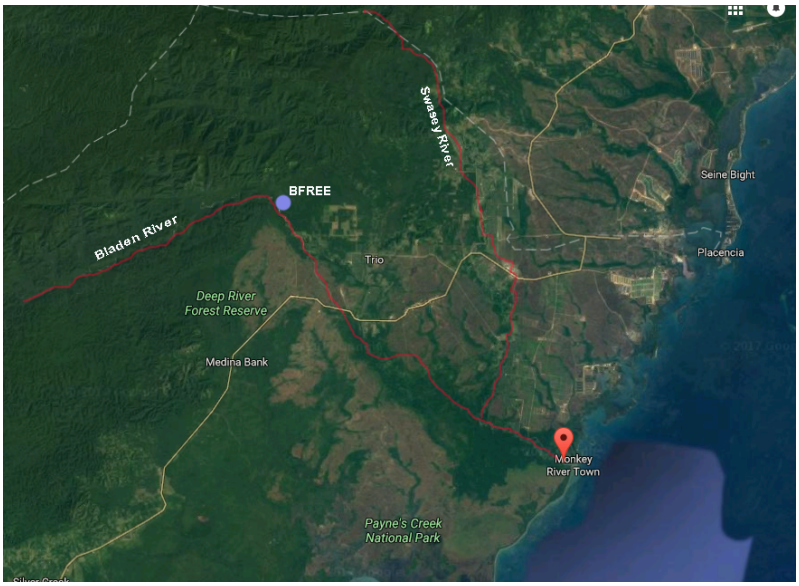
River Surveys: A field activity for student groups studying the Bladen River at BFREE and beyond

Author, Amy Treonis, Department of Biology, University of Richmond, Richmond, VA

Introduction:

The Bladen River is one of the most spectacular features of the BFREE field station, offering countless opportunities for ecological research. The Upper Bladen watershed flows through the tropical broadleaf forest of the Bladen Nature Reserve, arriving at BFREE in a remarkably pristine state. From there, the river flows downstream into the Monkey River and ultimately empties into the Caribbean Sea at Monkey River Town. The river flows through a landscape that is a mosaic of protected and agricultural lands, including cattle pastures, banana plantations and subsistence farms (i.e., milpa). Replacement of riparian vegetation with agriculture has destabilized soils in many places, resulting in increased erosion and sedimentation throughout the watershed. Ultimately, this impacts both wildlife and people that depend on the river's health. The river's course has also been affected by natural events, such as Hurricane Earl in 2016.



Map of the Monkey River watershed, showing potential river survey locations.

Monitoring the physical, chemical and biological properties of rivers is an important strategy for environmental protection. The US EPA performs a National Rivers and Streams Assessment (NRSA) in order to determine the condition of the nation's waterways and to monitor for changes over time. This assessment encompasses many groups of indicator variables, almost any which could be incorporated into a course-based study of the Bladen River or, more broadly, rivers or streams in the Monkey River watershed. The course activities outlined here focus on aspects of the river that could be affected by increased sedimentation. However, a river survey activity can be easily modified depending on the course focus, time available, and

instructor expertise. For example, benthic macroinvertebrate kick net sampling is not described here but could be incorporated. The NRSA Field Operations Manuals are useful for ideas about modifying this activity.

A River Survey activity was piloted in March 2017 for a fourteen-student undergraduate Field Ecology course from the University of Richmond. The goal was to compare and contrast the Bladen River near BFREE to the downstream condition at Monkey River. At BFREE, three 100-m river reaches were surveyed using a selection of protocols from the NRSA Field Operations Manual for wadeable rivers. The reaches included one across the BFREE road-crossing of the river "Upper Bladen", another downstream location "Middle Bladen", and a lower downstream location "Lower Bladen" where the river's course had recently been altered following the flooding caused by Hurricane Earl. All were within walking distance of the BFREE field station. On the Monkey River, a single 50-m reach was surveyed using a modified protocol to account for the reliance on boats to survey this region. This design, combined with a visit to a Banana Farm in between BFREE and Monkey River and discussion with Monkey River Village residents, coalesced into an important case study of freshwater resources and conservation in Belize. However, even surveying a single reach of the Bladen near BFREE would provide students with unique and valuable experience.

Principal Ecological Question Addressed: How do the physical, chemical and biological characteristics of a tropical river change across its course, as it experiences natural and anthropogenic influences?

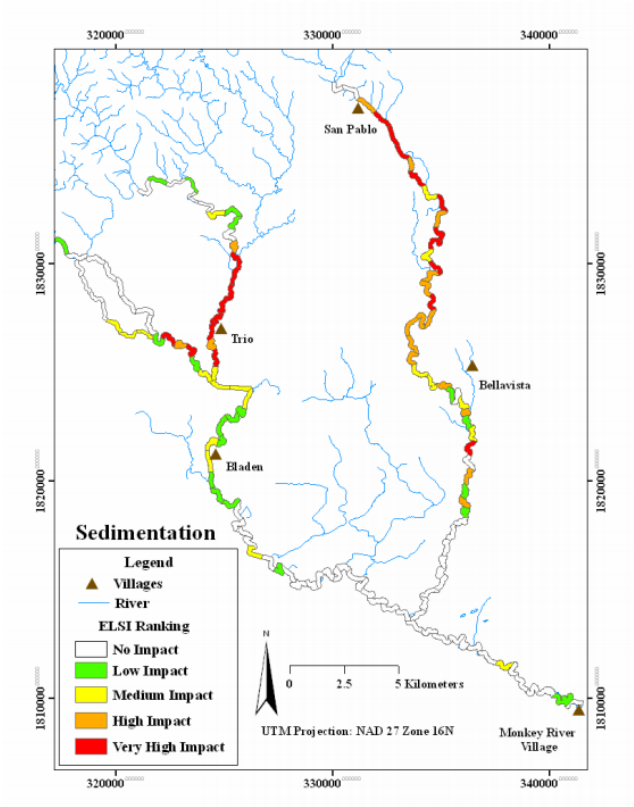
Student Outcomes: Upon completion of this experiment, students should:

- Be able to identify the characteristics of a pristine river or stream.
- Analyze and visually present data for comparison of stream locations.
- Articulate the threats to the Monkey River watershed.
- Connect anthropogenic activities to specific characteristics of surface waters in the Monkey River watershed.

Required Class Time: Each reach surveyed using the suggested protocol requires 60-90 minutes of time (excluding travel time in between reaches). Additional class time is required for data processing and interpretation.

Materials and Supplies needed:

- Field notebooks, writing implements
- 2 100-m tape measures (open reel)
- 1 10-m tape measure (open reel)
- Measuring tape lead weight attachment
- GPS unit
- Flow rate meter
- pH meter
- EC meter
- Thermometer
- Gravelometer
- Glass bottle for water sampling for turbidity
- Laminated, color turbidity scale
- Snorkel masks
- Fish identification resources (ideally on laminated cards)



Areas of the Monkey River watershed impacted by sedimentation. (Source: Esselman 2007)

Literature Consulted and Additional Resources (see http://library.bfreebz.org for many of these)**:**

Buck DG, Esselman PC, Villafranco J. 2011. Monitoring land use changes along riparian corridors in lowland tropical watersheds: Application of human impact mapping and estimation of local stress intensity. *Mesoamericana* 15: 51-62.

Clapcot J *et al*. 2011. Sediment Assessment Methods: Protocols and guidelines for assessing the effects of deposited fine sediment on in-stream values. New Zealand, Cawthron Institute. (http://www.cawthron.org.nz/media_new/publications/pdf/2014_01/SAM_FINAL_LOW.pdf)

Esselman PC. 2001. The Monkey River baseline study: Basic and applied research for monitoring and assessment in Southern Belize. Master of Science Thesis. University of Georgia.

Esselman PC, Buck DG. Hydrologic Assessment of the Monkey River Watershed, Belize.

Esselman PC, Freeman MC, Pringle CM. 2006. Fish assemblage variation between geologically defined regions and across a longitudinal gradient in the Monkey River Basin, Belize. *Journal of the North American Benthological Society* 25:142–156.

FishBase: http://www.fishbase.org/search.php

Greenfield DW, Thomerson JE. 1997. Fishes of the Continental Waters of Belize. University of Florida Press.

USEPA. 2013. National Rivers and Streams Assessment 2013-2014: Field Operations Manual – Non-Wadeable. EPA-841-B-12-009a. U.S. Environmental Protection Agency, Office of Water Washington, DC.

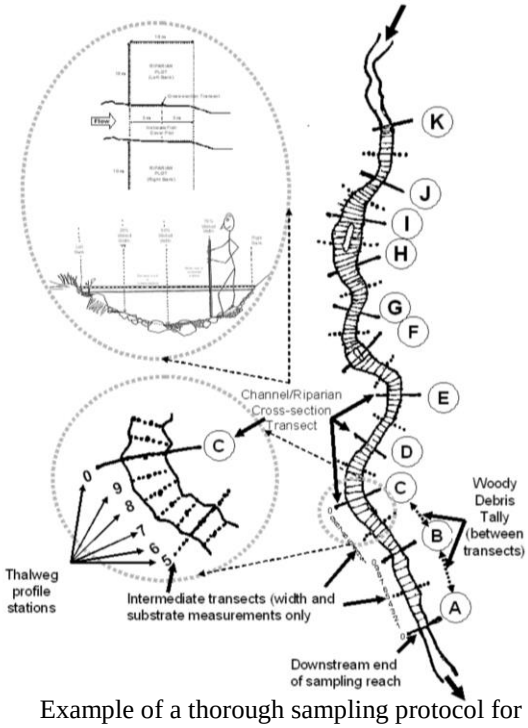
USEPA. 2013. National Rivers and Streams Assessment 2013-2014: Field Operations Manual – Wadeable. EPA-841-B-12-009b. U.S. Environmental Protection Agency, Office of Water Washington, DC.

Suggested Student Handout:

Upstream land use change is negatively affecting the Monkey River watershed. The primary land use activity is agriculture, which creates conditions that promote soil erosion and increased sediment in the river. The Bladen River runs through the BFREE field station, and this river ultimately ends up in the Monkey River. Remote sensing image data is being collected on the Monkey River watershed to document changes over time. To date, very little data has been collected on the ground. We will be performing two river surveys (the Bladen, near BFREE, and the Monkey River at Monkey River Town). These surveys will focus on establishing baseline measurements of the physical characteristics of the rivers and will characterize the physical environment that is habitat for periphyton, micro/macroinvertebrates, and the insects, fish, turtles, crocodiles and other creatures that live in the river. More physical diversity is desirable to promote biodiversity.

At the Bladen River near BFREE:

- We will measure out 3 100-m reaches, beginning at the downstream reach and working upstream.
  - Each reach will be divided into 51 2-m sections.
  - Starting downstream, every 2 m, a thalweg profile will be obtained. This includes recording:
    1) Depth of thalweg
    2) Width of river
    3) Type of flow (pool, run or riffle)
    4) Presence of soft sediment at thalweg
- Over every 20-m section the following will be measured:
    1) Woody debris tally
    2) Flow rate measurement
    3) Wolman pebble count (50 pebbles)
    4) Turbidity assay
    5) Description of riparian vegetation structure and evidence of human impacts
    6) Water pH, EC, temperature
    7) Fish scan
    8) GPS measurement



Example of a thorough sampling protocol for a wadeable river. The described protocol suggested for this course-based survey is a simplified version of this. Source: EPA National Rivers and Streams Assessment 2013/14 Field Operations Manual.

At the Monkey River:

- We will measure out one 50-m reach. The Monkey River is wide, making width measurements with a measuring tape generally not possible. The river may or may not be wadeable, depending on rainfall and location, but most measurements can be obtained from a boat.
- Every 10 m, a thalweg profile will be obtained. This includes recording:
  1) Depth of thalweg
  2) Type of flow (pool, run or riffle)
  3) Presence of soft sediment at thalweg measuring point
  4) Flow rate measurement
  5) Turbidity assay
  6) Description of riparian vegetation structure and evidence of human impacts
  7) Water pH, EC, temperature
  8) GPS measurement
- Every 20 m section will have:
  1) Description of riparian vegetation structure and evidence of human impacts
  2) Fish scan
  3) Woody debris tally

Suggested Approach: Students will be divided up into 3 teams. Each team will be responsible for a list of tasks at each of three survey sites. Teams will switch task lists at each site so that everyone gains experience with the methodology. Students will have to define protocols for methodically collecting the various types of data in order to be accurate and consistent.

Team A: Thalweg profile:

1) Using the tape measure, define the 100 m reach that will be surveyed. A pair of students will need to hold the ends of the tape for the duration for all the groups to reference.
2) Using weighted measuring tape, measure the depth of the river (substrate surface to water surface) at the deepest point (i.e., the thalweg).
3) Using a levelled tape measure, measure across the river with the tape meeting the bank at a 90° angle.
4) Wadeable: Pool = stagnant, Run = smooth moving, Riffle = fast, churning
5) Non-wadeable: Pool = smooth surface, deep, slow flow, Glide = smooth surface, unbroken, low velocity, Riffle = small ripples, waves, eddies, Rapid = whitewater, Cascade = water plunges
6) At the point where the thalweg depth is determined, observe if unconsolidated, loose (*soft*) deposits of small diameter (<16 mm) sediments are present directly beneath weight. *Soft sediments* are defined here as fine gravel, sand, silt, clay or muck readily apparent by "feeling" the bottom with the rod (i.e., does it feel mushy?).

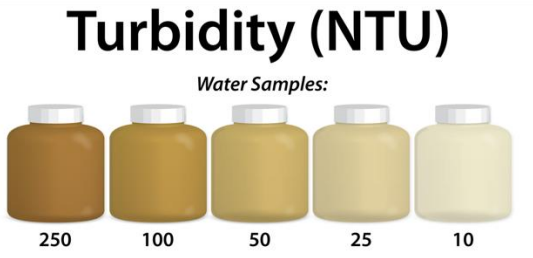
Team B:

1) GPS, Flow rate, pH, EC, temperature: Use instruments, measure at thalweg
2) Wolman pebble count (wadeable rivers only). Perform a zig zag walk throughout the river segment. Every stop, until 50 stops are completed, assess the size of the substrate under left big toe using the gravelometer.
3) Turbidity assay: Collect water sample in clean glass bottle and compare to color chart.

Performing a pebble count using a gravelometer.

Team C:

1) Woody debris tally (wadeable only): Count the number of wood pieces in the water that are at least 10-cm diameter, 1.5-m long
2) Description of riparian vegetation structure and evidence of human impacts: Note relative sparsity of vegetation, presence of visible human structures, roads, trails, near shoreline.
3) Fish Scan (wadeable only): Using snorkel masks, explore the water and note what you see over a 10-minute scan period. Ideally, identify species and indicate relative abundance.



NTU = Nephelometric Turbidity Units (these values correlate to the measurements that would be taken with a nephelometer)

Example datasheets for field notebooks:

Team A:

Location on reach (m)	Thalweg depth (m)	River width (m)	Water character (pool, riffle, etc.)	Soft sediment (present/absent)
0				
2				
4				
…	…	…	…	…
96				
98				
100				

Team B:

Location (m)	GPS	Flow rate (m/s)	pH	EC µS	Temperature (°C)	Turbidity (NTU)
10						
30						
50						
70						
90						

Team C:

Location (m)	Woody Debris Tally	Vegetation description	Human impacts	Fish survey
10				
30				
50				
70				
90				

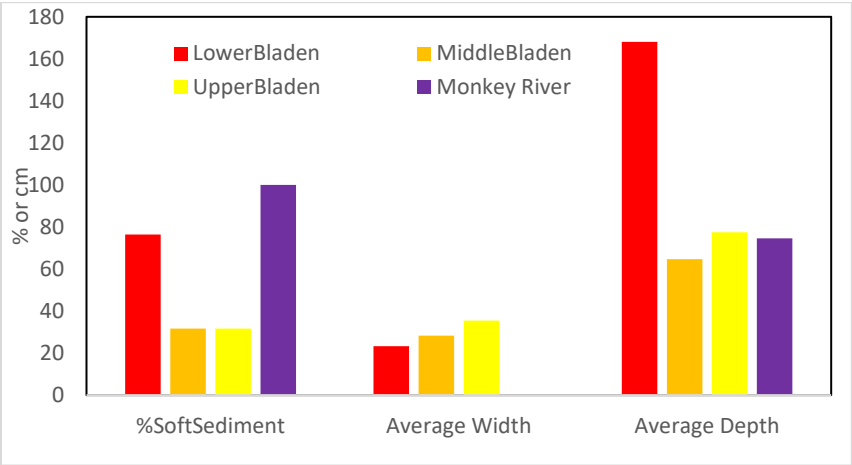
Team C: Pebble count (repeat for each reach: 10, 30, 50, 70, & 90)

Sample	Pebble class
1	
2	
3	
…	…
50	

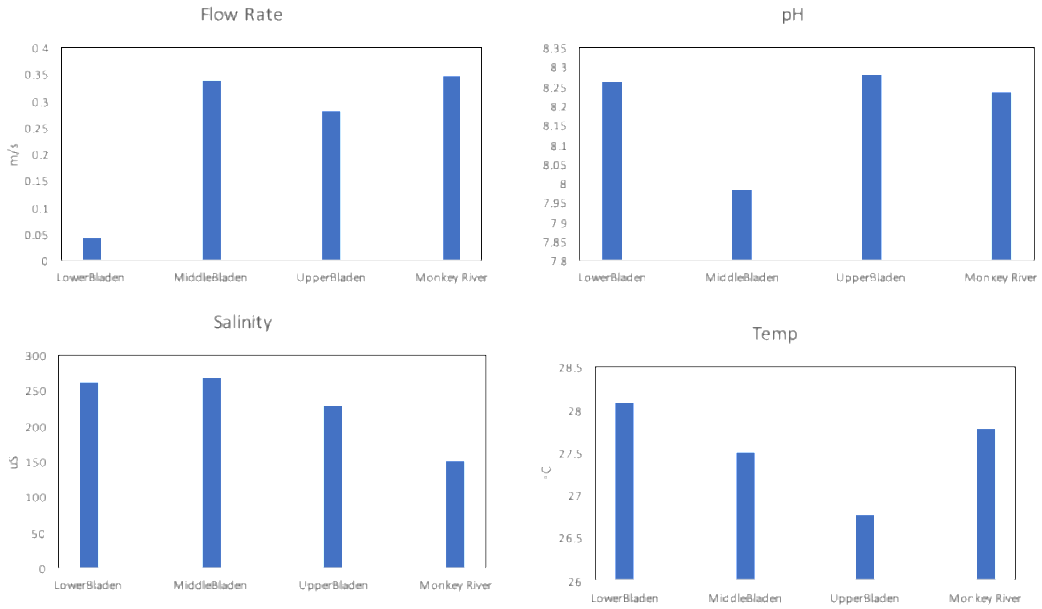
Data Analysis:

While there are many possible ways the data from a river survey can be studied, most variables can be presented either as averages across the points within a reach or as frequency distributions. Students can be encouraged to study the data collected and develop their quantitative presentation skills.

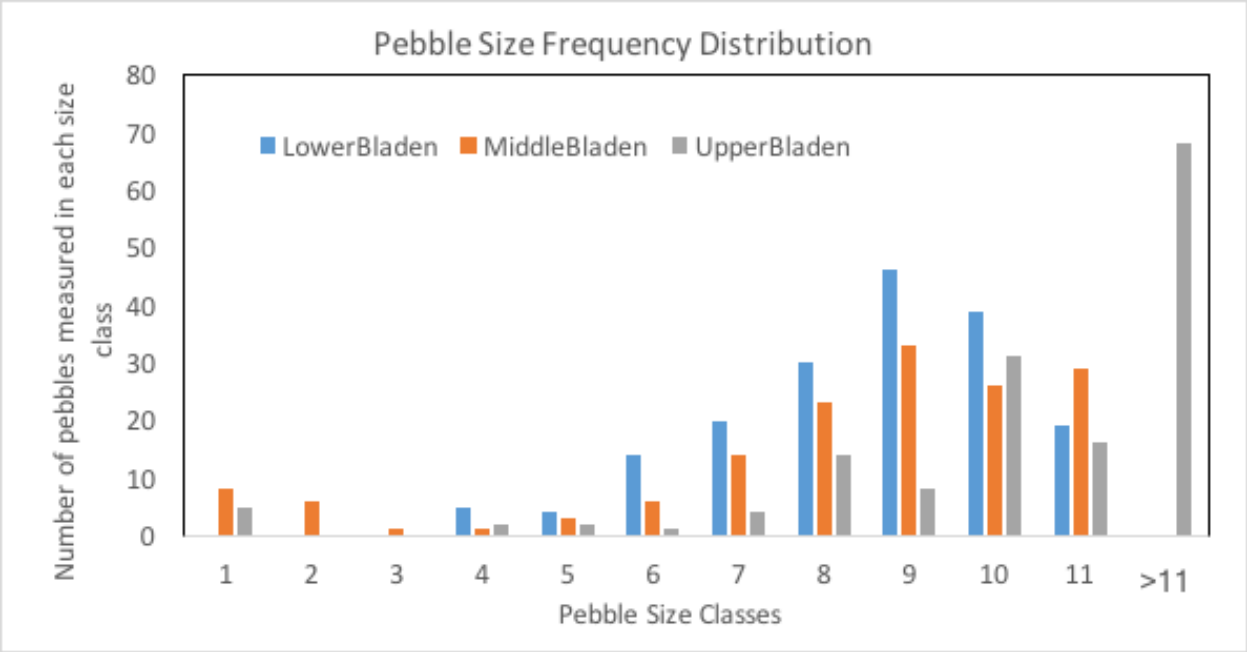
Examples:



This data shows the high degree of sedimentation in both the Monkey River and the part of the Bladen River recently impacted by flooding due to a hurricane.



The reaches show variation in physico-chemical properties. The Lower Bladen Reach, which represents a new flow pattern for that part of the river, is distinct, with its low flow rate that is correlated to higher temperature.



The pebble count shows a difference between the upper Bladen (where the road crosses the river) and the middle and lower reaches. It is possible that either 1) the road crossing was selected because it was originally very rocky and/or 2) the road is having an impact on the river bed, causing sediment to wash away.

Instructor Notes:

- In March 2017, the students found this to be an enjoyable activity. Students love the river environment and the scenery, and they appreciated the chance to cool off in the water.

- Hiking between reaches in the Bladen River was difficult due to the rocks underfoot. It was manageable, but it would have been better to re-enter the adjacent trail on land, proceed upstream and then re-enter the river.

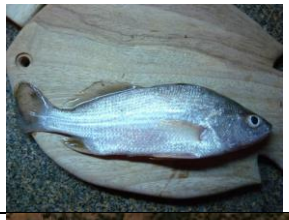
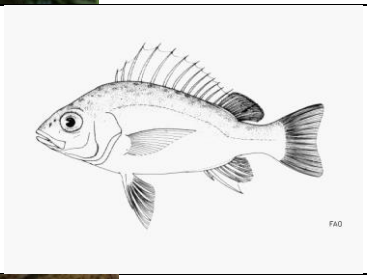
- Selection of reaches to survey is challenging without prior knowledge of the river. Unexpectedly, we found our Lower Bladen site to not be wadeable in some places, which hindered accurate measurements. Overall, we found the reaches we did sample to be interesting to survey and different enough to generate discussion.

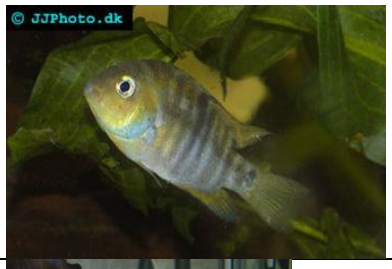
- The survey at Monkey River was challenging due to the unexpected width of the river and the shallowness. It was too wide to measure with tape measures. We did not expect to be able to wade in the Monkey River, but we wonder if the depth varies more than we discerned at the single reach we studied. It was too cloudy to easily survey for fish or woody debris, but not impossible. Some students did not feel comfortable going into the water due to the cloudiness.

- The Monkey River sediment was very deep and very distinct from the Bladen River. There was no point to doing a gravel survey – no rocks were detected.

List of fish species that could be present in Bladen River near BFREE (based on reporting in Esseleman et al. 2006):

Heterandria bimaclata (Twospot livebearer)	
Agonostomus monticola (Mountain mullet)	
Rhamdia laticauda (South American catfish or Guatemalan chulin)	
Astyanax aeneus (Banded or Central tetra)	
Brycon guatemalensis (Machaca or Macabil)	
Belonesox belizanus (Top minnow or Pike killifish)	

Gambusia luma (Sleek mosquitofish)	 
Poecilia mexicana (Shortfin molly)	
Xiphophorus helleri (Green swordtail)	
Atherinella sp. (neotropical silverside)	
Ophisternon aenigmaticum (Obscure swamp eel)	
Pomadasys crococ (Burrow grunt)	 
Amphilophus robertsoni (False firemouth cichlid)	

Archocentrus spilurus (Blue-eyed cichlid)	 
Cichlasoma salvini (Yellowbelly cichlid)	
Vieja maculicauda (Blackbelt cichlid)	
Gobiomorus dormitor (Bigmouth sleeper)	 
Awaous banana (River goby)