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Manoeuvring Mussels: Importance of Habitat in the Resilience of Freshwater Pearl Mussels to Increased Flooding under Climate Change

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Freshwater Group Meeting 2013

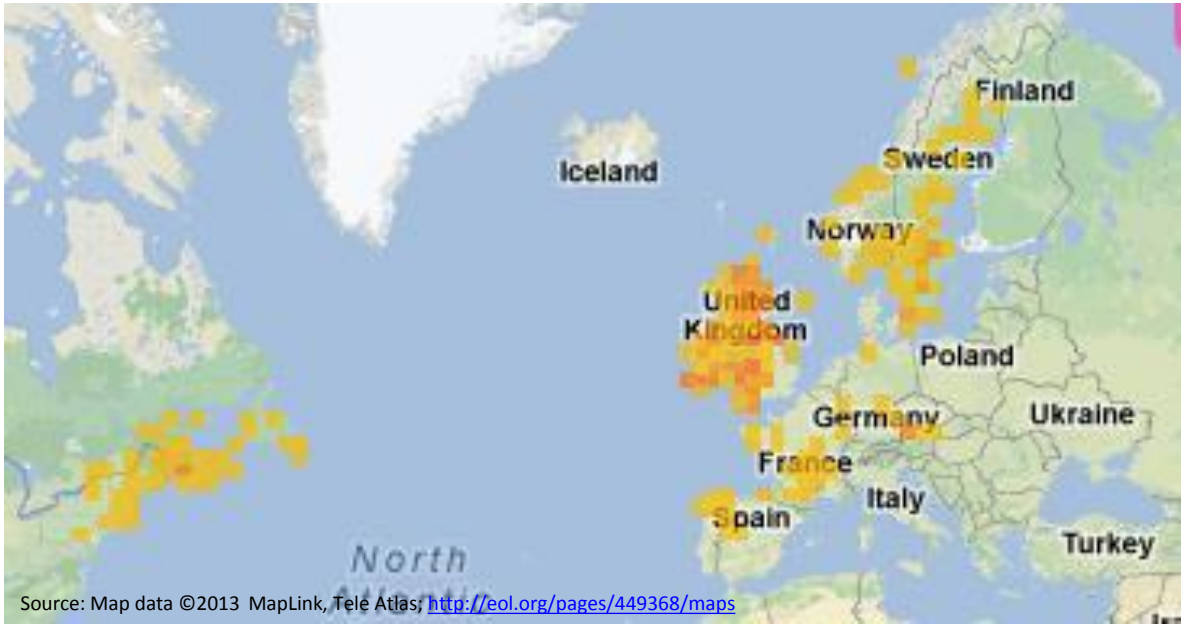
The Freshwater Pearl Mussel

- Large freshwater bivalves
- Filter feeders (50 litres a day)
- Life span of over 100 years
- OCCASIONALLY contain a pearl
- Cultural History

Source: www.cuttingrocks.com

Distribution

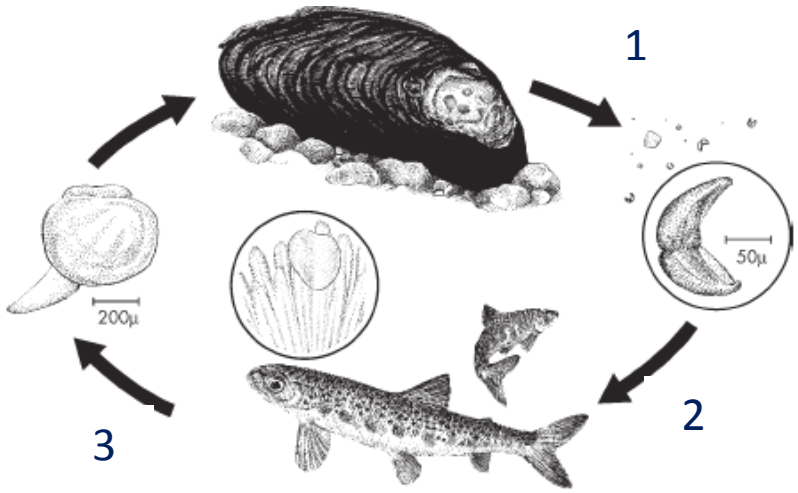
- Holarctic distribution
- 50% of global recruiting population resides in Scotland



Source: Map data ©2013 MapLink, Tele Atlas; http://eol.org/pages/449368/maps

Life Cycle

- June - July (1)
  - Mature males (> 12 years old) release sperm into water column
  - Sperm inhaled by the female to fertilise eggs
- July – September (2)
  - Females release larvae (glochidia) into water column
  - Glochidia snap onto gills of host salmon or brown trout where they are encysted with gill tissue
- May – Early June (3)
  - Juvenile mussel falls off host onto river bed where they borrow into sediment



Source: www.dolgellauanglingassociation.co.uk

Habitat

- Water Quality
  - Oligotrophic conditions
  - Temperatures less than 15°C
- Water Quantity
  - Depth 0.03 – 0.04 m
  - Velocities 0.25 – 0.75 m/s
  - Moderate high flows to remove algal mats and accumulation of fine sediments
- Substrate
  - Large stones or boulders with patches of sand or fine gravel to burrow into

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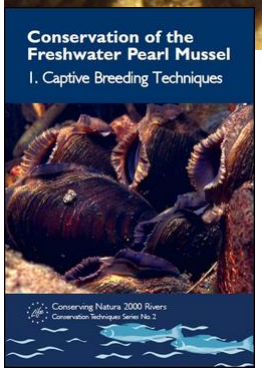
Threats and Conservation

- Threats
  - Illegal pearl fishing
  - Habitat Degradation
  - Declining fish host stocks
  - CLIMATE CHANGE
- Conservation Measures
  - Legal Protection
  - Captive Breeding
  - Maintain healthy fish stocks
  - Reduce habitat degradation

Source: wildlifedetective.wordpress.com



species action FRAMEWORK

CONVENTION DE BERNE
BERN CONVENTION

Conservation in a Changing Climate: Increased Flood Frequency

- Advantages
  - Encourage mussel recruitment
  - Increased flushing flows to remove macrophytes and algae
  - Reduces potential of silt build up
- Disadvantages
  - Habitat destruction
  - Increased mortality of juveniles
  - Entrainment downstream to unsuitable habitat
  - Entrainment onto bank /gravel bars & abandoned

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Entrainment …

Aim: Predict the potential effect of increased flood frequencies on freshwater pearl mussel entrainment

- *Velocity entrainment occurs*
- ***Importance of habitat on freshwater pearl mussel entrainment velocity***
- *Best protection mechanism in resisting entrainment (burial, alignment, sheltering)*
- *Identify populations most resilient to increased flood frequency*

Resistance to Entrainment

- Protection Mechanisms
  - Burial
  - Alignment
  - Sheltering
- Morphology
  - Shell Curvature
  - Foot

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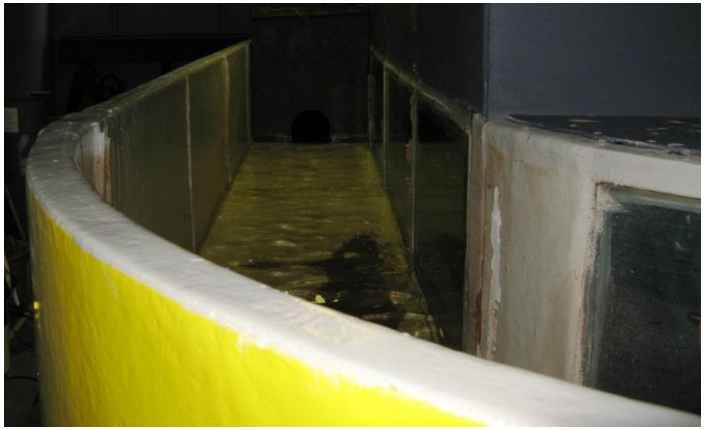
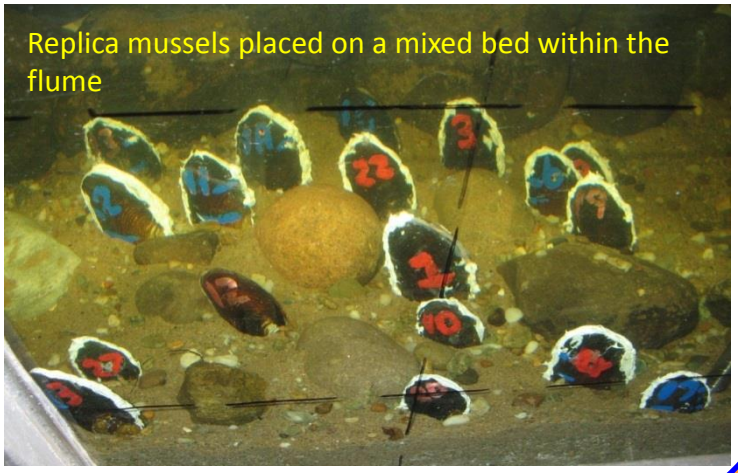
Measuring Entrainment

- The Flume
  - Recirculating flume
  - Build replica river bed
  - Place replica mussels into bed
- Changing Variables
  - Habitat
  - Burial Depth
  - Orientation





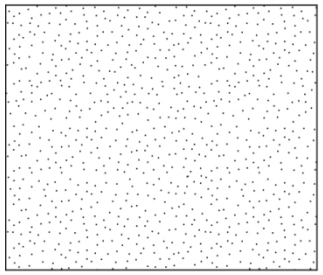
Replica mussels placed on a mixed bed within the flume

Measuring Entrainment

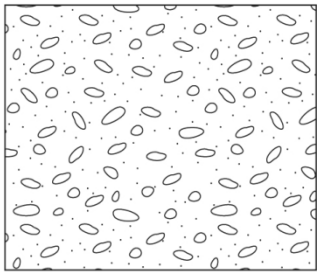
Flume Procedure

1. Build replica mussel bed
2. Fill and turn on pump
3. Wait 45 seconds for velocity to stabilise
4. Record near-bed velocity at 6 locations within bed for 30 seconds
5. Record any mussel movement and flume point
6. Turn-up pump & repeat 3 to 6

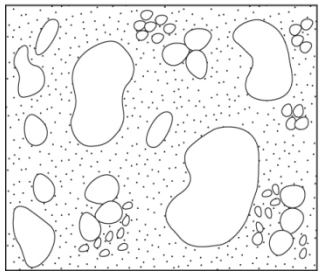
Sand



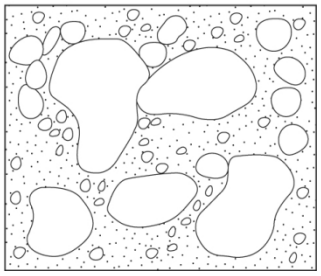
Gravel



Mixed Bed



Boulder Bed



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Measuring Entrainment

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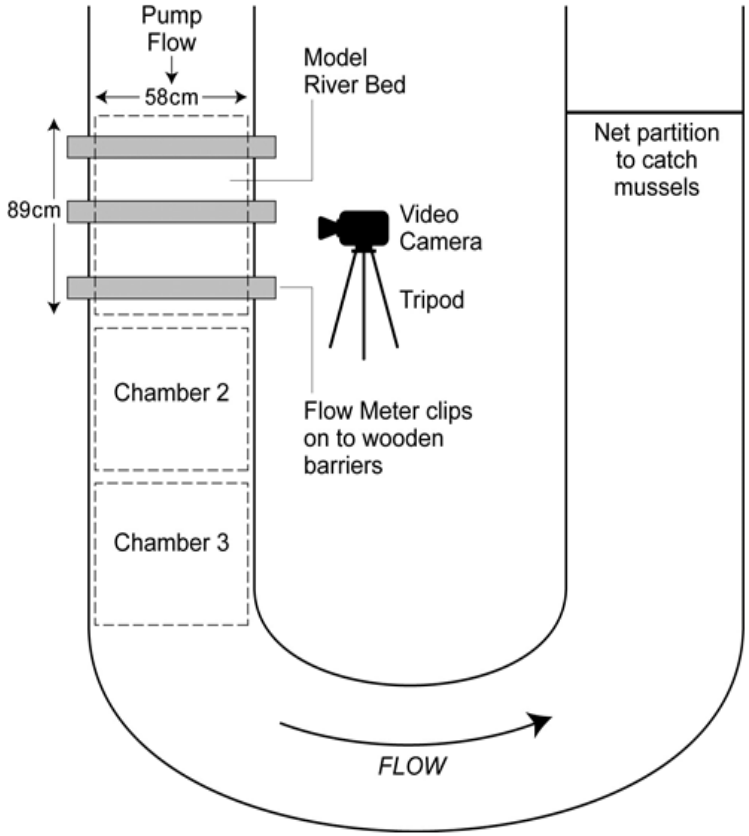

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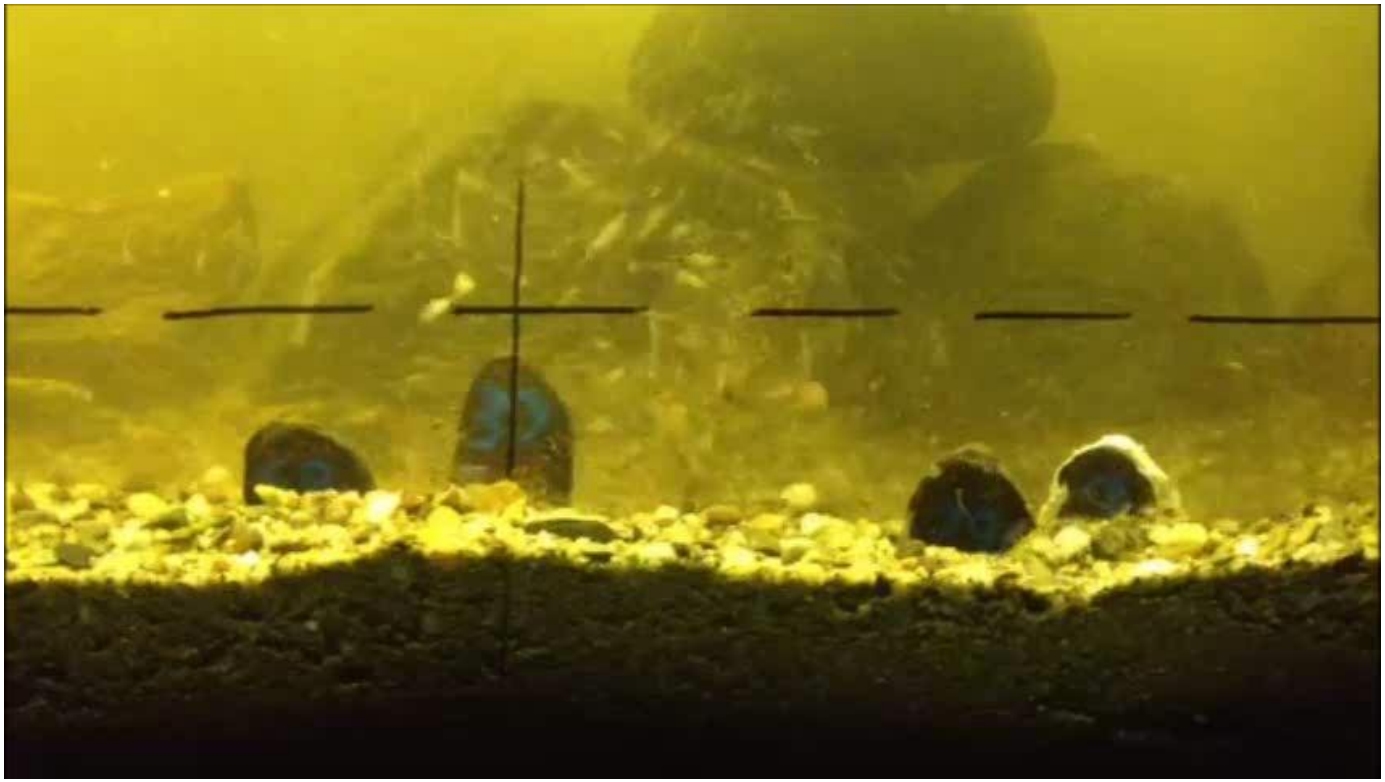
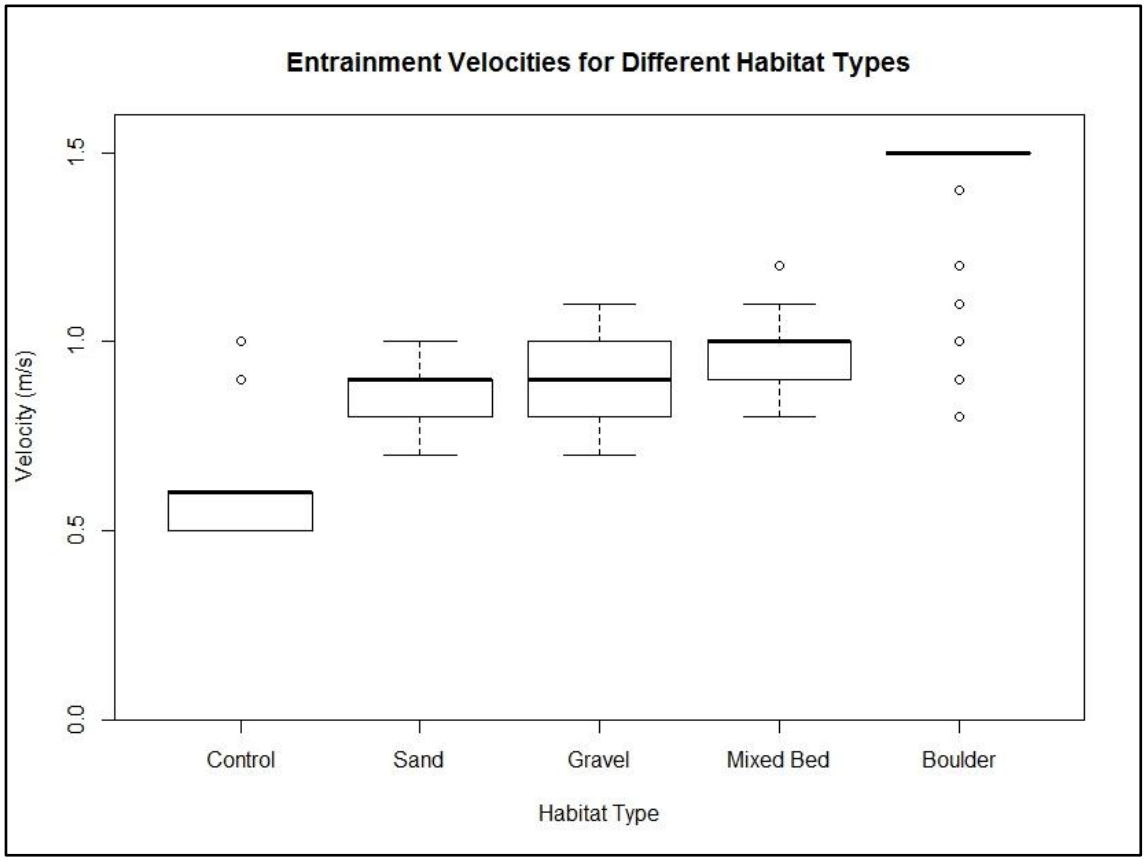
Measuring Entrainment



Did Habitat effect Entrainment Velocity?

- ***Coarser bed material increased entrainment velocity***



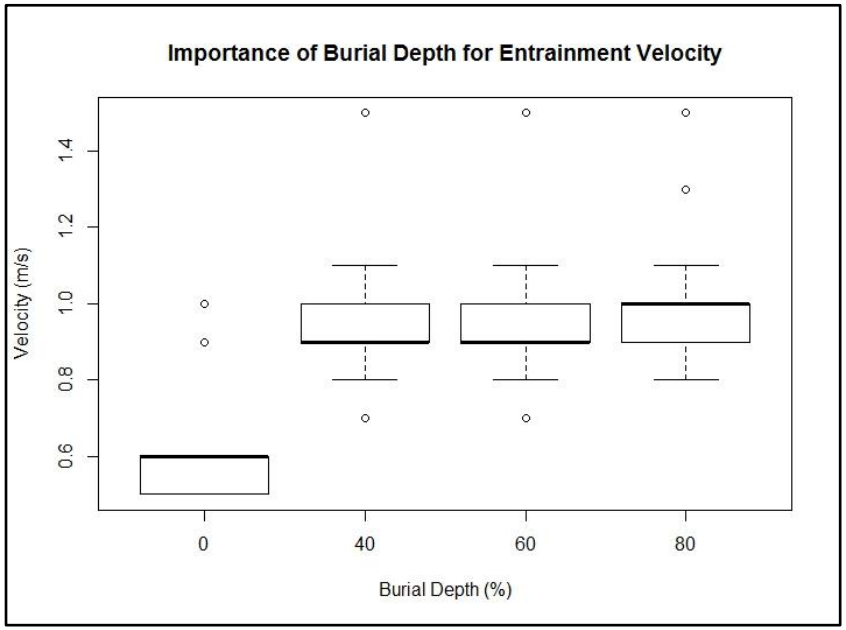
Habitat was found to have a significant effect on entrainment velocity: [H=133.96, df = 80, N=329 p=<0.001]

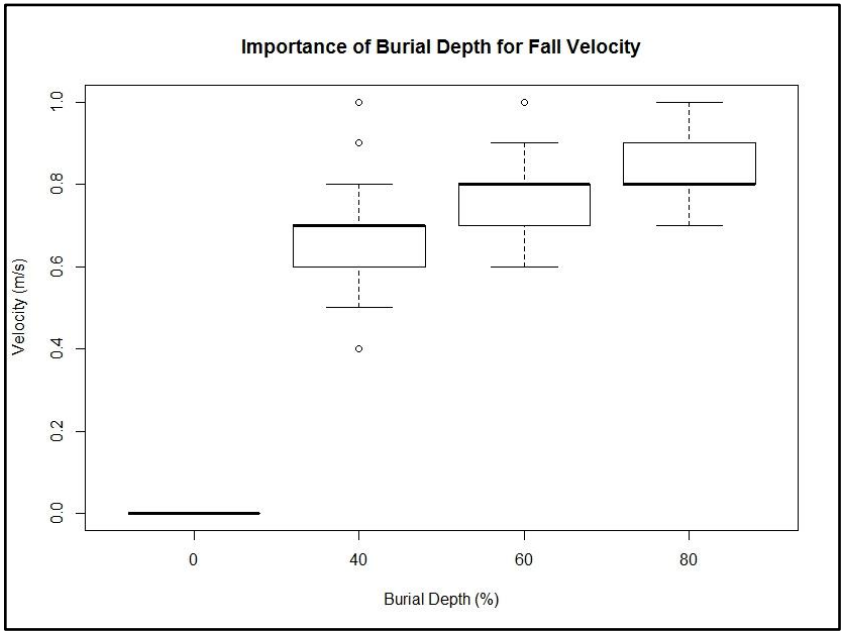
Post-Hoc Testing

- No significant difference between sand and gravel habitats

Did Burial Depth Effect Entrainment and Fall Velocity?

- ***Burial does increase entrainment and fall velocity***





Burial Depth was found to have a significant effect on entrainment velocity: [H=32.28, df = 3, N=211 p=<0.001]

Post-Hoc Testing

- No significant difference between 40%, 60% and 80% burial

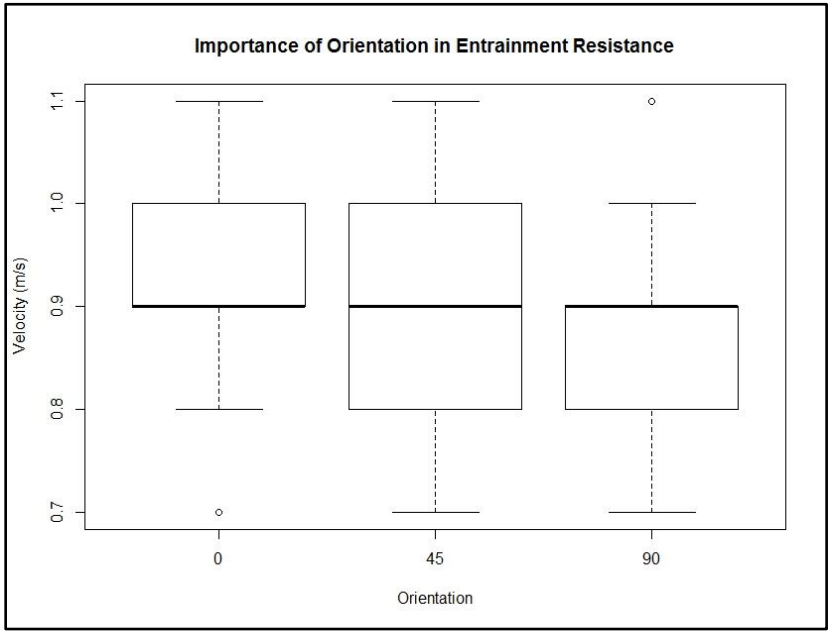
Burial Depth was found to have a significant effect on fall velocity: [H=86.65, df = 3, N=211 p=<0.001]

Post-Hoc Testing

- No significant difference between 60% and 80% burial

Did Orientation effect Entrainment and Fall Velocity?

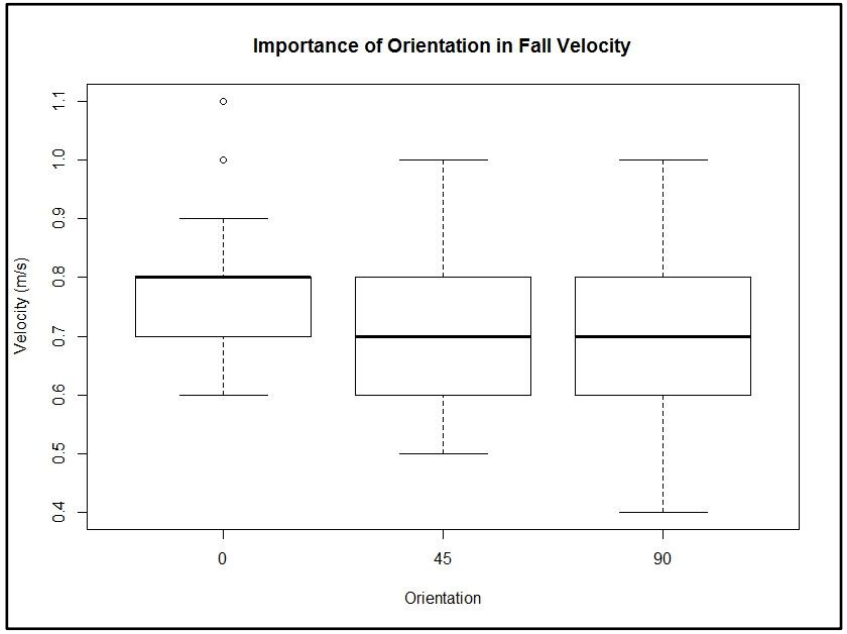
- ***Orientation had a significant effect on entrainment and fall velocity***



Orientation was found to have a significant effect on entrainment velocity: [H=9.01, df = 2, N=169 p=0.011]

Post-Hoc Testing

- Only a significant difference between 0° and 90°



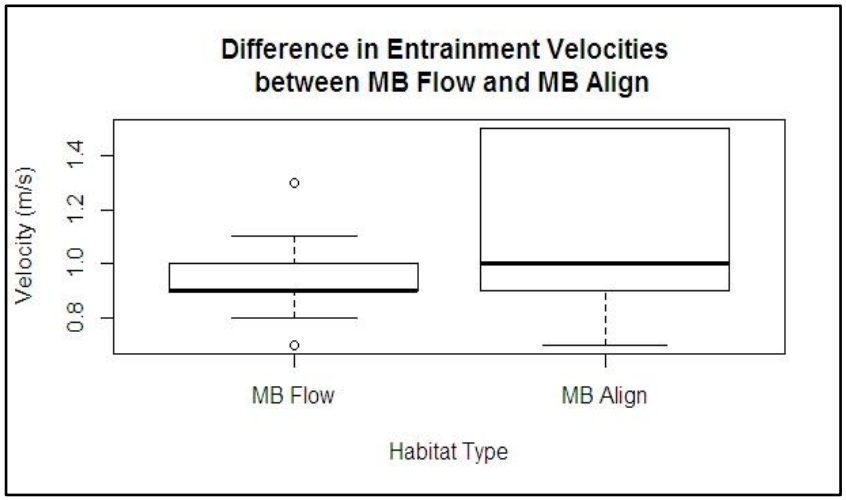
Orientation was found to have a significant effect on entrainment velocity: [H=33.05, df = 2, N=155 p=<0.001]

Post-Hoc Testing

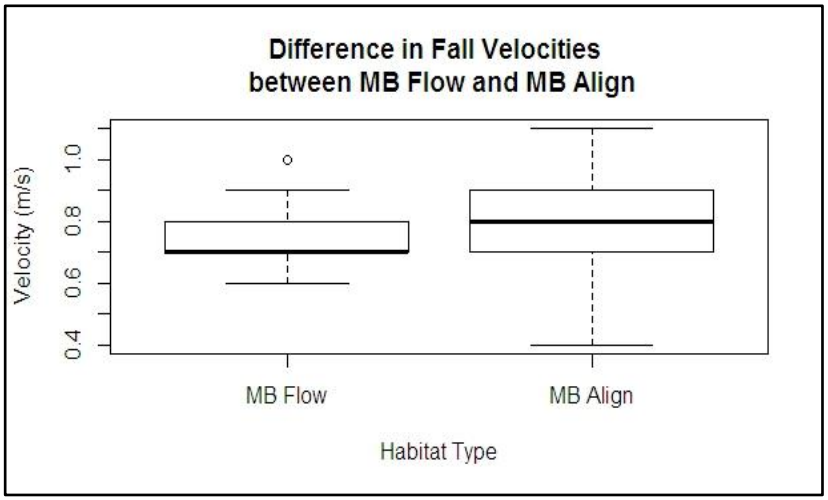
- Not a significant difference between 45° and 90°

Boulder verse Flow Alignment?

- ***Mussels aligned to the surrounding boulders tended to have a greater entrainment and fall velocity than those aligned to the flow***



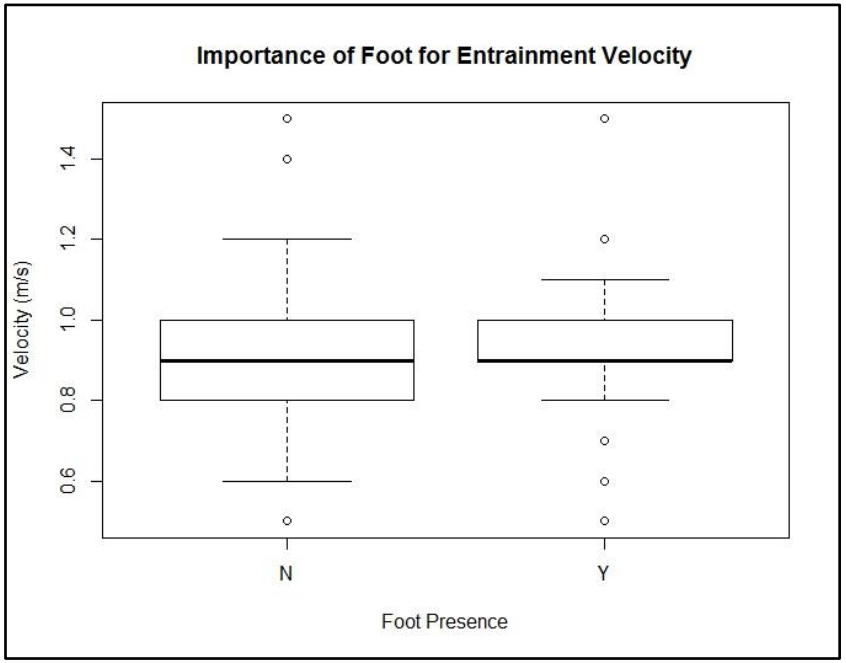
W = 6452.0, p = 0.0037

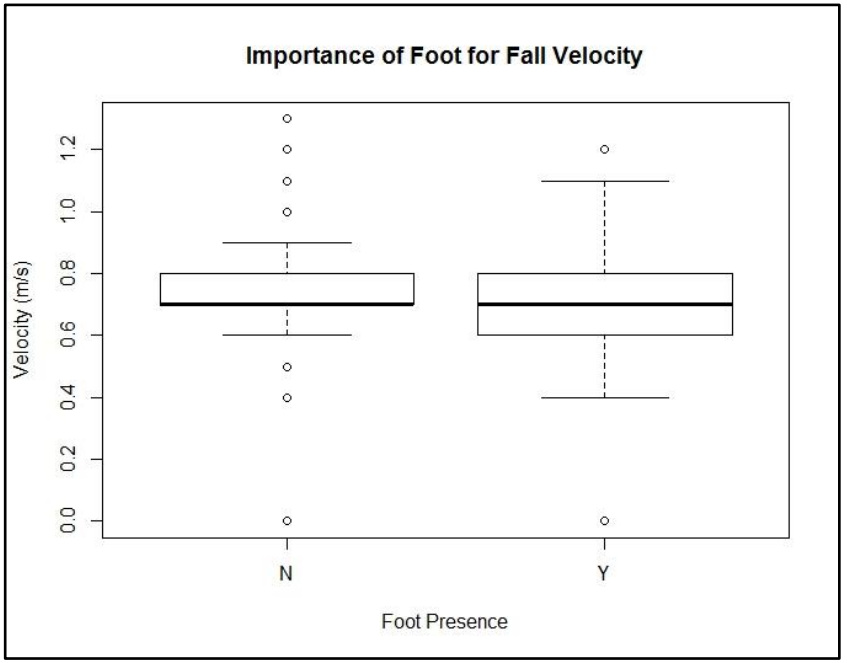


W = 6521.0, p = 0.0079

Importance of Foot for Entrainment and Fall Velocity?

- ***Mussel Foot had no significant effect on entrainment velocity***



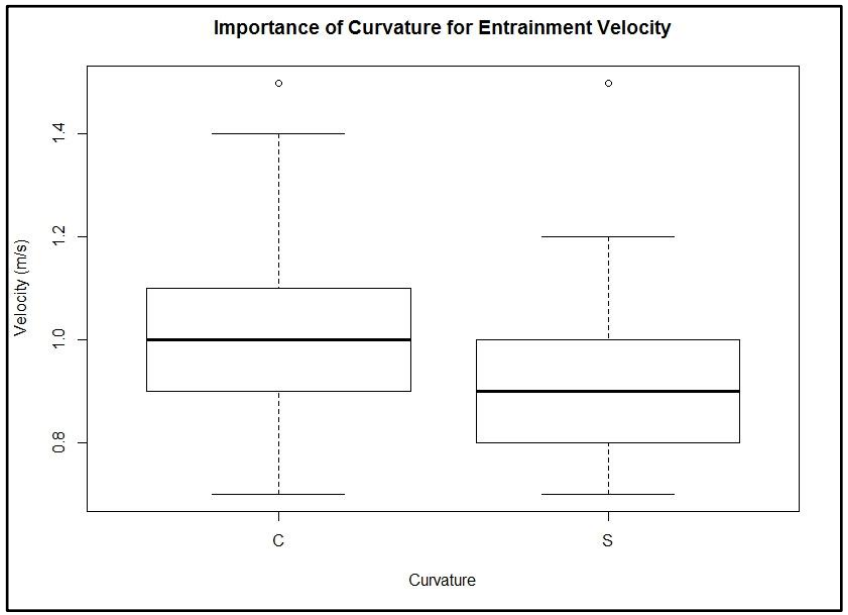


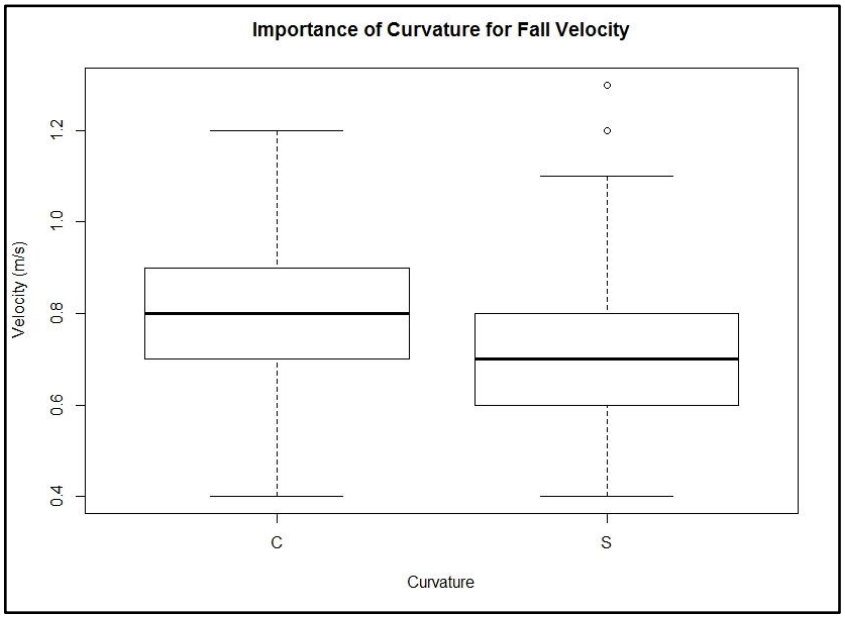
W = 12384.5, p-value = 0.173

W = 13482.5, p-value = 0.9565

Importance of Curvature for Entrainment and Fall Velocity?

- ***Curved mussels showed greater resistance to entrainment than straight mussels***





W = 15638, p-value = 0.01023

W = 15414.5, p-value = 0.02187

What do these results tell us …

- Mussel populations which currently live in habitats with large boulder and cobbles are expected to be the most resilient to an increase in flood frequency
- Being orientated parallel to the flow does slightly increase entrainment and fall velocity
- Burial does increase entrainment velocity but the effected of increasing burial depth is limited
- Although only slightly statistical significant mussels orientated to surrounding boulders and with greater curvature did show greater resistant to entrainment

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What does this mean for conservation?

- Conservation efforts should prioritise river reaches and populations which live in mixed bed and boulder habitats as these habitats will be the most resilient to future changes in climate
- Mussels reintroduced to rivers from captive breeding programmes should be places in river habitats which are dominated by boulders and cobbles
- Effect of different river management practices on mussel stability can be more easily modelled

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Next step …

- Geomorphic river type modelling at the catchment scale to highlight mussel populations most vulnerable to a change in flood frequency

- Investigate further the link between mid-column velocity and near bed velocity to predict potential changes in the frequency of mussel entrainment with climate change

Acknowledgements

Funding

- Scottish Environmental Protection Agency
- Scottish National Heritage

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Questions ...