Can UV exposure deter another “bloody” invasive?

Understanding the role of UV in the spread of bloody red shrimp (*Hemimysis anomala*) in the Great Lakes

20 December 2022

Ohio Aquatic Invasive Species Committee (OAISC) Meeting

Addison Zeisler, Nikki Berry, Erin Overholt, Thomas Fisher, and Craig Williamson

Miami University

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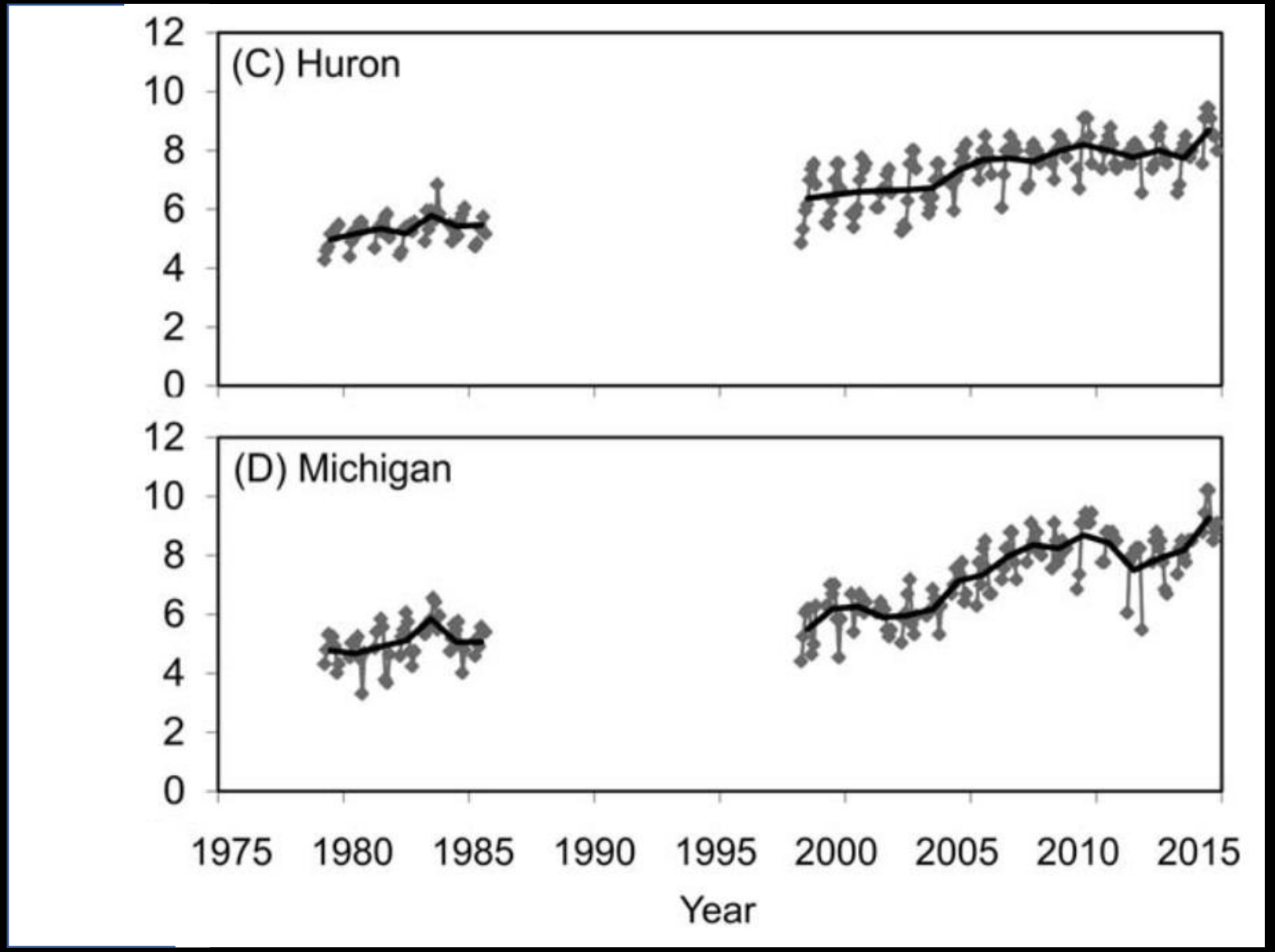
MIAMI UNIVERSITY

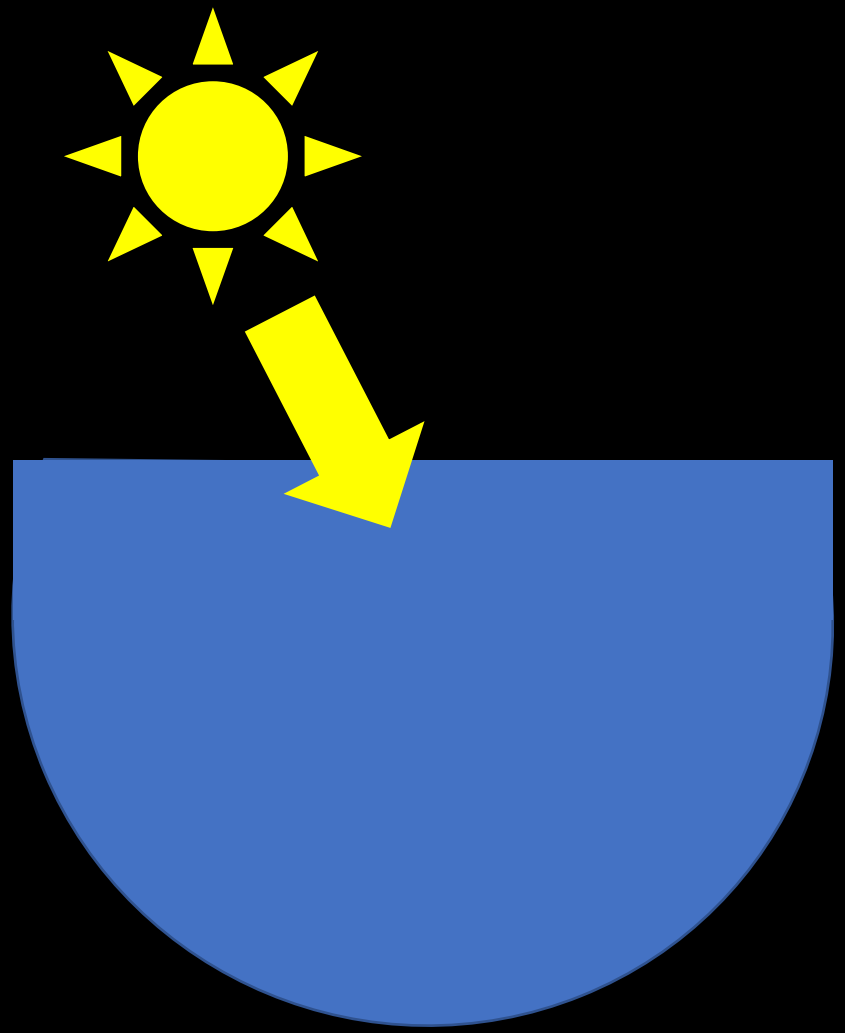
OXFORD, OH • EST. 1809

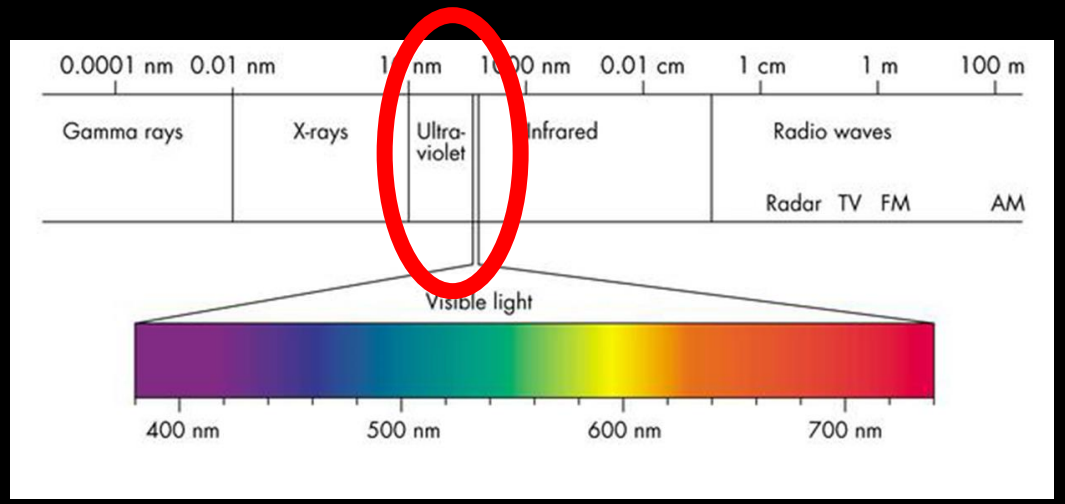
Great Lakes becoming more transparent



(Binding et al. 2015)

More transparent = more ultraviolet radition (UV)





Aquatic Organisms: *Death by Sunburn!*

ELSEVIER

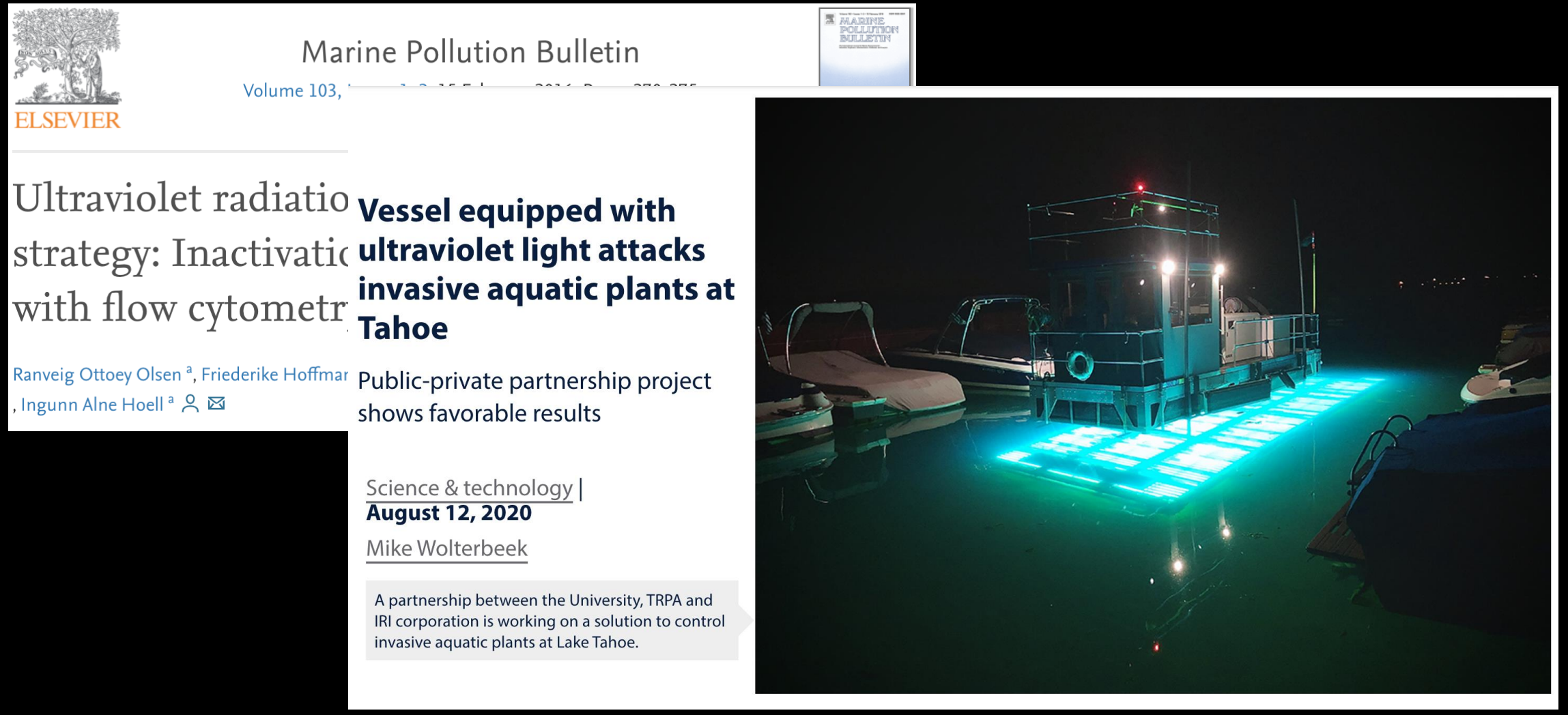
Marine Pollution Bulletin

Volume 103, Issues 1–2, 15 February 2016, Pages 270-275

Ultraviolet radiation as a ballast water treatment strategy: Inactivation of phytoplankton measured with flow cytometry

Ranveig Ottoey Olsen [a], Friederike Hoffmann [b, c], Ole-Kristian Hess-Erga [d], Aud Larsen [c], Gunnar Thuestad [a], Ingunn Alne Hoell [a]

Aquatic Organisms: *Death by Sunburn!*



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Marine Pollution Bulletin

Volume 103,

Ultraviolet radiatio
strategy: Inactivatic
with flow cytometr

Ranveig Ottoey Olsen [a], Friederike Hoffmar
, Ingunn Alne Hoell [a]

Vessel equipped with ultraviolet light attacks invasive aquatic plants at Tahoe

Public-private partnership project shows favorable results

Science & technology |
August 12, 2020

Mike Wolterbeek

A partnership between the University, TRPA and IRI corporation is working on a solution to control invasive aquatic plants at Lake Tahoe.

Aquatic Organisms: *Death by Sunburn!*

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Marir

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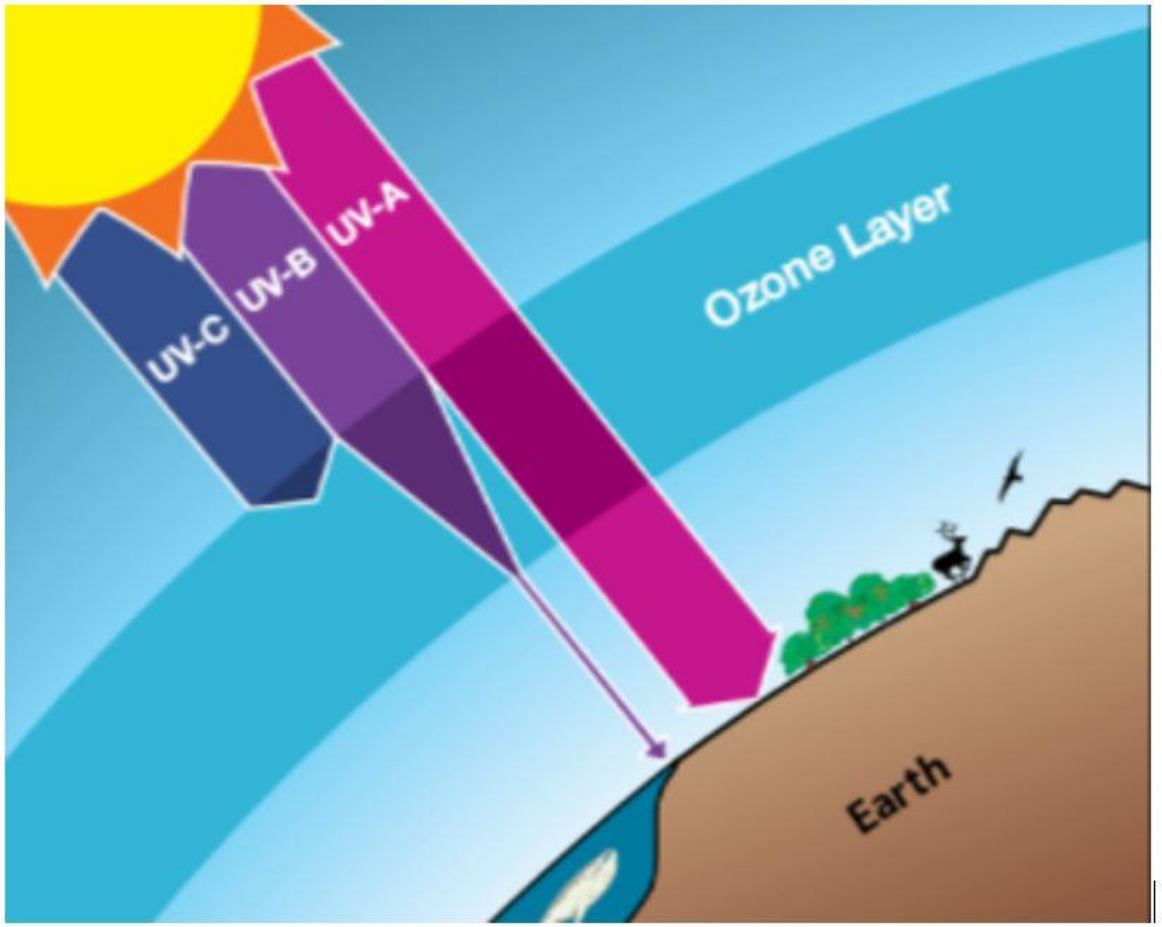
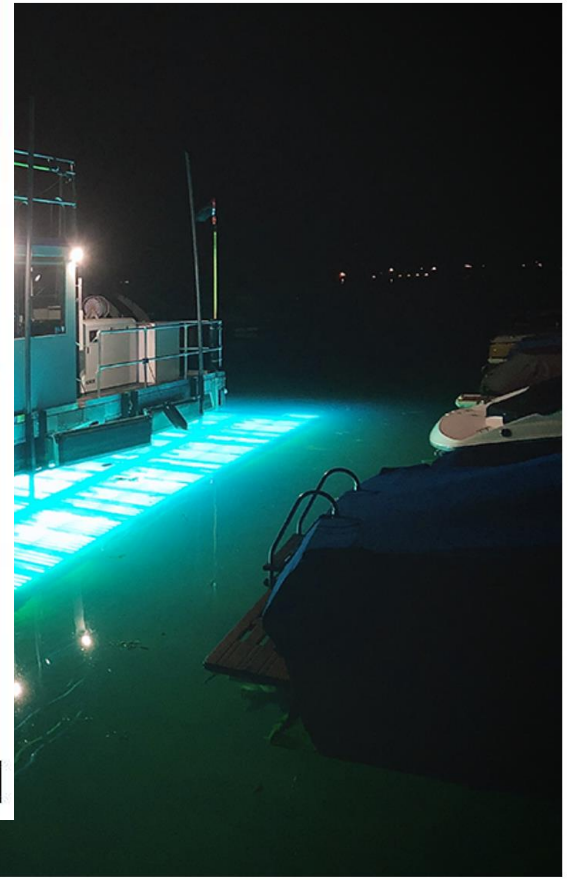
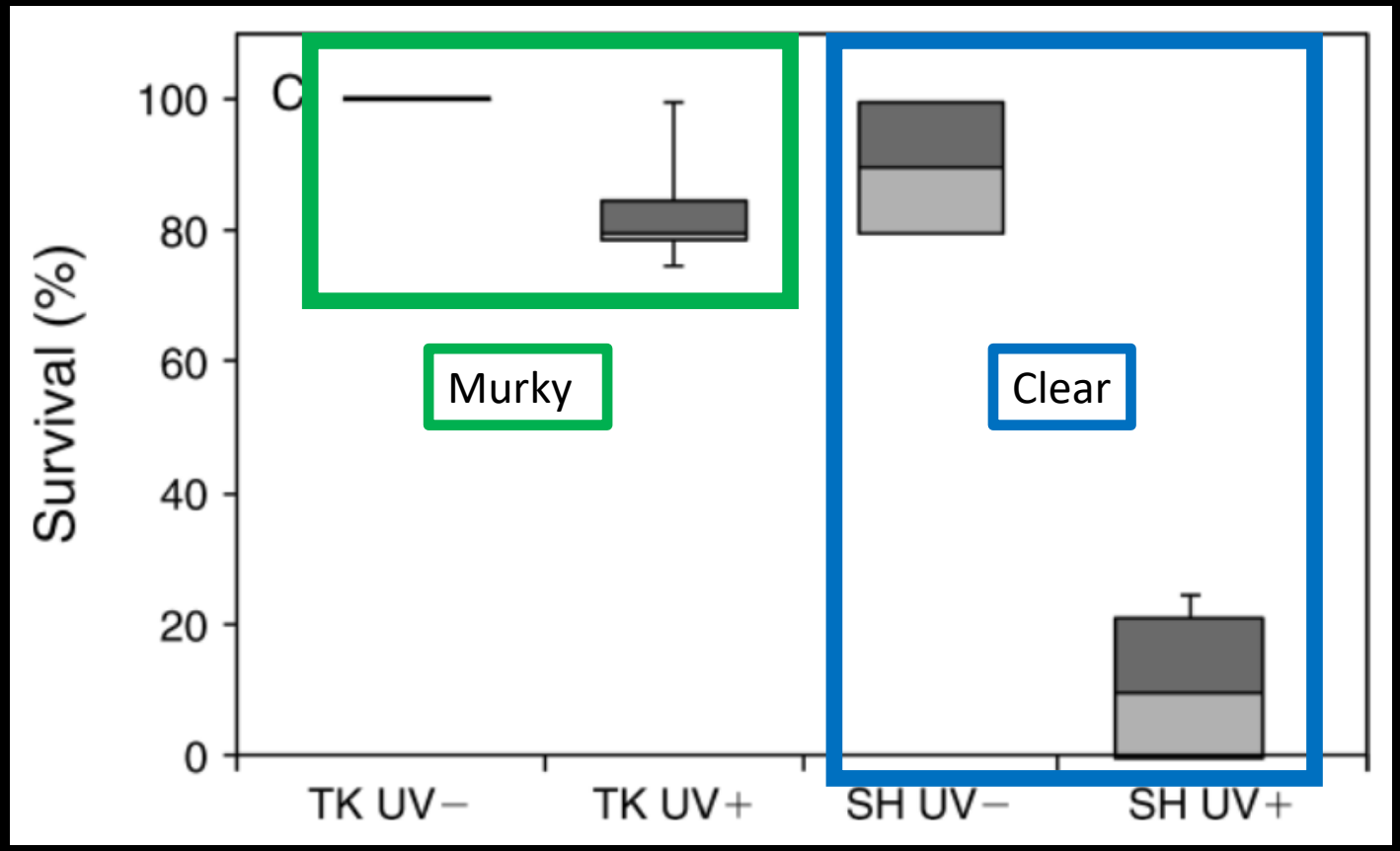




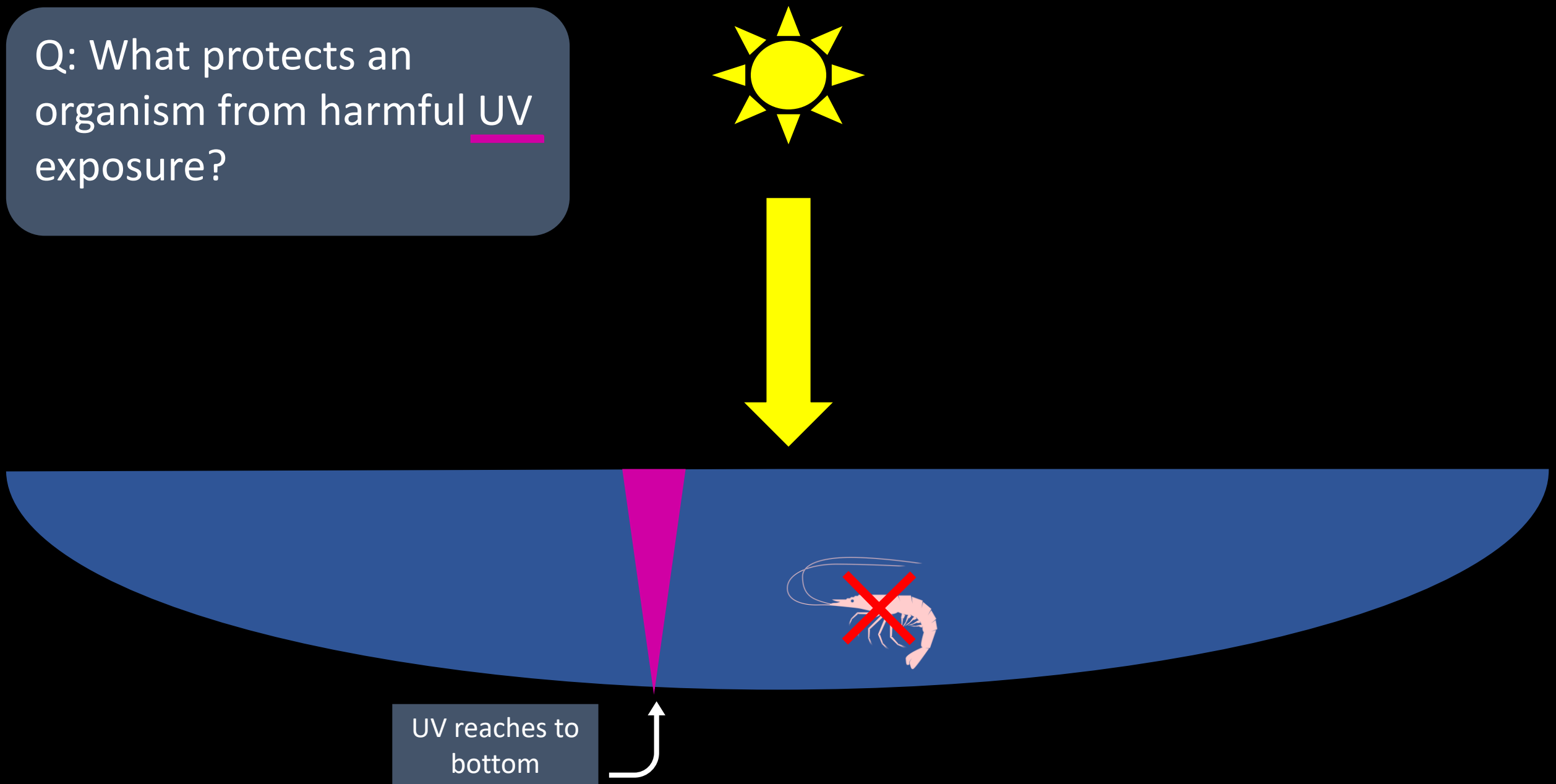
Aquatic Organisms: *Death by Sunburn!*

Lake Tahoe:
Larval
Bluegill



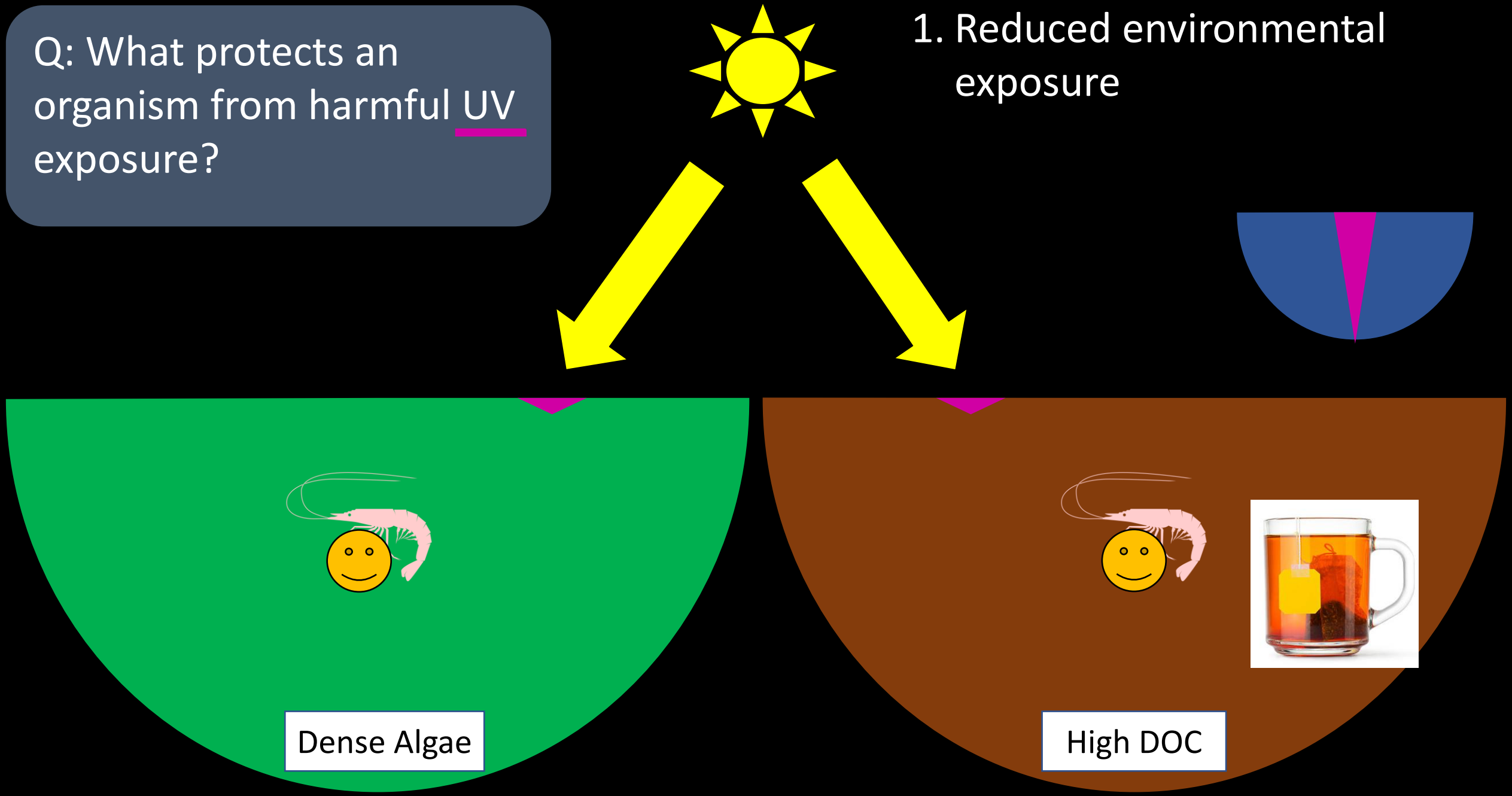
(Tucker et al. 2010)

Q: What protects an organism from harmful UV exposure?



Q: What protects an organism from harmful UV exposure?

1. Reduced environmental exposure



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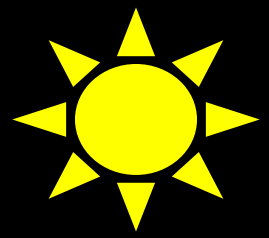
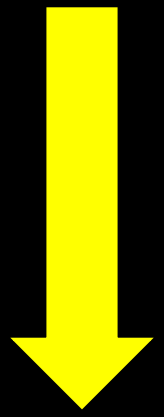
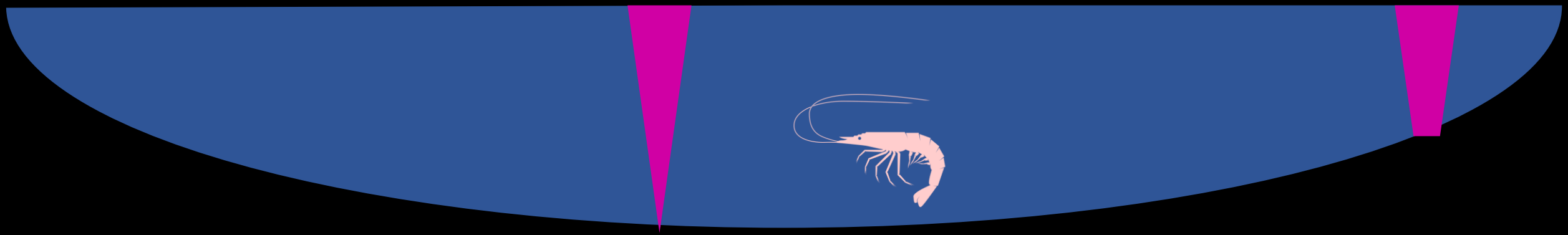


1. Reduced environmental exposure
2. Behavioral protection





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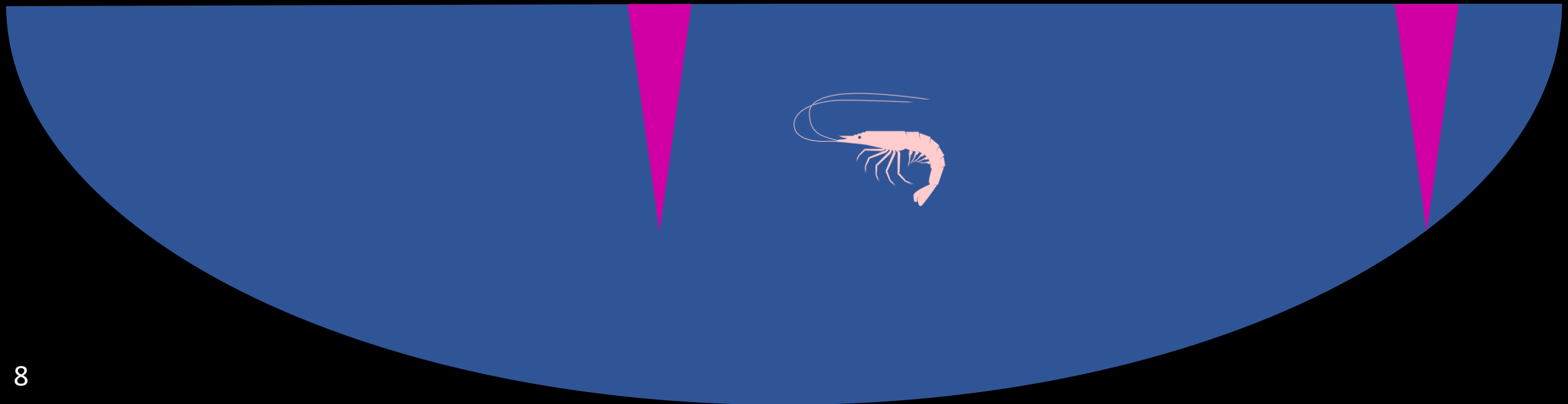

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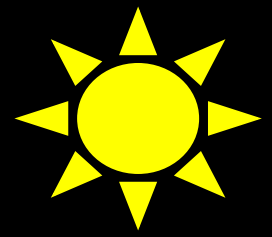
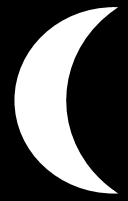
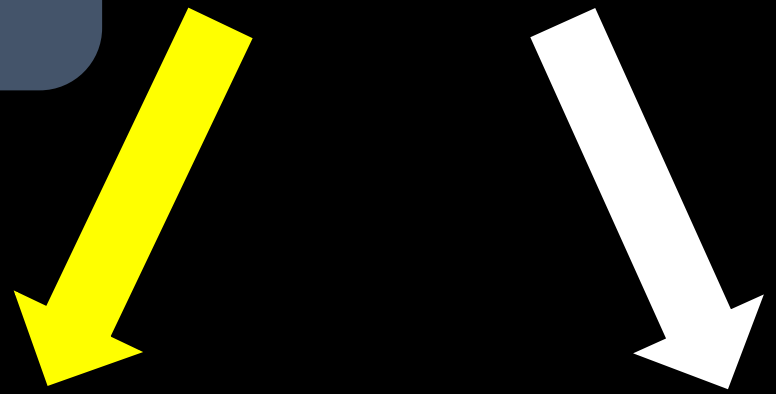




1. Reduced environmental exposure
2. Behavioral protection
   a. Diel Vertical Migration (DVM)



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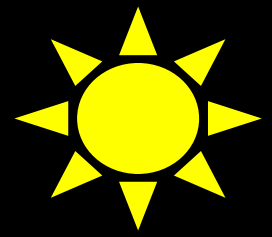

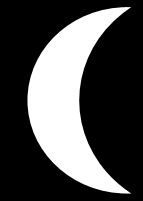

1. Reduced environmental exposure
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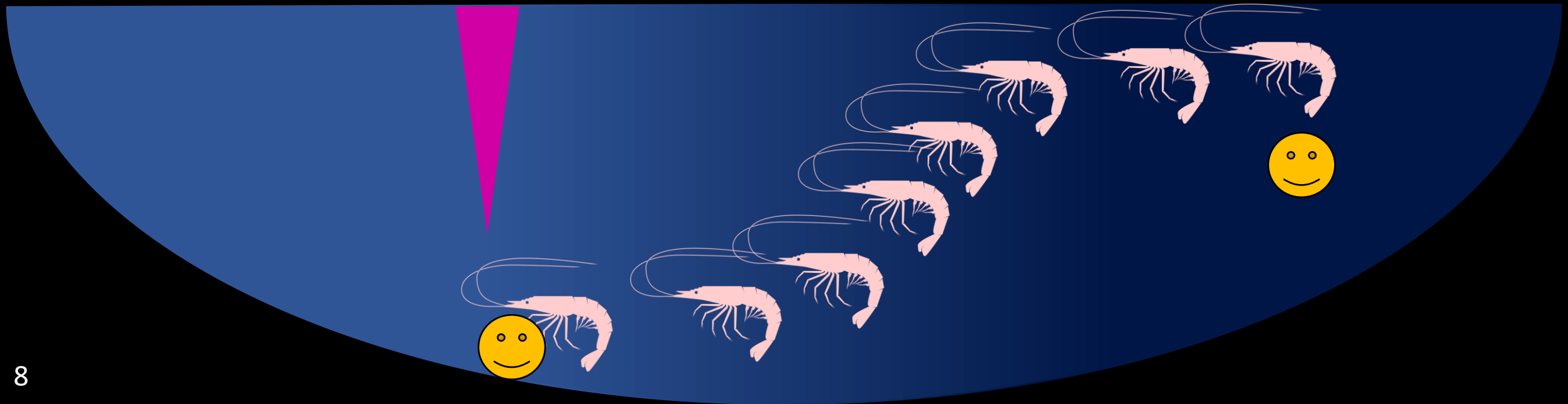

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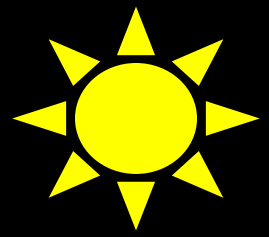
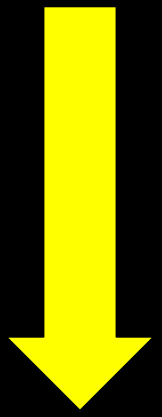
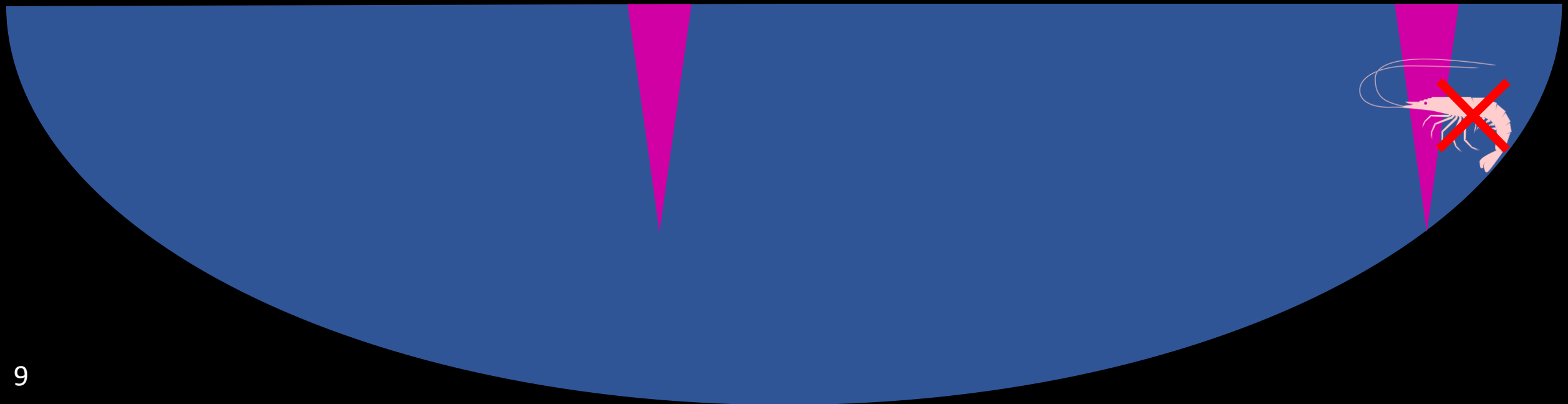


1. Reduced environmental exposure
2. Behavioral protection
   a. DVM





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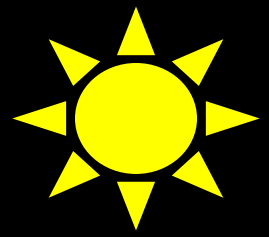
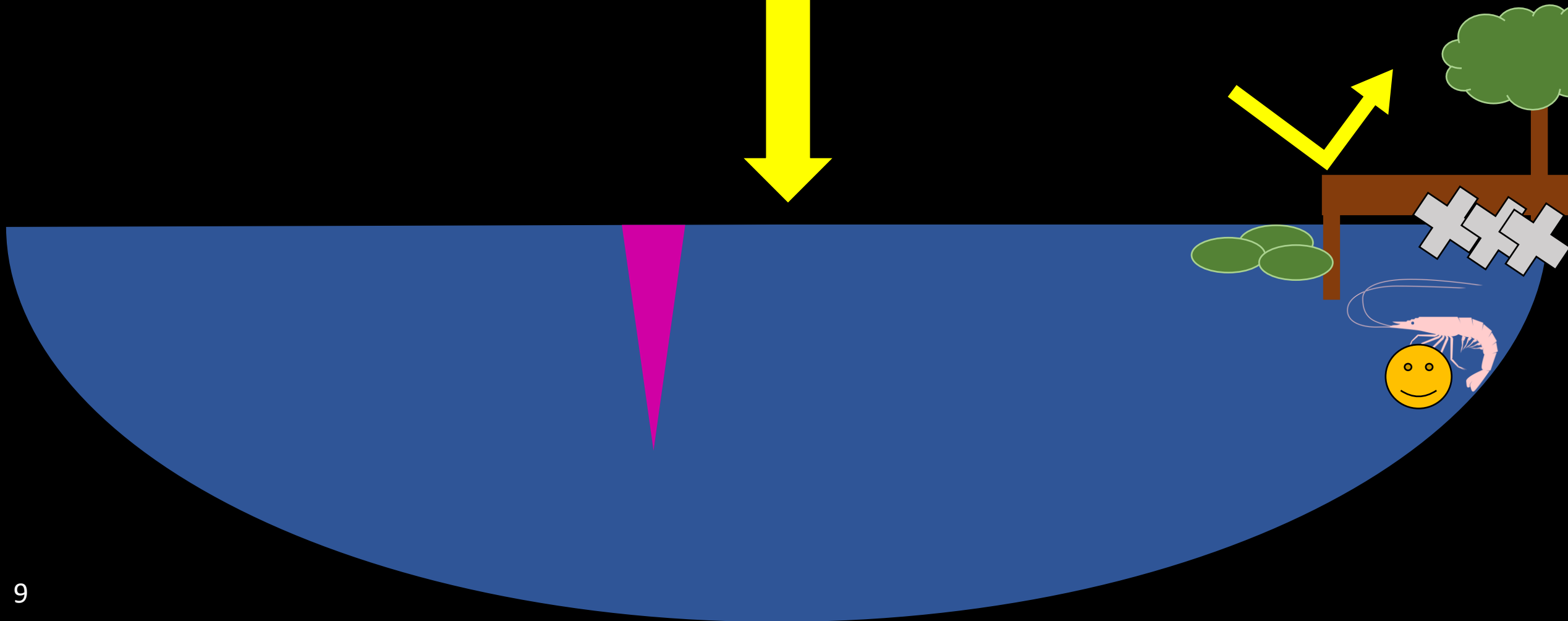


1. Reduced environmental exposure
2. Behavioral protection
   a. DVM
   b. Horizontal avoidance



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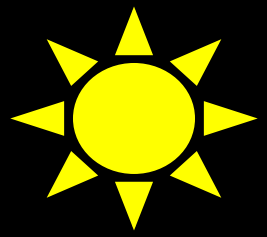
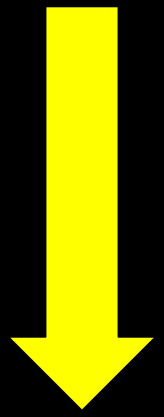
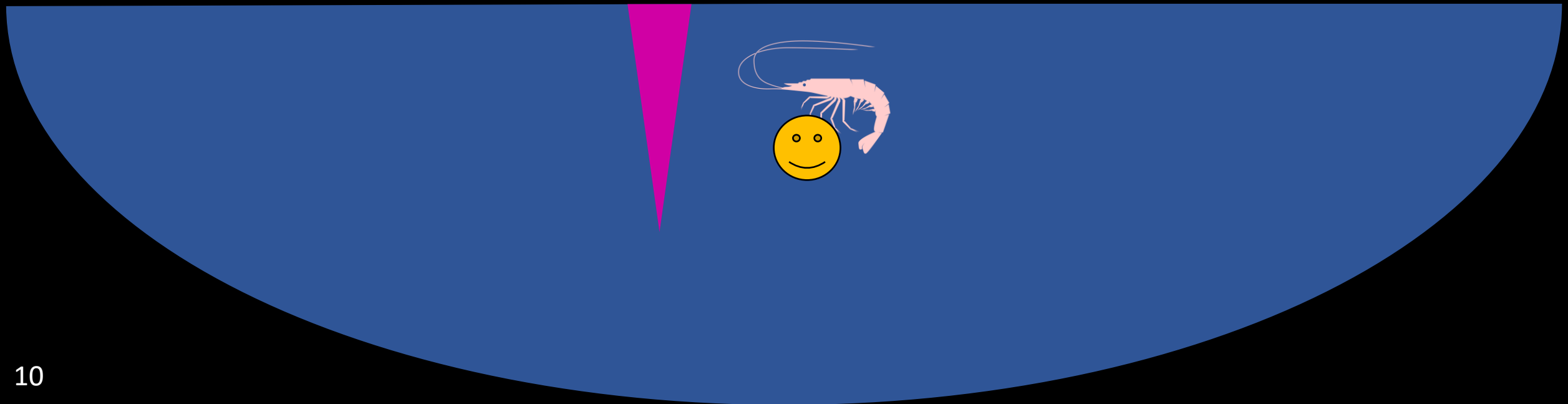




1. Reduced environmental exposure
2. Behavioral protection
   a. DVM
   b. Horizontal avoidance
3. Tolerance
   a. Pigmentation
   b. Photoenzymatic repair
   c. Dark repair



Hemimysis anomala: What do we know?

1. Reduced environmental exposure – Maybe: higher DOC
2. Behavioral protection
    a. DVM
    b. Horizontal avoidance
3. Tolerance

Hemimysis anomala: What do we know?

1. Reduced environmental exposure – Maybe: higher DOC

2. Behavioral protection

    a. DVM – Yes

    b. Horizontal avoidance

3. Tolerance

Hemimysis anomala: What do we know?

1. Reduced environmental exposure – Maybe: higher DOC

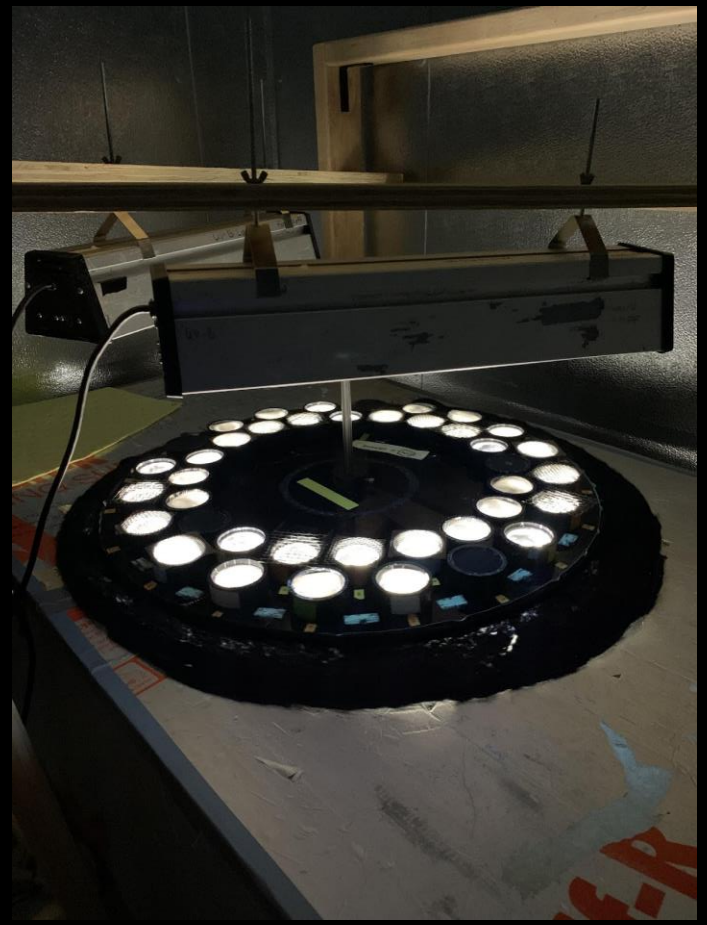
2. Behavioral protection

    a. DVM – Yes

    b. Horizontal avoidance – Maybe: found near piers, break walls – UV?

3. Tolerance – Unknown

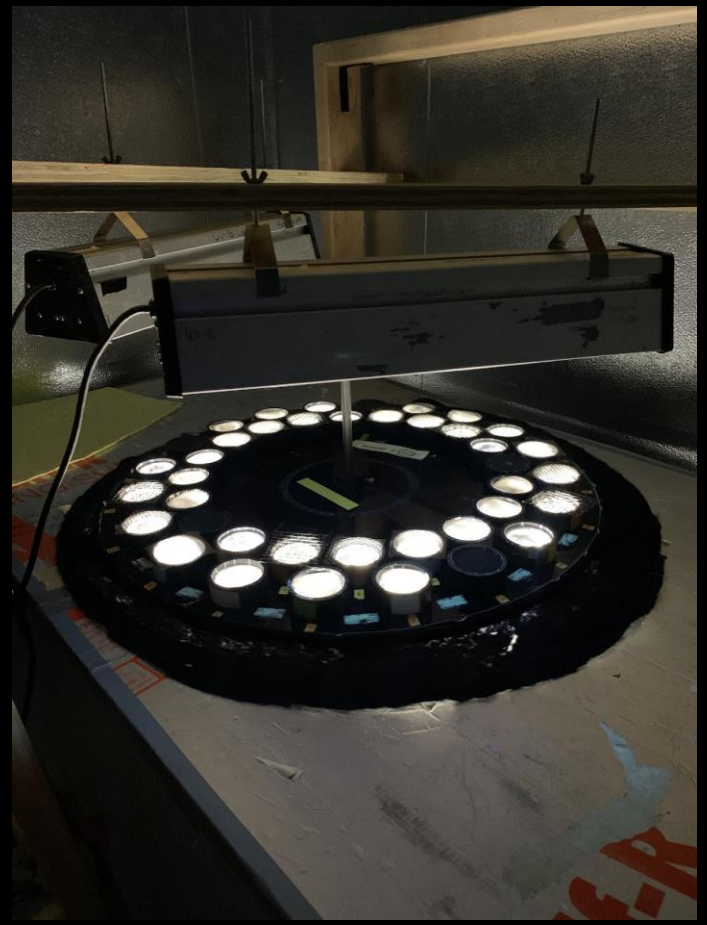
Q: Tolerance: What is the UV-B exposure level that kills 50% of *Hemimysis* (LE50)?

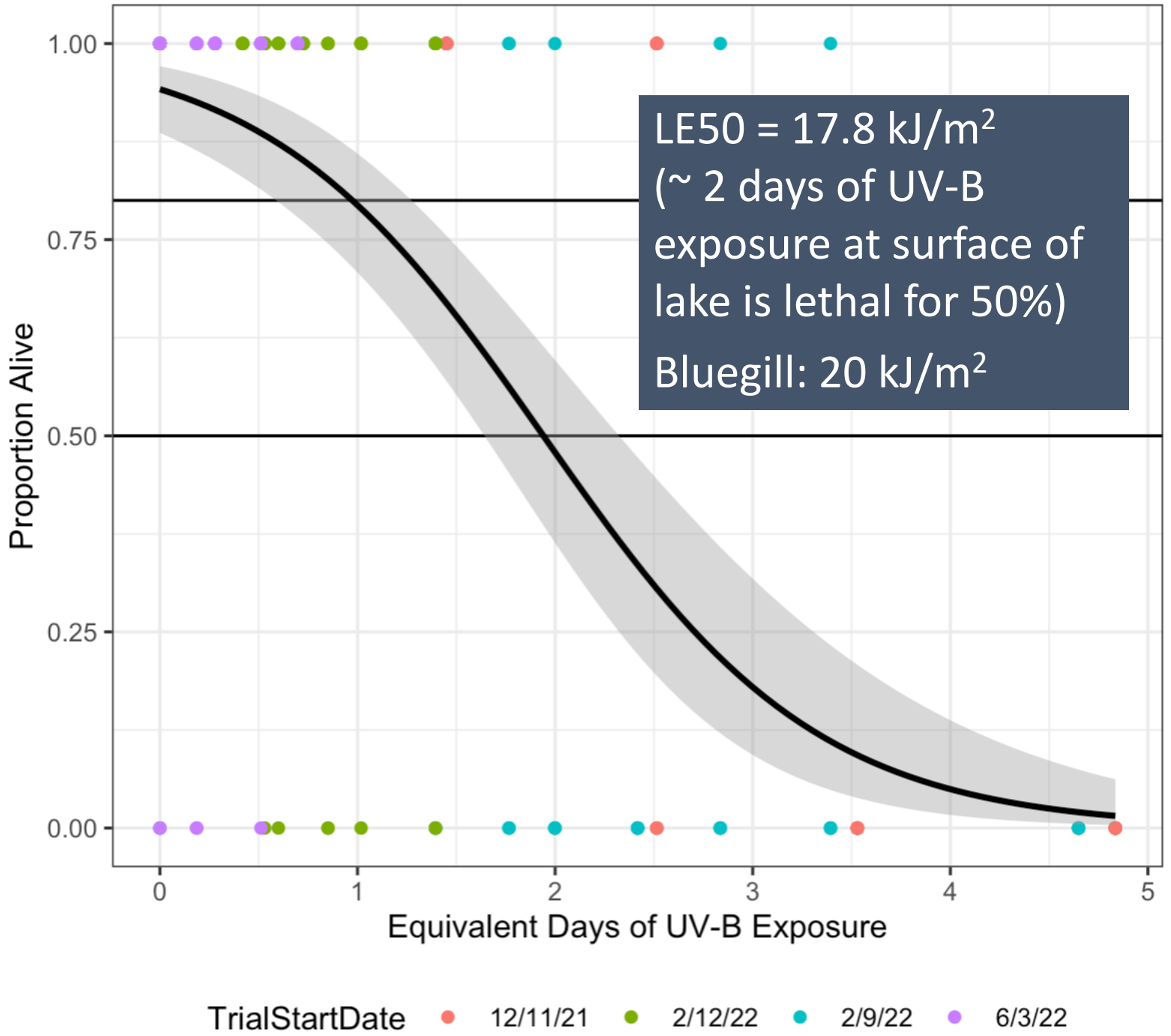


Methods:

1. Placed 1 *Hemimysis* in dish per replicate
2. Exposed to 12 hours UV-B
    - N = 5 to 10 reps / exposure level / trial
3. Tracked survivorship for 5 days post exposure

Q: Tolerance: What is the UV-B exposure level that kills 50% of *Hemimysis* (LE50)?





Hemimysis anomala: What do we know?

1. Reduced environmental exposure – Maybe: higher DOC

2. Behavioral protection

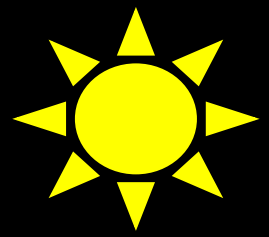
    a. DVM – Yes

    b. Horizontal avoidance – Maybe: found

3. Tolerance – Low: LE50 = 17.8 kJ/m^2

*These exposures are with UV lamps. What happens in natural sunlight?

Q: Does UV-B exposure in sunlight influence survivorship of *Hemimysis*? Does DOC affect survivorship?



Methods:

1. Placed 1 *Hemimysis* per replicate dish
2. Combination of two treatments:
   - With or without UV-B Exposure
   - DOC Concentration (0.6 mg/L, 6.7 mg/L, 10.0 mg/L)
   - N=20 dishes per treatment
3. Exposed to ~12 hours to natural sunlight (dawn to dusk)
4. Tracked survivorship for 5 days post exposure

*May 24th, 2022; UV-B exposure ~ 8 kJ/m^2 (Mostly Sunny Day)
(~80% of a full day's exposure to UV-B radiation during summer solstice for a similar latitude and elevation).

UV-B present, Low DOC

UV-B absent, Low DOC

UV-B present, Med DOC

UV-B absent, Med DOC

UV-B present, High DOC

UV-B absent, High DOC

Q: Does UV-B exposure in sunlight influence survivorship of *Hemimysis*? Does DOC affect survivorship?

All UV- at 95%

Solar UV-B can decrease survivorship, and DOC* may provide refuge from UV-B.

* Effect of DOC on survivorship not statistically significant

Hemimysis anomala: What do we know?

1. Reduced environmental exposure – DOC can potentially reduce mortality

2. Behavioral protection

    a. DVM – Yes

    b. Horizontal avoidance – Maybe: found near piers, break walls – UV?

3. Tolerance – Low: LE50 = 17.8 kJ/m^2; *Still low in natural sunlight*

Hemimysis anomala: What do we know?

1. Reduced environmental exposure – DOC can potentially reduce mortality

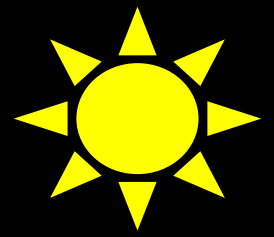
2. Behavioral protection

    a. DVM – Yes

    b. Horizontal avoidance – Maybe: found near piers, break walls – UV?

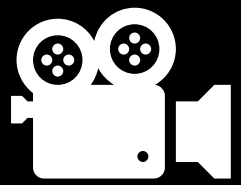
3. Tolerance – Low: LE50 = 17.8 kJ/m^2; *Still low in natural sunlight*

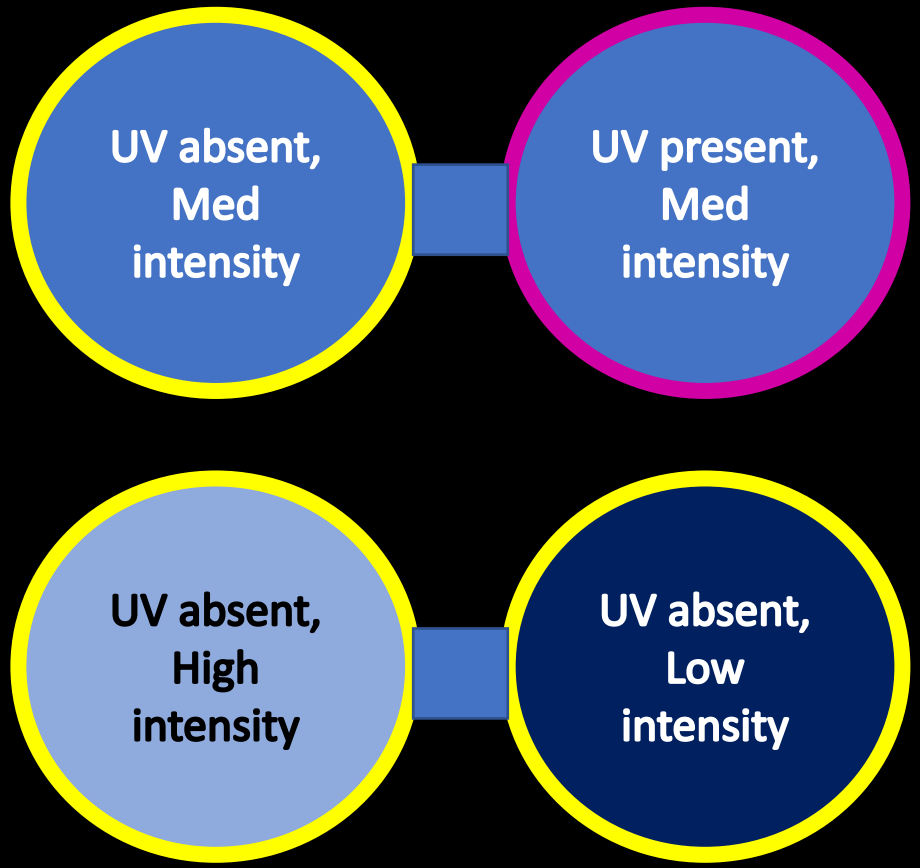
Q: Do *Hemimysis* respond behaviorally to UV? To visible light? Does behavior change with light intensity?



Methods:

1. Placed 1 *Hemimysis* in each enclosure
    a. UV+ / UV-
    b. High visible light / low visible light
2. Recorded for 10 minutes
    a. Amount of time in each side
    b. Light conditions during each trial





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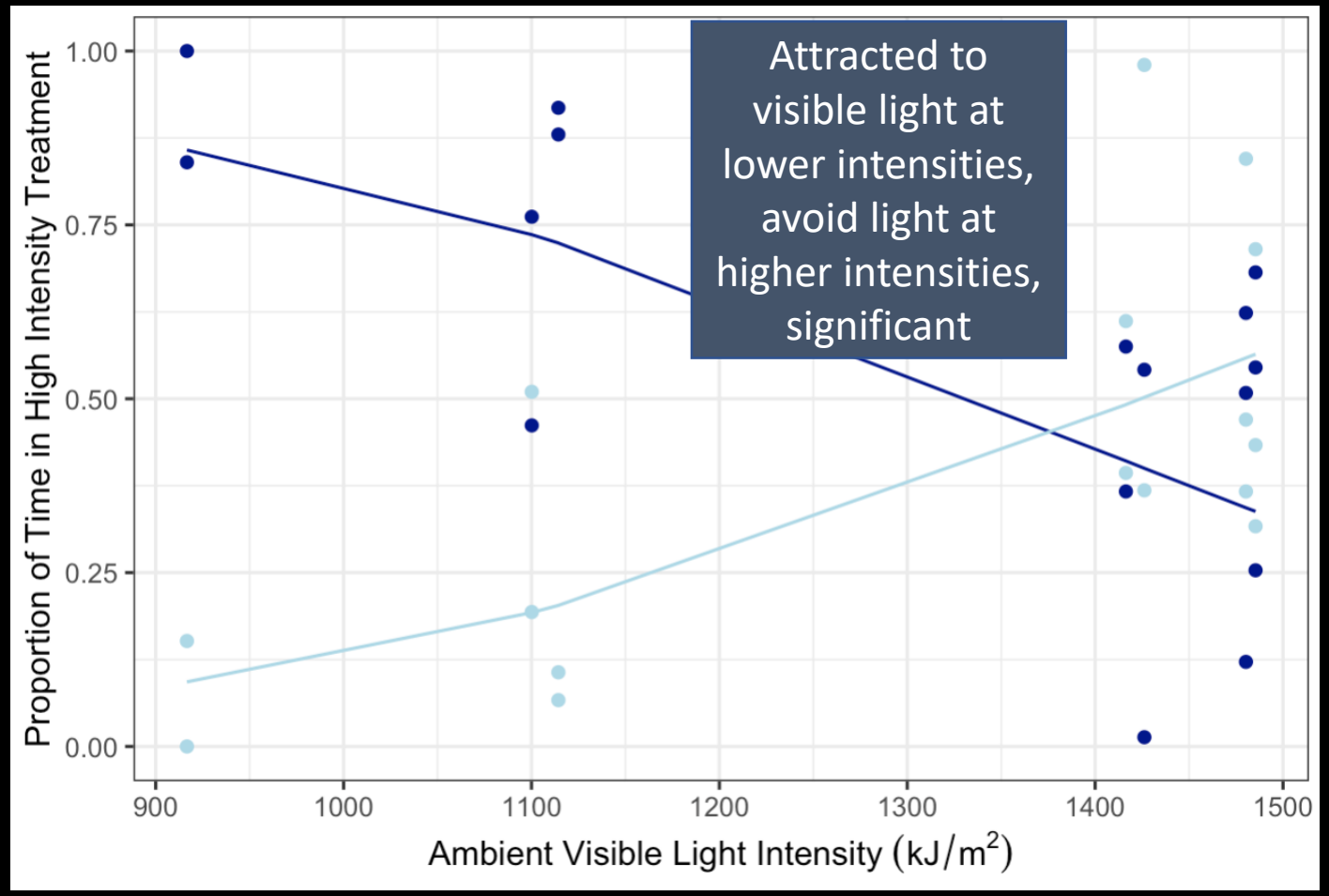
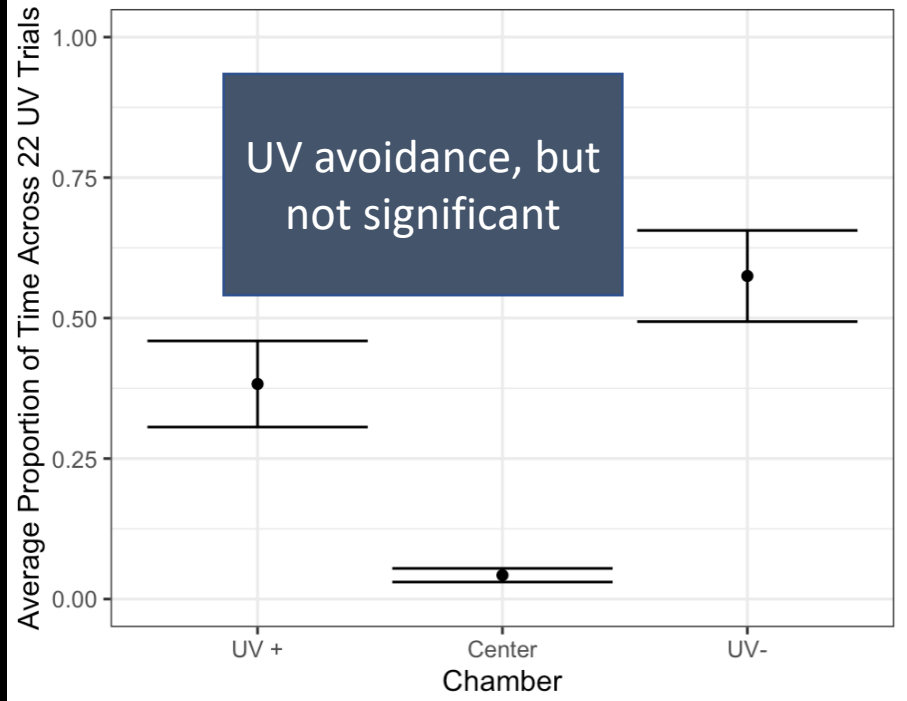
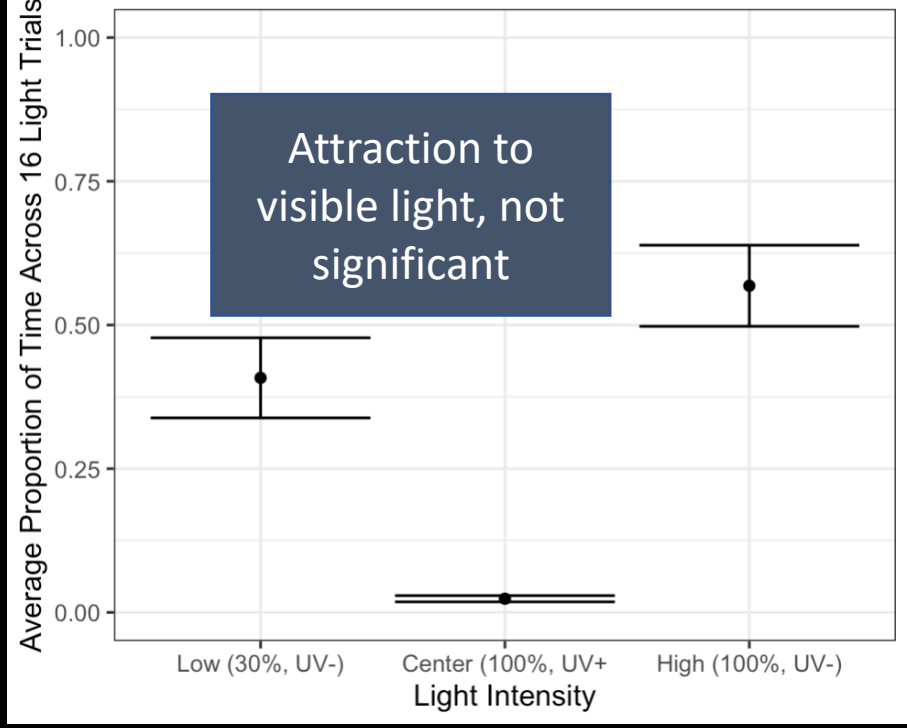


*No UV





Hemimysis anomala: What do we know?

1. Reduced environmental exposure – DOC can potentially reduce mortality

2. Behavioral protection

    a. DVM – Yes

    b. Horizontal avoidance – Maybe: Avoid high VL intensities → avoid UV

3. Tolerance – Low: LE50 = 17.8 kJ/m^2; *Still low in natural sunlight*

Applications

- Water clarity = management strategy
  - Eastern Lake Michigan tributary DOC levels: 1-15 mg C/L
    - (High DOC treatment for solar phototron = 10 mg C/L)

- Target less clear water bodies and UV refugia in clear water bodies for intolerant species

Thank you!

- Beth Mette, Miranda Strasburg, Global Change Limnology Lab (Miami OH)
- Kevin Keeler USGS Great Lakes Science Center (Ann Arbor)
- Steve Pothoven NOAA Great Lakes Environmental Research Center (Muskegon)