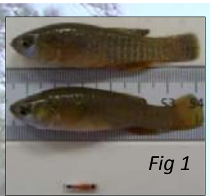

Fig 1

Using passive integrated transponder (PIT) tags to estimate movement and survival of mummichog (*Fundulus heteroclitus*) in a saltwater estuary

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Background

Passive integrated transponder (PIT) tags (Fig 1) have been used little in marine waters. However, they are attractive for studying fishes in low-energy saltwater estuaries because they allow for more detections and thus more precise estimates of vital rates relative to traditional mark-recapture methods (Hewitt et al. 2010).

Anthropogenic stress to the North Carolina coastal plain mirrors a global trend; estuaries are becoming more compromised in their ability to serve as nurseries for resident and transient fishes (Hinrichsen 1998). The mummichog, *Fundulus heteroclitus,* (Fig 1) is an ideal species by which to study impacts of anthropogenic habitat alteration to estuaries because they have small home ranges and exhibit high fidelity to home marshes (Lotrich 1975). To date, tidally-based movement patterns of this species have been estimated using changes in rates of relative abundance in different habitats and different tidal stages (Teo and Able 2003; Bretsch and Allen 2006) rather than ideally monitoring individual fish. We sought to determine the utility of PIT tags and a mutiplexing transceiver (Fig 2) as tools to monitor marsh residency, movement, and survival of mummichogs in a saltwater estuary.

Objectives

1.Determine feasibility of using PIT tag gear to monitor fish in saltwater.
2. Describe movement of mummichog in a tidal creek.
3. Estimate survival & detection probability.

Fig 2. Transceiver

We placed an array of three custom tag-detecting antennas and weiring near the mouth of Porters Creek, NC. Porters is a 600 m-long 2nd order polyhaline estuary with fringing *Spartina* marsh (background photo) with semi-diurnal tides. Depths near the array are ~1.0 m at MHW and 0.1 m at MLW (Fig 3). Current speeds average ~0.4 km/h on ebb tide.

A multiplexing transceiver recorded tag interrogations. We captured and tagged 43 mummichog near the array on Nov 8, 2010. Patterns of residency and movement were monitored from Nov 9 – 23, 2010. Generalized linear models (GLMs) were fit to these data to relate upstream/downstream movement to tidal direction, tidal stage (hourly depth), and lunar phase (daily depth). Estimates of detection probability and apparent survival were modeled with a Cormack Jolly Seber (CJS) model; the CJS model included water temperature as a covariate and was fit to data collected from Nov 2010 to May 2011.

Fig 3. Porters Creek PIT tag-detecting array at low- (left) and high- tide (right).

Results

The interrogation system made 14,006 detections over the 15 d period to examine movement in Nov 2010. The majority of interrogations occurred over depths <0.5 m (Fig 4). Detections decreased in frequency over depths shallower than those over which low antenna amperage (<~2 amps) compromised detection efficiency (Fig 4). The relationship between detection efficiency (instances of a detections by the middle antenna given detection by outer antennas) and depth was not significant (Fig 5).

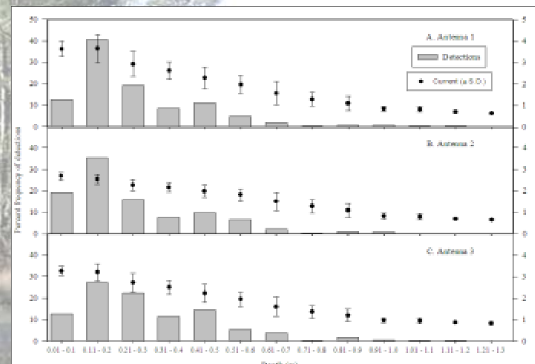

Fig 4. Detection frequency and mean electrical current (±S.D.) vs. depth for Porters Creek antenna array.

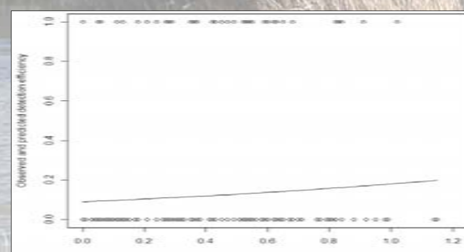

Fig 5. Detection efficiency success (1) / failure (0) for middle antenna and non-significant logistic curve.

Mean depth of movement past the array was shallow: 0.23 m upstream and 0.42 m downstream. Fewer fish moved past the array, and more stayed upstream, over neap tides (Nov 11-17) than spring tides (Nov 9-10 & 18-23) (Fig 6).

(Results, con't) The best fit GLM described movement as a function of tidal direction and depths, and their interactions. Upstream residency in the marsh creek increased around neap tides.

Forty tagged fish were resighted over six months ending May 2011. The median occasion-specific value of apparent survival (137 occasions) of 0.984 corresponded to ~90% loss over 6 months. Temperature was related to detection probability but not to apparent survival; greatest detection probabilities were associated with warmest occasions (Fig 7).

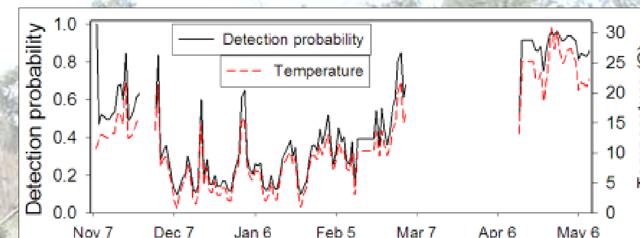

Fig 7. Detection probability and water temp: Nov 2010 – May 2011.

Discussion

Numerous detections allowed us to track fine-scale mummichog movements. Movements upstream early on flood tides and downstream late on ebb tides allow mummichogs to maximize marsh residency. Redundancy in the array (3 antennas) and a multiplexing reader allowed us to track movement even with imperfect detection.

We found that PIT tags and custom-made autonomous detection arrays can be applied in low-energy saltwater creeks, where resighting fish is difficult with traditional methods, to increase rates of detection and precision about estimates of movement and vital rates of marsh fishes. Future work in more marsh creeks will determine if these vital rates vary with habitat alteration.

Literature Cited

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Fig 6. Observed (triangles) and predicted movement (red line) up- (1) or downstream(0) (left y axis) vs. tidal depth (line) & lunar depth (large dots) (right y axis).