

Can Atlantic Salmon Eggs Adapt to Oxygen Stress?

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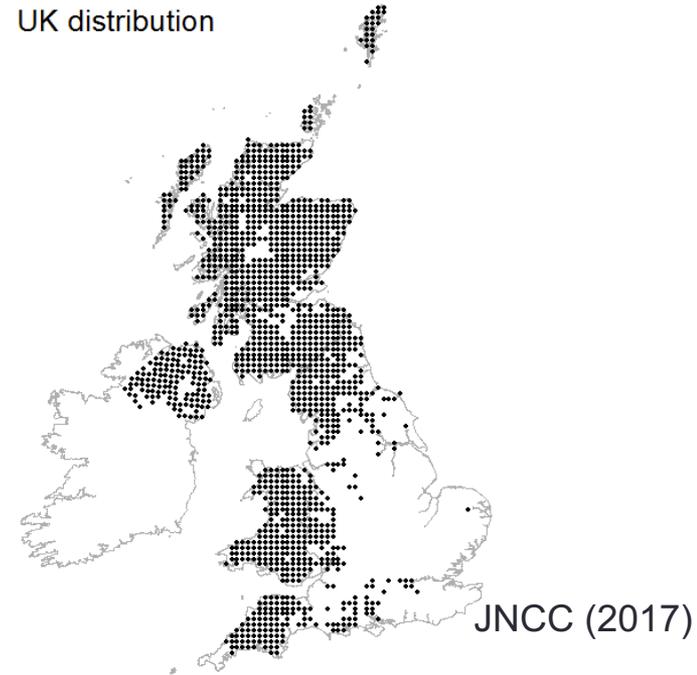
Introduction

- Salmon in UK rivers
- Why study salmon eggs?
- The incubation environment
- Oxygen supply and stress
- Salmon egg structure
- Variation among populations
- Structural variation affects tolerance to oxygen stress
- Management implications
- Conclusions

Salmon in UK rivers

- Found throughout the UK
- Wide range of environments
- High value species
 - Economically
 - Ecologically
 - Socially

UK distribution



Why study salmon eggs?

- High rates of mortality have long-term impacts;
- Easier to access environments
- Easier to identify and treat sources of pollution



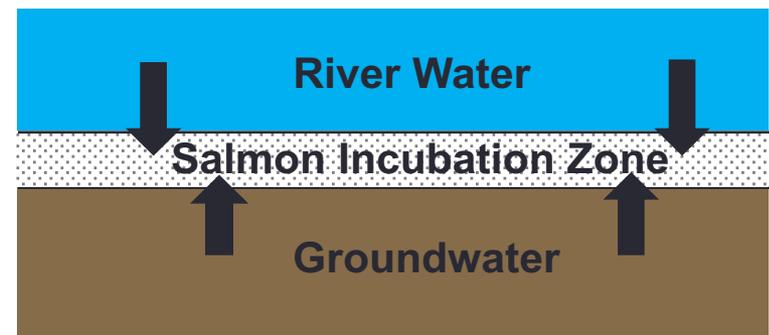
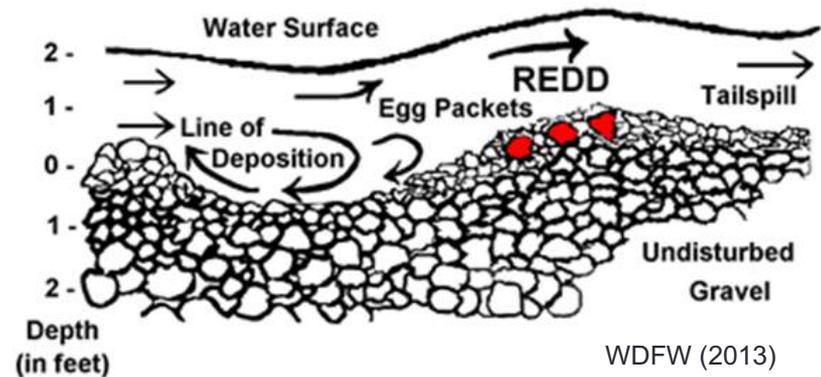
Salmon Incubation Environment

- Eggs deposited in nests known as redds;
- Redds are constructed from gravels
- Each female can lay more than 10,000 eggs



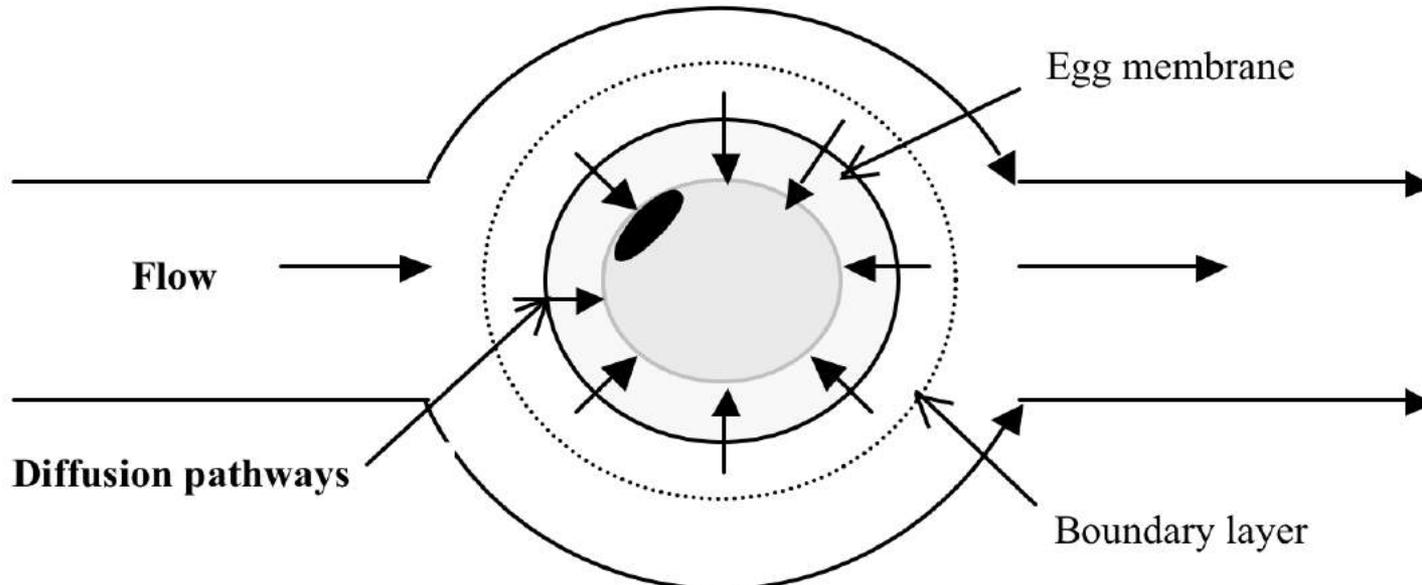
Salmon Incubation Environment

- Salmon redds provide the ideal incubation environment for delivery of well oxygenated water;
- Located in the riverbed – subjected to interactions between groundwater and surface water.



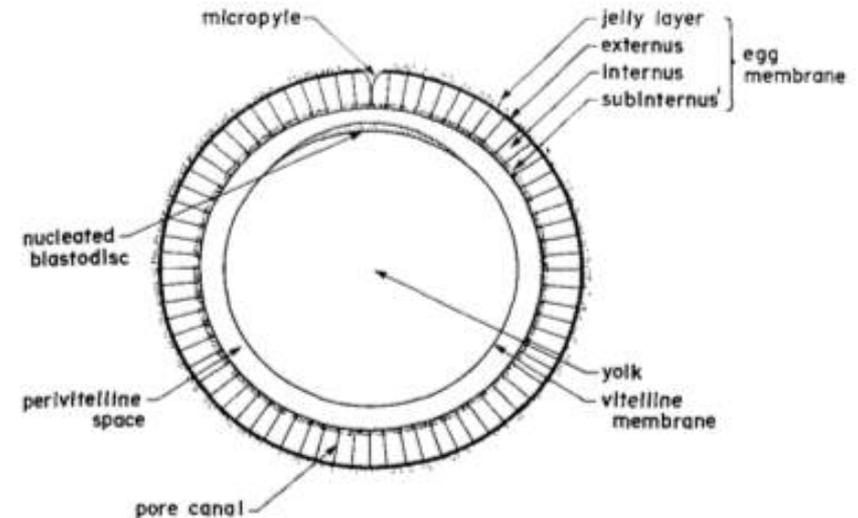
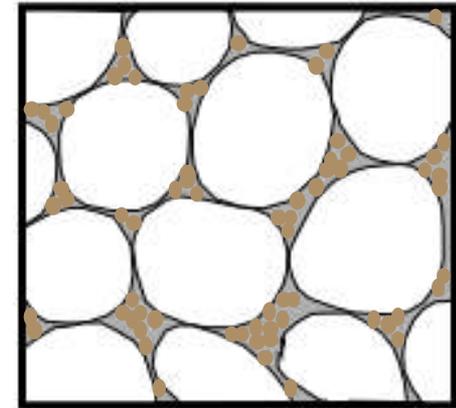
Oxygen Supply to Salmon Eggs

- Oxygen obtained from thin film of water surrounding egg known as the boundary layer
- Rate of oxygen supply determined by oxygen concentration and flow rate



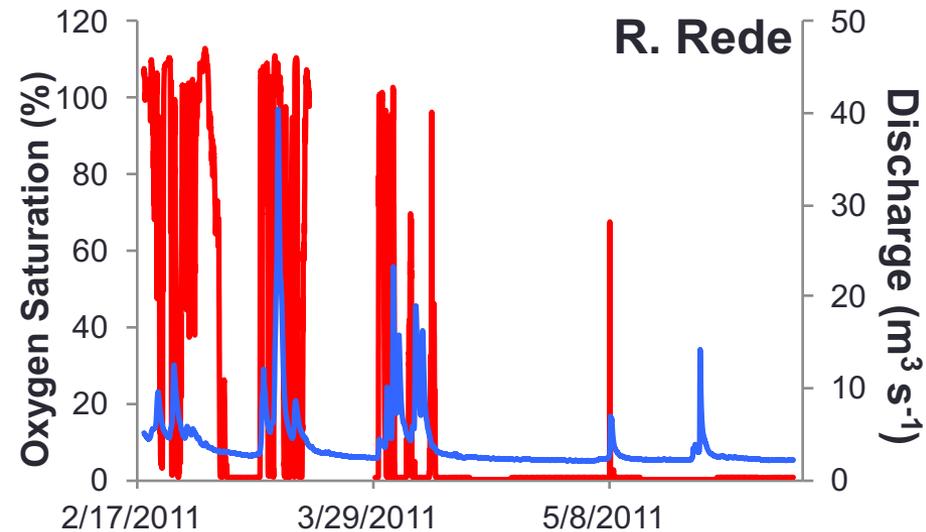
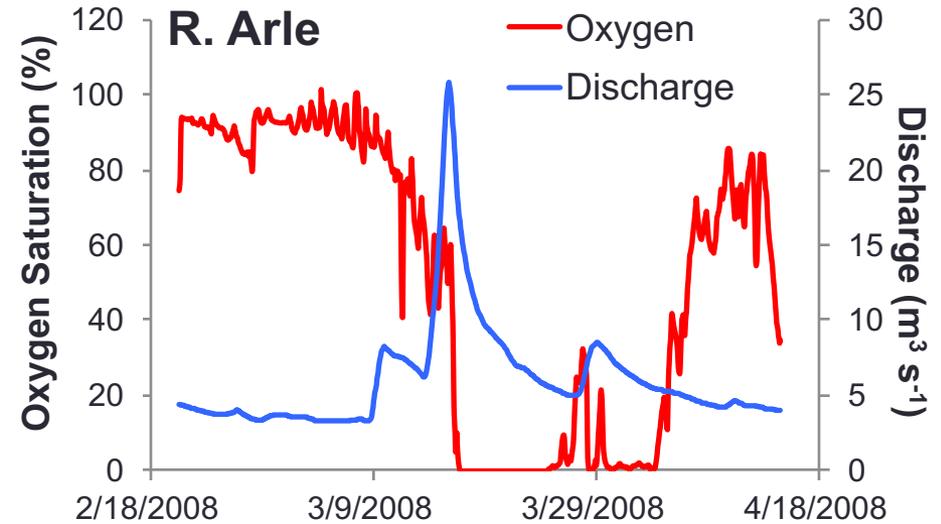
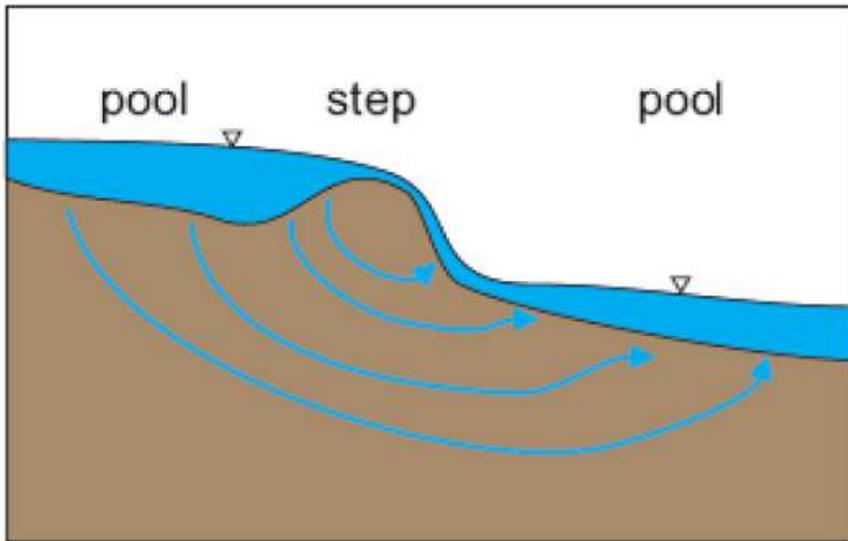
External causes of oxygen stress

- Sedimentation
 - Plugs spaces between gravels
 - Reduces flow rate



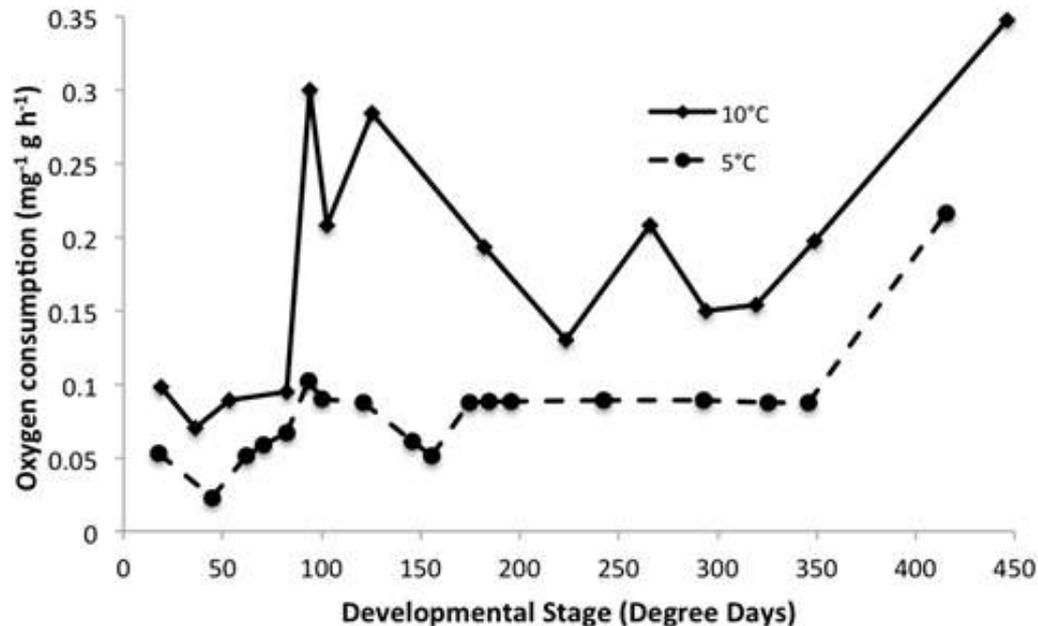
External causes of oxygen stress

- Groundwater upwelling
 - Chemical and biological reactions in the ground strip oxygen from water



Oxygen Demand

- Oxygen demand is influenced by temperature and developmental stage.



- Oxygen stress occurs when the oxygen demand of the egg exceeds the supply;

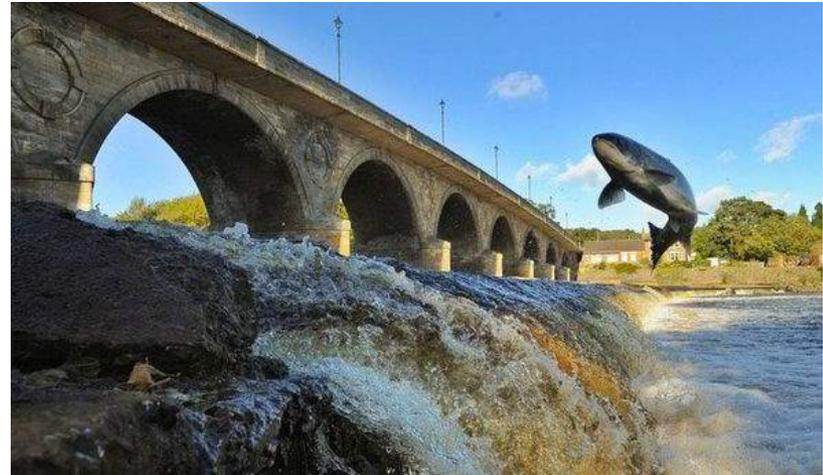
UK Variation of Oxygen Stress

- Different river types throughout the UK offer different spawning environments;
- Different spawning environments mean differing oxygen supply;
- Opportunity for adaptation?



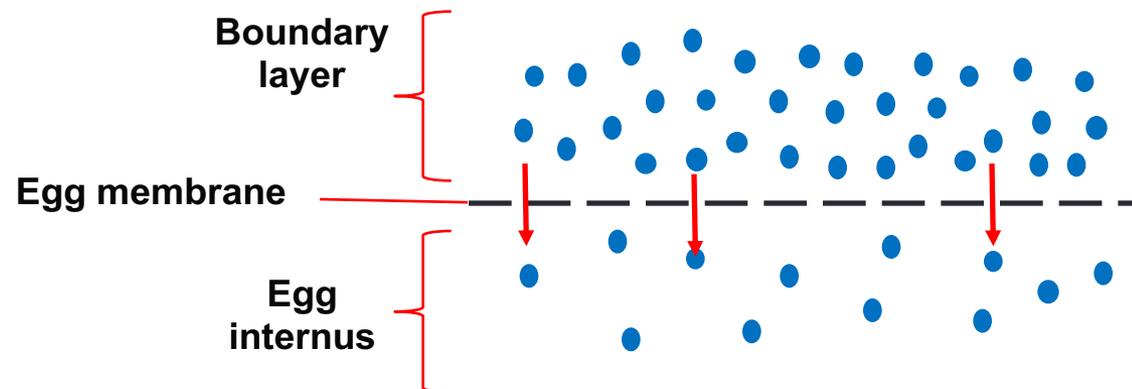
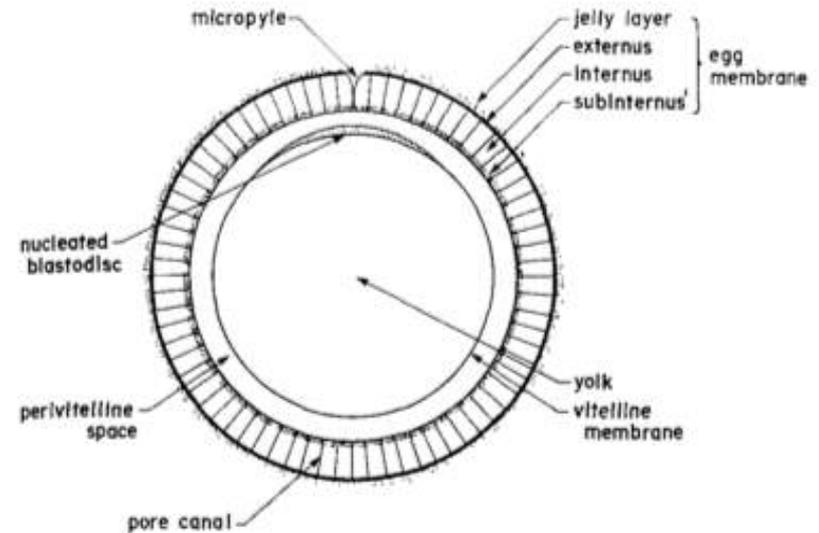
Can salmon adapt to low oxygen?

- Salmon are ideal species to study adaptation
- Returning to spawn in native rivers means there are many isolated populations
- More than 80 known genetic adaptations of Atlantic salmon



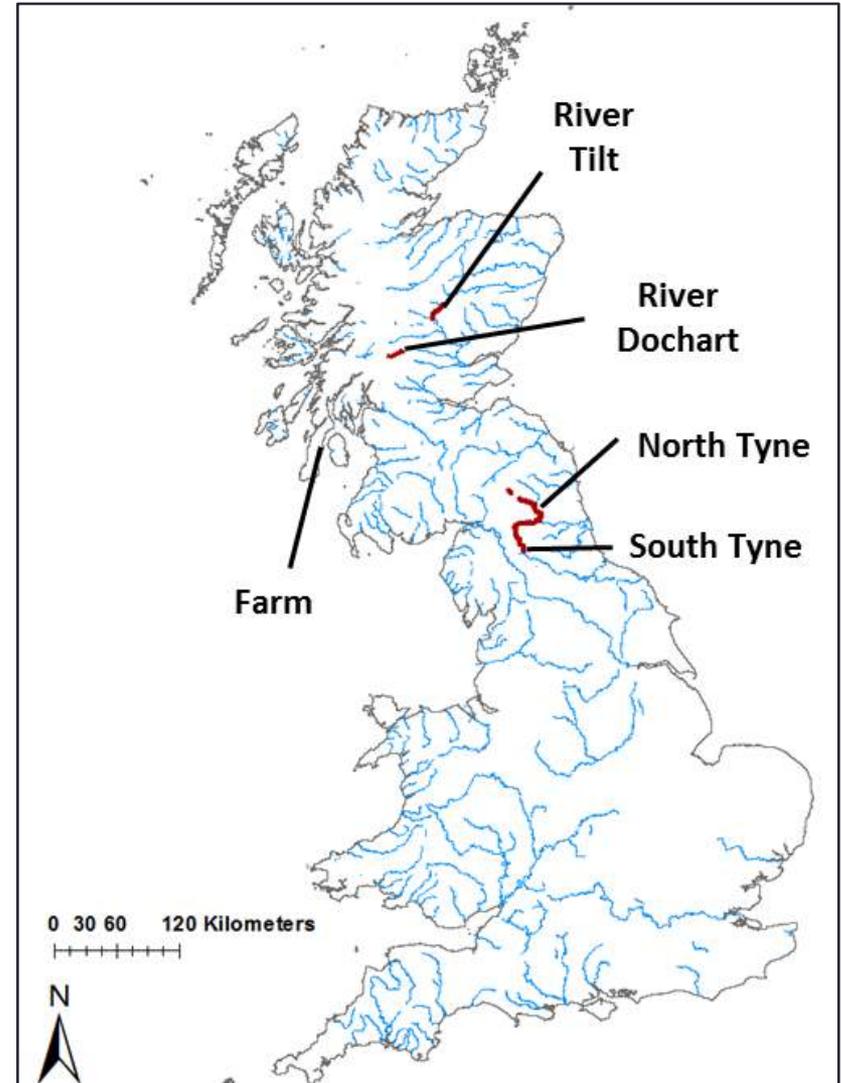
Egg membrane structure

- Membrane composed of micropores through which oxygen diffuses;
- Egg membrane is a barrier to oxygen diffusion;
- Differences in membrane structure could influence response to oxygen stress



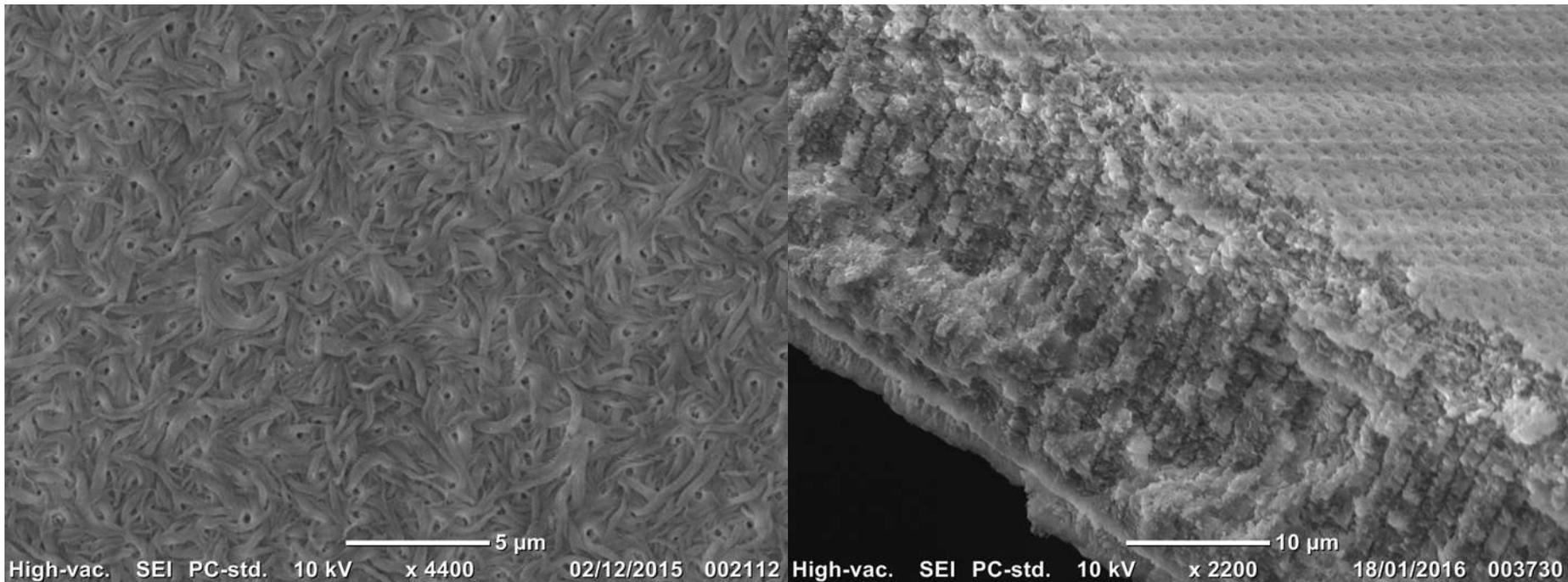
Methods

- Eggs from 5 populations to represent different spawning habitats
 - Farmed;
 - River Tilt (River Tay);
 - River Dochart (River Tay);
 - North Tyne
 - South Tyne



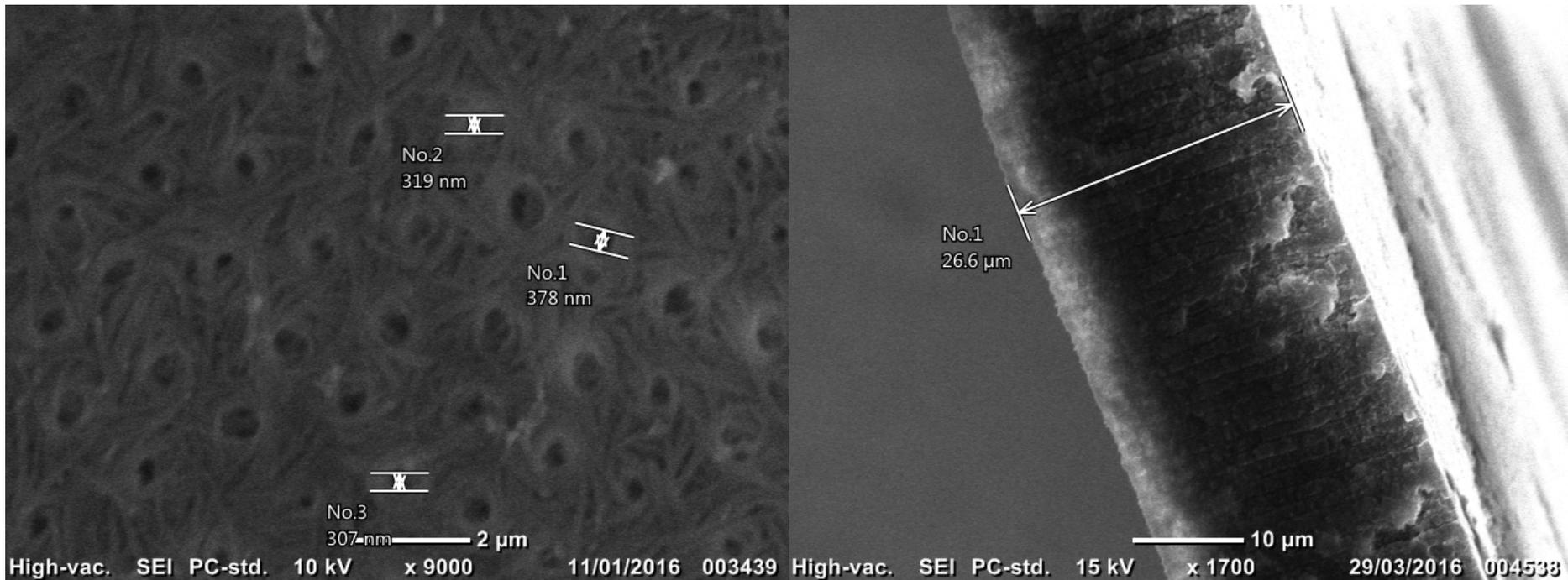
Methods

- Dissect membrane from egg;
- Observe membrane under electron microscope;



Methods

- Measured:
 - egg size
 - pore diameter and density (porosity) and membrane thickness;

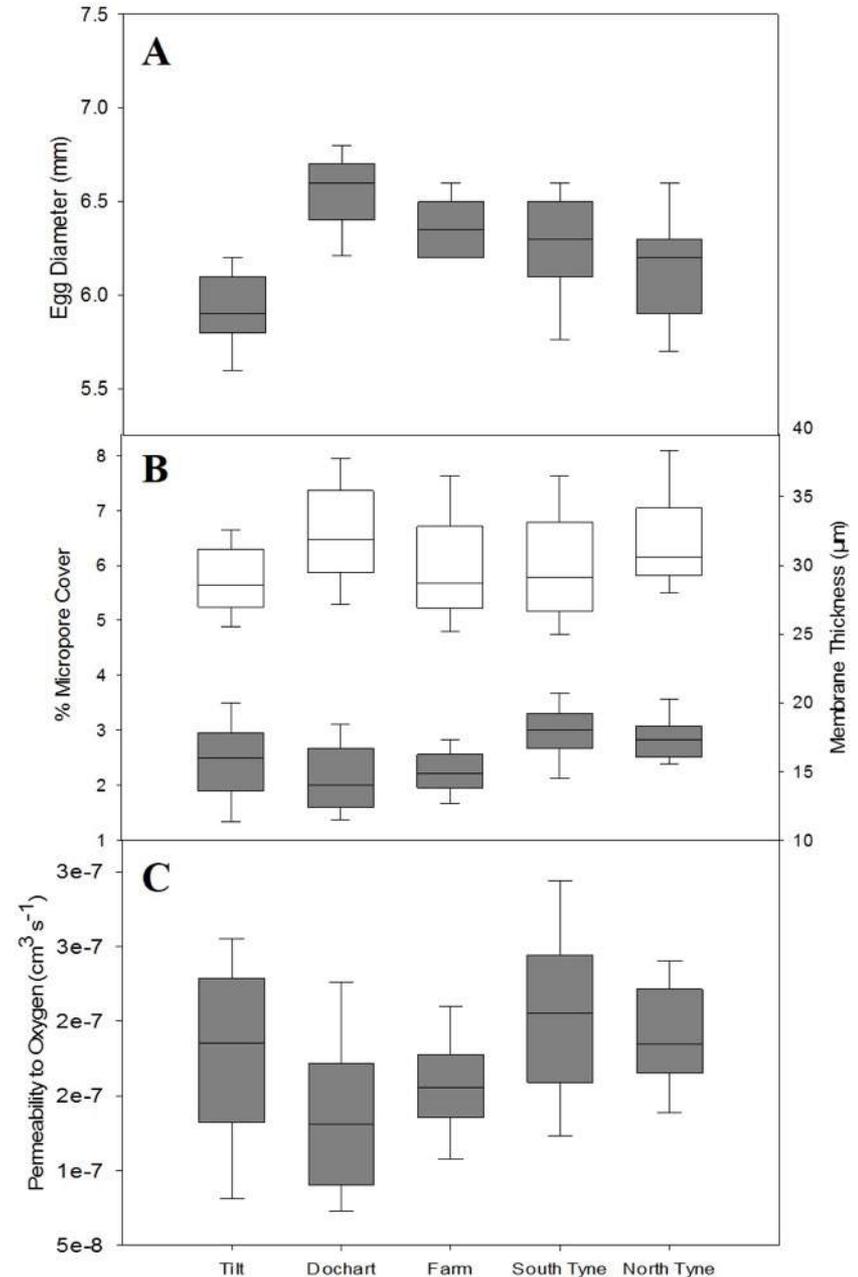


- Calculated membrane permeability to oxygen

Results

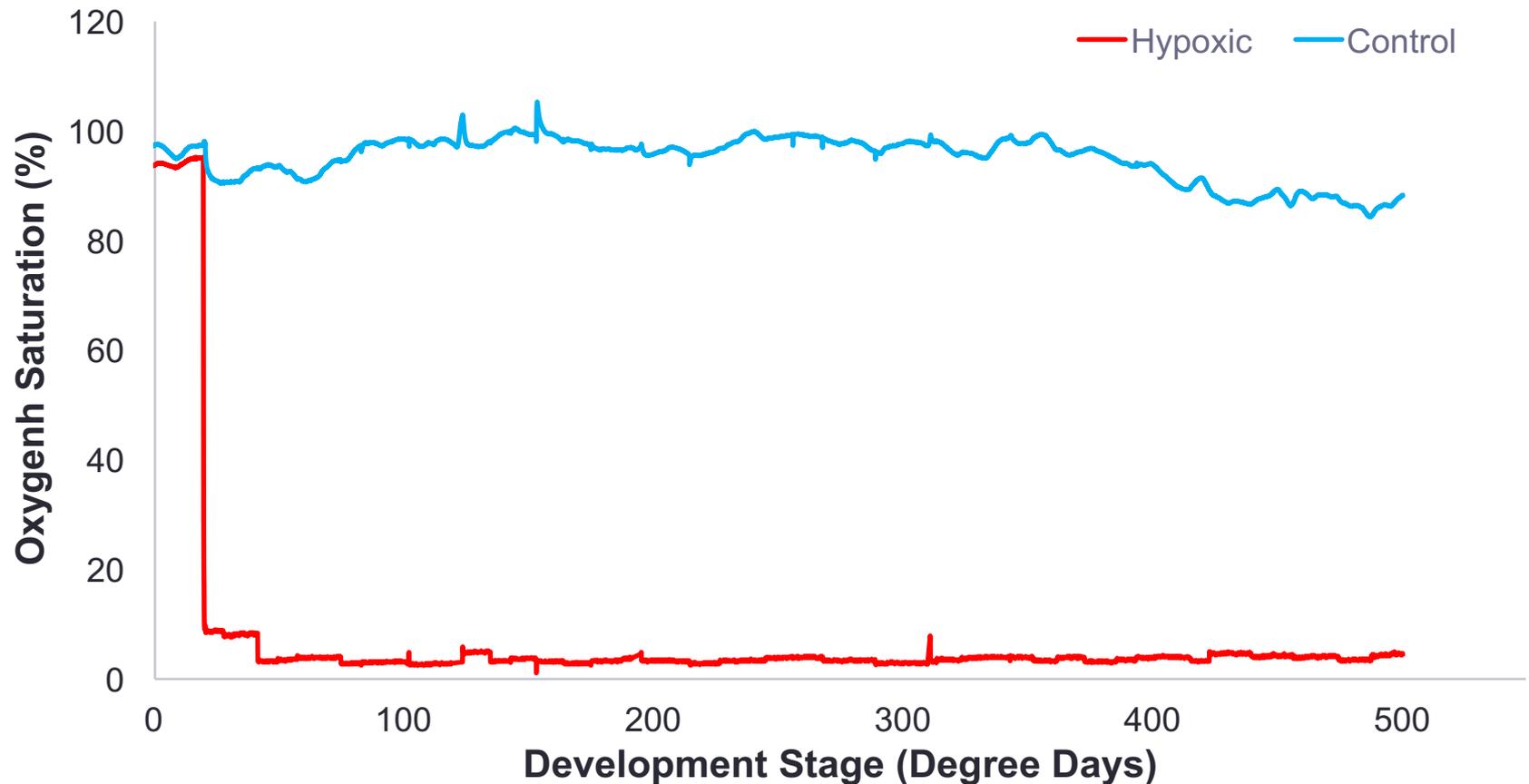
- Significant differences among populations in terms of egg size;
- Differences in porosity (micropore coverage) and membrane thickness;
- Differences in membrane permeability imply River Tyne and River Tilt eggs will be most tolerant to low oxygen.

However, this is only theoretical. Other features could influence sensitivity to oxygen stress.



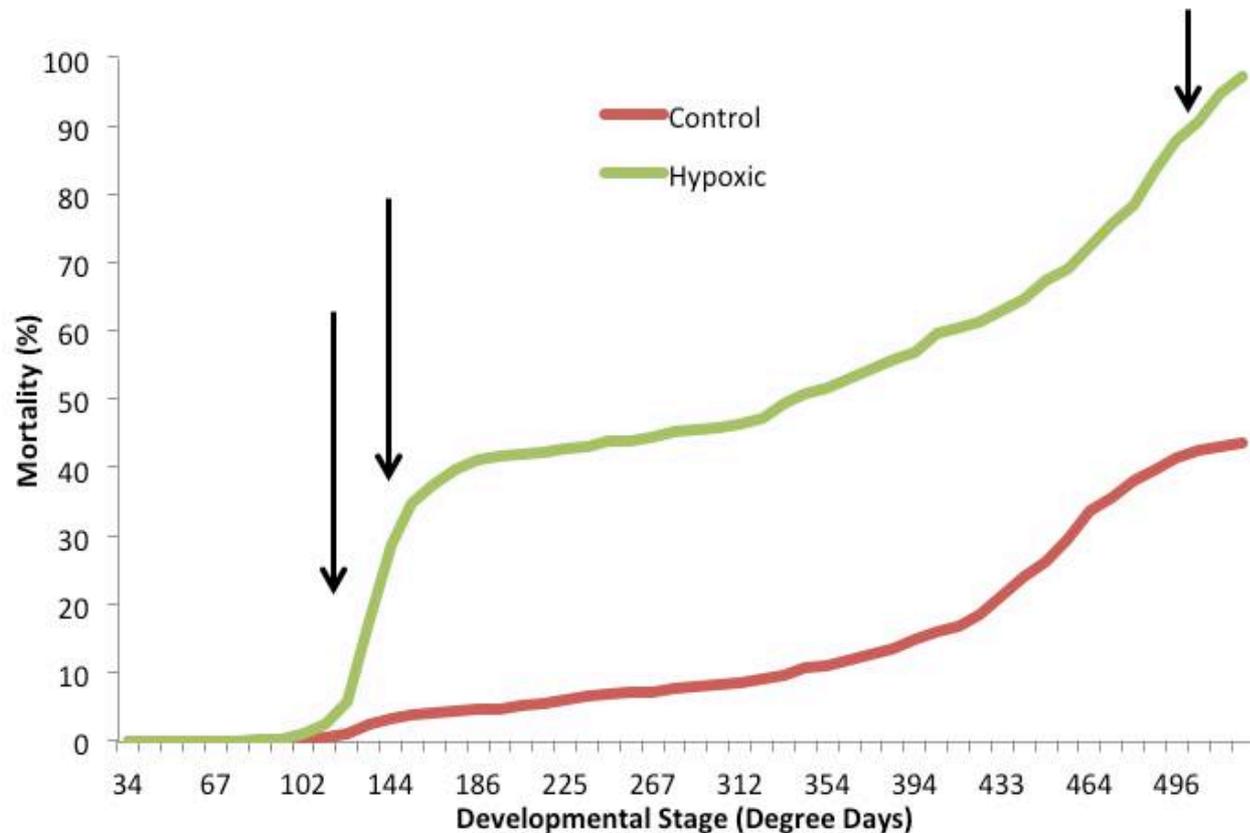
Part 2: Methods

- Eggs of one population (farmed), exposed to extreme, continuous low oxygen.



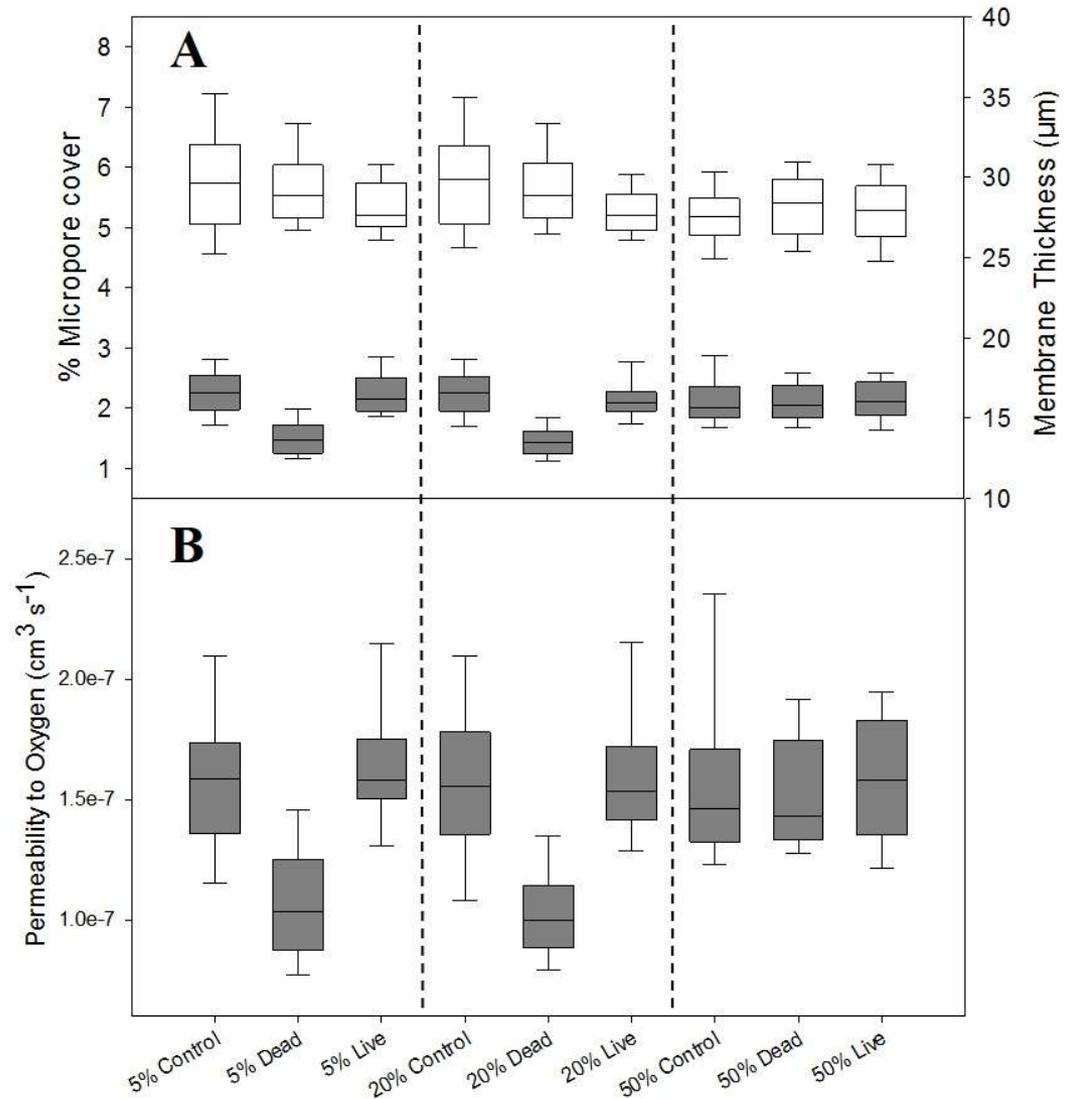
Methods

- An equal number of dead, live and control eggs removed when mortality in low oxygen conditions exceeded
 - 5%
 - 20%
 - 50%



Results

- Convincing evidence that membrane permeability influences sensitivity to low oxygen;
- Pattern lost at 50% mortality threshold, other factors possibly responsible for mortality



Implications

- Altered spawning habitat could influence long-term survival and result in the loss of adaptations;
- Possible consequences for supportive breeding
- Interbreeding with non-native (e.g. farmed) individuals could cause loss of adaptation;
- Population straying, which increases with climate change, could drive loss of adaptation.

Conclusions

- Salmon eggs are exposed to a range of different conditions throughout the UK.
- Variation in incubation conditions means oxygen supply to eggs varies among populations.
- Differences in egg structure among populations could affect tolerance to oxygen stress.
- Therefore it is important to maintain incubation conditions where possible.



Thank You

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