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Presentation

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Development of an Estuarine Health Index for the Swan Estuary, Western Australia: METRIC SELECTION

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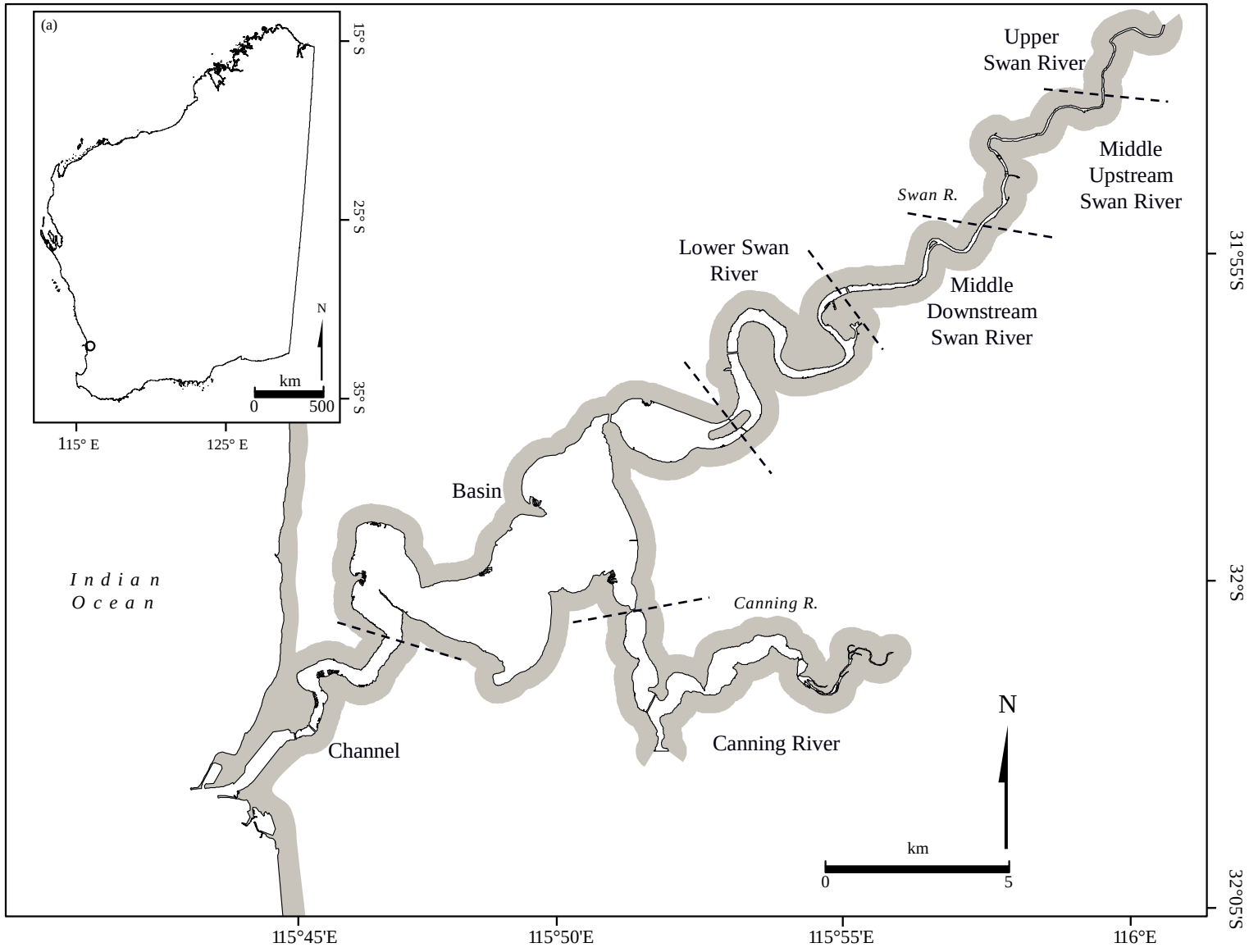
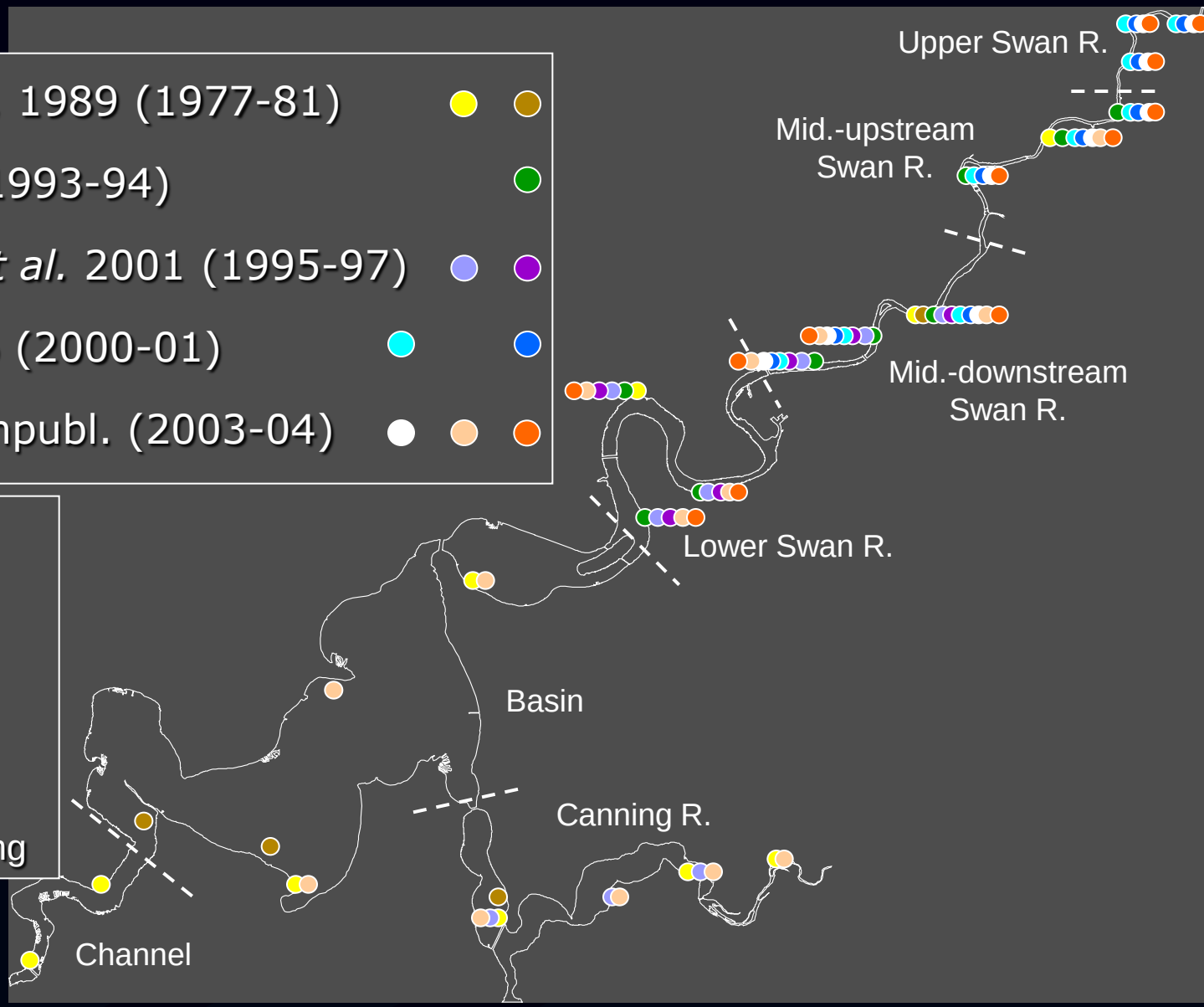

(a)
15° S
25° S
35° S
115° E
125° E
N
km
0
500
Upper
Swan River
Middle
Upstream
Swan River
Swan R.
Lower Swan
River
Middle
Downstream
Swan River
Basin
Indian
Ocean
Canning R.
Channel
Canning River
N
km
0
5
31°55'S
32°S
32°05'S
115°45'E
115°50'E
115°55'E
116°E

Metric Selection: Inter-annual Change Approach

- Loneragan *et al.* 1989 (1977-81)
- Sarre unpubl. (1993-94)
- Kanandjembo *et al.* 2001 (1995-97)
- Hoeksema 2006 (2000-01)
- Valesini *et al.* unpubl. (2003-04)

Sampling methods:

- Nearshore
  - 21 m seine
  - 41 m seine
  - 133 m seine
- Offshore
  - Multimesh gillnetting



Metric Selection: Inter-annual Change Approach

Eliminate highly correlated / redundant metrics + **Select metrics which consistently highlight inter-annual change** = Select suite of metrics which efficiently represents ecosystem health

- Distance-based linear modelling (DISTLM)
- Non-linear multivariate techniques (BIOENV / BVSTEP)
- Multiple data sets and analyses →
- Weight of evidence approach

Eliminate highly correlated / redundant metrics from candidate list

Refined metric lists

0 – 1 model matrix

0 – 1 model matrix

BIOENV

DISTLM

Reference (interannual model matrix)

Seasonally and regionally adjusted

Fish metric data

ρ_S

Best subset of fish metrics

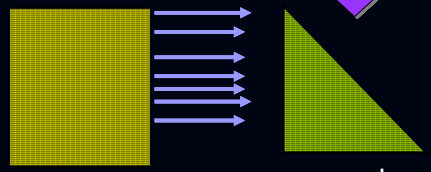


Table: Subset of models (fish metric combinations) identified as being substantially supported by evidence ($\Delta_i \leq 2$) from distance-based linear modelling of 21 m data set.

AIC_c	Number of metrics	Metrics selected *	Δ_i	log likelihood	w_i	Evidence ratio
-338.28	8	1,2,4,5,6,11,13,14	0	1.00	0.09	1.00
-338.01	7	1,4,5,6,11,13,14	0.27	0.87	0.08	1.14
-337.71	8	1,3,4,5,6,11,13,14	0.57	0.75	0.07	1.33
-337.44	9	1,2,4,5,6,11,12,13,14	0.84	0.66	0.06	1.52
-337.38	7	4,5,7,11,12,13,14	0.9	0.64	0.06	1.57
-337.32	7	4,5,6,7,11,13,14	0.96	0.62	0.06	1.62
-337.29	8	2,4,5,6,7,11,13,14	0.99	0.61	0.06	1.64
-337.1	9	1,3,4,5,6,11,12,13,14	1.18	0.55	0.05	1.80
-337	8	1,4,5,6,11,12,13,14	1.28	0.53	0.05	1.90
-336.97	8	3,45,6,7,11,13,14	1.31	0.52	0.05	1.93
-336.76	9	1,2,4,5,6,9,11,13,14	1.52	0.47	0.04	2.14
-336.69	8	3,4,5,7,11,12,13,14	1.59	0.45	0.04	2.21
-336.59	8	1,4,5,6,9,11,13,14	1.69	0.43	0.04	2.33
-336.57	8	2,4,5,7,11,12,13,14	1.71	0.43	0.04	2.35
-336.37	9	1,2,4,5,6,7,11,13,14	1.91	0.38	0.04	2.60
-336.36	8	1,4,5,6,7,11,13,14	1.92	0.38	0.04	2.61
-336.35	9	1,2,4,5,6,10,11,13,14	1.93	0.38	0.04	2.62
-336.3	9	2,4,5,6,7,11,12,13,14	1.98	0.37	0.03	2.69
-336.29	9	1,2,4,5,6,8,11,13,14	1.99	0.37	0.03	2.70
-336.28	9	1,3,4,5,6,9,11,13,14	2	0.37	0.03	2.72

* **Metric Numbers:** 1. *No species*; 2. *Dominance*; 3. *Sh-W*; 4. *Prop trop spec*; 5. *No trop spec*; 6. *No trop gen*; 7. *Prop detr*; 8. *Prop benthic*; 9. *No benthic*; 10. *Feed guild comp*; 11. *Prop est spawn*; 12. *No est spawn*; 13. *Prop P olorum*; 14. *Tot no P olorum*

Decision Rule: select metrics occurring in ≥ 50 % of models in the $\Delta_i \leq 2$ subset

Weight of evidence approach

Offshore

Metric sets for incorporation into Estuarine Health Index

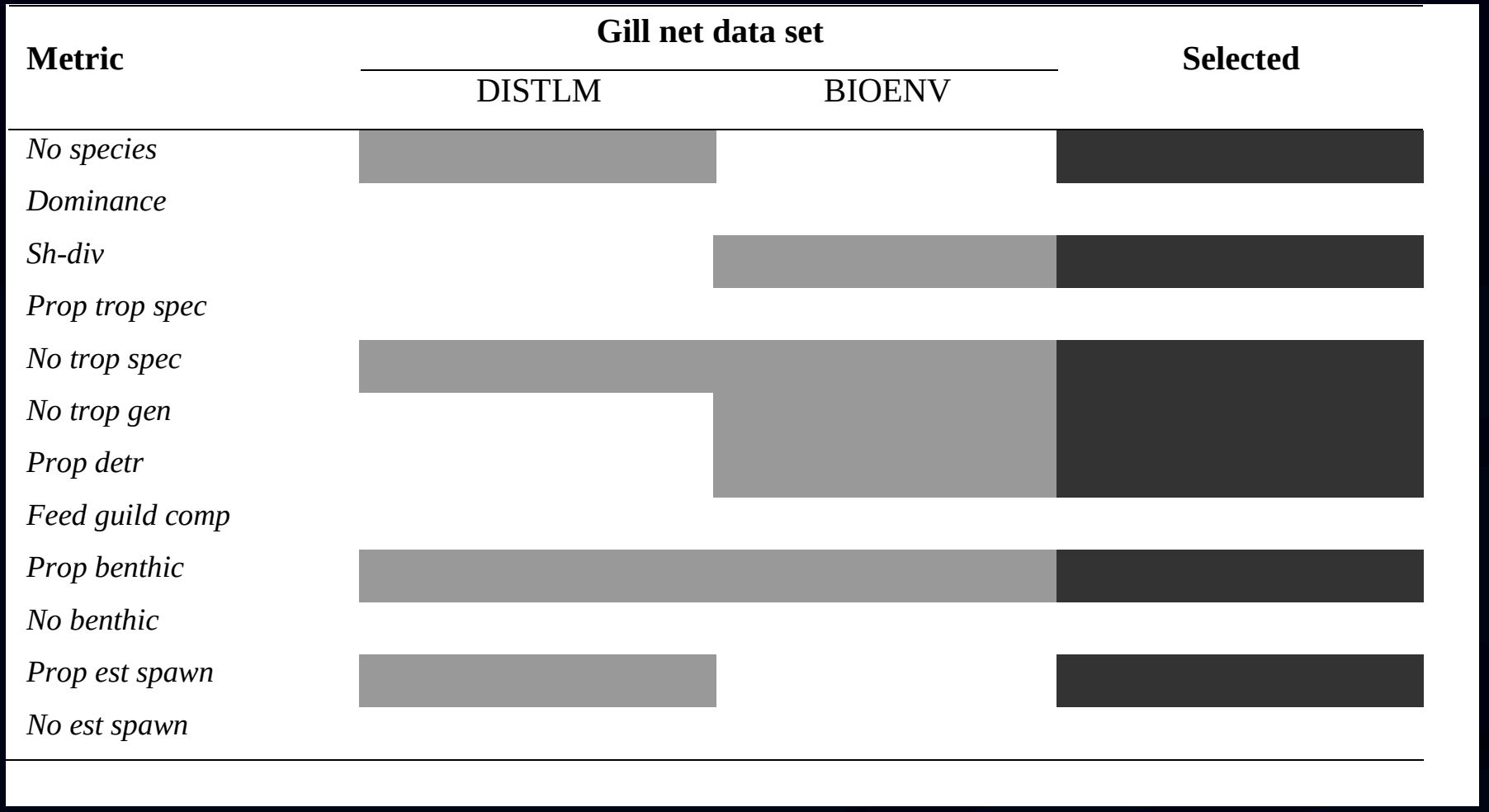
Nearshore

Nearshore metrics

Metric	21 m data set		41 m data set		102-133 m data set		Selected
	DISTLM	BIOENV	DISTLM	BIOENV	DISTLM	BVSTEP	
No species							
Dominance							
Sh-div							
Prop trop spec							
No trop spec							
No trop gen							
Prop detr							
Feed guild comp							
Prop benthic							
No benthic							
Prop est spawn							
No est spawn							
Prop P. olorum							
Tot no P. olorum							

Decision Rule: select metric if identified from >1 of the six analyses

Offshore metrics

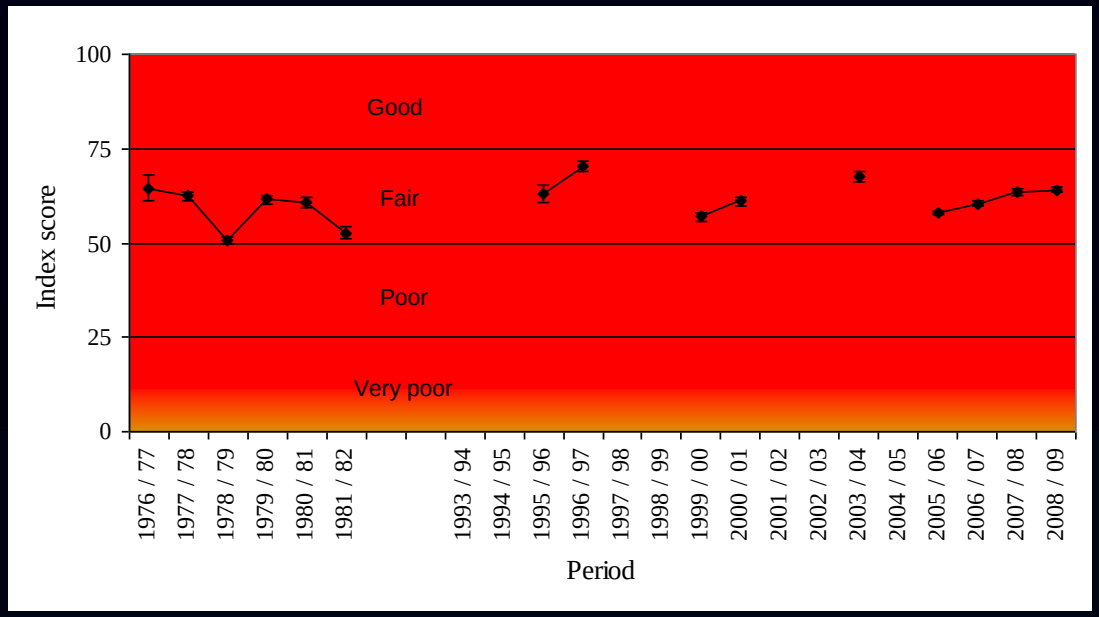


Decision Rule: select metric if identified from either of the two analyses

Selected metrics

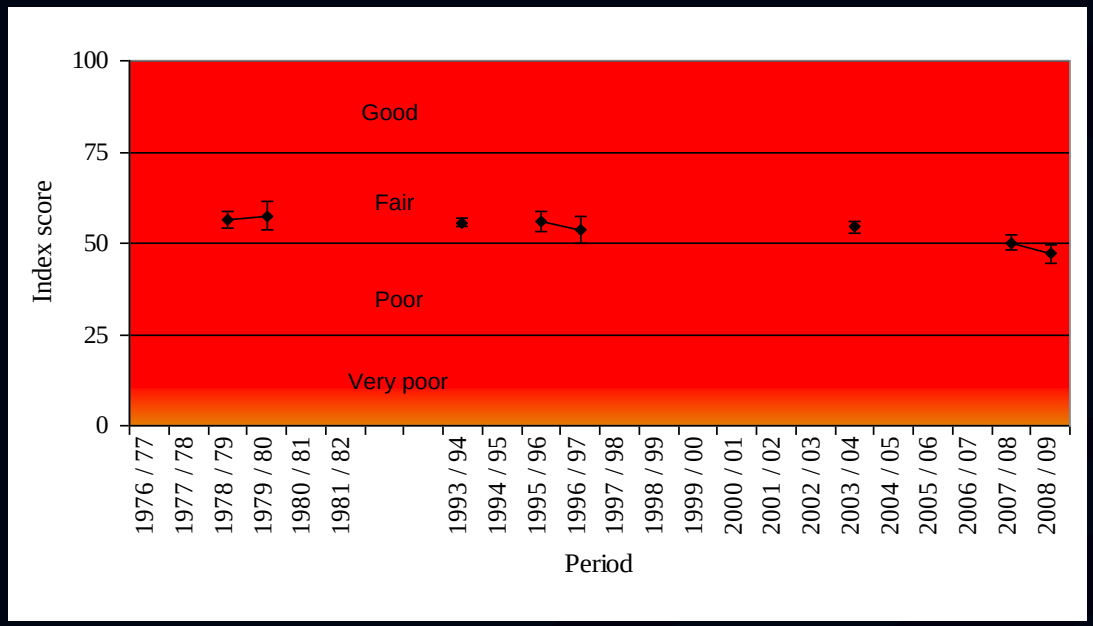
Metric	Nearshore	Offshore
No species	■	■
Dominance		
Sh-div		■
Prop trop spec	■	
No trop spec	■	■
No trop gen	■	■
Prop detr	■	■
Feed guild comp		
Prop benthic	■	■
No benthic	■	
Prop est spawn	■	■
No est spawn	■	
Prop P. olorum	■	
Tot no P. olorum	■	

Index performance and implications: TRENDS



Mean (± s.e.) nearshore health index scores

- Health of nearshore waters 'fair', although…
- Historical scores less reliable
- Evidence of recent increase in nearshore health index scores



Mean (± s.e.) offshore health index scores

- Offshore scores more reliable
- Health of offshore waters has declined:
- 'Poor' for first time in three decades
- Evidence of fish shifting to nearshore waters in recent years?

Outcomes

Implications for Management

- Quantitative assessment of estuary health
- Monitor changes in health over time
- Inform management decisions
- Communication tool for public
- Potential for wider applicability

Outstanding issues

- Assess intra-seasonal variability
- Determine sensitivity to specific stressors
- Need for complementary indicators

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Images courtesy: F. Valesini, D. Morgan, M. Allen, T. Linke, S. de Lestang

SWAN RIVER TRUST

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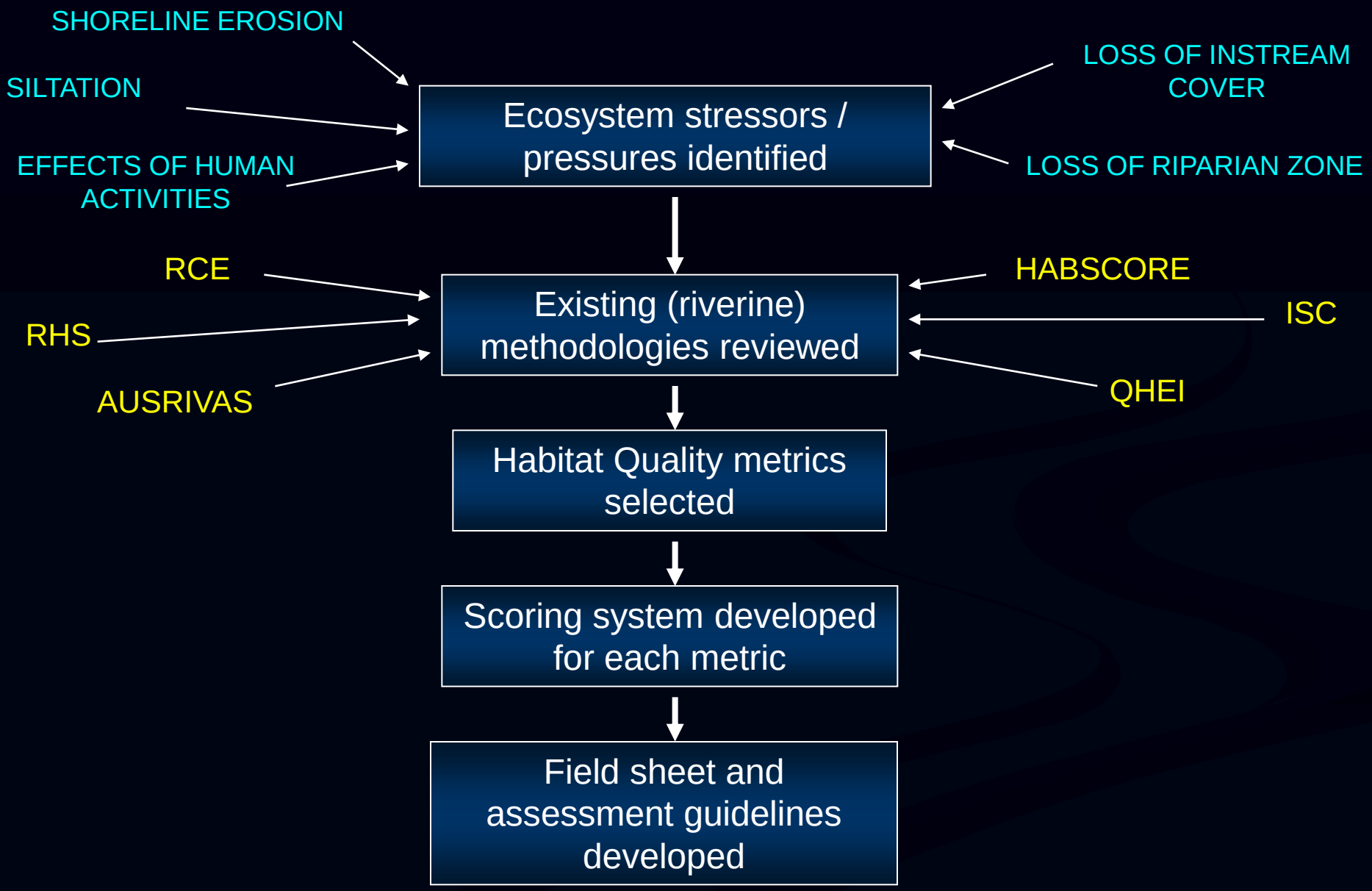
Department of Water
Government of Western Australia

Department of Fisheries
Government of Western Australia

wamsi
western australian marine science institution

Development of Habitat Quality Assessment Scheme



Metric Selection: Habitat Quality Approach

- Rapid Visual Assessment
- Scores for physical Habitat Quality metrics →
- Total Habitat Quality Index Score used to assign site to:

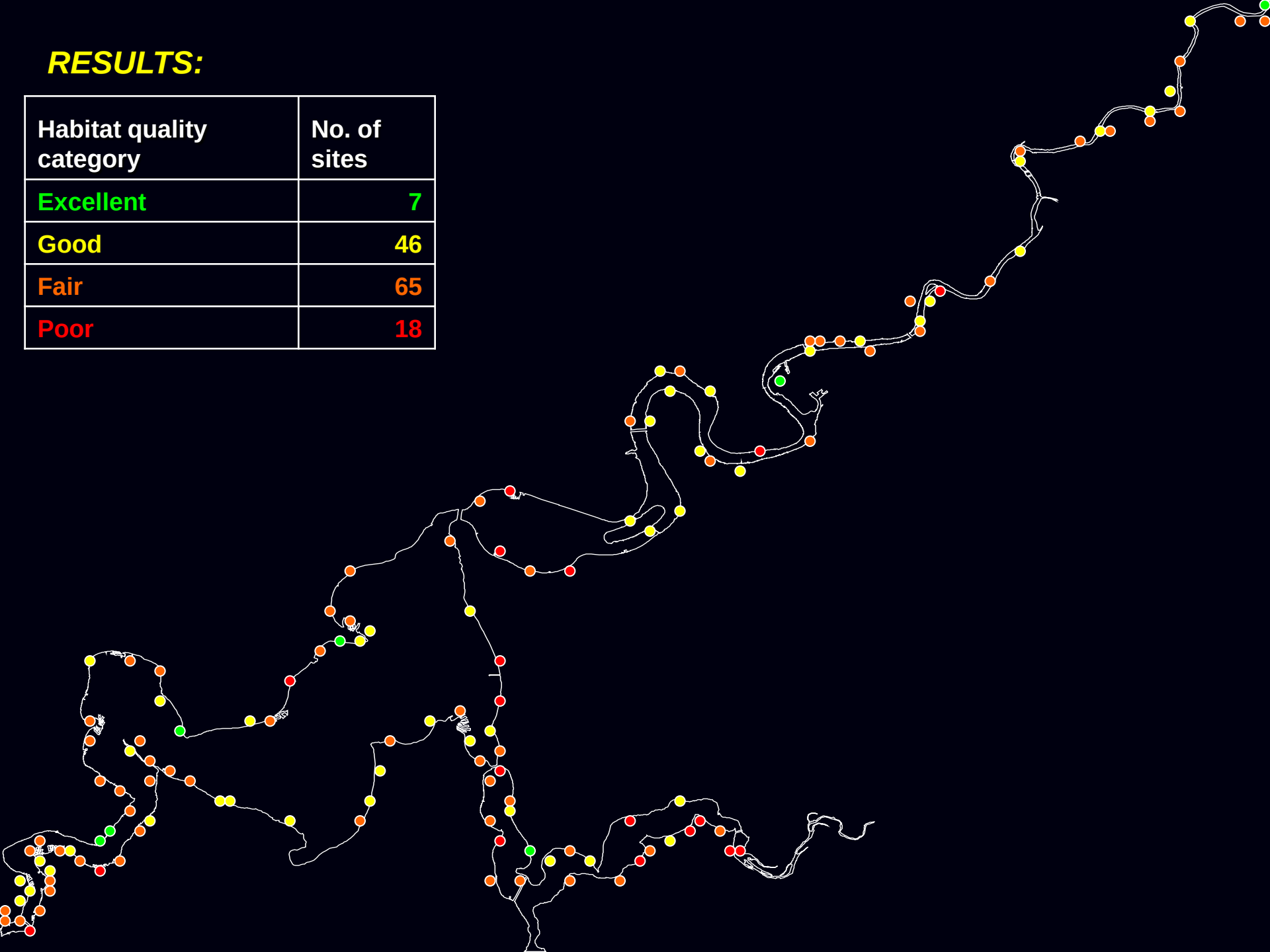
Excellent	Good	Fair	Poor
HQI > 79	HQI 79 - 54	HQI 53 - 31	HQI < 31



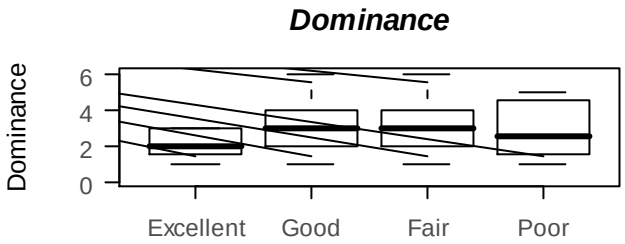

- Water quality parameters also recorded

RESULTS:

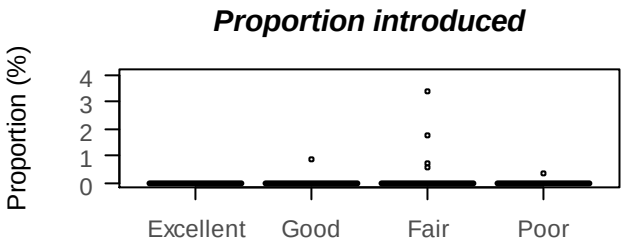
Habitat quality category	No. of sites
Excellent	7
Good	46
Fair	65
Poor	18

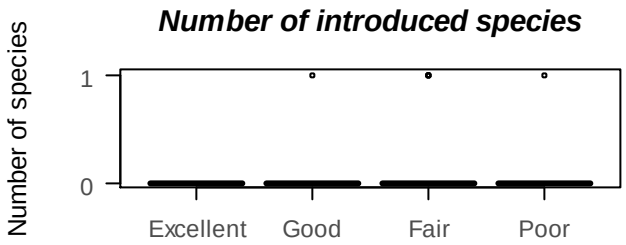


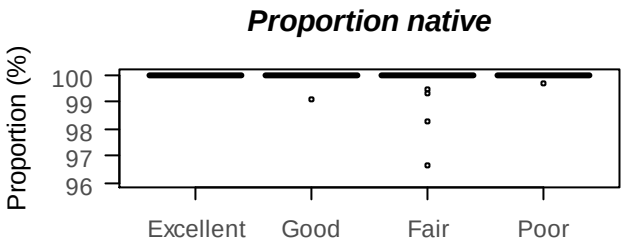

Species richness
Species richness
12
9
6
3
0
Excellent
Good
Fair
Poor

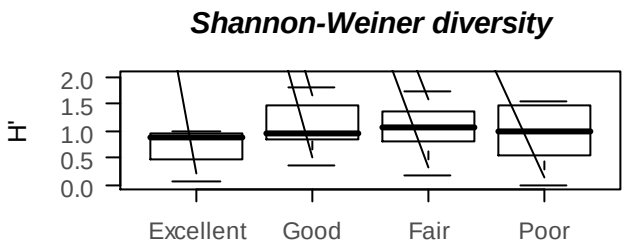

Dominance
Dominance
6
4
2
0
Excellent
Good
Fair
Poor

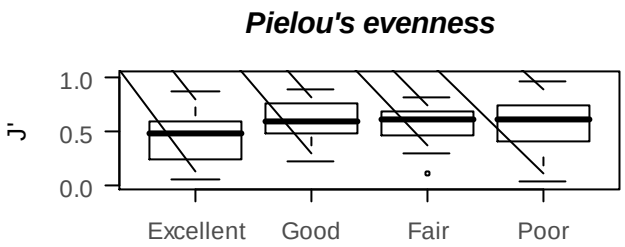

Total density
Density
4000
3000
2000
1000
0
Excellent
Good
Fair
Poor


Proportion introduced
Proportion (%)
4
3
2
1
0
Excellent
Good
Fair
Poor

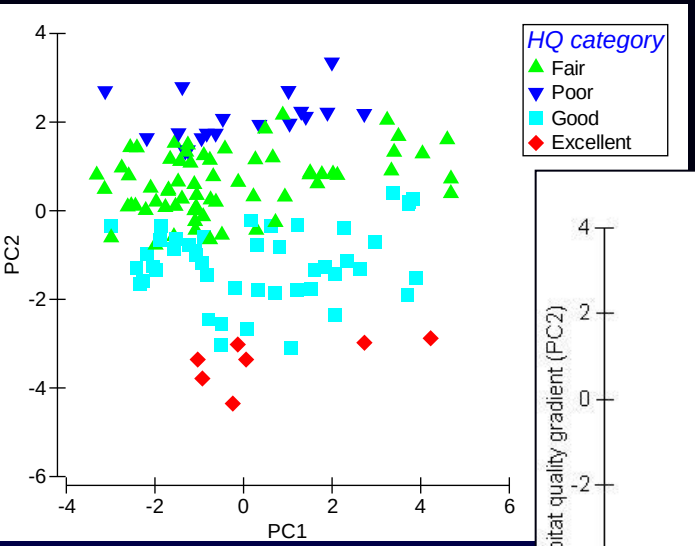

Number of introduced species
Number of species
1
0
Excellent
Good
Fair
Poor


Proportion native
Proportion (%)
100
99
98
97
96
Excellent
Good
Fair
Poor


Shannon-Weiner diversity
H'
2.0
1.5
1.0
0.5
0.0
Excellent
Good
Fair
Poor

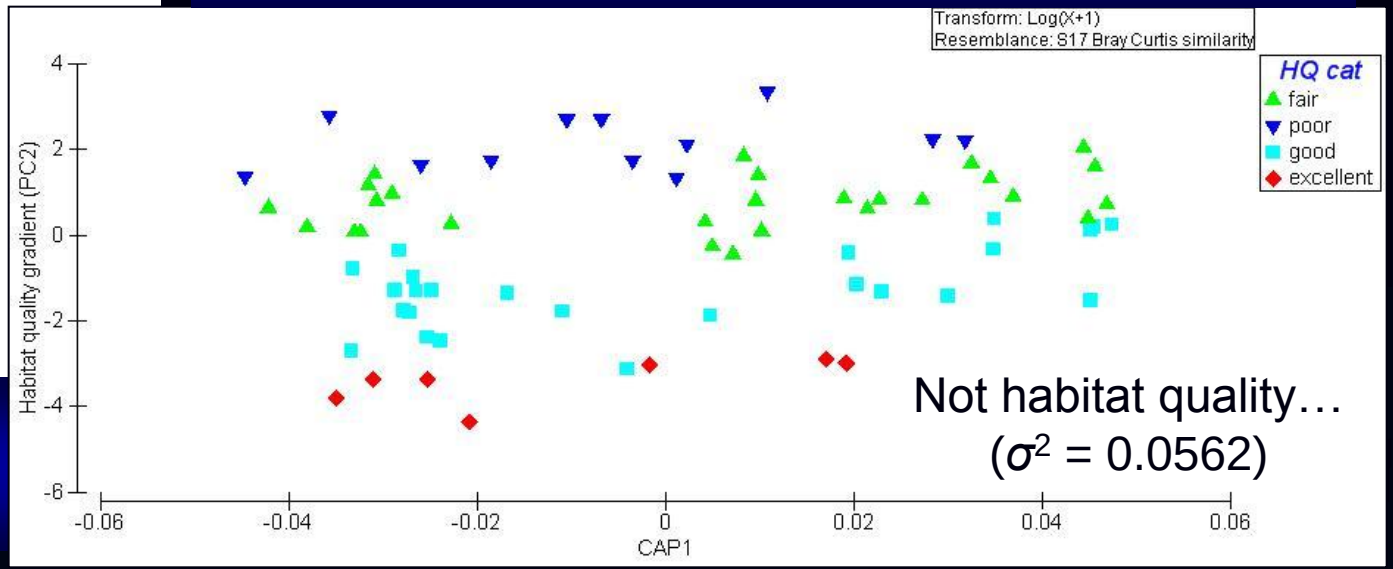

Pielou's evenness
J'
1.0
0.5
0.0
Excellent
Good
Fair
Poor

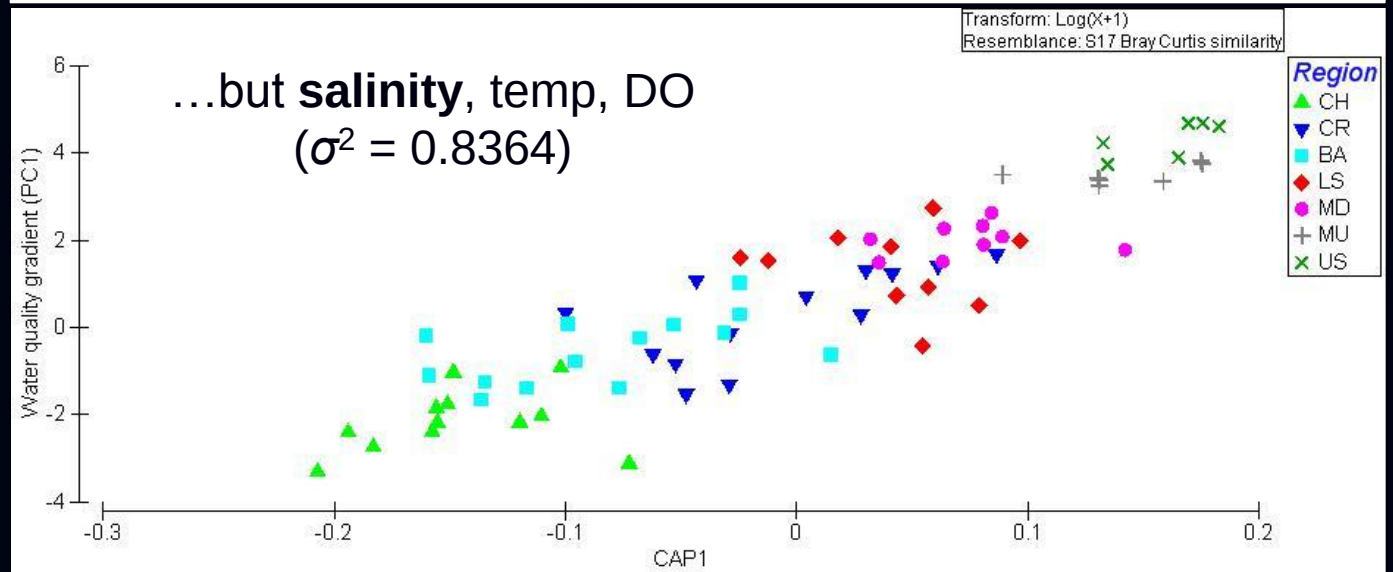
What is structuring fish communities?



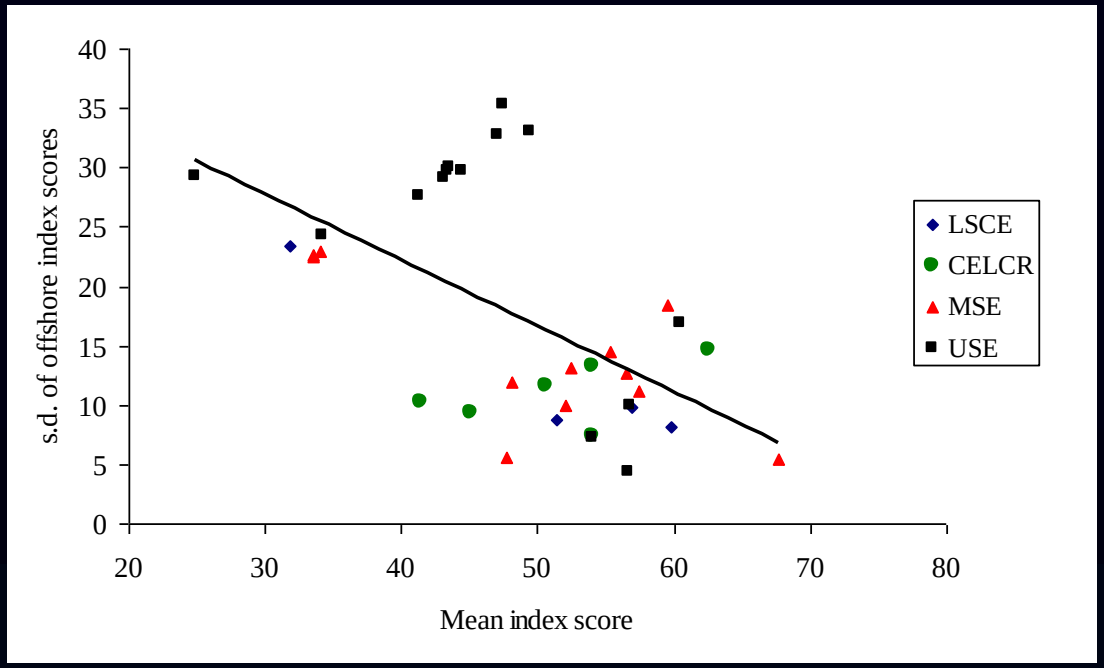
PCA – normalised scores, habitat quality metrics and water quality variables

PC's & log-transformed fish community composition data
→ Canonical correlation analyses (*CAP*)





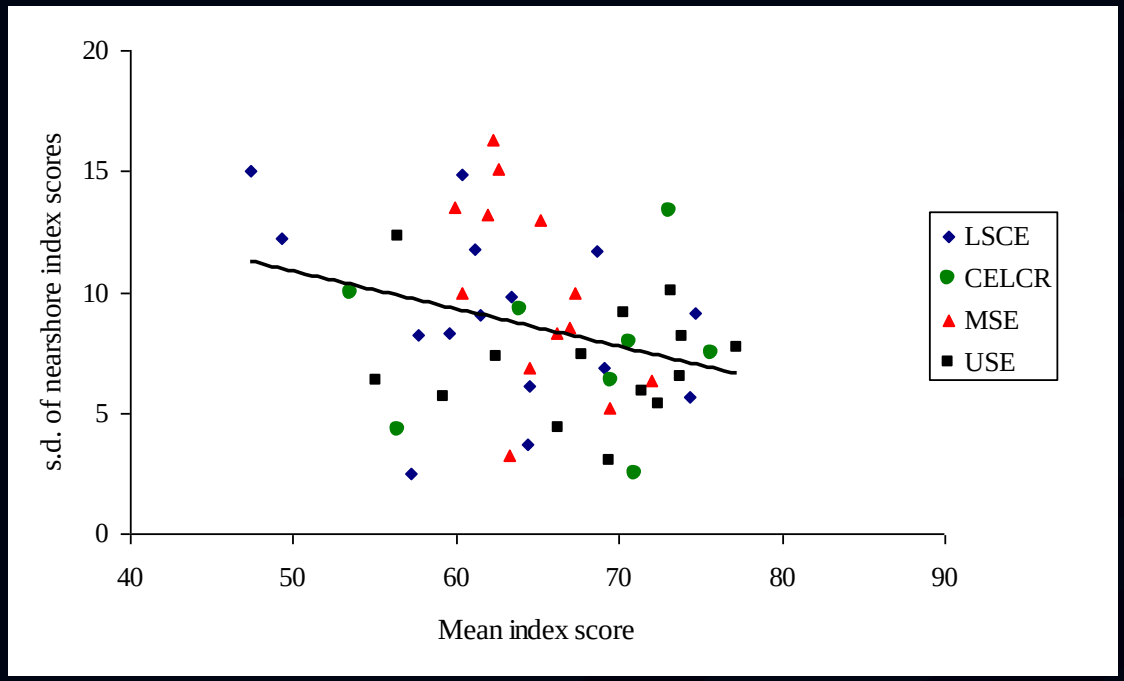
INDEX VARIABILITY



Mean *vs* s.d. of offshore health index scores among seasons

❖ Offshore sites exhibit more variable scores

❖ Offshore waters are in poorer health than the nearshore waters of this system



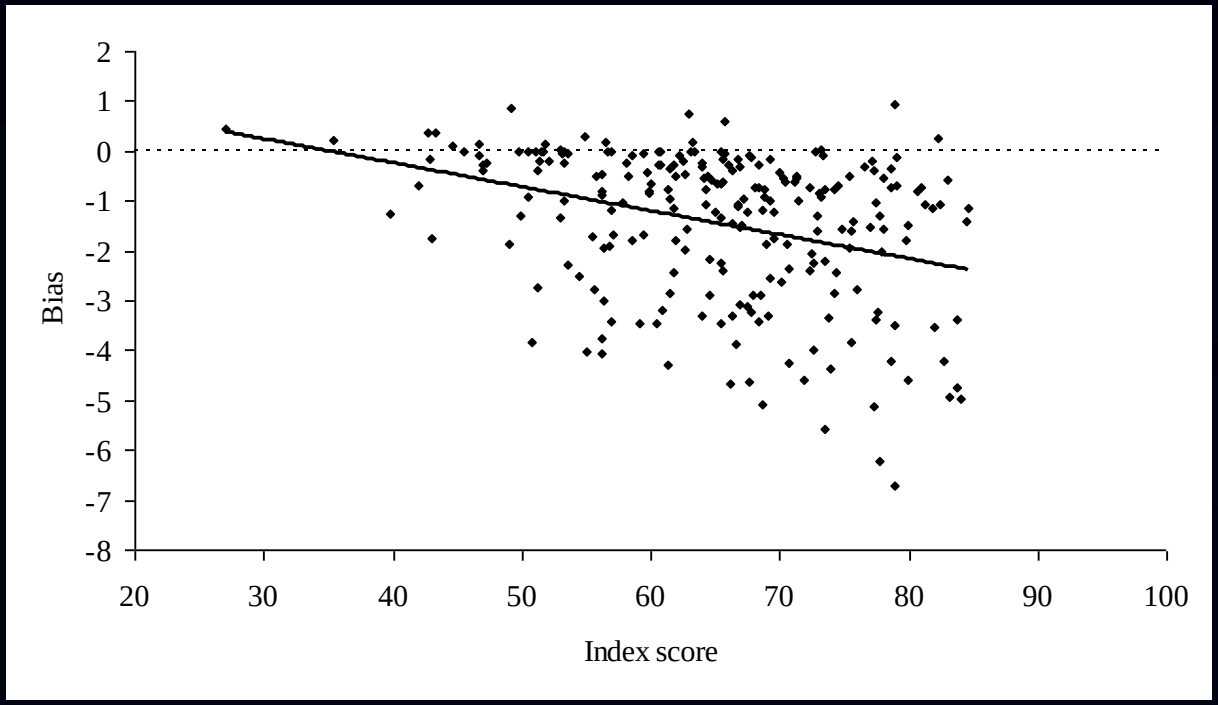
❖ Health index scores from offshore sites in Upper Swan are low and highly variable

❖ Reflects perceived problems in this region of the estuary

Mean *vs* s.d. of nearshore health index scores among seasons

Index precision and reliability

- Bootstrapping → effects of random sampling variability on index precision
- Bias of index scores = (Original index score – Bootstrapped index score)



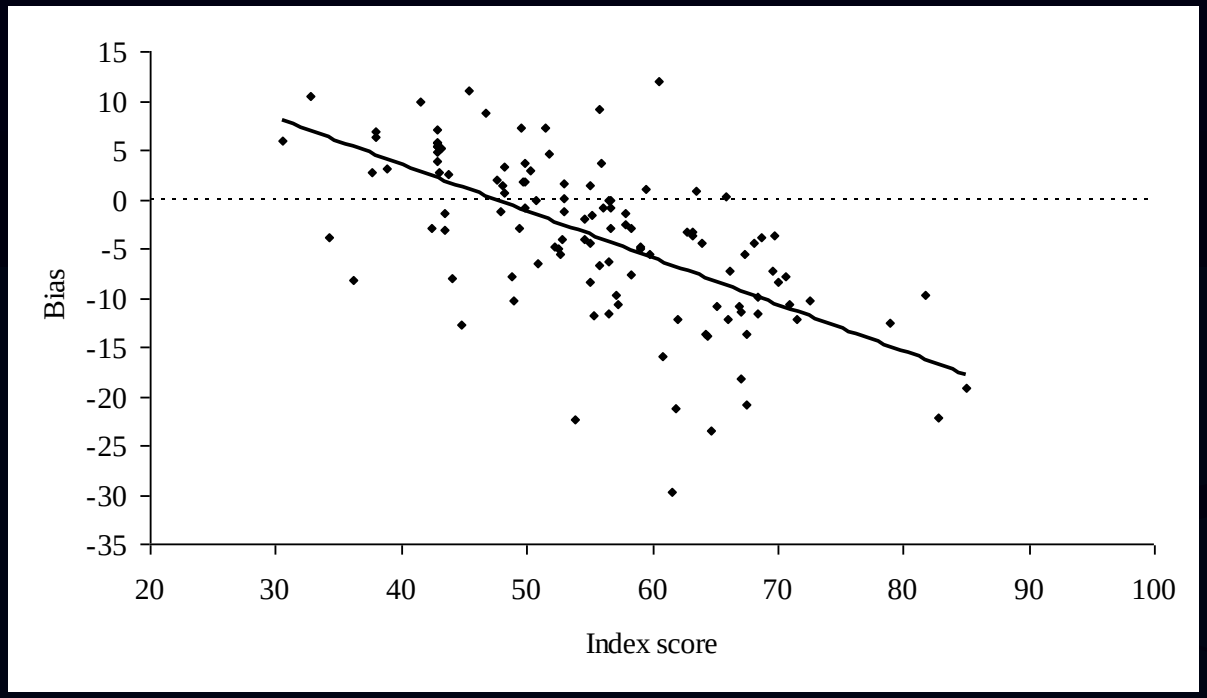
Bias of the nearshore index scores from each site visit throughout the Swan Estuary in 2007-09

❖ < 25% of nearshore index scores varied by > 10 points due to random sampling error

❖ Mean bias of nearshore index scores was 1 – 2 points:

❖ Change in health status classification in only 7% of cases

Index precision and reliability



Bias of the offshore index scores from each site visit throughout the Swan Estuary in 2007-09

- Precision of offshore scores less than that of nearshore scores
- Change in health status classification in 26% of cases
- Inconsistent bias of offshore scores: confidence limits may be appropriate