Examining Behavior of Lumpfish, *Cyclopterus lumpus,* Under Different Light Levels

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May 12th, 2021

Sea Grant
New Hampshire

As part of fulfillment of Tech 797 requirements

Introduction - Jackie

The lumpfish, *Cyclopterus lumpus,* is a teleost and member of the marine family Cyclopteridae. It is native to the North Atlantic and Arctic oceans and can range as far south as the Chesapeake Bay (Heessen et al., 2015). They are sexually dimorphic and have oblong shaped bodies with tubercles protruding from each flank. The females tend to grow larger than males with average size up to 50cm long while males typically do not exceed 30-40cm (Muus et al., 1999). The appearance of males and females is consistent with blue, grey, yellow, and brown coloration. Male lumpfish turn orange red during breeding seasons. Perhaps the most notable physiological characteristic is the suction discs formed by its pelvic fins, allowing lumpfish to suction themselves to rocks, sea bottoms, tank bottoms, and other surfaces.

The male lumpfish guards the eggs for 6-7 weeks until hatching (Britannica, 2016). Baby lumpfish spend a few months living in coastal waters after hatching. Once grown, they migrate to the pelagic zone where they feed on small pelagic organisms such as zooplankton and other fish eggs (Davenport, 1985). Upon reaching maturation, lumpfish migrate to coastal areas for spawning between the months of March and August (Kennedy, 2018). The females lay eggs in two clutches about two weeks apart producing 50,000-220,000 eggs in total (Kennedy, 2018).

Lumpfish have historically been sought after by fisheries for their nutritionally dense roe which is used to produce inexpensive caviar substitutes (Hui, 2016). Lumpfish caviar is a popular dish in Iceland, Greenland, Norway, and certain parts of Canada. The roe is made of ripened egg masses rich in vitamin B12 and omega-3 fatty acids. Some North Atlantic countries eat the meat of the fish by boiling and smoking it.

In addition to using lumpfish for nutritional purposes, they are a valuable aquacultural tool in commercial salmon farms. Lumpfish are used as “cleaner fish” in farms to reduce outbreaks of parasitic sea lice (Morado, 2019). Salmon farms in Norway, Scotland, and Iceland benefit from using lumpfish as an alternative to chemical treatments to delouse salmon. Cleaner fish are typically denoted as a species of smaller fish that consume and remove ectoparasites, mucus, and dead skin from a host fish known as the "client fish" (Grutter, 2004). The lumpfish is categorized as a specialized facultative cleaner fish because they do not rely solely on consumption of lice (Dunkley et al., 2018). Salmon are able coexist with lumpfish when they are introduced into their salmonid sea cages, demonstrating a mutualistic interaction that benefits both the lumpfish and salmonids.

Little research has been done regarding the behavioral activity of lumpfish. One study by Kennedy et al. (2015) has suggested that lumpfish are semi-pelagic/semi-demersal fish because their behavior between day and night varies. It was found lumpfish spend more time in the pelagic zone during the night and spend more time near the seabed during the day. The goal of our study was to determine how light exposure affects the activity of lumpfish. If light exposure has an influence on the behavior of lumpfish, it may be possible to increase their productivity as cleaner fish. By finding a way to increase activity without contributing to additional physiological stress, lumpfish may be able to become more efficient consumers of sea lice.

Figure 1: *C. lumpus* swimming at the UNH Coastal Marine Laboratory. Photo credit: J. Klombers

Methodology and Design – Jackie

Ethical Statement

This study was approved by the Institutional Animal Care & Use Committee (IACUC) at the University of New Hampshire. All fish were handled with proper care and humane treatment.

Methods

Experimentation was conducted at the Coastal Marine Laboratory in New Castle, New Hampshire where the photoperiod was maintained at 12 hours light, 12 hours dark. Lumpfish in a grow-out tank initially were observed using a TLCPRO 200 time-lapse video recorder mounted overhead. A red lamp positioned above the tank was programmed to turn on for 10 hours per night for nighttime filming. Data from the TLCPRO 200 were collected for 72-hour intervals. It was determined that in order to track lumpfish behavior, individual fish needed to be recorded in solitary tanks instead of the community grow-out tank. Twenty trials were conducted in which an individual lumpfish was selected at random and placed into a 200 L, 0.9 m diameter, round tanks. Tanks were set up with a quadrat grid splitting the tanks into four quadrants. A TLCPRO 200 was fastened above the tank and the red light positioned above the middle of the tank. Movement and activity data were recorded for 72 hours, after which the fish was returned to the grow-out tank and a new lumpfish added to the experimental tank for the next trial.

Figure 2: Experiment set up of 200 L, 0.9 m diameter round tank. Behavior was tracked using the quadrat above to determine lumpfish location and activity.

Data was obtained from the TLCPRO 200 after each trial. The data were then coded using the classification techniques shown in Table 1, which was derived from another study conducted by Stavel et al. (2019). The scoring technique was used to determine, and code lumpfish behavior based on their obvious behavior, activity, and locomotion observed in the time-lapse recordings. Statistical analyses were then performed to determine if significant ($p < 0.05$) relationships existed between movement and light exposure, and activity levels and light exposure.

Score	Activity Level	Description
1 Bottom	X	Sucker attached to tank bottom
2 Side	X	Sucker attached to tank side
3 Hover	X	Hovering with no horizontal or vertical locomotion
4 Swimming	5: Moved Slightly 6: Moved Far	Evidence of locomotion to different quadrant

Table 1: Scoring technique used to code behavior of lumpfish

Results – Joe

A one-way ANOVA was performed on the data gathered for the fish movement values. There was a significant relationship between light level and lumpfish activity levels (one-way ANOVA, $p<0.001$). A one-way ANOVA was also performed on the data gathered pertaining to the lumpfish quadrat locations over time. There was not a significant difference between quadrat location of the lumpfish over time (one-way ANOVA, $p=0.898$).

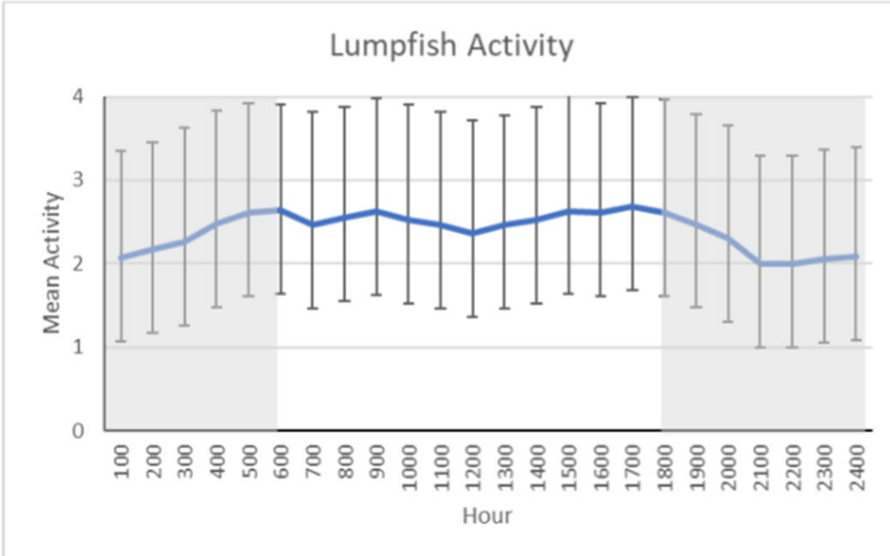

Figure 3: Lumpfish activity over time graph. Mean data represented condensed into one 24-hour period. ANOVA p<0.001).

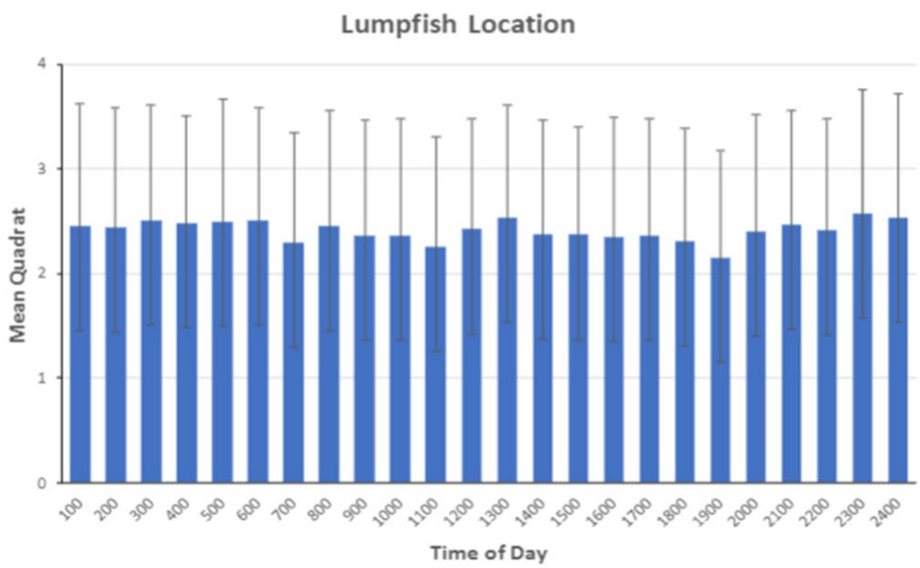

Figure 4: Lumpfish quadrat location over time graph. Mean data represented condensed into one 24-hour period. ANOVA p=0.898).

Conclusion – Joe

The goal of this study was to determine if there was a correlation between light levels over a regular photoperiod and the activity of lumpfish. The hypothesis was that a difference in light level would change *C. lumpus* behavioral patterns. If a connection could be found between light levels and activity in lumpfish, the research could possibly be expanded on to allow for more efficient use of lumpfish as cleaner fish in salmon farms.

The method used for data analysis was to compare both activity scores and movement scores over time to photoperiod. These were then simplified into mean values, represented both as the full 72-hour cycle and also condensed into a 24-hour scale. A one-way ANOVA compared both sets of data in order to determine a relationship. A significant relationship was found between light levels and general activity. This was displayed by decreased activity during dark periods, but there was no significant relationship between light levels and lumpfish movement around the tank.

One possible limitation with the experiment data could be that the tanks were too small. Having larger tanks could provide more space for the lumpfish to move around, possibly leading to a clearer preference of quadrat movement in relation to light. Another possible issue could be the time intervals used on the time lapse cameras. Longer photographic intervals could result in missing important movements from the lumpfish, skewing the data. In order to rectify this, shorter photographic intervals would have to be used, requiring much longer data analysis phases. The data collected in this study points to a clear connection between *C. lumpus* activity and the light levels around them.

Future studies could include examining whether alteration of photoperiod makes a further difference in lumpfish activity or movement within a tank, whether photoperiod has an effect on feeding level and speed of the lumpfish, or whether the same effect could be achieved in places with day-night cycles that change drastically throughout the seasons (i.e. the far north).

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