Investigating Feasibility of Acoustic Telemetry and Habitat Use of Adult Hickory Shad, *Alosa mediocris*, in the Mullica River/Great Bay Estuary, New Jersey

Gregory A. Henkes[1], Thomas M. Grothues[2], and Kenneth W. Able[2]

[1]Bates College, Department of Biology, 363 Bates College, Lewiston, Maine 04240

[2]Rutgers University Marine Field Station, Institute of Marine and Coastal Sciences, 132 c/o 800 Great Bay Blvd., Tuckerton, NJ 08087

Abstract

Hickory shad, *Alosa mediocris*, is an anadromous fish classified with its more abundant congeners as "river herring". Little is known about the ecology of hickory shad because of low abundance and false identification. We utilized acoustic telemetry to track the movements of hickory shad within the Great Bay/Mullica River estuary. Mobile distribution tracking following an established protocol for other species in a established grid failed to relocate any tagged hickory shad; however, they were tracked by a complementary fixed hydrophone array in the estuary. Hickory shad retained gastrically implanted tags in tanks and at liberty. Captive tagged specimens experienced mortality similar to untagged captives probably related to captivity, but tags may interfere with eating over long scales. Hickory shad entered a small embayment at night near or on high tides. This behavior and others may make the species cryptic to established hydrophone sampling designs.

Introduction

The hickory shad is an anadromous fish that shares similarities with other closely related river herrings such as the more abundant blueback herring, alewife and American shad. All of these species ascend coastal rivers and streams during the spring and early summer to spawn in fresh water; this period may be relatively long (Bigelow and Schroeder 2002). Hickory shad are most abundant in the Chesapeake Bay and in North Carolina. Additionally, Rountree and Able (1997) found a single adult-sized cohort of hickory shad around Little Egg Harbor Inlet in a night-time gill net study; however, no conclusions about habitat or tidal movements were made. Because of their low abundance, hickory shad are considered of little importance to commercial fisheries, but they may cryptically contribute to other "herring" catches. Hickory shad have recently become popular as sport fish and in some regions their roe is prized above that of all other herring (Bigelow and Schroeder 2002).

The related American shad are gastrically tagged during spring migration; however, they do not feed during this time (Olney *et al*. in review). Use of this tagging technique on hickory shad during the summer growth phase may stress or starve the fish. Because so little is known about the ecology of hickory shad, establishing an appropriate protocol for acoustic tagging and tracking, as well as understanding basic movement and habitat utilization within an estuarine system is critical information for future studies on this species.

Because Atlantic coast estuaries are so productive, hickory shad may utilize fresh waters, eelgrass beds, and sandy bottoms beyond spawning (Rountree and Able 1997). The Mullica River and Great Bay estuary (Fig. 1) is one of the most diverse and undisturbed estuaries on the northwestern Atlantic coast making it an ideal location to study the behavior and movement of hickory shad (Good and Good 1984).

Figure 1. The study area in the Mullica River/Great Bay estuary on the coast of southern New Jersey. Highlighted panels show (a) the 114 waypoints used for distribution tracking and (b) the location of fixed hydrophones complementing mobile telemetry.

Figure 2. Process of tagging: (a.) *Alosa mediocris* specimen, (b.) gastric insertion of an acoustic tag, (c.) Floy T-bar ID tagging, (d.) antibiotic injection and (e.) fork length measurement.

Methods

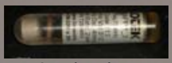
Figure 3. Lotek Wireless Inc. CAFT 11_3 acoustic transmitting tag (Code 112).


Figure 4. Lotek Wireless Inc. SRX_400 telemetry receiver/processor.


Figure 5. Dock used for Hickory Shad release and capture and support of a fixed boat basin hydrophone.

Tagging: Hickory shad (n=10) were caught by hook and line. Individually coded acoustic (76.8 KHz) transmitting tags (CAFT 11-3, Lotek Wireless Inc., St. Johns, Canada) were gastrically implanted through the mouth (Fig. 2b) (see Dodson *et al.* 1972; Adams *et al.* 1998; Bridger and Booth 2003; Olney *et al.* In Press). Transmitters (11 x 46 mm, 4.2 g in water) emitted an ultrasonic pulse every two seconds (Fig. 3). Additionally, a recognition tag (Floy Inc., Seattle, WA) was inserted into the dorsal margin, anterior to the dorsal fin (Fig. 2c.). An injection of oxytetracyclin (Liquamyacin®) at 0.1 mg/kg fish into the dorsal musculature guarded against infection (Fig. 2d.).

Feasibility: Tagged hickory shad (n=9) were retained in captivity to examine amenability to carrying gastrically implanted transmitters. Active or inactive ("dummy") tags were inserted into the experimental fish as for released fish, but these were held in recirculating, ambient seawater at RUMFS. Control fish (not tagged) were caught and held under identical conditions. Fish were fed 3 times during experiment at approximately 10 day intervals and the tank was changed or cleaned 5 times at approximately 5 day intervals. The health of all fish and response to tagging were monitored over 4 weeks and qualitative observations noted. Notes included tag regurgitation, infection, abnormal behavior, and feeding. After 4 weeks, surviving fish were sacrificed and dissected to investigate internal responses to tagging (or no tagging).

Telemetry: A tracking protocol currently in use for other fishes including smooth dogfish and striped bass was applied. A baffled hydrophone (LHP-1) coupled with an SRX-400 receiver/processor (Lotek Wireless, Inc.) was deployed while tracking tagged fish from a boat (Fig. 4). A fix (meter scale) was attempted on the position of fish by triangulation when a power level of >115 dB was reached at a gain of no more than 15. Listening stations covering the Great Bay/Mullica River estuary area at 1 km intervals were visited approximately three times a week (Fig. 1a). A fixed array of hydrophones (including a hydrophone in the RUMFS boat basin) logged fish passage between tracking events (Fig. 1b & 5) (Grothues *et al.* 2005). Contact efficiency on fixed hydrophones was calculated for fish 120 for all times found within the hydrophone array by dividing total possible contacts within a fixed time period given a two second burst tag by the actual number of contacts recorded in that time period.

Results

Table 1. Survivorship of hickory shad with gastrically implanted, active (numbered) or inactive tags while kept in re-circluating seawater at RUMFS. All mortalities not linked to tagging or starvation were considered tank related.

Fish #	Tag #	T-bar tag	Total Elaspsed Time (days)	Total Length (in.)	Cause of Mortality
1	27	No	6	>10	Tank related
2	Non-functional	No	13	>10	Tank related or starvation
3	15	Yes	4	>10	Tank related
4	1	Yes	28	13.75	Sacrificed
5	No tag	Yes	3	>10	Tank related
6	15	Yes	2	10.5	Tank related
7	27	Yes	2	13	Tank related
8	No tag	No	24	11.25	Sacrificed
9	27	Yes	3	12.25	Tank related or detritus ingestion

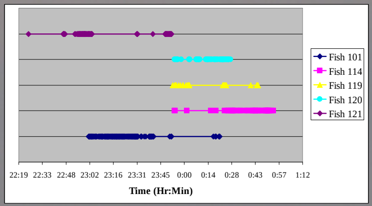

Figure 6. Residence time of 5 individual hickory shad immediately after acoustic tagging and release into the RUMFS boat basin as captured by a fixed hydrophone in the boat basin.

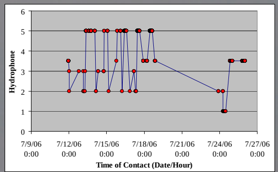

Figure 7. Temporal spatial movements of hickory shad 120 within the fixed hydrophone array in the Great Bay estuary. Contacts represent individual movements over a 15 day period. A contact at hydrophone 3.5 indicates a return to the RUMFS boat basin.

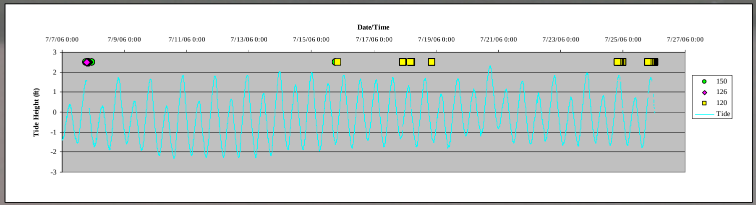

Figure 8. Returns of tagged *A. mediocris* to the RUMFS boat basin over a 21 day period relative to tide. Tidal information from the USGS data logger at Little Egg Harbor near Tuckerton, NJ. n=3 returning fish and 666 total contacts.

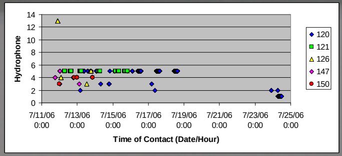

Figure 9. Temporal spatial overlap of 5 individual hickory shad outside of the RUMFS boat basin over a 15 day period. Only 50% of tagged fish were contacted outside the boat basin..

Results

Feasibility Study:

- 86% tagged fish and 50% control fish died due to tank related injuries within 29 days of captivity (Table 1).
- Average survivorship in tank was 9.4 days +/- 10.02 days per fish (Table 1).
- No fish regurgitated tags. No internal response to tagging was evident from biopsy.
- Gut lumen of tagged fish were largely occupied by the acoustic tag.
- 25% of dissected fish (both tagged and control) contained food.
- Detritus content was found in the guts of 25% of dissected fish (both tagged and control).

Telemetry Study:

- 63% of fish were relocated in the RUMFS boat basin after their release on 7/11/2006. The mean residency time in the boat basin of those fish was 62.6 minutes +/- 21.41 minutes (Fig 6.).
- Fish 120 (released 7/11/2006) moved extensively during a 15 day period preferring creeks and main channels (Hydrophones 2, 3, 5, and the RUMFS boat basin) just inside of Little Egg Harbor Inlet (Fig. 7).
- 30% of tagged fish returned to the RUMFS boat basin over a 20 day period. The average residency time for a return event was 46.7 minutes +/- 80.5 minutes. Return to the boat basin is linked to high tide or in the middle of ebb and flood tides from twilight until dawn (Fig. 8).
- Fish movement outside of the RUMFS boat basin was primary among hydrophones 2, 3, 4, and 5 with varying frequency. Movement for fish 126 across Great Bay at hydrophone 13 was recorded on the night of 7/11/2006 (Fig. 9).
- Mean contact efficiency was 7.33% +/- 6.1% for fish 120 for all relocation events at hydrophones 1, 5 and the RUMFS boat basin. Specific to location, efficiency was 7.22% for the RUMFS boat basin, 8.41% at hydrophone 5, and 0.35% for a 5 hr period of localization near hydrophone 1.

Discussion

- This feasibility/scaling study of hickory shad demonstrated that tagged fish survive up to 26 days at liberty (as of the printing of this poster) in the estuary and up to 28 days in contained, recirculating seawater.
- Feeding may be impaired by gastric tagging, however, untagged fish experienced similar mortality. It is unclear whether tagged fish at liberty experienced mortality. It is possible to eliminate feeding stress by intra-peritoneal tag implantation.
- Tagged hickory shad remained inside the Little Egg Harbor Inlet did not make repeated excursions into or out of the inlet, nor did they move up the Mullica River towards fresh water.
- Distribution tracking failed to relocate any tagged hickory shad. This protocol would have to be modified for future studies. Changing the protocol to night time tracking or in channels at low-tide may increase relocation efficiency.
- Low contact efficiency for 2 sec burst rate acoustic tags in hickory shad suggests the need for increased spatial resolution for a hydrophone array and greater coverage around small embayments and estuarine creeks. The behavior particular to hickory shad (location in water column, speed of swimming, or route of movement) has made them largely cryptic to this array.
- Although many contacts were made with multiple fish over the course of this study, the track of an individual fish is not entirely clear as expected sequential contacts were often missed. This anomaly could be due to movement into particularly loud areas (boat traffic, wave action, other tagged fish) and relatively quiet ultrasonic tags.

Acknowledgments

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