

## Fish liberation - 3R methods in fish physiology

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**Minimizing stress** is critical when working experimentally on fish as it may override the investigated effects and diminish the welfare of the animal. Here, we explore three *refined* systems that all permit sequential recordings which *reduce* the number of animals used in each study in accordance with the 3R principles. Mutual for the three systems is that they are capable of long-term heart rate recordings in fish without any wires attached. The first system is completely non-invasive and includes external electrodes that record bio-potentials produced by the heart and ventilatory muscles directly from the water. These recordings can be made continuously without any limitations in time but is restricted to fresh water, one animal per tank and depends on the tank to fish ratio. The second system is a *data storage tag* that can store timed recordings of heart rate and temperature for up to 3.5 months. The third system is a *biotelemetry system* that can measure ECG, blood pressure, gut blood flow, temperature and movements (through a 3D accelerometer). This latter system can either transmit or store data continuously for 2-3 weeks. These two last systems both require invasive surgical procedures as they are implanted into the abdominal cavity of the fish. However, after recovery the fish can be released, without any restrains, back to the rest of the school. Our results shows that these systems can be used to improve the quality of the physiological data and at the same time improve the welfare of fish used in science.