Hydraulic assessment of flow regimes to facilitate fish passage through natural riffle barriers: Shoalhaven River below Tallowa Dam, New South Wales, Australia

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Aims of presentation

- Outline results of field-based and 2D hydraulic model fish passage assessments through natural riffles downstream of a major water supply reservoir.
- Outline flow regime option that we think will result in improved conditions for fish passage.
- Focus on Australian Bass – top level predator, iconic sportfish, deepest bodied native freshwater fish in river system.
- Minimum depth and maximum velocity tolerances reasonably well established in literature.
Hydrological effects of Tallowa Dam

- Catchment area 5750 km²
- Operational capacity 35 GL
- Drought reserve for Sydney’s water supply
- Tallowa Dam has a low operating capacity relative to inflows – frequent spills during wet years
- During dry years (eg. 2005) small events <1.1 year flood can be fully captured, flood peaks minimally impacted
- Environmental flow studies primarily focussed on effects of ‘flatlining’ of low flows
- Dam effects primarily occur within 0.5 - 2 m of low flow water level
- Minimum depths for fish passage a key consideration
Shoalhaven River – freshwater section

- 21 major riffles from dam to tidal limit – distance 25 km
- Riffles vary from 20-300 m length, separated by pools about 830 m in length
- Wide-shallow, steep-turbulent riffles considered most problematic to fish passage

Shoalhaven River
Tallowa Dam
Grassy Gully gauging station
Yalwal Creek
Tidal Limit

0 2 4 Kilometres
Examples of wide-shallow riffles

- Wide shallow riffles are thought to be depth limiting for fish passage
- Exhausted fish observed trapped within wide-shallow riffles
Examples of steep-turbulent riffles

Steep-turbulent riffles are thought to be velocity limiting for fish passage under low flow conditions.

Approximately 1 m headloss over 20 m, slope ~0.05

Velocities >1.8 ms\(^{-1}\) over distances ~10 m or greater considered problematic for adult Australian bass.
Field data collection and analysis

- Upper 15 km of 25 km long study area only accessible by canoe or plastic hull boat
- Rapid assessment surveys measured riffle depth and velocity, recorded locations with differential GPS at two controlled flow release rates
- Airborne laser, topographic survey and bathymetric survey data combined into DTM’s
- Two dimensional hydraulic modeling with River2D to assess fish passage across ‘worst case’ riffles and rapids
What flow depth for adult bass passage?

- Adult bass body depth ~15 cm
- Recommended minimum fish passage depth ~20 cm
Rapid fish passage assessment - depth

- Differential GPS enabled integration of field measures with aerial photography and hydraulic model data
- At 130 MLD\(^{-1}\) flow depths below minimum criteria (20 cm) for fish passage in 6/21 riffles from dam to tidal limit
- Wide-shallow riffles most problematic for fish passage at 130 MLD\(^{-1}\) flow
- Assessment at 300 MLD\(^{-1}\) recorded no significant depth limiting problems to fish passage
Rapid fish passage assessment - velocity

- At 130 MLd$^{-1}$ problematic thalweg velocities > 1.8 ms$^{-1}$ recorded in two riffles.
- At 300 MLd$^{-1}$ problematic thalweg velocities > 1.8 ms$^{-1}$ recorded in four riffles.
- Confirmation that steep-turbulent riffles form the most problematic velocity barriers to fish passage at 130-300 MLd$^{-1}$ flow.
- Some offsets between DGPS locations and field velocity measurements (safety concerns and DGPS error).
River2D model calibration

- Riffle 6 (depth limiting) model calibrated to depth, Riffle 10 (velocity limiting) model calibrated to velocity.
- Reasonable calibration achieved for both riffles over range of flows (130-300 MLd\(^{-1}\)).
- Calibration confounded by field data offsets (±1m) and high depth and velocity variability over short distances (due to very coarse substrate).
- Relatively easy to calibrate to depth OR velocity.
- More difficult to calibrate to both variables. Depth calibration, velocities too low, velocity calibration, depths too low.
Riffle 6 – 2D hydraulic modeling results for ‘worst case’ wide-shallow riffle

- Excellent spatial agreement between field measurements and modelled riffle depths
- Thalweg depth of 15-20 cm a major issue at 130 MLd$^{-1}$ flow or less, fragmentation across lower riffle and riffle entrance
- At 130 MLd$^{-1}$, ~20 m with thalweg depth <15 cm. Total distance of ~30 m with thalweg depth <20 cm
- At 300 MLd$^{-1}$, continuous thalweg with >20 cm depth through riffle
- Target environmental flow range for facilitating fish passage across wide-shallow riffles ca. 300 MLd$^{-1}$
Riffle 10 – 2D hydraulic modeling results for ‘worst case’ steep-turbulent riffle

- Maximum thalweg velocities for all flows $\geq 2$ ms$^{-1}$, problem for upstream fish passage?
- Field measurements show thalweg velocities increase with increasing flow
- Key question – does increasing flow make the velocity challenge easier or harder for fish passage?
- Analysis of depth averaged velocity along left and right bank 15 cm depth contours
- Modelled 15 cm depth approximates 20 cm actual depth
Increasing flow rates from 130 MLd\(^{-1}\) to ~500 MLd\(^{-1}\) reduces magnitude of velocity challenge through steep/turbulent riffles.

Increasing flow rates facilitate passage along edges of high velocity thalweg.

2D hydraulic modeling combined with GIS enables detailed quantification of changes to velocity (and depth) challenges to fish passage for a wide range of flows.
Flow regimes to facilitate bass passage

- Post-spawning adults migrate upstream in late winter and spring.
- Which broad transparency / translucency flow regime options (80/20, 90/30) will best facilitate post-spawning upstream adult bass passage?
- Trade-off between higher baseflow but slightly lower variability or slightly higher variability but lower baseflow.
- Shoalhaven River Scientific Advisory Panel settled on 80/20 flow regime.
Conclusions

- Rapid field assessment and hydraulic modeling results for fish passage assessment consistent and complementary.
- Both approaches indicated need to increase flow releases from Tallowa Dam to 300-500 MLd$^{-1}$ flow range to facilitate upstream fish passage.
- Rapid field assessment method is simple, spatially extensive and can provide data for hydraulic model calibration.
- 2D hydraulic modeling enables detailed quantification of the severity of depth and velocity challenges to fish passage and how these challenges change with flow.
- Further studies using Vemco acoustic telemetry to track fish movements and migrations through river system.