

## **Shelters increase lumpfish (*Cyclopterus lumpus*) welfare when used appropriately as a biological control method in Atlantic Salmon (*Salmo salar*) aquaculture**

*Assessing the welfare implications of using shelters in lumpfish husbandry in salmon production*

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### **Introduction**

Atlantic salmon (*Salmo salar*) aquaculture is a significant and expanding global industry, experiencing various challenges to its productivity (Smejkal & Kakumanu 2018). The considerable impact of sea lice on production has prompted the development of novel strategies to control the parasite (Torrissen et al. 2013). The use of lumpfish (*Cyclopterus lumpus*) is an efficient and efficacious biological control method that is becoming increasingly popular. However, there is insufficient information regarding the species' husbandry requirements and biology. Mortalities are often considerable as a result and therefore, welfare is potentially inadequate (Brooker et al. 2018). The utilisation of shelters within the aquaculture setting may improve lumpfish welfare by reducing predator exposure and metabolic stress. Recent research has characterised the species' stress response, metabolic profile and behavioural characteristics, bolstering the argument for shelter inclusion (Hvas et al. 2018; Leclercq et al. 2018; Staven et al. 2019). However, further research has highlighted the importance of feeding method when considering deployment of hides (Johanessen et al. 2018). These advancements are critical in understanding the specific requirements of lumpfish and appreciating how meeting these acts to improve welfare.

### **Discussion**

Shelters may increase lumpfish welfare by limiting exposure to potential predators within the aquaculture environment (Johanessen et al. 2018). While the relationship between lumpfish and salmon is predominantly symbiotic, there is considerable potential for stress in cleaner fish due to their status as a prey species (Staven et al. 2019). Providing evidence for this stress is critical in highlighting the importance of investigating methods to improve welfare.

Recent research has attempted to quantify the ex situ stress response using physiological indices such as cortisol and glucose (Hvas et al. 2018). Minimal changes to these parameters was observed, highlighting the need for studies reflecting the realistic stressors present on a salmon farm. Further investigation has explored the physiological stress response of lumpfish in situ and reported that predator interaction does elicit a strong response that decreases with habituation. It should be noted that physiology-based stress parameters are both limited and understudied in lumpfish (Hvas et al. 2018; Staven et al. 2019). Inexperienced lumpfish were also found to exhibit signs of behavioural stress, including burst swimming and the maintenance of a significant distance from Atlantic salmon (Staven et al. 2019). It is evident that lumpfish welfare is adversely impacted by predator exposure, and strategies to alleviate this should be investigated. Staven et al. (2019) did not consider the effect of shelters on indicators of stress, however other studies have attempted to explore this connection

(Johanessen et al. 2018).

Shelters also provide lumpfish the opportunity to rest amid challenging environmental conditions, thus reducing metabolic stress and improving welfare (Johanessen et al. 2018). Aquaculture systems are aerobically demanding for lumpfish given the species' sluggish nature and absence of a swim bladder (Hvas et al. 2018). They possess a 'sucker' for attachment to surfaces – a biological feature that may be exploited in the production setting through the inclusion of shelters and hides (Hvas et al. 2018).

Contemporary research into lumpfish biology has reinforced the understanding that the species is aerobically limited despite its pelagic behaviour. The study also found that lumpfish used their sucker to reduce metabolic demands in currents by adhering to smooth surfaces (Hvas et al. 2018). Shelters may provide an opportunity for attachment, thus reducing aerobic demands and increasing welfare. It can be hypothesised that smaller lumpfish would benefit most from shelters given these individuals exhibited reduced swimming ability while achieving greater suctioning capacity (Hvas et al. 2018). In salmon aquaculture, lumpfish are deployed when they are relatively small and thus aerobically vulnerable (Brooker et al. 2018). This highlights the positive welfare implications of including shelters for cleaner fish, especially given the concurrent benefits of predator avoidance (Staven et al. 2019).

Exploring the behaviour of lumpfish in pens with shelters has highlighted the necessity of hides in cleaner fish husbandry (Leclercq et al. 2018). While the previously examined studies are inferred to bolster this conclusion, Leclercq et al. (2018) give direct evidence supporting their use. The study used acoustic telemetry to track lumpfish movement and found that the species inhabits shallow depths and uses shelters frequently. These findings strongly substantiate the need for species-specific hides, considering other cleaner fish preferentially occupy deeper areas of the pen (Leclercq et al. 2018). The study bolsters the biological data gathered by Staven et al. (2019) and Hvas et al. (2018), suggesting lumpfish may use shelters as a refuge from predators and metabolic exhaustion.

Contrastingly, shelters may negatively impact welfare if the availability of feed and hides is not carefully considered (Johanessen et al. 2018). A recent study measured differences in health indicators among fish experiencing separate feeding and shelter arrangements. Weight gain and body condition were lower in fish that were fed automatically and had access to shelters relative to other combinations (Johanessen et al. 2018). While Johanessen et al. (2018) were limited in the feeding strategies they considered, the results suggest that shelters cannot be used as a blunt tool for welfare maximisation. The study supports the establishment of feed times, whereby adequate resources can be obtained by every individual. This may act to accentuate the welfare benefits of extensive and appropriate shelter availability.

## **Conclusion**

The current climate of lumpfish research centres around improving husbandry practices to maximise both production and welfare outcomes. A burgeoning area of study is the use of shelters to facilitate stress reduction in the species. Recent advances have been made by exploring lumpfish biology and physiology to indirectly substantiate the use of hides (Hvas et al. 2018; Staven et al. 2019). The benefits of shelter inclusion have also been validated and questioned by direct investigations of their efficacy

(Johannessen et al. 2018; Leclercq et al. 2018). It appears that shelters have a legitimate role in maximising lumpfish welfare, however, further research should investigate husbandry factors that may negatively interact with hide availability. As Atlantic salmon aquaculture grows, stakeholders should not discount the effect of production on its most little-known constituent – the lumpfish.

## References

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