The Effects of Light Pollution on the Activity of Juvenile Bonefish (*Albula vulpes*)

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Rationale

- Light pollution has been shown to affect the fecundity, behavior, predation, and migration of a variety of animals (e.g. frogs, birds, turtles, zooplankton, etc.)[1]
- There has been little research conducted on the effects of light pollution on aquatic animals
- Bonefish are economically important, accruing 141 million USD annually in The Bahamas and over 1 billion USD in Florida[2]
- The adult bonefish population decline has led to the IUCN classification of "near threatened" in Florida[3]
- While there is some research on the adult population, there is a large gap of knowledge on juvenile bonefish
- Juvenile bonefish have not been found along the Florida coast, but can be found in The Bahamas; one hypothesis is near-shore light pollution in Florida altering habitat use, which could result in higher predation[1]

Fig 1: A juvenile bonefish during dip net sorting

Fig 2: Development has led to high levels of light pollution on the Florida coast

Objective: To determine the behavioral consequences of various forms of light pollution on juvenile bonefish

Methods

- 51 juvenile bonefish were captured at the Rock Sound Airport Flats by spot-seining, transported back to the Cape Eleuthera Institute and acclimated for at least 48 hours
- Four bonefish were separated into four tanks each treatment day. Tanks were marked with lines along the bottom of the tank as a proxy for the lateral distance each fish traveled (15.6 cm intervals)
- Three different treatment groups were tested (n = 8 per treatment):
  1. Night control
  2. Intermittent light (H4 halogen)
  3. Constant light (high-pressure sodium bulb)
- The light types were chosen to represent the likely forms of light pollution the juveniles would be exposed to in their habitats. These are car headlights and near-shore street lighting
- Fish activity was filmed between 22:00-02:00, as this is the potential rest period for juvenile bonefish
- Lines crossed were recorded by scan sampling two hours of light exposure (22:00-00:00) and two hours of recovery (00:00-02:00) and converted to average lateral distance (m)

Fig 3: The collection process of spot-seining and dip netting to juvenile bonefish

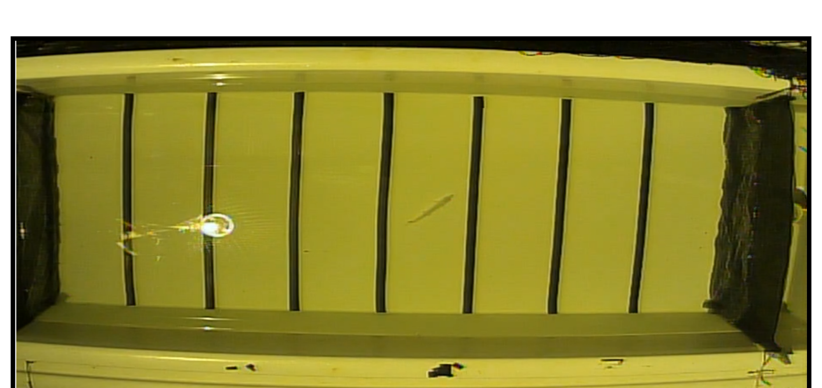


Fig 4: A still from the behavioral video analysis

Results

- Our experimental design violated the independence assumption of an ANOVA, and we needed to randomize fish ID. Therefore we used a linear mixed-effects model using 'R' software
- Significance was calculated as a p-value < 0.05

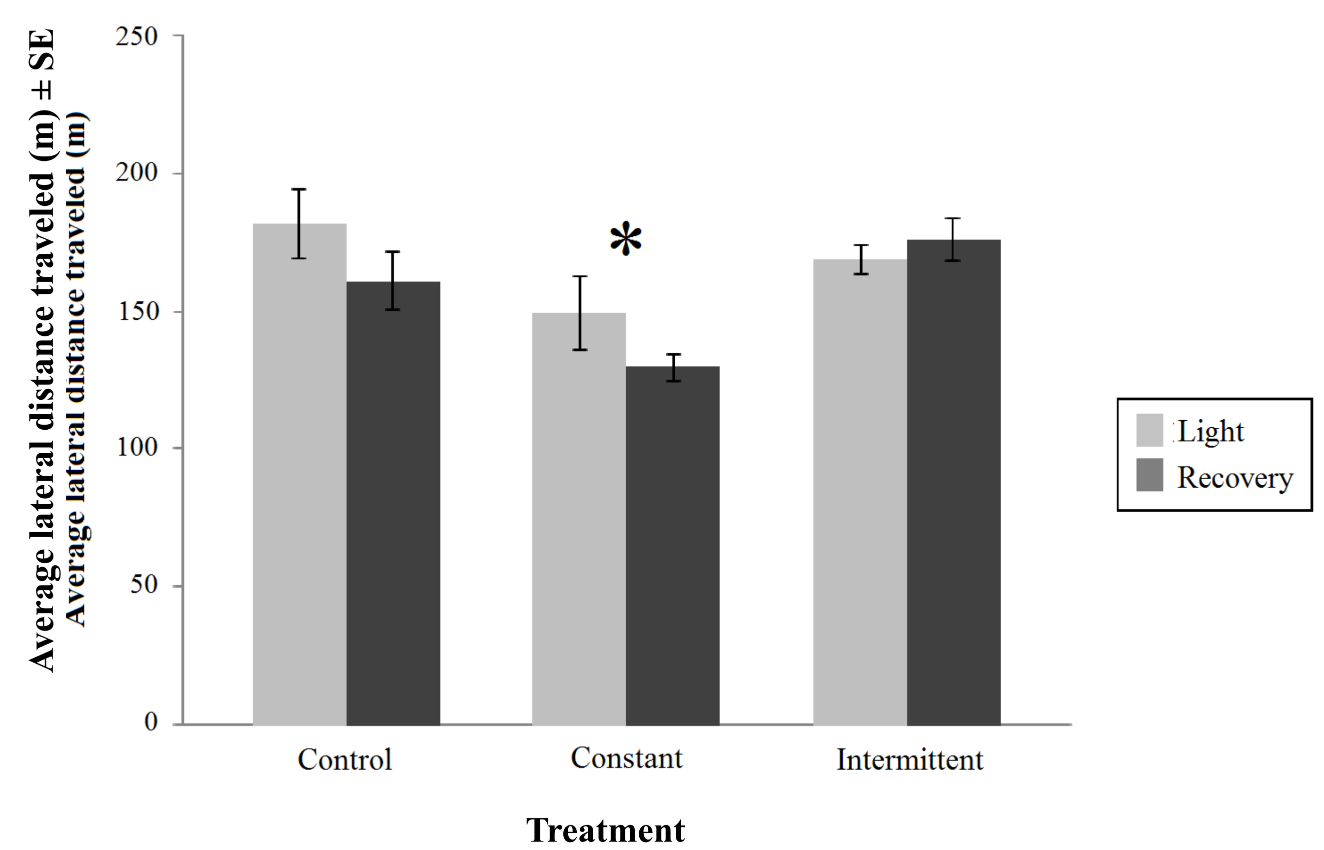


Fig 5: Average lateral distance traveled in meters by juvenile bonefish across all treatments, during light exposure and recovery (± SE). The asterisk(*) denotes significance.

Table 1: Statistical outputs from a linear mixed-effects model comparing average lateral distance traveled (in meters) across light treatments and time. Italics and highlighting denote significance.

Variables	Parameter	DF	p-value
Control-Constant	Treatment	2, 37	*0.045*
Control-Intermittent	Treatment	2, 37	0.95
Intermittent-Constant	Treatment	2, 37	*0.039*
Light-Recovery	Time	1, 37	0.67
Treatment:Time	Treatment, Time	1, 37	0.96

Table 2: Average lateral distance traveled (in meters) for all treatments over time, both during light exposure and recovery after light exposure (± SE)

Treatment	Time Point	
	Light (m)	Recovery (m)
Control	181.9 ± 24.9	160.9 ± 21.5
Constant	149.3 ± 27.4	129.6 ± 9.9
Intermittent	168.5 ± 10.3	176.3 ± 15.6

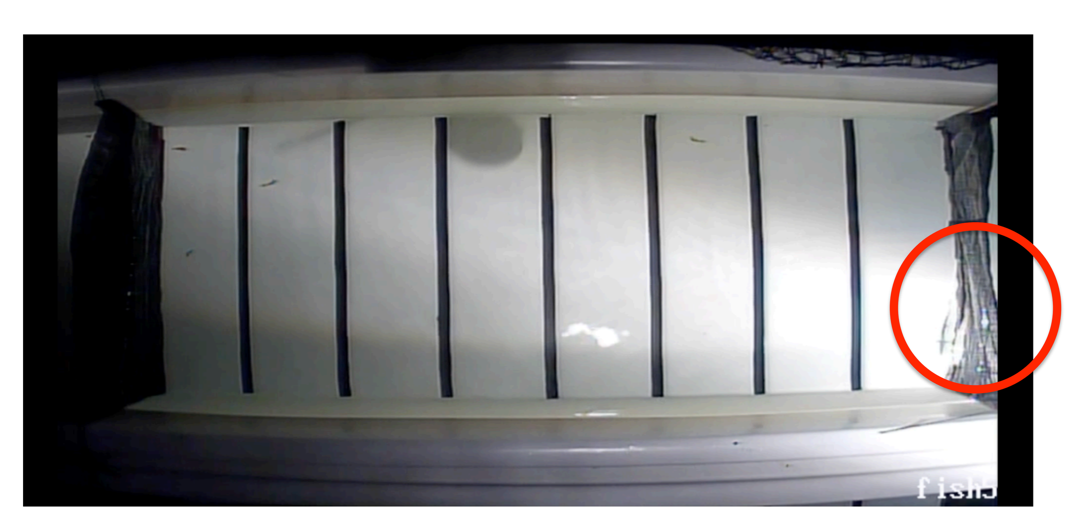
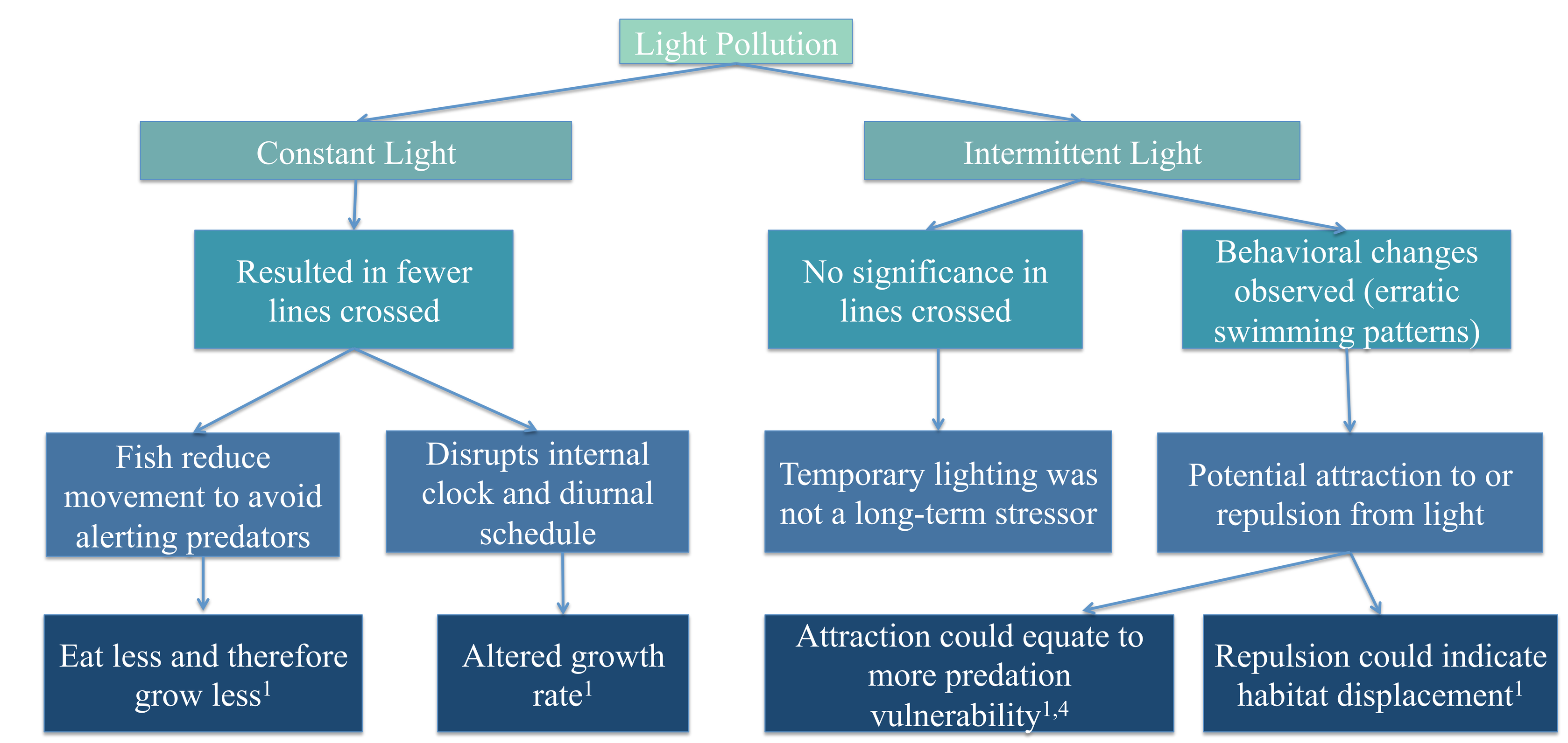


Fig 6: Observational evidence showed a potential attraction to intermittent light sources that disrupted normal swimming behavior.

Discussion

Interpretation of results and potential long-term effects



Applications

- This research could inform management decisions and influence legislation regarding light pollution in coastal areas, encouraging:
  - The use of different types of light bulbs for coastal lighting
  - Incorporation of sensors to dim streetlights
  - Installation of light shields to redirect illumination
- The methods used for capture, transport and housing of juvenile bonefish are the first of their kind and provide a reference for future studies

Fig 7: A diagram of a streetlight that dims according to the phase of the moon

Fig 8: A shielded streetlight

- Directions for future research could include how light pollution effects juvenile bonefish habitat usage and schooling behaviour, whether they are attracted to or repulsed by light, the effects of light pollution across trophic levels, and determining the physiological consequences of light pollution using respirometry

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