CONNECTIVITY AMONGST MARINE, ESTUARINE AND FRESHWATER SYSTEMS AND ITS IMPLICATIONS FOR ESTUARINE FISH COMMUNITIES

10TH WIOMSA SYMPOSIUM

DAR ES SALAAM
30 OCTOBER 2017

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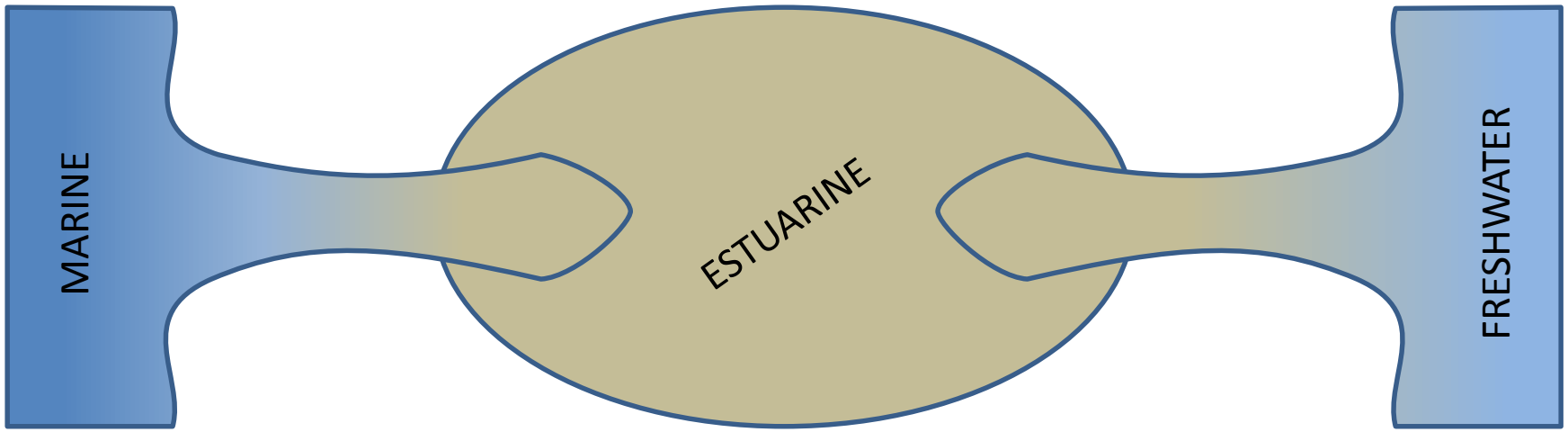
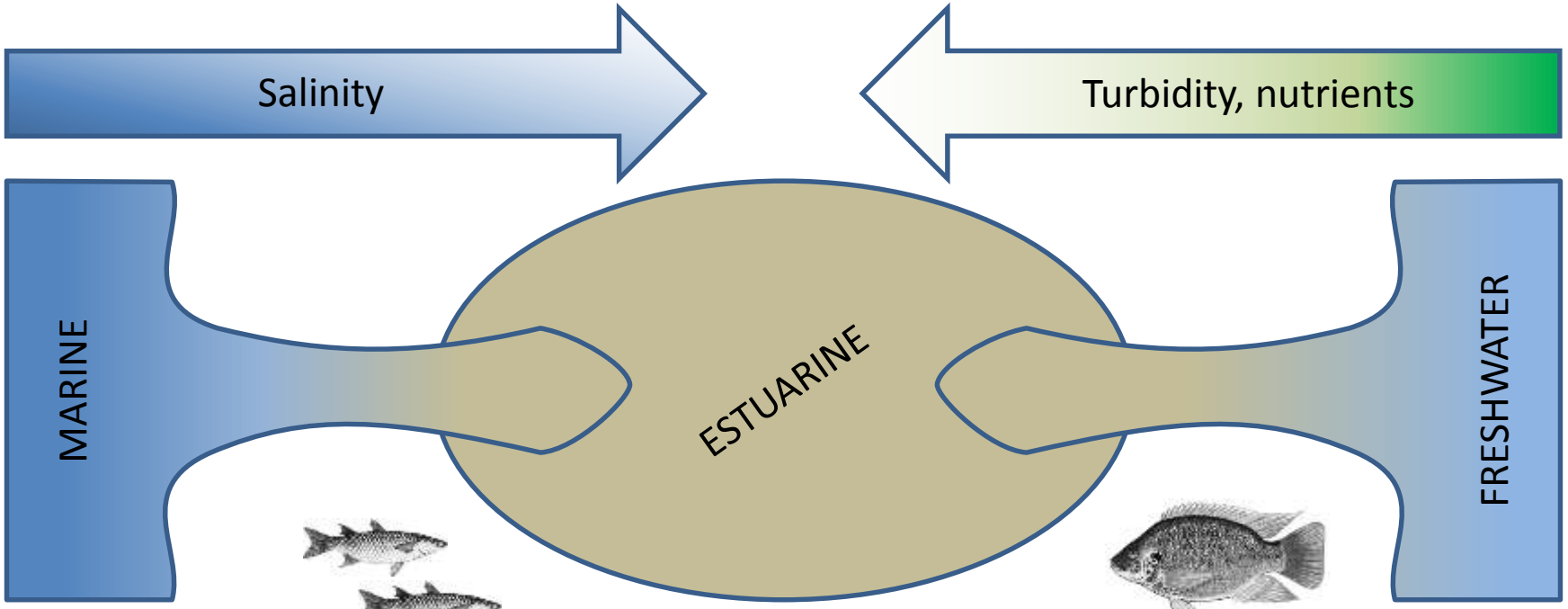
Connectivity

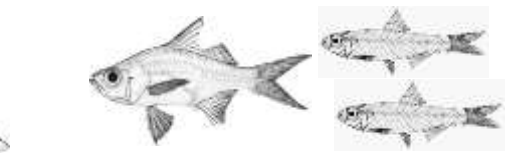
- Connectivity ~ “the state of being connected or interconnected” (Oxford dictionary)
- Estuarine connectivity ~ “a facilitator of the movement of materials or effects that occurs at multiple scales: within the estuary, between the estuary and other contiguous marine and terrestrial systems, and between habitats within the estuary” (Dale & Sheaves 2016)



Connectivity

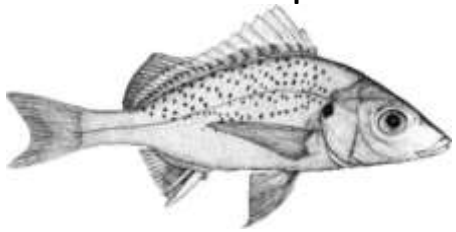


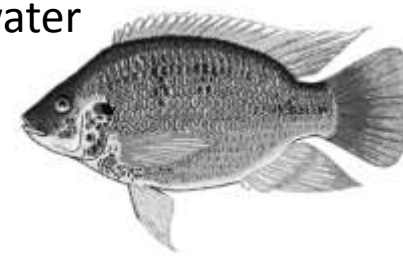
Estuarine dependant marine



Estuarine resident

Freshwater

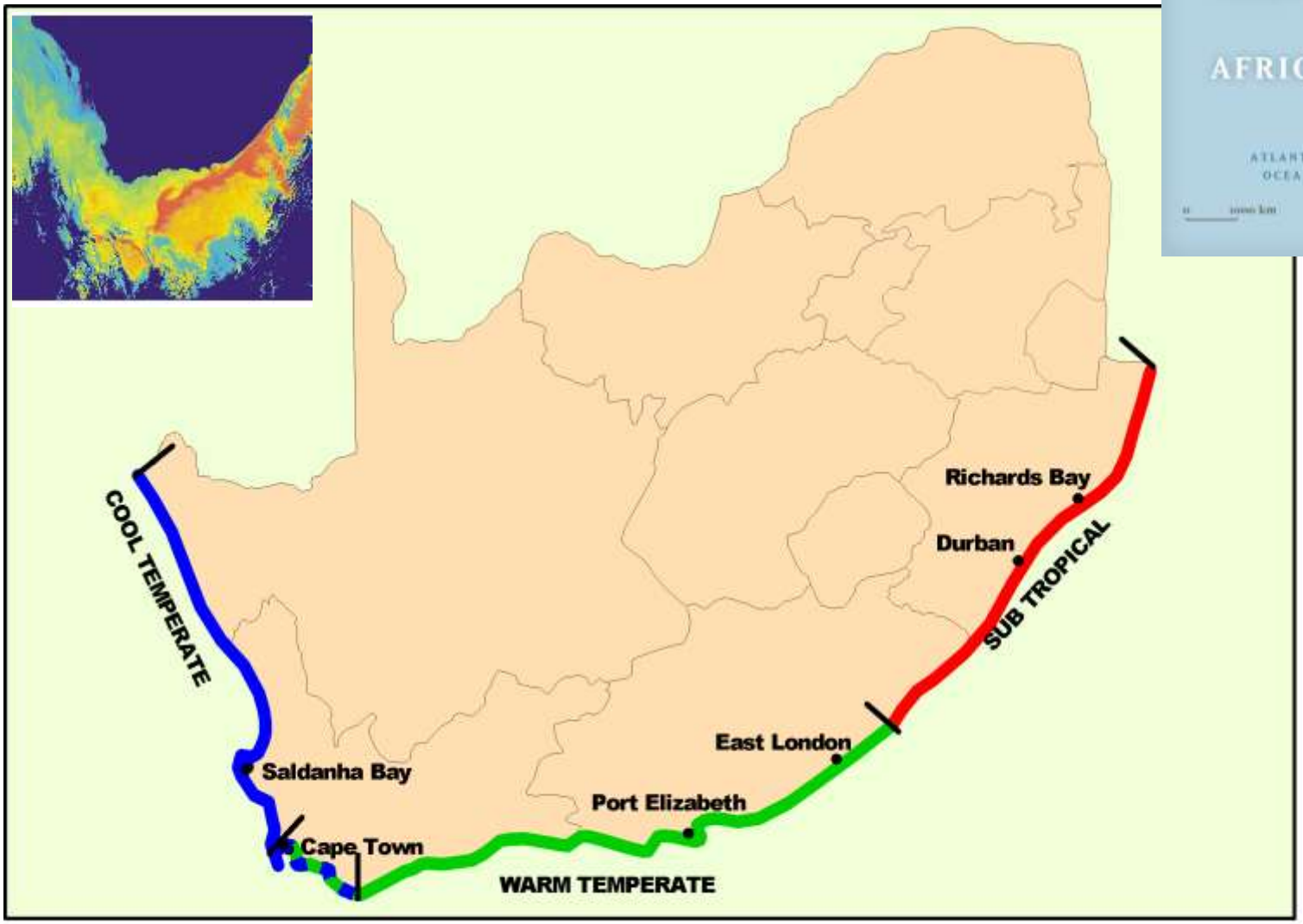




Aspects of connectivity

- Marine / Estuarine connectivity (mouth state in estuaries)
- Marine / Estuarine / Freshwater connectivity (linked coastal lakes and connectivity barriers)
- Habitat / Life cycle connectivity (seagrass / sandbanks / Cape stumpnose)

Location



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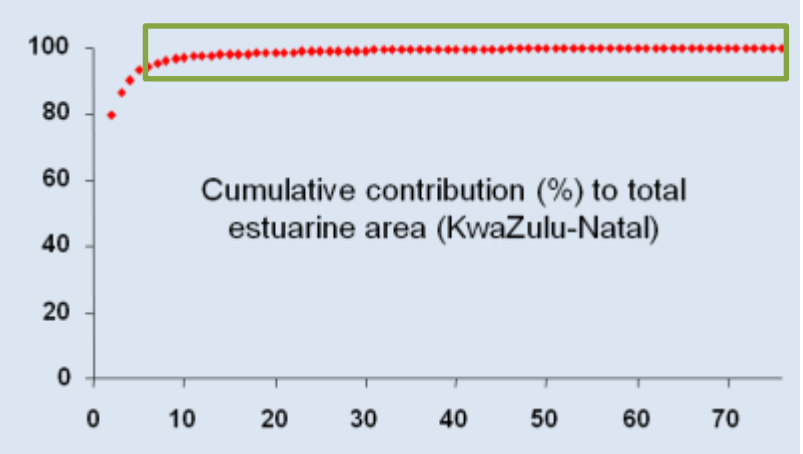
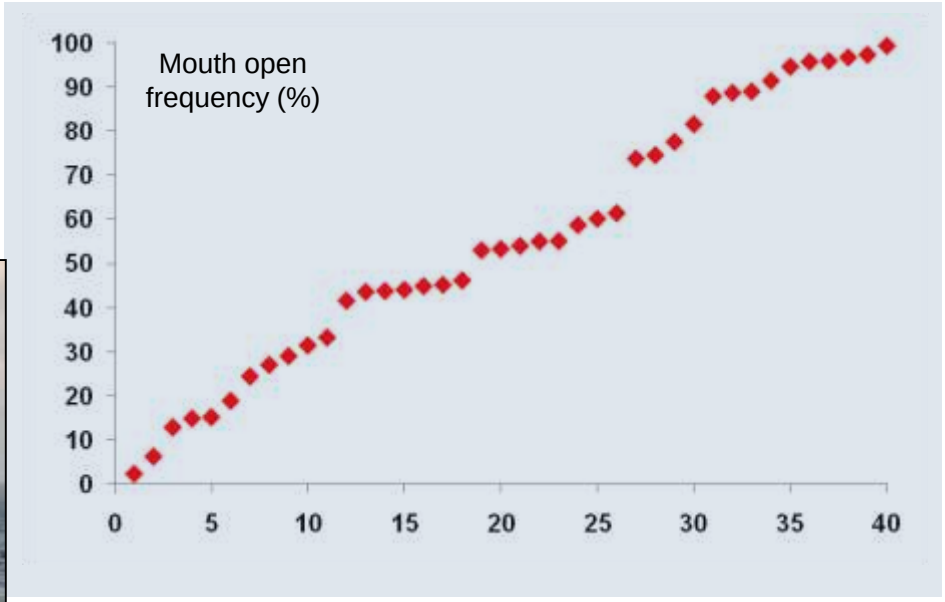
Mouth state in KwaZulu-Natal estuaries: *Marine connectivity*

- TOCE's predominate, most are small (< 10 ha)
- Numerically important in KwaZulu-Natal



Mouth state: sampling and data

- Consistently sampled by gear and season
- Catches standardised to CPUE
- 10 years mouth observations
- National estuarine features database

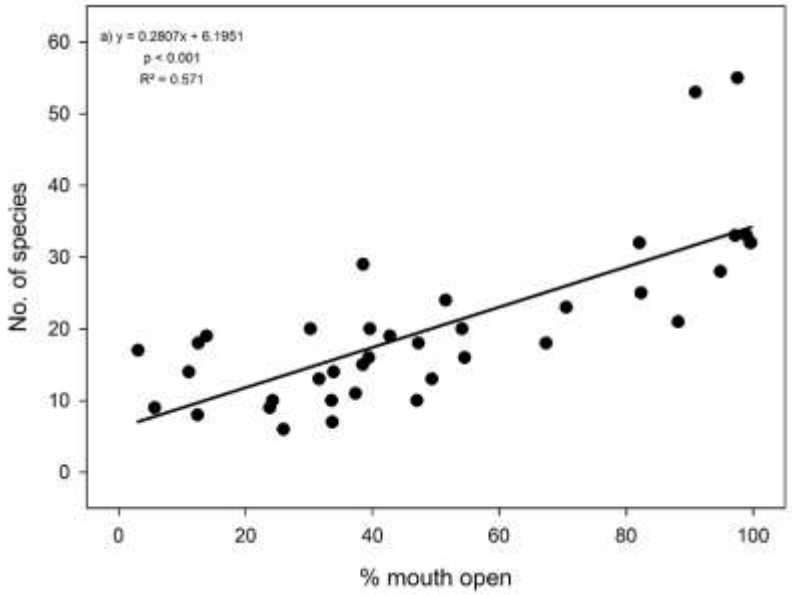


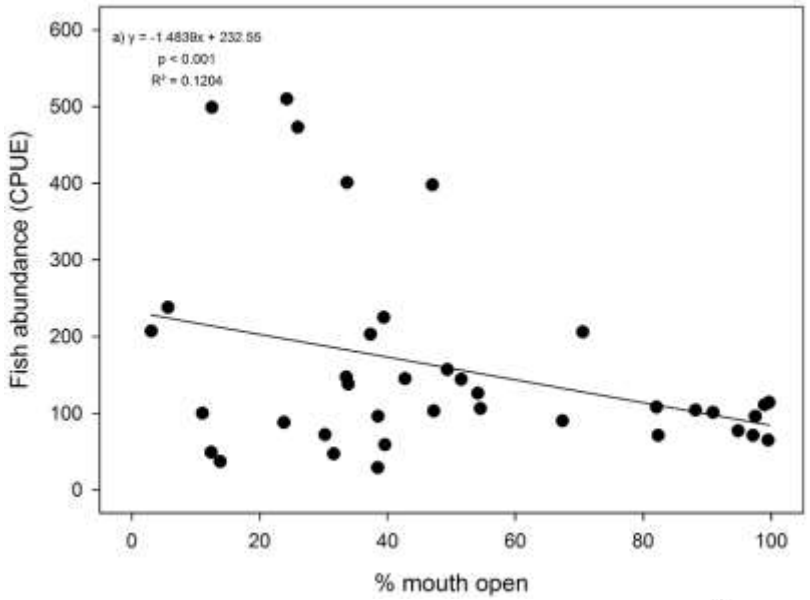
NAME	Orange (G	Buffels	Spoeg	Groen	Sout	Olifants	Jakkalsvlei	Wadrift
Catchment_Area_(km2)	601590.8	9876.004	1409.072	4676.427	1441.942	49075.2	616.5688	689.5703
Reference_MAR_(m3x106)	10833.01	9.33	1.07	0.456	1.5	1070.1	3.508	13.256
Present_MAR_(m3x106)	4142.9	6.66	0.177	0.445	1.5	715	2.502	9.774
Catchment_Erodibility (scaled from le roux)	5	4	4	4	3	4	1	2
Degree_of_protection/Incident_wave_energy (1=Very protected, 5= Exposed)	5	4	2	5	5	5	2	3
Surfzone_width (m) (proxy for neashore energy)	385	255	110	140	226.6667	235	84	83.75
Berm_width (m)	134.8	208.4	144.984	189.334	220.7775	203.275	63.1725	188.6
Open Mouth Category (1=100-75; 2=75-50; 3=50-25; 4=25-0)	1	4	4	4	4	1	4	4
%Mouth_Open	95	5	5	5	5	100	20	1
Inlet_contriction(1=Y; 0=N)	0	0	0	0	0	0	0	0
Openwater_(ha)	460.619	4.86728	1.98891	14.6261	28.1292	335.413	3.33923	63.8945
Ratio_MAR/Size	0.001112	0.007308	0.112368	0.328676	0.187528	0.004691	0.013346	0.065372
Openwater_perimeter_(km)	72.3144	2.47501	1.78039	5.66369	13.8594	91.4525	1.51782	15.7375
Floodplain_(ha)	2609.17	53.2151	121.275	319.629	557.429	2077.51	56.5924	509.781
Floodplain_perimeter(km)	51.0156	5.07501	11.977	17.4135	17.1197	94.9121	5.51897	25.0486
Estuary_length_FishSwim_ (km)	12.91483	1.42157	2.55804	1.95535	4.79868	37.62849	1.27419	9.08092
Estuary_Strait_lenght_(head_coast_as_Crow_flies)(km)	10.49725	1.27786	2.21323	1.6267	3.3296	20.21263	2.02534	4.93175
Estuary_Sinosity_ratio(proxy as watercolum_habitat_diversity)	0.812818	0.898908	0.865882	0.831923	0.693857	0.537163	0.890576	0.81102
Shape_Roundness	0.125081	0.259639	0.106239	0.13246	0.239005	0.028981	0.213481	0.1021
Shape_Roundness_Ratio	63.69668	19.66571	11.1712	25.82433	20.29615	36.67622	22.00015	40.60018
Est_Depth(m)	2.5	1	1	1	1	3	3	1
Calculated_Volume	11515468	48672.82	19889.09	146261	281292.4	10062396	13502.27	638945.3
Daily_Flushing_Rate_(MAR/days)/Volume	2.577358	0.525173	0.147393	0.008542	0.01461	0.29136	0.28782	0.05684
Degree_of_inclseness_(openwater/floodplain)(Proxy_for_Riperian_refugee)	0.176539	0.091464	0.0164	0.04576	0.050462	0.16145	0.059005	0.125337
Evaporation_rate(mm/a)	2698.7	2564.3	2491	2459.4	2433	2460.9	2352	2337.6
Intertidal salt marsh	144	0	4.87	12	0.36	91.94	0	0

Mouth state: influence on community structure (univariate)

- Regression/DistLM

Response variable	P	R^2
Number of species	<0.001*	0.571
Abundance (CPUE)	0.032*	0.120
Species diversity (H')	<0.001*	0.437





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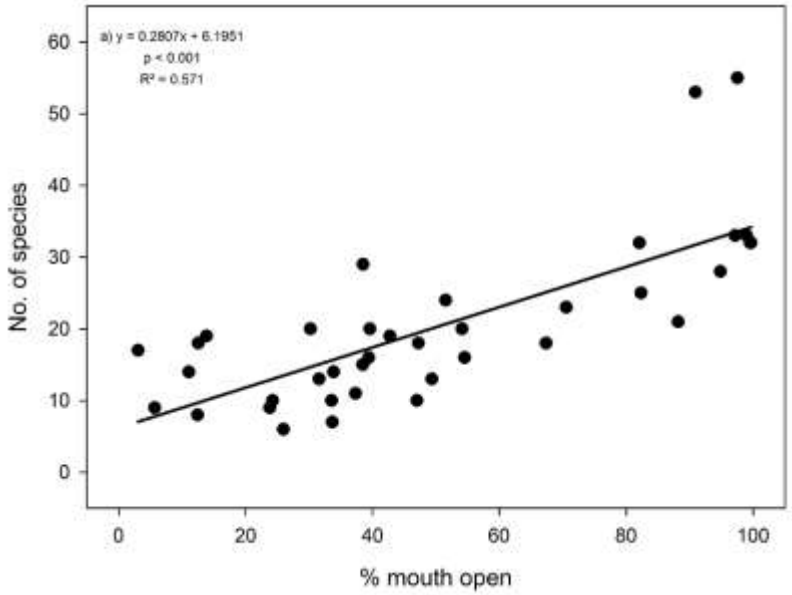
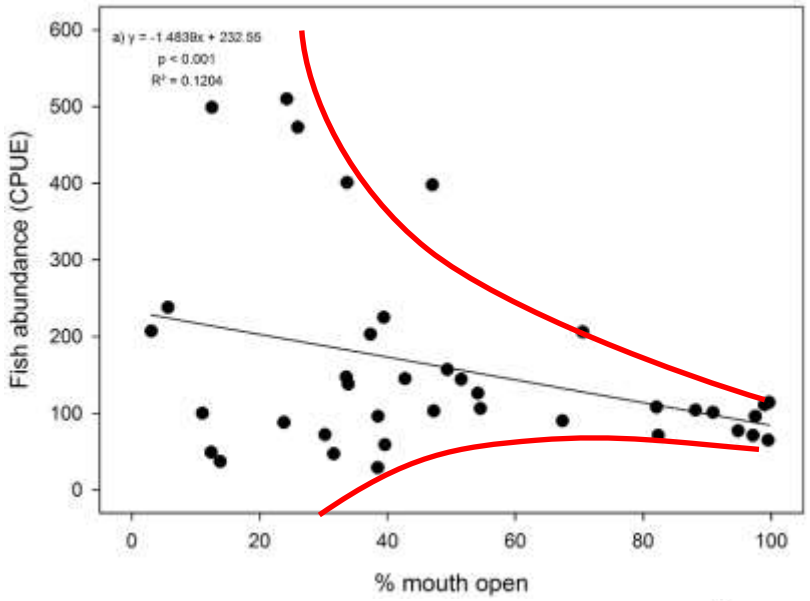
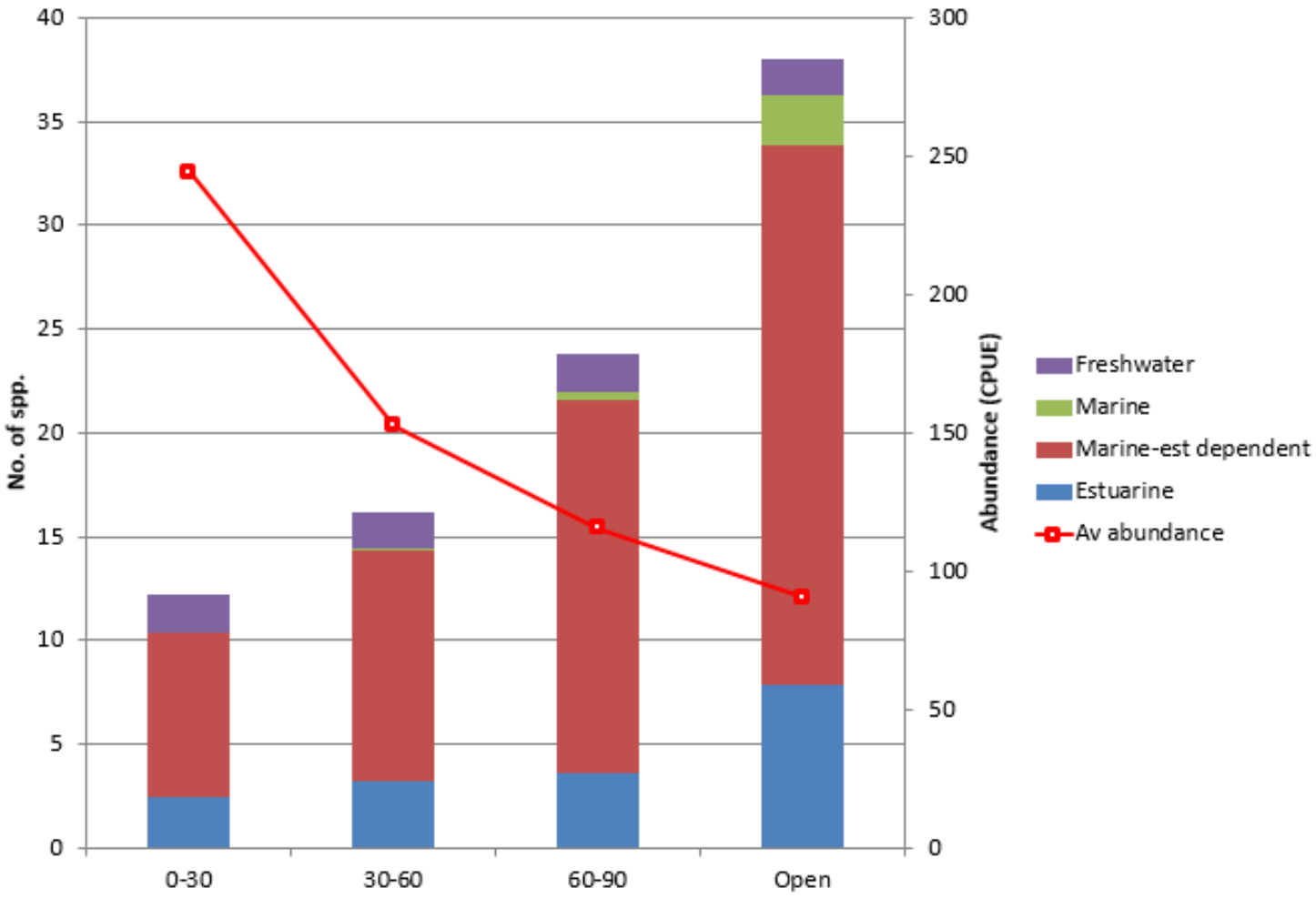


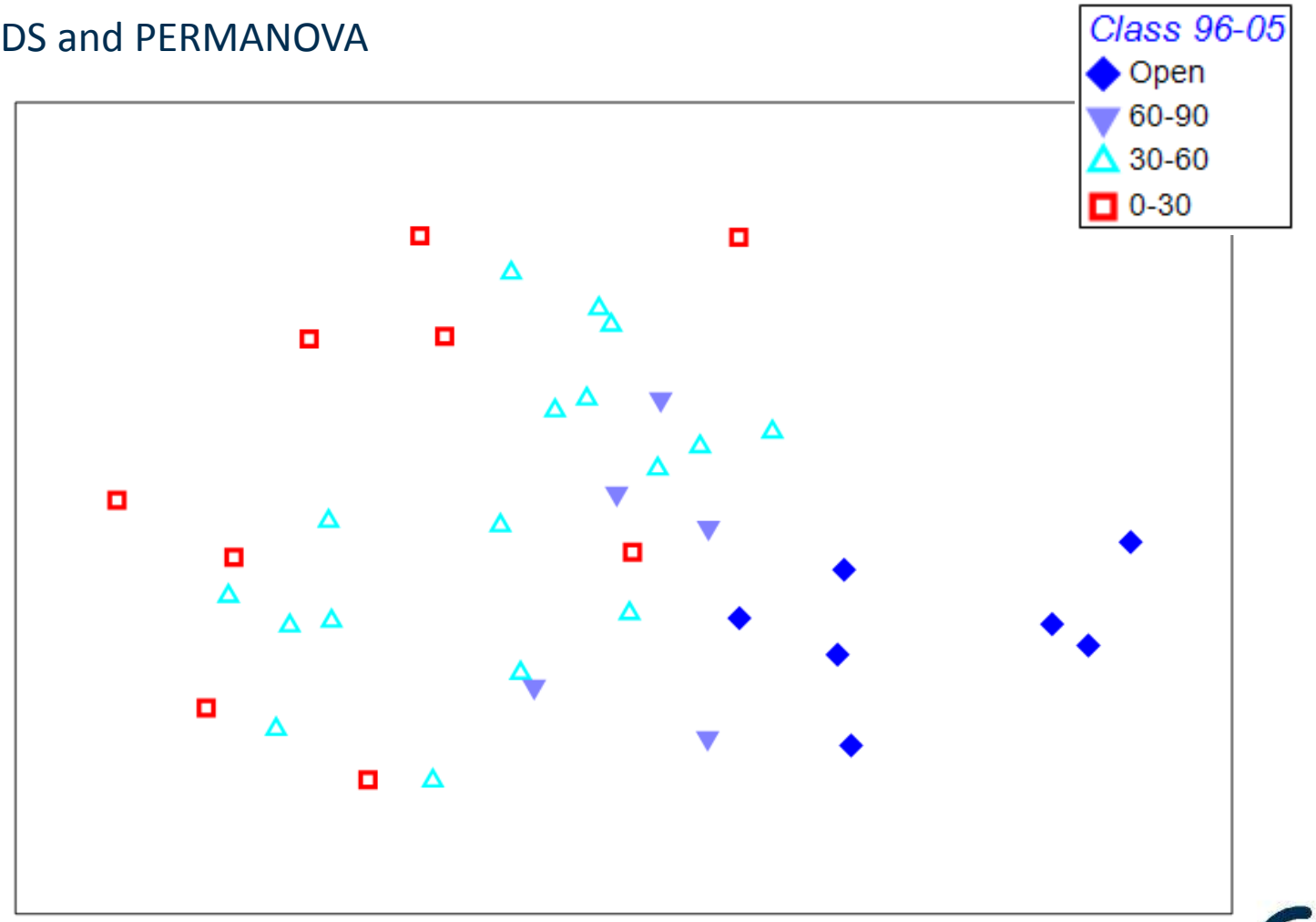


Mouth state: influence on estuarine guilds



Mouth state: influence on community composition (multivariate)

- MDS and PERMANOVA



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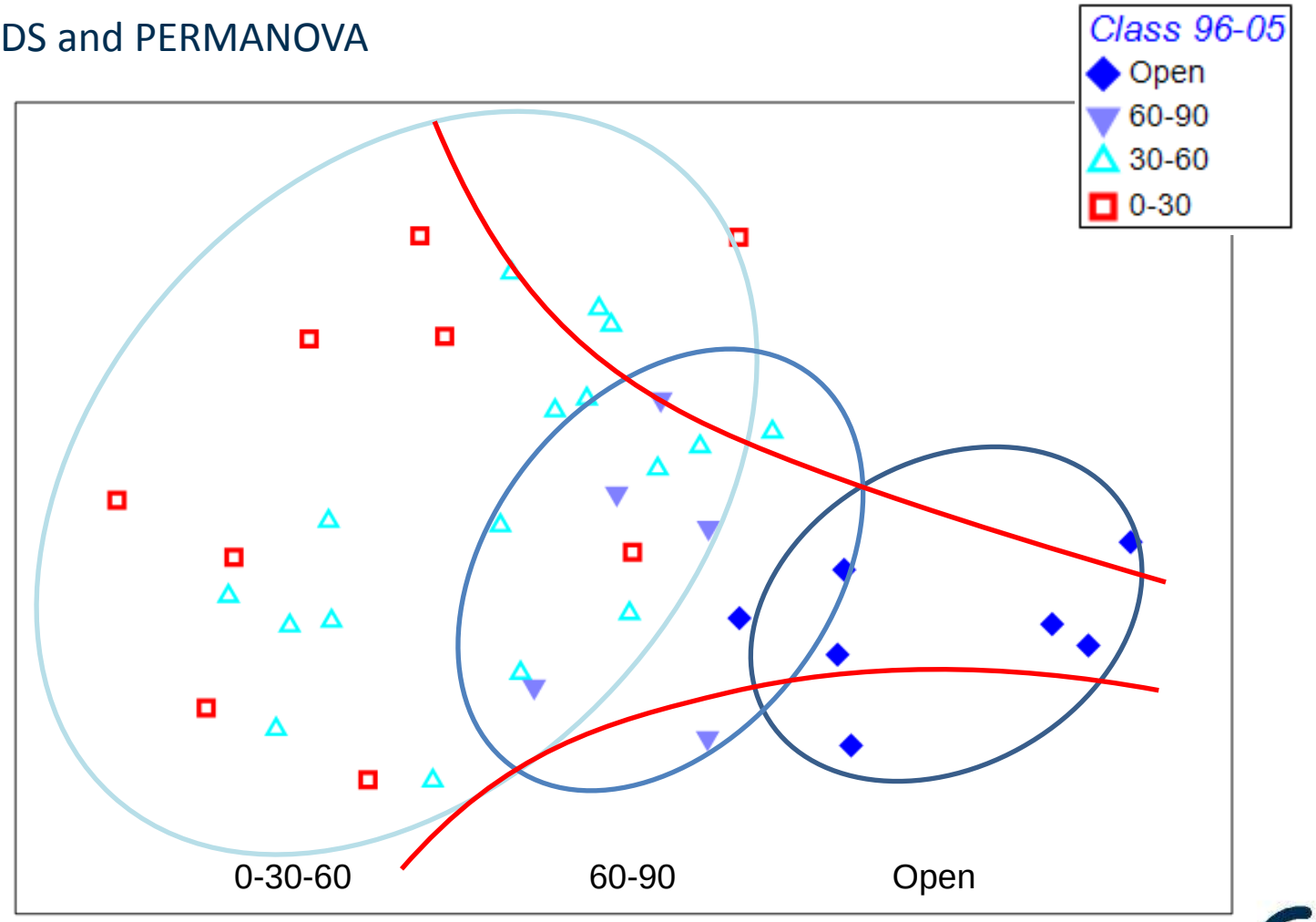
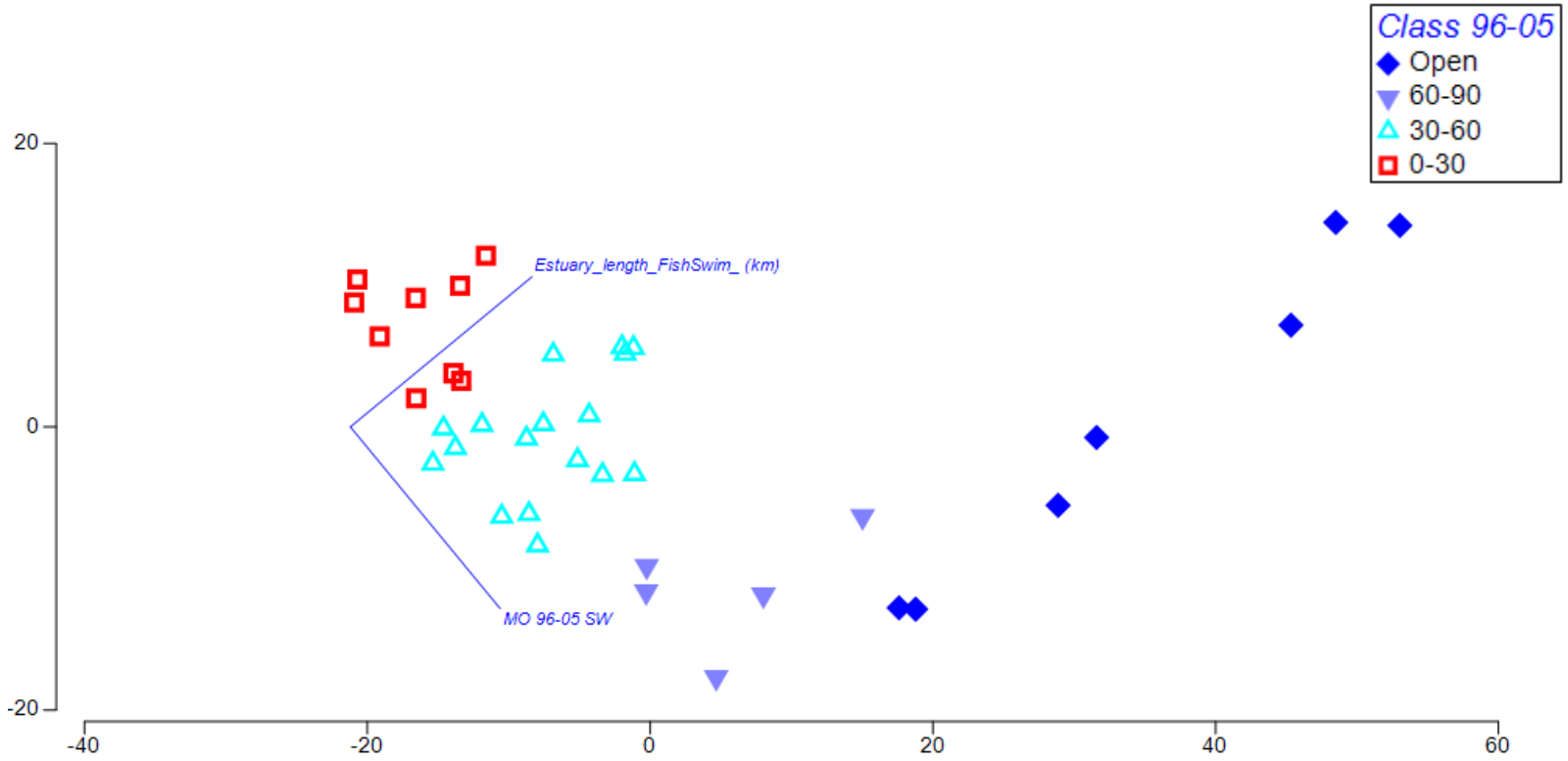


Mouth state: (and other estuarine features) influence on community composition (multivariate)

- Redundancy analysis (dbRDA)
- Estuarine length becomes important in permanently open estuaries



Mouth state: synthesis

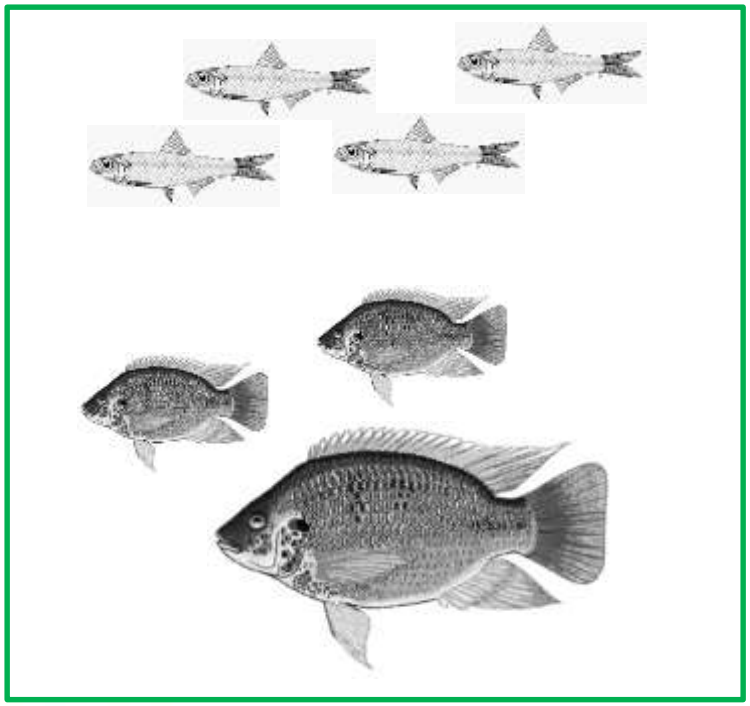
- Fish communities are predictable in systems with different marine connectivities
- There are thresholds in mouth open frequency that drive major changes in fish communities

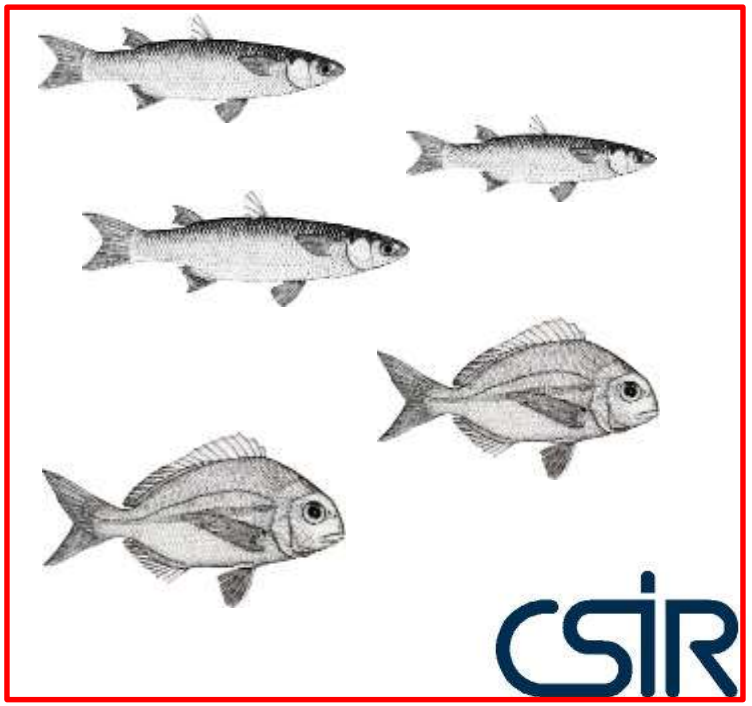
Temporary open closed			Open
Predominantly closed		Predominantly open	Open
0-30	30-60	60-90	>90

- Species influential in this are identifiable
- Connectivity is more important than physico-chemistry in estuaries that become disconnected from the sea
- In open estuaries system size and length becomes important

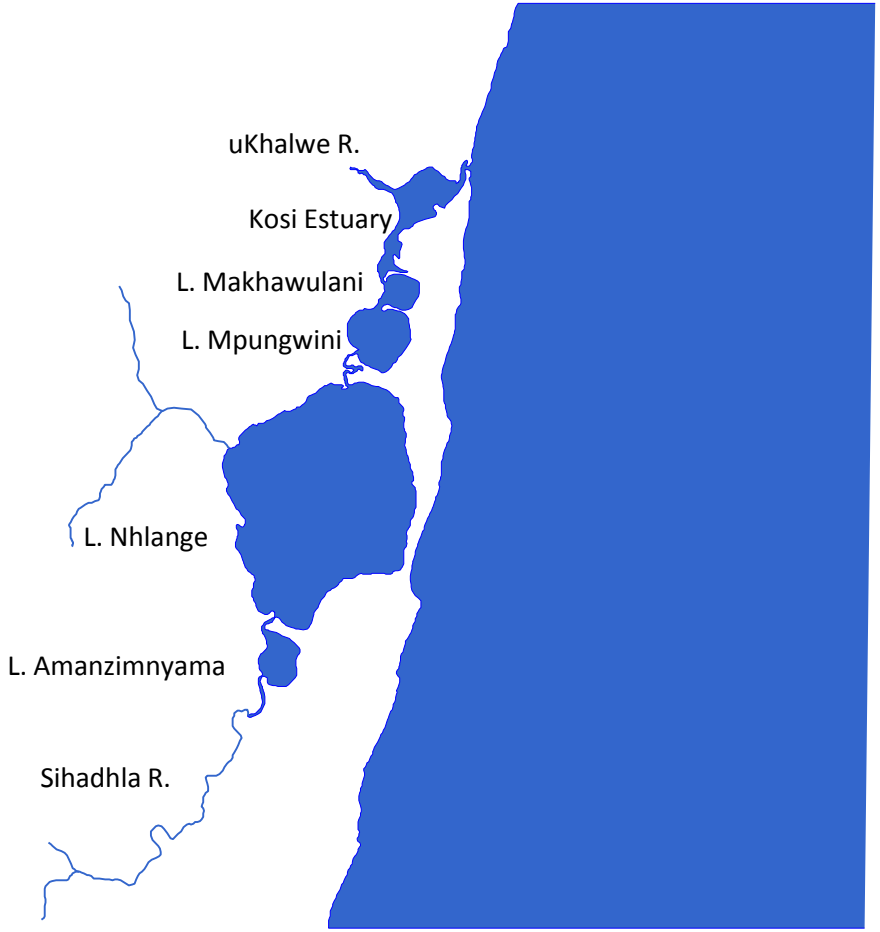
Mouth state: synthesis

- There is greater variability in fish assemblages in predominantly closed estuaries (which are generally more stable over space and time) [????]
- Stability favours development of superabundant populations of selected freshwater and estuarine species
- Recruitment windows for marine species are limited and possible not synchronised with spawning periods. Species occurrences can be random, with some exception





Coastal lakes: *Marine / Estuarine / Freshwater connectivity*



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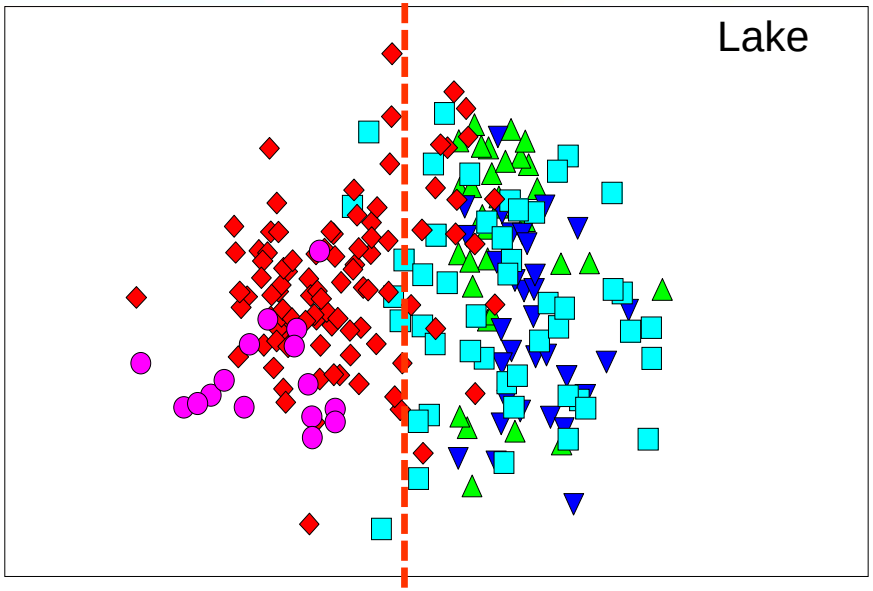
Coastal lakes: Kosi Bay

- Two years, bi-seasonal sampling: 8 trips/year
- Random sites within selected lake and estuary reaches

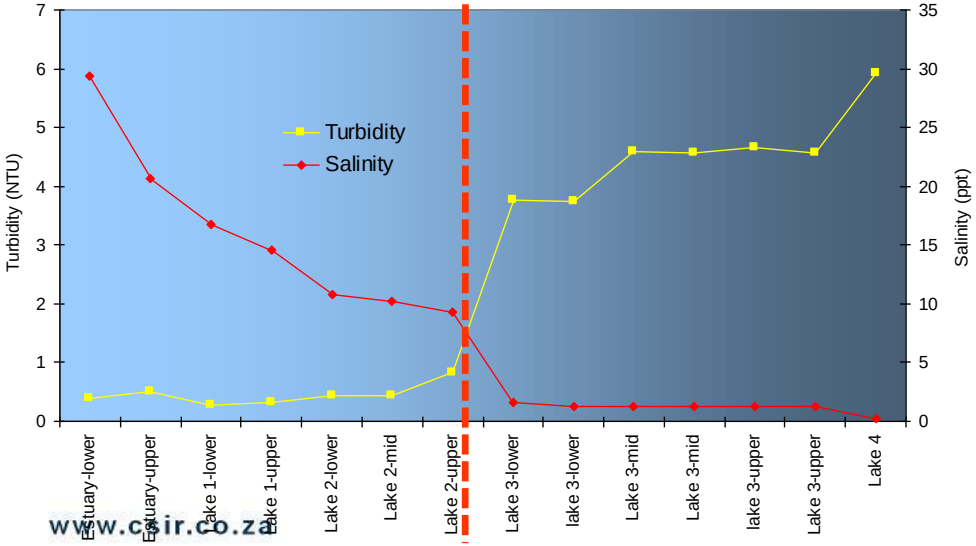
Coastal lakes: Kosi Bay

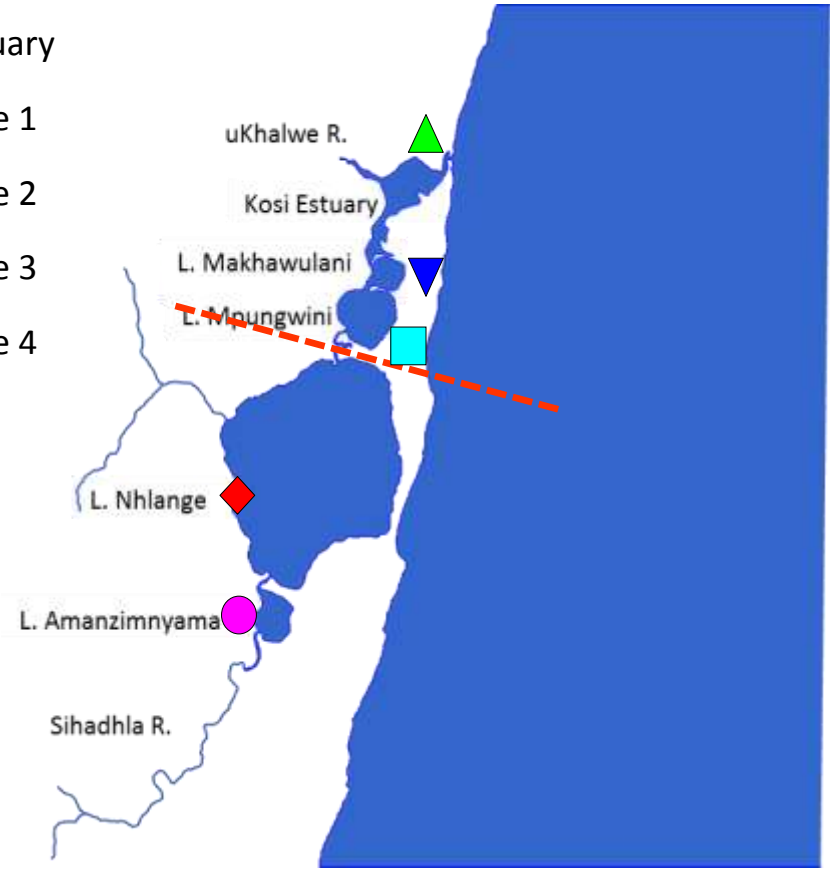
- Lakes yield similar species as estuaries

Coastal lakes: Kosi Bay



Estuary
Lake 1
Lake 2
Lake 3
Lake 4





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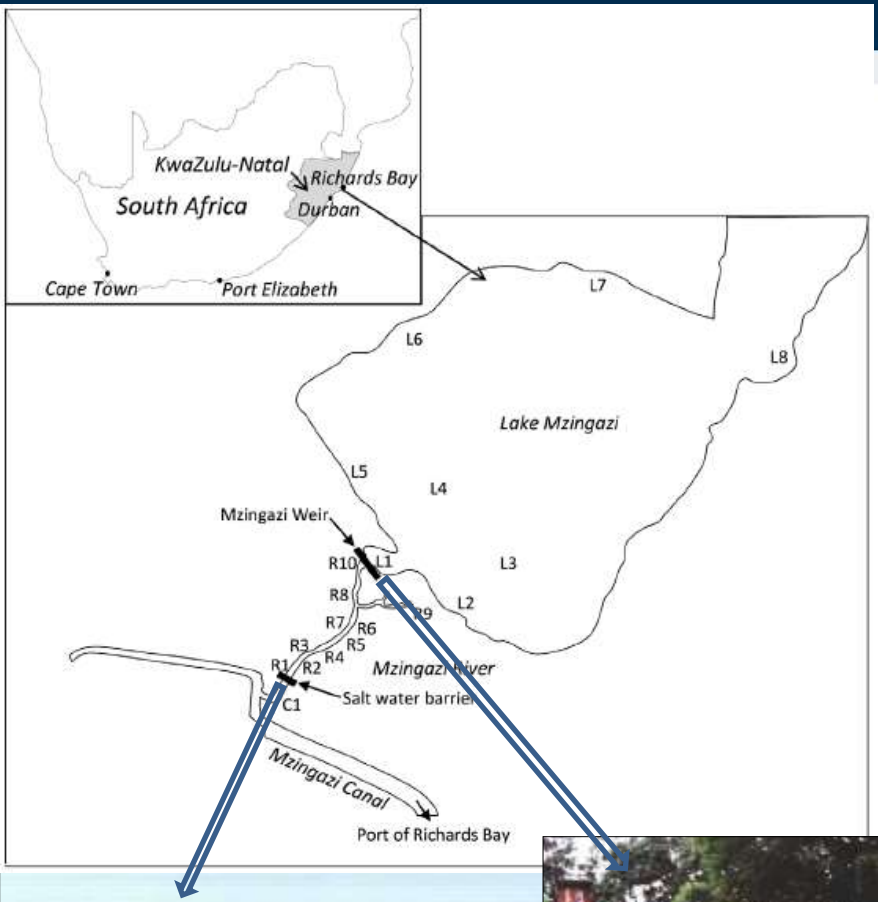
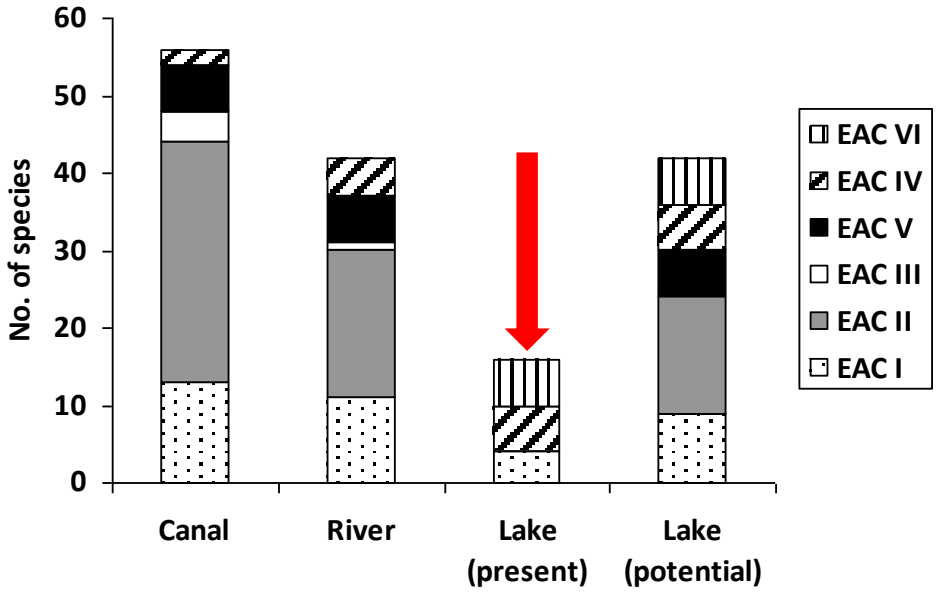
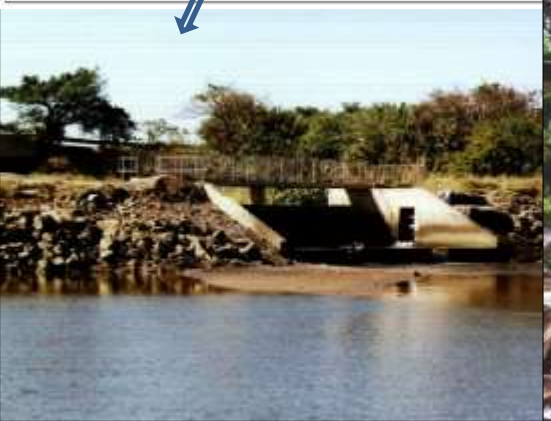
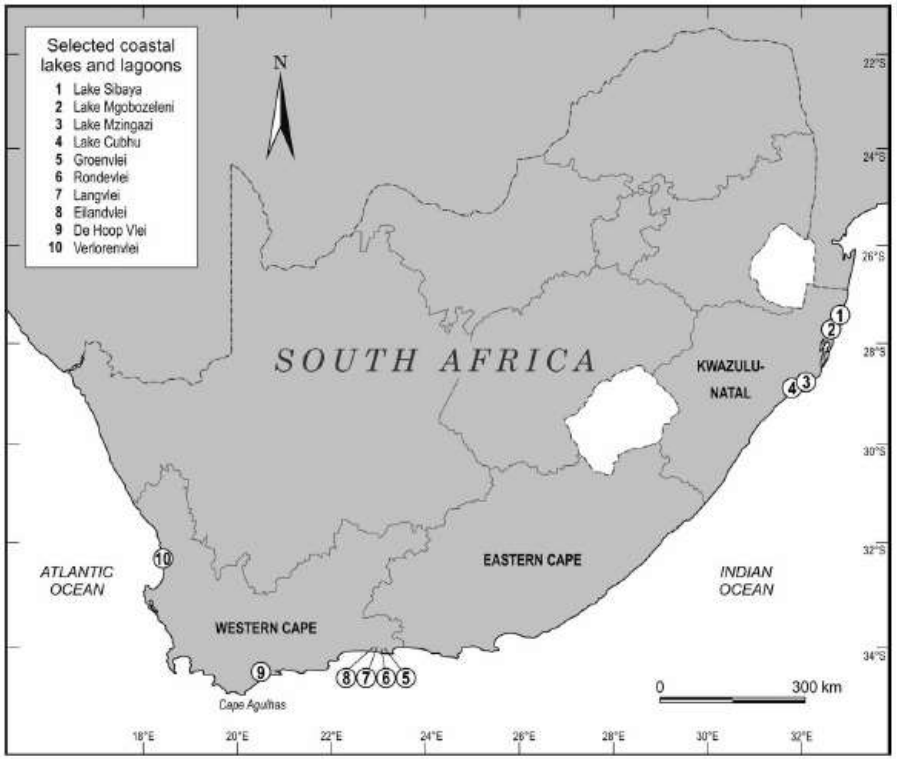
Coastal lakes: Connectivity barriers on Zululand coastal lakes

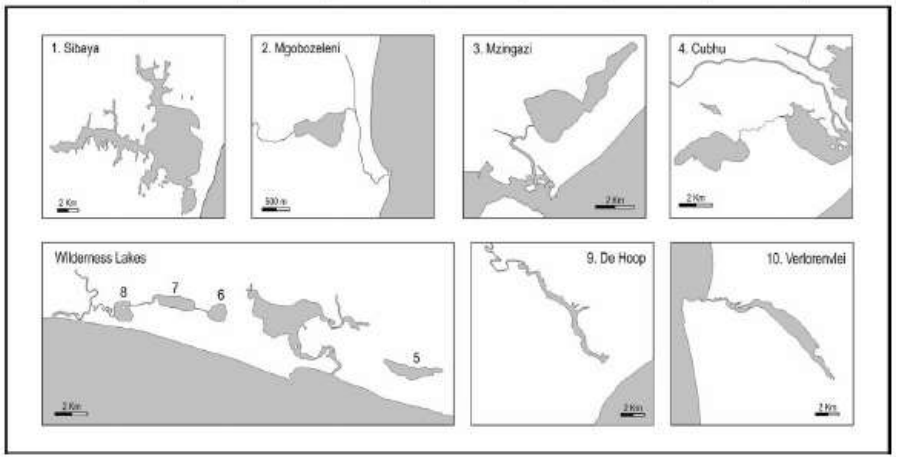


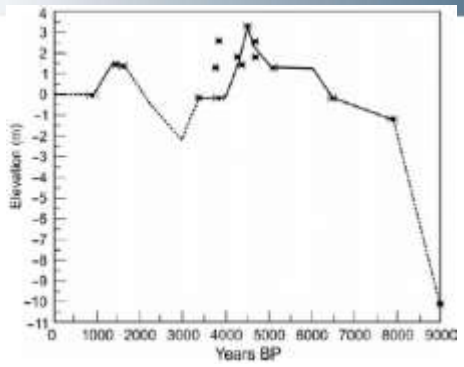


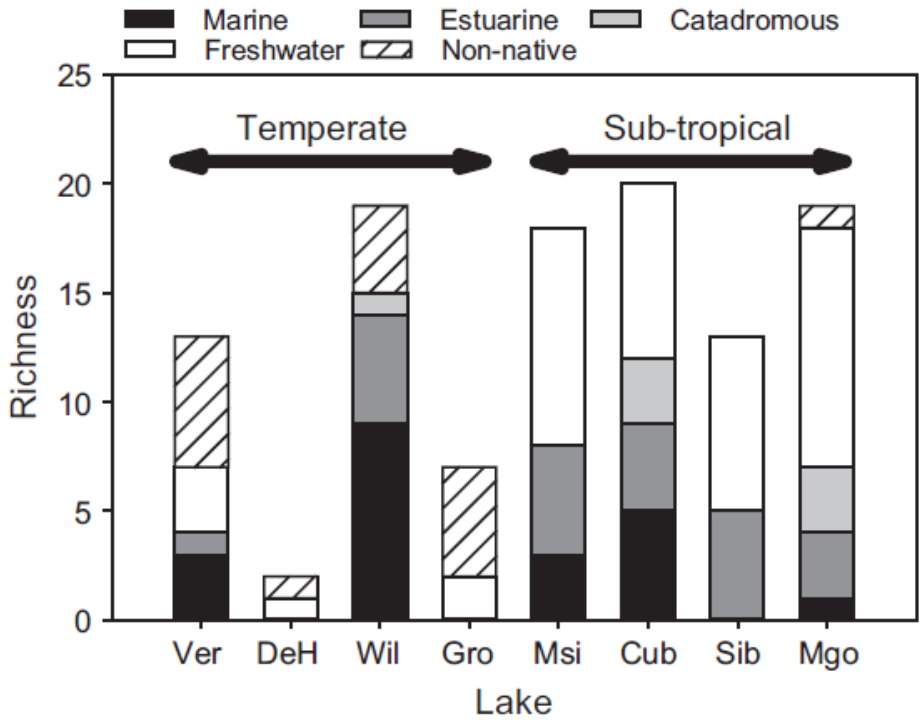


Coastal lakes: Connectivity and geological time scales







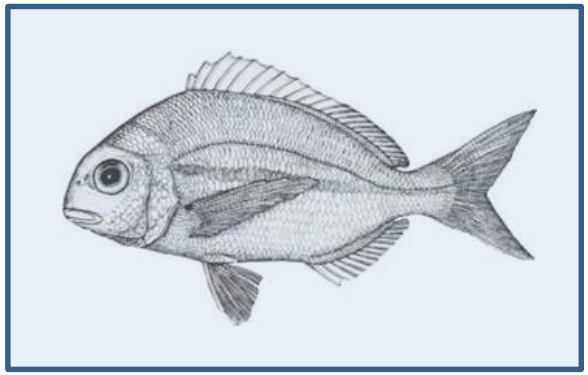


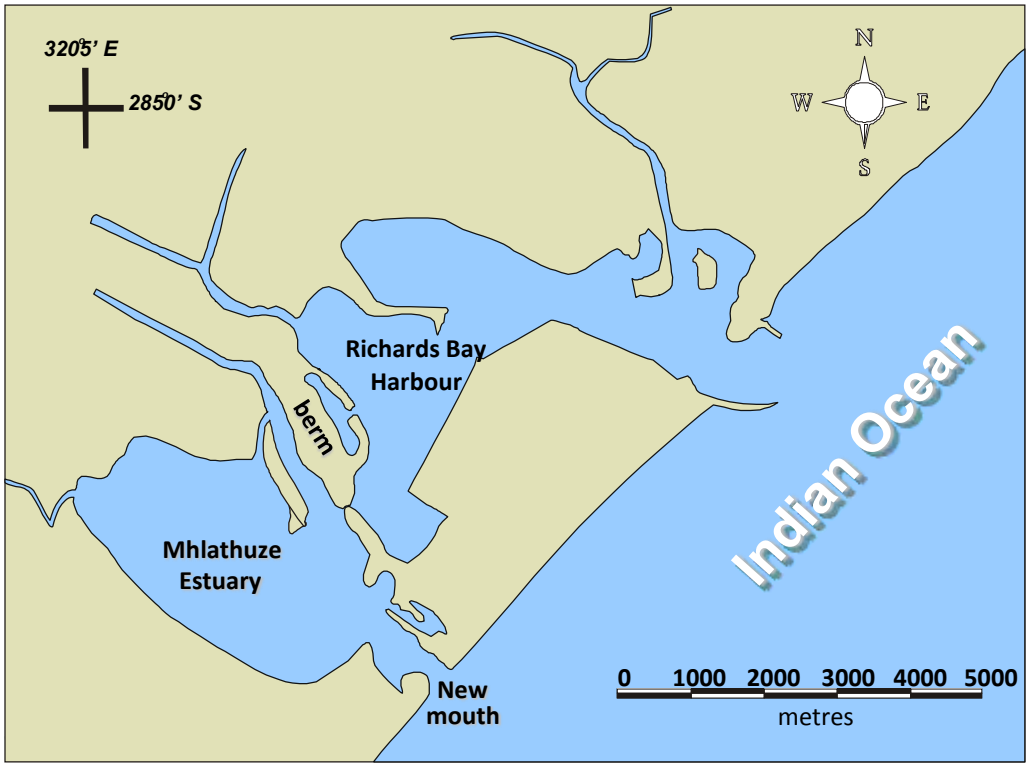
Whitfield AK, Weerts SP, Weyl OLF (2017). A review of the influence of biogeography, riverine linkages, and marine connectivity on fish assemblages in evolving lagoons and lakes of coastal southern Africa. Ecology and Evolution 1–17.

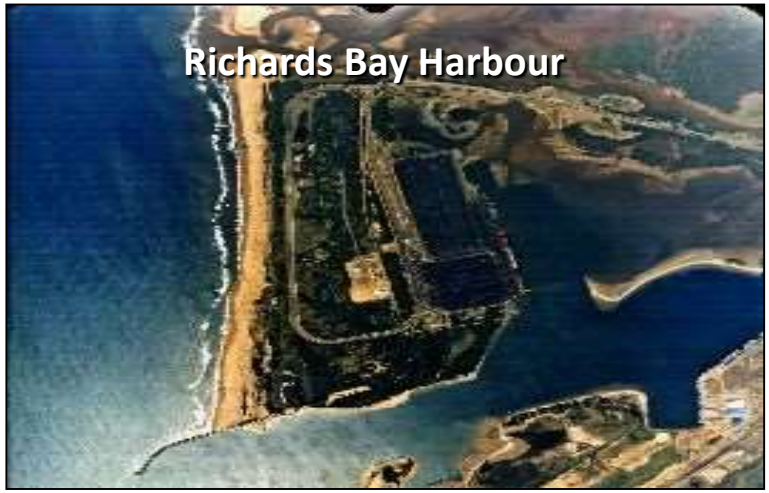
Coastal lakes: synthesis

- Distance from sea is a primary determinant of marine and freshwater species occurrences in coastal lakes
- Physico-chemical conditions are (usually) strongly covariate but low (no) salinity is not prohibitive for recruitment of marine species
- Connectivity constraints (and barriers in particular) play an important role (especially for marine and estuarine species)
- Across bioregions, biogeographic considerations can be significant, especially for freshwater fish richness
- Connectivity breaks render coastal lakes prone to establishment of non-native and alien freshwater species (Whitfield et al. 2017)

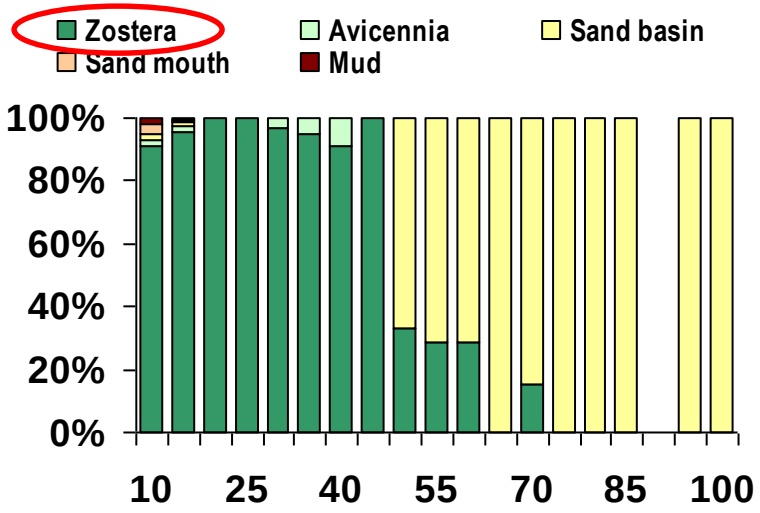
Connectivity: *Habitat / Life cycle connectivity*



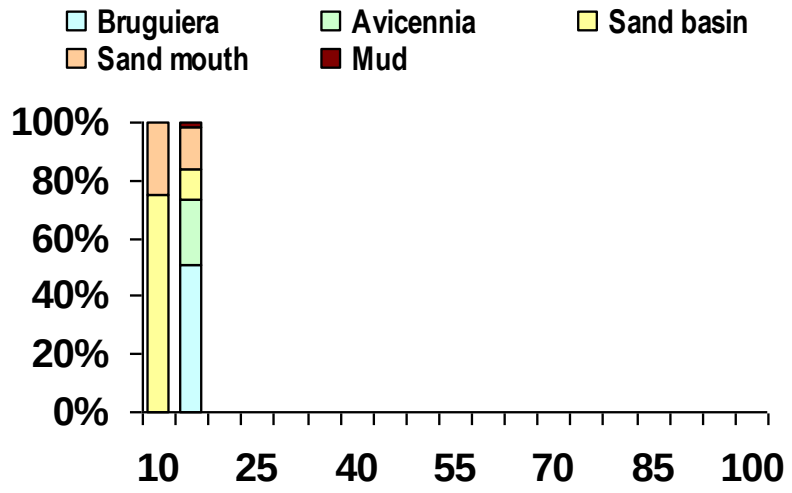




Connectivity: Zostera / Cape stumpnose

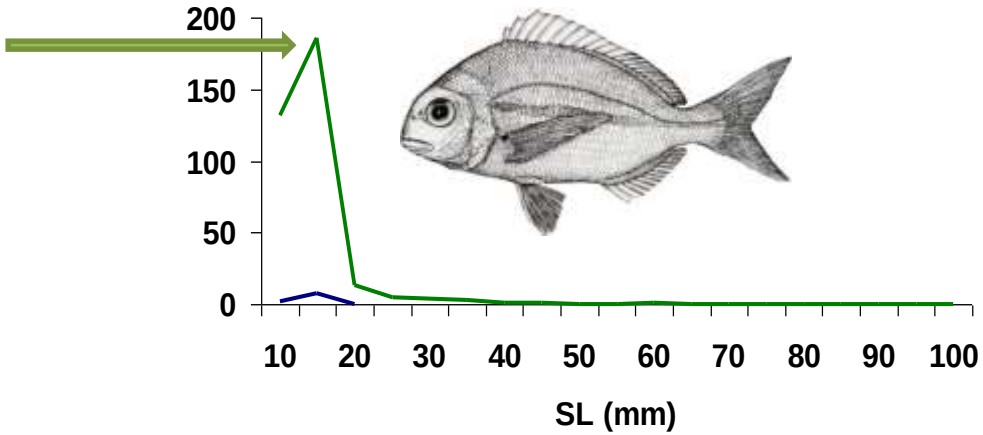


Mhlathuze Estuary



Richards Bay Harbour

Larval recruitment



Connectivity in estuarine systems: knowledge implications

- Mouth management plans (marine connectivity)
- Freshwater allocations (marine connectivity)
- Impoundments (barriers to marine and estuarine connectivity)
- Impoundments (alien freshwater species)
- Sea-level rise / Drought (increased connectivity and salinity into coastal freshwaters)

Thank you

Related presentations, this conference

- Connectivity between estuarine populations (Madagascar – mainland Africa)
- Poster 147 – "Estuarine lakes: linkages and lineages across longitudes in the Western Indian Ocean"

Acknowledgements and references

- Alan Whitfield and Digby Cyrus, PhD supervisors
- Dave Voorvelt in Whitfield (1998) "Biology and Ecology of Fishes in Southern African Estuaries". South African Institute of Aquatic Biodiversity (Line drawings of selected fish)

- Dale P & Sheaves M. (2016). Estuarine Connectivity. In Encyclopedia of Estuaries, Encyclopedia of Earth Sciences Series pp 258-260
- Whitfield AK, Weerts SP & Weyl OLF. (2017). A review of the influence of biogeography, riverine linkages, and marine connectivity on fish assemblages in evolving lagoons and lakes of coastal southern Africa. Ecology and evolution.

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