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Live fast, die young: Behavioural and physiological impacts of light pollution on a marine fish during larval recruitment

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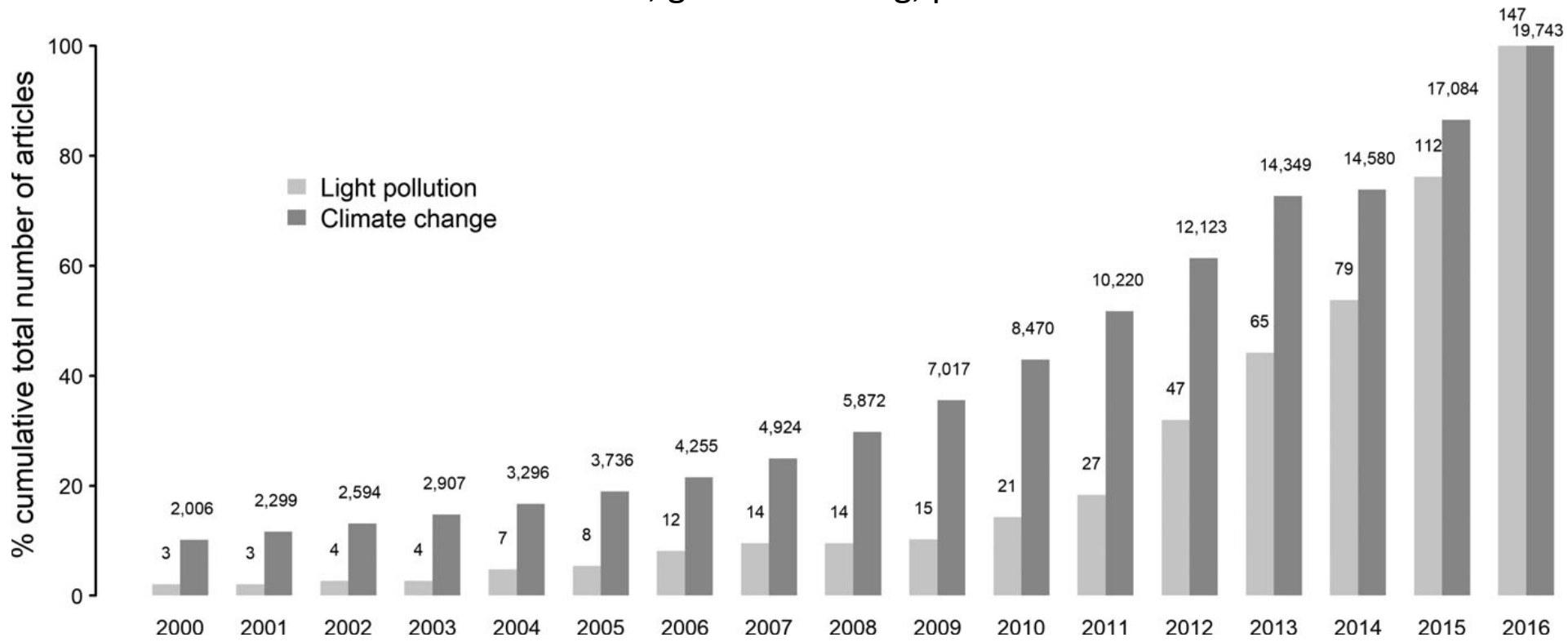
Light Pollution

- Impacts across biomes, ecosystems, species and behaviours
- Driver of global change → we should be just as concerned about ligh pollution as we are about GHGs, global warming, plastics…



(Davies & Smyth, 2017)

Why we need to focus on ALAN:

- **Globally widespread**: 23% of the the land surface, 80% of the world's human population, 22% of the world's coastal regions
  → **the degree of exposure has been increasing year after year as a consequence of the increasing global population**
- **Sphere of influence**: point sources, large-scale sources → **skyglow**
- **Evolutionary novelty**
- **Diversity of biological responses**
- **Sensitivity of biological responses**

(Davies & Smyth, 2017)

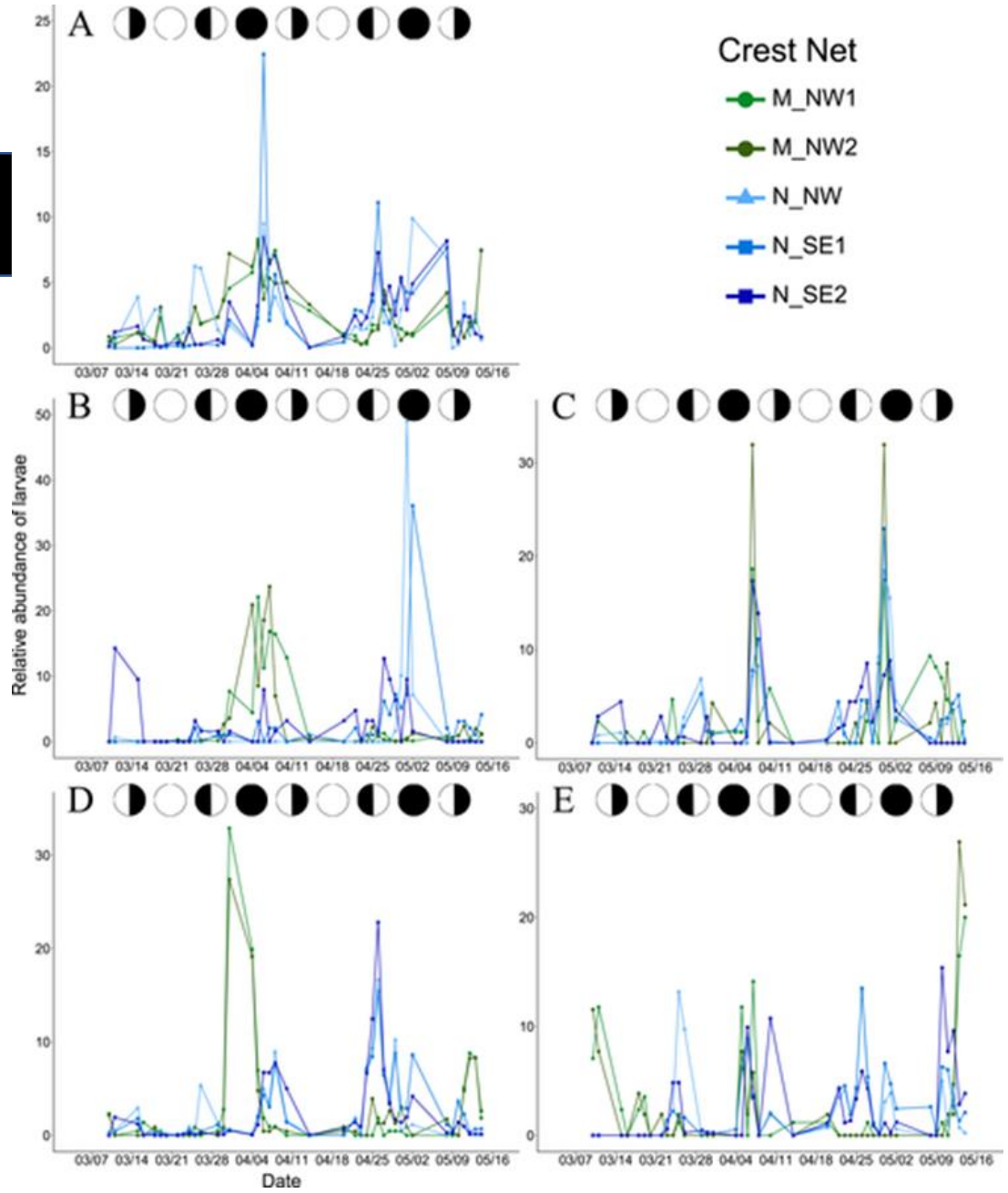
Impacts on Marine Life

- **Knowledge gap**: coral reef environments
  - ➡ **Hot-spots of biodiversity**
  - ➡ **Facing threats from several natural and anthropogenic stressors**

Coral reef fish:

- **Lunar cues:**
  - regulate reproductive periodicity in adults
  - regulate the timing of reef colonisation (settlement) by larvae
- **Settlement:** critical interval in determining population persistance

➡ **Any impacts on behaviour and physiologial functions in this critical life transition could have unpredictable effects at different levels of biological organisations**



(Besson *et al*, 2017)

Aims: Investigate impacts of ALAN on:

a) Behaviour
b) Endocrine functions
c) Growth and survival

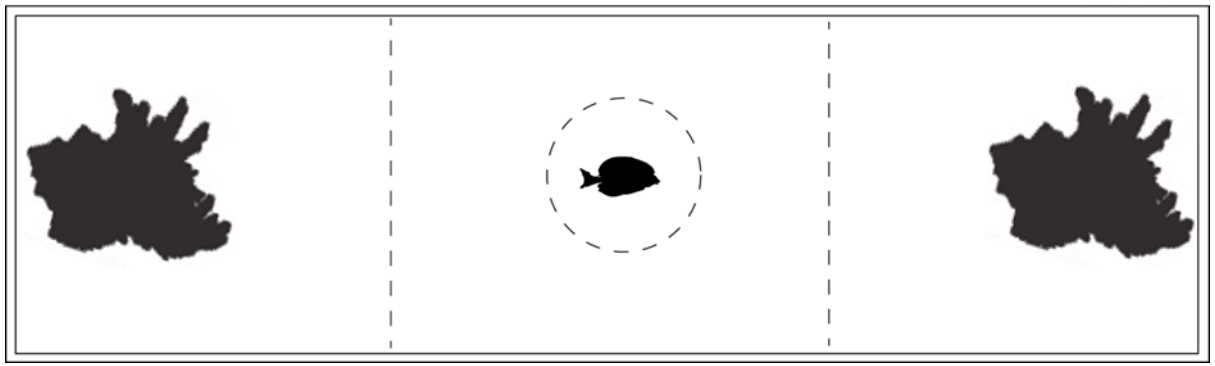
Study species:

- *Acanthurus triostegus*
- Collected during settlement near Temae Beach, Moorea Island, French Polynesia
- Split into 2 groups in the lab:
  -Control group 12hL:12hD
  -ALAN exposed group 12hL:12hL

1) Habitat choice experiments:

Testing preference to habitats with or without ALAN:

- Binary choice chamber on day 1:

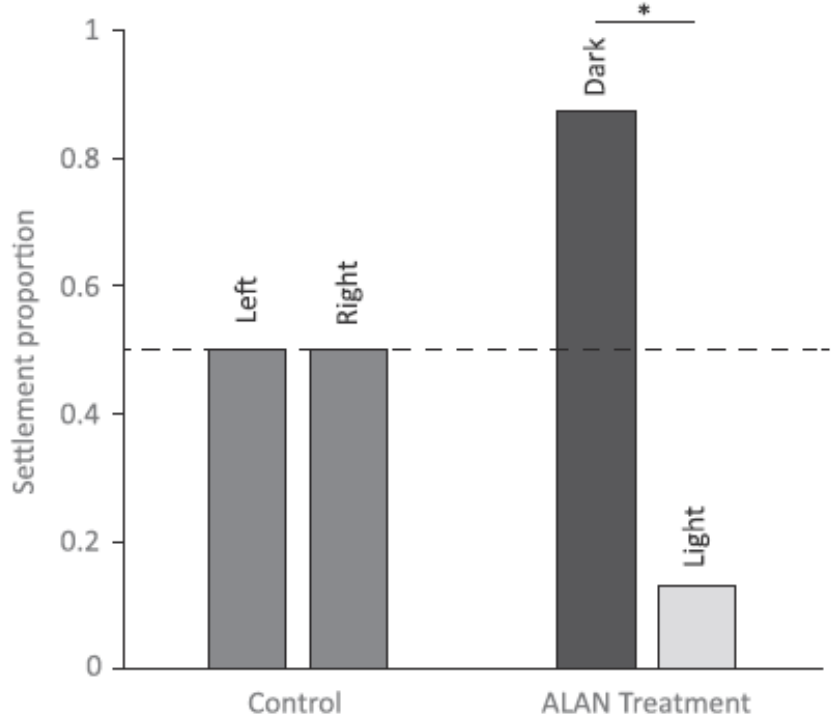


If in one of the side chamber → DECISION

If in the middle zone → NO DECISION

Results:

Settling larvae selected darker habitats



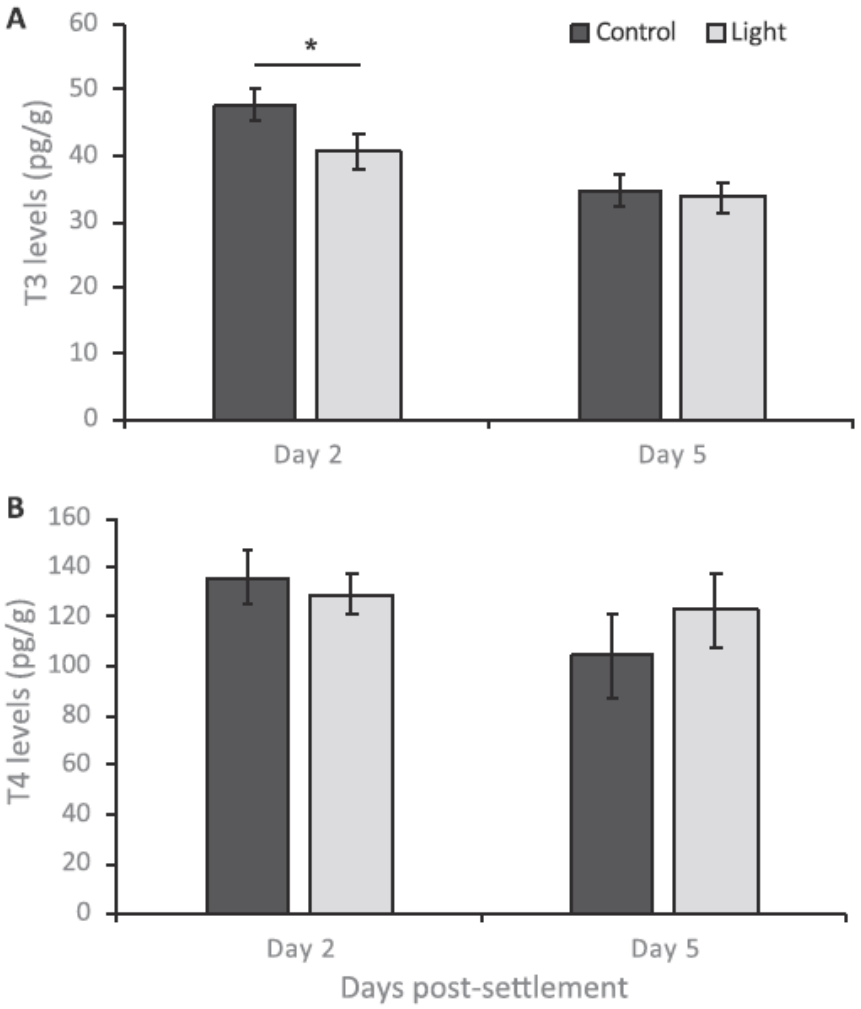
2) Endocrine responses:

Thyroid hormone levels:

- T_4 & T_3 measurements at day 2 and day 5 post-settlement (n=8-10)

Results:

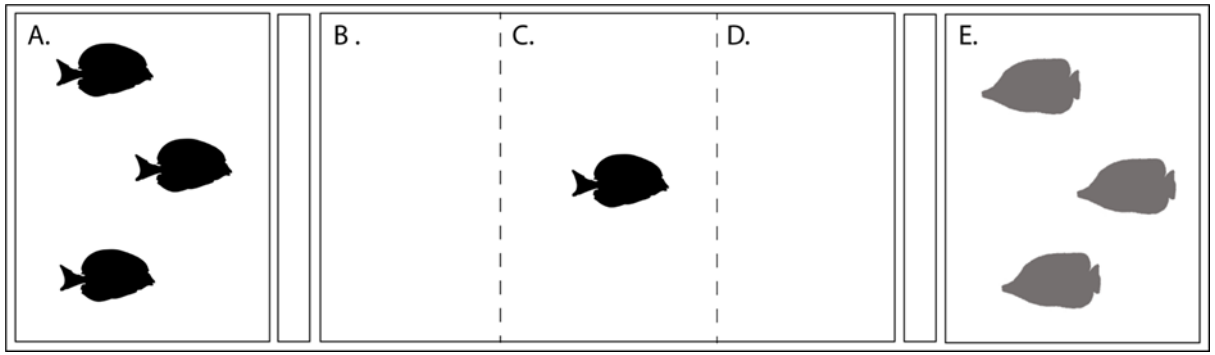
- ALAN exposure lowered T3 levels at d2; by d5 levels evened out between the two treatment groups
- No difference was found in T4 levels between the two groups at d2 and d5



3) Conspecific visual cue response:

Testing behavioural response to visual stimuli:

- Three compartment chamber on day 10 (n=40):



- *Chaetodon citrinellus*

Results:

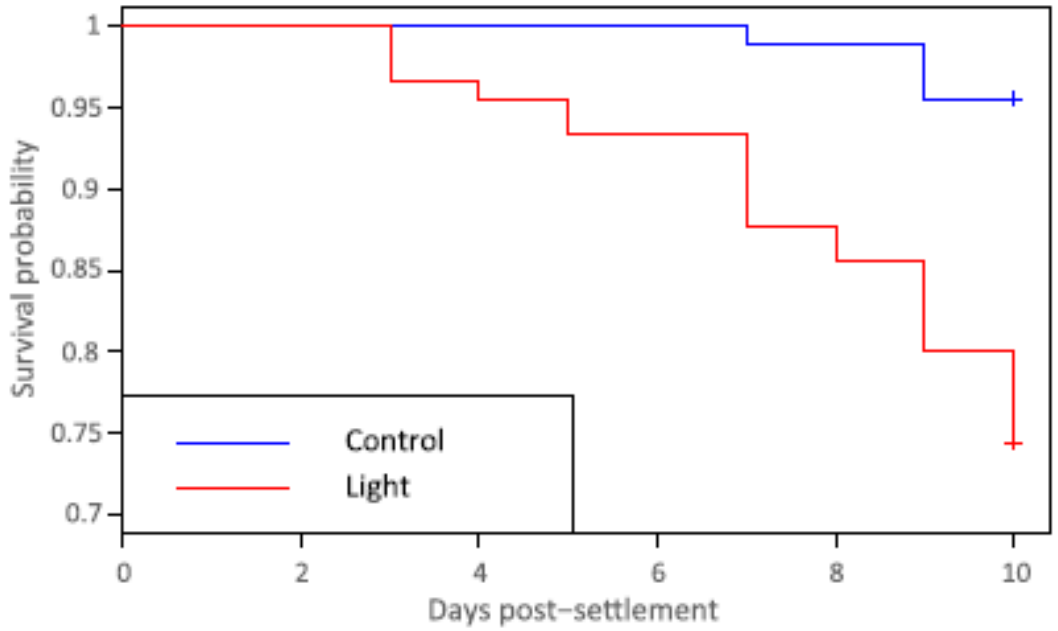
- ALAN exposed fish swam faster but did not alter visual cue responses :
  -75% of individuals from both groups preferred the compartment closest to conspecifics
  -time taken to make a decision:

1.2 sec ALAN fish **21.4 sec control**

4) Post-settlement growth and survival:

a) **ALAN effect on growth rate:** weight and otoliths on day 10 (n=80)

b) **Mortality:** n° of deaths during the experimental period



Results:

a) **ALAN fish grew faster and heavier**: +7.1% greater growth

b) **ALAN fish showed a decreased probability of survival**: 4% control fish experienced mortality compared to 26% in the ALAN treatment

5) Predator – Prey interaction:

Predation experiments on day 10 (n=8-10):

- Circular tanks with rocks for shelter
- *A. triostegus* were tagged with subcutaneous coloured tag (2 different colours for ALAN treated and control fish)
- Nocturnal predator: *Pterois radiata*

Results:

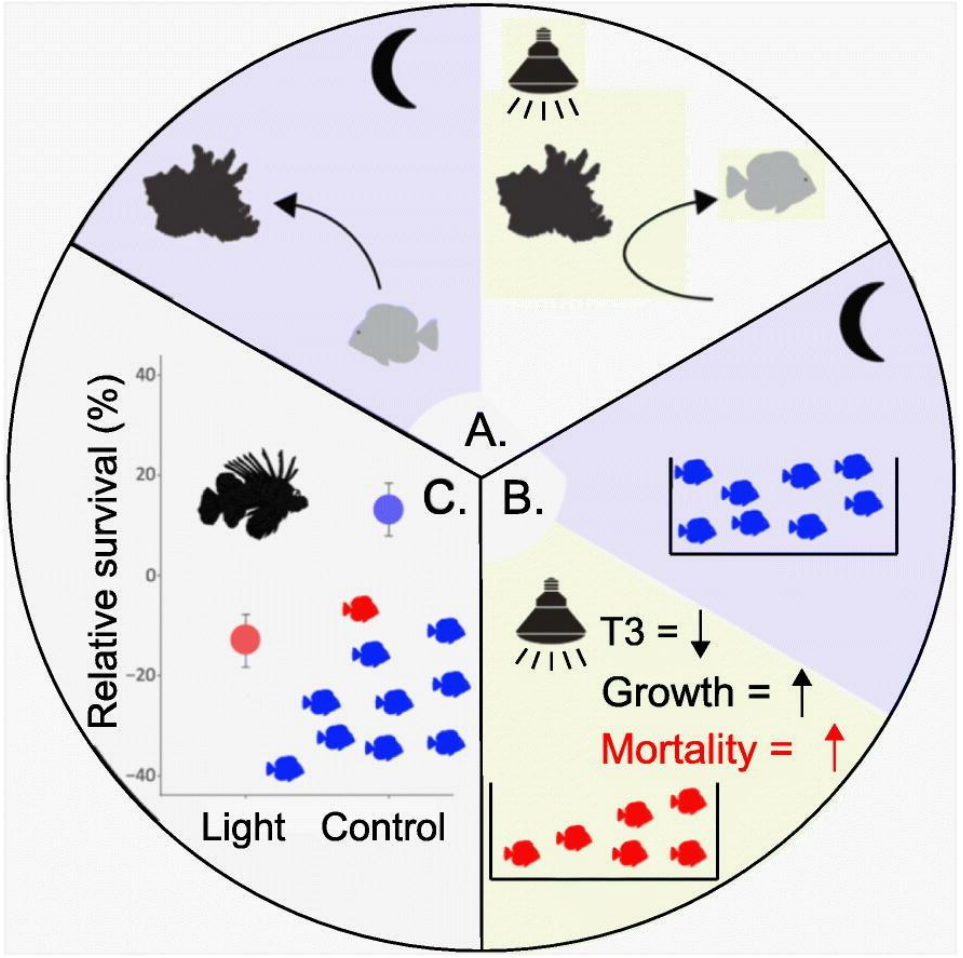
- **ALAN exposure increased probability of predation:** fish exposed to ALAN experienced higher rates of predation compared to control ones, with relative mortality ratio as high as 9 : 1

Results

→**Significant evidence that the presence of ALAN changes the behaviour and physiology of coral-reef fish during larval recruitment.**

Changes such as:

- Habitat avoidance (A.)
- Altered growth and increased mortality (B.)
- Increased susceptibility to predation (C.)
- Endocrine disruption



Discussion

- **Endocrine disruption** could impair fish development and further **impact relative survival** when ALAN fish face predators
- Mortality of reef fish due to predation is highest around the time of larval settlement and recruitment, **exposure to ALAN may increase predation risk and decrease recruit survival**, impacting population
- As degradation of visual acuity was not detected during visual cue tests, **increased vulnerability to predation** may **relate to changes in swimming behaviours** (which is often evidence of stess). In addition, **the physiological cost of hyperactivity** may have played a role in the **reduced survival rate** of ALAN fish
- **Heavier fish can be preferrentially selected by predators**
- **Sleep deprivation** can be another driver of physiological an behavioural changes and can cause **circadian disruption** which can **increase metabolic requirements and weight gain** via appetite upregulation

These results raise concerns about how coastal ecosystem will fare with increasing coastal development and the loss of natural darkness in the night sky.

References:

-Besson M, Gache C, Brooker RM, Moussa RM, Waqalevu VP, LeRohellec M, et al. (2017) Consistency in the supply of larval fishes among coral reefs in French Polynesia. PLoS ONE 12(6): e0178795. https://doi.org/10.1371/journal.pone.0178795

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