Dispersion of Nutrients and Its Temporal Variations Driven by Wind, Tides and Wave Conditions in Bocas del Toro, Panama

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1. Introduction

Urban development in coastal areas → Increase in nutrient loads → Eutrophication → Harmful Algal Blooms (HABs)

Transport processes serve as physical forces driving HABs (Nie et al., 2018; Freeman et al., 2019).

Bocas del Toro, Panama, is an island on the Caribbean coast. Its main town has experienced recurrent HABs in the last years.

Objective: Evaluate the dispersion patterns of NO_3 (modeled as a passive tracer) under two different oceanographic conditions.

2. Modelling approach

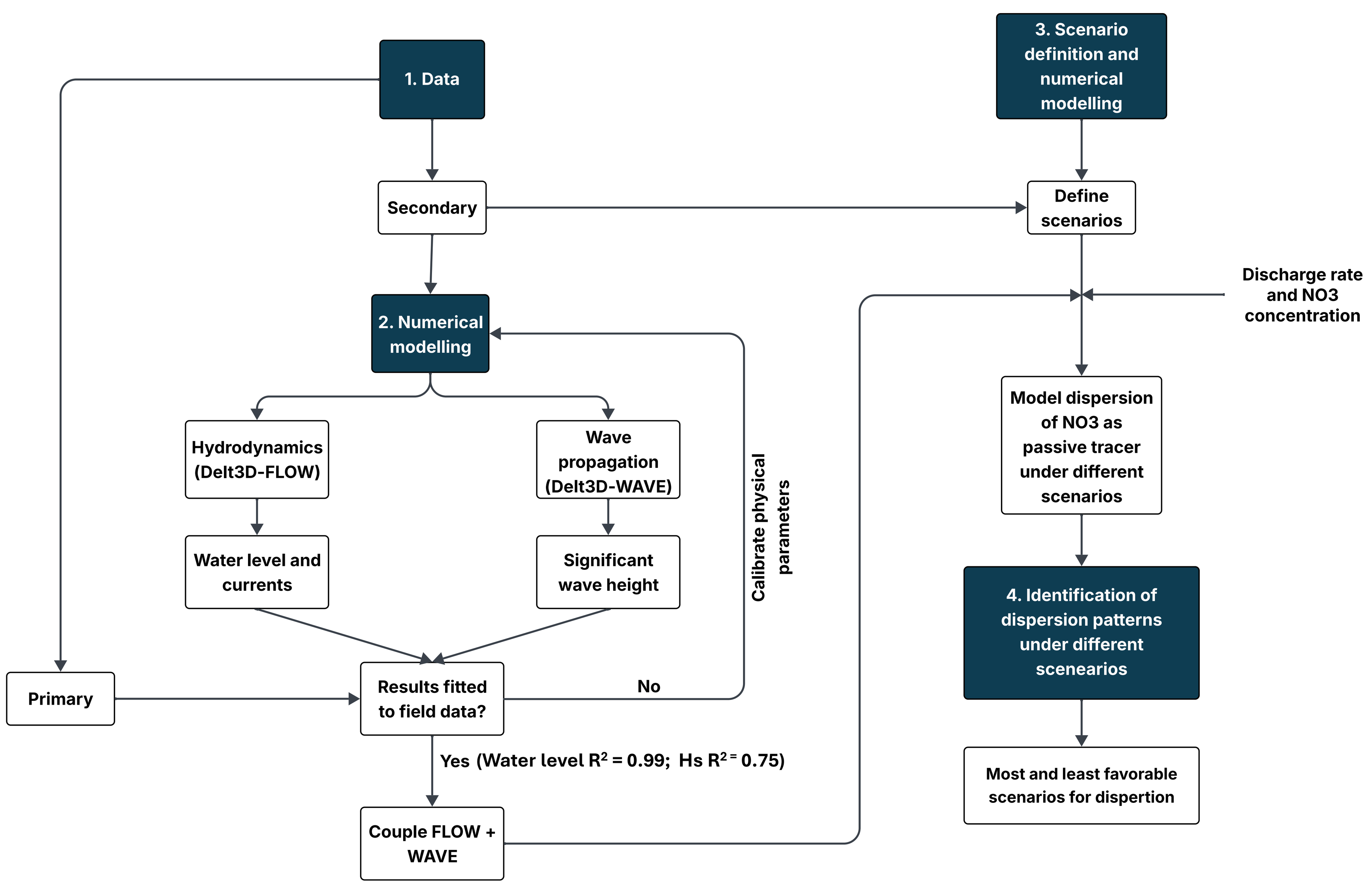
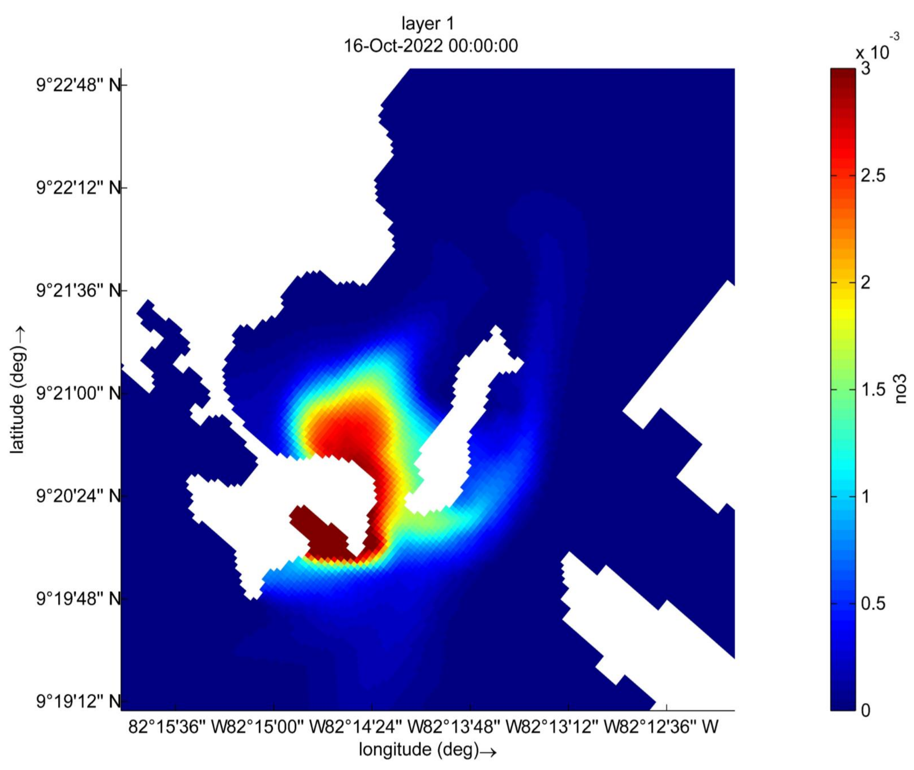


Figure 1. Conceptual workflow of the methodology used in this study.

3. Dispersion patterns



Scenario A

Tide: Spring
Waves: Hs < 1.0 m
Tp < 8 s
Dir NE
Winds: 1.8 m/s
255°

Figure 2. NO_3 concentration three days after release. Higher accumulation occurs in the inner bay.

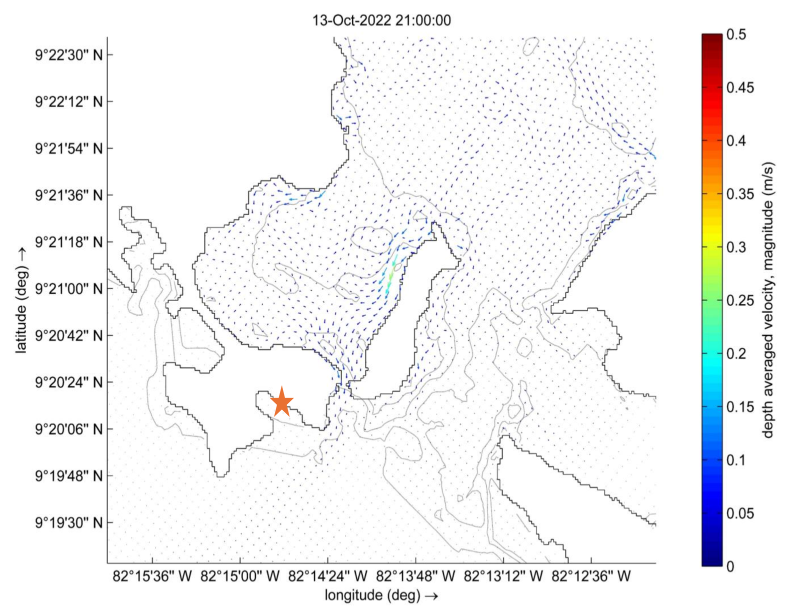


Figure 3. Wave-induced currents filed in the study area under Scenario A conditions. The star indicates the location of the sewage outfall.

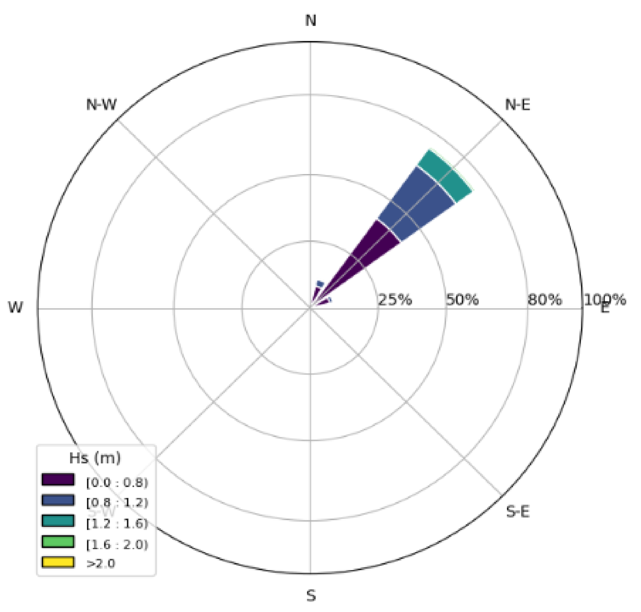
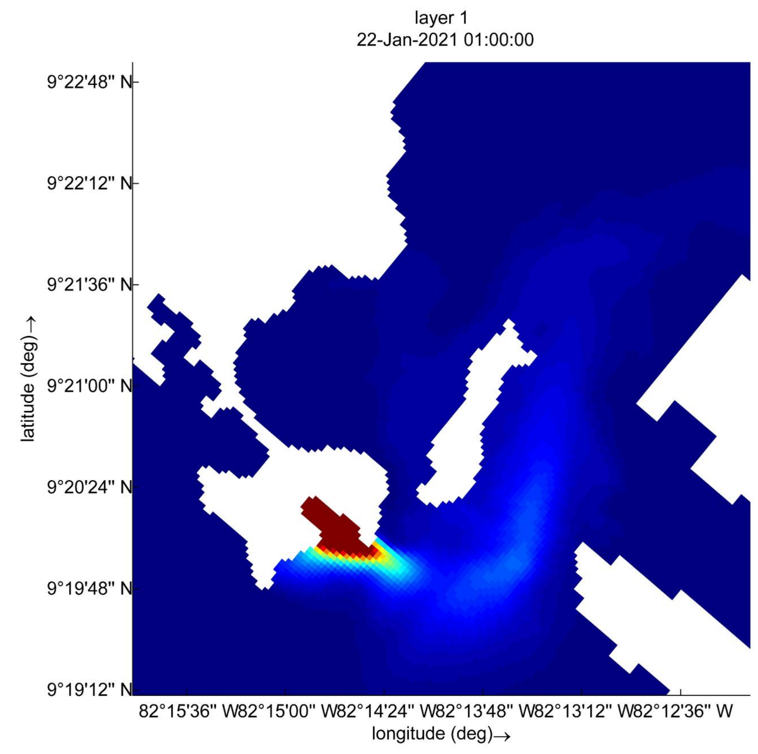


Figure 4. Wave rose for September-October-November over a 10-year period



Scenario b

Tide: Neap
Waves: Hs > 1.5 m
Tp > 8 s
Dir NE
Winds: 4.1 m/s
315°

Figure 5. NO_3 concentration three days after release. Large waves combined with weak tidal currents generate flow conditions that prevent NO_3 transport into the inner bay

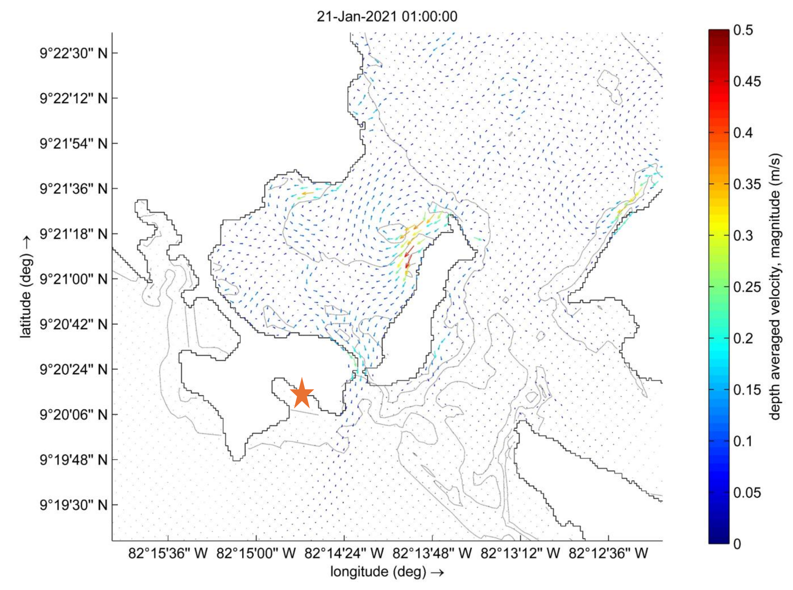


Figure 6. Wave-induced currents filed in the study area under Scenario A conditions. The star indicates the location of the sewage outfall.

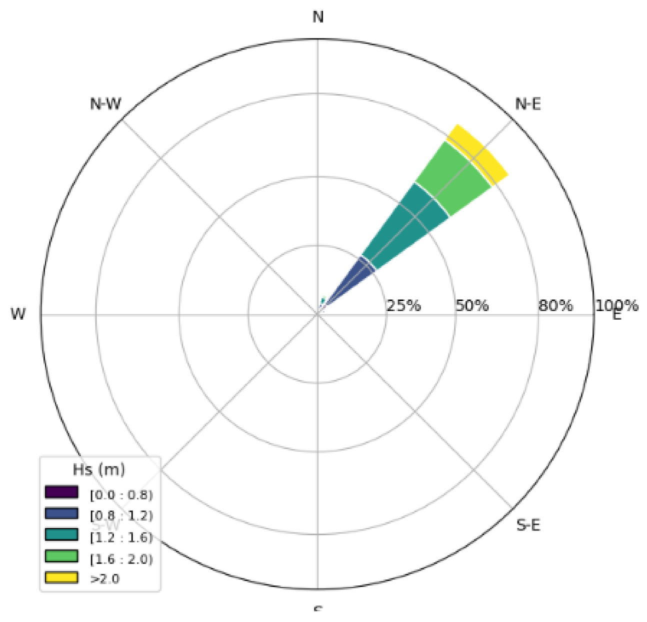


Figure 7. Wave rose December-January-February over a 10-year period

4. Conclusions

- Hydrodynamics in Bocas del Toro is dominated by tidal currents. However, due to their relatively weak velocities (<0.3 m/s), wave-induced currents can influence the circulation patterns and consequently nutrient dispersion.
- During periods of increased wave heights, such as December to February, wave action creates flow conditions that limit nutrient transport into the inner bay.
- Wave-induced currents, commonly ignored in nutrient dispersion studies, should be considered as they can affect the transport and distribution of nutrients in coastal zones.
- Future work: identify the combination of tides, waves and wind conditions that lead to higher accumulation in the inner part of the bay to link this knowledge with risk management.

References

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