

Is the world's largest African penguin colony influencing productivity in the nearshore waters?

SAMSS Vision 2022

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A wide-angle photograph of a coastal scene. In the foreground, a group of penguins stands on a dark, rocky outcrop. The water is a deep teal color, with white-capped waves crashing against the rocks. The sky above the water is clear and blue.

Introduction

Ecological roles of seabirds on marine ecosystems

Top predators



Seabirds exert top-down control on the population of their preys (fish and invertebrates).

Enhancers of primary production



Seabirds may exert bottom-up control through the effects of their excrement on the systems surrounding large colonies.

Role of seabirds on the N and P cycles

Seabird excrement is rich in content of two elements: N and P.

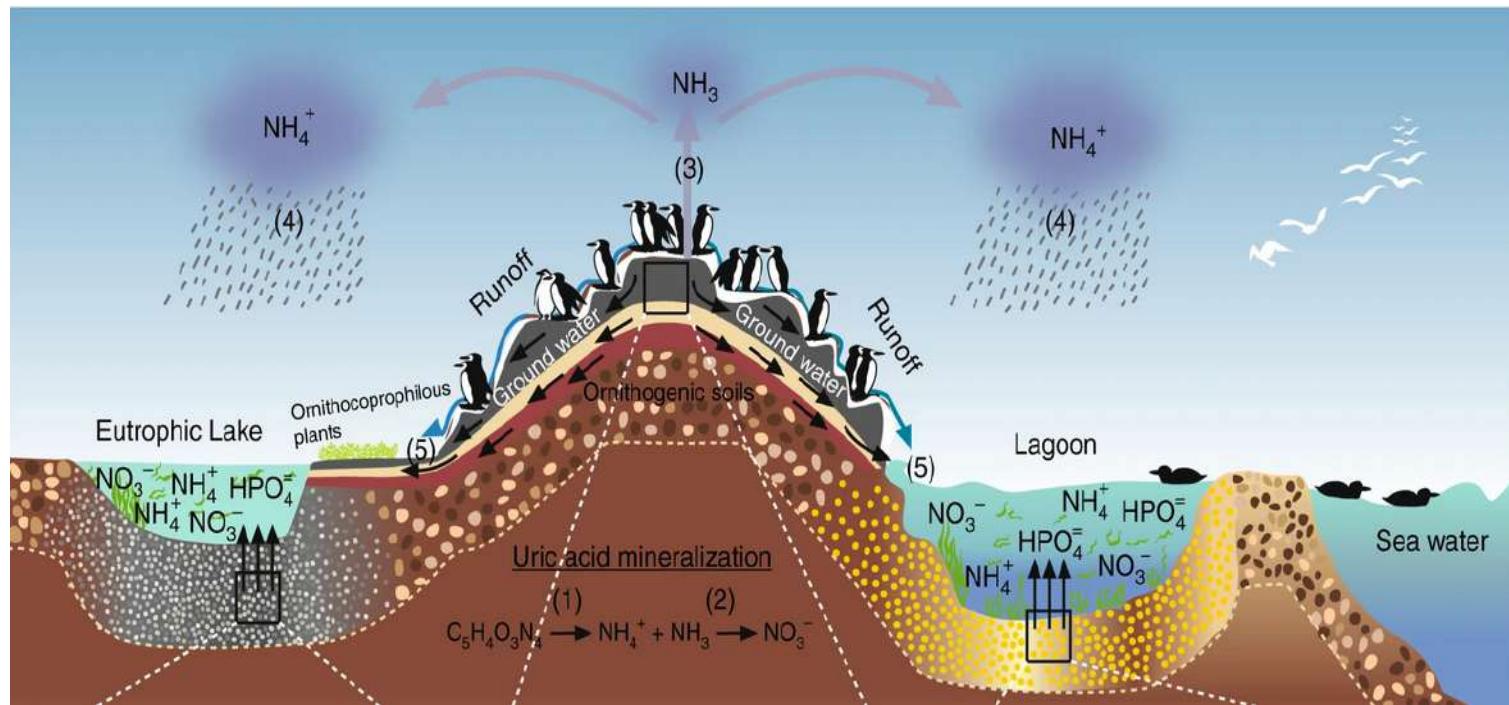


Figure 1. Schematic representation of the contribution of seabirds to the cycle of N and P. Copied from: Seabird colonies as important global drivers in the nitrogen and phosphorus cycles (Otero *et al.* 2018)

Trends of seabird populations

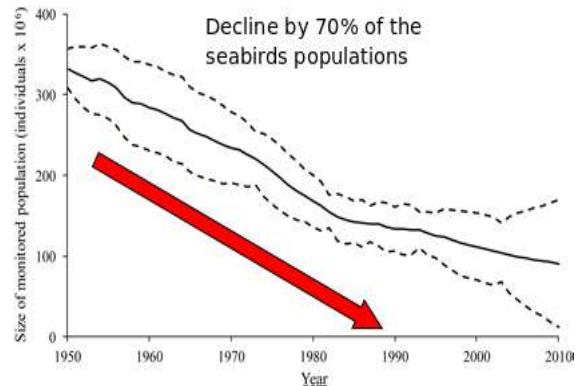


Figure 2. Population trend of global monitored seabirds from 1950 to 2010 (Copied from Paleczny *et al.* 2015).

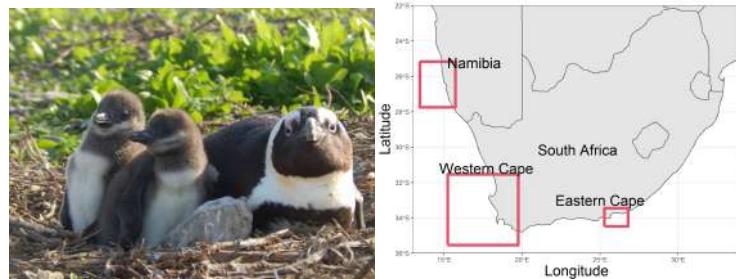


Figure 4. Areas of breeding colonies from African Penguin (*Spheniscus demersus*).

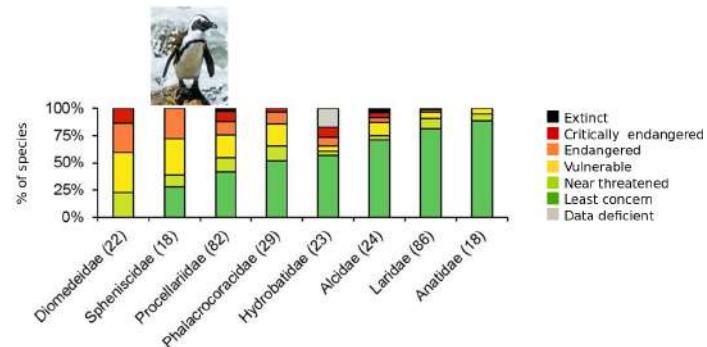


Figure 3. Percentage of seabird species in IUCN Red List categories (Copied from Croxall *et al.* 2012).

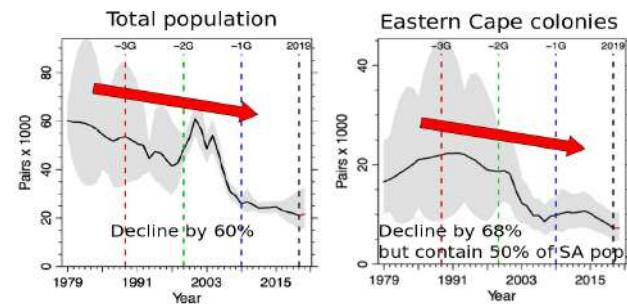


Figure 5. Declines in the the global population of African penguins (left) and in the colonies of Eastern Cape (right).(Copied from Sherley *et al.* 2020).

Objectives

- Evaluate *in situ* the differences in N and P concentrations between proximal and distal areas to St Croix Island, and their links with primary and secondary production.
- Estimate the N and P produced by African penguins at St Croix Island, and the amount of N entering the surrounding waters or being exported to the atmosphere.

A wide-angle photograph of a coastal scene. In the foreground, a group of penguins stands on a dark, craggy rock formation. The water is a deep teal color, with white-capped waves crashing against the rocks. The sky is a clear, pale blue.

Methodology

Fieldwork

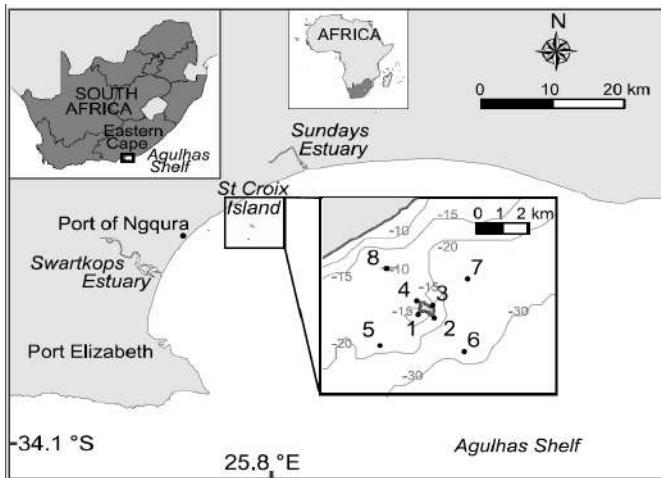


Fig.6. Map of Algoa Bay and the 8 stations sampled during Spring (Sep-Oct), Summer (Dec-Jan), Autumn (Apr-May) and Winter (Jun-Jul) 2017-2018.

- SST, Dissolved Oxygen, Nitrates, Nitrites, Ammonium and Phosphates.
- Chl-*a*, Small zooplankton and Fish larvae.

Modelisation

- **Bioenergetic model:** Estimation of N and P produced by African penguins during:
 - Breeding: Breeders, non-breeders and chicks.
 - Non-breeding:
 - Recovery
 - Molting
- **GUANO model:** Estimation of the magnitude of N exported mediating meteorological local conditions.
- NH₃ emitted to the atmosphere
- UAN and TAN washed-off to the water



Results

Production around St Croix Island

Stronger temporal than spatial variation in Algoa Bay. No significant difference between proximal and distal stations to St Croix Island.

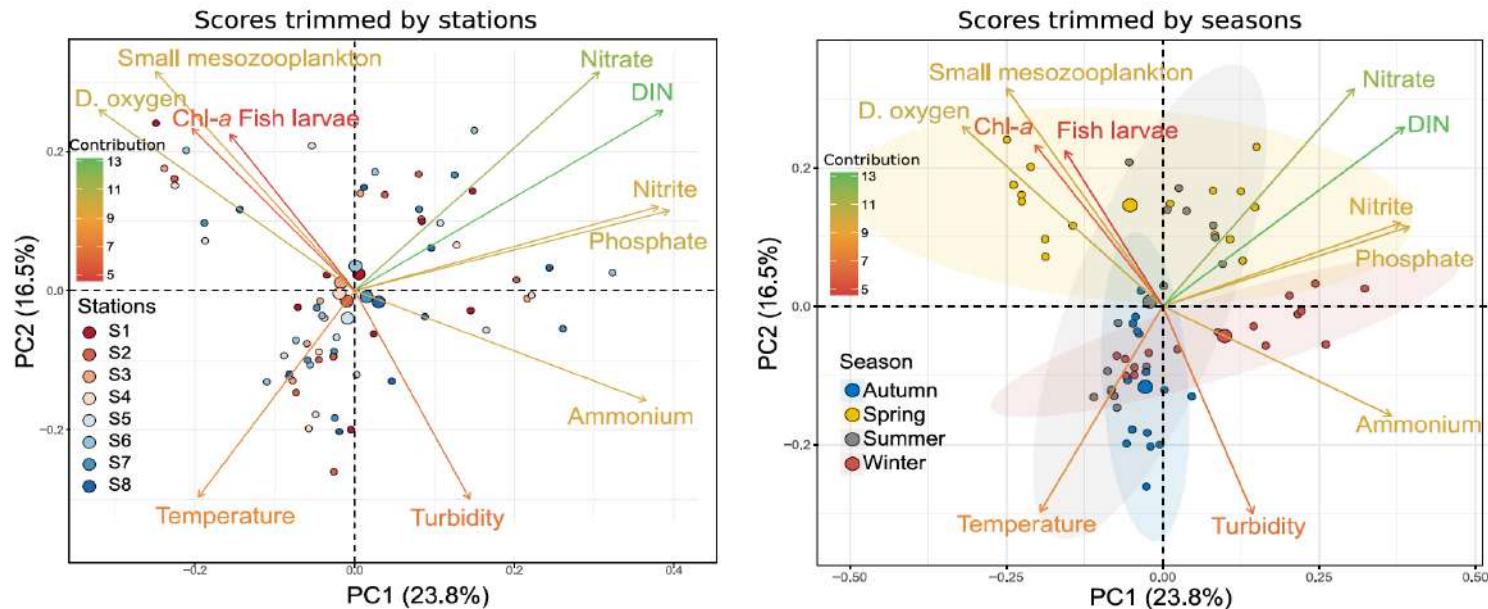


Fig.7. Biplot of the first and second Principal components (PC) that summarized the environmental conditions, primary (Chl- α as a proxy) and secondary production around St Croix Island, Algoa Bay. Scores were represented with colors for stations (left plot) and seasons (right plot).

N and P produced by African penguins

Highest excretion of N and P by breeders during breeding season (270 d). N and P production outside breeding season were lower because the attendance to the colony was reduced.

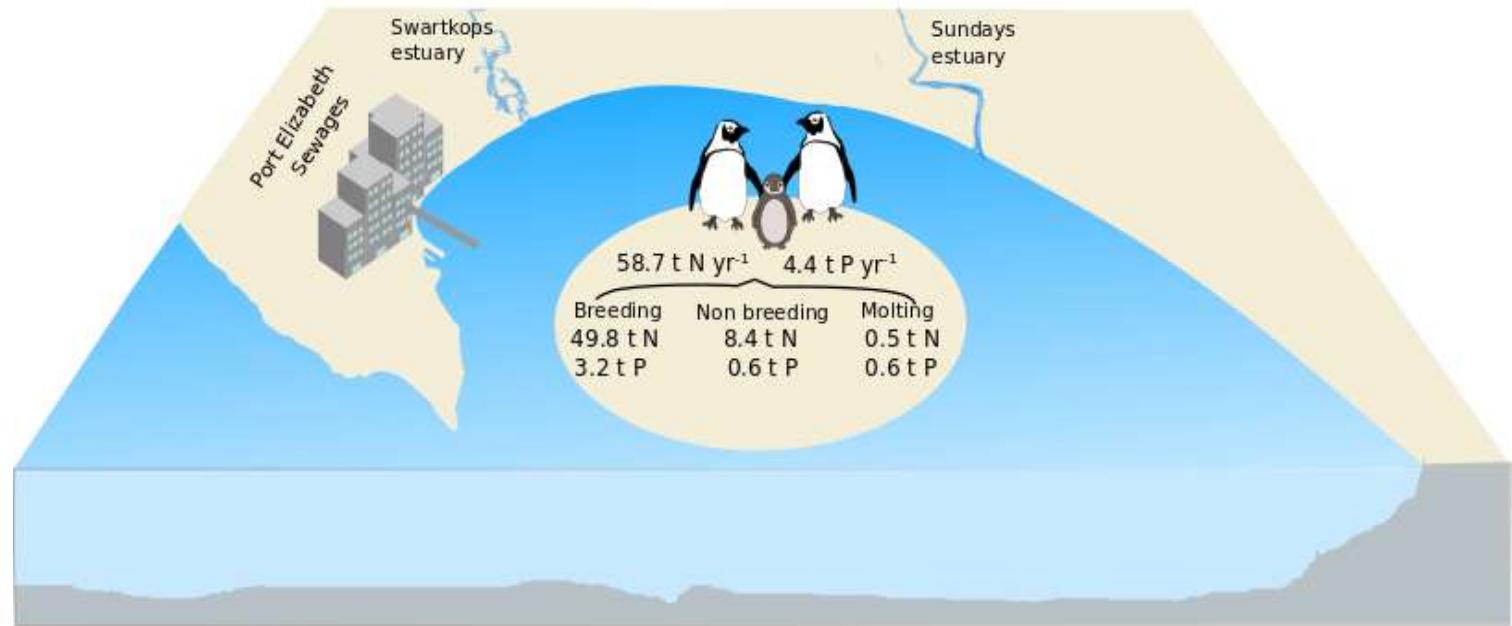


Fig.8. Schematic representation of the estimations of N and P produced by penguins during their different stages of the life cycle at St Croix Island.

N produced and exported

Most of the N produced was emitted to the atmosphere as ammonia, given the prevalent absence of precipitations and warm conditions at St Croix Island. Wash-off of N restricted to occasional heavy precipitations ($>3\text{mm m}^{-2}\text{ h}^{-1}$).

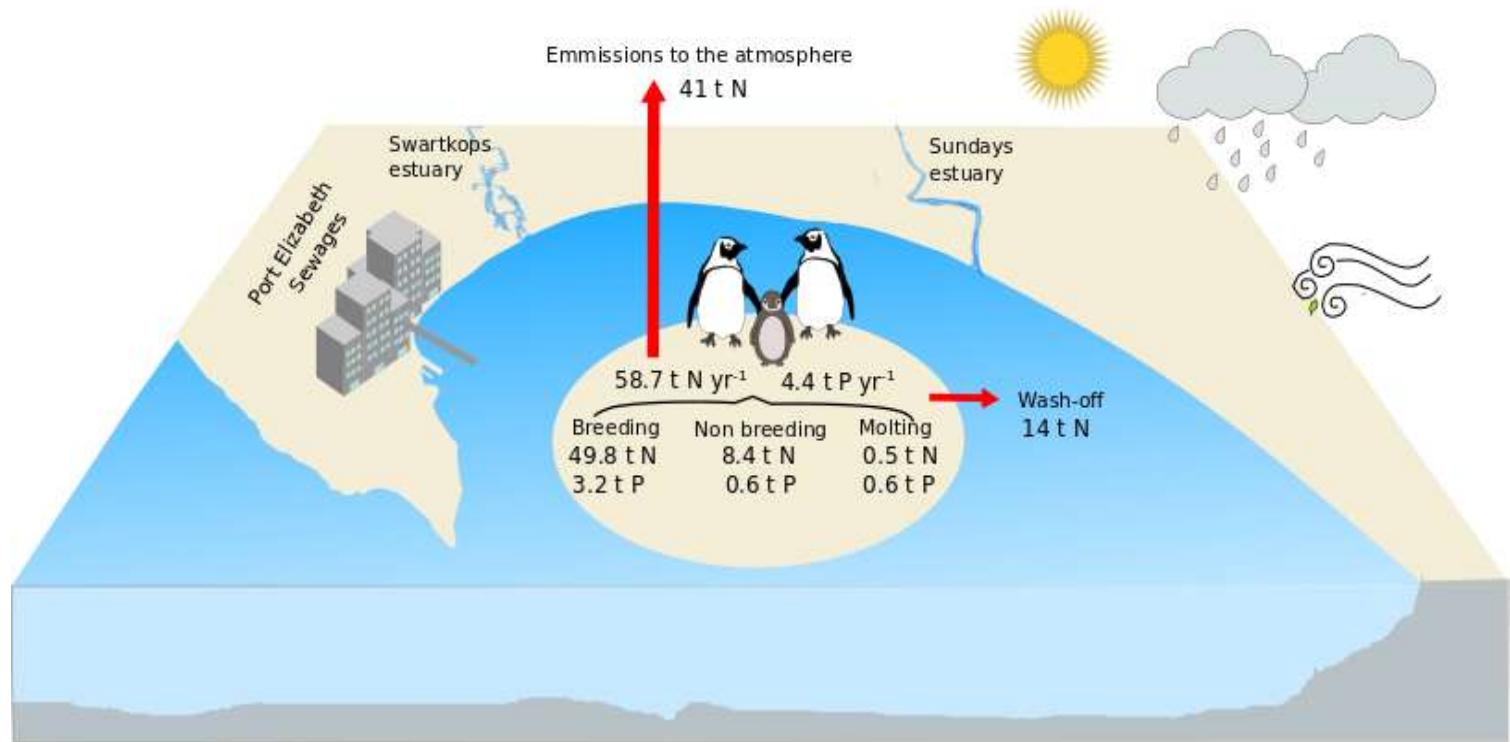


Fig.9. Schematic representation of the estimations of N emitted to the atmosphere as ammonia (NH_3) and N washed-off as Uric Acid Nitrogenate to the sea.



Conclusions and discussions

Runoff of N and P from anthropogenic origin overrun N and P produced by penguins in Algoa Bay

Sewage treatment plants discharged over 6 times more N and P than penguins excreted. N excreted by penguins similar to the discharge of local estuaries.

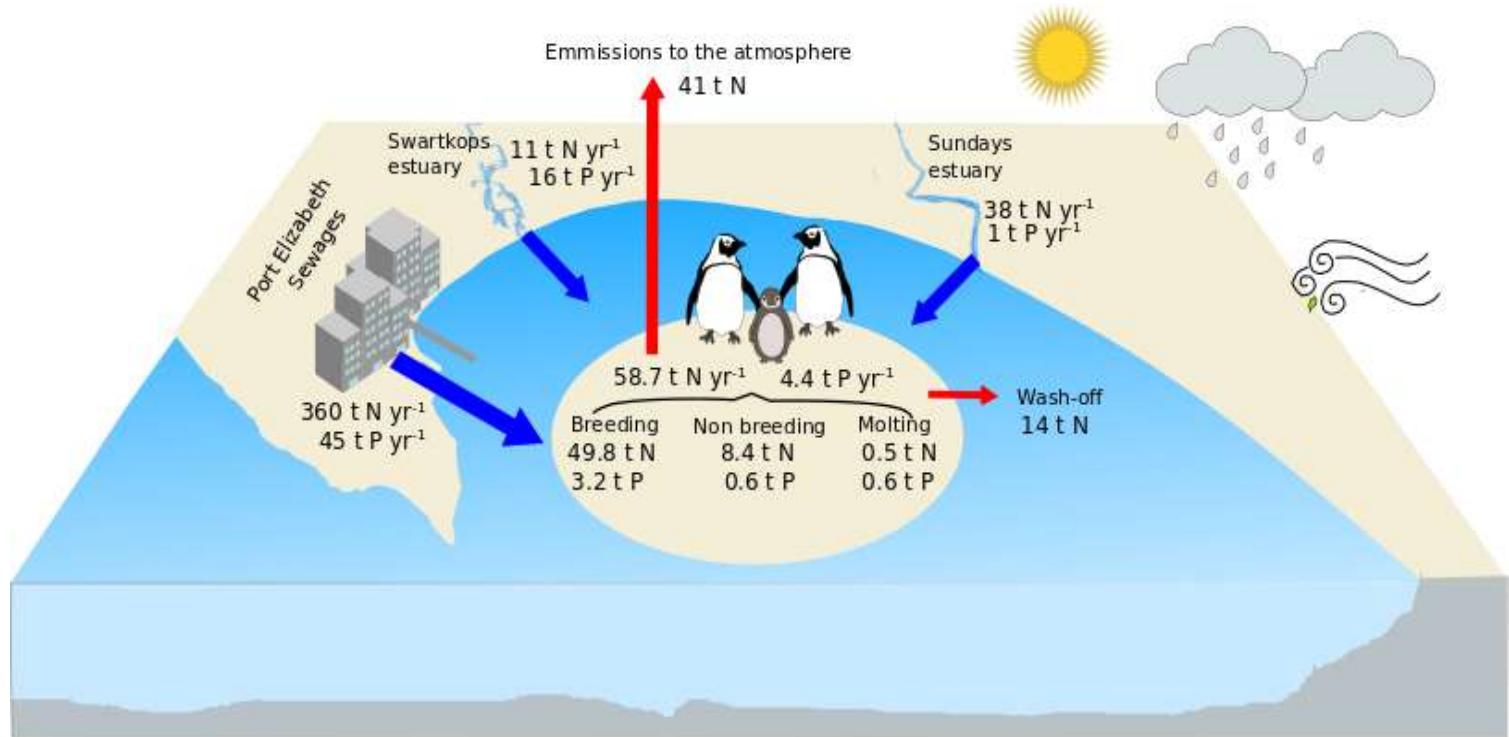


Fig.10. Schematic representation of the estimations of N and P inputs in the coastal waters of Algoa Bay.

Sensitivity and uncertainty of models

- Under projected scenarios of climate change for Eastern Cape a higher frequency of heavy rainfall may washed off larger amounts of N and P.
- In situ measurements of N and P excretions, atmospheric ammonia, and UAN washed-off; are required to validate the model estimations, improve the initial settings, and include new processes.

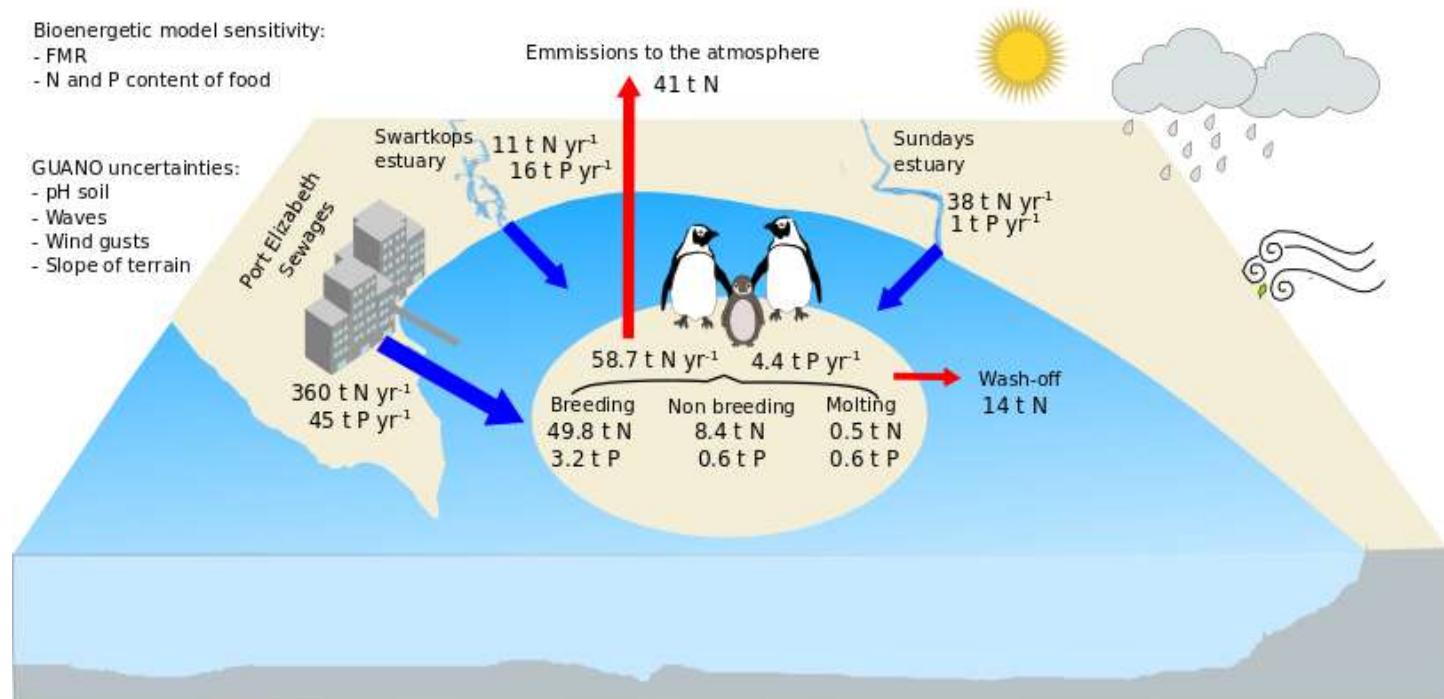


Fig.11. Schematic representation of the estimations of N and P inputs in the coastal waters of Algoa Bay.

Thanks for your attention!



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Link to the publication ↗ Is the largest African penguin colony in South Africa influencing local ocean productivity?