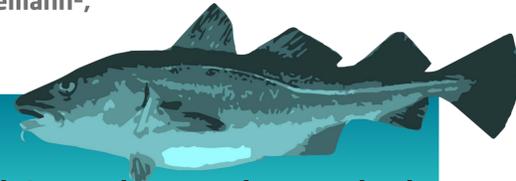


Effects of high-frequency strobed laser light on Atlantic cod (*Gadus morhua*) physiology and behavior

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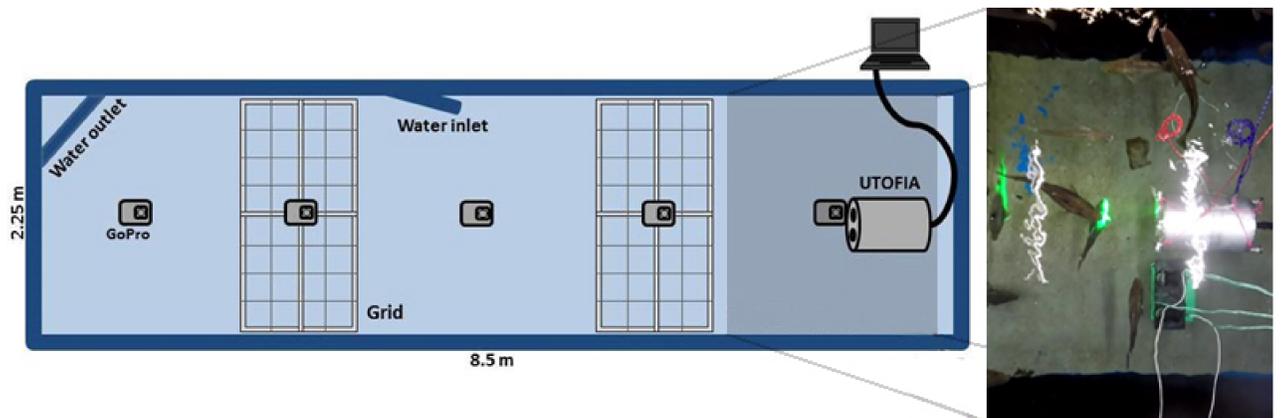


Background and Aim

The H2020 project UTOFIA is currently developing an underwater camera based on range-gated principal. It couples together a pulsed laser light source with a finely controlled camera that can capture video rate images and extend the imaging range by a factor of 2 to 3 over conventional systems, and also provide 3 dimensional information. The use of high-powered lasers however constitutes a potential hazard. Consequently, it is imperative to investigate if it may cause harm, distress or altered behaviour in marine organisms. Using Atlantic cod (*Gadus morhua*) as a model species we here investigated potential physiological and behavioural stress responses to the laser source.

The set-up

Figure 1. The experimental tank including the UTOFIA system, grids and GoPro cameras. The insert (photo) shows the cod swimming in front of the laser (green light).



Investigations

Heart rate, a good indicator of stress in fish, was logged with DST milli-HRT heart rate loggers (STARODDI) in ten free-swimming cod and data were analyzed using a mixed model.

Activity (including swimming speed) was assessed on twenty-eight cod with GoPro cameras (Figure 1). Video sequences were analyzed for activity and swimming speeds using Labtrack tracking software (BIORAS, DK) and a custom MatLab script, whereas distribution in the tank was quantified as the total number of trackings within that given video frame and time period.

The laser was operated from 13:00 to 13:10 on five consecutive days.

Results

Swimming speeds with laser on (green) and off (blue) were highly comparable, being on average 34 and 35 cm sec⁻¹ (Figure 2). This compares well with speeds of cod in the field, indicating un-stressed fish.

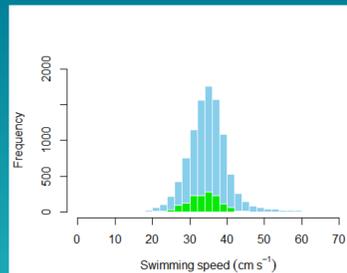


Figure 2. Swimming speeds with laser off (blue) and on (green).

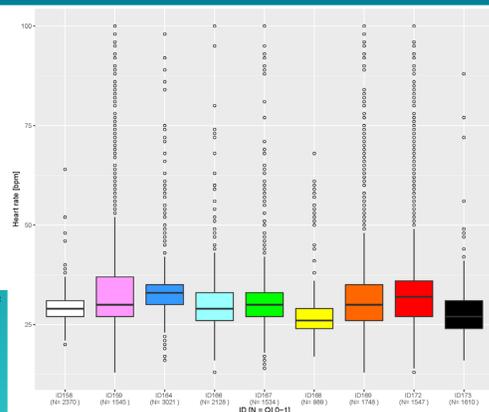


Figure 3. Heart rates of individual fish. Solid line is the median, bottom and top of box are 25th and 75th percentiles, respectively.

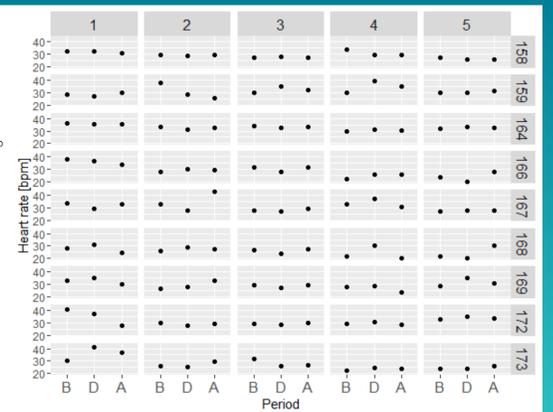


Figure 4. Individual heart rate before (B), during (D) and after (A) the UTOFIA laser was on for each of the five experimental days (day number top horizontal axis). Each dot represents the mean heart rate during 10 minutes.

Average basal heart rate of individual free-swimming cod ranged between 28 and 35 bpm (Figure 3), which is highly comparable to previous reports.

Measurements of individual heart rates before (B), during (D) and after (A) the UTOFIA laser was on for each of the five experimental days (Figure 4) revealed that there was no response in heart rate to the laser.

There was no behavioural response when the laser was operating, i.e. neither did the fish go closer or further away from the UTOFIA system (Figure 5).

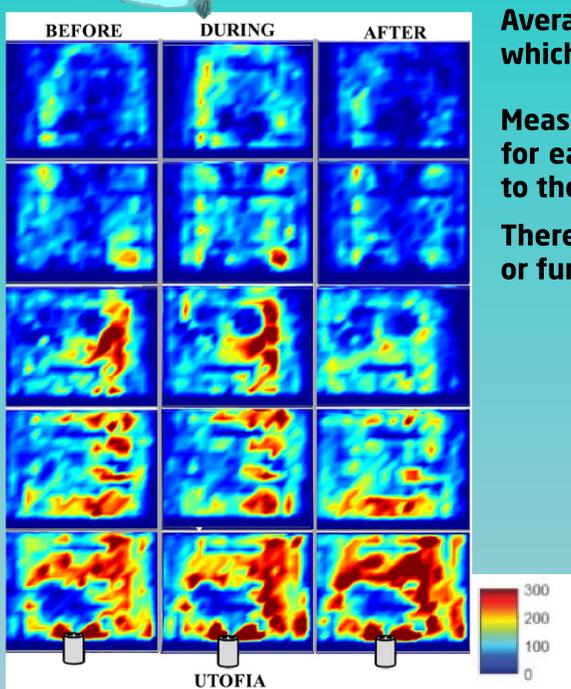


Figure 5. Example (day 4) of fish activity before, during and after the laser was turned on. Red indicate high activity, blue low activity.

Conclusions

Within the boundaries of the available experimental setup there was no documentable effects of the laser source in the UTOFIA system on cod heart rate, nor did the laser cause any avoidance reactions, as evaluated by distribution patterns of the fish within the tank and their swimming speed.