



Australian Government



AUSTRALIAN INSTITUTE
OF MARINE SCIENCE

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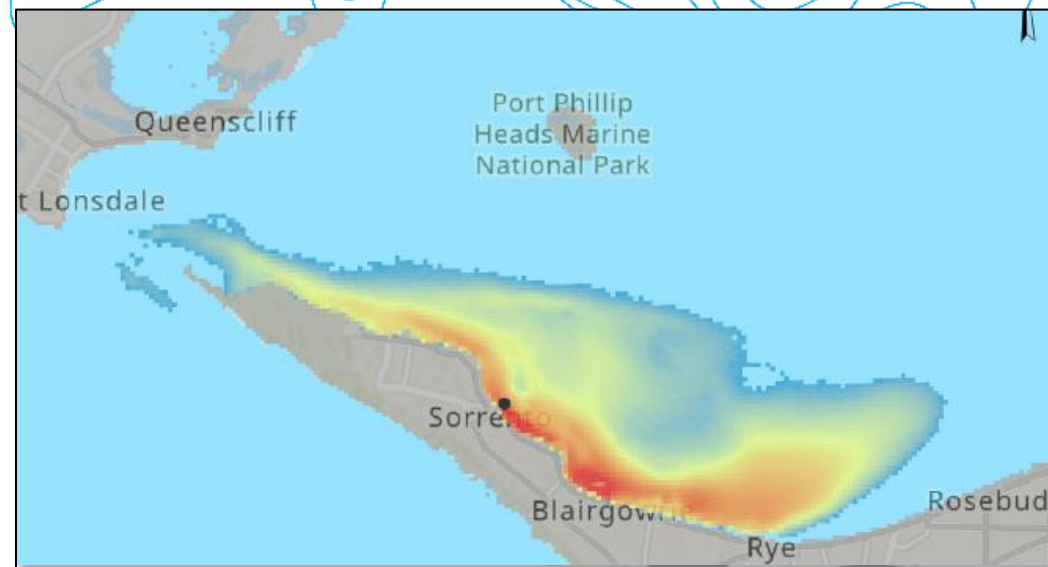
Australian Institute of Marine Science

**Ane Pastor Rollan², Craig Sherman²,
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1. Australian Institute of Marine Science
2. Deakin University, Centre for Marine Science.
3. Cawthron Institute, NZ
4. Department of Agriculture, Fisheries and Forestry (DAFF)



New recommendations in biophysical eDNA modelling for the early detection of marine pests.

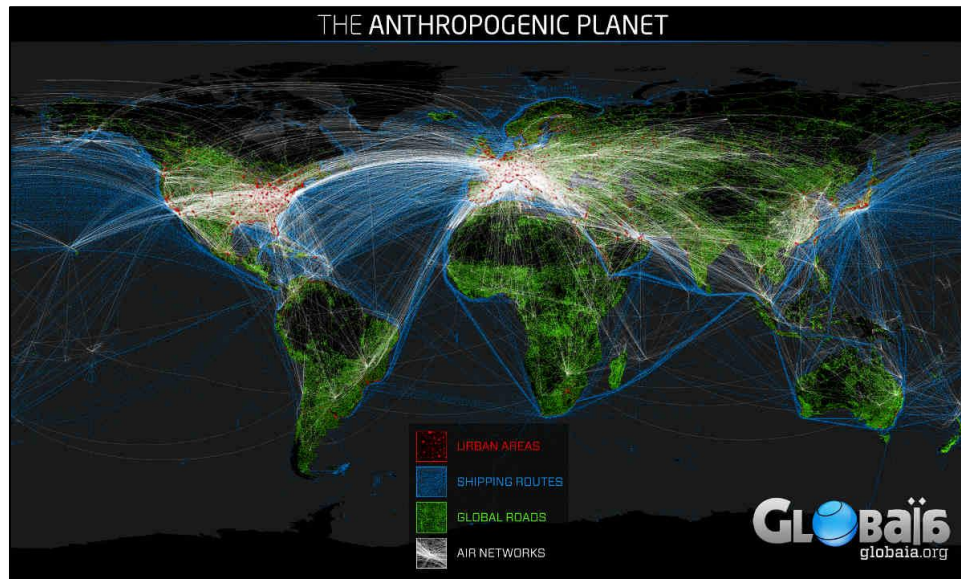


I acknowledge the Traditional Custodians of the land on which this work was completed and their strong connections to land, sea and community. I pay my respects to their Elders past, present & emerging.



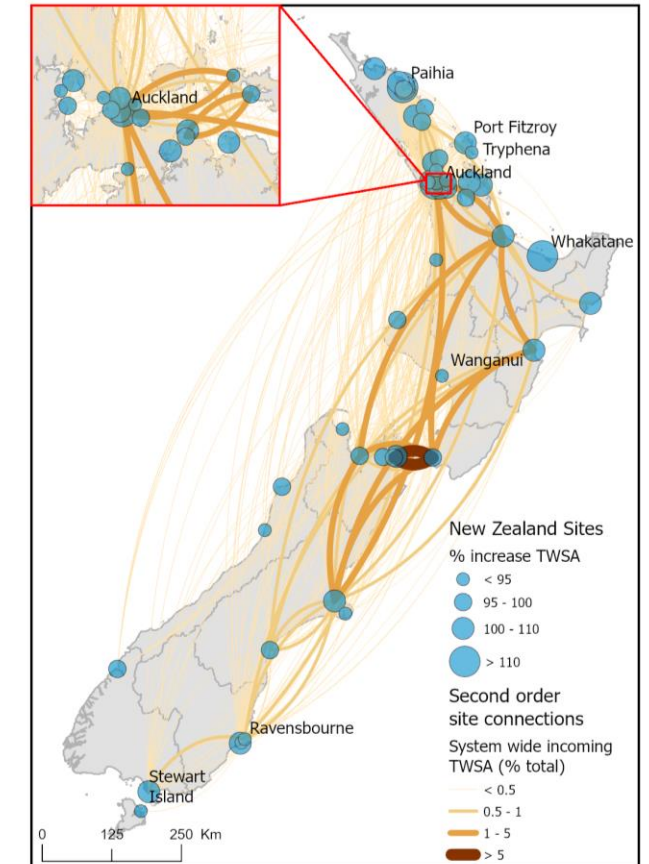
eDNA for Marine Biosecurity pests & disease management

- **Anthropocene** characterised by increased trade and travel
- **Maritime transport network** consists of 80% global trade
- Marine pests and disease incursion **risks dramatically increases**
- Biodiversity and socioeconomic **impacts can be severe**



Shipping density data adapted from National Center for Ecological Analysis and Synthesis

C. Second Order Upstream TWSA Exposure Risk



Faubel et al. in prep

eDNA for Marine Biosecurity

... and sampling strategies for early detection

- eDNA detection approaches are uniquely suited for e
- “how, when, and where to sample ...”
- “Increase detections... increase sample volume...”
- “understanding eDNA transport...”
- “sample further... more...”
- “decay... shedding... impacts long term detectability...”
- “eDNA dispersion... and sampling designs...”
- “eDNA attribution to vessel sources...”
- “... assess the effect of water volume...”
- “underscore the importance of proactive monitoring”

Keynote Presentation

Maximising eDNA's Informativeness for Marine Monitoring

Katrina West

Exploring environmental DNA transport v
biophysical models to enhance box jellyfis
detections

Scott Morrissey

Persistence and Decay of Environmental DNA
in Freshwater and the Implications for Weed
Biosecurity

Karen ... (via video link)

Research horizons for invasive marine species
detection with eDNA/eRNA

Michael Marnane

One size doesn't fit all: Tailoring eDNA
methodologies for marine biosecurity in data-
poor regions

Eva Aylagas

Early Detection of the 5th Crown-of-Tho
Seastar Outbreak on the C
Specific eDNA Marke

Sven Uthicke

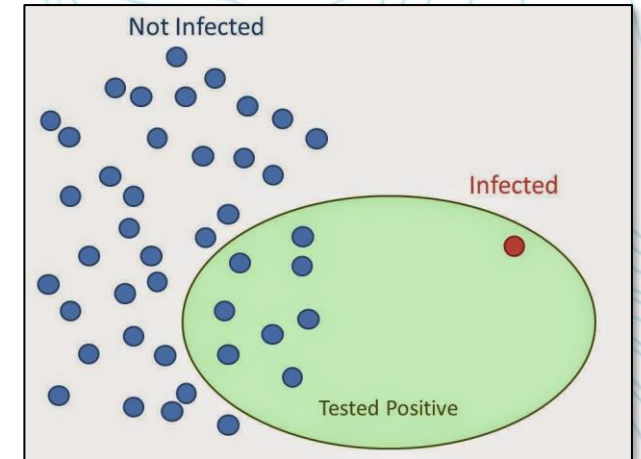
Sampling Approaches and Designs Using
Environmental DNA & RNA for Marine Biosecurity Spec

Surveillance
Michelle Scriver

eDNA for Marine Biosecurity

increasing detection likelihoods (& false positive paradox)

- **But, rare events** (incursions) lead to base rate fallacy and the false positive paradox (high false positives) – when a true detection is low (rare), ***the likelihood that a positive detection is false is inflated.***
- **May require false positive tolerance** and clear communication.
- ***Maximise true positives (sensitive) while limiting false negatives***



Environmental DNA

Open Access

Dedicated to the study and use of environmental DNA for basic and applied sciences

PERSPECTIVE | Open Access |

What do you mean by false positive?

John A. Darling, Christopher L. Jerde , Adam J. Sepulveda

First published: 02 May 2021 | <https://doi.org/10.1002/edn3.194> | Citations: 11

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ORIGINAL ARTICLE | Open Access |

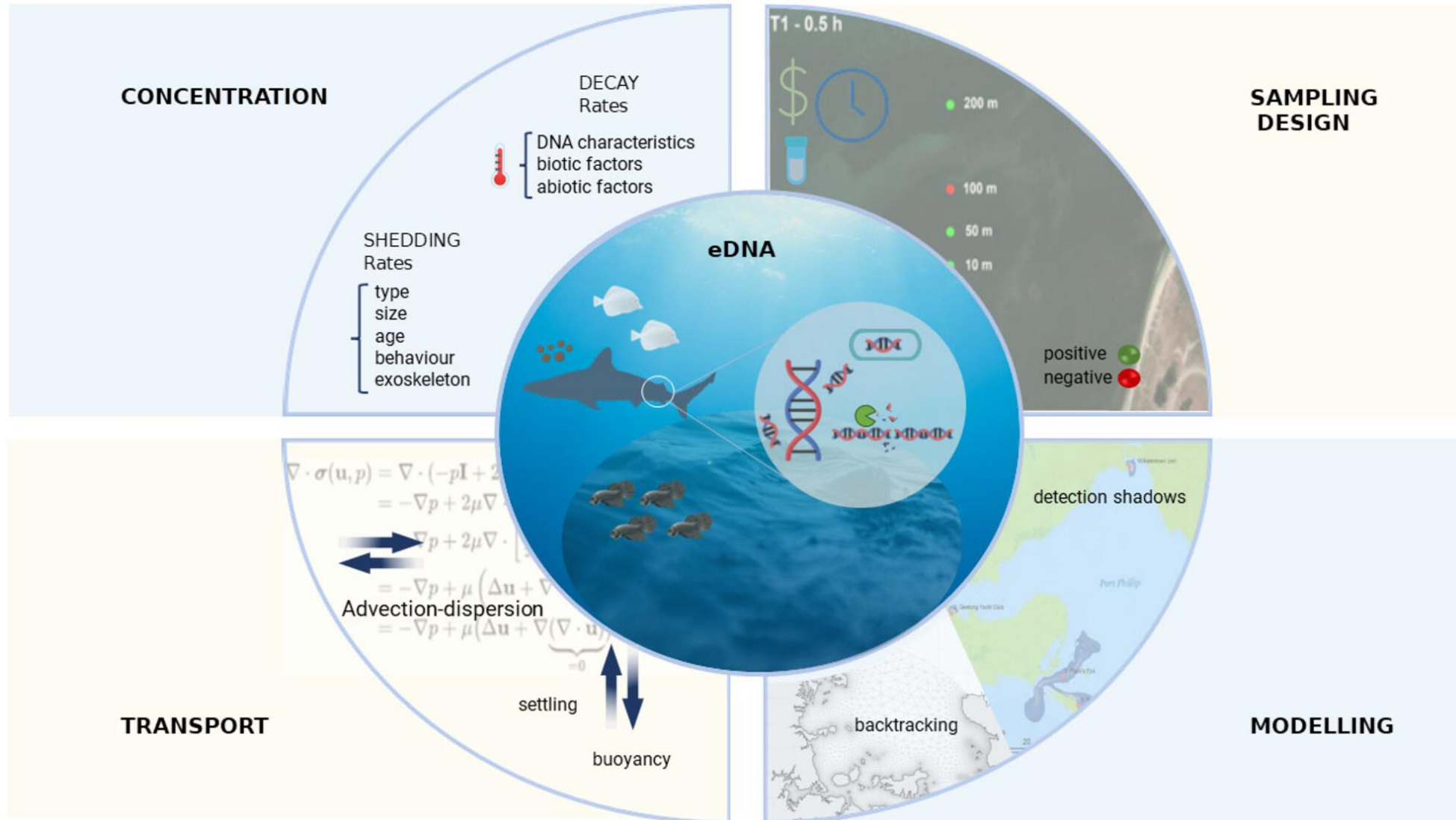
Accounting for false positive detections in occupancy studies based on environmental DNA: A case study of a threatened freshwater fish (*Galaxiella pusilla*)

Reid Tingley , Rhys Coleman, Nathaniel Gece, Anthony van Rooyen, Andrew R. Weeks

First published: 07 August 2020 | <https://doi.org/10.1002/edn3.124> | Citations: 5

eDNA for Marine Biosecurity

Aim: increasing detection likelihoods with improved sampling



eDNA for Marine Biosecurity

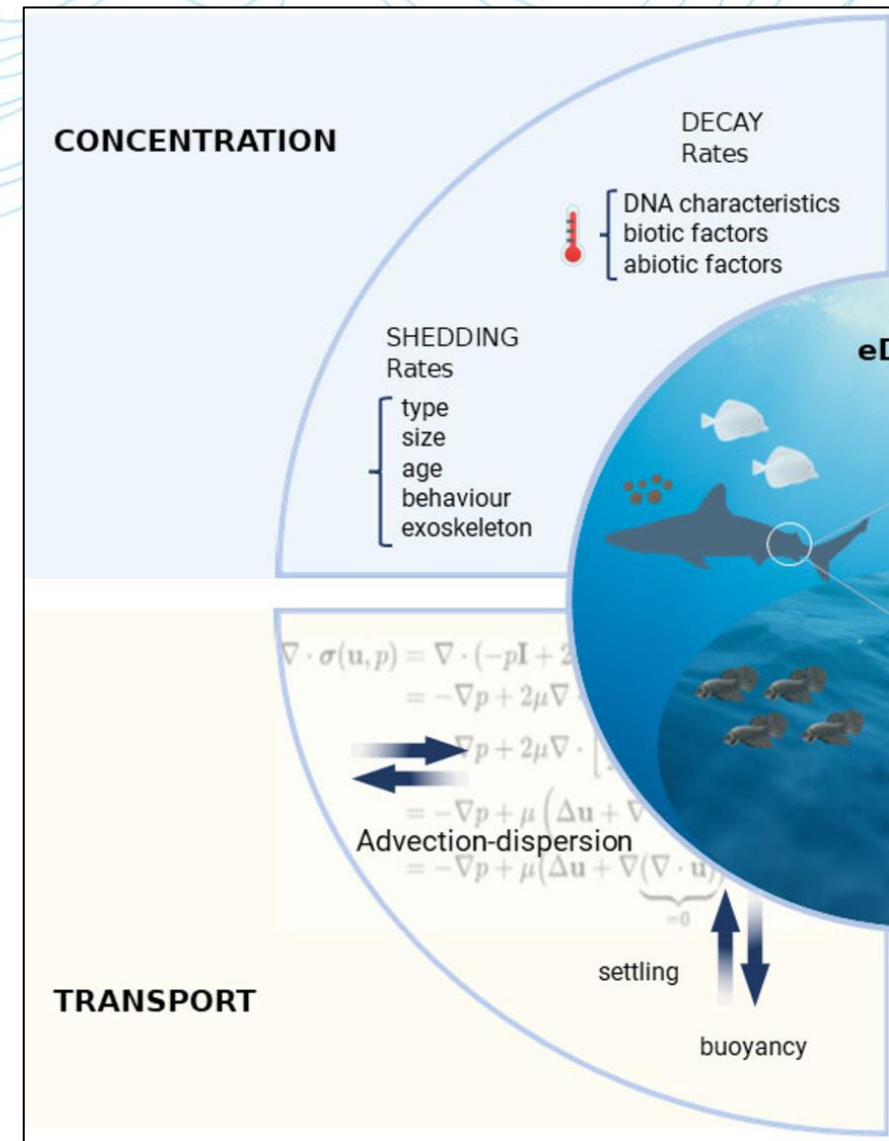
eDNA Concentration & Transport

Shedding & Decay (eDNA Concentration)

- Heterogeneous composition (free, tissue...)
- Life-stage and species-specific (major unknown)
- Decay is fast with half-life \sim 1-2 days.

eDNA 3D Transport

- Location and depth of release, buoyancy
- Waves, tides, winds, Ekman, stratification
- Spatial-temporal variability in movement



All impacts detection!

eDNA for Marine Biosecurity

Field Sampling Design

To review our understanding of spatiotemporal dynamics

- Review of past 10 years of studies
- Clear description of “site” and “sample” levels
- Maximising true positives (species detections)
- Some guidance exists (controls, replicates, volume...)
- Spatial and temporal sampling strategies are needed

Results:

- 500 to 50,000 km² extent, 100 samples /study
- Geographic pattern analysis, less temporal
- Single depth sampling (65%), some multi-depth
- No cohesive/ justified sampling strategy or protocol exists.

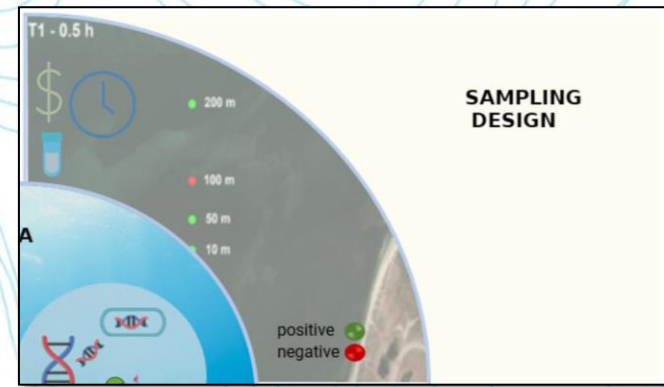


TABLE 1 | Summary of eDNA studies over the past 10 years (excluding reviews)

| Reference | Scope of study | Number of filters |
|--------------------------|------------------------------------------------------|-------------------|
| Takahara et al. (2012) | Fish biomass | 10–50 |
| Weltz et al. (2017) | Native species detection | < 10 |
| Furlan et al. (2019) | Invasive species detection | 100–200 |
| Murakami et al. (2019) | Detection & temporal experimental | 100–200 |
| Antich et al. (2021) | Monitoring | 10–50 |
| Ely et al. (2021) | NIS species detection | 50–100 |
| Schwentner et al. (2021) | Native species monitoring/ multispecies detection | 10–50 |
| Tingley et al. (2021) | Experimental | 10–50 |
| West et al. (2021) | Monitoring | > 200 |
| Coutts et al. (2022) | Restoration | 100–200 |
| Ellis et al. (2022) | Invasive species detection | 50–100 |
| Jensen et al. (2022) | Native multispecies detection | 50–100 |
| Uthicke et al. (2022) | Native species monitoring | 10–50 |
| Von Ammon et al. (2022) | Native multispecies detection | 100–200 |
| Alexander et al. (2023) | Native multispecies detection | 100–200 |
| Zaiko et al. (2023) | NIS species detection | 100–200 |

Note: We present study attributes related to the scope of the study, number of water filters use location where water samples were taken regardless of the design or number of replicates) with points included in the sampling design.

eDNA for Marine Biosecurity

Biophysical modelling

Approach

Empirical Data

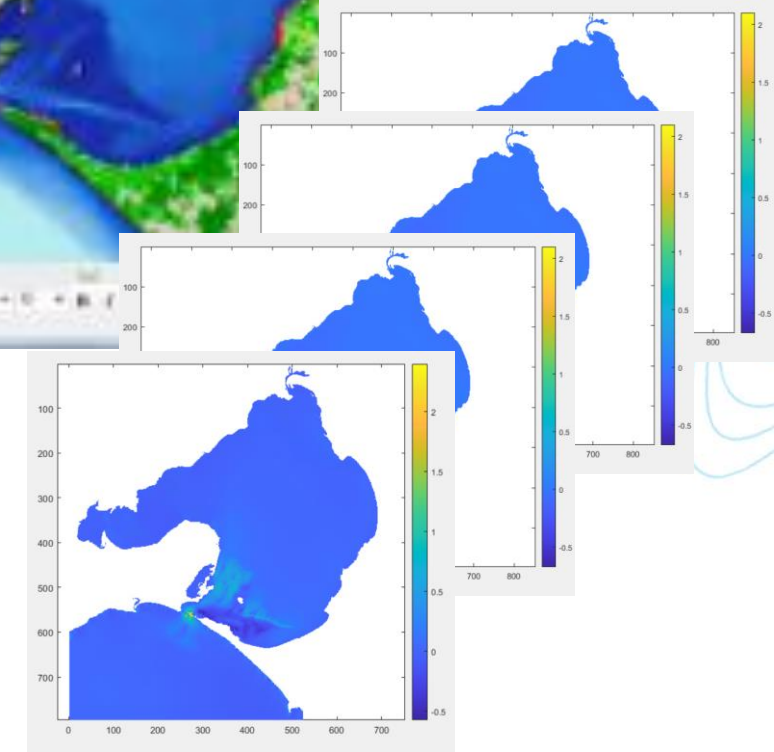
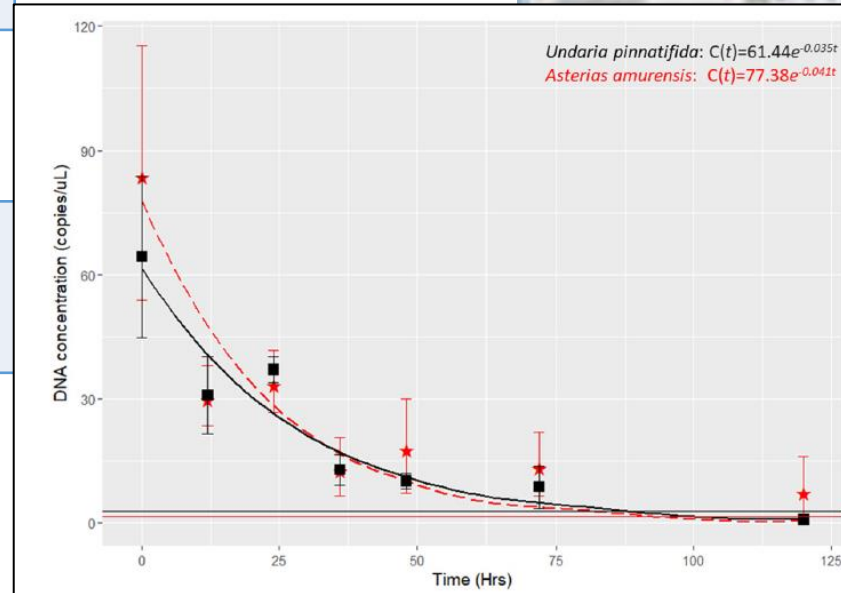
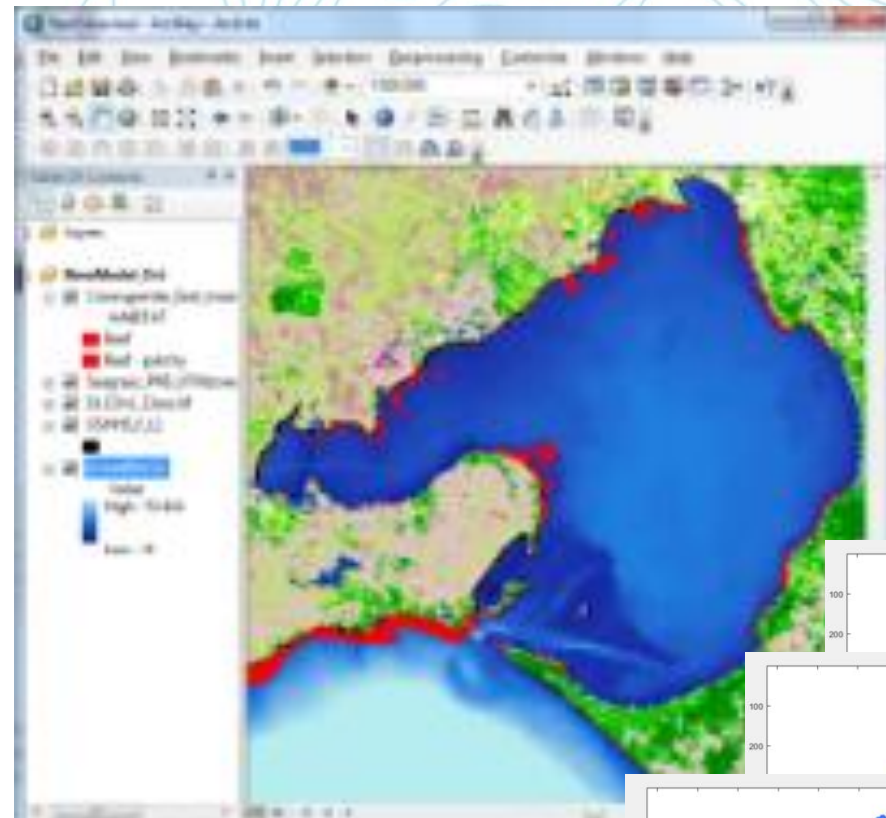
Decay rates

eDNA “behaviour”

Buoyancy

Initial concentration
/ abundance

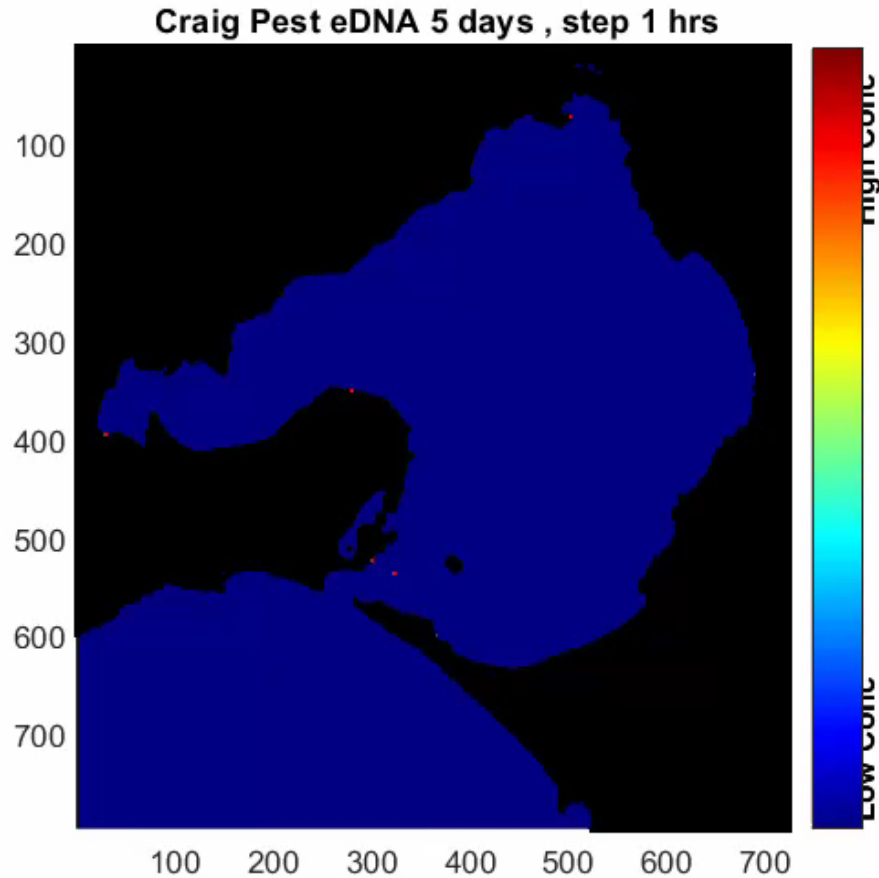
eDNA release /
shedding properties



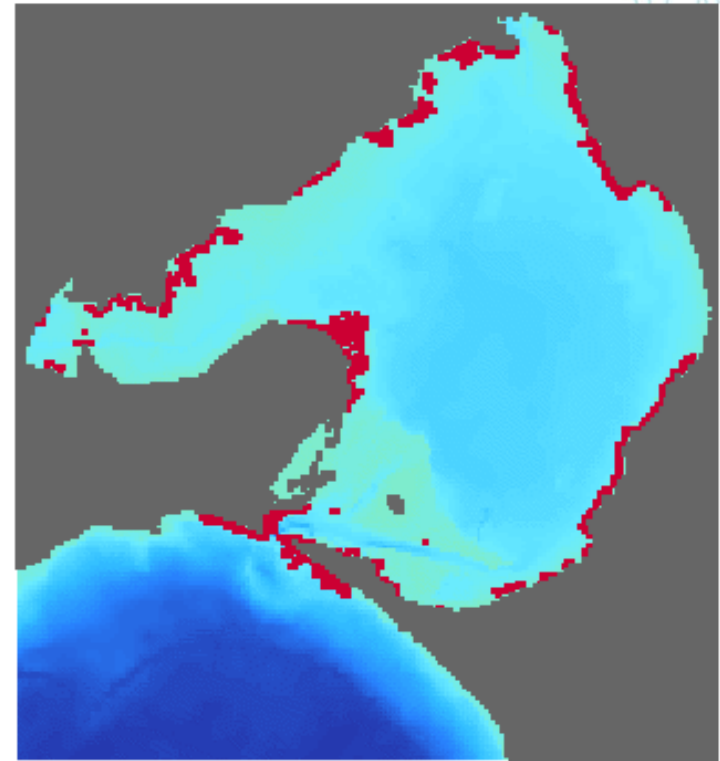
eDNA for Marine Biosecurity

Biophysical modelling (*< 10 studies to date*)

$$\frac{\partial N}{\partial t} = -u \frac{\partial N}{\partial x} - v \frac{\partial N}{\partial y} + K \left(\frac{\partial^2 N}{\partial x^2} + \frac{\partial^2 N}{\partial y^2} \right) - \mu N$$



Passive Behaviour (day 0.0)

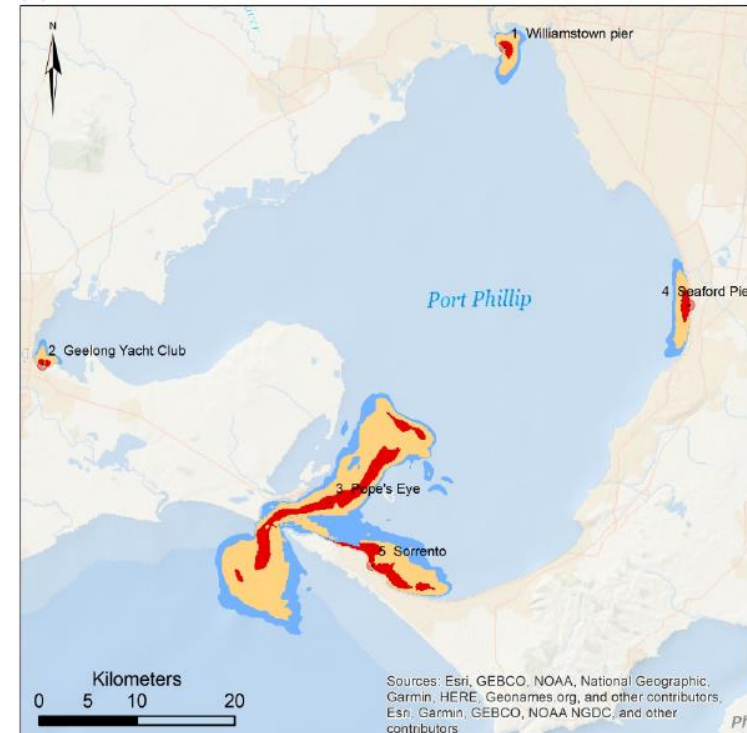
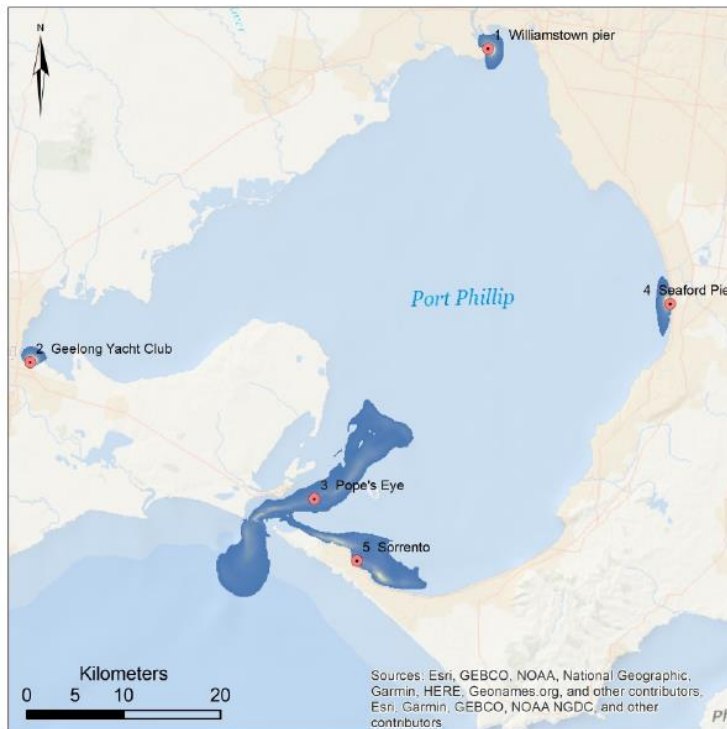


eDNA for Marine Biosecurity

Biophysical modelling: *Variability in eDNA footprint*

To understand spatial-temporal variability

- **Result:** 2-10 km eDNA footprint; similar across species, extreme variance.
- **Impact:** frequent alongshore transport, 15 km max extent.



eDNA for Marine Biosecurity

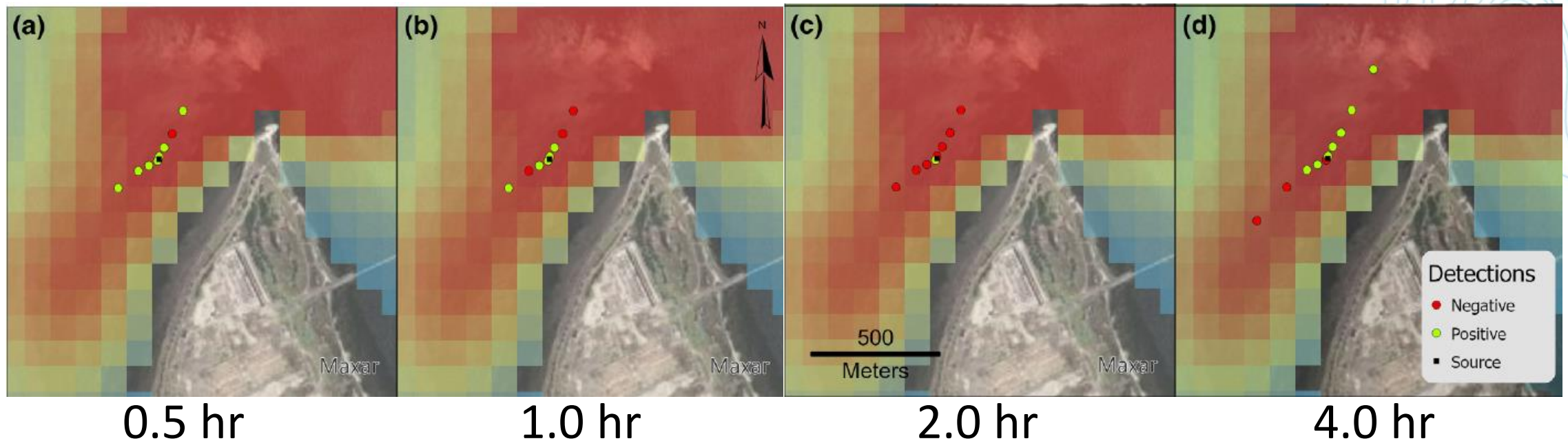
Biophysical modelling: *Field sampling and false negatives*



Louis Jones

Empirical test of field sampling and false negatives

- **Approach:** Known source, known hydrodynamics, stratified sampling.
- **Result:** 40% false negatives in samples per site (up to 87% per period).
- **Impact:** More samples and water-column sampling reduces false-negatives.

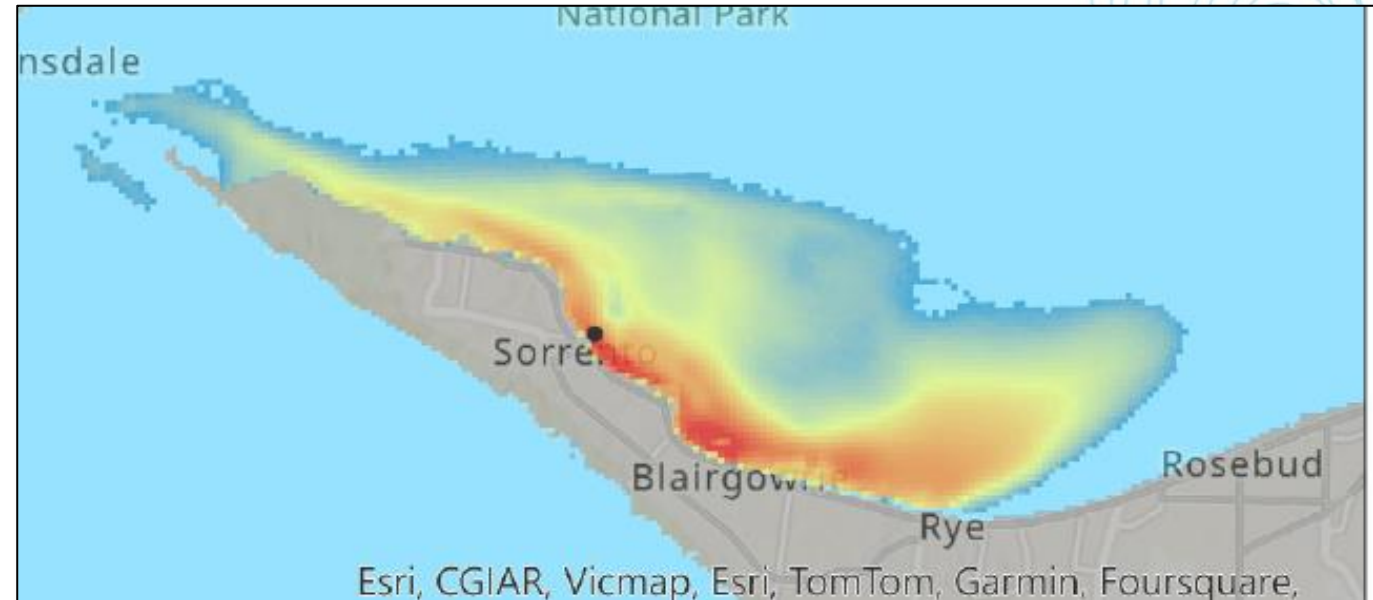
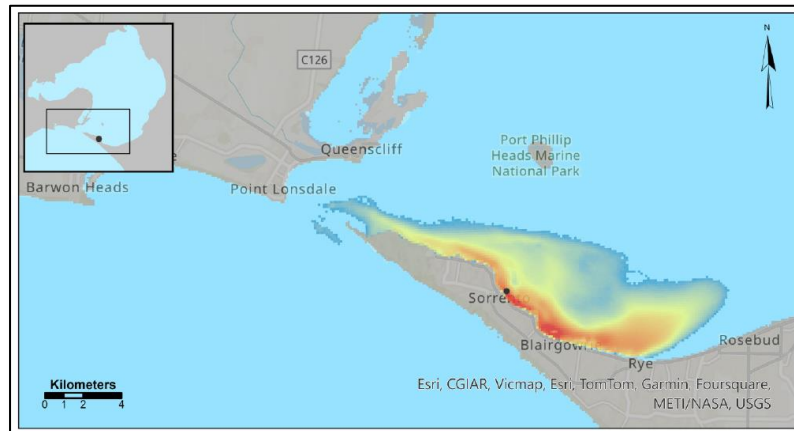


eDNA for Marine Biosecurity

Biophysical modelling: *Backtracking to identify sources*

To identify potential DNA sources to water sample...

- **Approach:** OceanTracker with reversed physics backtrack from water sample
- **Result:** Source probability heatmap, 15 km extent alongshore .
- **Impact:** Understanding seascape extent (*source attribution*) of water sample.



eDNA for Marine Biosecurity

Management and Surveillance Recommendations

Rec I: Sampling should **include the water column**... buoyance and water flow may have strong impact.

Rec II: A well-designed spatial sampling strategy should work for **multiple species**... given similarity in decay rates.

Rec III: Shore-based and **alongshore sampling** should be effective for many coastal taxa.

Rec IV: Surveillance with **backtracking** can help understand spatial-extent of **potential false negatives**.

Rec V: Coupling biophysical modelling within the field sampling strategy will help **optimise effort and minimise false negatives**.

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Environmental DNA

REVIEW **OPEN ACCESS**

Current Trends in Biophysical Modeling of eDNA Dynamics for the Detection of Marine Species

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