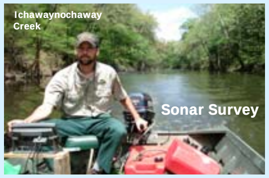
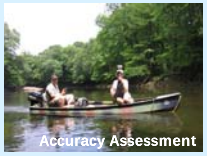
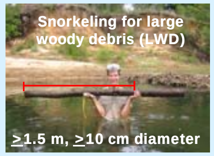
Mapping Habitat in Navigable Streams Using Low-Cost Side Scan Sonar







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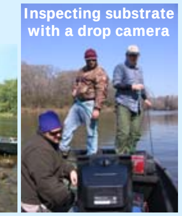
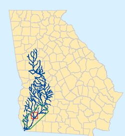


A Remote Sensing Technique is Needed for Riverscape Research in Stream Systems

- Side scan sonar is a hydroacoustic device that produces imagery of underwater features across the entire stream channel
- The Humminbird® side imaging system ($2000) generates high resolution imagery and employs an adjustable transducer facilitating surveys of shallow, rocky, and turbid systems

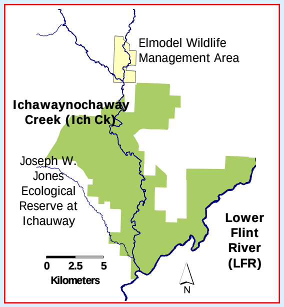
OBJECTIVES: 1) develop techniques for data capture and image geoprocessing for use within a GIS to 2) produce habitat maps of Lower Ichawaynochaway Creek (**Ich Ck**) and the Lower Flint River (**LFR**) and 3) evaluate and validate the mapping method and accuracy of the habitat maps

Project Areas – a Coastal Plain Creek and River



Flint River Basin

Green box defines 124-km extent of LFR map, Red box defines extent of IC map area enlarged right



Ich Ck
- mean width 35 m
- mean depth 3.1 m (during survey)
- gradient <0.001%
- 27 km mapped (Elmodel-Flint R.)

LFR
- mean width 102 m
- mean depth 4.4 m
- gradient <0.001%
- 124 km mapped

The Process of Sonar Habitat Mapping

Step A – Conduct Sonar Survey → **Step B** – Geoprocess Sonar Data → **Step C** – Develop Classification Scheme → **Step D** – Create Habitat Map → **Step E** – Assess Map Accuracy

How long does each step take?	
A.	11 min/km
B.	12 min/km
C.	varies with effort
D.	128 min/km
E.	varies with effort see methods
Total	2.5+ hrs/km

Methods by Step

A. Sonar surveys conducted April 2008 during high flows (Humminbird® 981c SI, range 24.4 m per side Ich Ck, 48.8-70.1 m per side LFR. Boat track and depth record (3-sec interval) also obtained. Alternative transducer placement surveys conducted on Ich Ck.

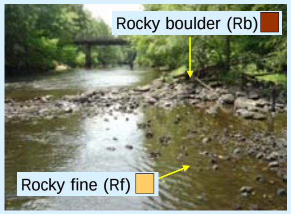
B. Sonar data geoprocessed using custom tools and techniques we developed for use in ArcGIS 9.2/9.3 to produce sonar image maps- SIMs (i.e. rectified raster image layers).

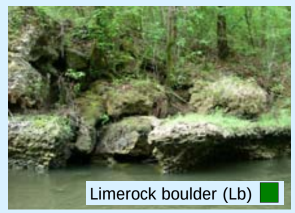
C. Classification schemes defined by on-site examination of sonar image features during low water. Minimum map units identified- 28 m² Ich Ck, 314 m² LFR.

D. Substrate polygons digitized and classified using SIMs in GIS, large woody debris identified in both raw images and SIMs and digitized. Ich Ck map developed and assessed prior to LFR map.

E. Accuracy assessments included 1) reference data collection at random points (50-70 per class, buffered by 3 m from polygon edges) with visual classification of ≥28 m² at each point, 2) enumeration of LWD present in 6 Ich Ck reaches, each ~500 m. Additional assessments on Ich Ck (data not shown here) included 3) transect-based characterization of substrates and bankfull channel width, 4) measurement of field objects to evaluate image transformation, and 5) GPS marking of fixed objects to evaluate map position accuracy. Overall time invested in Step E- 4.5 person-hrs/km.

Map Classification Schemes Included 7 Classes





*All photos above from Ich Ck. Three classes not depicted- Unsure presumed rocky (UR), and Unsure Sandy (US): areas distorted in sonar imagery. Limerock outcrop (Lo) in LFR: outcrops of massive chunks of limerock along river margin.

High Map Accuracy Achieved for Both Streams

Error matrices below portray classification accuracy

Ichawaynochaway Creek

Classified Substrate	Actual Substrate					Total points	User's Accuracy
	S	Rf	Rb	Lf	Lb		
S	60	6	1	0	0	67	90%
Rf	8	54	2	5	0	69	78%
Rb	0	8	59	1	3	71	83%
Lf	4	7	1	51	8	71	72%
Lb	0	3	16	8	42	69	61%

Overall Classification Accuracy $= \frac{\#\ \text{correct}}{\text{total}\ \#\ \text{points}} = \frac{266}{347}$ = 77%

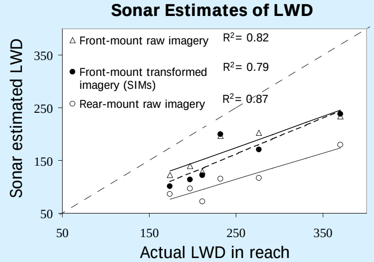
Lower Flint River

Classified Substrate	Actual Substrate					Total points	User's Accuracy
	S	Rf	Rb	Lf	Lo		
S	38	5	0	7	0	50	76%
Rf	6	36	4	4	0	50	72%
Rb	1	1	46	0	1	49	94%
Lf	3	5	1	39	1	49	80%
Lo	0	0	0	0	47	47	100%

Overall Classification Accuracy $= \frac{\#\ \text{correct}}{\text{total}\ \#\ \text{points}} = \frac{206}{245}$ = 84%

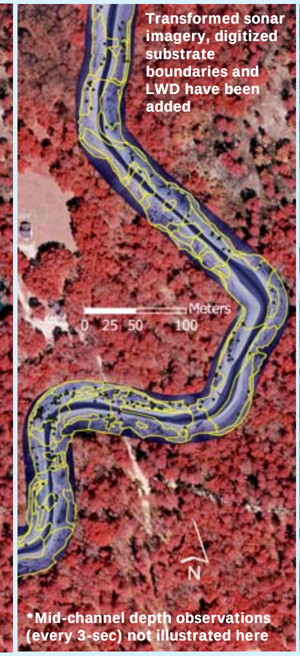
- Green cells represent correctly classified points, eg. 60 of 67 Sandy correct 60/67=90%
- Orange cells highlight larger errors. Eg. S was confused with Rf- Why? In both streams, sonar resolution sometimes limited our ability to differentiate sand from gravel or pebble substrate.
- Confusion between Rb/Lb in Ich Ck was unavoidable due to particle size similarities. Limestone outcrop (Lo) was much easier to distinguish from Rb in LFR based on particle size and position
- LFR map accuracy somewhat higher than Ich Ck due to improved differentiation of Lo and Rb and larger MMU
- Future work should examine ways to improve discrimination of fine textured substrates- mud/sand/gravel

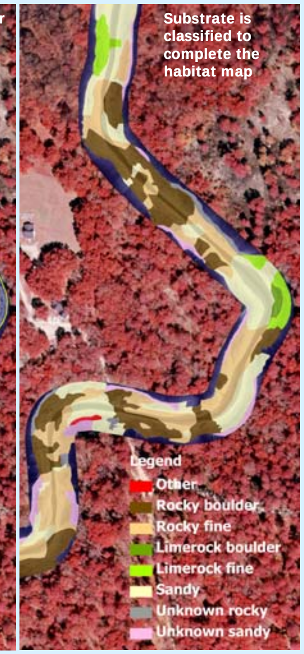
Sonar Estimates of LWD

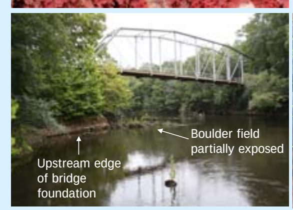


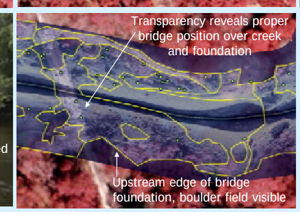
- Sonar does not reveal all LWD in stream reaches; we suspect mostly small LWD pieces are missed
- High correlations between sonar and actual LWD counts indicate that sonar can provide a reliable index to LWD present in streams; however front-mounting the transducer improves image quality revealing more LWD
- Regression can be used to calibrate sonar estimates to reflect actual LWD abundance
- Transformation of raw sonar images into SIMs does not greatly affect the ability to identify LWD

The Evolution of a Habitat Map









Applications are Widespread and Diverse

- Organism-habitat research in systems and at scales not previously feasible
- Studies of individual habitat use and behavioral patterns (eg. via radiotelemetry), identification/quantification/prediction of critical habitat (eg. sturgeon spawning habitat)
- Landuse associations with in-stream habitat (eg. patterns of LWD distribution with respect to riparian landuse)
- Monitoring habitat change over time (eg. sediment redistribution)
- Similar applications in lakes and reservoirs possible (eg. littoral zone mapping)
- Sonar habitat maps can be viewed in Google Earth

*Low cost, speed, flexibility, ease of training, and access to software are key traits of sonar habitat mapping. The future is now for riverscape research.

The Future of this Initiative

- To demonstrate the utility of low-cost sonar mapping we are applying the method in ongoing radiotelemetry studies of turtles and fish
- Research manuscripts detailing the important validation studies recently completed and presented in this poster are forthcoming
- To receive email announcements of impending web releases of software tools and training products, or to request a sonar mapping workshop please contact Adam at adam.kaeser@dnr.state.ga.us. For additional information on sonar mapping of LWD see Kaeser and Litts 2008. Fisheries 33(12): 598-597.

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