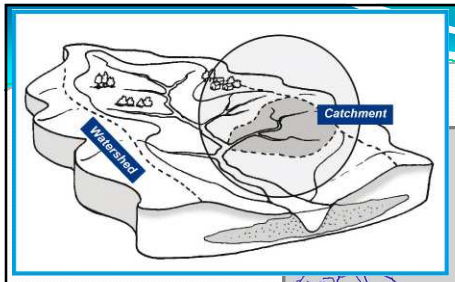
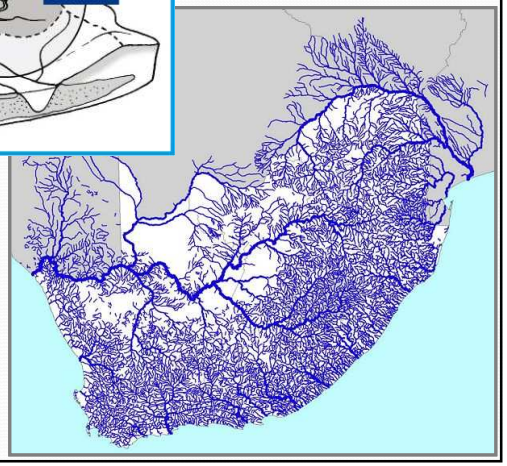
Nutrient Cycling and Transformation in Coastal Ecosystems

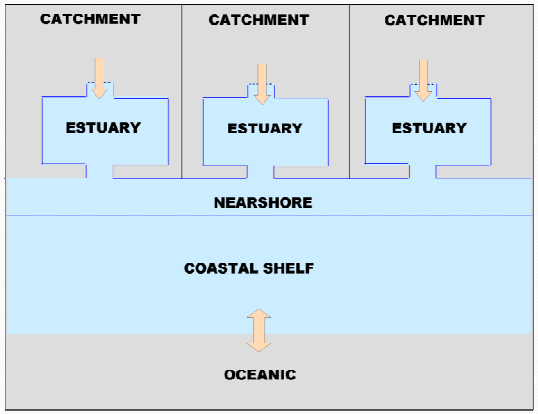
Introduction

- Approx. 300 estuaries along South Africa's 2500 km coastline.
- >70% open temporarily; closed intermittently by sand bar.
- They're an important component of the land-sea margin.
- Nutrient dynamics is a key abiotic driver of biological production in estuaries; 1° production in particular.



Estuaries represent the health of entire river catchments; bottlenecks.





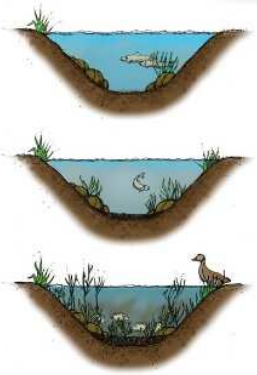
Schematic illustration of the coastal ecosystem

- Nutrient cycling and transformation (NCT) in estuaries is complex and easily perturbed by external (anthropogenic) forces.
- This leads to changes in trophic status, impacting on a system's ability to support higher trophic orders.
- Human activities (e.g. waste loading and alteration in transport and dispersion mechanisms) can potentially impact on the ecological services provided by estuaries on local or even regional scales.

NB changes in quality and quantity of freshwater input can change coastal ecosystems from natural.

Trophic Classification of Aquatic Ecosystems

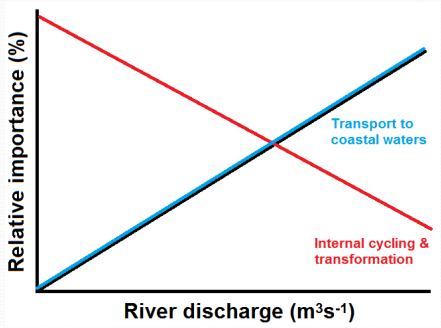
- Oligotrophic – Low levels of organic matter – tend to be deep and clear , oxygen rich bottom supports cold water fish such as trout , Phosphorus is limiting
- Mesotrophic – more organic matter, oxygen level in lake bottom is low
- Eutrophic- High levels of organic matter – abundant plant growth , poor clarity , stratified with oxygen poor bottoms
- A dead zone is an area where oxygen levels fall below 2 ppm



- Nutrient sources: Catchments (runoff & groundwater), upwelling (from oceanic boundary) and atmosphere.
- Chemical, biochemical and biological processes can influence NCT in estuaries.
- Often involves complex interactions between the water column (pelagic) and bottom sediment (benthic); bentho-pelagic coupling.

- Estuaries can filter or transform nutrients; river water chemistry modified as it passes from catchment to nearshore.
- Unique hydrodynamic and chemical regimes determine the extent to which nutrients are cycled and transformed within estuaries.
- Where river discharge is high, estuaries act as a conduit for catchment flows to coastal waters; NCT of catchment-derived nutrients largely occur at sea.

- As river discharge increases, the relative importance of internal NCT decreases within estuaries and the transport of dissolved and particulate matter from catchment and estuary to coastal waters increases.

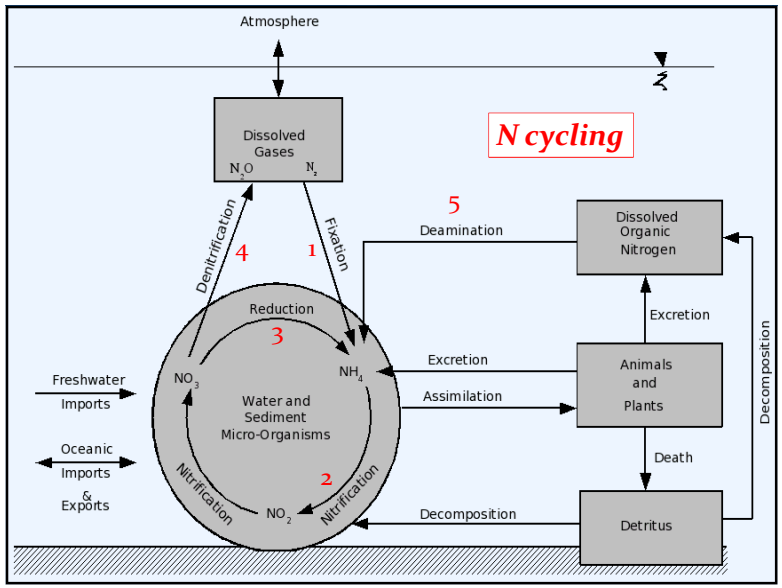


Limiting Nutrients in Coastal Ecosystems

- Nitrogen (N), phosphorus (P) and silicon (Si) are the primary limiting macro-nutrients for production in coastal ecosystems.
- Major forms of N in aquatic ecosystems:
  - Nitrogen (N_2) and nitrous oxide (N_2O) gases
  - Dissolved Inorganic Nitrogen (DIN), i.e. ammonium (NH_4^+), nitrite (NO_2^-) and nitrate (NO_3^-)
  - Dissolved Organic Nitrogen (DON), e.g. urea and uric acid
  - Particulate Organic Nitrogen (PON), e.g. as in detritus.

- NCT in estuaries and oceans are similar but organisms concerned and situations in which they take place differ.
- Process of ammonia release from decomposing proteins is slow and oxidation [$NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$] may take months in deep ocean environment.
- Vast reserves of DIN may only become available to 1° producers in the photic zone through upwelling events or convection currents.
- Decomposition and release of nutrients is more rapid in estuaries, particularly in shallow muddy areas, through diffusion, bioturbation and uptake by rooted plants.

- Animal, plant and bacterial diversity is much higher too and more concentrated in space.
- The river is the main source of N, much in the form of organic detritus; much animal and plant derived detritus is formed in the estuary.
- Marine dominated estuaries and those subject to upwelled water receive N from the marine environment.
- Atmospheric deposition is usually low and groundwater inputs are poorly studied.
- Cyanobacteria can fix atmospheric N_2 in the water column and in organic-rich muds.


Atmosphere
N cycling
Dissolved Gases
N_2O
N_2
Denitrification
4
1
Fixation
5
Deamination
Dissolved Organic Nitrogen
Excretion
Reduction
3
NO_3
NH_4
Excretion
Assimilation
Animals and Plants
Decomposition
Freshwater Imports
Water and Sediment Micro-Organisms
Oceanic Imports & Exports
Death
Nitrification
2
Nitrification
NO_2
Decomposition
Detritus