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Remotely sensed estimates of geomorphic and hydraulic characteristics to help elucidate fish evolution in the lower Congo River

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The lower Congo River drains the world's second largest drainage basin and is home to at least 135 fish species, 30% of which are found nowhere else on the planet. Its fish diversity and hydraulic characteristics are poorly understood, so we are investigating both using remote sensing image analysis. We estimated hydraulic quantities within the lower Congo River, a reach extending from Malebo Pool, near the twin capitals Kinshasa (Democratic Republic of Congo, DRC) and Brazzaville (Republic of Congo), to the river's Atlantic Ocean outlet near Matadi, DRC. Within this reach, the river drops 280 m in 350 km, creating some of the most spectacular rapids on Earth. We measured channel width and meander lengths using reflectance data from Landsat and ASTER to define the wetted channel within a coordinate system. Elevation data from the Shuttle Radar Topography Mission (SRTM) were smoothed and filtered using projection pursuit regression to yield channel slope. We estimated river depth, velocity, and discharge at 1-km intervals along the reach with previously derived empirical relations that use river planform geometry and slope parameters as independent variables. Our estimates correspond well with line transects measured during summer 2007.

The river features we have measured are the putative drivers of observed diversity and hypothesized evolutionary divergence among fishes. Major rapids, turbulence, and great depths within the channel may have been barriers to fish migration through evolutionary time, allowing sister taxa to diverge through genetic isolation. We used

object-oriented, contextual classification to measure the location of hydraulic features such as turbulence, convergent flow, rapids, and laminar flow, each of which may be evolutionarily significant macrohabitat features. The hydraulic and surface water classifications assembled to date provide quantitative descriptions of fish macrohabitat and macrohabitat connectivity throughout the lower Congo River and therefore provide physical descriptions that are essential for understanding fish evolution in this globally important river.

Our work has produced numerous replicable methods and observations:

- Indices of meandering consistent with physical concepts of hydraulic resistance and which yield reasonable estimates of velocity.
- Estimates of channel depth from width and slope; estimates of channel-forming hydraulics such as discharge and velocity. These were calibrated using ground-based measurements.
- Methods to estimate cross-channel variation in depth and velocity based on turbulence features.
- Characterized bounds of channel-forming velocity, an important constraint to fish movement.
- Quantitative basis for assessing the hypothesis that species evolution is linked to hydrogeomorphic complexity in the river.