Tracking the impacts of sewage overflows on ecosystem function using novel techniques

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Estuaries

- Among most productive and diverse ecosystems in the world
- Most impacted of coastal habitats (Clark et al., 2015).
- Subject to multiple anthropogenic pressures
  - Habitat loss, contamination by pollutants

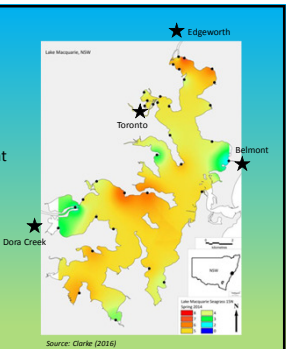
Source: Clarke (2011)

Sewage Pollution

- Increased urbanisation has led to sewage becoming a major stressor
- Impacts of sewage pollution
  - Alter structure and function of biological communities → repercussions for entire ecosystem
- Difficult to assess ecological impacts
  - Past focus on water quality alone

Lake Macquarie

- Largest estuary in NSW
- Extensive shoreline and catchment development
- Hunter Water
  - Four wastewater treatment works servicing Lake Macquarie
- Previous research found evidence of ongoing sewage inputs at specific locations around the lake
  - Ideal system to investigate impacts of sewage pollution



Source: Clarke (2016)

Stable Isotope Analysis

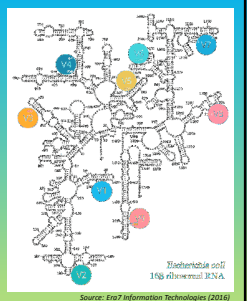
- Provides a tool to identify nitrogen sources based on characteristic nitrogen isotope values
- Sewage derived nutrients distinguishable on the basis of ratios of nitrogen ($^{15}N/^{14}N$) isotopes
- Secondary treatment of sewage enriches concentration of ^{15}N (Gaston et al., 2004).
  - Results in enriched $\delta^{15}N$ signature

Benthic Macroinvertebrates

- Most widely used bioindicators
  - Reliable and often predictable responses to anthropogenic pollution
- Moderate pollution → elimination of sensitive taxa and dominance of tolerant taxa with high densities (Dauer & Conner, 1980).

Benthic Microbial Communities

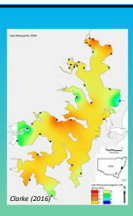
- High potential as bioindicators in coastal systems
  - Rapid response to environmental disturbances
  - Present in high densities in sediments
- Current knowledge of benthic microbial response to pollutants quite limited
  - 16S rDNA amplicon sequencing!

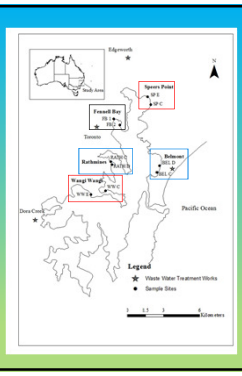


Source: Era7 Information Technologies (2016)

Study Design

- Four locations
  - Impacted and control site within each
- Fennell Bay used as 'true control'
- Sampling carried out over May and July
  - Dry weather sampling → capture background conditions





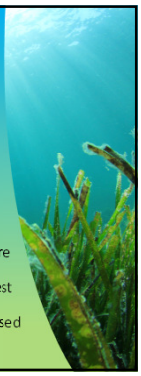
Aims

- Assess the effectiveness of a combination of tools to investigate the ecological impact of anthropogenic pollution in coastal ecosystems
  - 1) Establish if stable isotope signatures of sewage are detectable in organisms
  - 2) Examine how benthic microbial and macroinvertebrate community composition is altered in response to sewage inputs

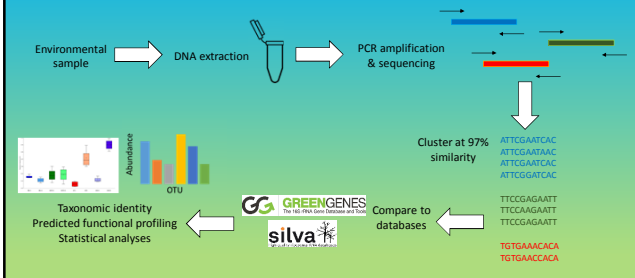
Methodology

- Stable Isotope Analysis
  - Nitrogen taken up first by primary producers
  - Seagrass *Zostera capricorni* & associated epiphytes

- Macroinvertebrates
  - Sampled from seagrass and bare sediments
  - Counted and identified to lowest possible taxonomic level
  - Abundance and diversity analysed



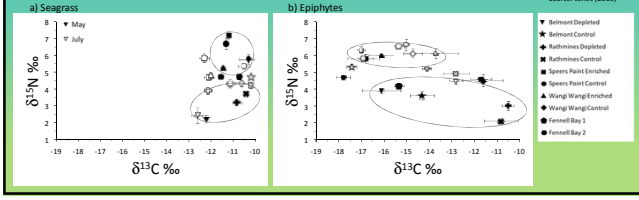
Microbial Communities - 16S Methods



Stable Isotope Data

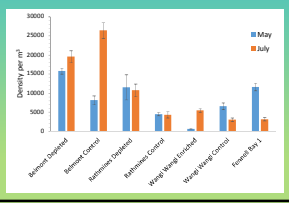
- Seagrass and epiphyte $\delta^{15}N$ reflected inputs of treated and untreated sewage
  - Consistent with previous research

Source: Jones (2016)



Benthic Communities

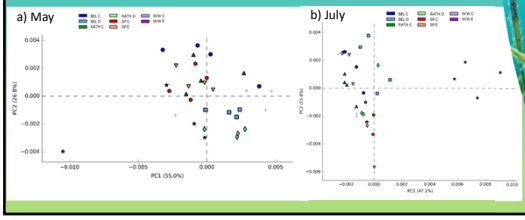
- Macroinvertebrates
  - Overall, strong seasonal and habitat differences, but no significant site differences
  - Closer look at polychaetes revealed site differences

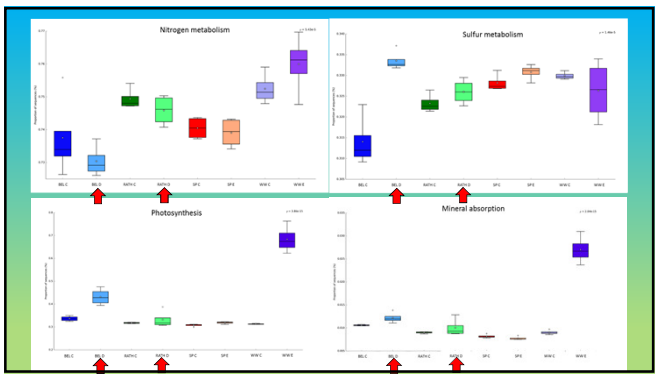


- Microbes
  - Significant seasonal and habitat differences
  - Site differences when habitats examined individually within each time point

Predicted Microbial Function

- Significant differences between sites in bare sediments in May and seagrass sediments in July





Discussion

- Stable isotope analysis
  - Consistent depleted $\delta^{15}N$ signature at Belmont and Rathmines → untreated sewage dominant nutrient source
  - Broader range of $\delta^{15}N$ signature at Speers Point and Wangi Wangi
- Macroinvertebrate communities
  - Greater polychaete densities consistent with continuous input of untreated sewage
  - Polychaetes considered to be one of the most reliable indicators

Microbial Communities

- Most shifts at Belmont and Rathmines sites
- Shifts in communities stronger when exposed to constant than intermittent stress (Birrer et al., 2018).
  - Nitrogen and sulfur have major role in sediment productivity – changes likely to have repercussions for entire ecosystems (Nogales et al., 2011; Birrer et al., 2018).

Summary & Conclusion

- Constant untreated input at Belmont and Rathmines → evidence that these inputs impact benthic communities here
- Rapid urbanisation to coastal systems → need to find practical methodologies to monitor and assess ecological impacts of anthropogenic pollution e.g. sewage
- Integrated use of techniques used provides a tool to rapidly and cost-effectively investigate ecological impact of sewage pollution in coastal systems

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Thank you!