Using physiology to improve the health and sustainability of cleaner fish (lumpfish) production for the salmon aquaculture industry

Supervisory team:
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Project description:
Atlantic salmon production presents the gold-standard for the technological advancement of aquaculture, and its value both globally and nationally is significant (£733M p.a. in the UK). Nevertheless, this industry still has issues, with the effective control of sea-lice being a major challenge. By using other species of "cleaner fish" which feed on lice from salmon held within sea cages, the industry limits the use of physical/chemical treatments that have negative side-effects or environmental impacts. Lumpfish (Cyclopterus lumpus) have a big advantage as they are effective at sea-lice removal at low temperatures, unlike other cleaner fish species. Commercial production of lumpfish for salmon farms has therefore grown from a few thousands of fish in 2010 to >30 million in 2016. However, lumpfish production needs to a) grow further to meet demand, and b) move from capturing wild broodstock to sustainable production by closing the complete lumpfish life-cycle within aquaculture. However, the environmental requirements and welfare needs of lumpfish are not yet clear, so fundamental research into their physiological and behavioural responses to aquaculture conditions at all life stages is vital.

All intensive aquaculture is associated with elevated CO_2 but this has only recently been recognised as a key welfare and productivity concern across the aquaculture sector. Recent research has shown that high CO_2 can reduce fish growth, impair sensory-related behaviour, cognitive function and learning, and cause anxiety in fish. There is also evidence of impaired immune function in marine shellfish under high CO_2 conditions. Land-based recirculating aquaculture systems (RAS) are highly efficient in terms of water use, and offer greatly improved biosecurity. However, CO_2 levels are highest in RAS, and the processes used to manage these CO_2 levels often produce other changes in water chemistry (e.g. alkalinity and calcium levels) that are non-ideal for fish health and vital physiological functions such as ion and water balance, and acid-base regulation.

This PhD aims to address the knowledge gap regarding the sustainable production of lumpfish by assessing how elevated CO_2 and other aspects of water chemistry influence their physiology (metabolism, ion/acid-base regulation, feeding, and growth) and behaviour (particularly indicators of stress and welfare). The laboratories of Wilson and Ellis (Exeter) provide ideal expertise for in vivo physiological approaches, precision water chemistry control systems, and behaviour analysis. The CASE partner Ocean Matters Ltd., are the largest producer of lumpfish in the UK, and provide excellent expertise from running the largest marine RAS in Europe.