2018

Water clarity-based prediction of faecal bacterial density in New Zealand rivers

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Is it safe to swim at a selected site?

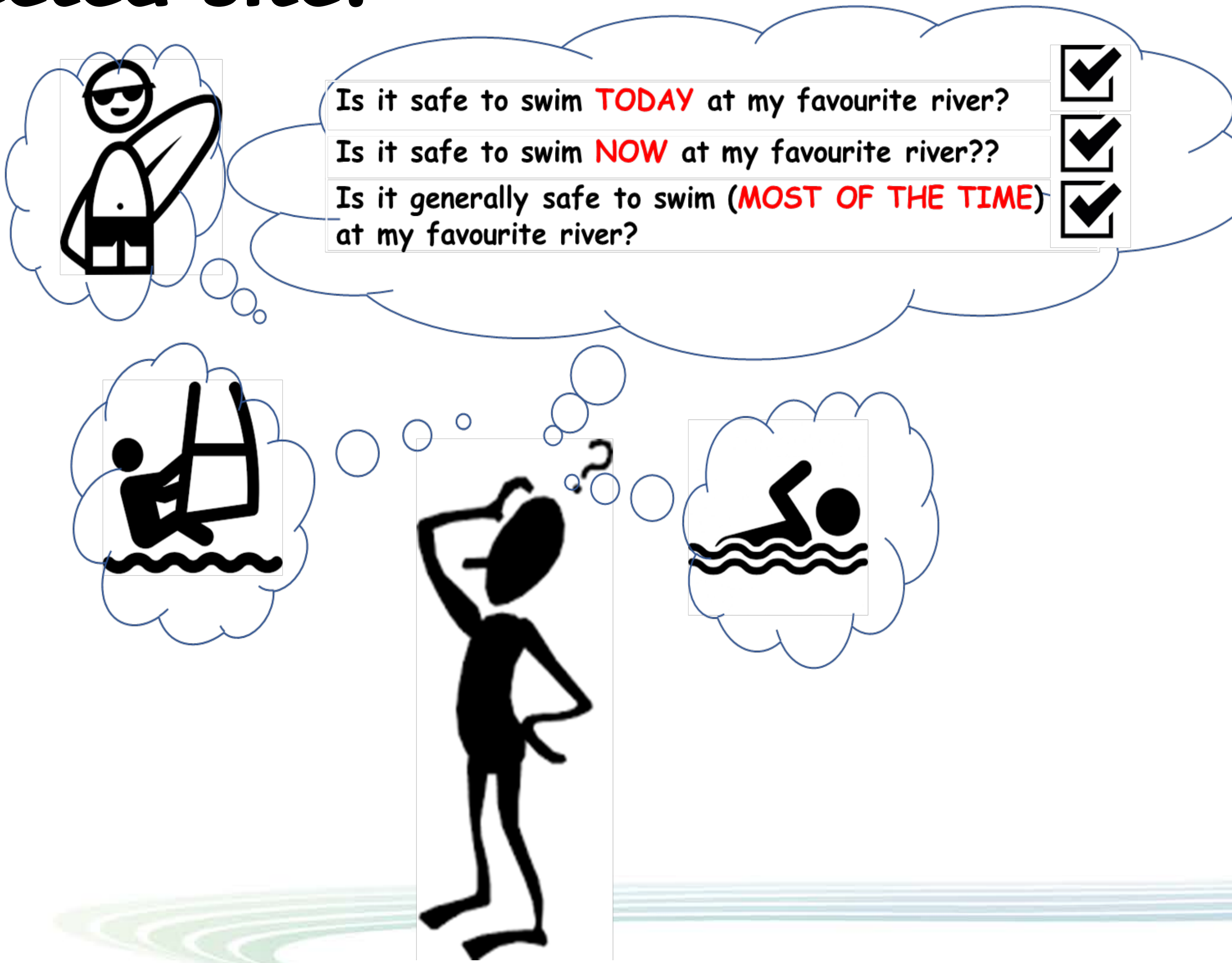
- Issues:

➢ Historic vs. Recent risks

➢ Current risks: Opportunities for predictive FIB modelling in WQ monitoring

➢ Public engagement in WQ monitoring and predictive FIB modelling

❑ Case study: Water Clarity-based FIB models for point-of-use (POU) prediction



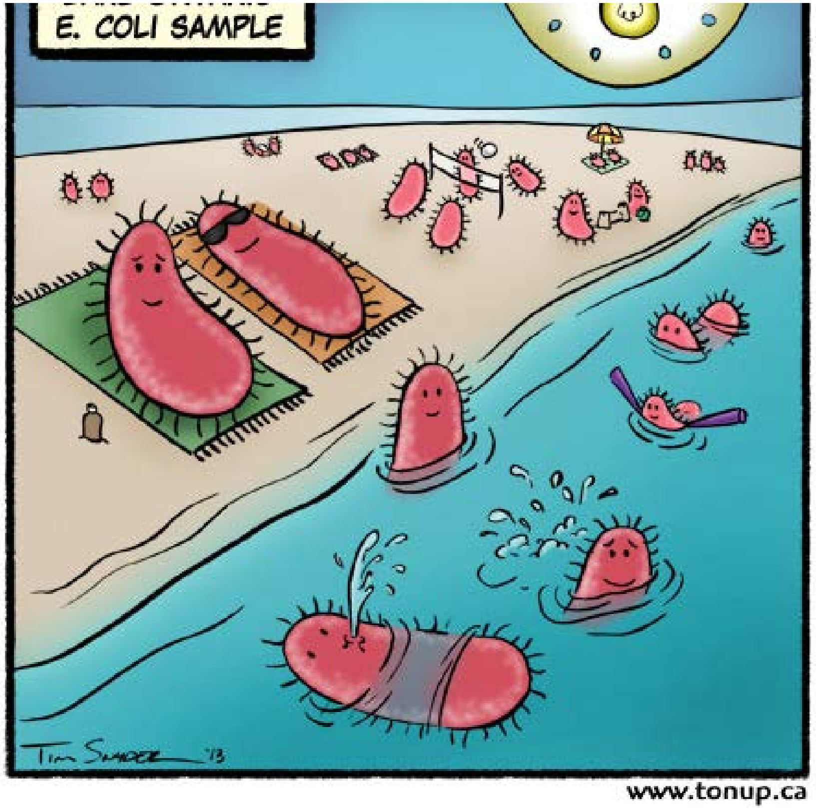
How do I know if it is OK to swim at my favourite river?

'Councils have communication strategies as part of their monitoring programmes to ensure the public are informed of a health risk at a beach or river as soon as possible.'

http://www.mfe.govt.nz/publications/fresh-water/microbiological-water-quality-guidelines-marine-and-freshwater-recreatio-25

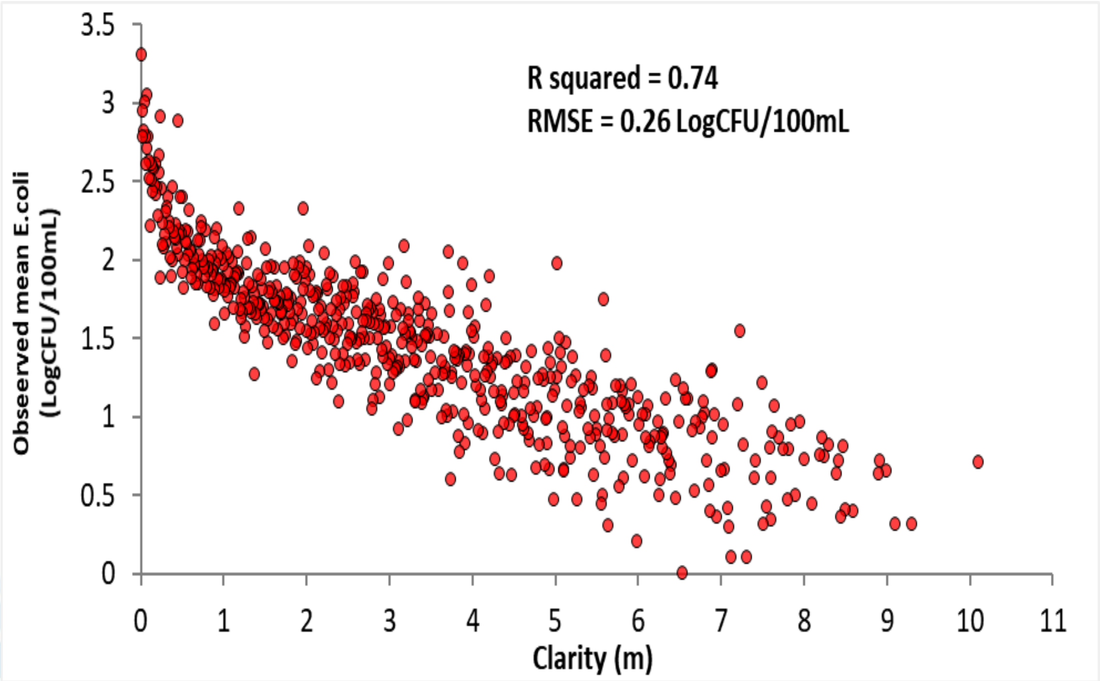
1. Historic vs. Recent vs. Current risks

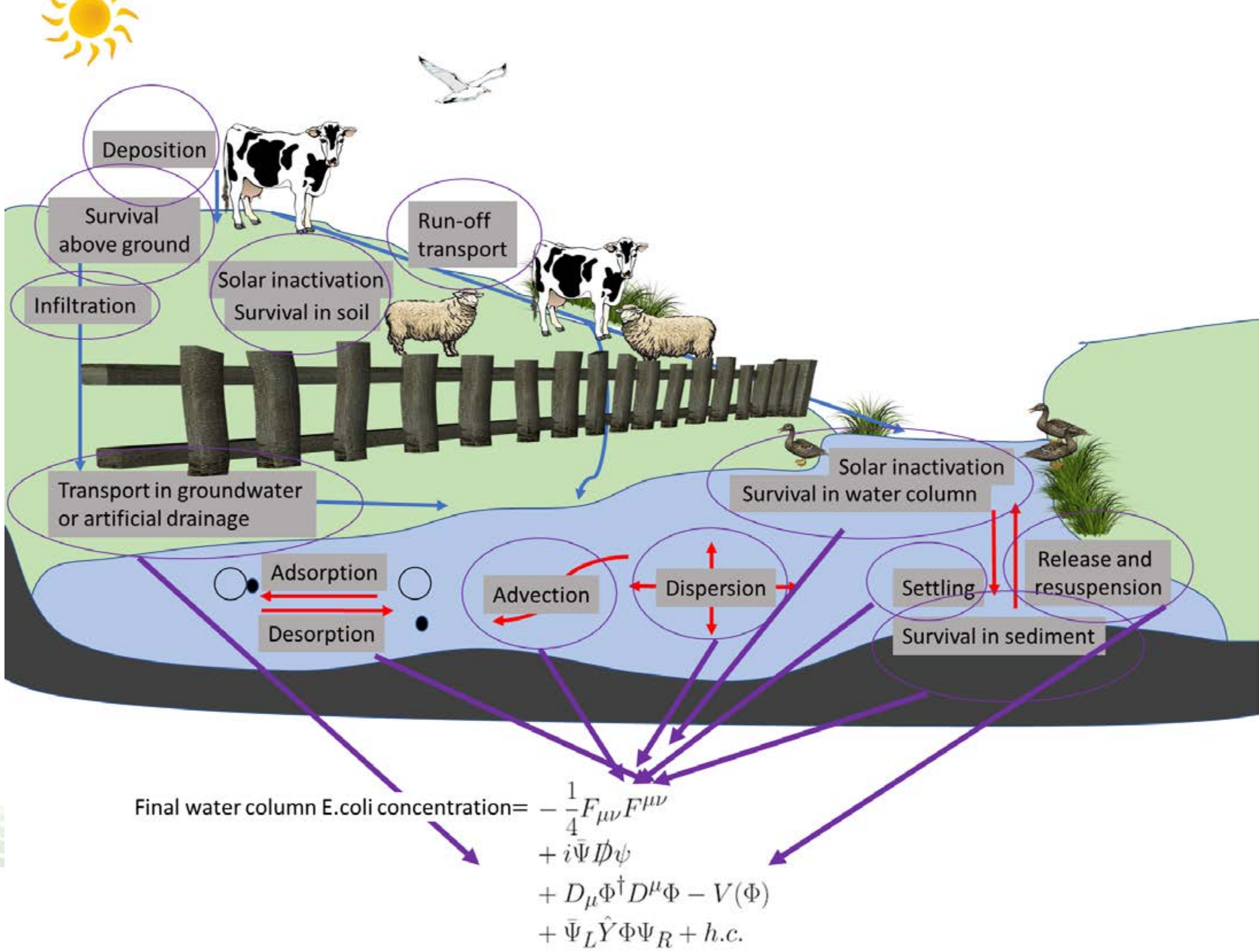
- Historic risks
  - NPS-FM: Four metrics
    - % exceedance of 540 *E. coli* / 100 mL,
    - % exceedance of 260 *E. coli* / 100 mL
    - median *E. coli* / 100 mL, and
    - 95th %ile *E. coli* / 100 mL.
  - NPS-FM suggest:
    - "Not safe to swim 50 % of the time", "Water quality falls within Band C", "for at least half the time, the estimated risk is <1 in 1000"
- Recent risks
  - Summer monitoring programs
    - Reliant on results from laboratory growth cultures
    - Metric: % exceedance of the 540 *E.coli*/ 100 mL
  - Summer monitoring programs tend to suggest:
    - Not safe to swim yesterday or two days ago!



2. Current Risks and Opportunities for predictive FIB modelling

- Current risks
  - Is it safe to swim now?
  - Can be based on near real-time predictive modelling e.g. Dada and Hamilton, 2016
    - Empirical models
    - Theoretical models



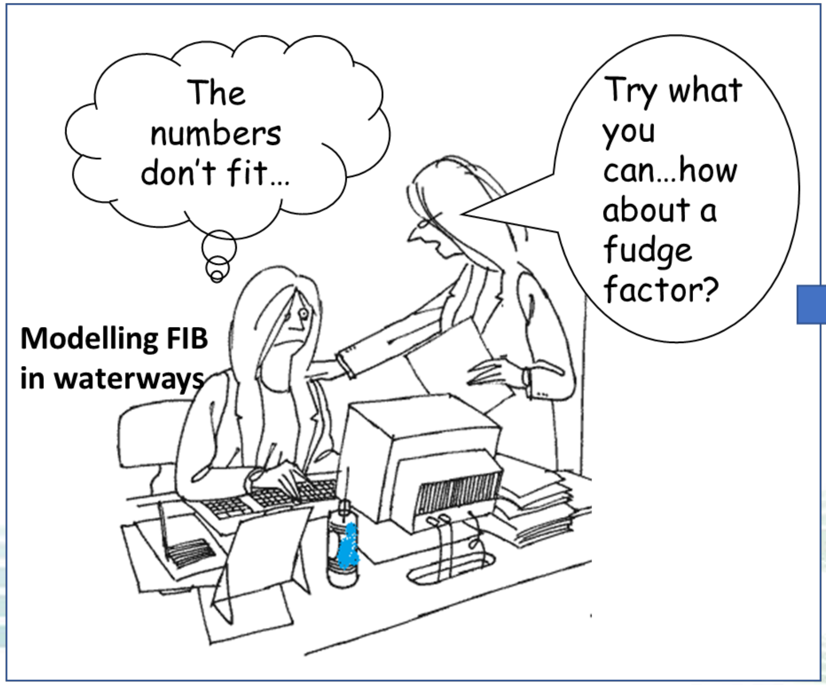


3. Public engagement (PE) in predictive FIB modelling

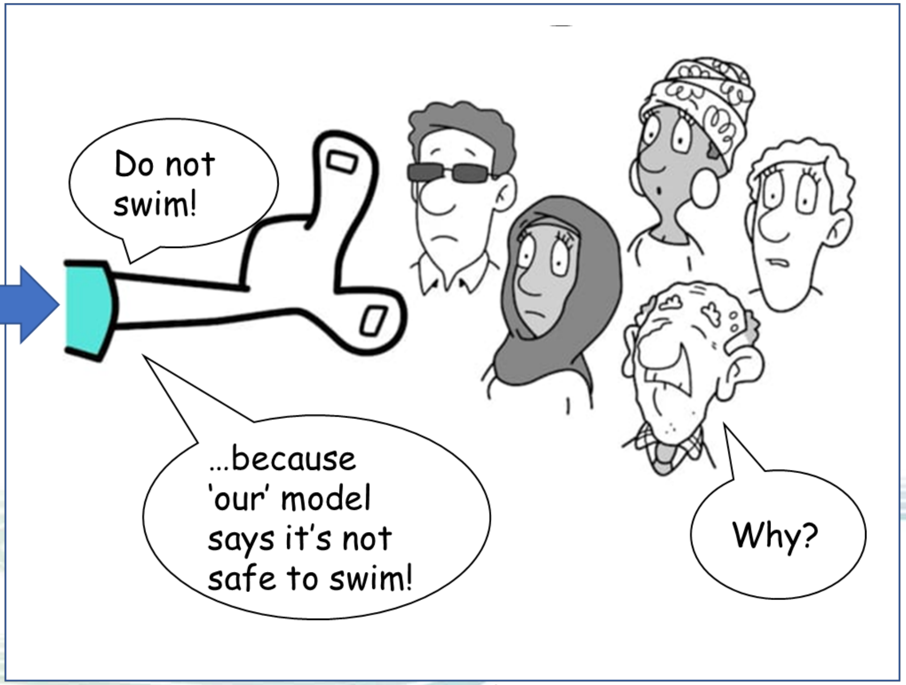
- PE exists for water sampling and quality monitoring (e.g. Storey et al 2016)
- Existing FIB Models are largely 'top-down'
- Citizen participation in predictive FIB monitoring and modelling
  - Beyond being simply 'advised when to avoid swimming', there is an increasing awareness among the public of the need to play both passive and active roles concerning their local water quality.

Traditional approach to FIB predictive modelling

Modelling environment

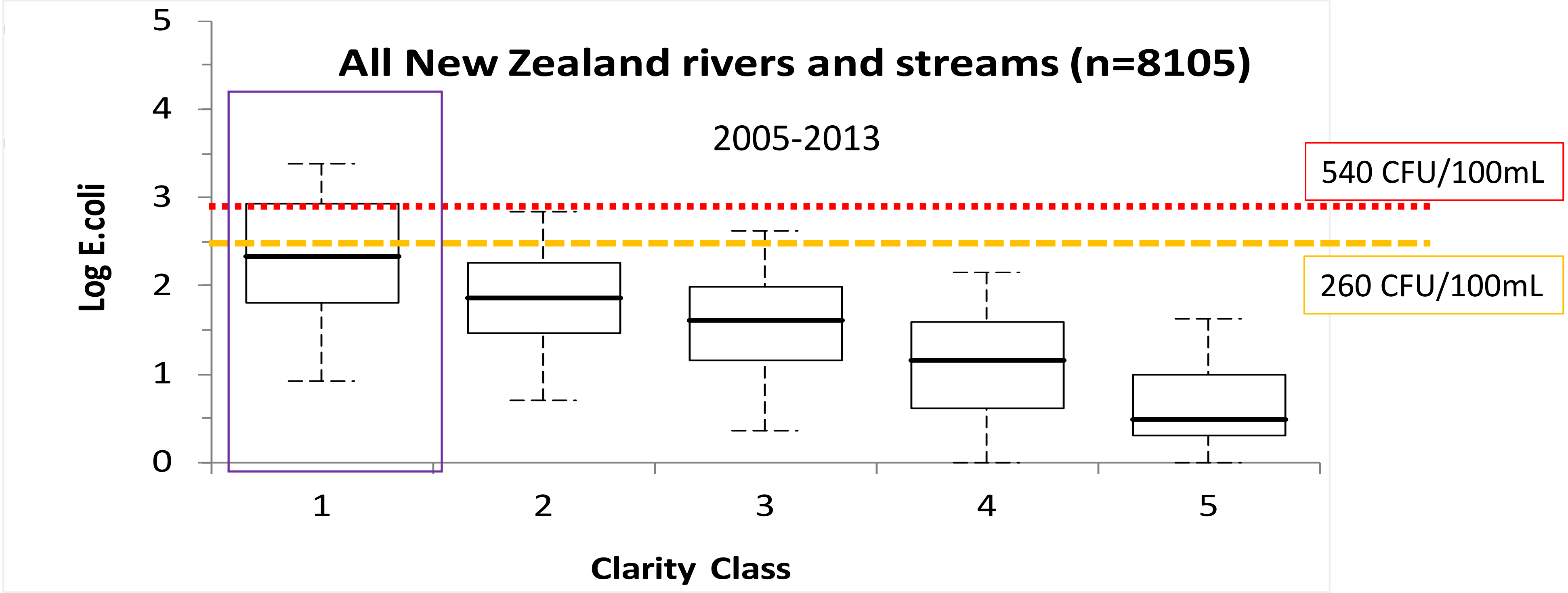


Compliance brief/Swimming advisories

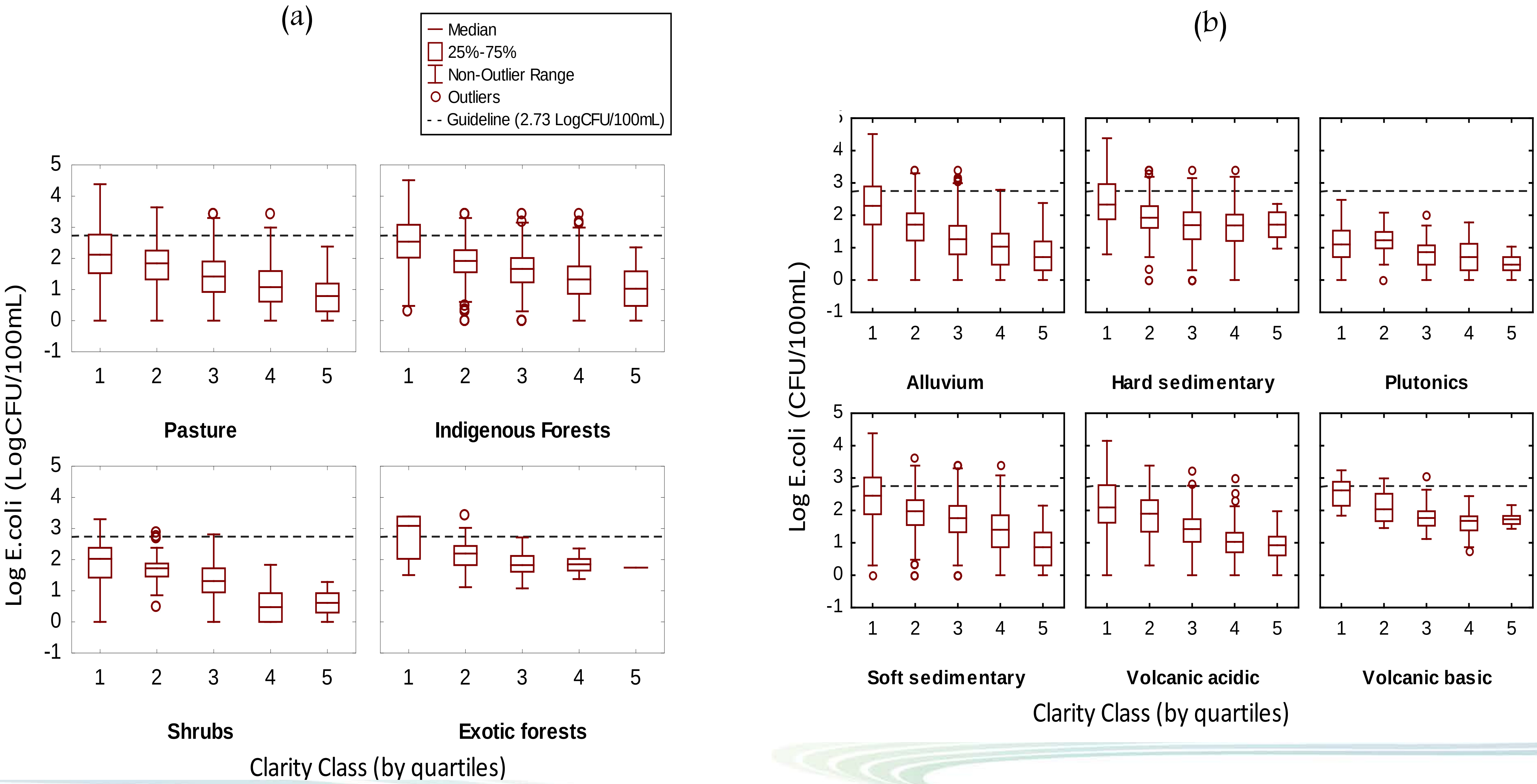


Modified from: www.hcpro.com/CCP-72660-1685 and https://vimeo.com/239652044

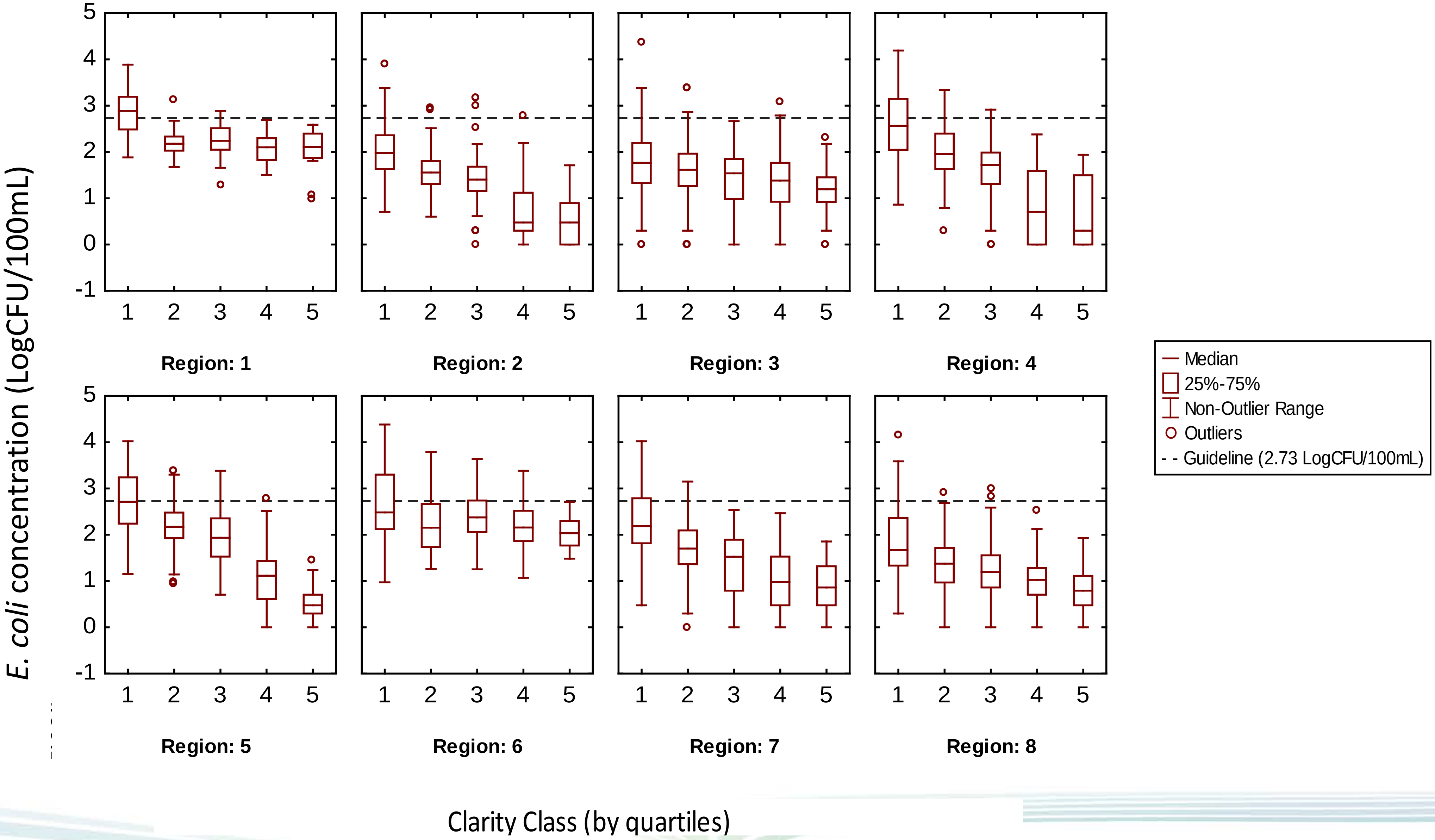
of water



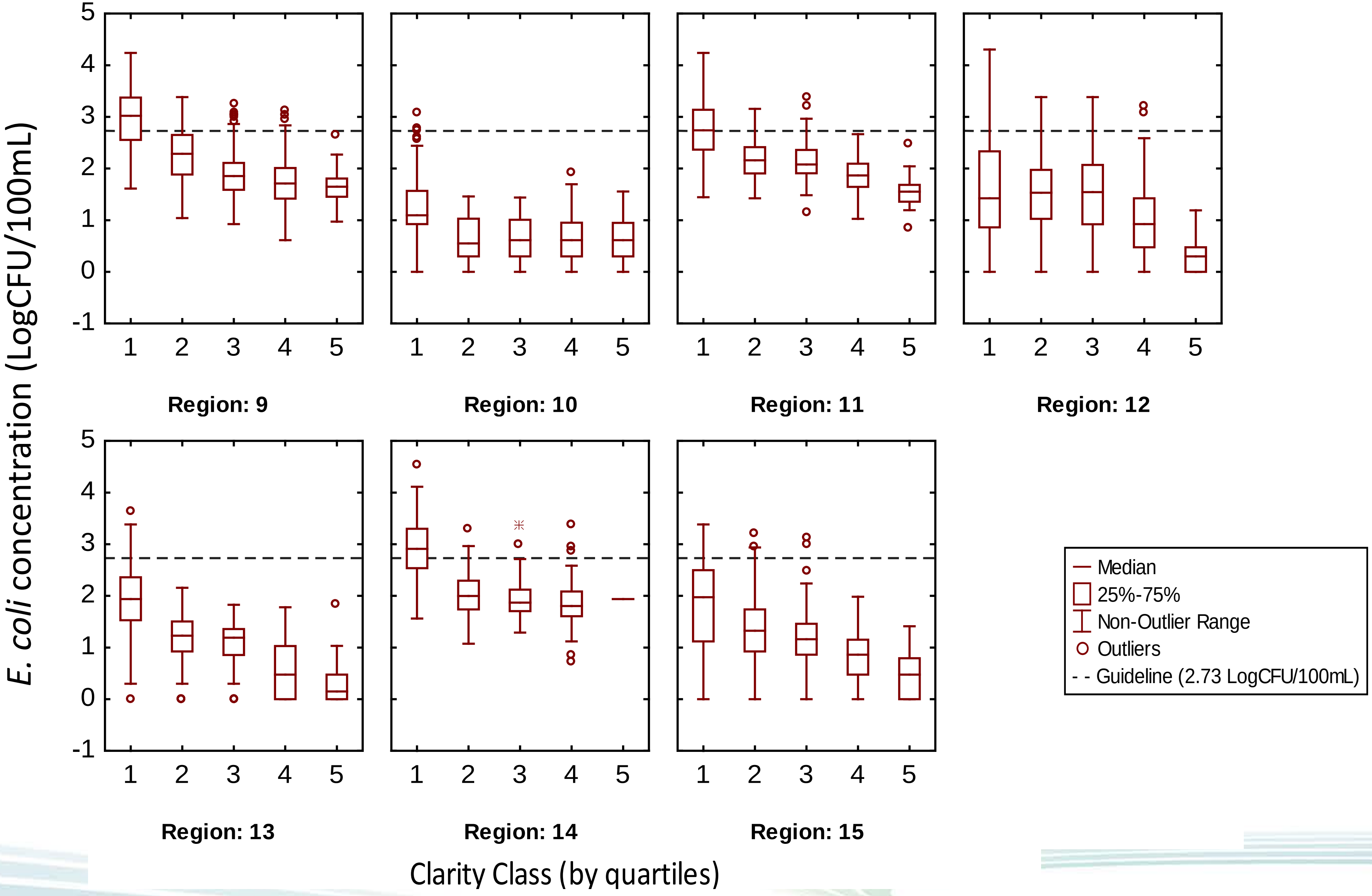
Classification scheme	Clarity Class	N	Mean *E.coli* (LogCFU/100mL)	Mean SE (LogCFU/100mL)
Clarity (m) < Quartile 1	1	2005	2.315	0.018
Quartile 2< m >Quartile 1	2	2036	1.845	0.014
Quartile 3< m >Quartile 2	3	2005	1.573	0.015
Quartile 4< m >Quartile 3	4	1653	1.102	0.016
m> Quartile 4	5	406	0.625	0.026



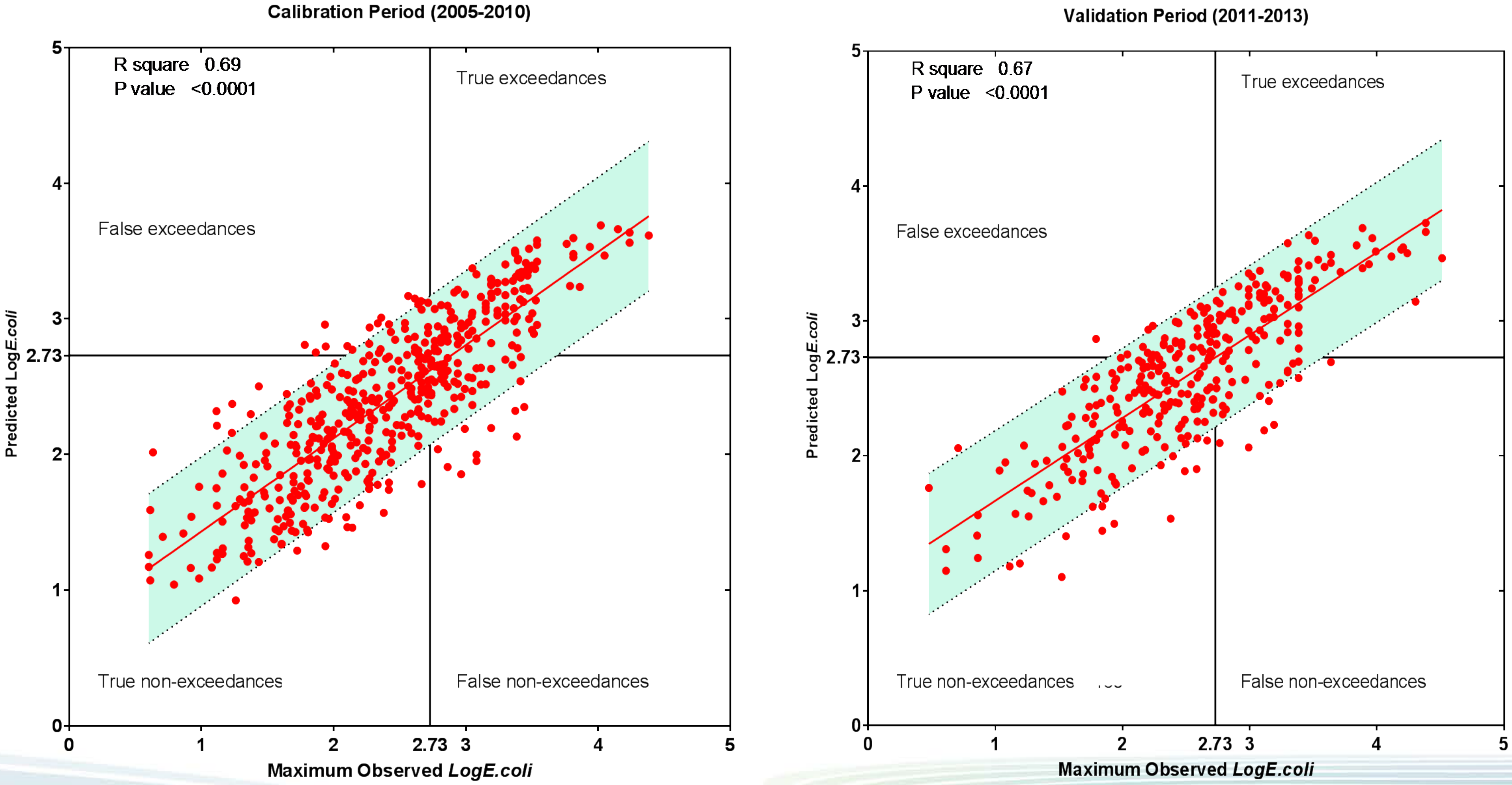
Box plots of 8105 datasets of river *E.coli* concentrations grouped by clarity class and categorized by a) land use and b) geology. Details of classification scheme in McDowell et al (2017)



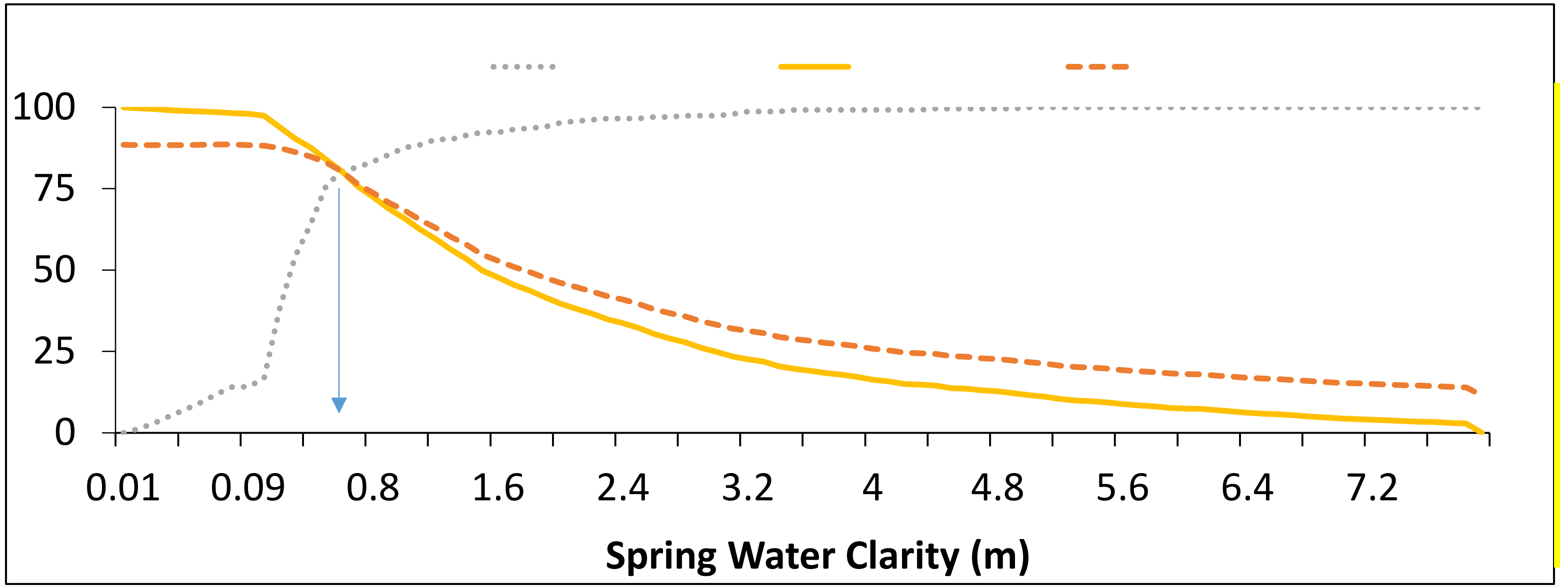
Box plots of 8105 datasets of river *E.coli* concentrations grouped by clarity class and categorized by region. RC: 1=AC, 2=BOP, 3=ECAN, 4=ES, 5=EW, 6=GDC, 7=GWRC, 8=HBRC



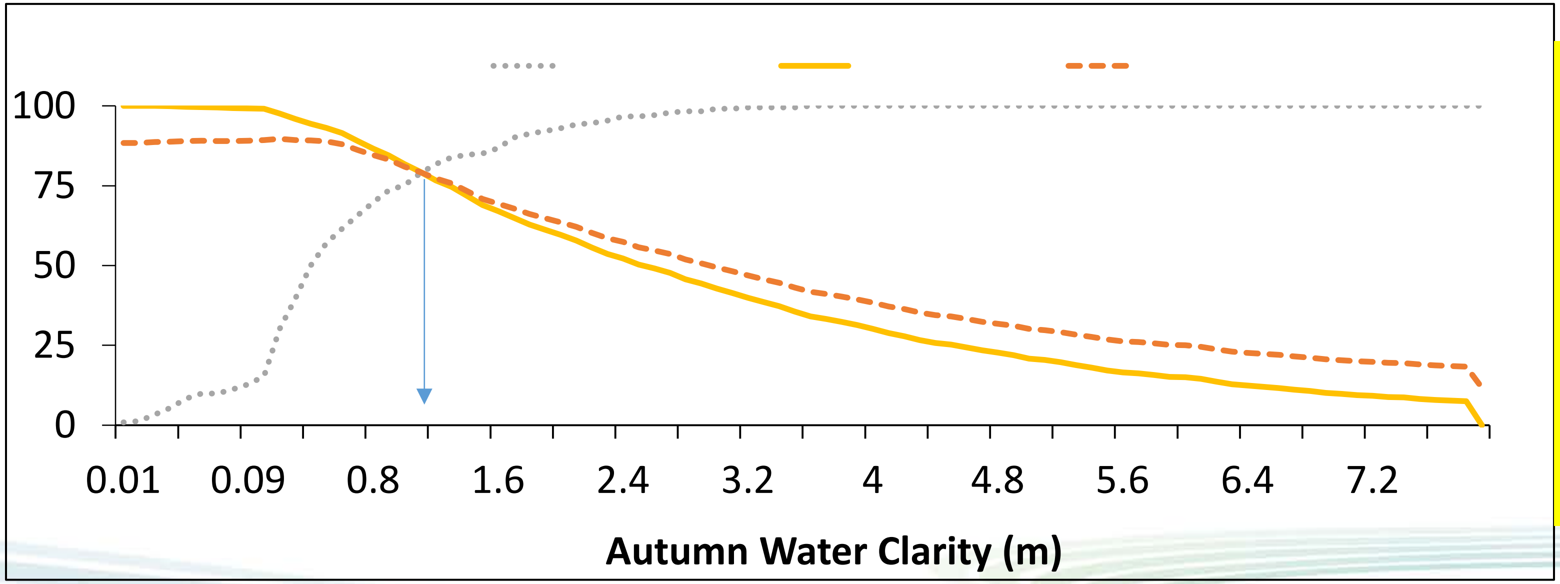
Box plots of 8105 datasets of river *E.coli* concentrations grouped by clarity class and categorized by region.
RC: 9=HRC, 10=MDC, 11=NRC, 12=ORC, 13=TDC, 14=TRC, 15=WCRC



Model performance plots fitted for New Zealand wide dataset using maximum value modelling approach: (a) Calibration Period, 2005-1010. (b) Validation Period, 2011-2013. Light green error bar indicates the 90% prediction interval.

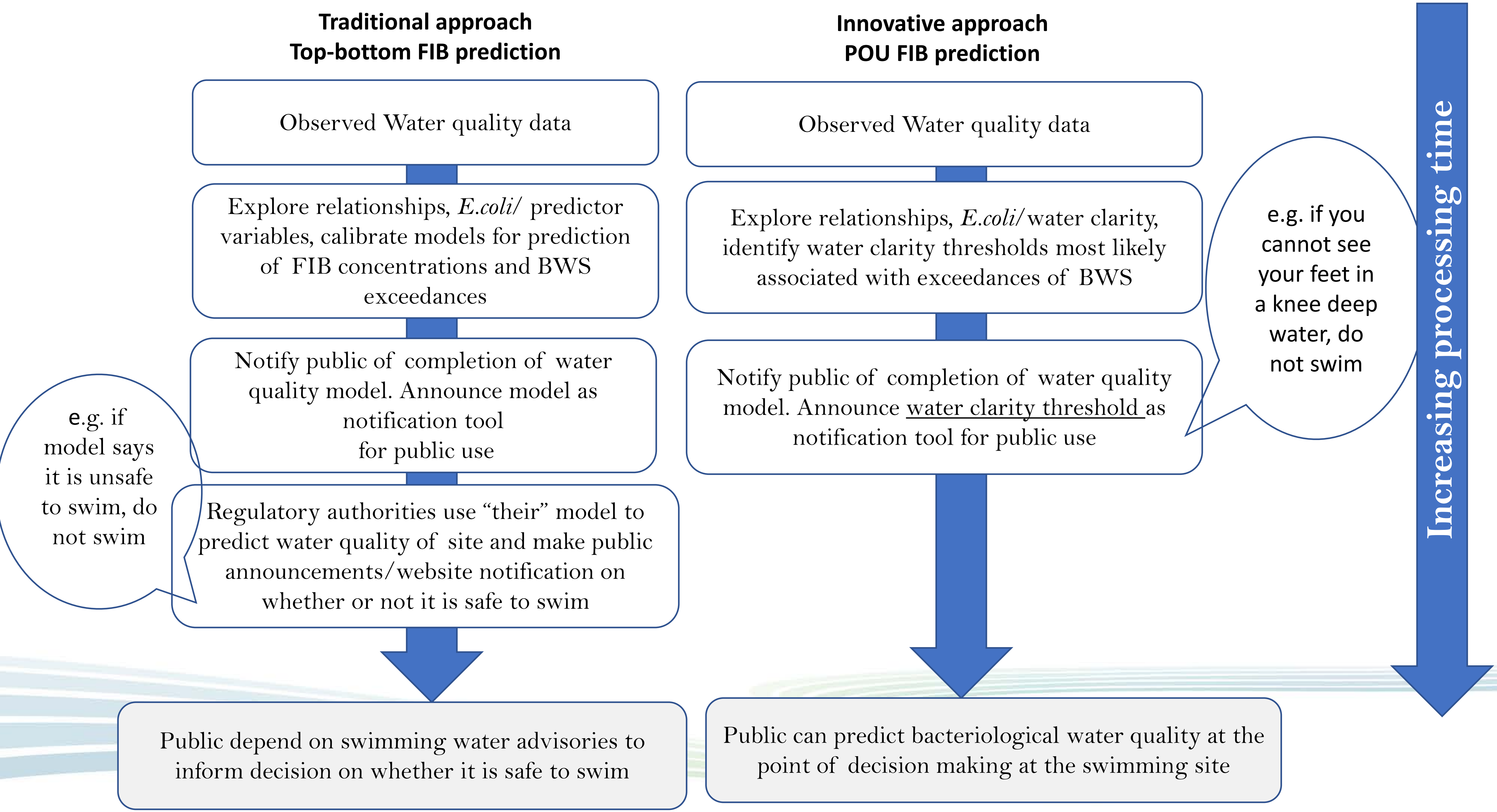


Spring and Winter "alert" value = 0.6m



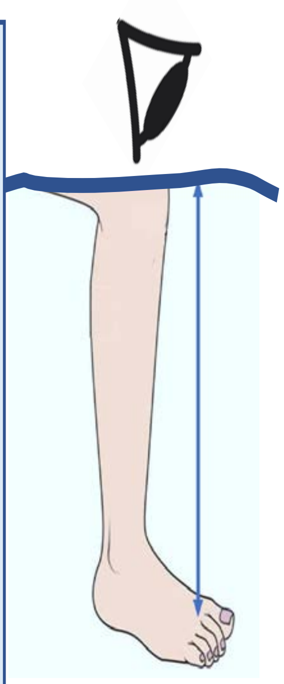
Autumn and Summer "alert" value = 1.2m

Seasonal plots of sensitivity, specificity and accuracy versus water clarity 'alert' value that predicts *E.coli* BWS exceedances nationwide. Performance of the classification scheme was assessed against a BWS of 540CFU/100mL


Traditional approach
Top-bottom FIB prediction
Observed Water quality data
Explore relationships, E.coli/ predictor variables, calibrate models for prediction of FIB concentrations and BWS exceedances
Notify public of completion of water quality model. Announce model as notification tool for public use
Regulatory authorities use "their" model to predict water quality of site and make public announcements/website notification on whether or not it is safe to swim
e.g. if model says it is unsafe to swim, do not swim
Public depend on swimming water advisories to inform decision on whether it is safe to swim
Innovative approach
POU FIB prediction
Observed Water quality data
Explore relationships, E.coli/water clarity, identify water clarity thresholds most likely associated with exceedances of BWS
Notify public of completion of water quality model. Announce water clarity threshold as notification tool for public use
e.g. if you cannot see your feet in a knee deep water, do not swim
Public can predict bacteriological water quality at the point of decision making at the swimming site
Increasing processing time

Water clarity-based FIB prediction

Visibility: You should be able to see at least **<u>xx</u>** metres underwater. E.g. If you cannot see your feet in a knee deep water, this suggests a high risk of elevated *E.coli*, don't bother swimming



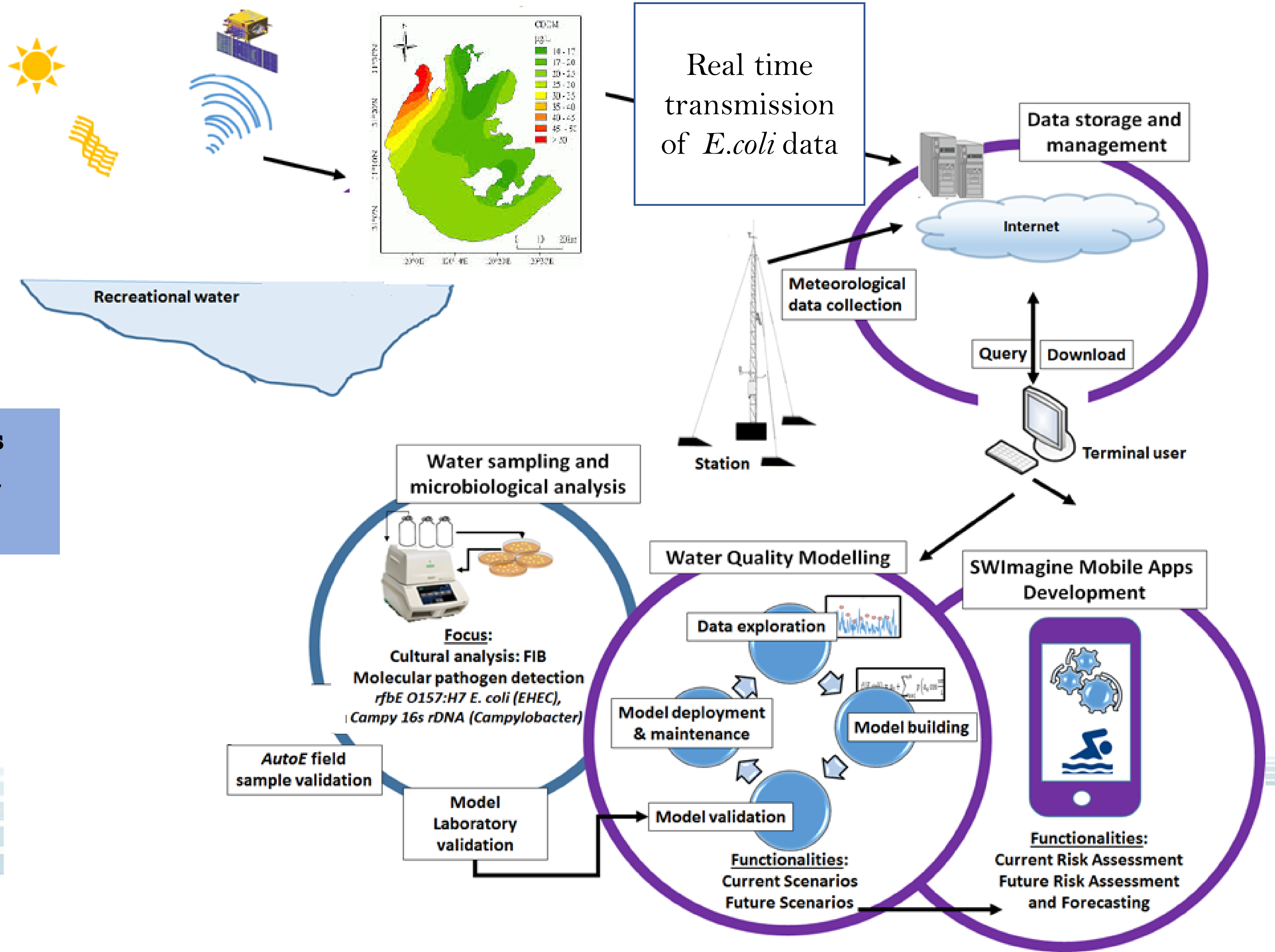
Potential Limitations/Challenges

- Require volunteer participant for real life validation before deployment
- Subjectivity in 'perceived' water clarity
- Water safe from an *E.coli* perspective may not necessarily be safe from a toxic algae or chemical perspective.

Scope for future studies

- Volunteer participants for real life validation

Future directions for water clarity-based *E.coli* prediction



Conclusion

- Predictive models can help capture current risks which are not reliably captured by existing monitoring systems

- Threshold/alert values for water clarity in New Zealand rivers can be used to reliably predict exceedances of *E.coli* BWS

- Scope exists for incorporation of water clarity based thresholds into public notification tools that allow the public to make POU prediction of whether a favourite swimming site is safe to swim or not, based on estimated *E.coli* concentrations.

References

- Dada, A. C., & Hamilton, D. P. (2016). Predictive models for determination of *E. coli* concentrations at inland recreational beaches. Water, Air, & Soil Pollution, 227(9), 347.

- Davies-Colley, R., Valois, A., & Milne, J. (2018). Faecal pollution and visual clarity in New Zealand rivers: Correlation of key variables affecting swimming suitability. Journal of Water and Health, wh2018214.

- McDowell, R. W., Cox, N., & Snelder, T. H. (2017). Assessing the Yield and Load of Contaminants with Stream Order: Would Policy Requiring Livestock to Be Fenced Out of High-Order Streams Decrease Catchment Contaminant Loads?. Journal of environmental quality, 46(5), 1038-1047.

- Storey, R. G., Wright-Stow, A., Kin, E., Davies-Colley, R. J., & Stott, R. (2016). Volunteer stream monitoring: Do the data quality and monitoring experience support increased community involvement in freshwater decision making?. Ecology and Society, 21(4).32