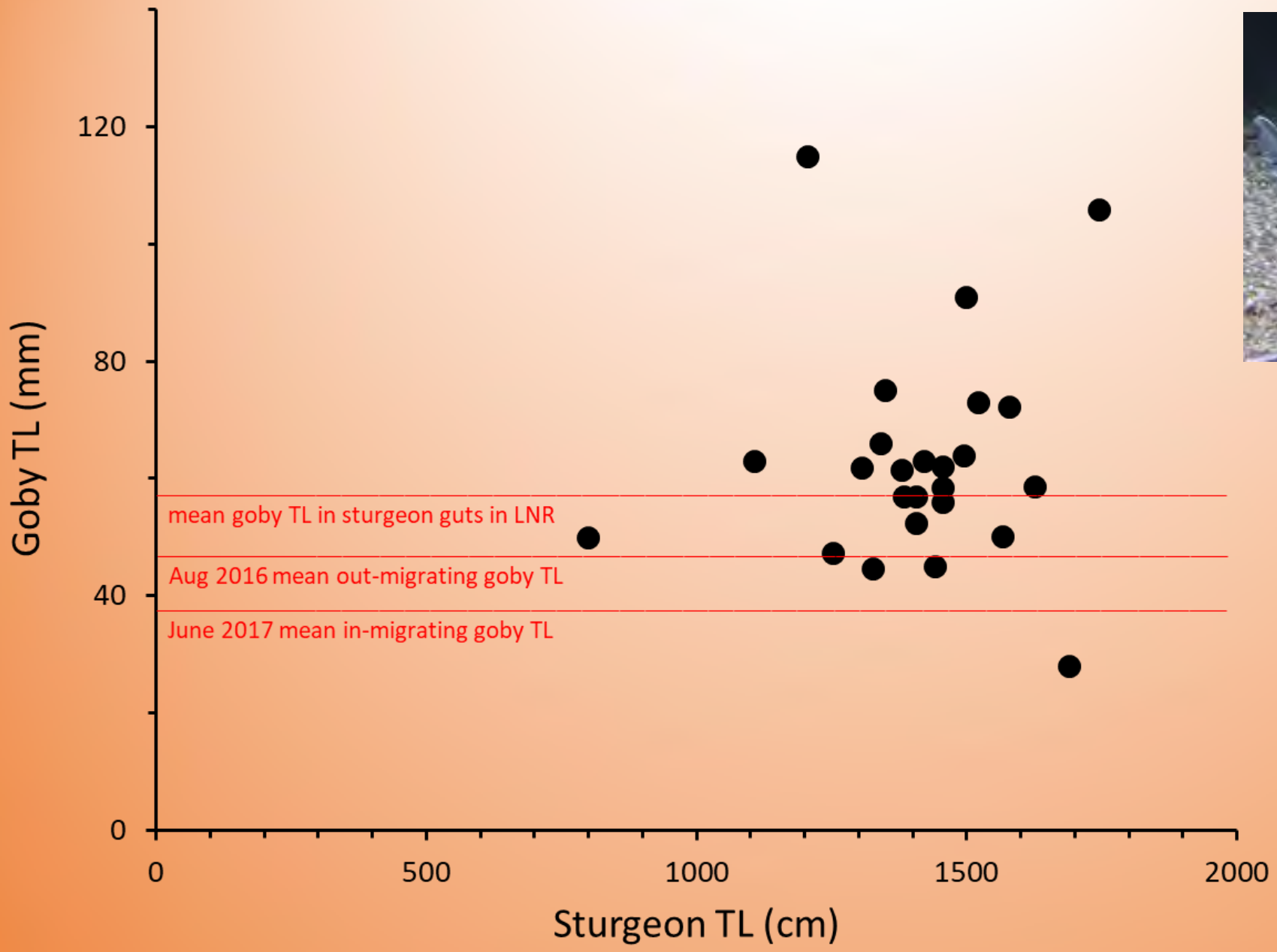
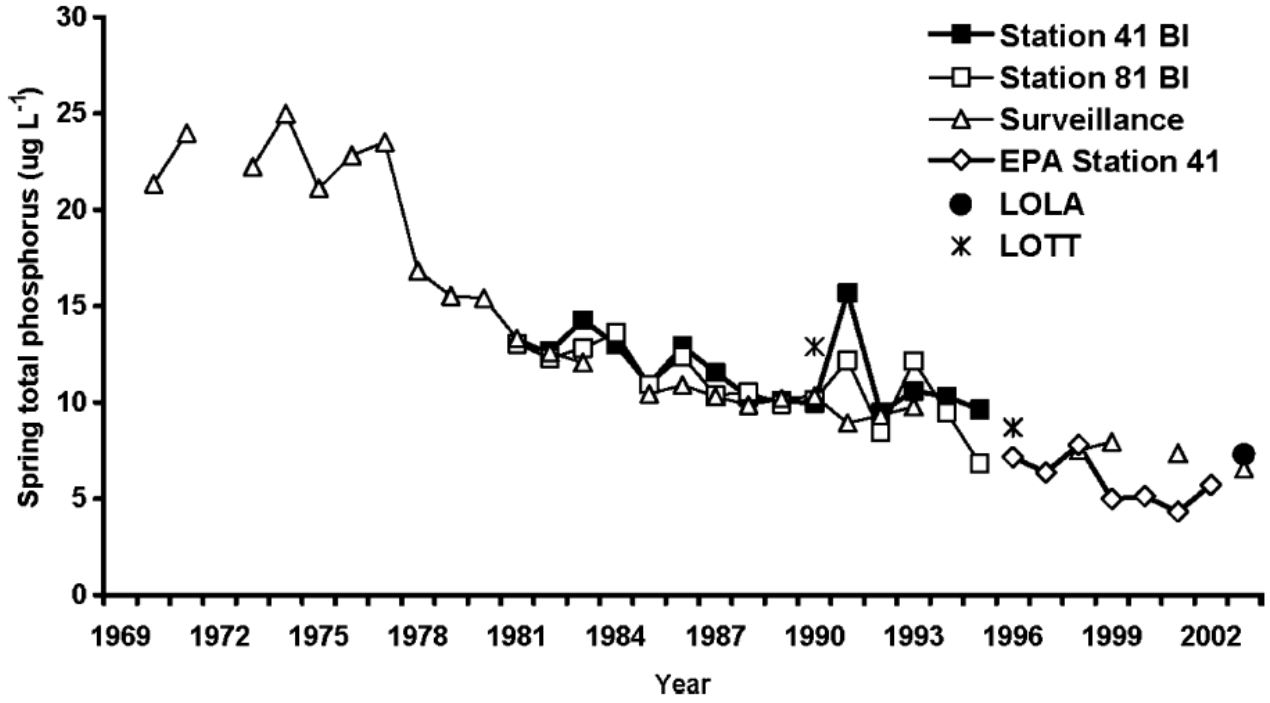
Possible explanations:

- YOY still too small to notice at outmigration
- outmigrating YOY grow enough during winter to observe in spring
- largest males already in spawning nests
- overwinter loss of large individuals


Goby TL (mm)
120
80
40
0
0
500
1000
1500
2000
Sturgeon TL (cm)
mean goby TL in sturgeon guts in LNR
Aug 2016 mean out-migrating goby TL
June 2017 mean in-migrating goby TL



gure 2. Spring total phosphorus trend in Lake Ontario, 1969–2003. Open and closed squares represent data from the Canadian oindex Program, 1981–1995. Open triangles represent data from the Canadian Surveillance project, 1969–2003. Open diamonds present data from EPA station 41. Asterisks are the lake-wide spring means from the LOTT study. Closed circle is the spring ke-wide mean for 2003. (Holeck et al. 2008)

Length-weight regression to convert to biomass:

Wet mass (g) $0.00896*TL^{3.1543}$
($R^2 = 0.984$, $F_{1,248} = 1109.4$, $P<<0.001$; Pennuto and Rupprecht 2016)

P in whole goby + 0.00585 g P/ g wwt (Bunnell et al. 2005)

~38 mT P in goby tissue in summer NS

~6.5% of monthly total P load entering U.S. waters heads offshore in ~ 3 week span

Annual mortality rate of 54% suggests ~20.5 mT P remains offshore

Conclusions

Round goby begin ONS movements by April, hyperabundant in NS in July/August (23 ^{o}C), begin OFS movements by October, and absent from nearshore by late November (9 ^{o}C)

Outmigrating population ~62% adult fish (>5 cm), but returning population ~65% juvenile fish (<5 cm)

Mean of ~200,000/ha (20/m^2) during summer in nearshore (~1-20 m depth)

Implications for nutrient translocation (~20.5 mT P), prey subsidies to offshore, prey base for other nearshore invertivores

Need further information on migratory cues (temp? photoperiod? spring bloom?) and navigation tools (olfactory? landmarks? geomagnetic?) to fully understand

Acknowledgements

GLC staff (M. Clapsadl, B. Haas) for boat use, WNY PRISM outreach