fishes

Editorial

Cleaner Fish in Aquaculture

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Biological control in fishes has been documented extensively and is a common form of symbiotic relationship between cleaners and fishes and shellfish globally, with the highest diversity in the tropics. Several reviews have examined the use of cleaner fish in aquaculture as well as epibionts, ciliates, and bacteria as biological controls of sea lice [1]. To date, the use of cleaner fish has been the only large-scale biological control measure that has been applied successfully in aquaculture. The advantages of cleaner fish are environmental, with a reduction in chemical use, a natural form of control that provides the continuous removal of lice. However, there are difficulties in measuring efficacy in large pens [2], the sustainability of wild wrasse stocks has to be monitored, the welfare of cleaner fish should be maintained, and losses of cleaner fish can be high. Cleaner fish have been demonstrated to work effectively in small-scale tank and cage trials [3] and there is increasing evidence of efficacy in larger commercial pens [4,5] and also as an integral part of integrated pest management (IPM) measures for sea lice [6]. Issues remain regarding the use and efficacy of cleaner fish, in terms of the health and welfare, vaccination, farm application, and rearing of the numbers of cleaner fish required by salmon farmers. Recently, several studies have been critical of cleaner fish use, or at least questioning welfare, survival [7], and efficacy issues [8]. This Special Issue on "Cleaner Fish in Aquaculture" focuses on many of the critical issues raised in earlier studies, with a focus on the ethical and optimal use of cleaner fish for sea lice removal in salmon aquaculture.

Imsland and Reynolds [9] reviewed all available large-scale studies on the use of lumpfish from Norway, Iceland, the Faroe Islands, and Scotland, covering sea temperatures from 2 to 15 °C, a salmon size ranging between 13 and 1050 g, and year-round use. The data reveal that lumpfish actively contribute to lower numbers of salmon lice on farmed Atlantic salmon in both experimental-size sea pens and industrial-scale rearing in open sea pens. Data show that it is possible to enhance lice grazing of lumpfish with the assistance of live-feed conditioning prior to sea-pen transfer, with selective breeding and targeted use of small juvenile lumpfish. The authors follow up by providing a list of best-practice conditions for the optimal use of lumpfish as cleaner fish in sea pens together with Atlantic salmon.

The lumpfish has proven to be an effective lice consumer at low sea temperatures [3–5]. However, the high mortality of cleaner fish in salmon cages is one of the most serious problems that the aquaculture industry in Norway faces at present. A study conducted by the Norwegian Food Safety Authorities revealed over 40% mortality of lumpfish deployed in Atlantic salmon net pens in Norway. The results from the survey showed that farmers associate lumpfish mortalities to the occurrence of disease as well as to handling and mechanical procedures such as mechanical delousing. The study also found that lumpfish vaccination without anaesthesia is common practice, despite the lack of scientific research showing any benefit of avoiding the use of anaesthesia during vaccination. Reynolds et al. [10] sought to map the actual causes of mortality and loss of lumpfish both in the hatchery and sea phase of production. The results from this study show that the causes of mortality varied within and between sites. For lumpfish in land-based facilities as well as those deployed in small-scale sea pens, the primary cause of mortality was identified as pathogens, while for lumpfish deployed at large-scale sea pens, transport, grading, and

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mechanical delousing were the primary causes of mortality. The results indicate that more research is required to clarify the best practices both in commercial hatcheries and salmon cages. Continuous health and welfare monitoring are essential to help identify when and which procedures and operations are detrimental, and thus, allow aquaculturists to adapt and improve practices.

The lumpfish has no swim bladder and thus relies on alternative methods for buoyancy, i.e., the body-density difference between the fish and its surroundings. Imsland et al. [11] measured the body density of lumpfish in Faroese fish farms and investigated the correlation between body density and different operational welfare indicators. The body density of the juvenile lumpfish used in fish farms was shown to be similar to the body density of wild lumpfish. Fulton's *K*, liver colour, HSI, standard length, and stomach fullness score were shown to be correlated to the body density. Fulton's *K*, stomach score, and standard length were negatively correlated with the body density, while HSI was positively correlated with the body density. The results of Imsland et al. [11] may help the industry to improve their understanding of the operational welfare indicators used for lumpfish. Additionally, the knowledge may help the aquaculture industry improve husbandry and feeding practices.

Lumpfish are widely used for removing sea lice in salmonid sea-based aquaculture. If these fish are to be harvested and used for human consumption, it is necessary to know how the physical stress associated with removing the lumpfish from the net cages affects the fish over the short term, and whether live storage in tanks, well-boats, or nets awaiting slaughter results in stress and mortalities. Foss and Imsland [12] investigated the effect of physical stress and mortality in a group of lumpfish recaptured from commercial net-cages, transported to holding tanks and stored for one week. Only minor and temporary effects on primary and secondary stress responses were seen in lumpfish recaptured from net cages and transported to holding facilities, indicating that lumpfish cope well with short transportation. These findings are important in a context in which lumpfish are harvested for reuse, e.g., human consumption or processing, following their lice-eating stage in net cages.

We hope that you will come to agree that the papers published in this Special Issue are important for further ethical use of cleaner fish for the removal of sea lice in aquaculture. Overall, these studies highlight ways for optimal and ethical use of lumpfish as cleaner fish. These studies raise new questions and challenges that must become the subject of future work.

Conflicts of Interest: The author declares no conflict of interest.

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