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Development and application of an agent based model for glass eel selective tidal stream transport

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Development and application of an agent based model for glass eel selective tidal stream transport

J. de Bie, T. Benson, J. Gaskell, P. Vezza, J. Kerr, D. Lumbroso, M. Owen, P. Kemp
Introduction

• Three temperate species: *A. anguilla, rostrata & japonica*

• Highly migratory (>10^3 km)

• (Crit.) Endangered (IUCN)
  – Habitat fragmentation
  – Fishing
  – Climate change

• Protection / mitigation begins with juvenile stages (i.e. recruitment)
Introduction

- Larvae drift from spawning grounds to coastal areas
- Limited swimming
  - Usage of tides
  - STST
- Local variable environmental influence

Harrison et al. 2014
Aim

• Currently, annual recruitment estimates for *A. anguilla* are derived by catchment data by ICES.
  - Difficulties assembling and combining data to provide comprehensive overview

• ABMs have been successful in predicting/estimating recruitment for other fish species
  - Help evaluate recruitment success and possible areas for mitigation opportunities

• *Develop an ABM for upstream tidal migration of glass eels*
ABM development

• Literature review of role of environmental factors:
  – Water Temperature (metabolic processes)
    • Lab experiments $\rightarrow V_{\text{swim}}$ vs. T
  – Salinity
  – Light (e.g. day/night)
  – Turbidity & others...
  – Interactions and local differences
1. Initialisation
2. Salinity and tide assessment
3. Flood: drifting (or active swimming)
   - Flow assessment
4. Ebb: holding station
5. Edging (on/off)
   - Day/night

ABM development

- tstep = 0,
  Initialise $v_{\text{swim}}, \theta_{\text{swim}}$

- tstep = tstep + 1,
  Correlated random walk & flow advection

- Assess salinity
  $S > S_{\text{thresh}}$ and $|\text{grad}S| > \text{grad}S_{\text{thresh}}$

- Ebb
  $\theta_{\text{flow}} = -\text{grad}S \text{ dir. } \pm 90^\circ$
  Align against flow
  $\theta_{\text{swim}} = \text{atan2}(v_{\text{flow}}, -U_{\text{flow}})$

- Flood
  Align with flow
  $\theta_{\text{swim}} = \text{atan2}(v_{\text{flow}}, U_{\text{flow}})$

- Assess flow velocity
  $v_{\text{flow}} > v_{\text{swim}}$

- Edging
  Steer 45$^\circ$ towards slower flow, $v_{\text{swim}} = \text{initial } v_{\text{swim}}$

- Hold at bed
  Migrate to bed and stop
  $v_{\text{swim}} = 0$ and $v_{\text{flow}} = 0$

- Drift (or swim)
  $v_{\text{swim}} = 0$ (or initial $v_{\text{swim}}$)

- Day/night
Validation / Application

- Coupled to 3D hydrodynamic models
- 8 different ‘STST’ scenarios
- Validation in Thames Estuary using 2014(6) ZSL/EA
- Application to Milford Haven Waterway
1. NO STST
2. STST + DAY/NIGHT; swimming throughout water column on night flood
3. STST + DAY/NIGHT; swimming at surface on night flood
4. STST + no DAY/NIGHT; swimming at surface on floods
5. STST + DAY/NIGHT; drifting throughout water column on night flood
6. STST + DAY/NIGHT + EDGING; swimming at surface
7. STST + DAY/NIGHT + EDGING; drifting at surface
8. STST + no DAY/NIGHT + EDGING; drifting at surface
Results Thames

![Graph showing eel counts from May to October with data peaks in August and September. The graph includes multiple lines with different colors representing different eel groups.](image-url)
Results *Milford*

(8) STST + no DAY/ NIGHT + EDGING; drifting at surface
Results *Milford*

(8) STST + no DAY/ NIGHT + EDGING; drifting at surface
Conclusions

• ABM capable of representing upstream migration, matching catchment data
• Case study confirms glass eel impingement and provides estimate
• Possibilities to expand to other areas/species
Thank you!

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