Artificial illumination of trawl gear components to reduce Pacific halibut (Hippoglossus stenolepis) bycatch in the U.S. west coast bottom trawl fishery

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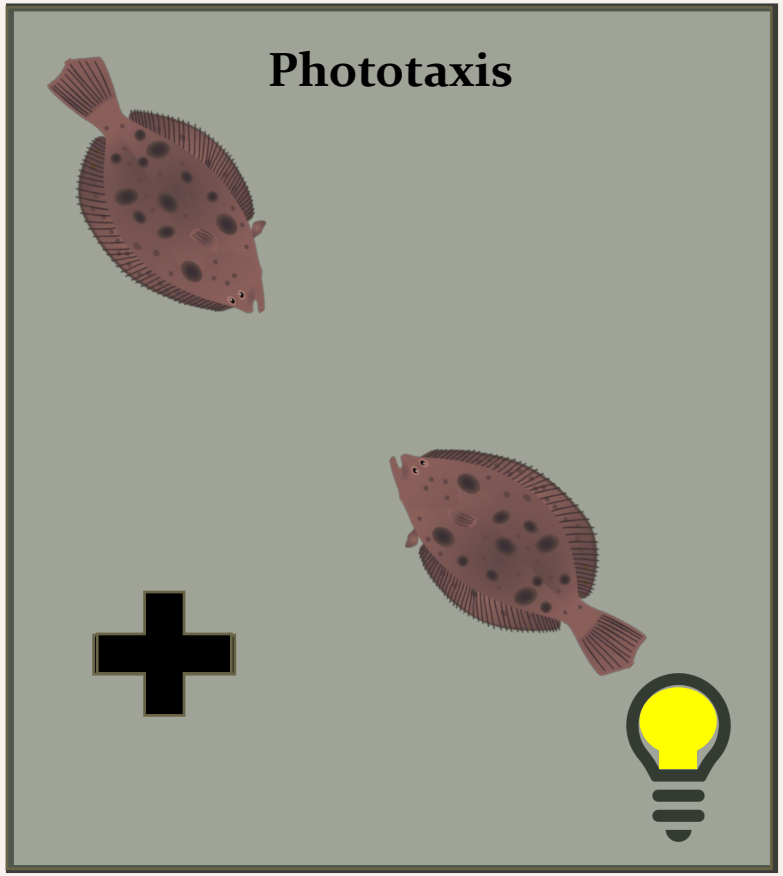
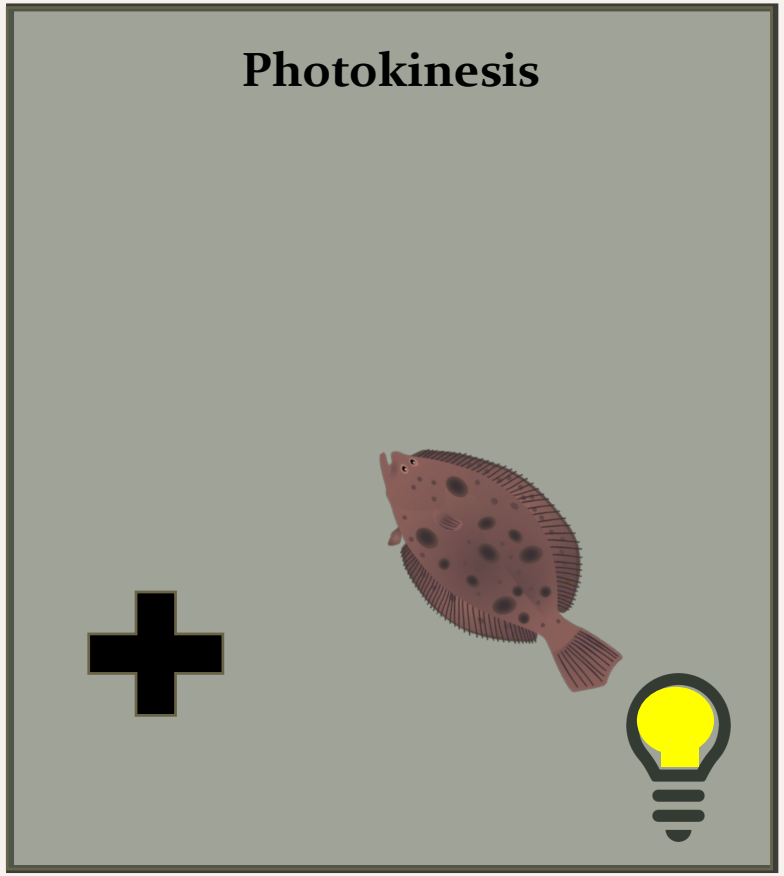
Behavior in response to light





He, 2010; Nguyen & Winger, 2019

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Tests of artificial light for bycatch reduction in an ocean shrimp (*Pandalus jordani*) trawl: Strong but opposite effects at the footrope and near the bycatch reduction device

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ABSTRACT

We investigated how the addition of artificial light in the vicinity of the rigid-grate bycatch reduction device (BRD) and along the fishing line of an ocean shrimp (*Pandalus jordani*) trawl altered fish bycatch and ocean shrimp catch. In separate trials using double-rigged shrimp nets, with one net incorporating artificial lights and the other serving as a control, we 1) attached one to four Lindgren-Pitman Electralume® LED lights (colors green or blue) in locations around the rigid-grate BRD, and 2) attached 10 green lights along the trawl fishing line. Both experiments were conducted with rigid-grate BRDs with 19.1 mm bar spacing installed in each net. Contrary to expectations, in 12 paired hauls the addition of artificial light around the rigid-grate increased the bycatch of eulachon (*Thaleichthys pacificus*), a threatened anadromous smelt species, by 104% (all by weight, $P=0.0005$) and slender sole (*Lyopsetta exilis*) by 77% ($P=0.0082$), with no effect on ocean shrimp catch or bycatch of other fishes ($P>0.05$). In 42 paired hauls, the addition of 10 LED lights along the fishing line dramatically reduced the bycatch of a wide variety of fishes with no effect on ocean shrimp catch ($P>0.05$). Bycatch of eulachon was reduced by 91% ($P=0.0001$). Bycatch of slender sole and other small flatfishes were each reduced by 69% ($P<0.0005$). Bycatch of darkblotched rockfish (*Sebastes crameri*), a commercially important but depressed rockfish species, was reduced by 82% ($P=0.0001$) while the bycatch of other juvenile rockfish (*Sebastes* spp.) was reduced by 56% ($P=0.0001$). How the addition of artificial light is causing these changes in fish behavior and bycatch reduction is not known. However, in both experiments the addition of artificial light appears to have greatly increased the passage of fishes through restricted spaces (between BRD bars and the open space between trawl fishing line and groundline) that they typically would not pass through as readily under normal seafloor ambient light conditions.

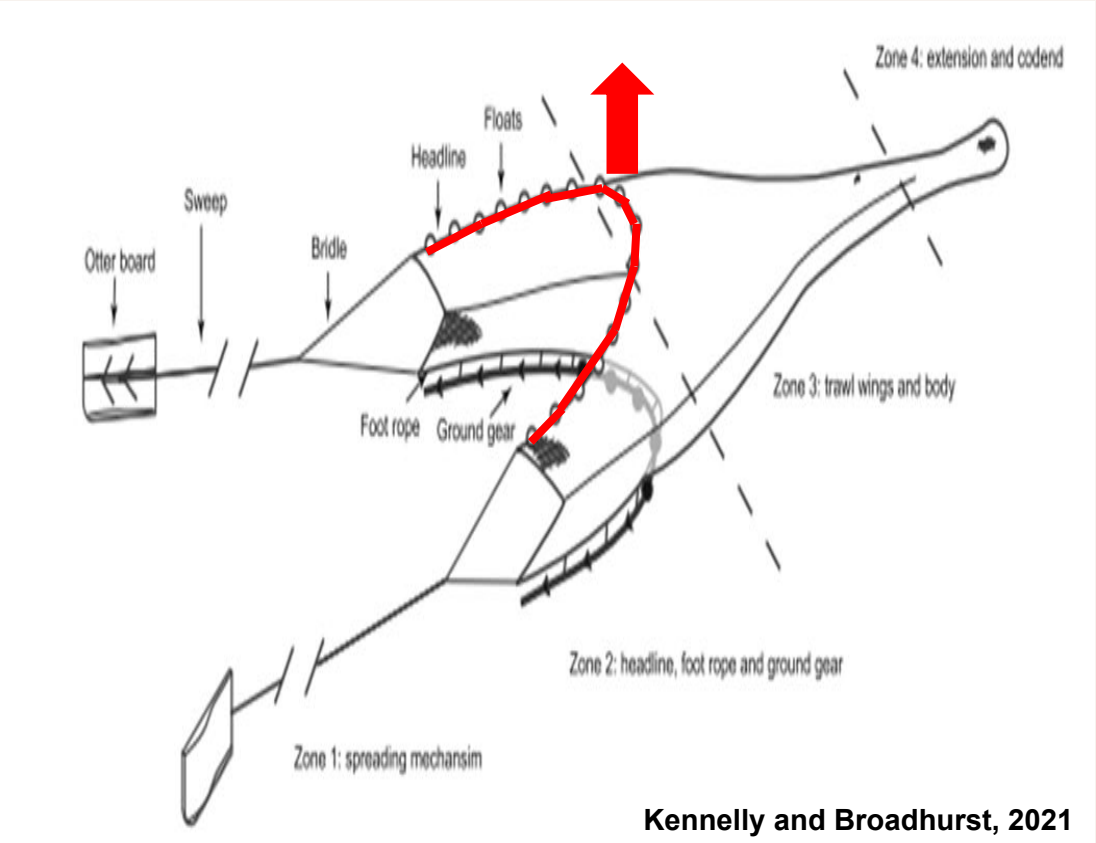
Artificial light for halibut bycatch

- Pacific halibut (*Hippoglossus stenolepis*) is a prohibited species for the fishery.
- The annual bycatch quota is limited, and a vessel may not fish with a deficit in quota.
- Studies conducted off the Oregon Coast have found that the addition of green LEDs to low-rise trawl gear greatly reduced the number of halibut caught.

Lomeli et al., 2021

Impetus for this study

- Recent regulation changes permit high-rise bottom trawls in areas they were once restricted.
- Halibut have shown to rely less on cryptic behavior and rather swim away or even over an approaching net.
- The authors of Lomeli et al. (2021) note that halibut could have escaped capture by going either above or below the illuminated bridles of the low-rise trawl.



Kennelly and Broadhurst, 2021

Ryer et al., 2008;
NOAA, 2018

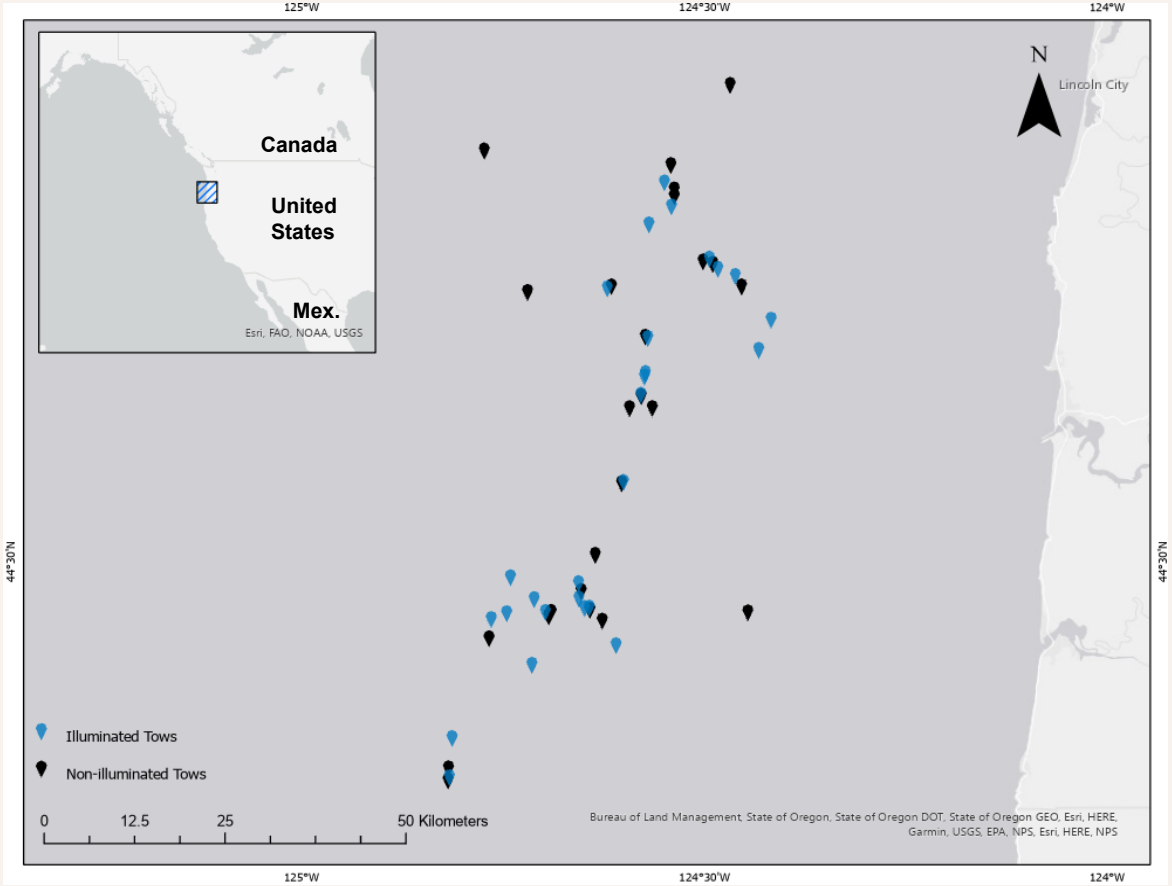
Objectives

Goal: examine the efficacy of artificial illumination on high-rise trawls to reduce halibut bycatch.

1. Conduct length dependent catch comparison and catch ratio analyses.
2. Examine the physiological condition of halibut caught in the trawl gear.
3. Observe fish behavior in response to an approaching high-rise trawl.

Field site and sampling

- Field work was conducted off the coast of Oregon during August of 2022.
- Fishing operations were conducted during daylight hours at bottom depths ranging from 99 to 348 meters.
- The average tow duration was 33 minutes with a range of 20 to 45 minutes.
- In total, 52 tows were conducted (27 illuminated versus 25 non-illuminated).

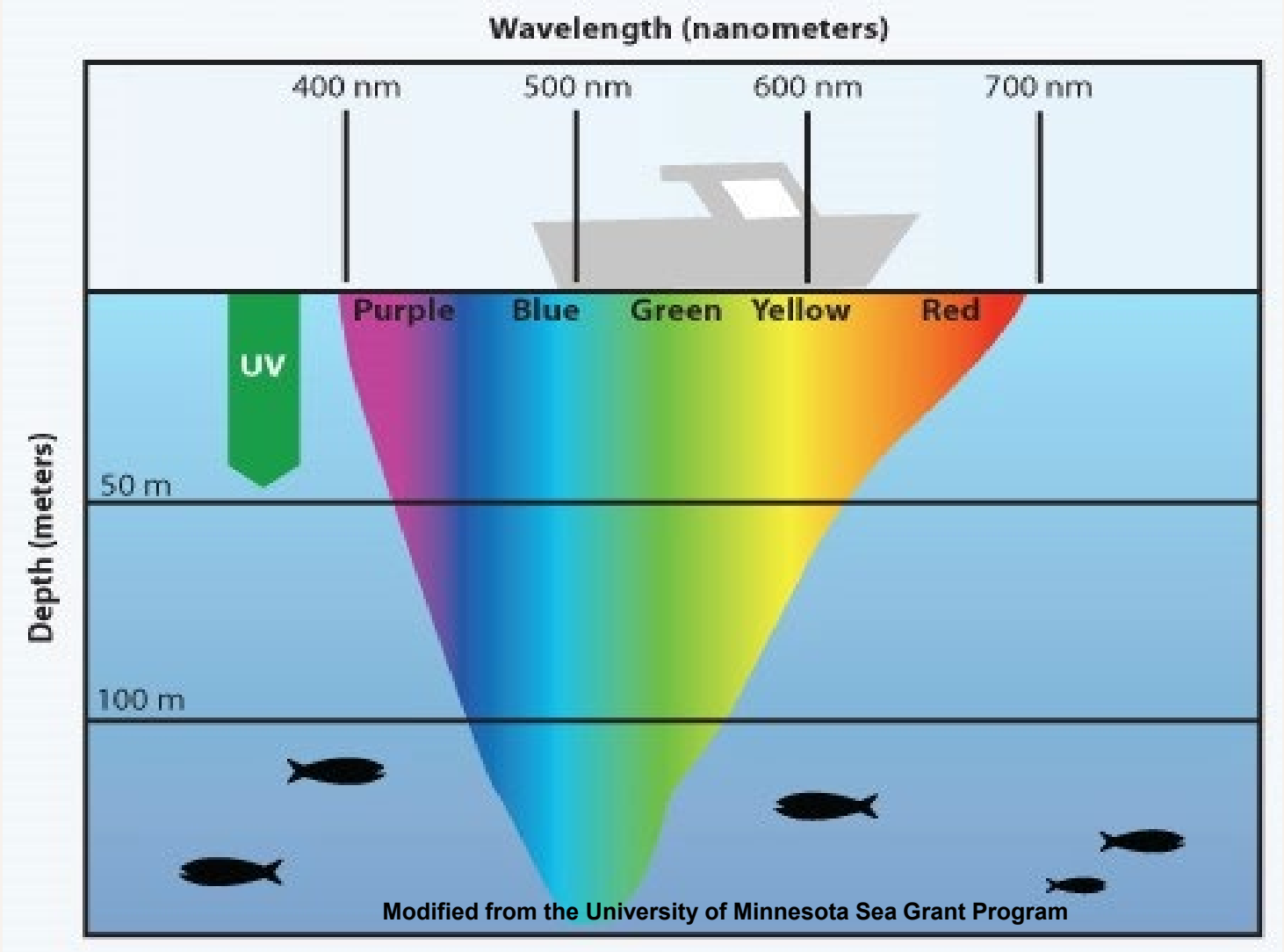


Artificial illumination

- Green Lindgren-Pitman Electralume® LED fishing lights centered on 519nm were used for this study.

"Why use green lights?"

- Green-blue light is the predominant spectral component of coastal waters in our study region.
- These lights were the same type used in the previous studies and would facilitate a comparison of the results.



Bowmaker et al., 1990

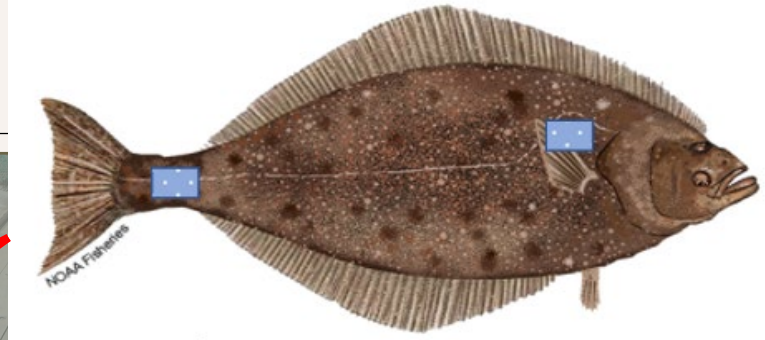
Field site and sampling

- For every tow, catch was sorted and weighed by species.
- Length measurements were recorded to the nearest centimeter for Pacific halibut and three target species:
  - Dover sole (*Microstomus pacificus*)
  - Petrale sole (*Eopsetta jordani*)
  - Sablefish (*Anoplopoma fimbria*)

SELNET and data analysis

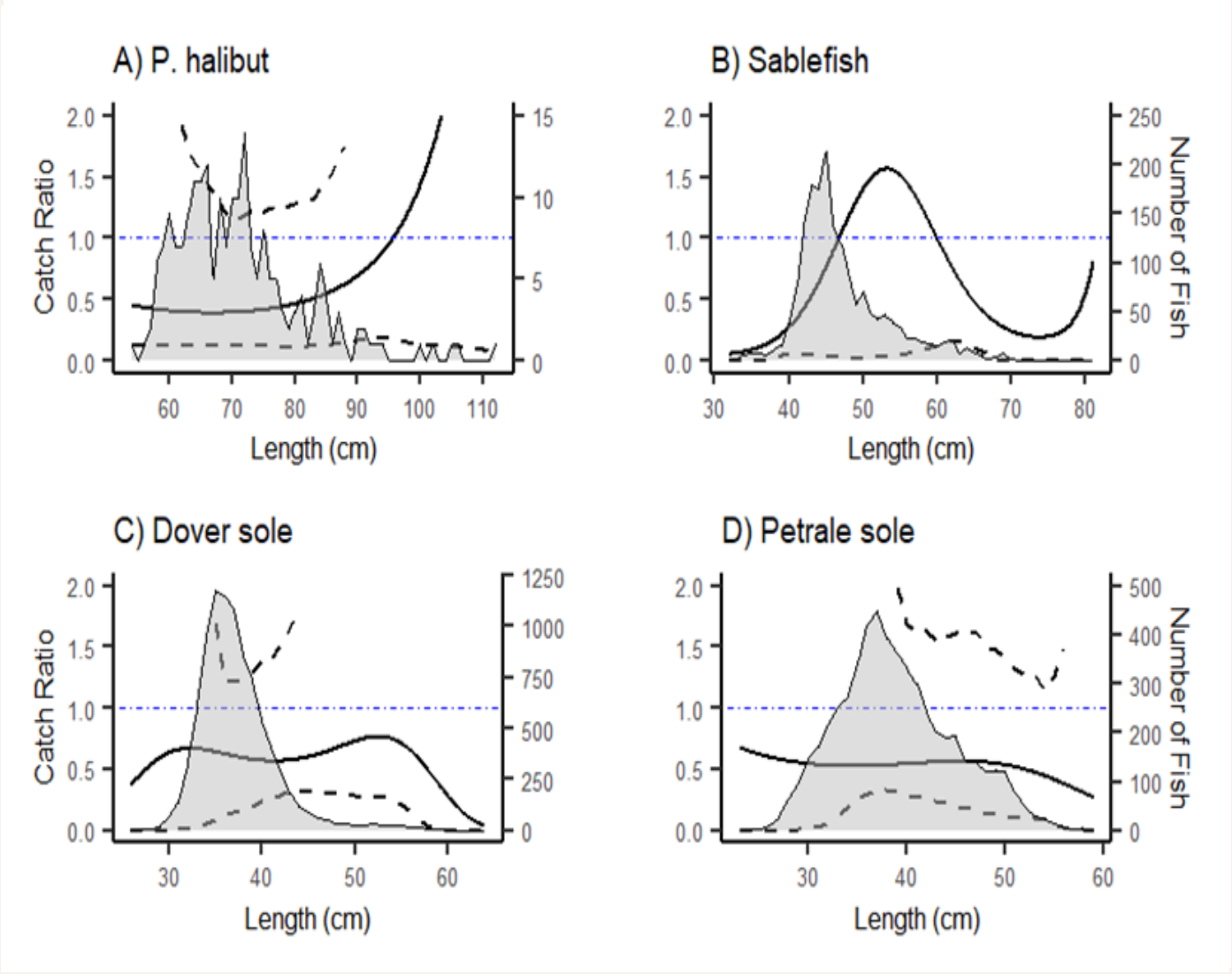
- SELNET was used to evaluate catch ratio analyses and conduct length-dependent catch comparisons.
- This type of study assumes data follow a binomial distribution as an individual fish can be captured in either one of two gears (e.g., the illuminated versus non-illuminated trawl).
- The double bootstrap method was used to account for the uncertainty due to between tow variation.

Physiological assessment

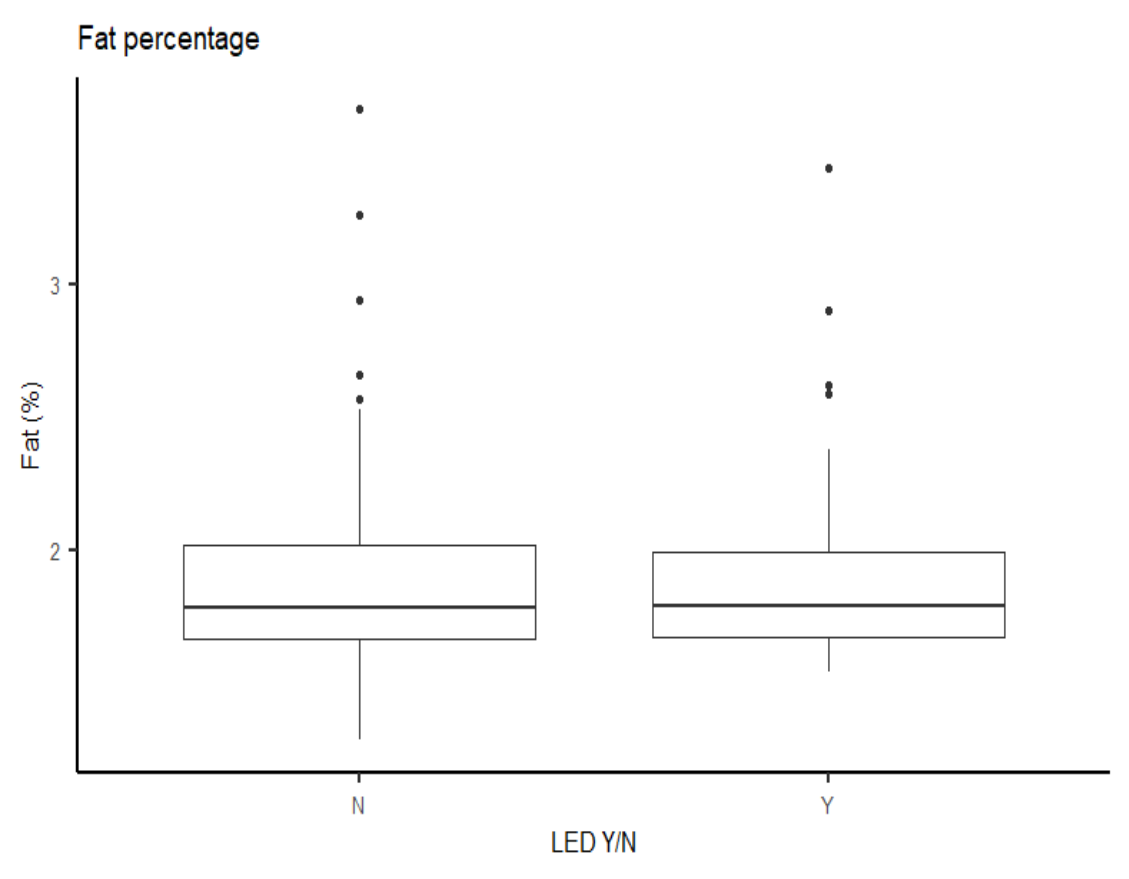


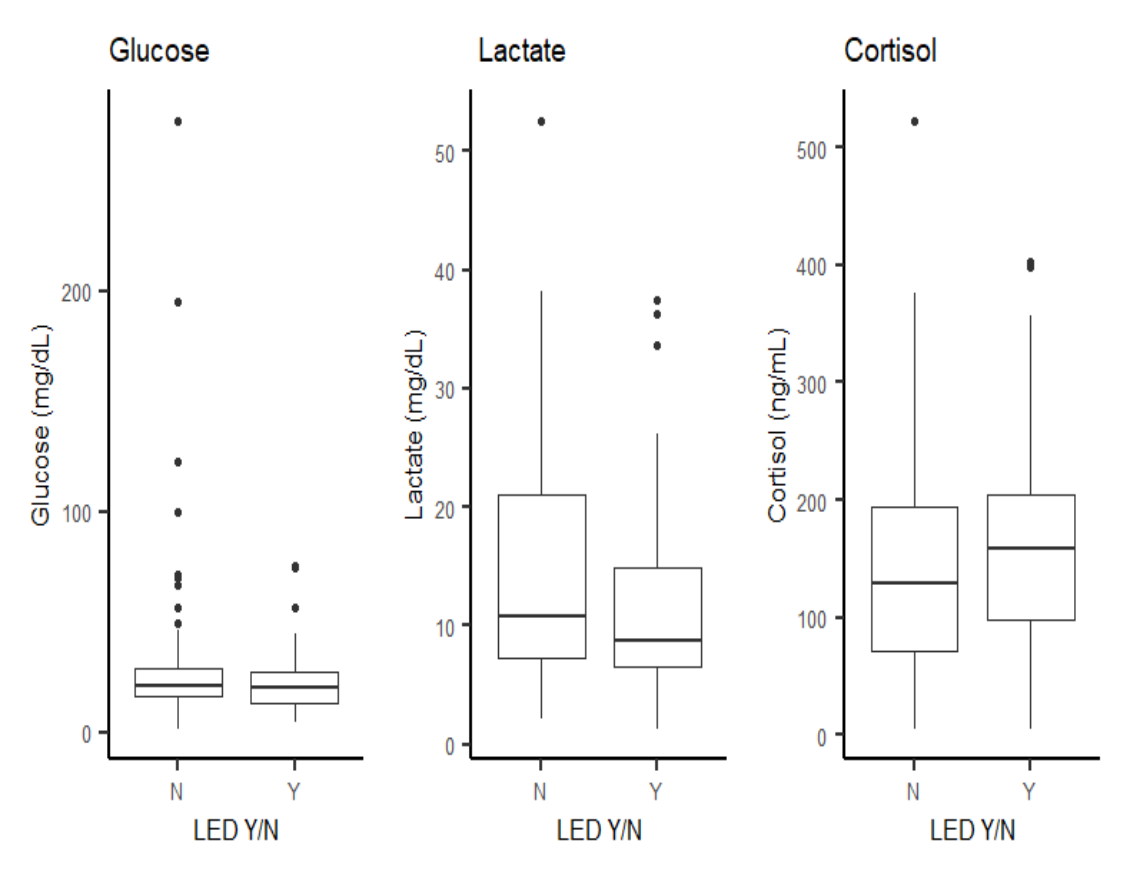
Catch comparison and catch ratio analyses

- The illuminated tows demonstrated a decrease in catch efficiency compared to the non-illuminated tows.
- Length-dependent analyses found no significant difference between illuminated and non-illuminated tows.



Physiological assessment





Conclusions

- Based on my results, there is little evidence to suggest that the addition of LEDs on the bridles of the high-rise trawl gear was effective at reducing Pacific halibut bycatch.
- These results differ from the previous studies.

Thank you so much!

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My advisor and committee:

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- Noëlle Yochum
- Mark Lomeli
- Rich Brill
- Donna Bilkovic

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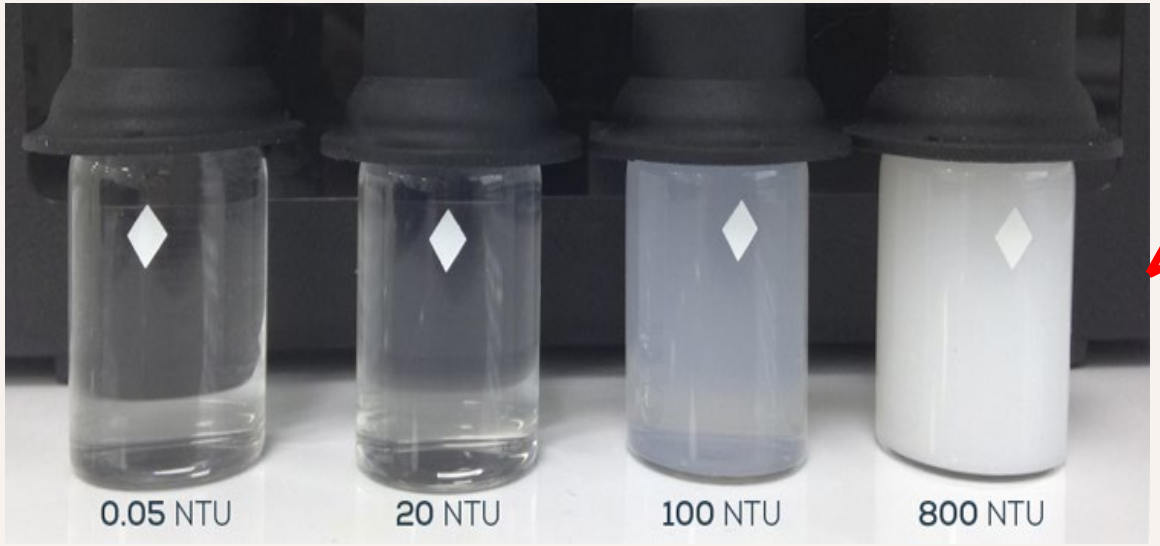
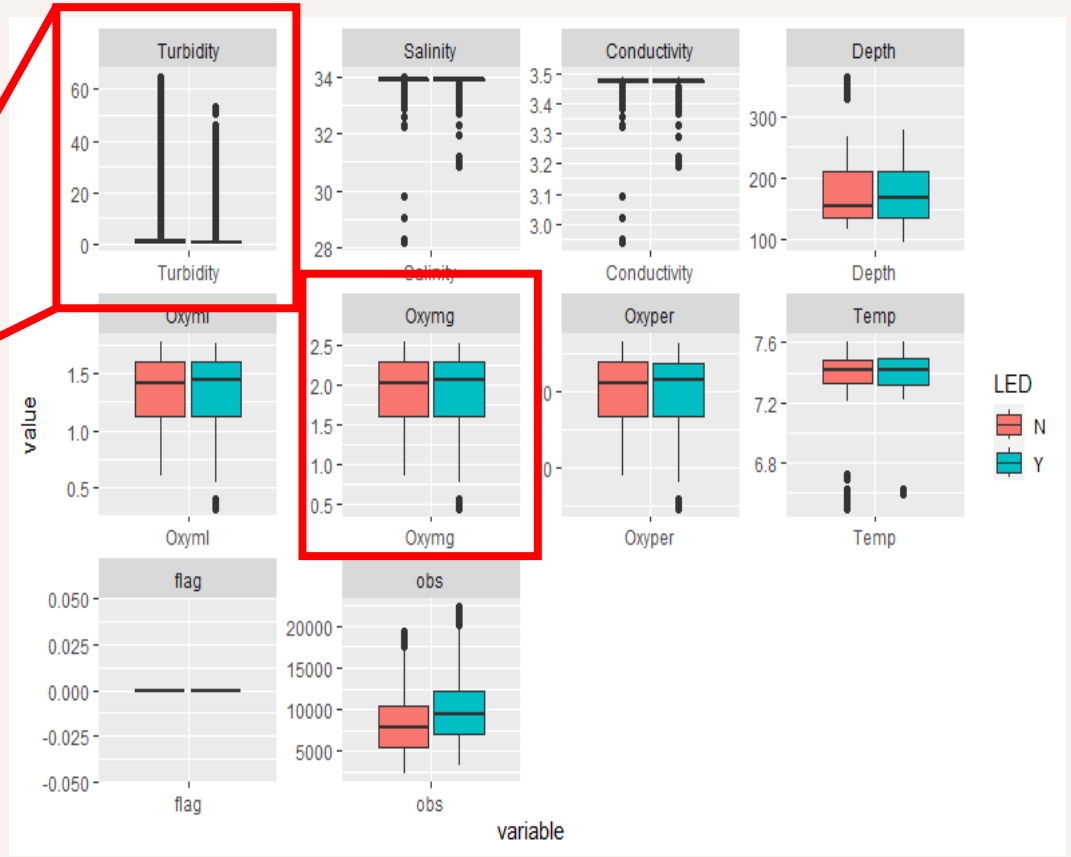
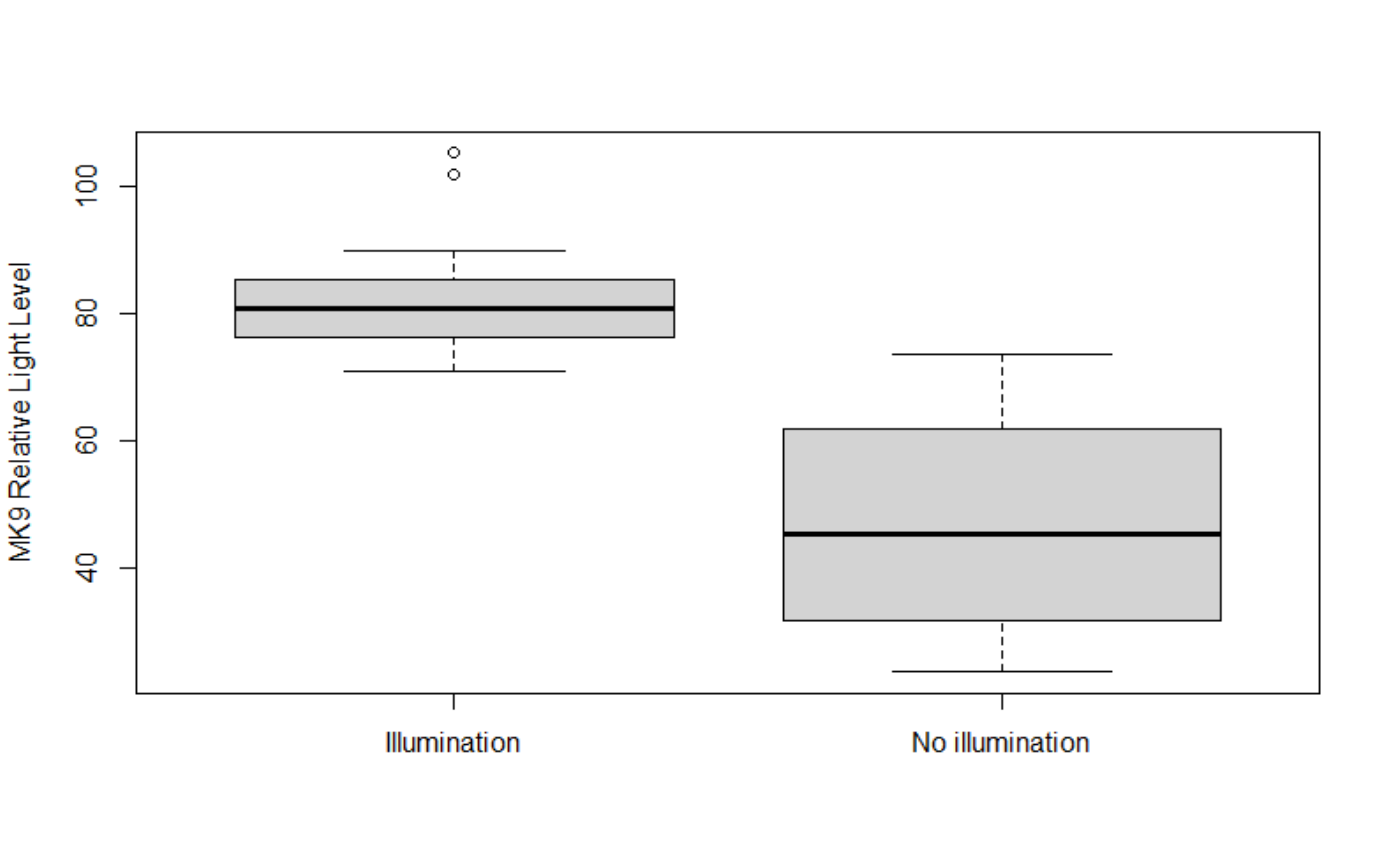
- Edwin Sanchez
- Kaitlyn Clark
- Will Shoup
- Andie Munoz

Abiotic conditions (*current work*)





Relative light levels



Tows 9 &16 excluded*

Fat meter

Assumption: Fatty Individual = Healthy

- For halibut, fat is stored primarily around the middle of the fish.
  - Fat reserves in the caudal end of the fish would be burned at a higher rate than those in rostral areas due to energy requirements.
- The Distell Fat Meter emits a low- powered microwave that excites water molecules in an organism's tissues.
  - The sensor converts the measured water content and lipid content in the tissue with species-specific models.