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Continuous physiological monitoring of fish welfare during sea cages rearing and the journey to slaughter

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The husbandry conditions in intensive fish farming can impose high levels of negative stress and cause both high mortality and inferior meat quality. Yet, in modern fish farms where tens of thousands of fish are held together, stress and welfare are not easily assessed. By using novel implantable bio-loggers, in combination with plasma cortisol levels, we monitored physiological indicators of stress in individual rainbow trout (*Oncorhynchus mykiss*) swimming with 5000 conspecifics in a sea cage during their last 3-4 weeks to before slaughter. We could identify and quantify stressful events that occurred both in the sea cages and during harvest. Following surgical implantation of the bio loggers, transportation and reintroduction with conspecifics, it took ~4 days for heart rate to return to baseline levels and for a clear circadian heart rate rhythm to emerge. The increased heart rates caused by stress from farming practises (*i.e.* crowding and transportation) corresponded well with increases in plasma cortisol levels. Moreover, air exposure during brailing and aquatic hypoxia triggered a hypoxic bradycardia until fish were returned to oxygenated water whereupon heart rate significantly increased to repay the accumulated oxygen debt. Repeated stress induced by multiple subsequent farming practises clearly had a cumulative and long-lasting effect as heart rate peaked at ~25 beats min⁻¹ above the normal circadian rhythm following the combined stressors of crowding, brailing and transportation, and remained significantly elevated by ~9 beats min⁻¹ the following morning. This study demonstrates that monitoring heart rate using implantable bio-loggers is a useful tool for assessing stress levels of freely swimming fish in sea cages. This opens up a broad range of possible applications allowing investigations of environmental and/or anthropogenic stressors on the welfare of fish in scenarios realistic for the aquaculture industry.

Keywords: Welfare, Bio-loggers, Stress, Hear rate