

The Round Goby Botulism Connection

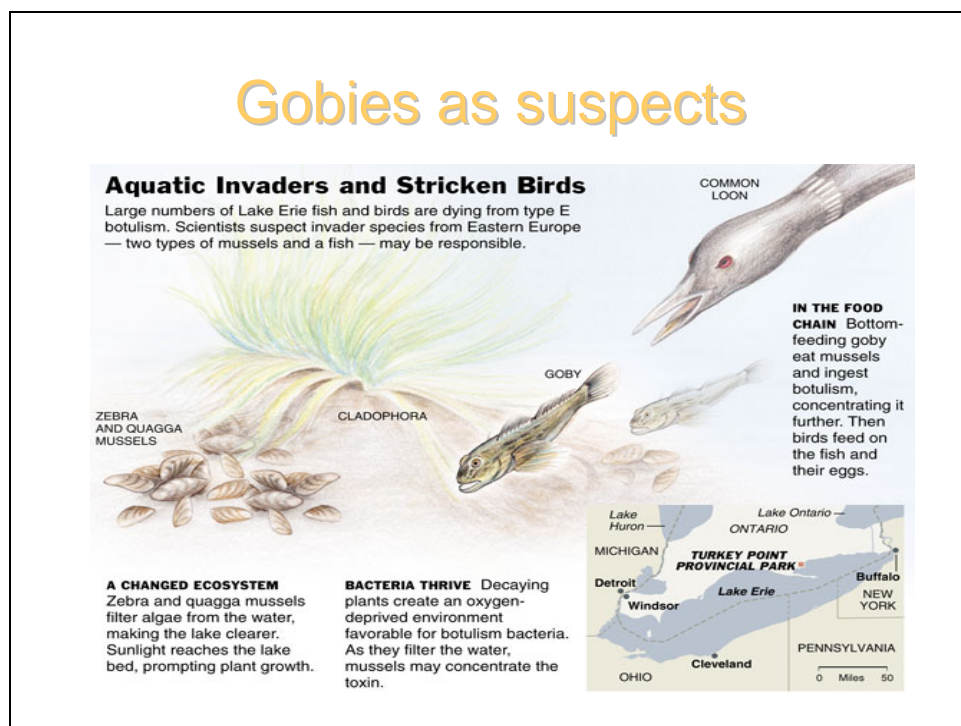
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Round gobies in Pennsylvania waters of Lake Erie

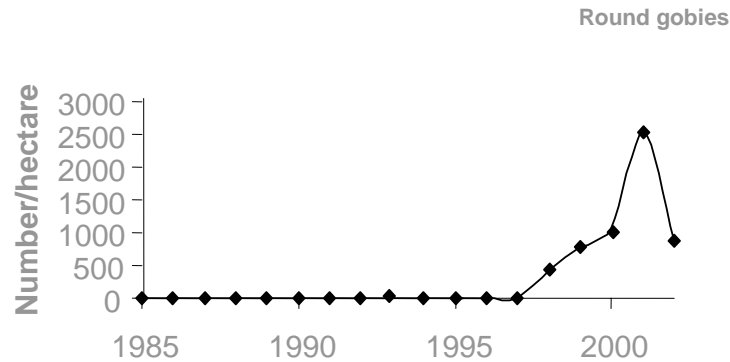
- First goby caught in Lake Erie was in 1993, in Grand River Harbor, Ohio.
- Found in 1995 at the mouth of the Ashtabula River.
- October of 1996, caught off of Presque Isle by the Pennsylvania Fish and Boat Commission.

Goby population expansion

- Round goby population increased exponentially over the next several years.
- This population increase coincided with increases in cases of avian botulism.
- Were round gobies playing an important role in this outbreak of avian botulism?



Populations declined in 2002



Are round goby populations being effected by avian botulism?

No real evidence of this.

- Inshore populations have increased rather than decreased.
- No large amounts of gobies found when there have been large fish kills, with the exception of the summer of 2002 and this appeared to occur with a cold-water upwelling.
- Large males are known to die after spawning events.
- Do not see evidence for this while diving.

Do round gobies contribute to the avian botulism problem by carrying botulism?

- Diet studies have shown that gobies in the lakes do consume large numbers of zebra mussels.
- Gobies could perhaps acquire botulism from the ingestion of mussels.
- Transfer botulism to fishes and birds that prey on them.

Ward Stone Lab Results

- Gobies are susceptible to the botulism toxin.
- Majority died within 24-hours of ingesting botulism infected loon livers.
- Botulism infected gobies tend to move slowly and erratically.
- Remained on the bottom even after death.

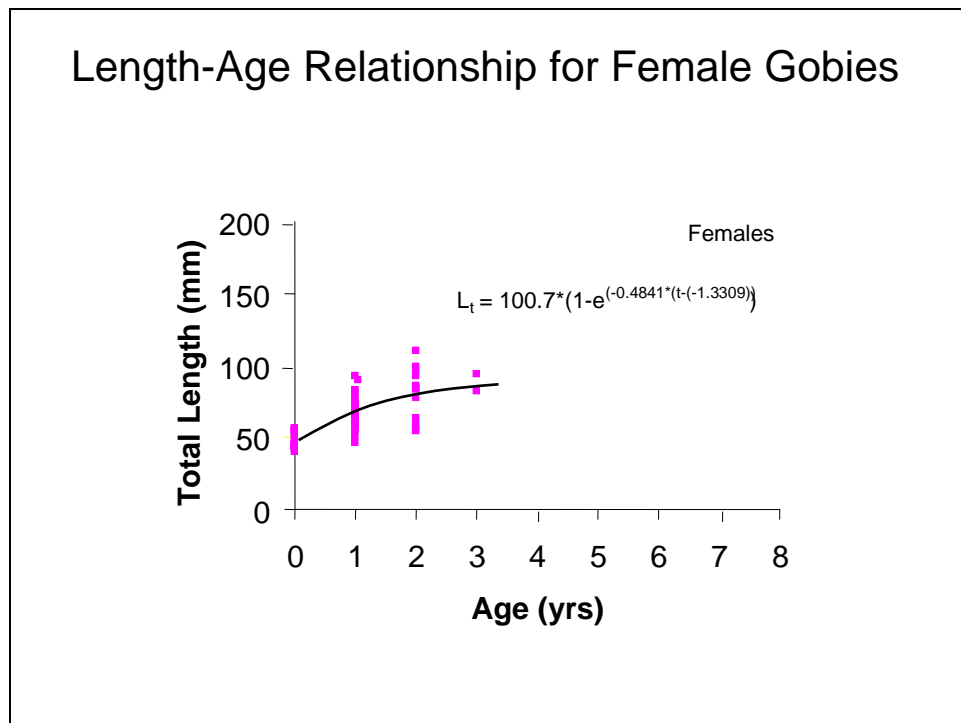
Sick Phase

- Make them more susceptible to predatory fishes.
- Transfer method for botulism from mussels to larger game fish.

- One problem with this is that you would expect to see more bottom scavenging fishes, like catfish and carp, affected as well.

Goby Studies

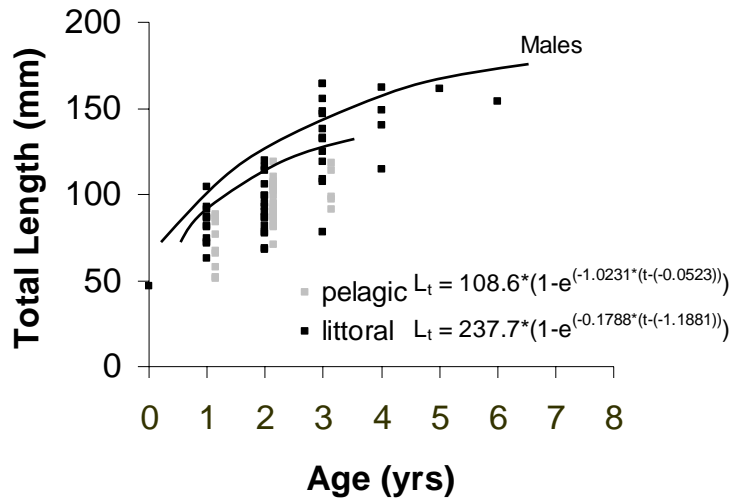
- Age vs. Length and Sex.
- Diet studies examining frequency of goby prey by size class between the lake and bay.
- Examining the total amounts of prey between stream, bay-dwelling gobies by season.
- Diets of game fishes.



Length Age Relationships for females

- The Von Bertalanffy equation for female gobies.
- $L_t = 100.7 * (1 - e^{(-0.4841 * (t - (-1.3309))})}$
- The oldest female was approximately 3-years of age at a length of 110.3 mm.
- Substantial variation within age classes.
- Probably caused by multiple spawning events throughout the season.

Length-Age Relationship for Male Gobies



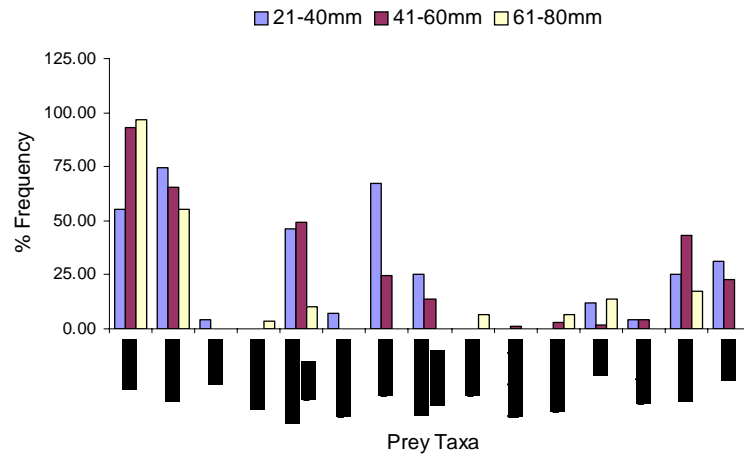
Length Age Relationships for Males

- Oldest male was approximately 6-years old at 164.5 mm.
- Again, there is substantial variation within age classes.
- There was no difference between theoretical maximum length of pelagic and littoral males.
- Differences in K indicate that pelagic and littoral males are on different growth trajectories.
- Difference may be due to different habitat or sampling differences.

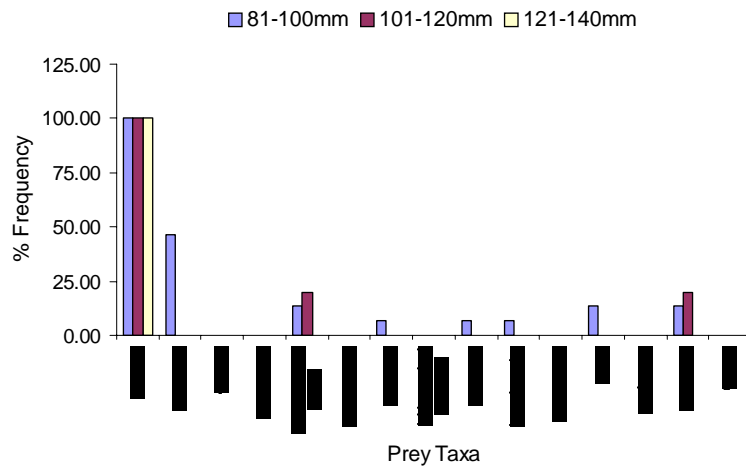
Goby Diet Studies

- Two different studies in which several different comparisons were made.
- Differences between stream vs. lake gobies.
- Diets of males vs. females.
- Comparisons of diets among different size classes.

Gobies smaller than 80 mm

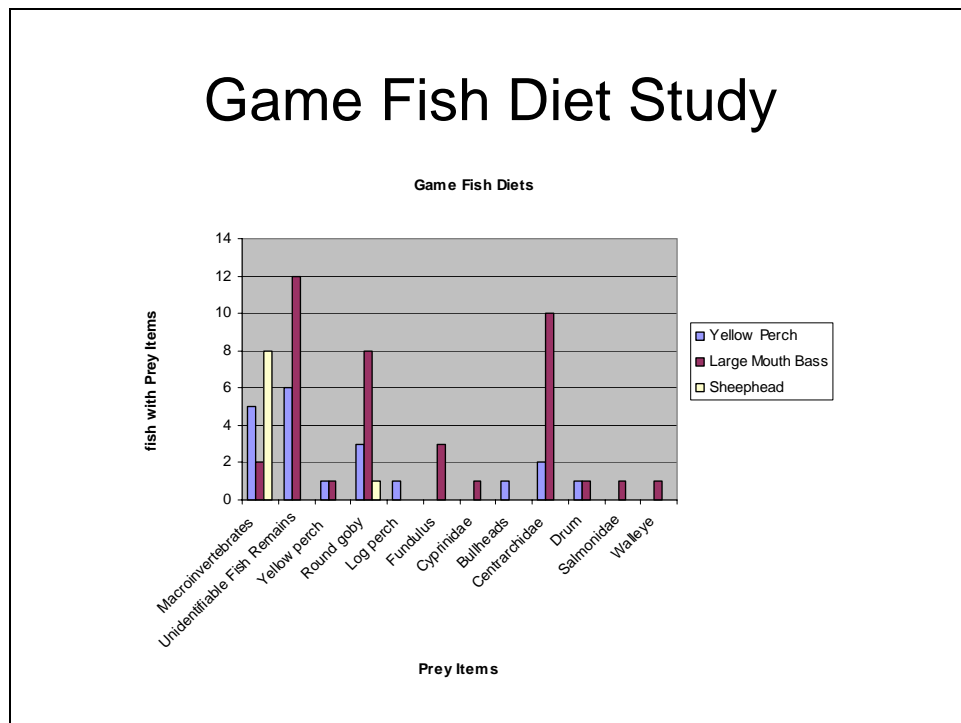


Gobies Larger than 80 mm



Goby Diet Results

- Female gobies (which tend to be smaller) have a more diverse diet.
- Stream gobies, regardless of size, tend to eat many fewer (almost no) mussels, as compared to lake gobies.
- Gobies larger than 80 mm (Age 1+) feed almost exclusively on mussels.



Diet Study

- 22% of largemouth bass, 16% of yellow perch, and 10% of sheepshead fed on gobies.
- Sheepshead also fed on large amounts of chironomid larvae.
- Other fishes, such as blue gills, occasionally fed on gobies as well.

PAFBC Yellow Perch Diet

- June 2001 - Oct 2003 PAFBC collected 927 yellow perch.
- 19% of fish with prey in stomachs were eating round gobies.
- Only 5% of these fish were eating gobies of age 2+.

Discussion

- Results of our studies and others indicate that almost all predatory fishes are feeding on round gobies.
- Larger gobies (greater than 80 mm) are feeding almost entirely on mussels.
- If there is a connection between avian botulism found in mussels and gobies it is probably affecting fishes that can feed on larger gobies.

Goby Toxicity

- Fishes were collected randomly from May 2002 through May 2003, from the Pennsylvania water of Lake Erie (mostly from Presque Isle Bay) by hook and line and boat electro-fishing.
- Pennsylvania Animal Diagnostic Laboratory System at New Bolton Center received gobies.
- Conducted heavy metal analysis and assayed for botulinum toxin.

Fishes examined

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|----------------------------------|------------------|
| • 50 Round gobies | • 3 Crappie |
| • 25 Smallmouth bass | • 1 Bluegill |
| • 2 Largemouth bass | • 1 Yellow perch |
| • 5 Northern pike (one was sick) | |

Results

- No *Clostridium botulinum* found in any of these fishes.
- *Clostridium bifermentans* was recovered from intestinal samples of a round goby.
- Arsenic levels were detectable in all of the fish livers examined (0.207 ppm in a northern pike (*Esox lucius*) to 6.07 ppm in a pooled group of goby livers).
- Hg values found in livers of sampled fishes in this study ranged from insignificant (<0.05) to 9.42 ppm, with gobies representing the extremes of the range.
- Hepatic levels of Se in this study ranged from insignificant in a bluegill (*Lepomis macrochirus*) to 2.27 ppm in a large steelhead (*Oncorhynchus mykiss*).

Discussion

- Extensive numbers of investigations have indicated that heavy metals alter a number of parameters of the hosts' immune system and can lead to increased susceptibility to infection auto immune diseases and allergic manifestations.
- High levels of mercury, arsenic or selenium could be transferred up the food chain causing immunosuppression in fish-eating birds.
- For example, high levels of Se were found in a pelican that died from Type C avian botulism in the Sultan Sea in California.

What does all this tell us about the goby avian botulism connection?

- Gobies below 80 mm in length are not consuming large numbers of mussels.
- Gobies are not immune to botulism toxins.
- Larger gobies' behavior does not make them easy prey items for birds.
- Game fish are consuming large numbers of gobies; however, yellow perch appear to consume smaller sized gobies.
- We may need to examine multiple stressors in order to better understand this problem.

Acknowledgements

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