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Coral Reef Ecotoxicology – An Australian's Perspective

Andrew Negri
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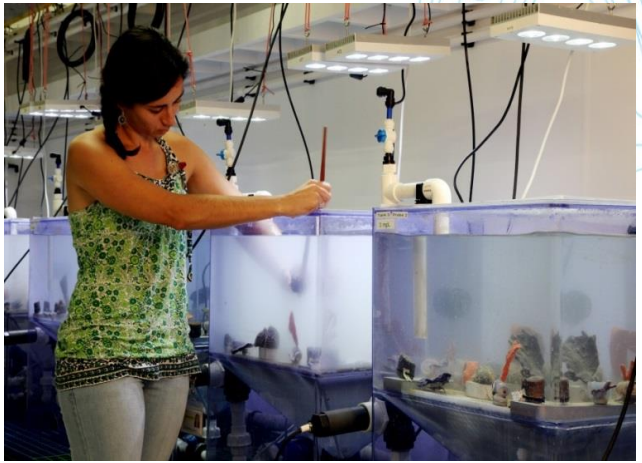
AIMS: Australia's tropical marine research agency.

AIMS - Australia's Tropical Marine Research Agency

- 250 staff, 20 PostDocs, 80 PhD students
- Publicly funded
- Servicing government, industry and community need



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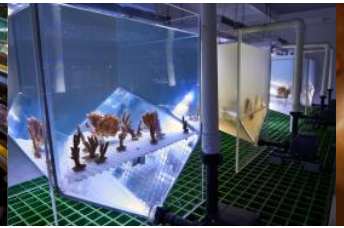
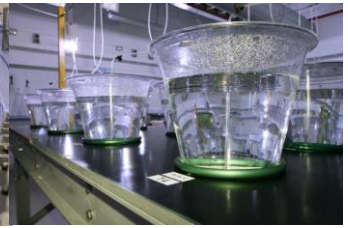
The National Sea Simulator

https://www.aims.gov.au/seasim

World's most advanced research aquarium facility

- Used to investigate impacts of :
  - Dredging,
  - Hydrocarbons, pesticides, metals, nutrients
  - Climate change
  - Crown-of-thorns
- Reef restoration

Pollution and the Great Barrier Reef

- Metals
- Sediments
- Petroleum hydrocarbons
- Personal care products
- Nutrients
- Coal
- Pesticides
- Microplastics

Pergamon

Marine Pollution Bulletin Vol. 41, Nos. 7–12, pp. 428–434, 2000

Printed in Great Britain
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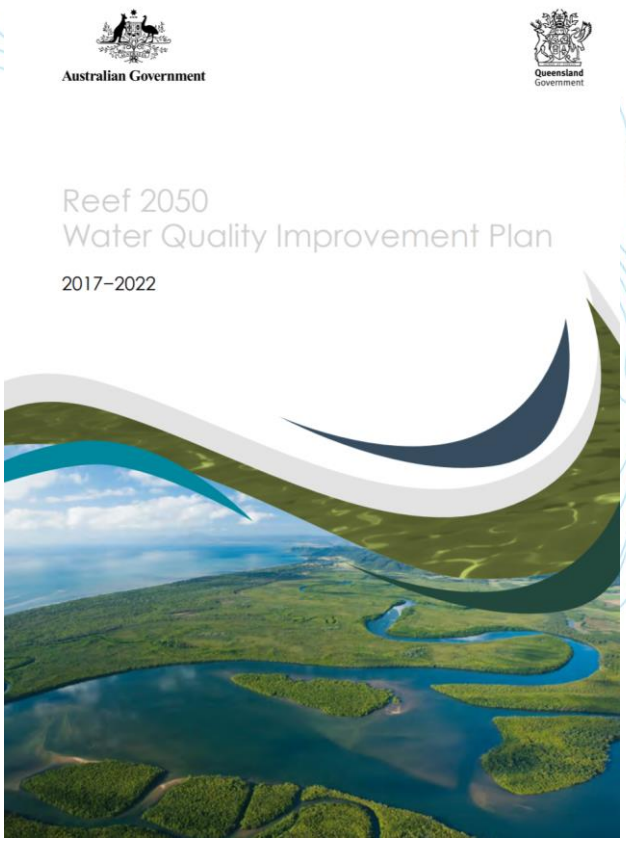
Water Quality in the Great Barrier Reef World Heritage Area: Past Perspectives, Current Issues and New Research Directions

DAVID HAYNES* and KIRSTEN MICHALEK-WAGNER
Great Barrier Reef Marine Park Authority, 2-68 Flinders Street, P.O. Box 1379, Townsville 4180, Qld, Australia

Priority pollutants for Australian coral reefs (GBR)

- Metals
- Sediments
- Petroleum hydrocarbons
- Personal care products
- Nutrients
- Coal
- Pesticides
- Microplastics



https://www.reefplan.qld.gov.au/

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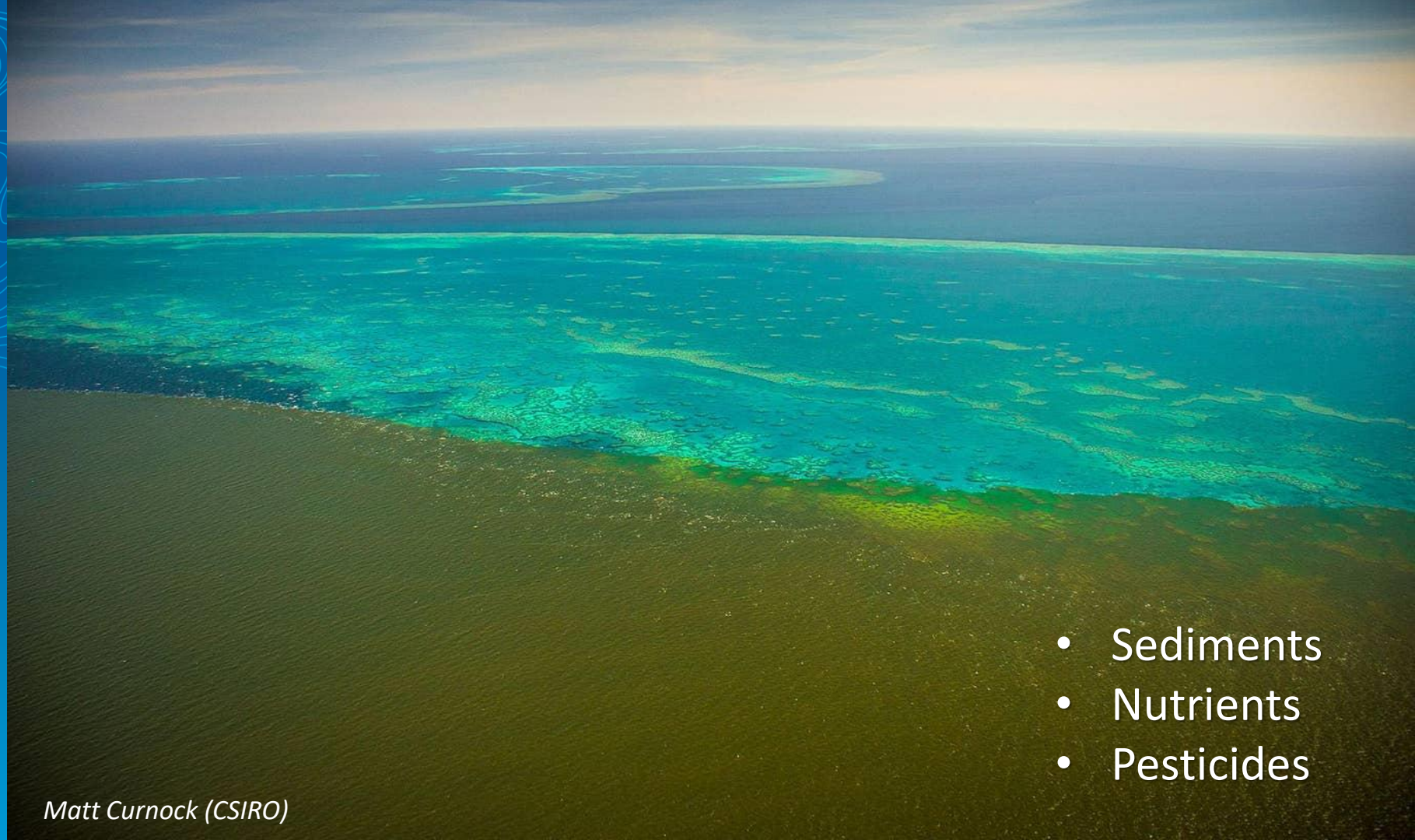

Matt Curnock (CSIRO)

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Other priority pollutants for Australian coral reefs

- Oil spills (rare but can be catastrophic)
- Antifoulants (ship groundings)

UV filters and Australian swimmers

- Freshwater reservoir
- 70 swimmers
- Up to 7.3 µg/L

1. OC: octocrylene
2. BMDBM: avobenzone
3. 4-MBC: 4-methylbenzylidene camphor
4. BP3: 2-hydroxy4-methoxybenzophenone
5. BP1: 2,4-dihydroxybenzophenone
6. BP8: benzophenone 8
7. PB4: benzophenone 4

Science of the Total Environment 754 (2021) 142373

Contents lists available at ScienceDirect

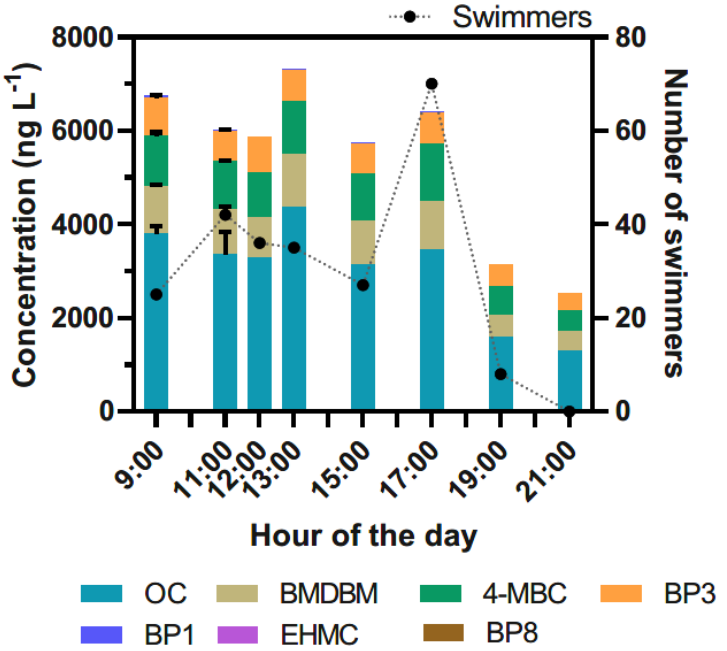
Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

The presence of selected UV filters in a freshwater recreational reservoir and fate in controlled experiments

Elissa O'Malley [a,*], Michael S. McLachlan [b], Jake W. O'Brien [a], Rory Verhagen [a], Jochen F. Mueller [a]

[a] Queensland Alliance for Environmental Health Sciences (QAEHS), The University of Queensland, Brisbane, Australia
[b] Department of Environmental Science (ACES), Stockholm University, Stockholm, Sweden



UV filters and Australian coral reefs

Science of the Total Environment 719 (2020) 135140

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Review

Sources, presence and potential effects of contaminants of emerging concern in the marine environments of the Great Barrier Reef and Torres Strait, Australia

Frederieke J. Kroon [a,*,1], Kathryn L.E. Berry [a,b], Diane L. Brinkman [a], Rai Kookana [c], Frederic D.L. Leusch [d], Steven D. Melvin [d], Peta A. Neale [d], Andrew P. Negri [a], Marji Puotinen [e], Jeffrey J. Tsang [f], Jason P. van de Merwe [d], Mike Williams [c]

- No monitoring data
- 2 M visitors GBR/year
- Possible maximum 700 visitors per reef site
- Possible concentrations?

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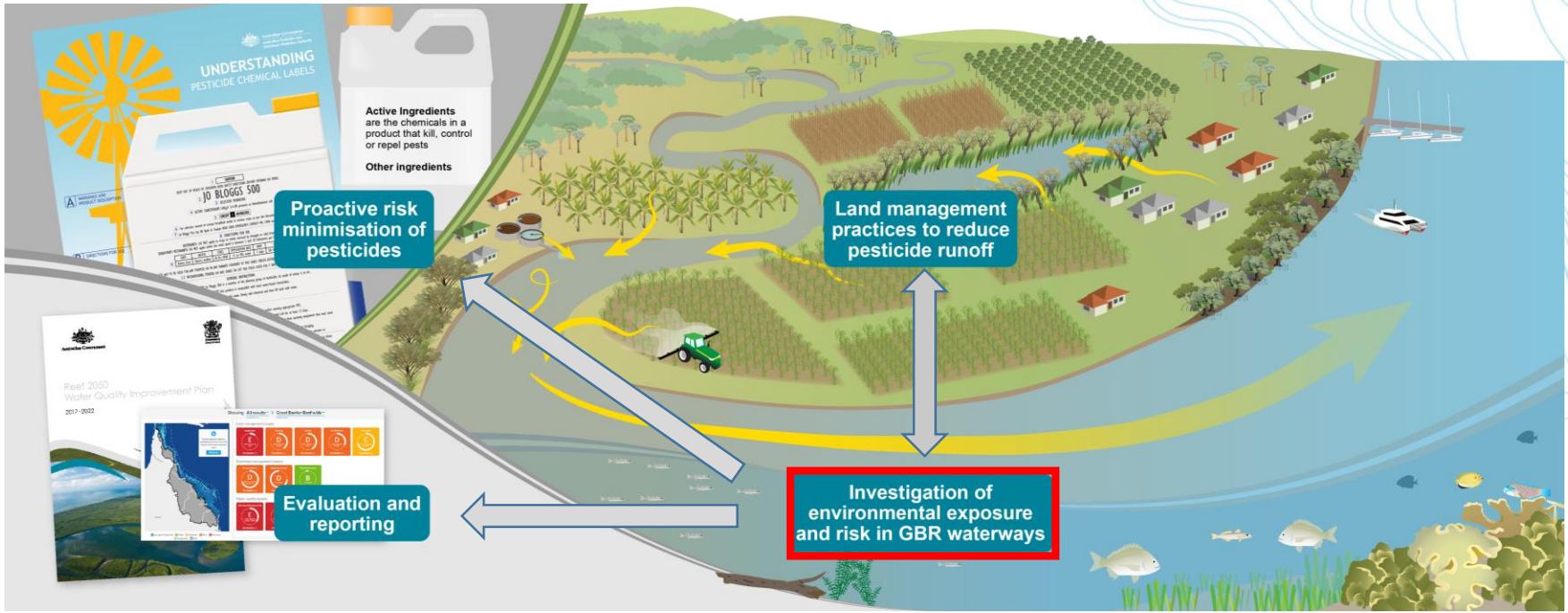
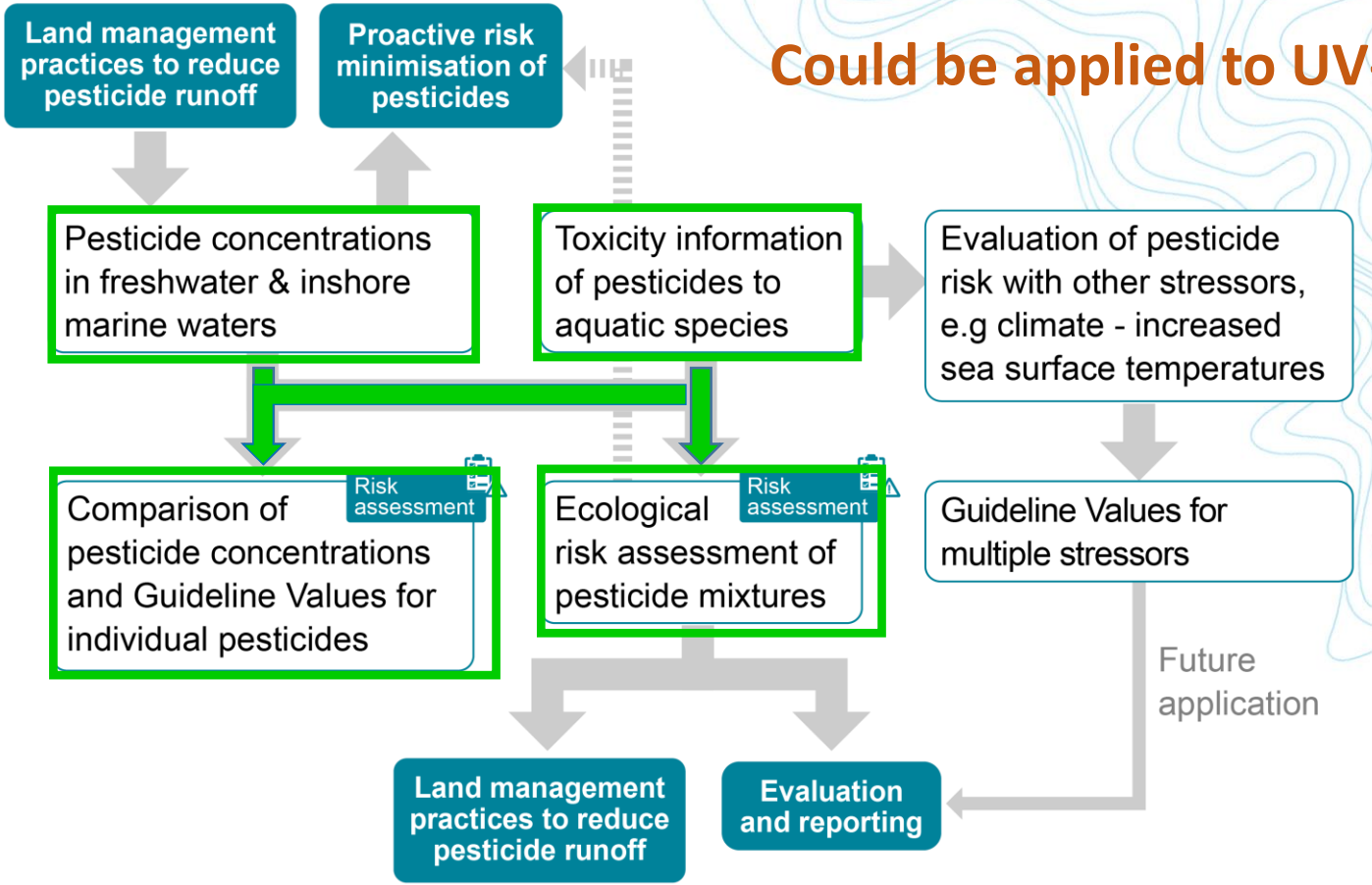
Australian approach: Integrated pollution management

Pesticide management



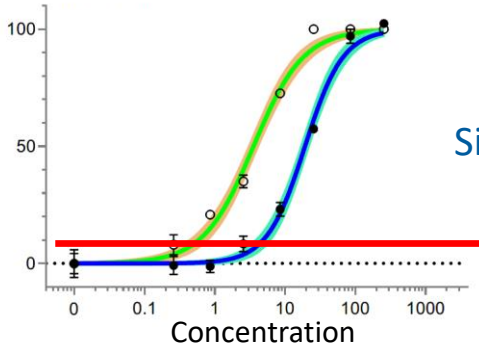
https://synthesis.nesptropical.edu.au/pesticides/pesticide-management/

Could be applied to UV-filters



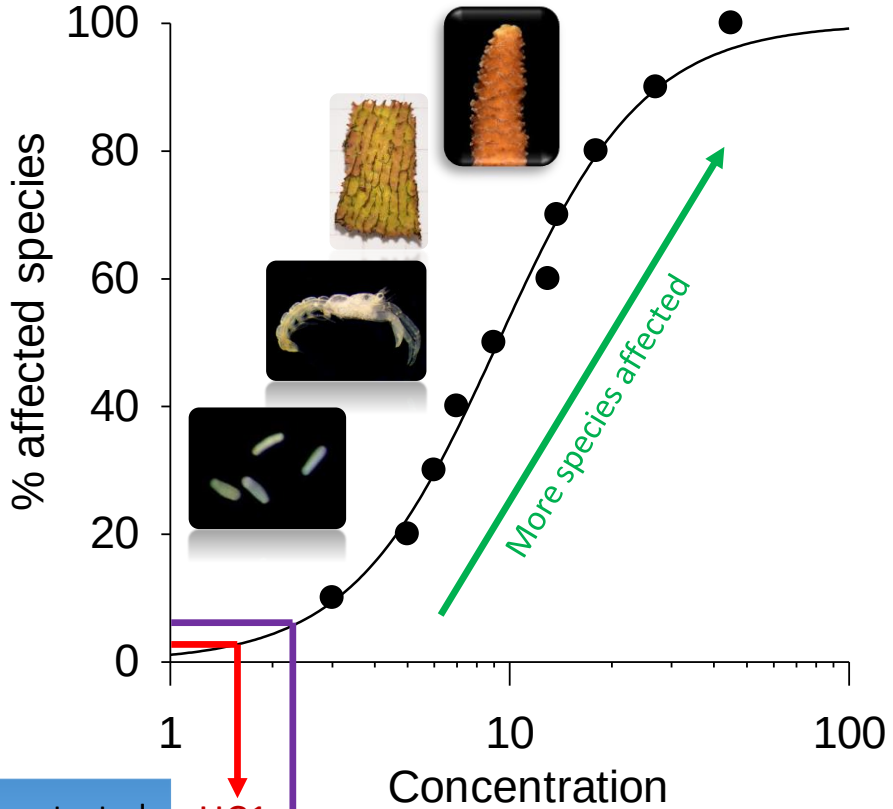
https://synthesis.nesptropical.edu.au/pesticides/pesticide-management/

Toxicity threshold for risk assessments



Thomas et al. Sci. Rep. 10, 7612

Single species tests EC10



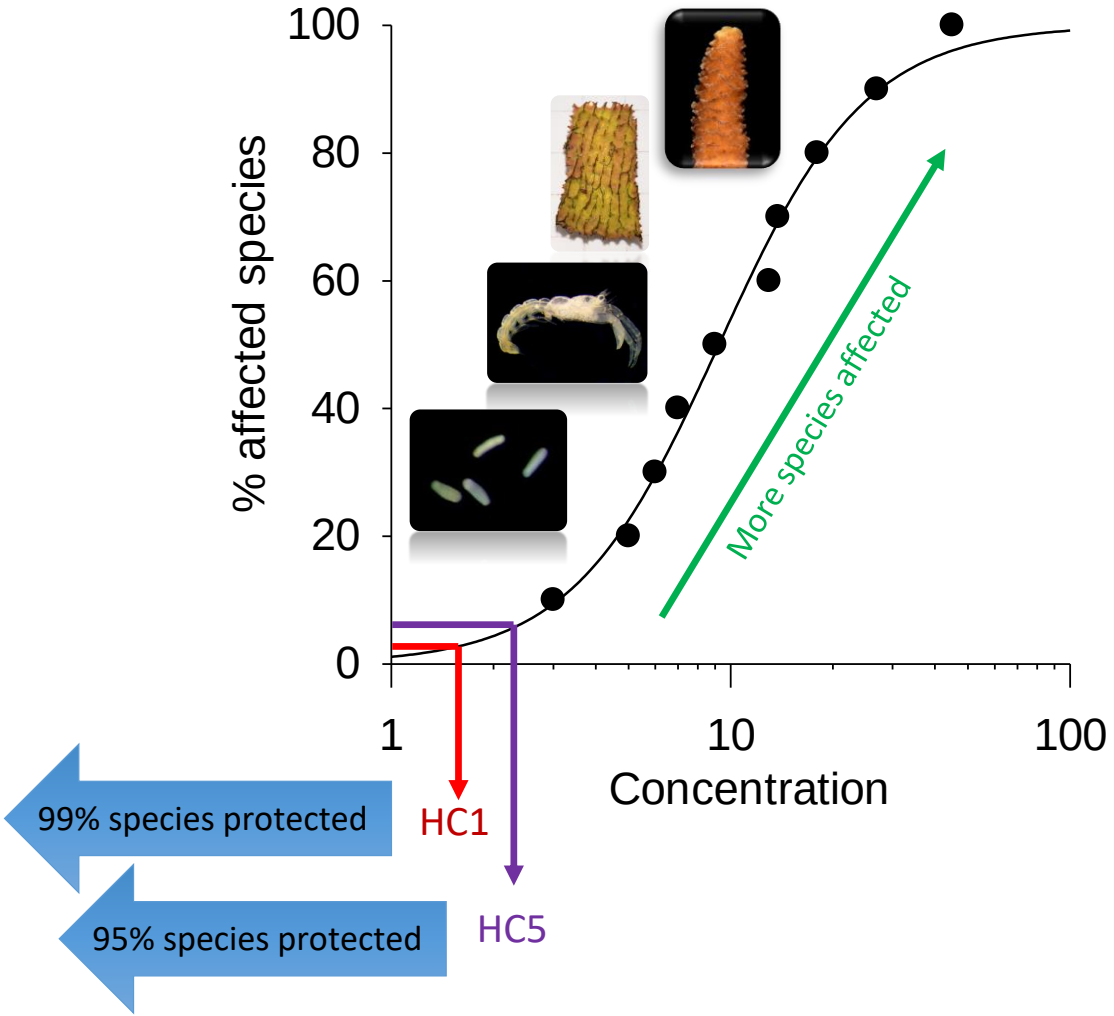
Water Quality Guideline Values

99% species protected

95% species protected

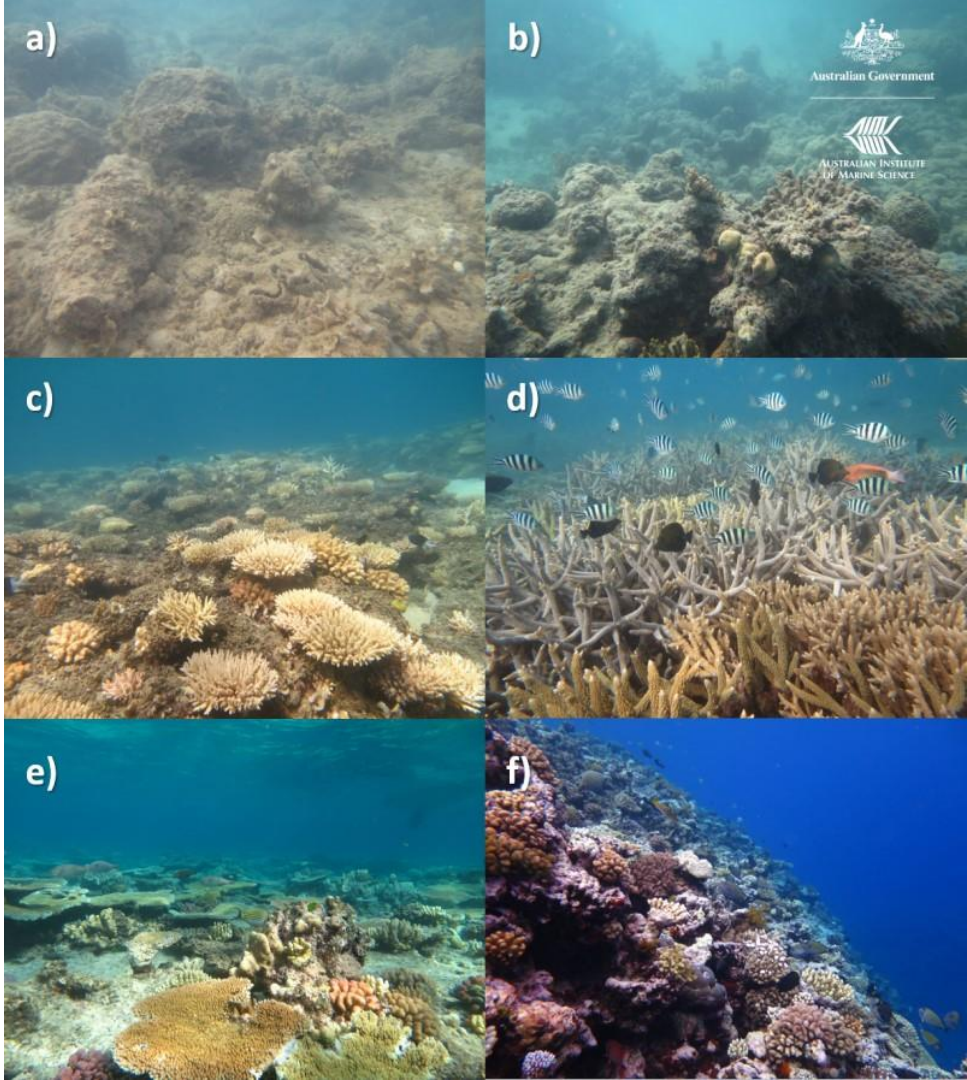
Toxicity threshold for risk assessments

- SSD from diverse taxa
- Could derive WQGVs (HC1 and HC5) for coral reef species only
- Need a good reason to exclude taxa
- Is there any evidence for corals to be more sensitive than other species?



Confidence in toxicity data

- Little toxicity data for corals and reef species
- Corals are foundation species
- Toxicity data should be reliable and meaningful
- Confidence by all stakeholders in the data



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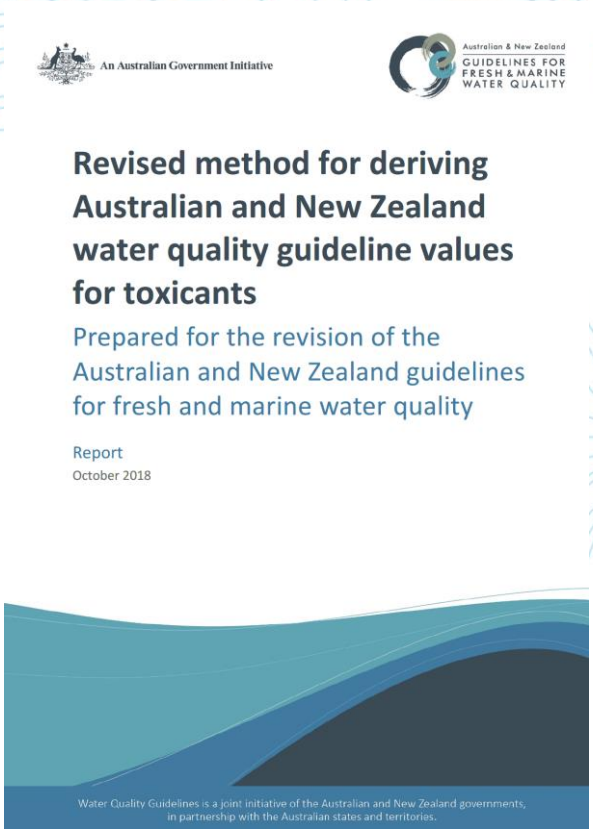
Toxicity data criteria

Examples

- Ecologically relevant effect
- Measured concentrations
- Modelled thresholds (EC10 > NOEC)
- Chronic (long-term) exposures
- Reliable WQGV (HCx) requires ~15 species…

All prospective data should be screened and meet quality criteria



https://www.waterquality.gov.au/anz-guidelines/guideline-values/derive/warne-method-derive

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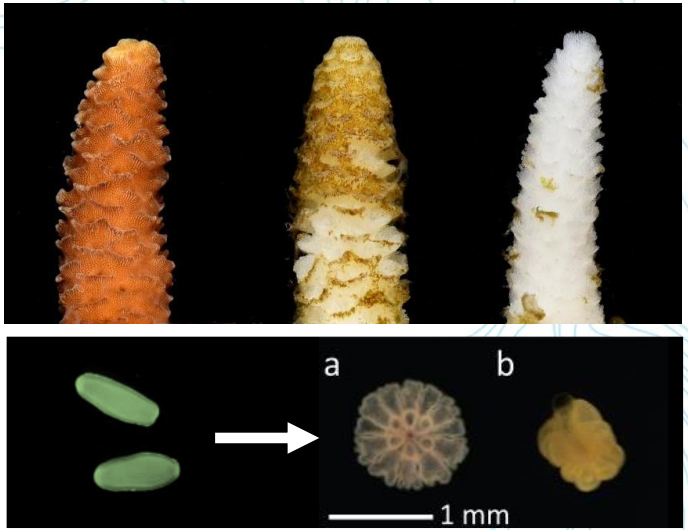
Reliable biological effects in corals

Examples



- ✓ Mortality (partial mortality)
- ✓ Growth
- ✓ Reproductive (fertilisation, larval settlement)
- ✓ Bleaching (cell counts > pigments)
- ? Tissue swelling
- ✗ Behavioural (swimming, polyp behaviour)
- ✗ Biomarkers, gene expression
- ✗ Response of cell lines
- ✗ Photosynthesis, respiration and quantum yield of symbionts

Challenges for assessing risk

Exposure > ecological thresholds

- Develop SSDs to derive HC1 and HC5 values (inherently conservative)
- Assess exposure to mixtures exceeding HC1 and HC5 (ms-PAF)
- Contribution of formulations to toxicity – assess like an oil spill….
- Effects of co-stressors – UVR and heatwaves
- Effective monitoring

Co-stressors: UV radiation

Science of the Total Environment 781 (2021) 146676

Contents lists available at ScienceDirect

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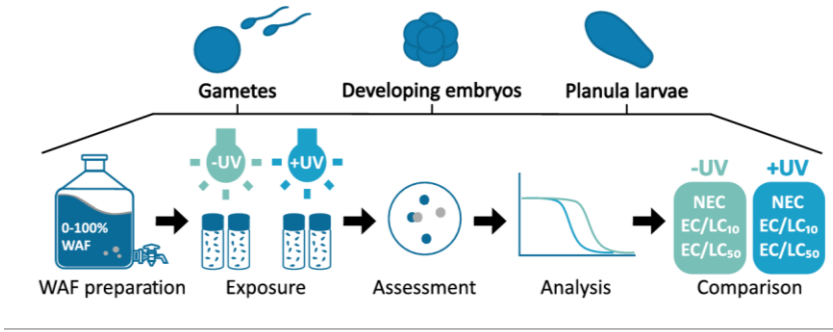
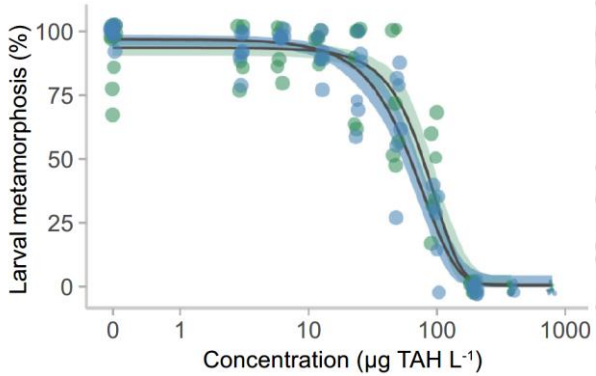
journal homepage: www.elsevier.com/locate/scitotenv

Comparative sensitivity of the *early life stages* of a coral to heavy fuel oil and UV radiation

F. Mikaela Nordborg [a,b,c,*], Diane L. Brinkman [c], Gerard F. Ricardo [c], Susana Agustí [d], Andrew P. Negri [a,c]

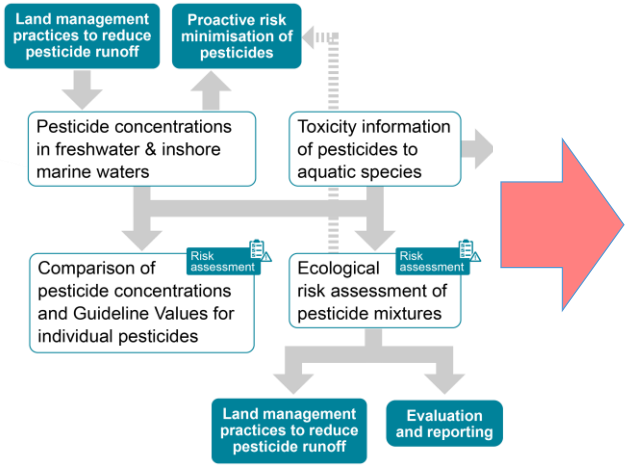




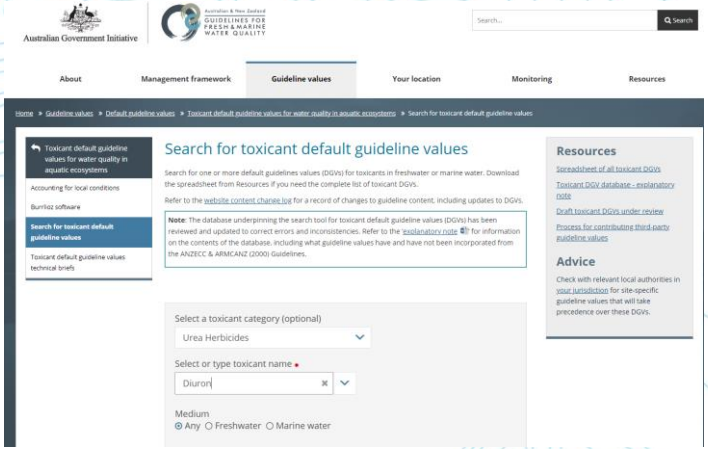
Phototoxicity – increases harm

Photodegradation – reduces exposure….

Making effect and exposure results accessible and meaningful

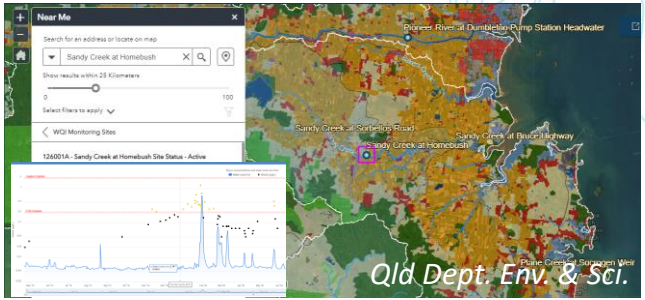


Taken up in the National guidelines



https://www.waterquality.gov.au/anz-guidelines/guideline-values/default

Pesticide reporting portal



https://arcg.is/19rnf8

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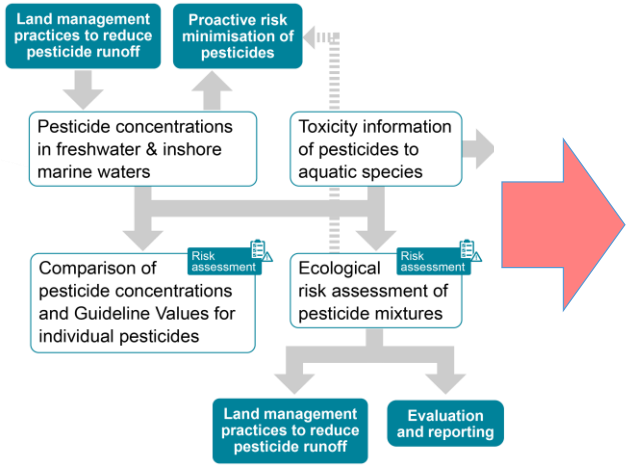
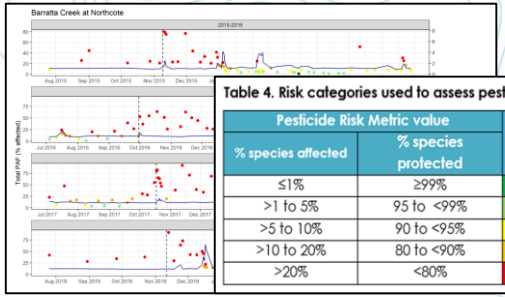


Pesticide risk metric

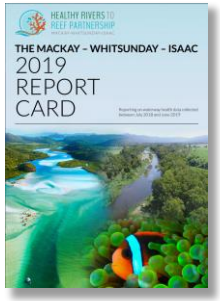


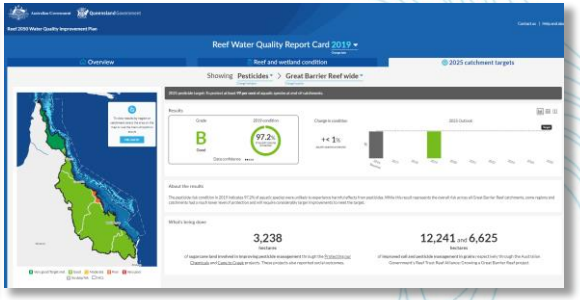
University of Qld, Qld Dept. Env. & Sci.

Table 4. Risk categories used to assess pesticide risk

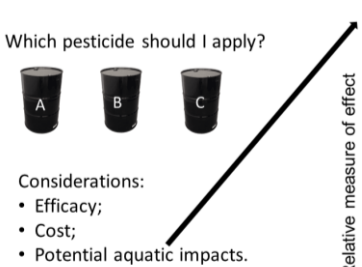
Pesticide Risk Metric value		Risk Category	Ecological Condition (ANZWQG)
% species affected	% species protected		
≤1%	≥99%	Very low	High Ecological Value
>1 to 5%	95 to <99%	Low	Slightly to Moderately Disturbed
>5 to 10%	90 to <95%	Moderate	Highly Disturbed
>10 to 20%	80 to <90%	High	
>20%	<80%	Very high	

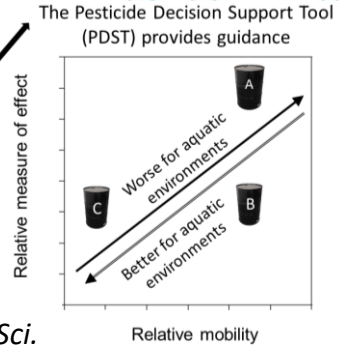
Report cards





Pesticide selection tool





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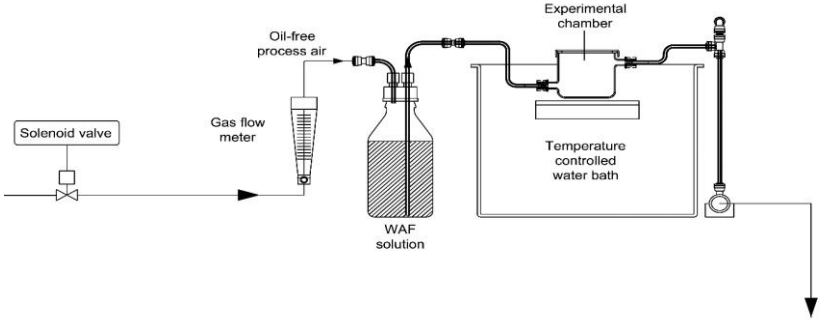
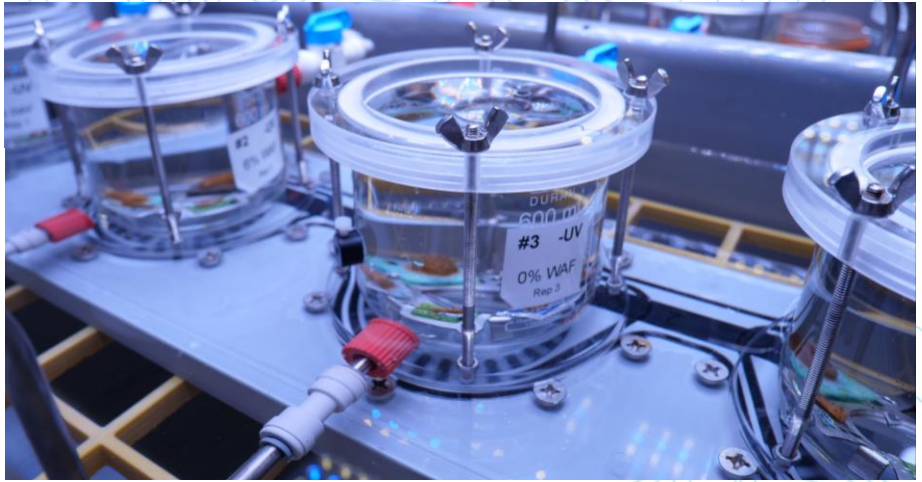
Thank you

National Sea Simulator





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Australian Government
Department of Health
Therapeutic Goods Administration

Australian regulatory guidelines for sunscreens

Version 2, July 2021

TGA Health Safety Regulation

Australian Government
Great Barrier Reef Marine Park Authority

ntepa Northern Territory Environment Protection Authority

Queensland Government
Department of Environment and Science

GOVERNMENT OF WESTERN AUSTRALIA
Environmental Protection Authority