# Case studies of modified South African estuaries and implications for ecological restoration in these systems

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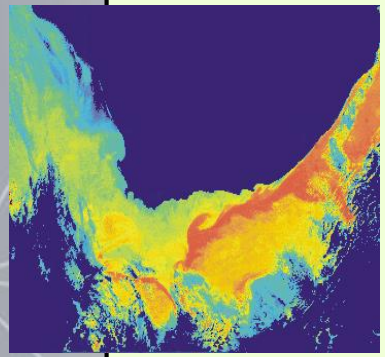
# Four estuarine systems: Perturbation, intervention, trajectories of change

- St Lucia: Agriculture, mouth manipulation – Restoration
- Nhlabane: Mining, dam - Mitigation
- Richards Bay/Mhlathuze Estuary: Port development - Mitigation
- Durban Bay: Port development - Mitigation

*What can we learn from these to guide successful ecological restoration in South African estuaries?*

# Introduction – Estuaries of KwaZulu-Natal

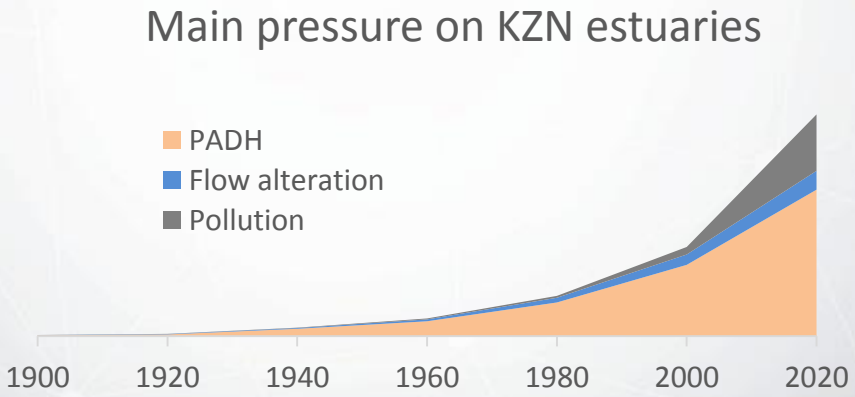




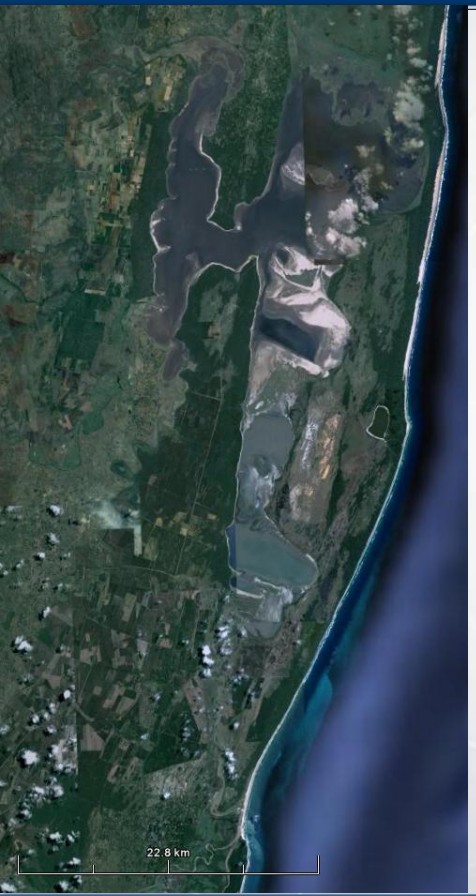

- St Lucia
- Nhlabane
- Richards Bay/Mhlathuze
- Durban Bay

# Introduction – Estuaries of KwaZulu-Natal

- Most threatened of all coastal habitats
- Port development, urban development, agriculture, mining
- Habitat loss and flow modification
- Pollution in the last 20 years, eutrophication and fish kills



# St Lucia estuarine lake




- Estuarine lake - largest in Africa
- SA's flagship estuary
- World Heritage Status
- RAMSAR site of national importance
- 80% of KZN estuarine area
- Important fish and prawn nursery
- Bird roosting, feeding and breeding area


- 60 km S-N
- s/a 350 km$^2$
- Shallow (ave. depth 1 m)
- Small catchments except for Mfolozi at mouth

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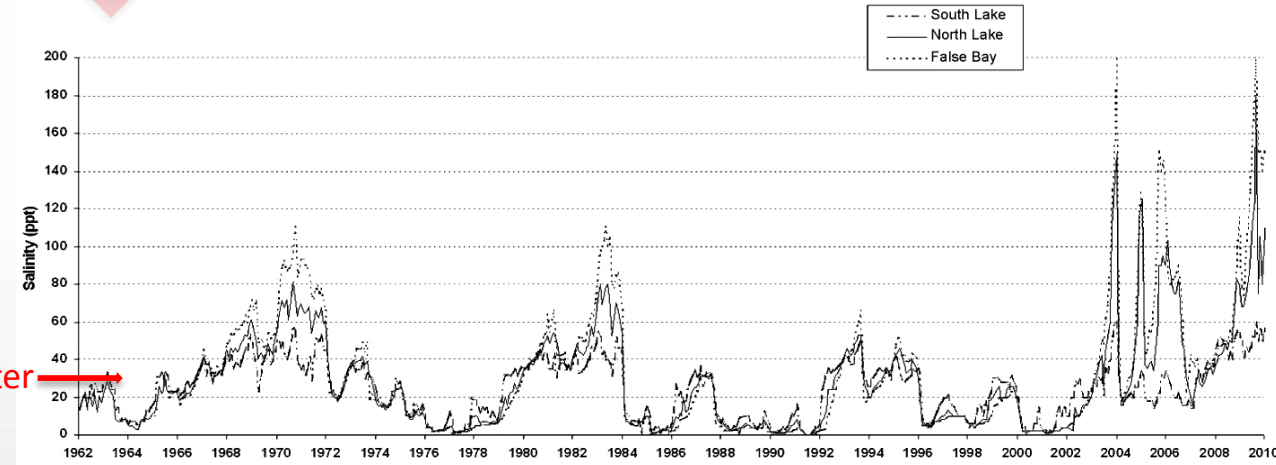
# St Lucia - perturbation



- Removal of Mfolozi swamps for agriculture
- Increased sediments at St Lucia mouth
- Mouth closure
- Mouth manipulation (separation)
- Mouth closure and hypersalinty
- Mouth management by dredging

Seawater




Nel HA, Perissinotto R, Taylor RH, Carrasco NK (2011). Salinity Tolerance of the Bivalve *Solen cylindraceus* (Hanley, 1843) (Mollusca: Euheterodonta: Solenidae) in the St Lucia Estuary. African Invertebrates 52: 575-586

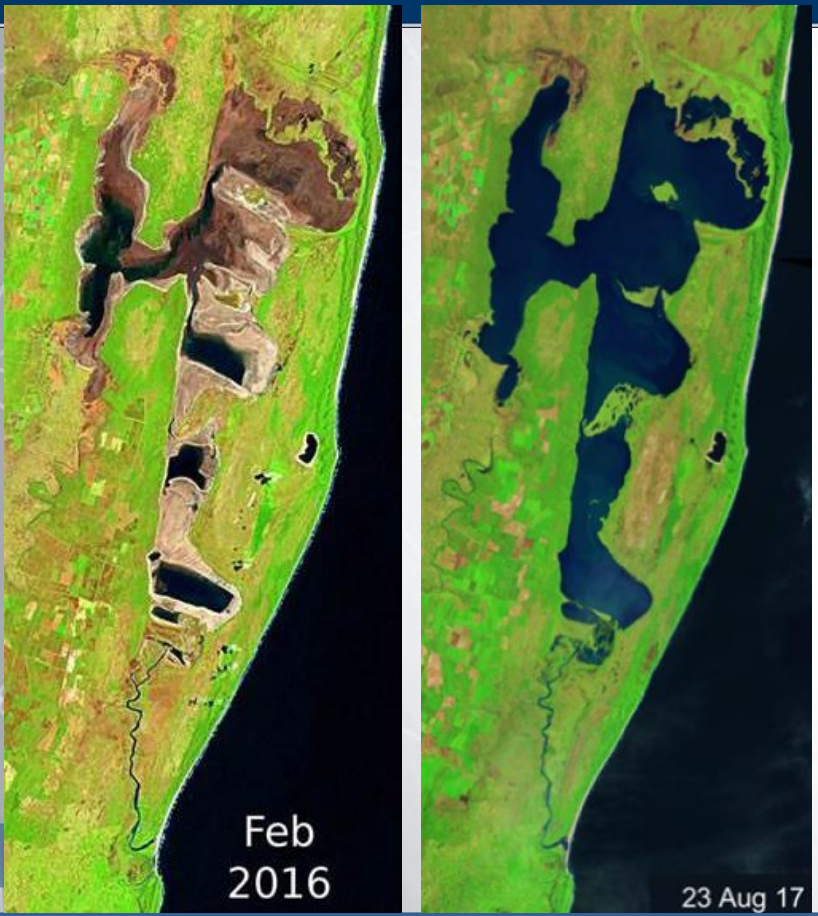
# St Lucia - perturbation

# St Lucia – intervention (restoration)

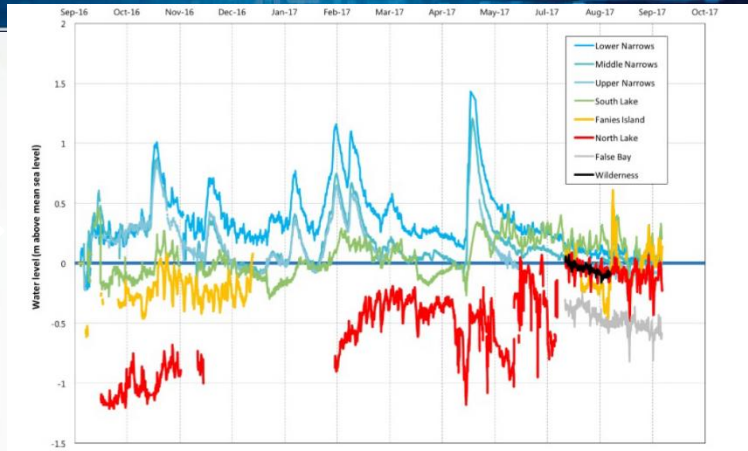
- R65 million spent on St Lucia Estuary restoration project
- 1.4 million cubic metres of sand (60 years of dredge spoil) removed

https://isimangaliso.com/newsflash/isimangaliso-healing-nature/

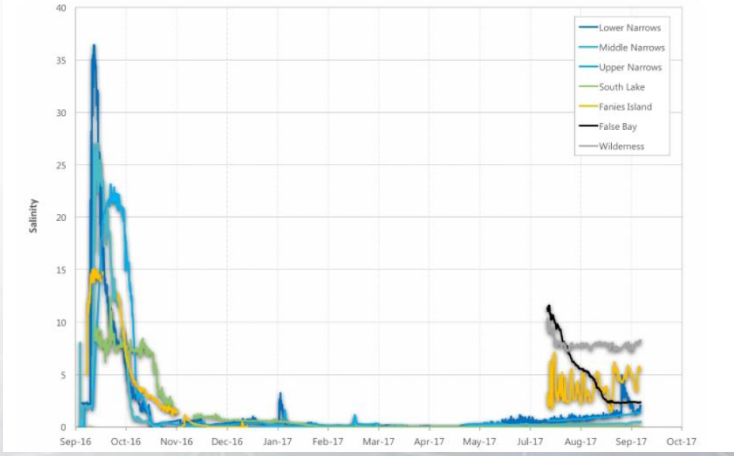
# St Lucia – restoration success




Water level




Salinity




https://isimangaliso.com/newsflash/isimangaliso-lake-st-lucia-changing-time/

# St Lucia – or not?

# St Lucia – or not (2)?

Umfolozi Sugar Planters Ltd (UCOSP) and farmers

vs

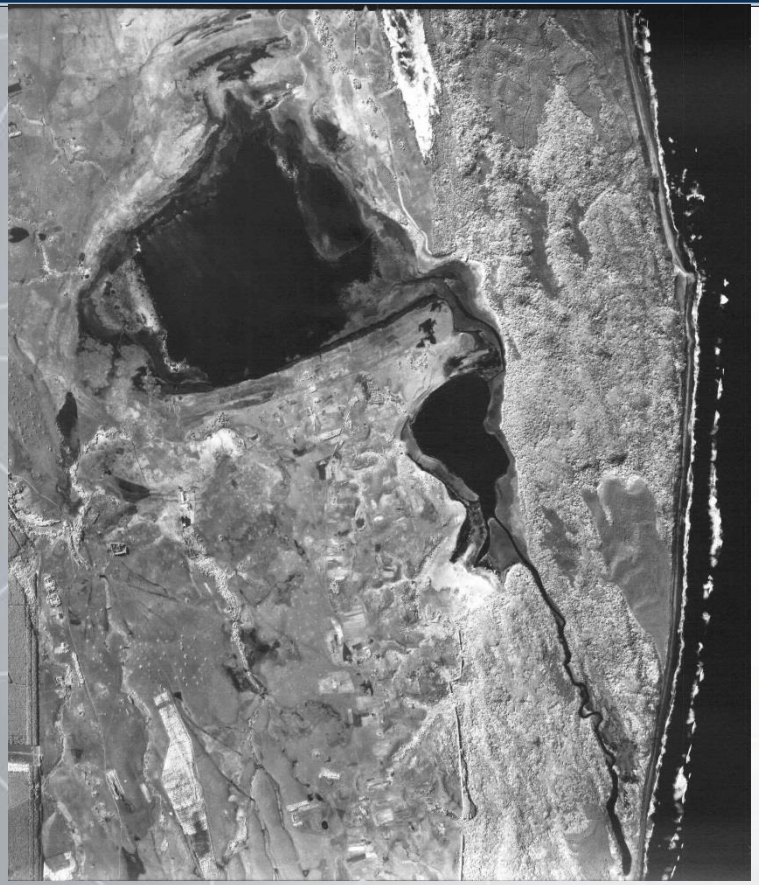
iSimangaliso, the Departments of Environment Affairs, Water and Sanitation, Rural Land Reform and Development and Agriculture Forestry and Fisheries

# St Lucia - synopsis - hanging in the balance

- Well studied, science-based
- Natural recovery processes adopted

- Are sediments short-term or do they reflect lack of restoration in the lower catchment?
- Will the project be supported by local communities?

# Lake Nhlabane



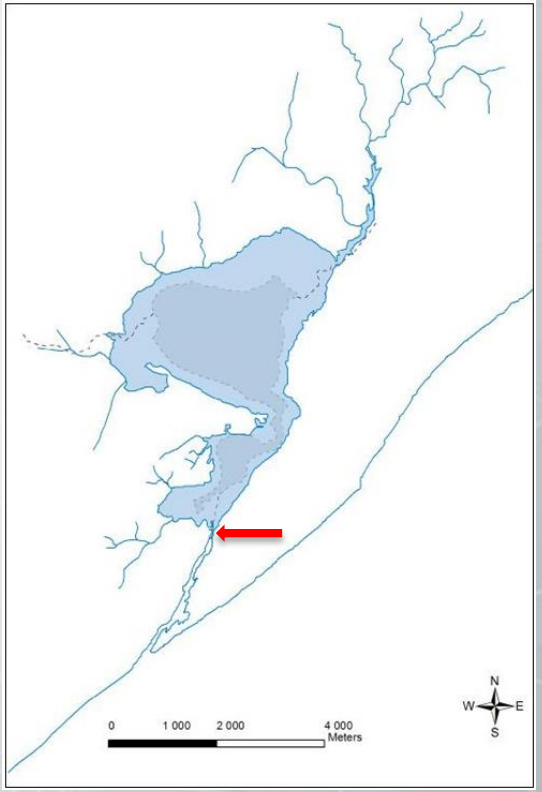
- Estuarine lake – Clearwater system
- Seasonal connection to the sea
- Important fish nursery
- Important bird area

- 6 km S-N

# Lake Nhlabane - perturbation

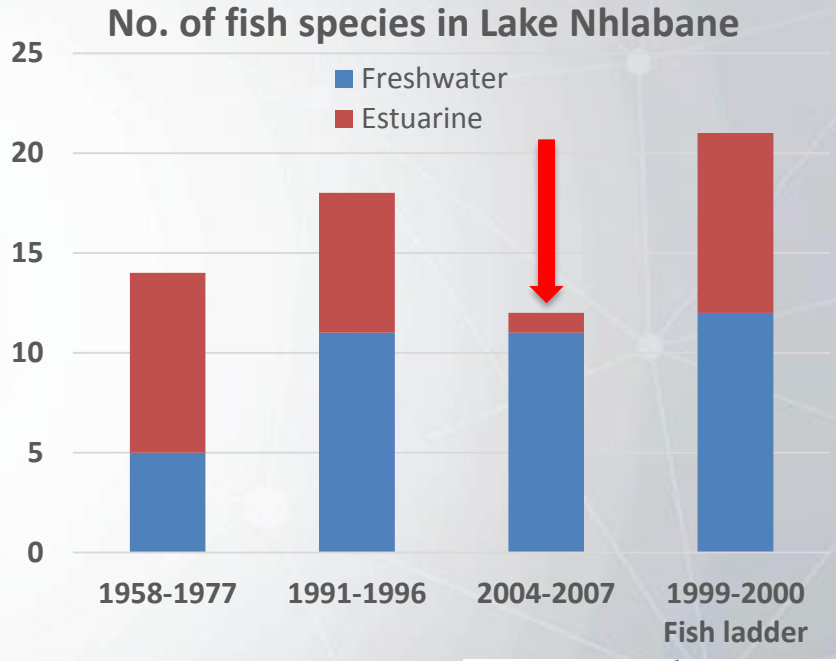
Construction of barrage at south basin in 1977 for mine water

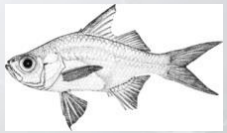
- Raised in 1999 (+6 m)
- Flow reduction
- Increased mouth closure
- Reduced flushing
- Loss of connectivity

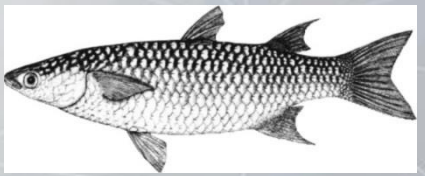


# Lake Nhlabane - intervention (fish ladder)

| SPECIES | LAKE SURVEYS | | | FISHWAY SURVEYS |
|---|---|---|---|---|
| | PRE-BARRAGE | POST-BARRAGE | | |
| | 1958 - 1977 | 1991 - 1996 | 2004 - 2007 | 1999 - 2000 |
| *Acanthopagrus berda* | X | | | X |
| *Monodactylus sp.* | X | | | X |
| *Pomadasys commersonnii* | | X | | |
| *Rhabdosargus holubi* | | | | X |
| *Mugil cephalus* | X | | | X |
| *Valamugil robustus* | X | | | |
| *Elops machnata* | X | | | |
| *Liza macrolepis* | | X | | |
| *Liza alata* | X | X | X | |
| *Gerres acinaces* | | X | | |
| *Caranx ignobilis* | | | | X |
| *Caranx sexfasciatus* | | | | X |
| *Anguilla spp.* | | X | | X |
| *Myxus capensis* | X | X | | X |
| *Megalops cyprinoides* | X | | | |
| *Ambassis productus* | X | X | | X |
| *Eleotris fusca* | | X | | X |
| *Eleotris melanosoma* | | | | X |
| *Hypseleotris dayi* | | | | X |
| *Gilchristella aestuaria* | X | X | X | X |
| *Awaous aeneofuscus* | | | | X |
| *Glossogobius callidus* | | X | X | X |
| *Glossogobius giuris* | X | X | | |
| *Redigobius dewaali* | | | | X |
| *Clarias gariepinus* | X | X | X | |
| *Clarias theodorae* | | | X | |
| *Oreochromis mossambicus* | X | X | X | X |
| *Pseudocrenilabrus philander* | X | X | X | X |
| *Tilapia sparrmanii* | | X | X | X |
| *Aplocheilichthys spp.* | | X | X | X |
| *Barbus bifrenatus* | | | X | |
| *Barbus paludinosus* | | X | X | |
| *Barbus viviparus* | | X | X | X |
| No. estuarine/marine spawners | 9 | 7 | 1 | 9 |
| No. freshwater spawners | 5 | 11 | 11 | 12 |
| Total no. of species | 14 | 18 | 12 | 21 |





# Lake Nhlabne – successful or not?

**Fish ladder as a temporary mitigation**

- Design issues
- Maintenance issues
- Scientific knowledge?

**Decommissioning and restoration**

- Reluctance to remove infrastructure after mining
- Important source of freshwater

# Lake Nhlabne – synopsis

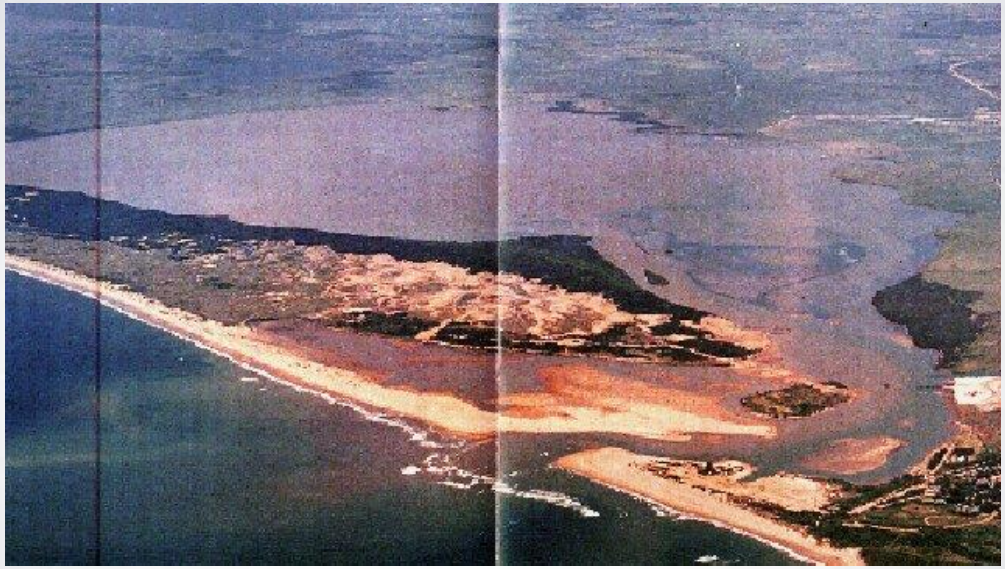
**Temporary mitigation (fish ladder)**

- Sufficient ecological knowledge?

**Restoration (barrage removal)**

- Commitment across all stakeholder groups?

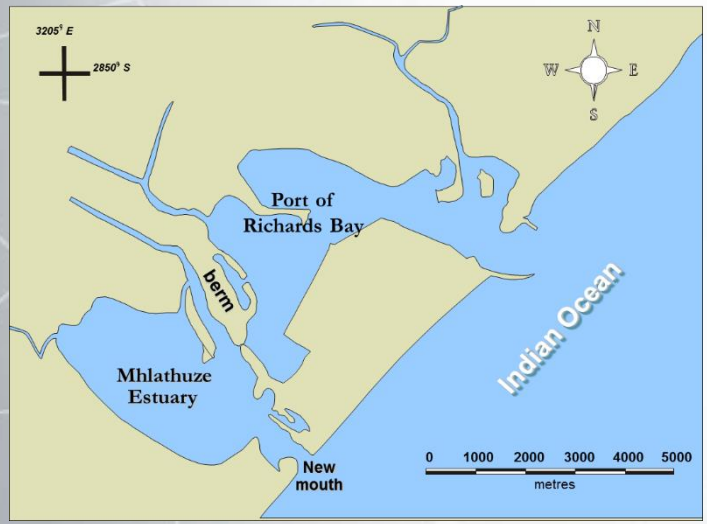
# Richards Bay/Mhlathuze



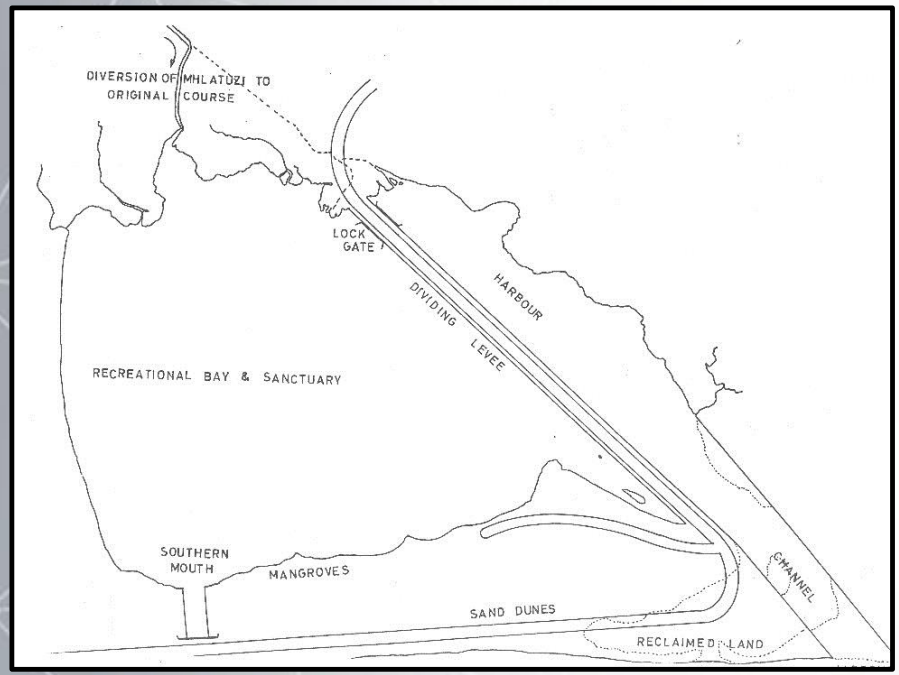
- Estuarine lake
- Permanent connection to the sea
- Important fish and prawn nursery
- Limited tidal range and therefore limited mangrove area
- Important estuarine habitat (eelgrass *Zostera capensis*)

# Richards Bay/Mhlathuze - perturbation

- Port development in 1975
- Re-routed and channelized river inflow
- Massive destruction of pristine estuarine habitat




# Richards Bay/Mhlathuze - intervention (conservation area)




- Large scale “design” of a remnant area to serve conservation and recreational purposes
- Re-routed river
- Tide gates to allow flow between systems
- New estuary mouth
- Predicted changes in tidal range

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# Richards Bay/Mhlathuze – successful (or lucky)?

- Predicted changes in tidal range occurred☑
- Intertidal mudflats☒
- Tide gates failed ☒
- Tidal prism kept the mouth permanently open
- Natural recovery by biological succession (to mangroves) in both new systems (>50% SA mangrove area)
- Intervention in the case of *Zostera*

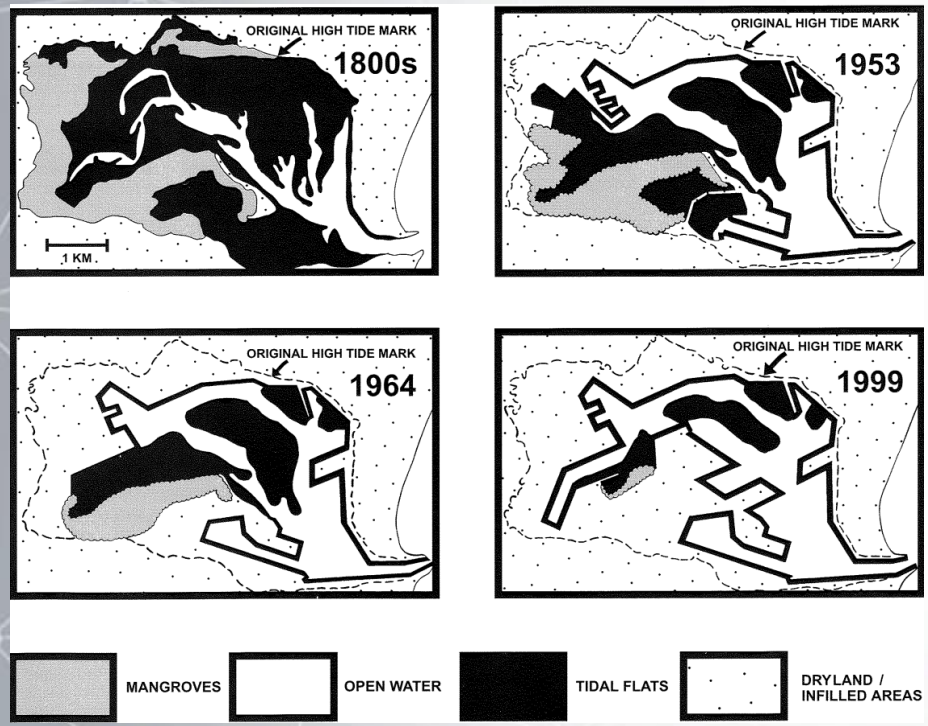
# Richards Bay/Mhlathuze - synopsis

- Massive changes: one estuarine lake an → estuarine bay + permanently open estuary
- Well studied (scaled physical model)
- Followed natural recovery processes
- Habitat replacement (overall habitat loss)
- Stable state in <20 years (with exception of *Zostera*)
- Nationally important estuarine resource

Last 20 years

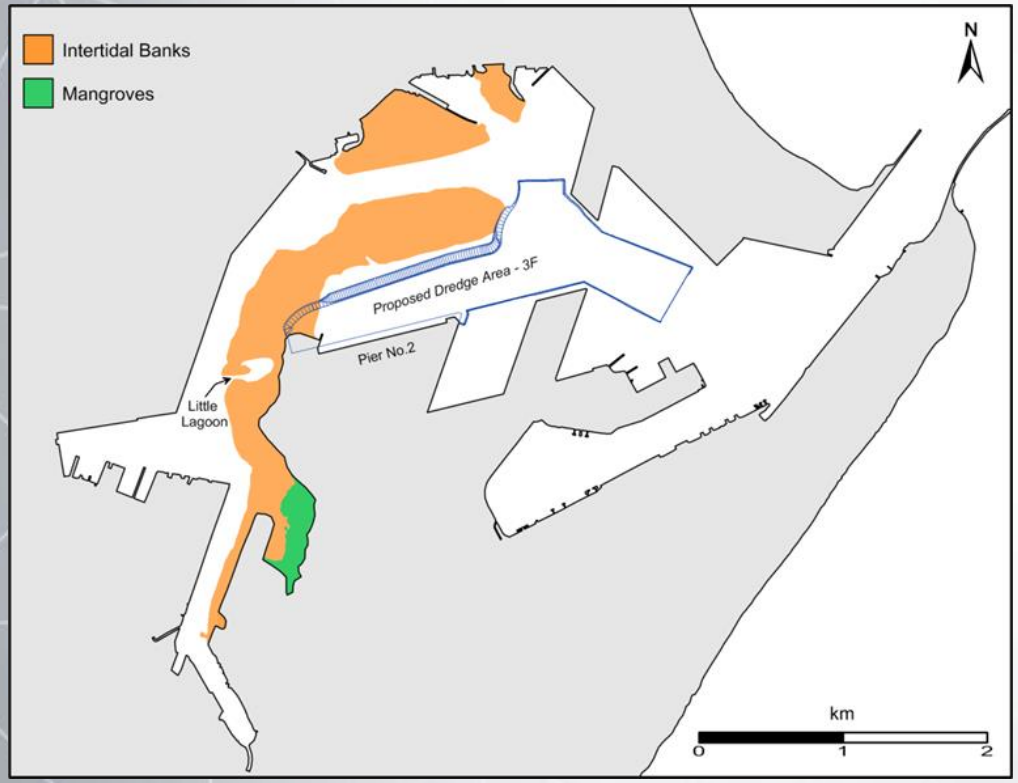
- Catchment water quantity and quality
- Invasive species
- Over-exploitation

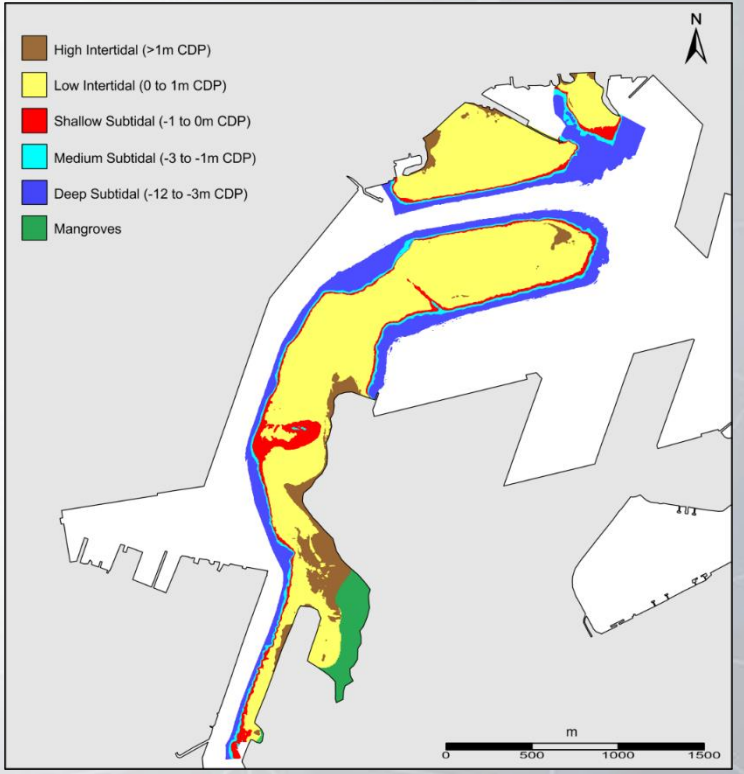
# Durban Bay – A highly modified estuarine resource



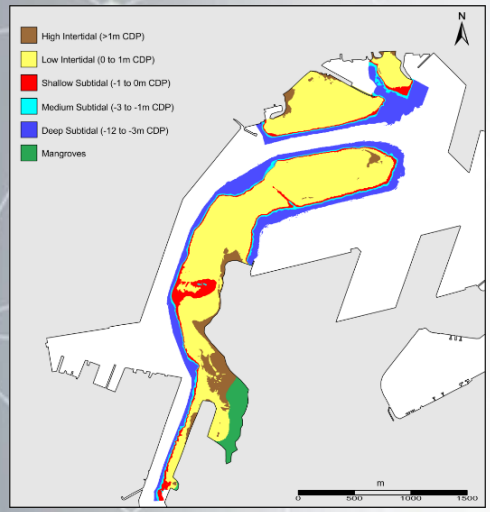

Allan DG, Sinclair JC and Rossouw J (1999). The waterbirds of Durban Bay: current status and historical trends. Durban Museum Novitates 24: 1–21.

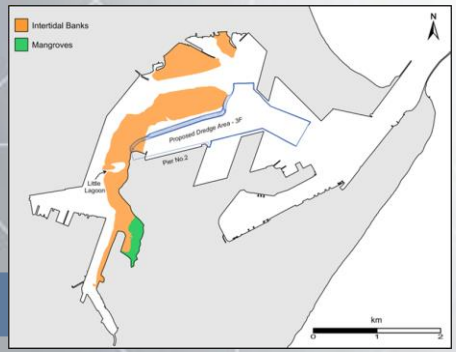
# Durban Bay – opportunity with development



# Durban Bay – leveraging on development

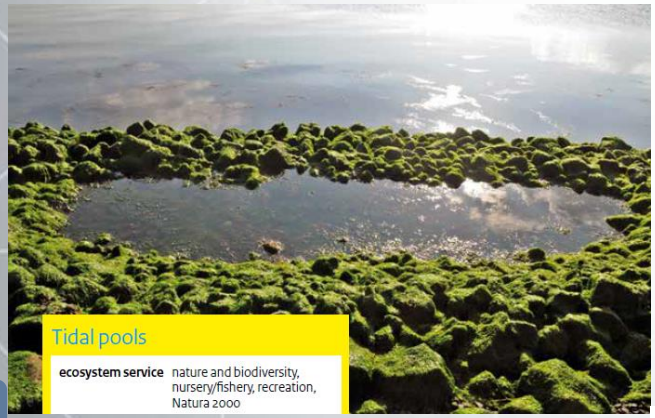


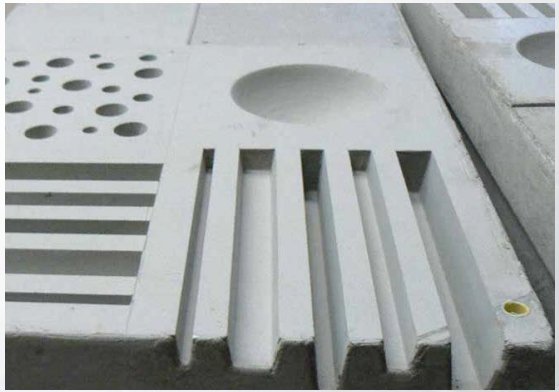




| Central Bay Tidal Banks | 3C long-term | 3D long-term | 3E development footprint | 3F development footprint | 3G development footprint | 3H development footprint |
|---|---|---|---|---|---|---|
| High Intertidal | -18128 | -18142 | -16495 | -16346 | -16346 | -16353 |
| Low Intertidal | -54937 | -22389 | 5194 | 40545 | 43216 | **45000** |
| Shallow Subtidal | 10580 | 23656 | 7943 | 40130 | 40130 | **44580** |
| Medium Subtidal | -6281 | -8982 | -9024 | -7993 | -7993 | -6522 |
| Deep Subtidal | -37411 | -51059 | -51135 | -58383 | -58383 | -53209 |
| Total | -106177 | -76916 | -63516 | -2048 | 623 | 13497 |
| | | | | | | |
| **Little Lagoon Tidal Banks** | **3C long-term** | **3D long-term** | **3E development footprint** | **3F development footprint** | **3G development footprint** | **3H development footprint** |
| High Intertidal | -1832 | -1832 | -1742 | -1742 | -1742 | -1742 |
| Low Intertidal | -1426 | -1426 | 1739 | 1739 | 1739 | 1739 |
| Shallow Subtidal | 3251 | 3251 | -7 | -7 | -7 | -7 |
| Medium Subtidal | 7 | 7 | 7 | 7 | 7 | 7 |
| Deep Subtidal | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 0 | 0 | 0 | 0 | 0 | 0 |

# Durban Bay – bioenhancement technolgies





Natura 2000

# Potential for restoration in estuaries

| Characteristic | Unpredictable environment |
|---|---|
| Inertia (ability to resist perturbations) | Low |
| Elasticity (speed that a system returns to its original state) | High |
| Amplitude (magnitude of perturbation and degree of displacement from previous state) | High |
| Dynamic property (variety and nature of forces operating within a system) | Robust |
| Maturity (degree to which a system approached climax state) | Low |
| Stability (tendency of a system to remain near an equilibrium or to return to it after a disturbance) | Resilient |

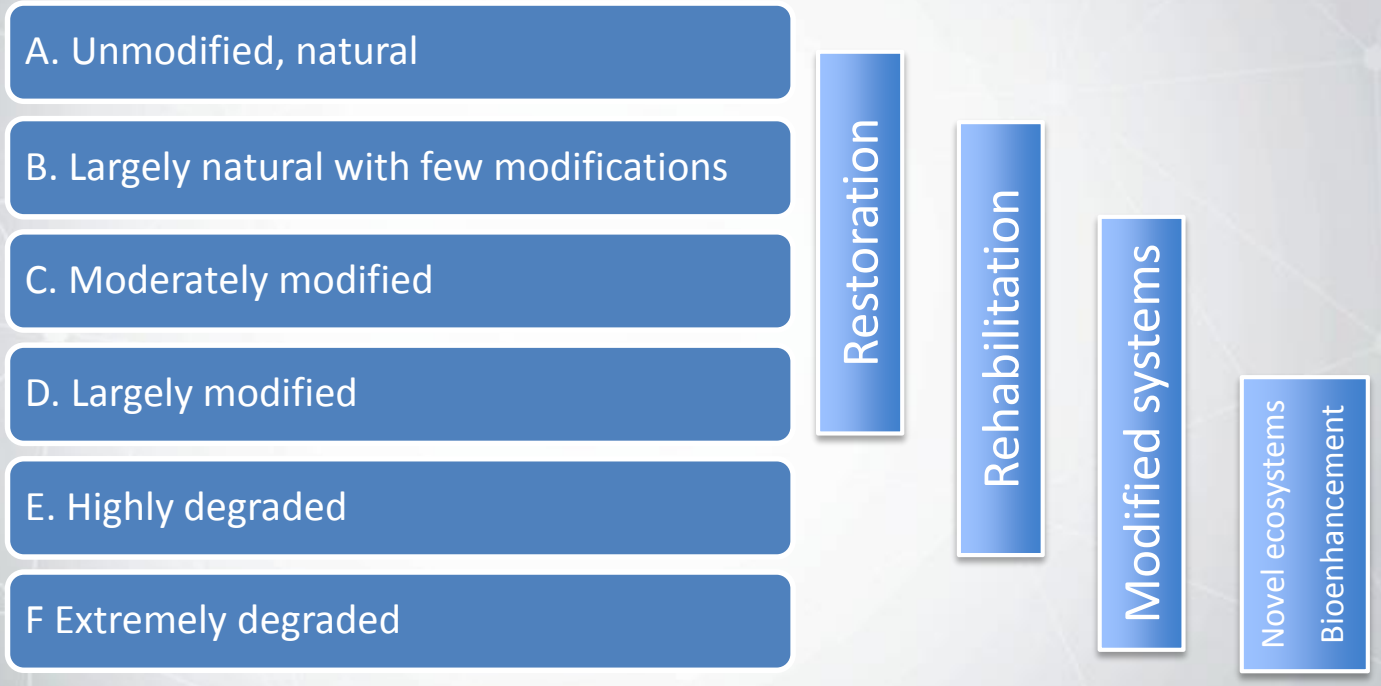
Whitfield 1990. Life-history styles of fishes in South African estuaries. Environmental Biology of Fishes 28: 295-308

# Potential for restoration in estuaries

1. We can create physical habitat and physico-chemical conditions (ecohydrology)
2. Connectivity – recruitment – natural succession
3. Stable states attained relatively quickly
4. Marine estuarine connectivity can be managed (can restore estuaries)
   - Water quality good
   - Main source of biota
   - POEs with good flushing
   - Climate change (sea level rise, berm heights and beach width)
5. Community involvement ?

1. Even well studied cases have failed in the past, scale is important (e.g. St Lucia)
2. Succession trajectories are sometime unpredictable
3. Not always predictable
4. Freshwater estuarine connectivity cannot (restoring catchments is difficult)
   - Water quality issues
   - Few biota (includes most threatened forms)
   - TOCEs with small catchments, specific sources
   - Global change (human pressure) and climate change (runoff and flows)
5. Community involvement ?

# Decision tree: Restoration/Rehabiltation/Bioenhancement



# Conclusion

1. We cannot have dead estuarine systems
2. Even ports must be more than ports
3. Restoration has to occur
4. We should embed Restoration Protocols into our existing estuarine management frameworks

# Thank you

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