Predicting physical habitat sensitivity to abstraction

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New version of the Rapid Assessment of Physical Habitat Sensitivity to Abstraction (RAPHSA) model

Original RAPHSA completed in 2006 for the EA; defined sensitivity to abstraction as the change in physical habitat with changes in river discharge

Several development needs identified in order to deploy the model operationally

Original and current version: ‘RAPHSA 1’
Alternative version: ‘RAPHSA 2’
Hydrology, hydraulics, habitat

- Discharge has indirect effect on river ecosystems
- River organisms respond to hydraulics, either directly (e.g. shear stress), or via physical habitat (i.e. depth and velocity)
- Habitat created by interaction between flow and channel morphology
- Discharge–habitat association provides way to assess ecological impacts of abstraction/flow change in a river
- Several habitat–discharge models based on these concepts (for example PHABSIM)
- Depth and velocity suitability for various species or life stages collated (e.g. field observation, experiments, expert knowledge)
- Suitability of 1 for depth or velocity means that any parts of the river with such depths or velocities are suitable as habitat
- At a given cross-section, depth and velocity suitability indices are combined to give the proportion of the cross-section that is usable as function of discharge
Sensitivity to abstraction

- Steeper curve = habitat more sensitive to abstraction/flow change
- Shapes of curves are controlled by the site hydraulic characteristics
- Same abstraction can lead to different impacts depending on transect and flow percentile

Juvenile trout (0–7cm); selected UK sites (each curve corresponds to a different transect)
RAPHSA 1 summary

- Predicted variable: weighted usable area (WUA) standardised by bankfull wetted width (WW2) ie WUA/WW2

- \( \frac{WUA}{WW2} = a + bn + cn^2 \)
  with \( n \) flow percentile rank (ie \( n^{th} \) flow percentile)

- Coefficients modelled using flow-dependent variables taken at the same \( n \) for a pool of reference sites

- Reference sites: PHABSIM studies totalling 516 transects in 64 river stretches
Operational development needs

(1) Improving representativeness of calibration dataset
- Original model using collection of PHABSIM studies totaling 516 transects at 64 river sites
- Limited geographical coverage
- Biased towards lowland permeable rivers

(2) Simplifying model
- To standardise information across sites, RAPHSA 1 uses flow percentile rank $n$
- Requires derivation of flow duration curve
- Requires numerous input variables
- Outputs as function of $n$; need back-transformation to be expressed as function of discharge
Selection of new calibration sites

- c. 4,000 sites with detailed panel data up to 2006 (EA)
- Matched against gauging stations => 645
  - Filtered for good hydraulics => 210
  - Filtered to keep sites capturing whole WUA & flow range => 90
Improved representativeness

Geographical coverage
RAPHSA 1 - black crosses
RAPHSA 2 - green dots

River types
RAPHSA 2 - dash black
UK rivers - solid blue
Simplified model

- To avoid using flow duration curves, relation between \( \ln(Q) \) and \( n \) approximated as linear; \( Q \) standardised with bankfull flow (approximated as \( Q^2 \))

\[ \frac{WUA}{WW^2} = a' + b' \ln\left(\frac{Q}{Q^2}\right) + c' \left(\ln\left(\frac{Q}{Q^2}\right)\right)^2 \]

- \( Q/Q^2 = 0 \) means no water; \( Q/Q^2 = 1 \) (or 100\%) means bankfull flow
- \( Q^2 \) (and additional variables at \( Q^2 \)) can be estimated from one field survey only by using Manning-Strickler (providing the gauging does not occur at low flows)
- Similar model structure but simplified formulation (fewer explanatory variables)
- Output habitat curves as function of \( Q/Q^2 \) (no back-transformation needed)
Model testing: MSEs

- Jackknifing procedure on RAPHSA 1, RAPHSA 2 with original sites only, RAPHSA 2
- Similar performance
- RAPHSA 2: slightly higher mean squared errors partly because of wider range of river types

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Model testing: (some) habitat curves

Observed data - black line with +

RAPHSA 1 - blue

RAPHSA 2 with original sites only - red

RAPHSA 2 - green
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Thank you for your attention!