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Dissolved Oxygen in the Clyde

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SEPA

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Introduction

- Description of Clyde estuary
- Factors affecting Dissolved Oxygen (DO) in water
- Data analysis- 40 years and >30k samples
- Modelling water quality

- ? Why are we doing this?

  Using science to improve our environment

Clyde Estuary

- Carved by glaciers during last ice age
- Inner estuary highly modified
- Tidal weir – maintain water level upstream
- Large discharges of organic material from Sewage Treatment Works (STWs) and Combined Sewer Overflows (CSOs)
- Low flow velocities; limited mixing
- Historical problems with water quality

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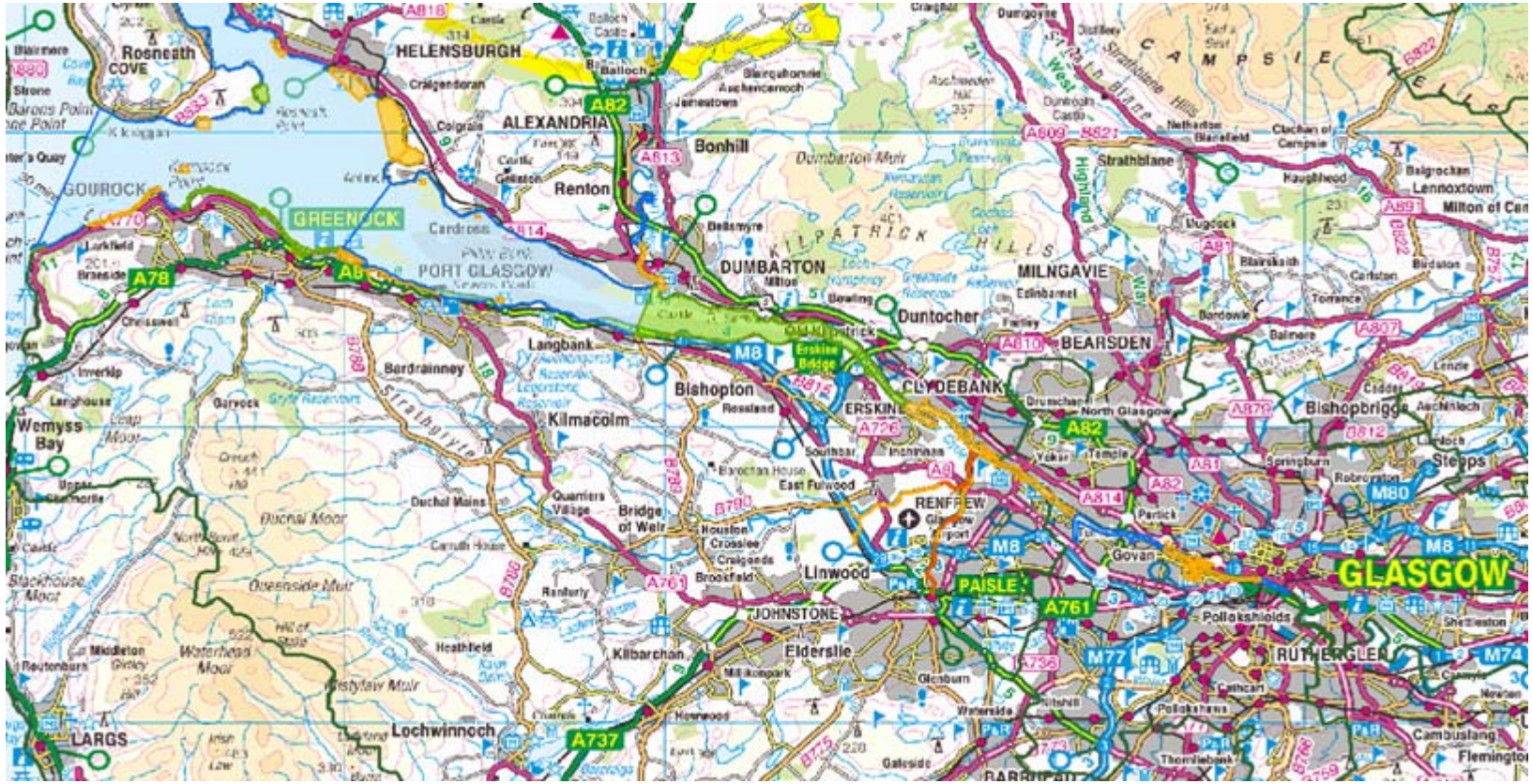

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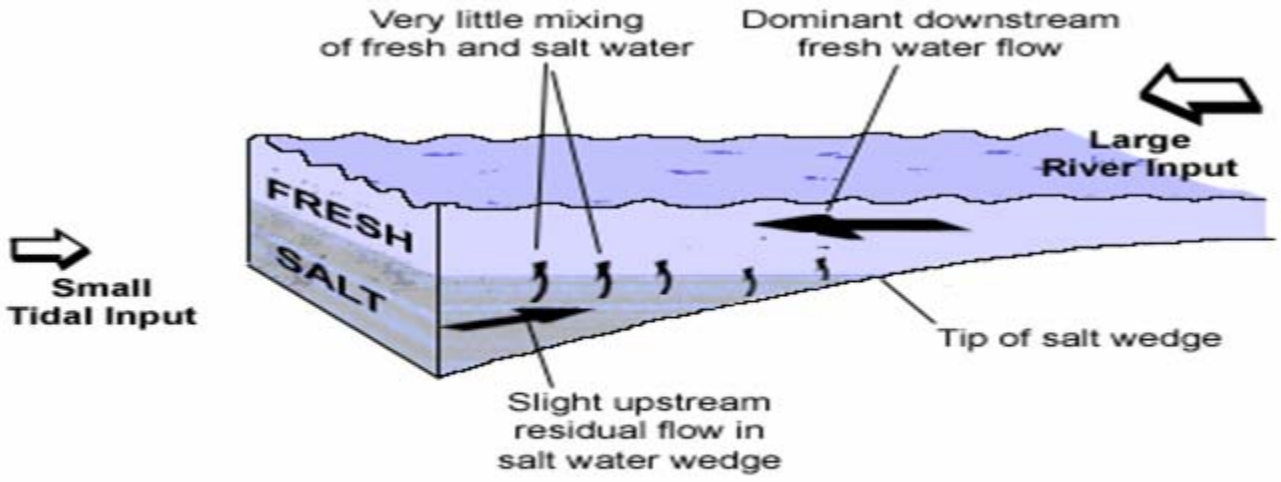
Stratification

- Distinct layers of fresh and saline water
- Depends on tide / river flow
- Stratification reduces vertical mixing



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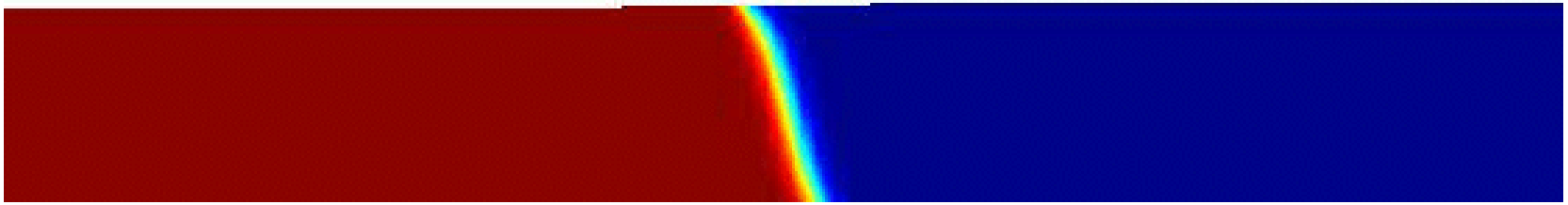
Stratification...



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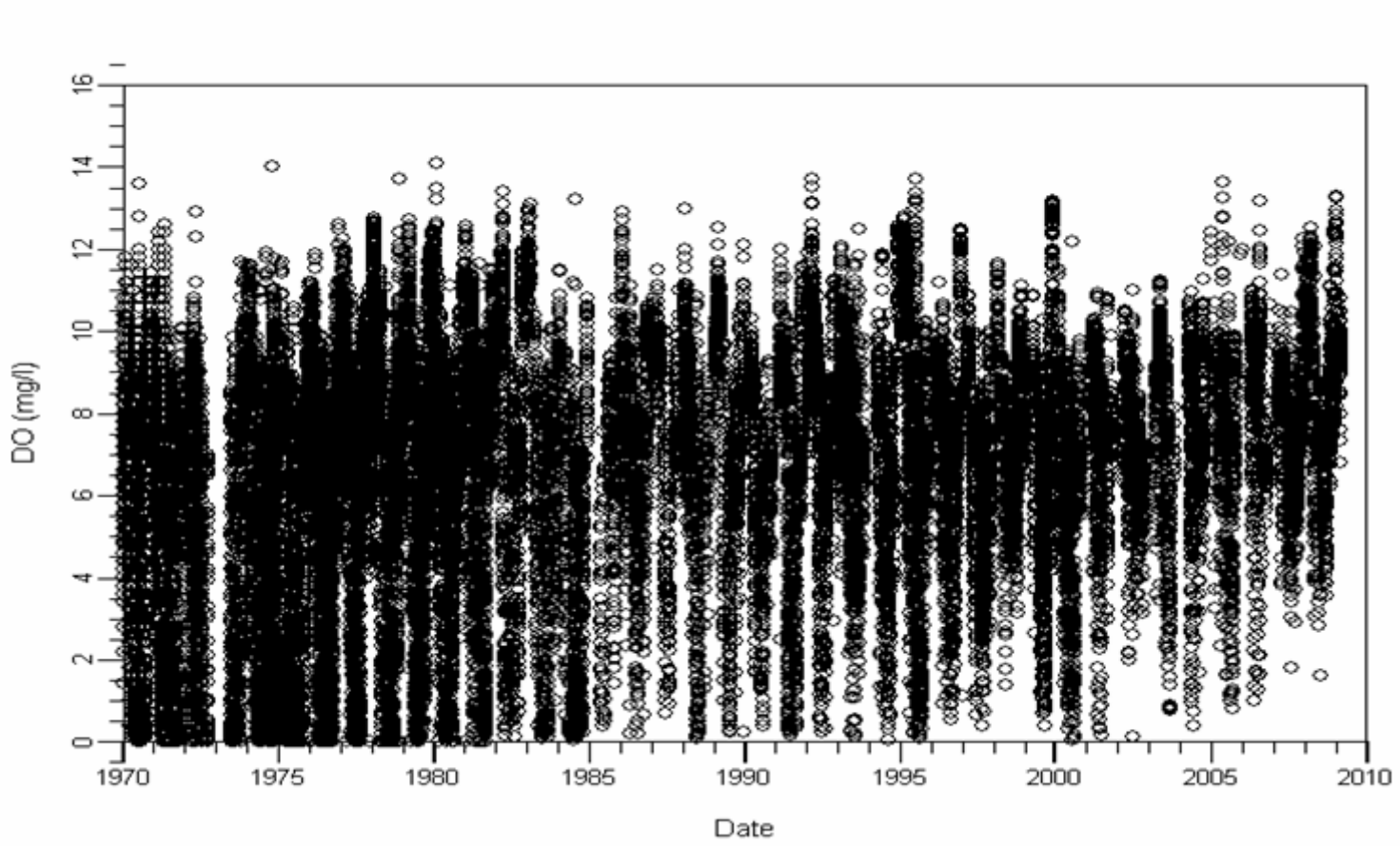
SEPA's River Runs

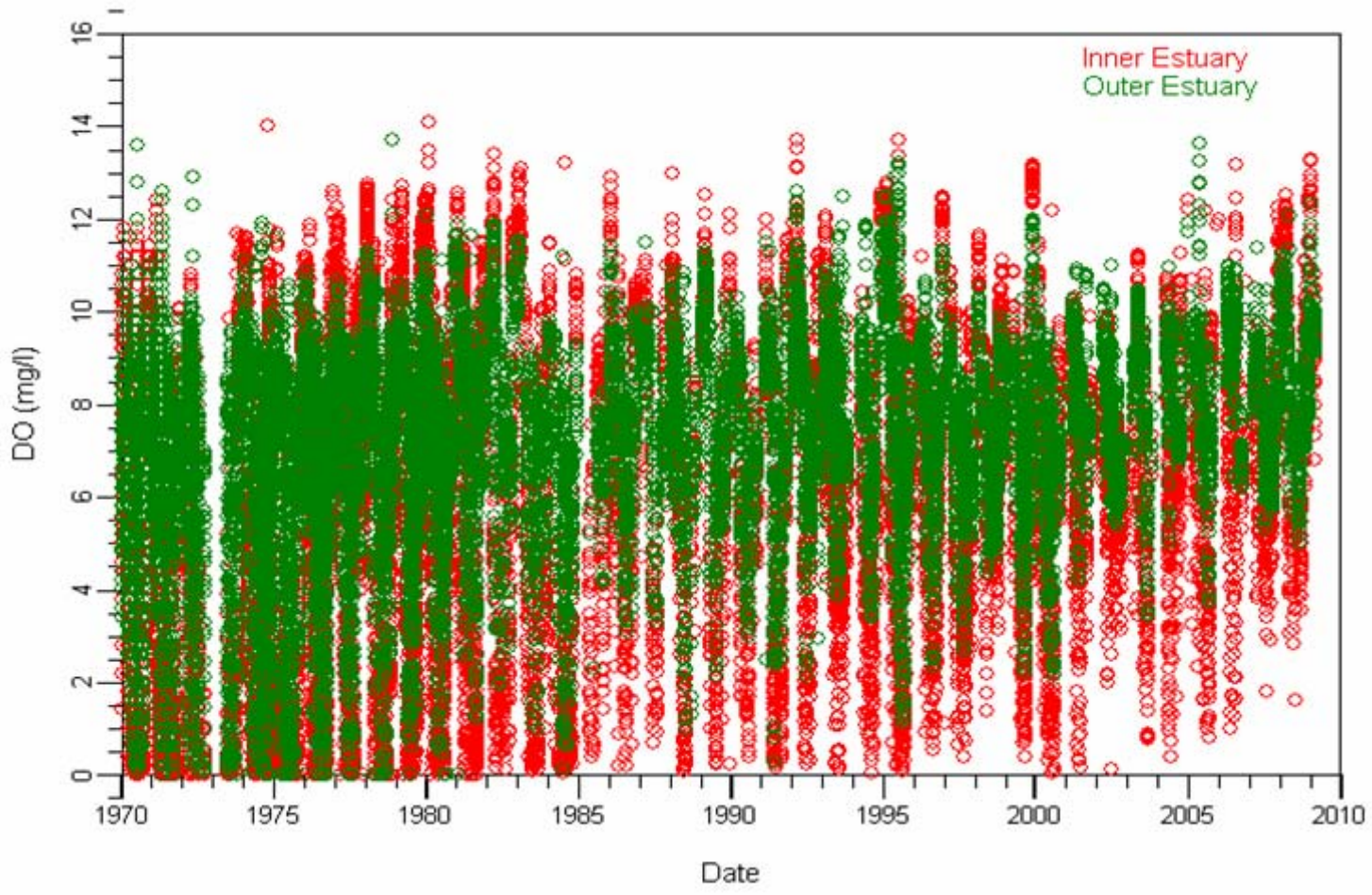
SEPA's River Runs

- 40 years and counting...
- > 34,000 DO, salinity and temperature samples
- For each river run, tidal state and river flow determined
- Data Analysis used to relate DO levels to:
  - environmental parameters
  - changes in inputs over the years

Plot of all DO data...

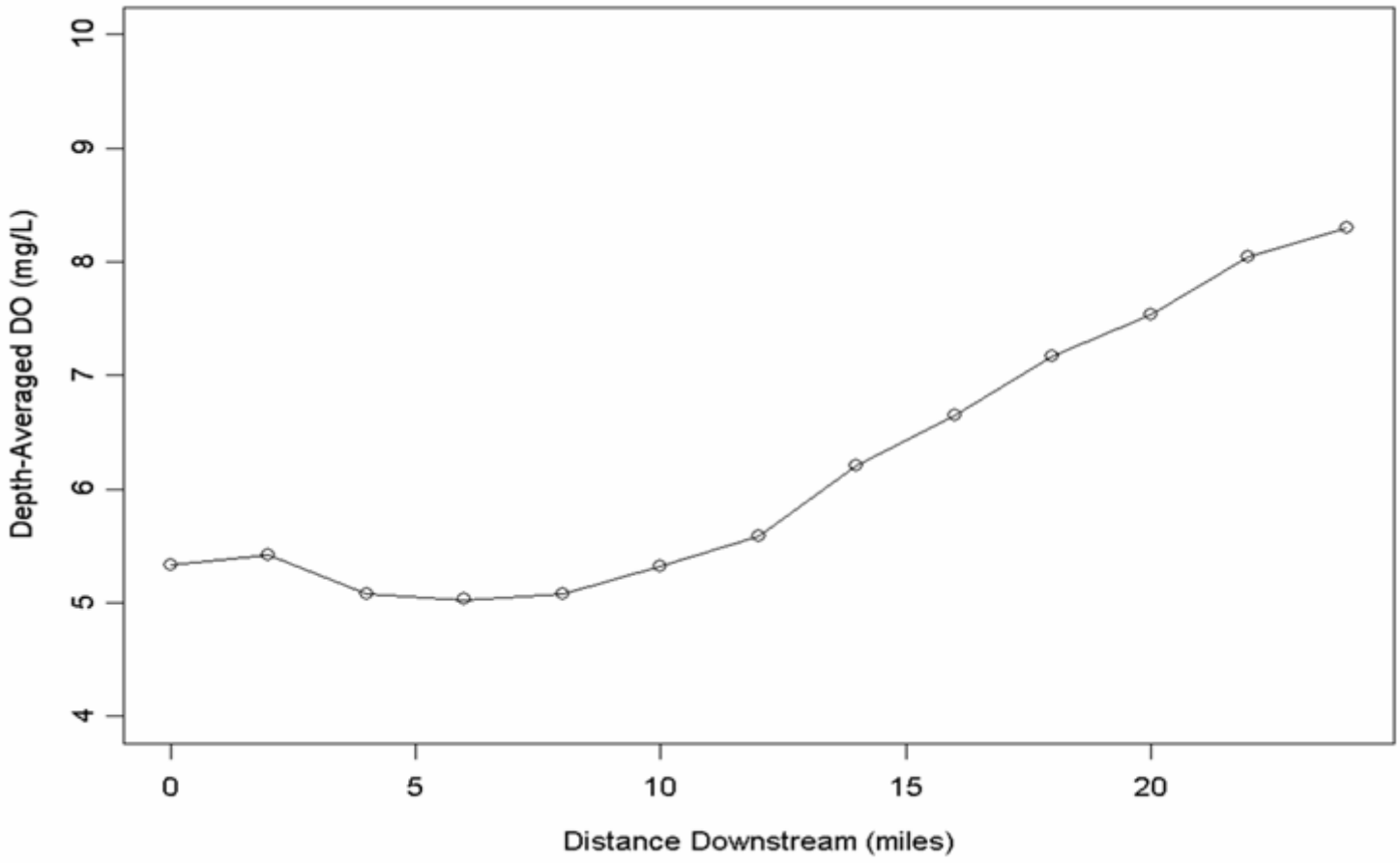


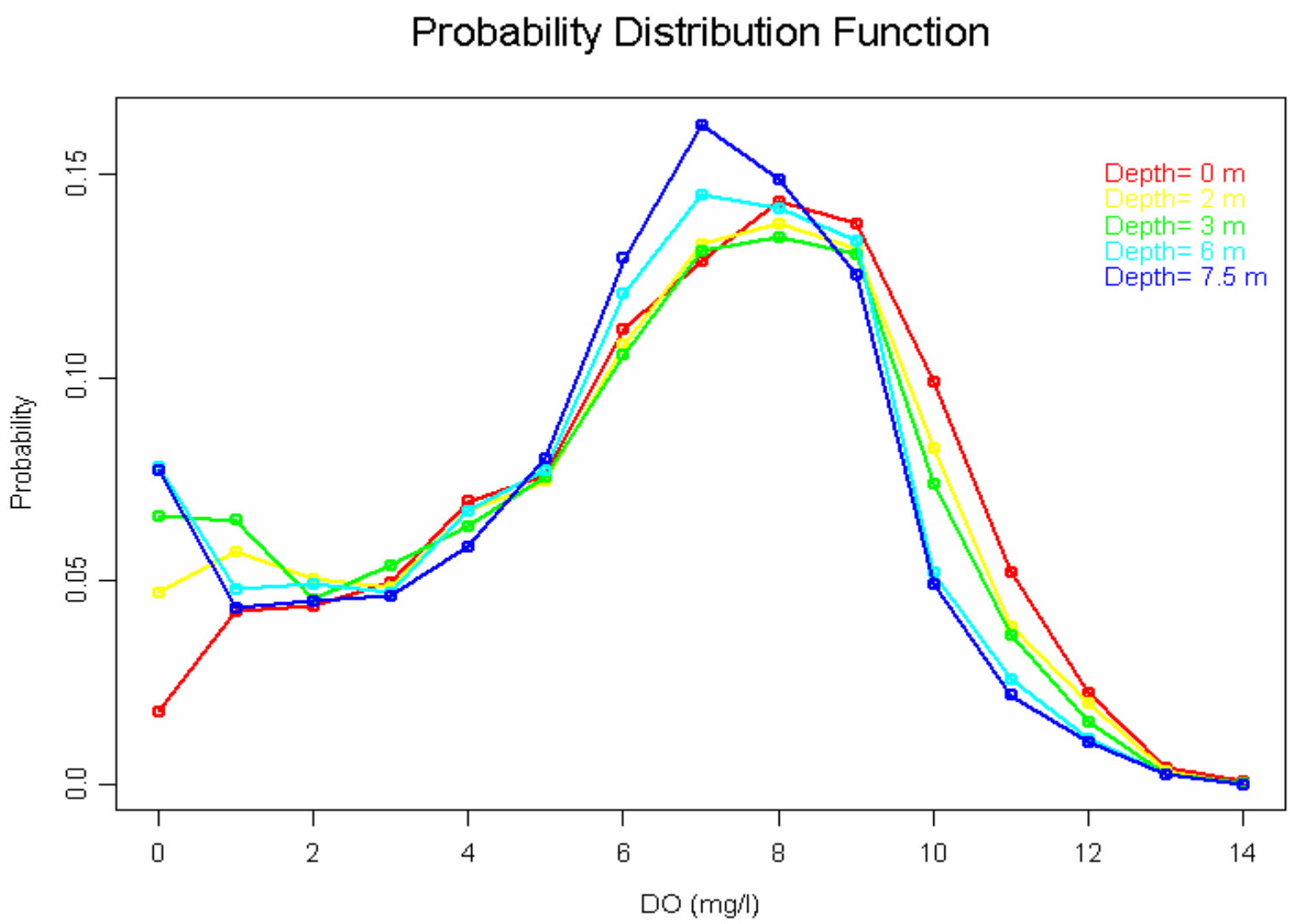
- Not hugely informative!



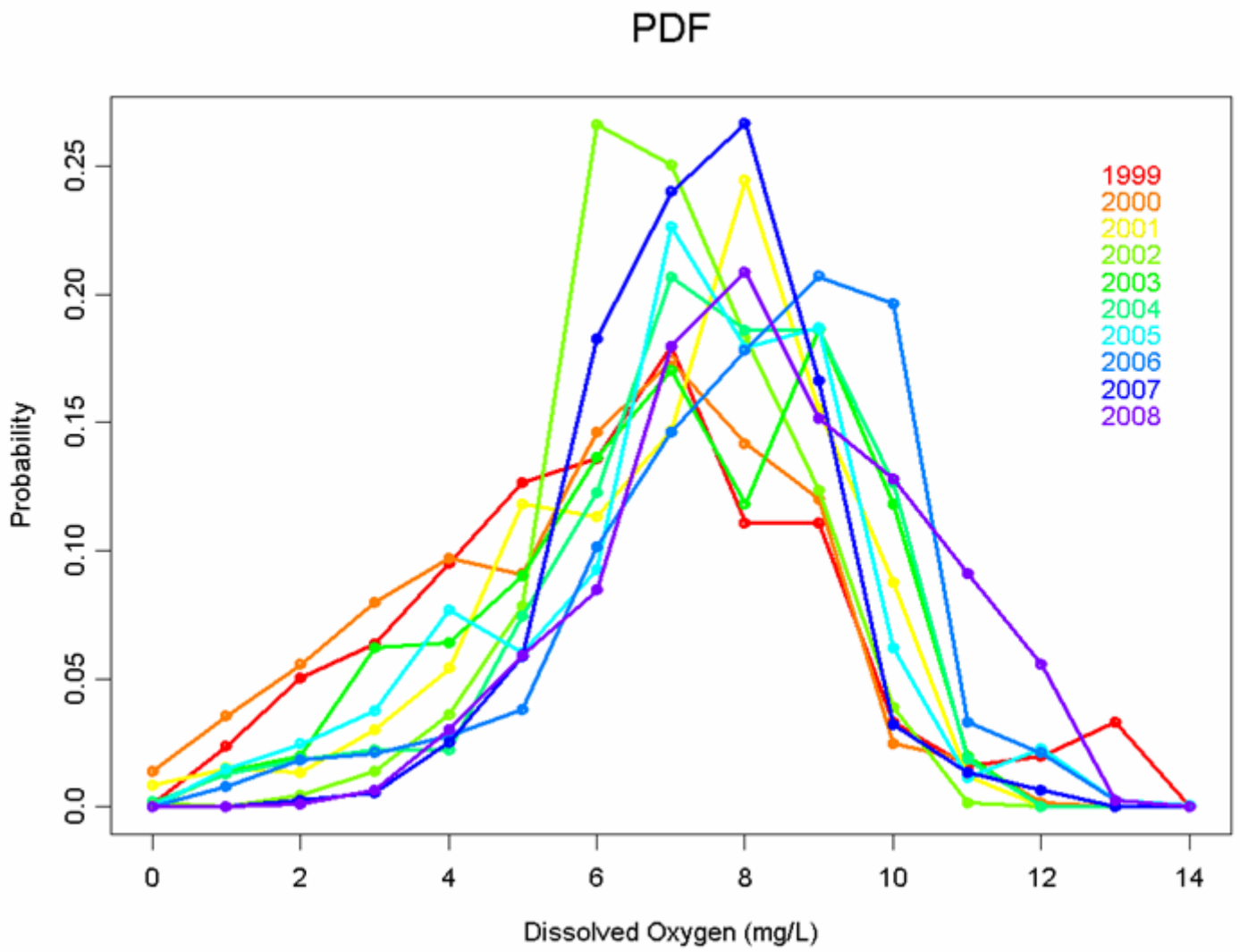
- Inner Estuary more variable than outer estuary
- Inner Estuary has more low DO values

Variation with Distance from Weir





- DO tends to be higher at water surface



- Median value fairly constant
- Lowest values improving

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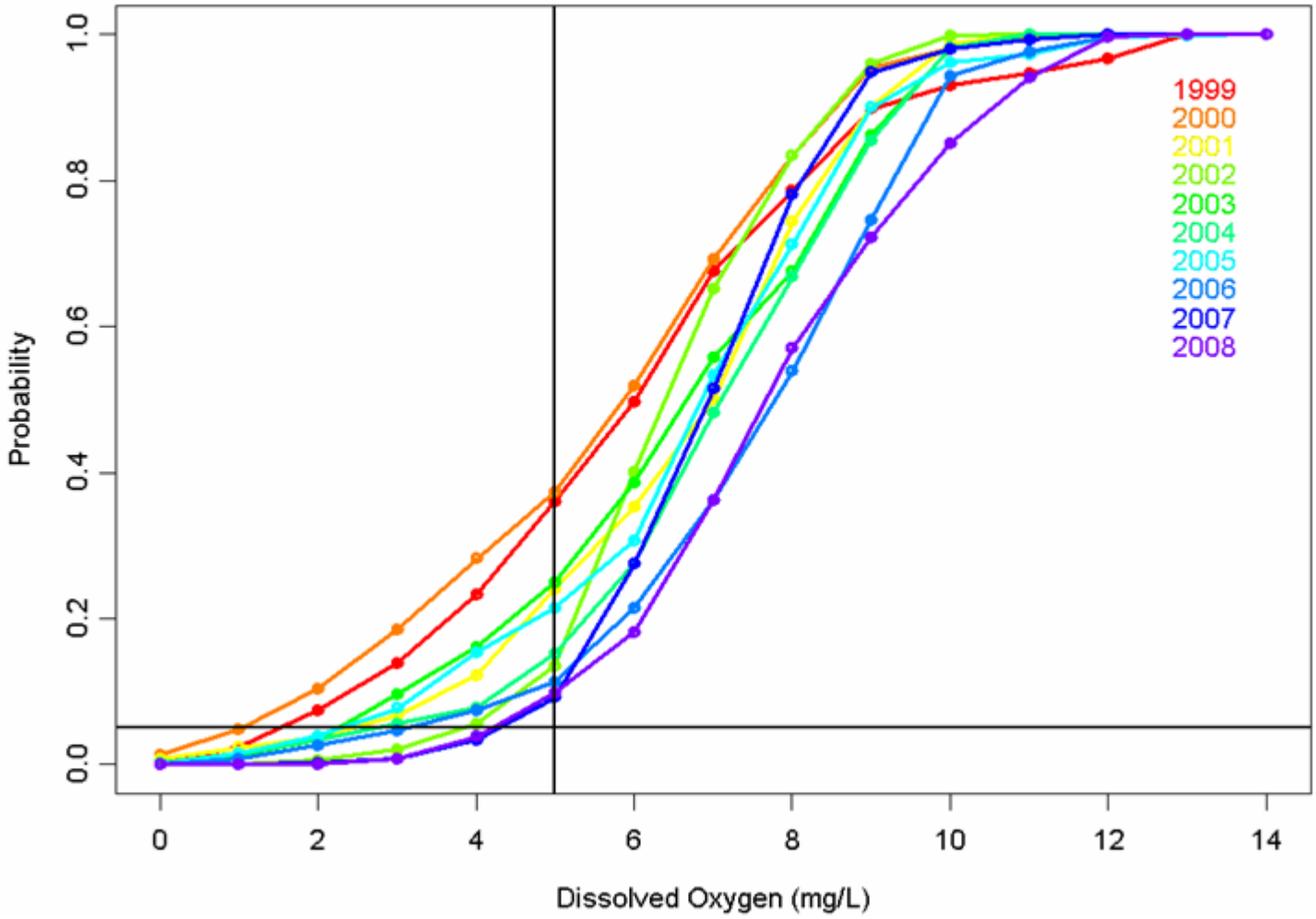
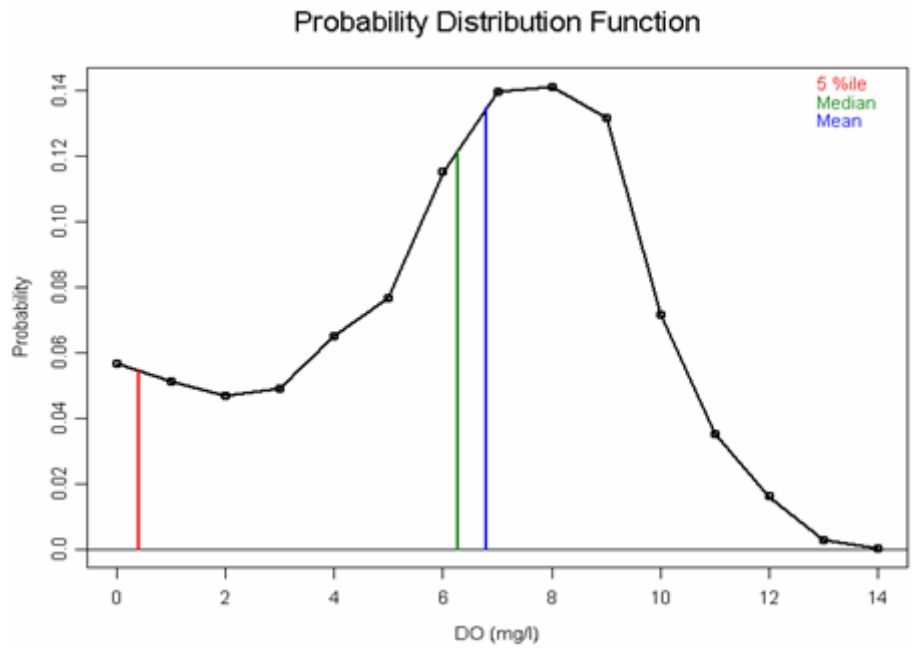
Cumulative Density Function



Quantifying DO...

- Mean/Median?
- Minimum?
- 5 Percentile!



Water Framework Directive

- Specifies standards and targets for DO
- Aim is to achieve good ecological status

Class	DO (mg/L)	Description
High	>5.7	Protects all life-stages of salmonid fish
Good	4.0 - 5.7	Protects resident salmonid fish
Moderate	2.4 - 4.0	Protects most life-stages of non-salmonid adults
Poor	1.6 - 2.4	Protects resident non-salmonid fish, poor survival of salmonids
Bad	<1.6	No salmonid fish. Marginal survival of resident species

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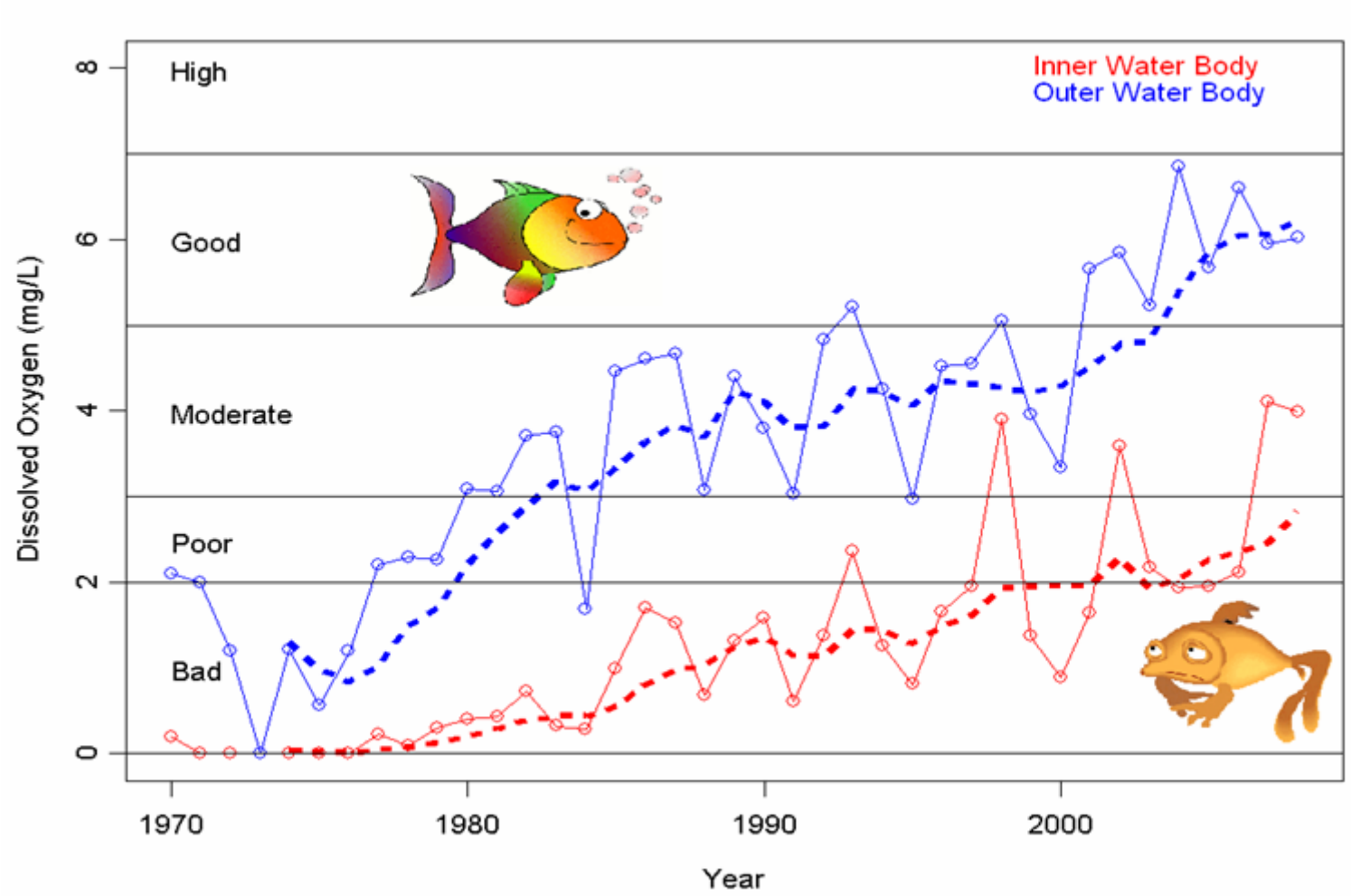
WFD Classification



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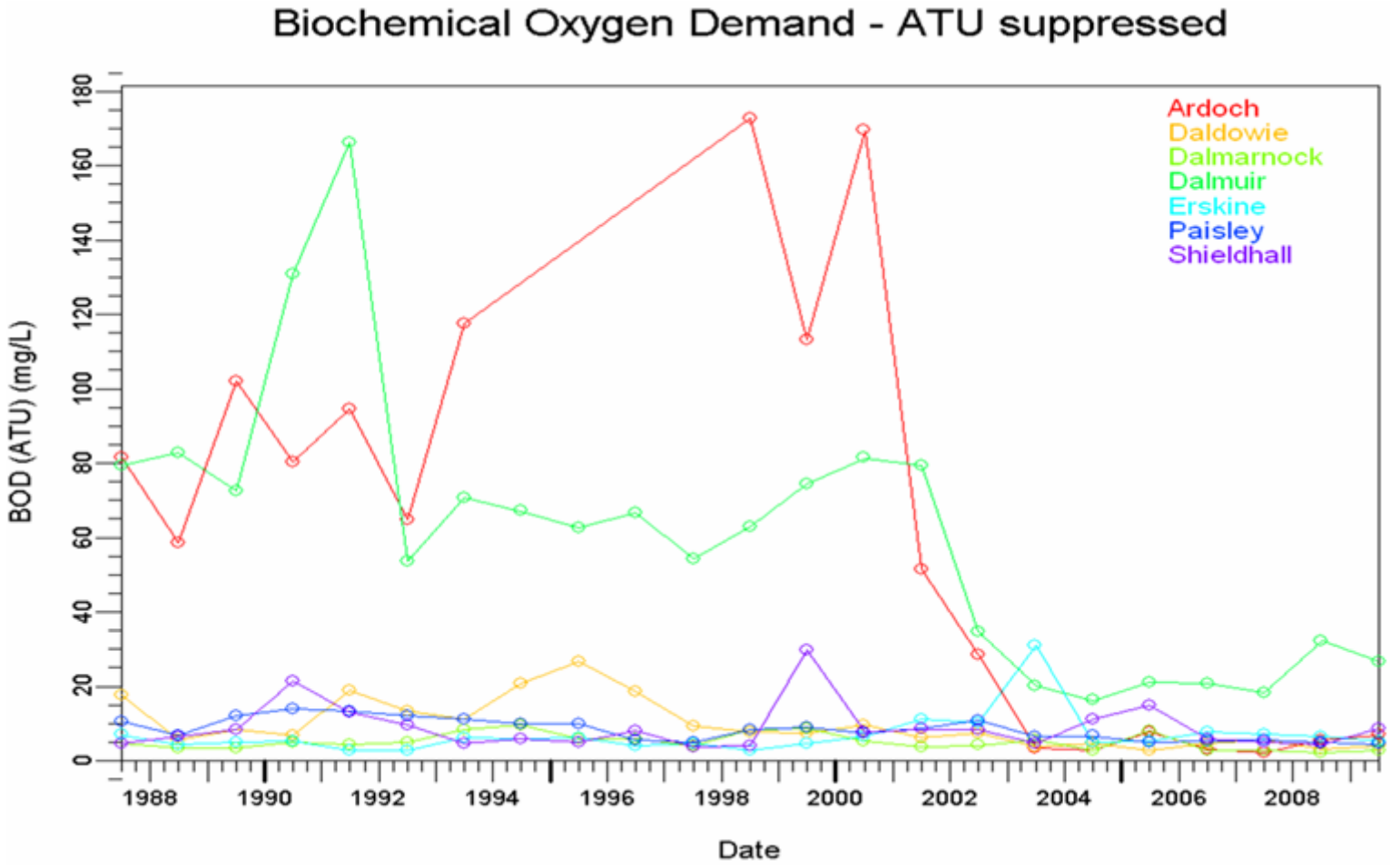
Why are things improving?



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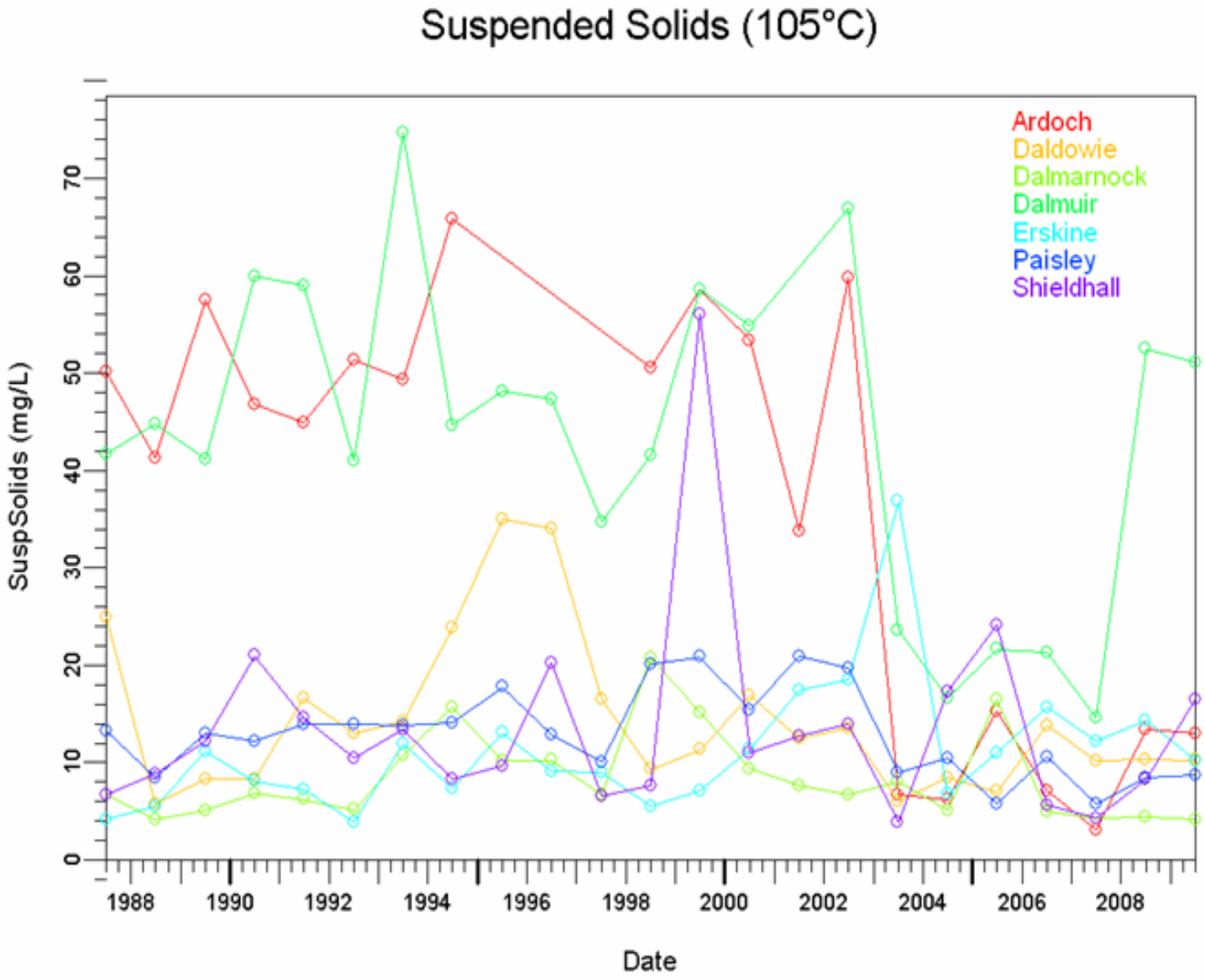

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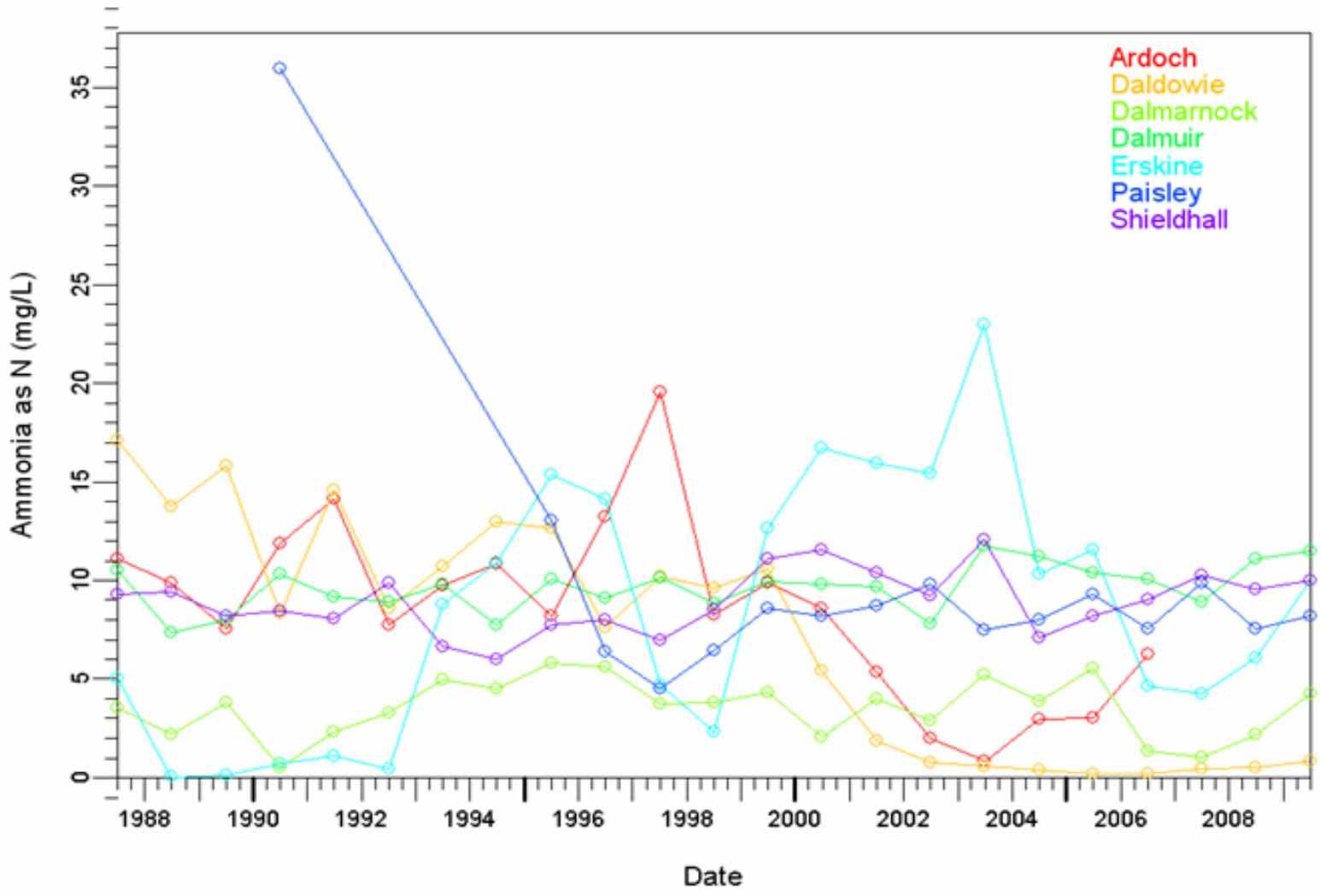
Ammoniacal Nitrogen (as N)

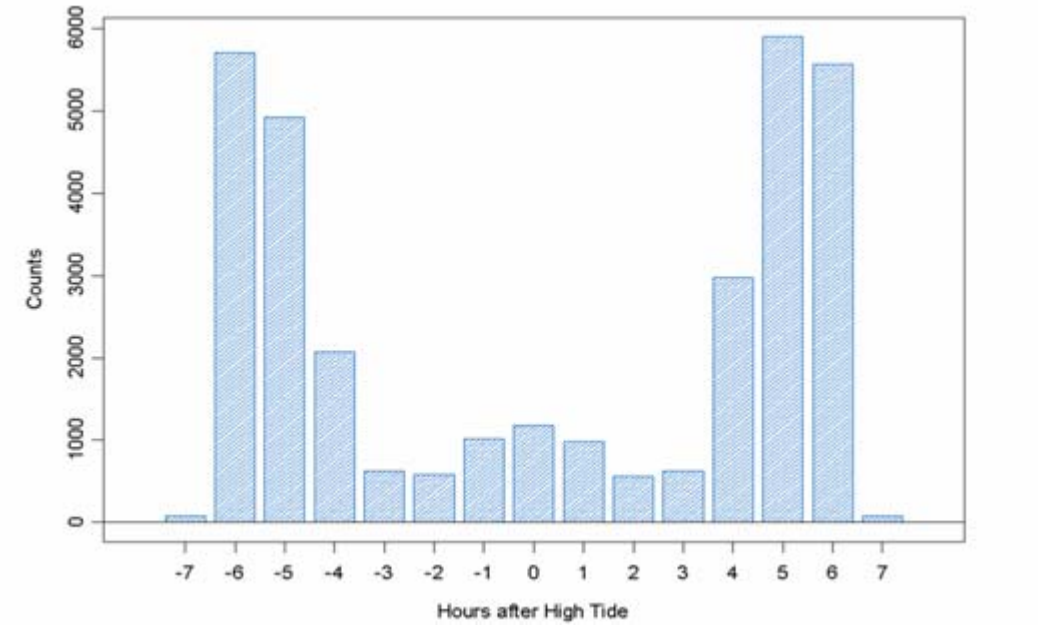


Data Analysis tells us:

- DO higher when river flow is high
- DO lower at low tide
- DO higher in winter
- DO sag ~6 miles from weir
- Worst case conditions therefore likely after a hot dry spell

Limitations of Data Analysis

- Unavoidable statistical biases
- Can’t predict future without extrapolation
- Doesn’t allow scenario testing

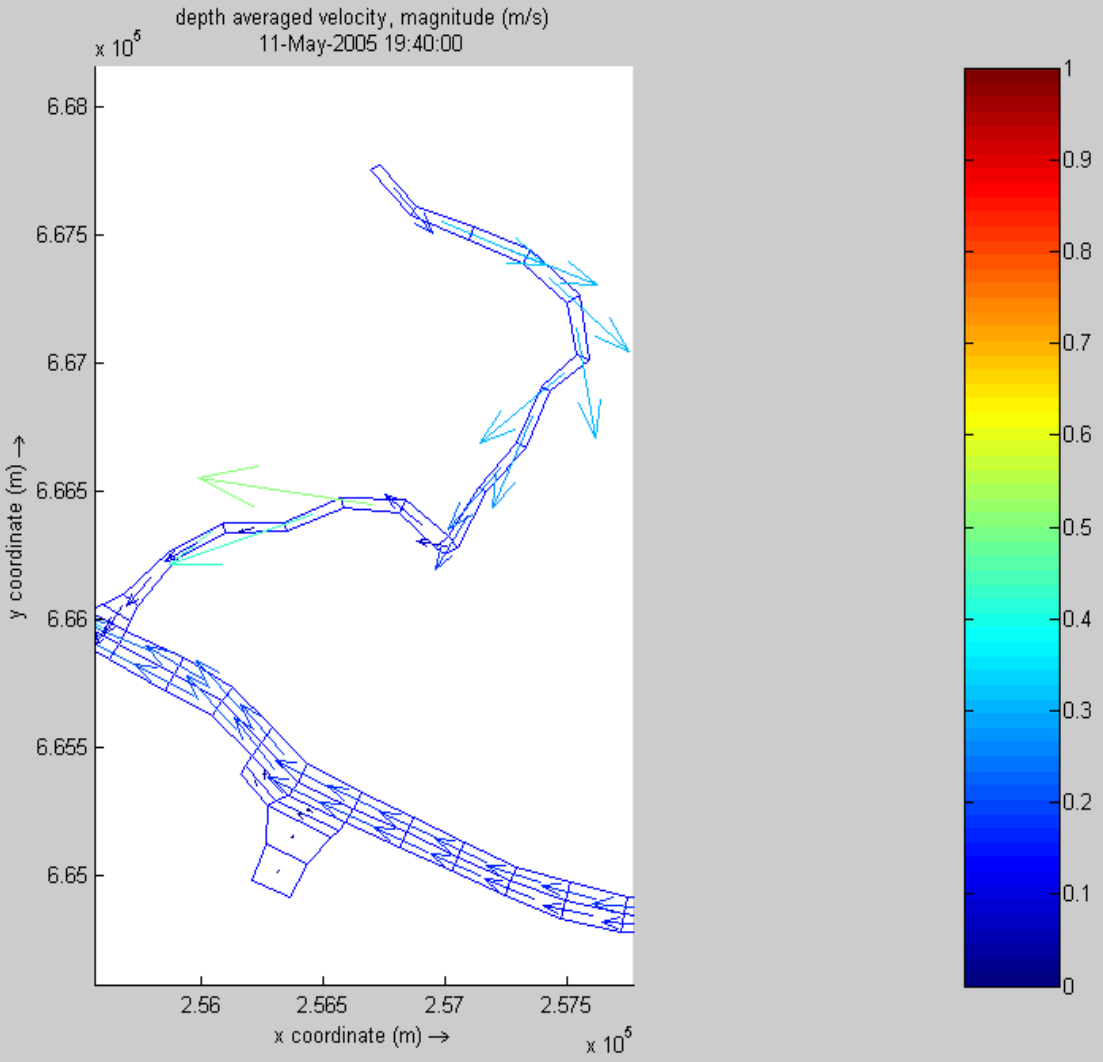


Modelling

- Data Analysis tells us what the water quality *is*
- Modelling can tell us what the water quality *could be*
- Not independent from each other- sample data required for model calibration

- First stage: determine hydrodynamics
- Water Quality modelling
- Particle Tracking- where do things end up?

Hydrodynamics



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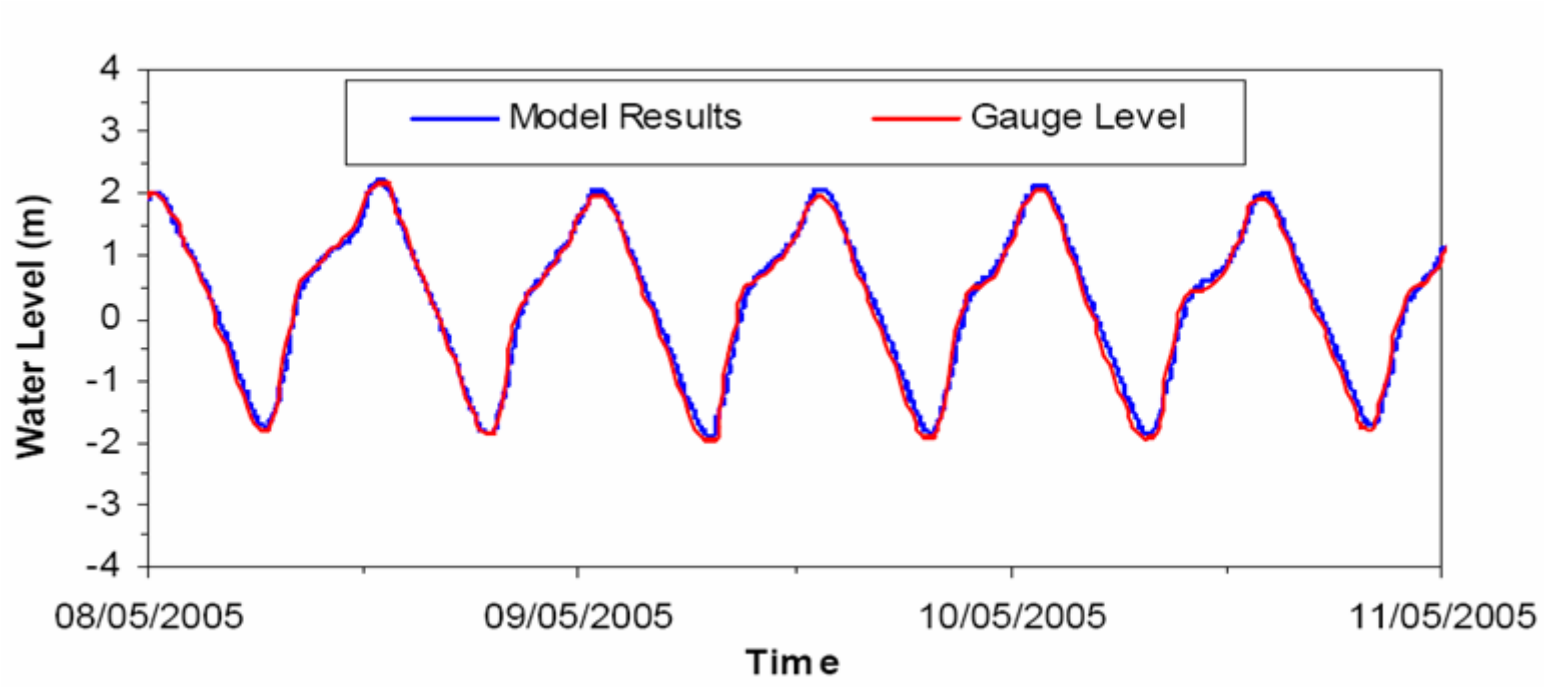
Water Level



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Flooding – an ongoing issue

Water Quality Modelling

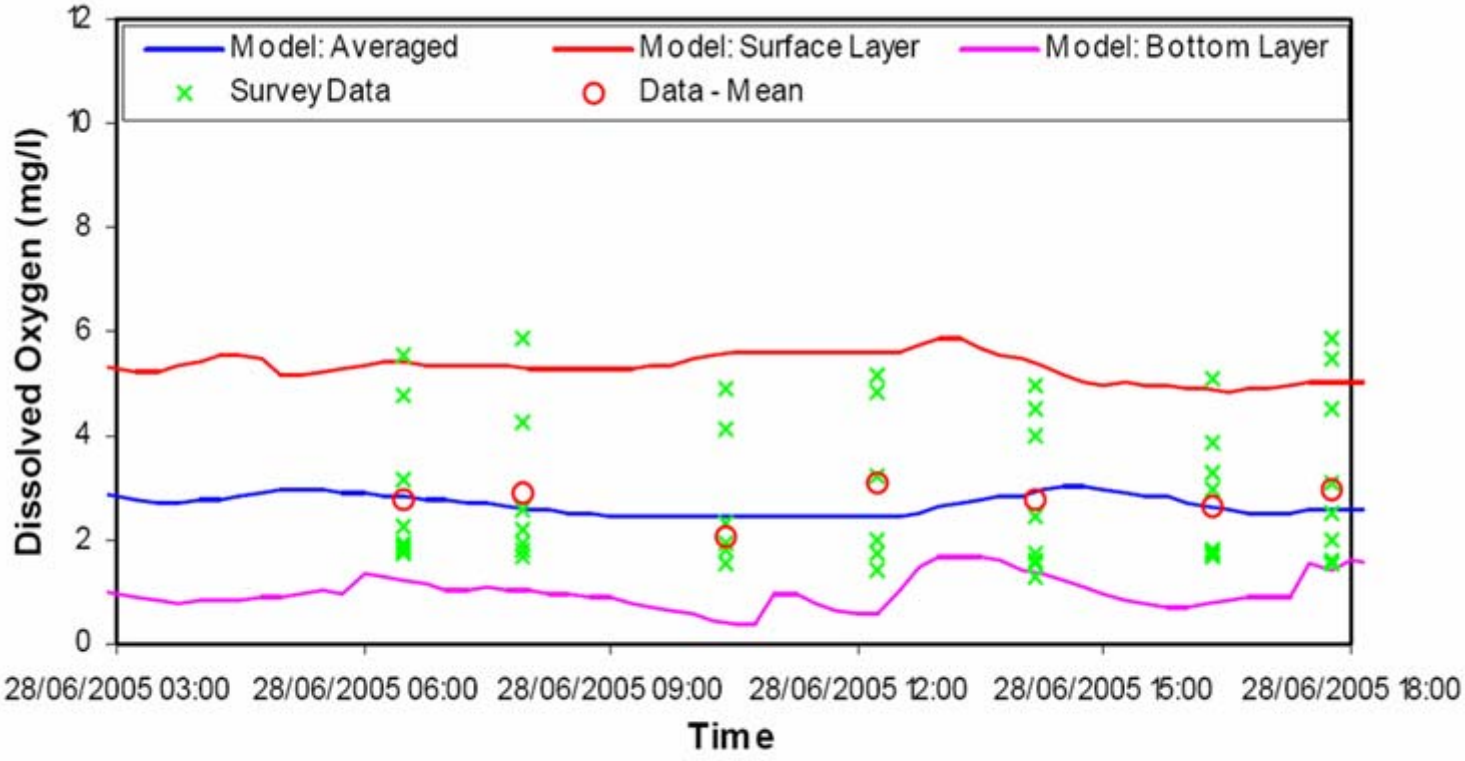

Figure 12-22 Model Calibration of Dissolved Oxygen: Glasgow Science Centre

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Particle Tracking Modelling

Why are we doing this?

- Further improvements in water quality are required to meet WFD targets
- There are a number of ways in which WQ can be improved
- Science is being used to help evaluate these options
- Scottish Water is spending millions of pounds on improving its infrastructure
- SEPA is working closely with Scottish Water to ensure that money is spent wisely

How to improve WQ further...

- Pipe Glasgow's sewage to the outer estuary
- Improve CSO network
- Change morphology of estuary to increase mixing
- Modify operation of the tidal weir
- Pump pure oxygen into the estuary

- These are expensive & may have other effects, eg on flooding
- No quick-fix single solution

Unanswered Questions...

- What causes trends and fluctuations in DO value?
- Why is water quality continuing to improve (and how far will it go) ?
- Can the inner Clyde achieve ‘good’ status?
- If so, what would be required and how much would it cost?
- Are these improvements worth the cost?

- Science can help provide answers!

Conclusions

- Levels of DO have increased dramatically over the past 4 decades, allowing fish to return
- Data Analysis can prevent DRIPS (**D**ata **R**ich, **I**nformation **P**oor **S**yndrome)
- Modelling can predict the impact of changes, and help decision making
- SEPA is collaborating the Scottish Water and other parties to improve water quality further
- Science plays an important role in decision-making

Acknowledgements

- The Glasgow Story
- Metoc
- Scottish Water
- Jim Fleming, Glasgow City Council