River fish classification in Scotland

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Fish classification in Scotland

- SEPA employed first freshwater fish specialists in 2008 to help deliver WFD requirements
- Aimed to include fish data in first RBMP
- Insufficient time to develop a detailed model for the first plan
- Simple interim tool developed, based largely on salmonids
- Aim was to ensure that the most important freshwater impacts on fish are recognised and addressed
- Data sourced from fisheries charities and government fish surveys

River type	Good +	Moderate	Poor	Bad
Salmon & trout rivers (< 10 m wide, and below natural obstacles)	**10+ salmonids /100m^2** **Fry and parr present**	**Missing fish species/age classes** **>1 salmonid/100m^2**	**<1 salmonid per 100m2**	**No fish**

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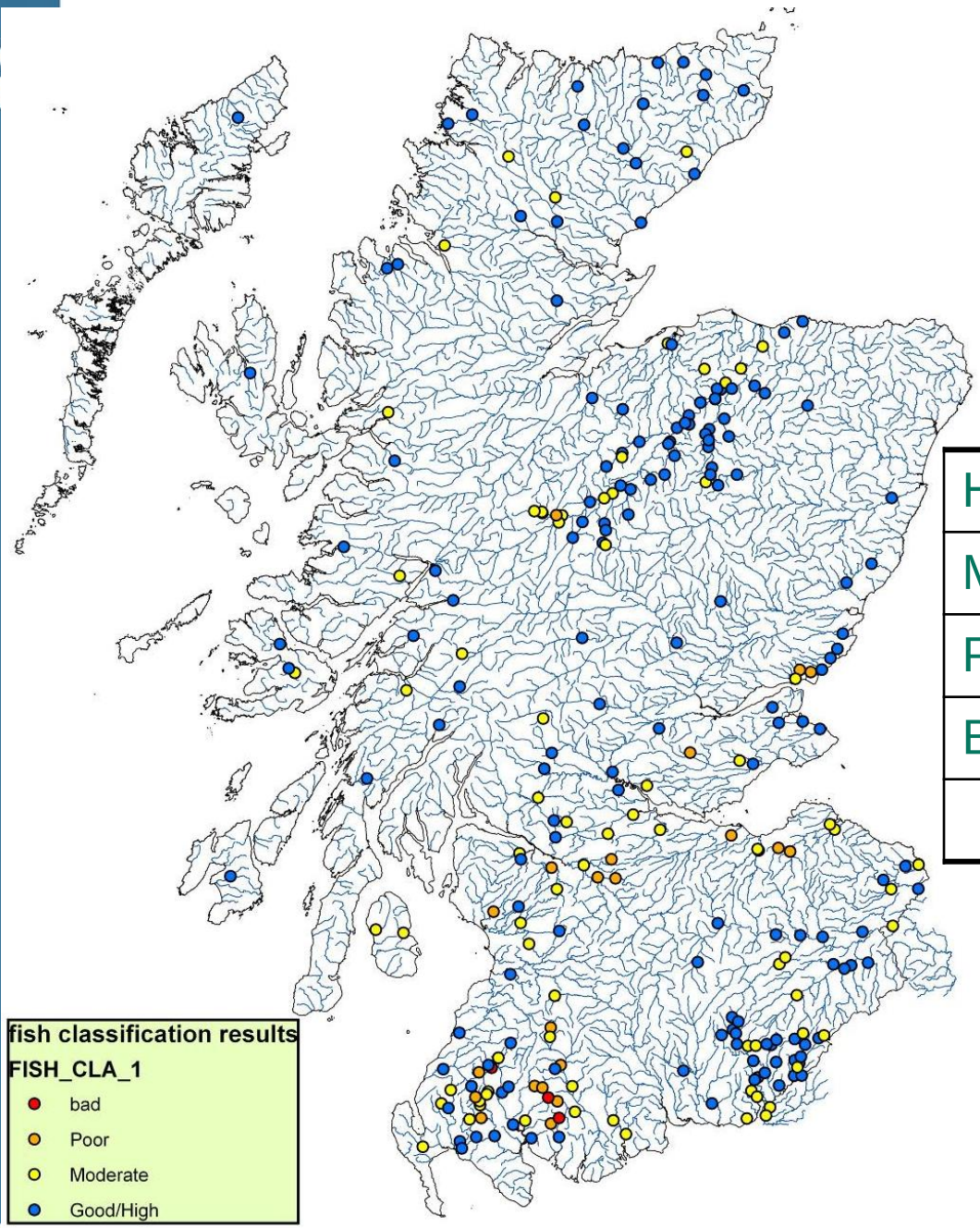
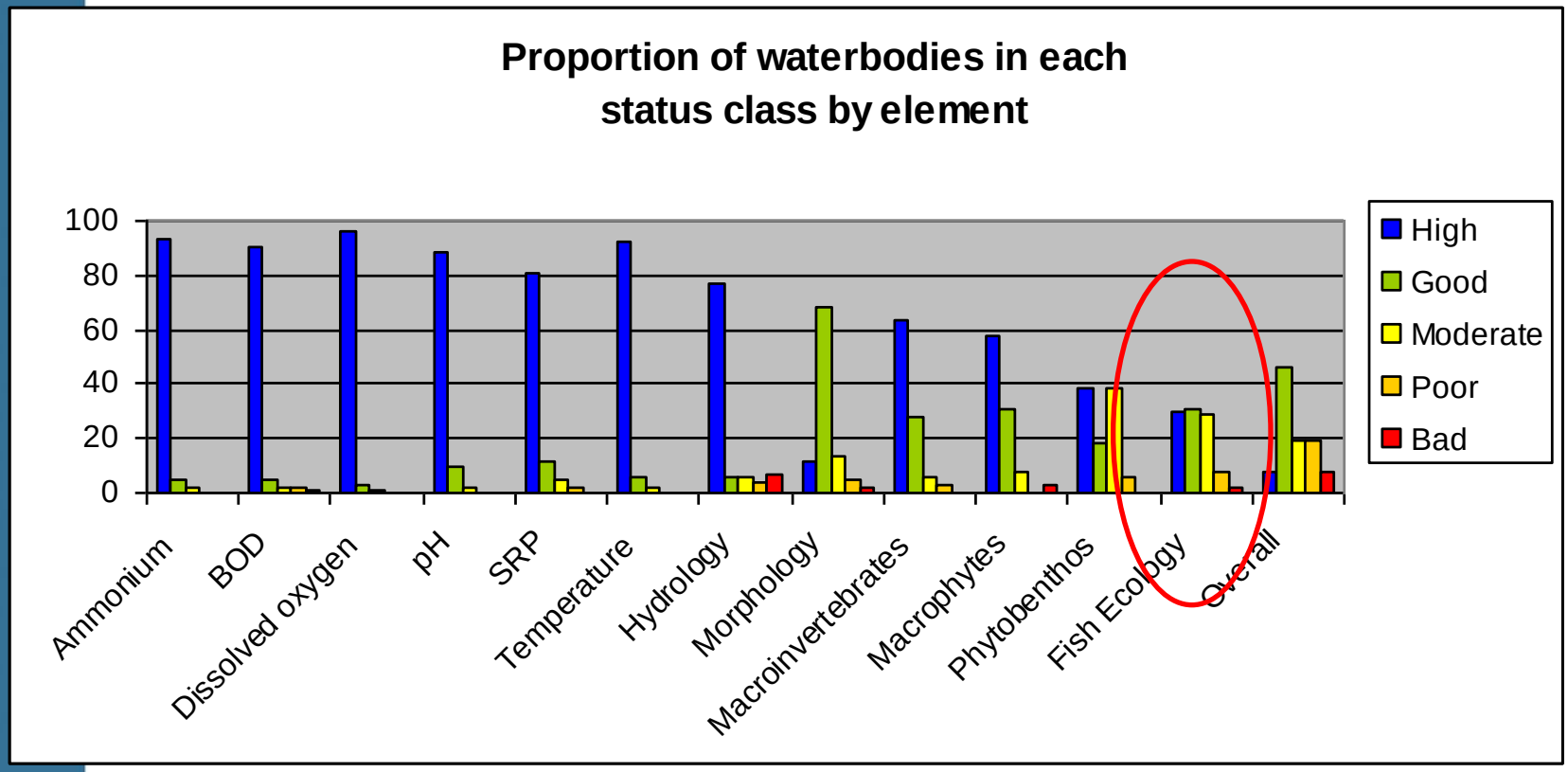
Salmon (>10 m wide and below natural obstacles**)**	**10+ salmon /100m^2** **Fry and parr present**	**Missing age classes** **>1 salmon /100m^2**	**<1 salmon per 100m2**	**No fish**
Brown trout (<3 m wide, small coastal catchments or sites above natural obstacles)	**10+ brown trout /100m^2** **Fry and parr present**	**Missing age classes** **>1 brown trout /100m^2**	**<1 brown trout per 100m2**	**No fish**



High/good	150	61%
Moderate	71	29%
Poor	20	8%
Bad	4	2%
total	245	


Proportion of waterbodies in each status class by element
100
80
60
40
20
0
High
Good
Moderate
Poor
Bad
Ammonium
BOD
Dissolved oxygen
pH
SRP
Temperature
Hydrology
Morphology
Macroinvertebrates
Macrophytes
Phytobenthos
Fish Ecology
Overall

Next steps

- Interim tool not WFD compliant, and oversimplistic
- FAME/EFI+ poor for neighbouring member states (England and Wales)
  - Issues with IBI approach, especially for naturally species poor communities
- Develop a more detailed, site-based and fully WFD compliant river classification tool
- Based on EA's FCS2 approach

FCS2 in Scotland

- Basic approach similar to Ireland, and England/Wales
  - Uses Bayesian-based modelling of **environmental**, **spatial** and **pressure** variables to predict:
  - **Prevalence** (the probability that a species is present) and average **abundance** of each species at each site.
  - Total observed count then compared to expectations at that site under reference conditions

Scottish model development

- Followed the same steps as the Ireland/ NI group
- Data supply issues different in Scotland
  - Lack of linked water chemistry sites
  - Most data from third parties
- 3702 fish surveys available, from 2390 sites, BUT…

1. Uneven spatial distribution of sites
2. Full water chemistry data only available for 50% of sites
3. Most salmonid data from single run surveys (70%)
4. Only categorical data available for most non-salmonid species (1-10, 11-100 etc.)
   - Additional module built into the model to account for this type of data
   - Increases uncertainty, but theoretically possible to derive EQRs

Species in the Scottish model

- Initially attempted to build models for all widely distributed species:
  - Atlantic salmon (0+ and 1++ age class categories)
  - Brown trout (0+ and 1++ age class categories)
  - Eel
  - Flounder
  - Lamprey (all species combined)
  - Minnow
  - 3-spined stickleback
  - Stoneloach

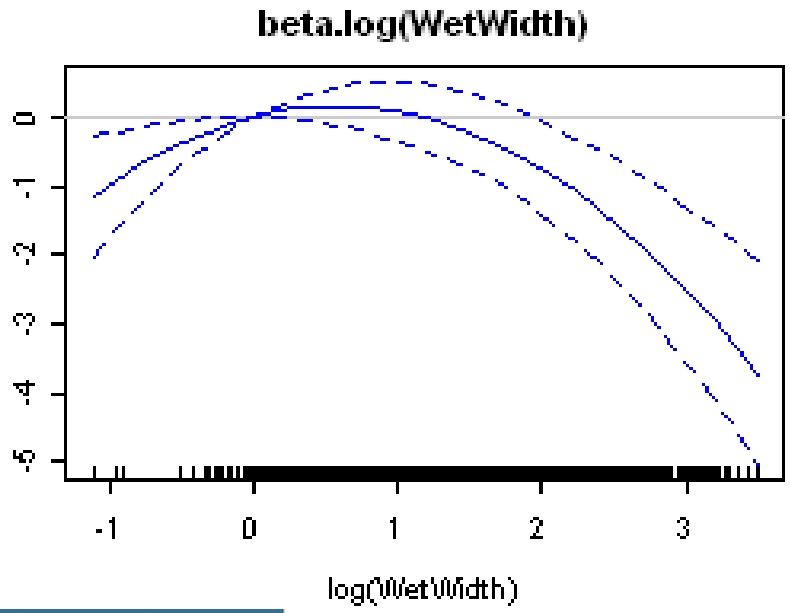
Scottish results

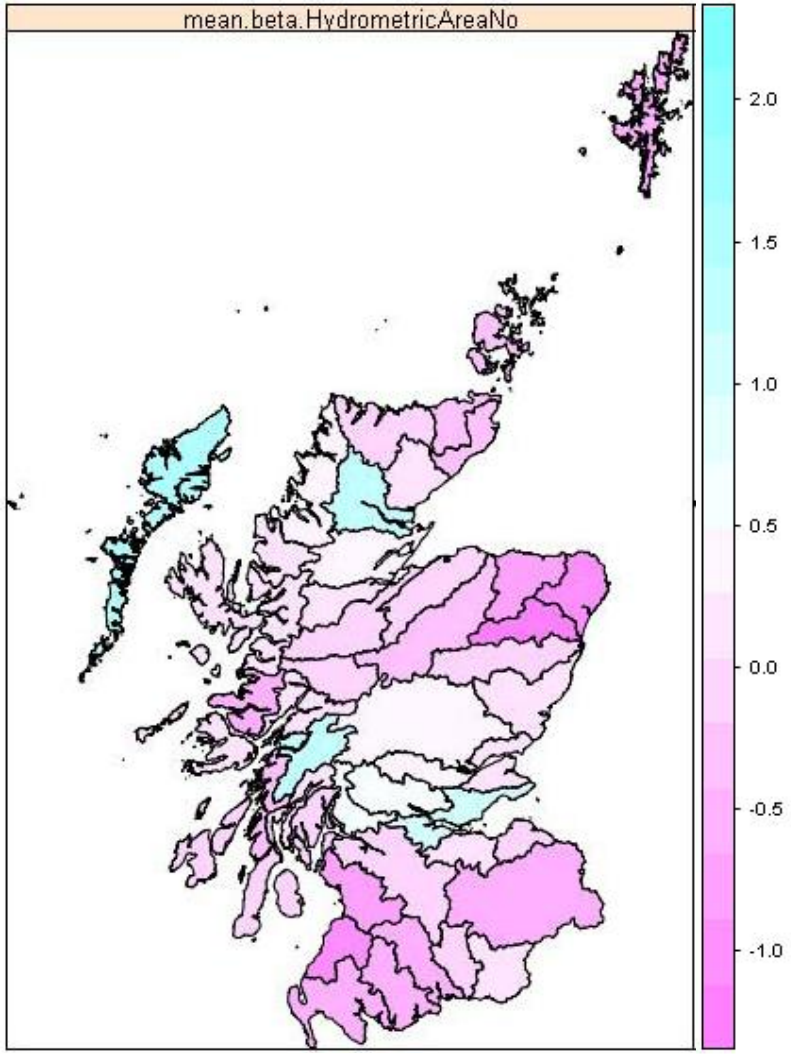
- First FCS2 model for Scotland was able to converge, but gave poor results
  - non-salmonid data was sparse and of poor quality
  - Missing chemistry variables resulted in no classification for large parts of Scotland
- Second run focussed on **salmonid data only**, with improved chemistry database
- Salmonids separated into 0+ and 1++ year classes and these treated as “species”
- Results appear more sensible, but are a less accurate reflection of the overall fish community

Covariate		Prevalence				Abundance			
		0+ S	1++ S	0+ T	1++ T	0+ S	1++ S	0+ T	1++ T
Geography	Impassable barrier D/S	✓	✓						✓
	Hydrometric area	✓	✓					✓	✓
	Slope	✓							✓
	Distance from source	✓	✓			✓	✓		
	Annual Mean flow				✓				✓
	Distance to sea		✓			✓	✓		
	Catchment area upstream							✓	
Region	E					✓			✓
	SW						✓		
	W					✓	✓		
	NW				✓				
Land use	% coniferous forest		✓						
	% wetlands	✓							
Water chemistry	SRP/MRP	✓	✓	✓	✓				
	Alkalinity					✓			
	pH							✓	
	Suspended solids							✓	✓
	Ammonium					✓	✓		
	DOC					✓		✓	
	Total P			✓			✓		
Survey site	Wet width	✓	✓			✓	✓	✓	✓
	Substrate % Large		✓				✓		
	Substrate % Small				✓				
	Substrate % Bedrock					✓			
	Salmon stocking history	✓							
Geology	Siliceous			✓					
	Calcareous				✓				

Covariate		Prevalence				Abundance			
		0+ S	1++ S	0+ T	1++ T	0+ S	1++ S	0+ T	1++ T
Geography	Impassable barrier D/S	✓	✓						✓
	Hydrometric area	✓	✓					✓	✓
	Slope	✓							✓
	Distance from source	✓	✓			✓	✓		
	Annual Mean flow				✓				✓
	Distance to sea		✓			✓	✓		
	Catchment area upstream							✓	
Region	E					✓			✓
	SW						✓		
	W					✓	✓		
	NW				✓				
Land use	% coniferous forest		✓						
	% wetlands	✓							
Water chemistry	SRP/MRP	✓	✓	✓	✓				
	Alkalinity					✓			
	pH							✓	
	Suspended solids							✓	✓
	Ammonium					✓	✓		
	DOC					✓		✓	
	Total P			✓			✓		
Survey site	Wet width	✓	✓			✓	✓	✓	✓
	Substrate % Large		✓				✓		
	Substrate % Small				✓				
	Substrate % Bedrock					✓			
	Salmon stocking history	✓							
Geology	Siliceous			✓					
	Calcareous				✓				

Example of posterior estimates of covariate terms : trout fry abundance, wet width and hydrometric area



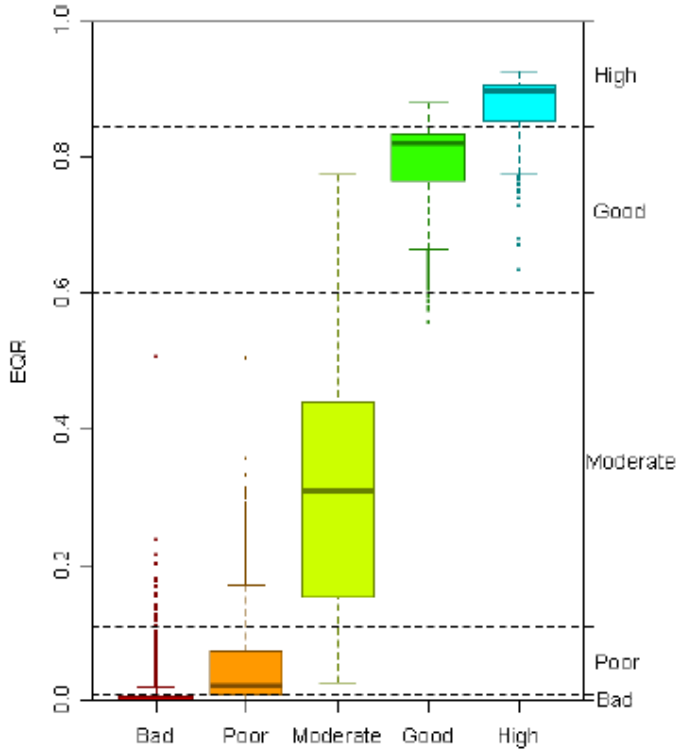


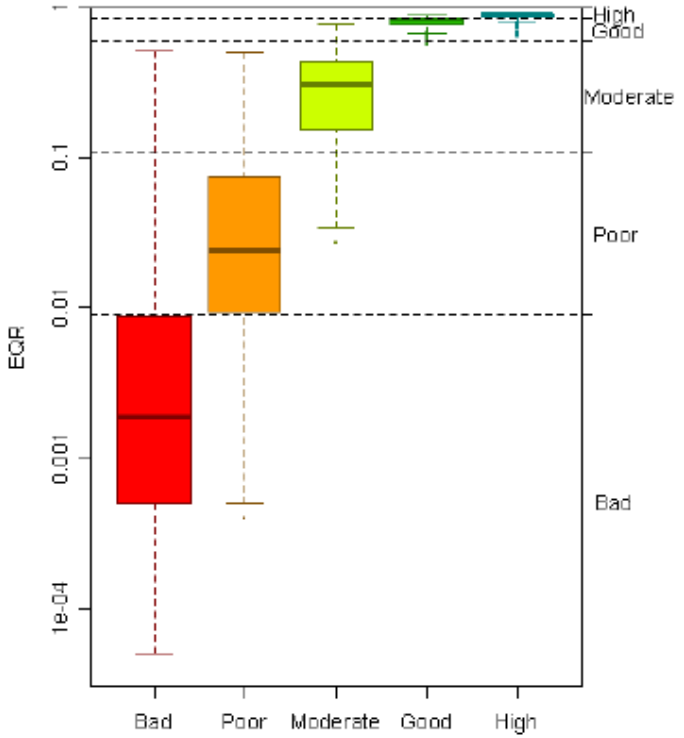
Setting class boundaries

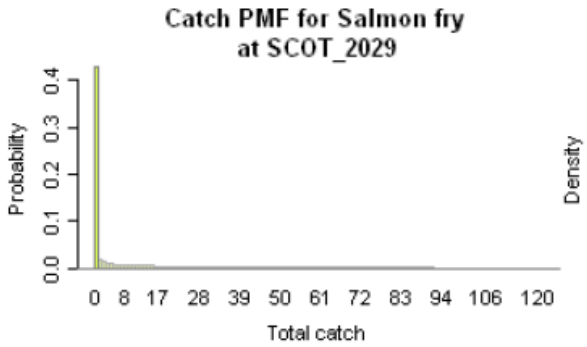
- Not finalised yet for 2nd model
- Suggestion for the first model run involved using **artificial datasets** to assess the EQR's for catches to match idealised class conditions

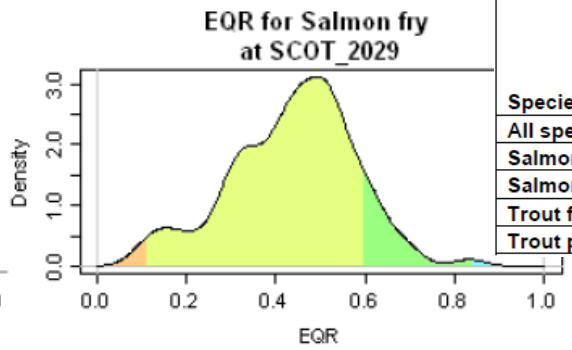
CLASS	Species present	Abundance
High	All expected species present. (Salmon **and** trout present)	At expected abundance
Good	All expected species present. (Salmon **and** trout present)	>80% expected abundance
Moderate	55% of expected species present (Salmon **or** trout present)	>55% of expected abundance
Poor	30% of expected species present (at least one year class present)	>30% of expected abundance

EQR range	Classification
0 ≤ EQR ≤ 0.009	Bad
0.009 < EQR ≤ 0.11	Poor
0.11 < EQR ≤ 0.6	Moderate
0.6 < EQR ≤ 0.845	Good
0.845 < EQR ≤ 1.0	High

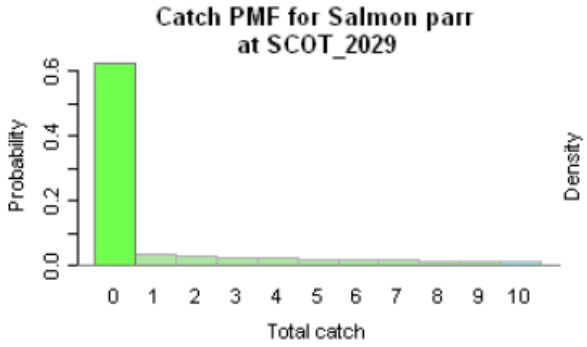


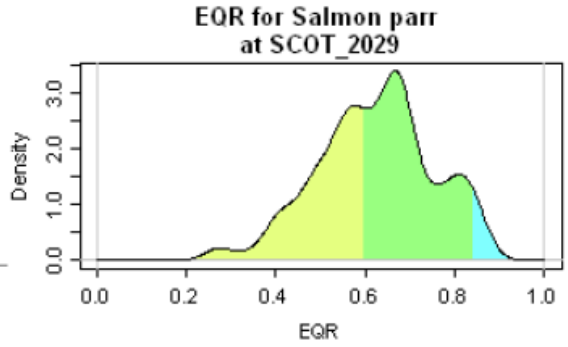


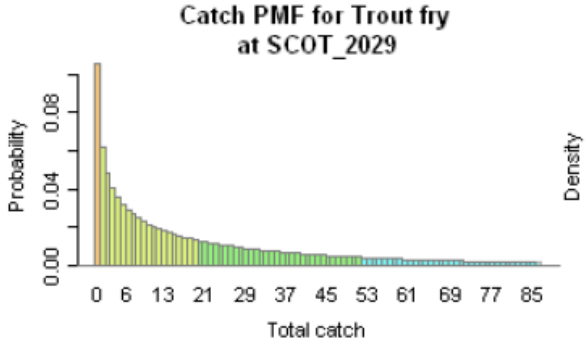


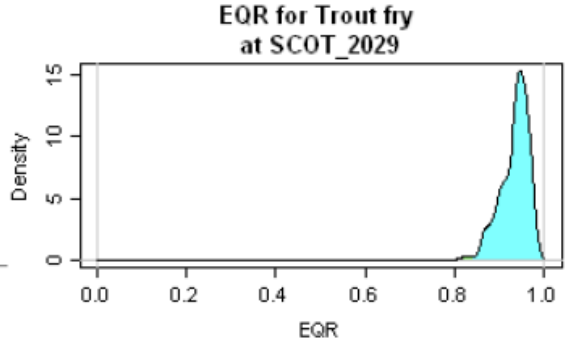


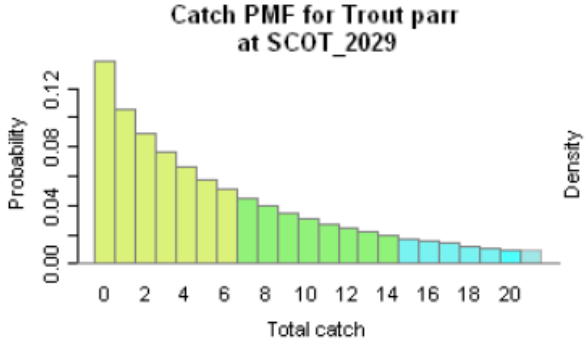
Species	Probability of class					Survey EQR mean	Observed total catch	Probability present	Expected total catch if present	Expected total catch
	Bad	Poor	Moderate	Good	High					
All species	0%	0%	5%	33%	62%	0.842				
Salmon fry	0%	1%	88%	11%	0%	0.437	0	0.602	99.966	59.991
Salmon parr	0%	0%	43%	54%	3%	0.623	0	0.422	10.740	4.508
Trout fry	0%	0%	0%	1%	99%	0.935	85	1.000	26.002	25.999
Trout parr	0%	0%	0%	4%	96%	0.911	20	0.996	7.978	7.949

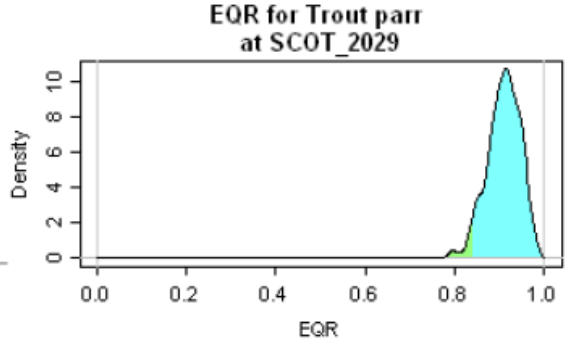




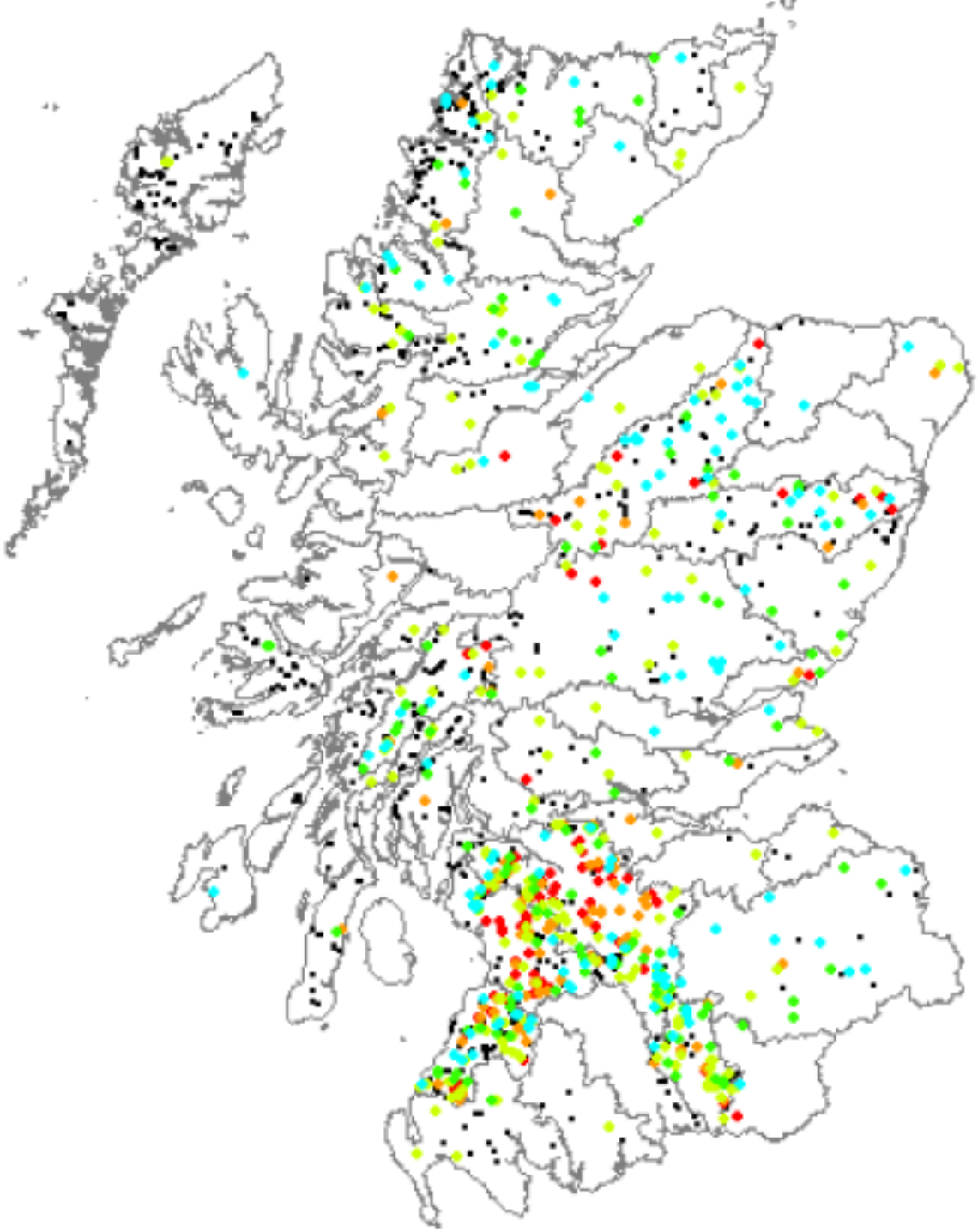








SEPA
Scottish Environment Protection Agency



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Pros and Cons of FCS2

Pros

- Detailed and unbiased, with few assumptions
- Statistically robust
- Will allow additional data to be added in future
- Extra models for new species can be built using the existing framework

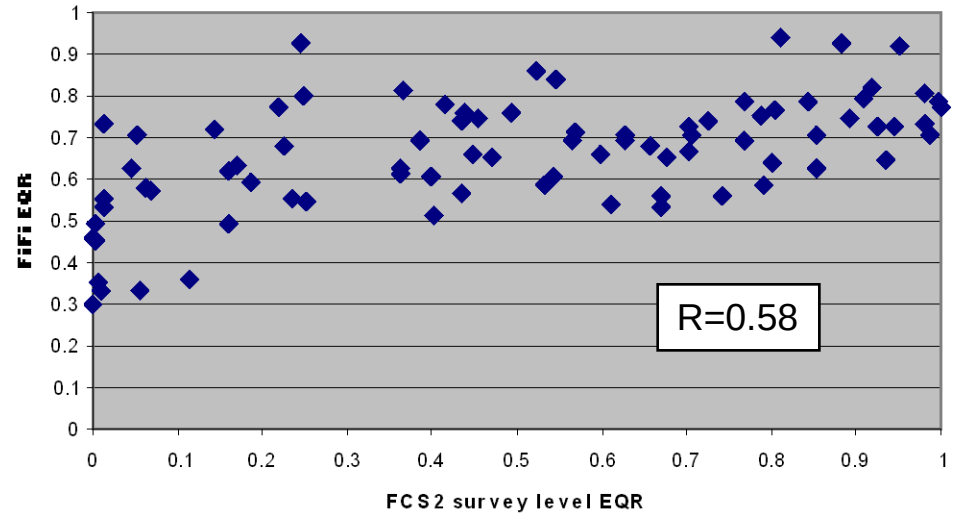
Cons

- Computationally intensive (4 weeks to run model fitting)
- Complicated and non-intuitive to understand
- Requires extensive fish and environmental data which is often not available
- Cannot be easily applied to external data

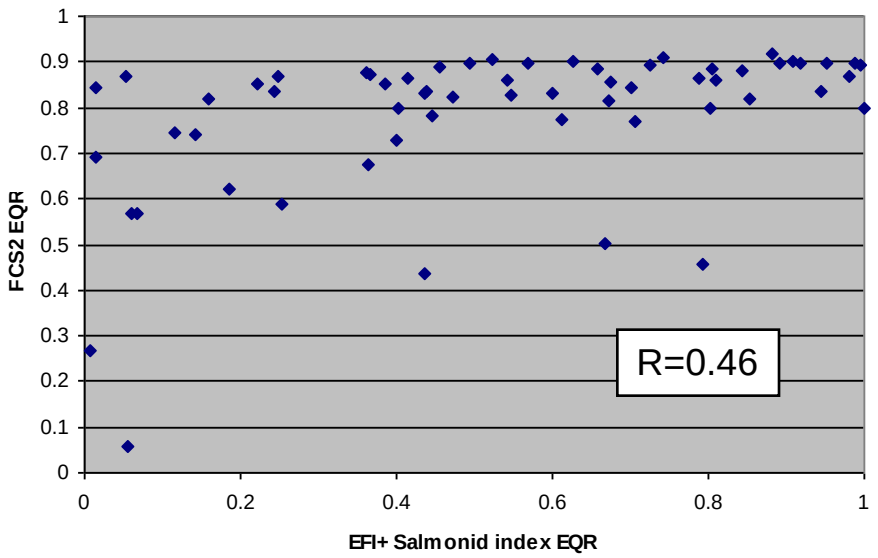
FCS2 and intercalibration

- Difficult (impossible) to run FCS2 using external data
- Correlate with common metric (option 2)?
- England and Wales correlations with EFI+ are poor
- Scottish results are also low

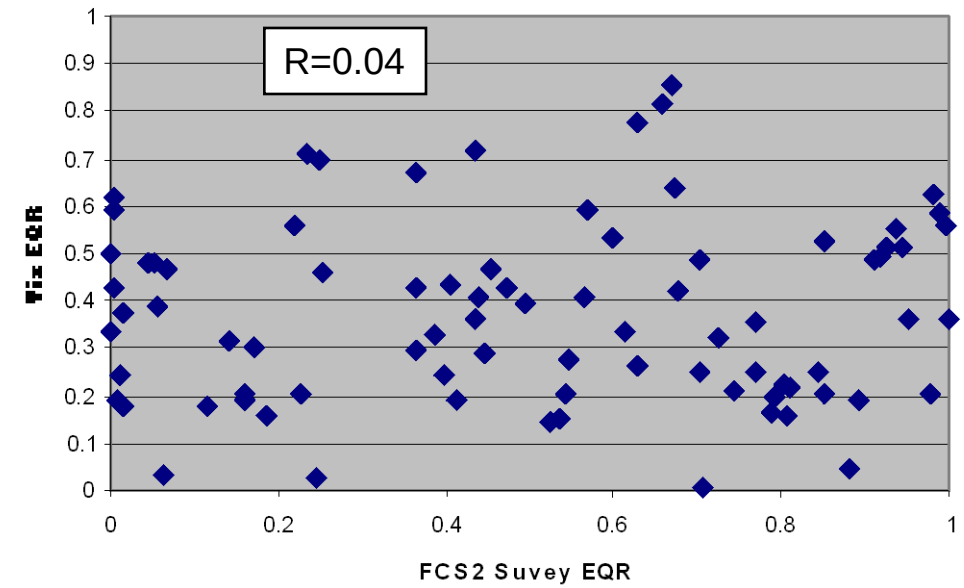
FCS2 vs FiFi



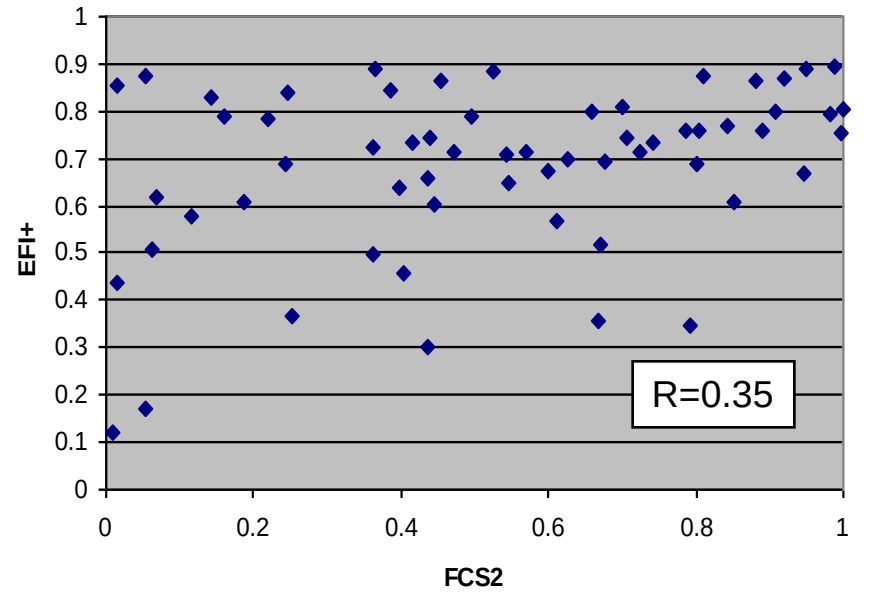
FCS2 vs EFI+ salmonid index



FCS2 vs Vix



FCS2 vs EFI+ mean



Next steps

- Review output and finalise class boundaries
- Run additional classifications on new data
- Check correlation with common metric, other Nordic GIG tools and old Scottish tool
- Assess possibility of intercalibration option 3 if necessary
- Extend model to other species when sufficient data become available
- Improve water quality dataset
- Consider incorporating hydrological covariates

Thanks for listening!