Water quality of the GBR and the Torres Strait: Understanding multiple pressures and cumulative impacts

Britta Schaffelke, AIMS (NERP Water Quality Program Leader)
Multiple pressures affecting our coasts

Higher sea temps  Ocean acidification  More extreme weather  Sea level rise
Water quality influencing many, complex processes

Anthony et al. 2013- report for GBRMPA Strategic Assessment
Open questions → objectives for NERP research

• Investigate the relationship between river discharges and water clarity in the GBR
• Investigate the responses of key marine organisms to cumulative pressures
• Investigate the threats to water quality in the Torres Strait
Research objective:
• investigate the relationship between GBR water clarity and river discharges.
Clear differences in photic depth (water clarity) between seasons

Processed satellite imagery provided by S. Weeks, Uni QLD
Explanatory variables:
water depth, waves and tides, river loads

Logan et al. 2014. NERP Project 4.1 Progress Report: Southern and Northern NRM Regions. AIMS, Townsville
River sediment loads influence water clarity far into the GBR lagoon

- Cross shelf and regional differences

Logan et al. 2014. NERP Progress Report: Southern and Northern NRM Regions. AIMS, Townsville
Objective:
Investigate the responses of key marine organisms to combined water quality and climate pressures

“Further building the resilience of the Great Barrier Reef by improving water quality, (...) will give it the best chance of adapting to and recovering from the serious threats ahead, especially from climate change.”
Combined water quality and climate pressures

Global
- Temperature
- Ocean Acidification

Local
- Nutrients
- Light/Sediments
- Pollution
- Low Salinity
Cumulative pressures

Repeated

Simultaneous

Chronic

Successive

Pulsed/Combined

Example

- Seasonal runoff
- Repeated dredging

- Dredging at 3 locations

- Input of nutrients from discharge

- Cots, cyclone, bleaching

- Temperature increase + nutrient runoff
- Ocean acidification + trawling
- Chronic nutrient input + dredging
95 day exposure to:
sediment, organic enrichment & nitrate

Corals exposed to organically-enriched suspended sediments bleach more easily and die at high temperatures than those grown in water with low nutrients.

Fabricius, Cséke, Humphrey, De’ath (2013), PLoS ONE
Atrazine 4% damage

- 26
- 28
- 30
- 32

Fv/Fm

- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 0.6
- 0.7

- 4.5 µg l⁻¹
- 12 µg l⁻¹

Temp.*Conc. p < 0.05

Temperature

Herbicide

Combined damage of 41%
= Synergistic Interaction
= Greatest problem when high temp & herbicides are combined

Temperature damage
- 22% damage

Temperature

0 µg⁻¹ atrazine
- 0.7
- 0.6
- 0.5
- 0.4
- 0.3
- 0.2
- 0.1

4.5 µg l⁻¹

12 µg l⁻¹

Temp.*Conc. p < 0.05

Temperature (°C)
Seagrass

Effect Size (% Reduction compared to Control)

- Effect of Temperature
- Effect of Light
- Combined
**Accumulative effects (chronic)**

*Long seagrass exposure to herbicides*

**Chronic exposure experiment (11 wks):**
- 2 seagrass species
- 4 diuron treatments
- Measure: photosynthesis, growth, energetics

---

**Cumulative mortality - *H. uninervis***

<table>
<thead>
<tr>
<th>Time (days)</th>
<th>Cumulative mortality from time 0 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>80</td>
<td>0</td>
</tr>
</tbody>
</table>

---

**% Inhibition (Ф/Fm’)**

- **0 g l⁻¹**
- **2.4 g l⁻¹**
- **0.9 g l⁻¹**
- **0.5 g l⁻¹**

---

**Exposure time (days)**
**Accumulative** effects (chronic)

- Impacts become more severe over time
- Long term effects on energy storage are identical to low light stress (effects are likely to combine)
Reduce pollution to protect from other pressures

Pollutant increase

X µg/L

32°C

Current threshold for Coral bleaching (no cumulative pressures)

30.5°C

Reduced threshold (in a cumulative scenario)

0 µg/L

Quantify to develop management targets for pollution
Include the reality of cumulative pressures in water quality guidelines and thresholds

Current 99% species protection guideline (no cumulative pressures)

99% species protection “Climate adjusted threshold) (in a cumulative scenario)
Objective:
Investigate threats to water quality in the Torres Strait

Butler et al, unpublished data.
Water quality threat analysis - local

- Ship groundings, oil spills, toxic cargoes:
  - large ships, increasing numbers
  - Limited exchange in and out of Torres Strait, polluted water would probably remain in TS for long time.
  - Ship grounding and oil spill on island/reef in TS catastrophic for small island communities. Limited response capability.

- Localised issues with management of
  - wastewater (sewage, marine outfalls) and
  - general waste (rubbish).
Water quality threats - regional

- Marine litter (ghost nets, plastic)
- Influence of large developments in PNG (continued Ok Tedi operation, gas platforms, oil palm expansion and Daru port development), likely to be restricted to the northern islands – Boigu, Saibai, Erub and Ugar.
  - Water from the Fly River predominantly moves to the east into the northern Coral Sea
  - The currents in this western region are generally from east to west
Current Project- heavy metal monitoring *

- Last heavy metal monitoring done 20 years ago.
- Will help understand the risks to Torres Strait sea country from future large scale development in PNG.

Activities:
- Measure how far heavy metals in Fly River are carried into the Torres Strait
- Use passive samplers (DGTs- Diffusive Gradients in Thin Films)

*Funded by the Torres Strait Regional Authority
Water quality research in the NERP—what did we achieve

- Better understanding of
  - scale of water quality pressures
  - Interactions between water quality (local) and climate change (global) pressures

- Developed systems and techniques to
  - Quantify and attribute changes in water quality
  - Assess responses of marine organisms to cumulative pressures
  - Conduct ecologically relevant ecotox tests

- Our data and knowledge informed major policy background documents:
  - Reef Plan Scientific Consensus Statement and associated risk assessments
  - Revision of water quality guidelines (ANZECC and GBRMPA)
  - GBRMPA Outlook Report
  - GBR Strategic Assessment
Future direction: Cumulative impacts – from effects to predictions

- **Shapes of response curves**: climate change and local pressure variables on more levels
- Effects of flood plumes, dredging (light/sedimentation): **magnitude** of disturbance vs **variability**
- Verify effects/relationships in the **field**
- **Combine data into predictive ecosystem-scale models**
- Acclimatisation/Adaptation → **Multi-generational** experiments
- “Climate-adjusted” thresholds for pollutants/runoff
- **Markers for exposure**: new indicators for monitoring
- **Emerging pollutants**: new herbicides, micro-plastics, coal dust
Marine ‘grand challenges’

1. Sovereignty, security, natural hazards
2. Energy security
3. Food security
4. Biodiversity conservation and ecosystem health
5. Dealing with changing climate
6. Optimal resource allocation
7. Urban coastal environments
8. Infrastructure

OPSAG = National Marine Science Committee
THANK YOU

NERP project teams:

Katharina Fabricius, Murray Logan
Sven Uthicke, Catherine Collier, Andrew Negri
Jon Brodie, Jane Waterhouse
+ students & technical staff

Torres Strait Regional Authority
Torres Shire Council
Torres Strait Islands Regional Council
+ many Torres Strait island residents