Cleaner Fish - the millions of hidden casualties of the salmon industry

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Executive summary

Lumpfish and wrasse species are remarkable animals with unique personalities and the ability for tool use. They even show some evidence of self-awareness. Relying on their natural (yet, opportunistic) ‘cleaning’ behaviour, the aquaculture industry uses millions of them (about 15 million produced in Scotland 2020) to eat sea lice from farmed salmon. The industry refers to them as ‘cleaner fish’, hiding their rights as individual sentient beings.

Poor handling and treatment methods, as well as unsuitable environmental conditions strongly threaten ‘cleaner fish’ health and welfare. Although mortality rates for lumpfish and wrasse used on Scotland’s salmon farms are not reported, they are suggested to be extremely high (up to 100%), and the fish who survive are killed at the end of the salmon production cycle. It is intolerable that such high numbers of animal deaths are being ignored. It is time to stop treating millions of sentient beings as a disposable resource and question their casual slaughter at the service of the salmon industry.

There are currently significant gaps in our understanding of these fish in the farmed salmon industry that prevent us from securing their welfare. Therefore, the Conservative Animal Welfare Foundation recommends that Marine Scotland commissions research and a full review into the use of cleaner fish in the aquaculture industry, that data is collated on an ongoing basis, and that the use of cleaner fish is suspended by 2027 until detailed welfare standards are developed and it is established that the industry can ensure the health and welfare of these millions of animals. Effective, and welfare-friendly alternatives for the prevention of sea lice in salmon farms exist. They should urgently be developed and prioritised.

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What are 'cleaner fish'?

The species

'Cleaner fish' is an umbrella term referring to species of fish that are used in the salmon industry to eat attached sea lice directly off salmon[1], hence 'cleaning' lice-infested fish. Two groups of fish are currently referred to as 'cleaner fish': lumpfish, or lumpsuckers, and wrasse, mostly ballan wrasse.

Lumpfish (*Cyclopterus lumpus* – Figure 1) are cold-water species found in the North Atlantic and the Arctic Oceans[2].

Figure 1. A lumpfish (Cyclopterus lumpus)

[1] Powell et al. (2018). Use of lumpfish for sea-lice control in salmon farming: challenges and opportunities. Reviews in Aquaculture, 10(3), 683-702.
[2] Powell et al. (2018). Review of lumpfish biology. Cleaner fish biology and aquaculture applications, 6, 98-121.

They possess a sucker to adhere to objects and other fish[3]. In the wild, lumpfish spend their time on the seafloor as well as in the water column[4] (i.e., they are semi-pelagic) where they can live up to nine (males) or 14 years (females)[5]. It is the males that care for and guard the eggs laid by the females[6].

Ballan wrasse (*Labrus bergylta – Figure 2*) are the largest wrasse found in European waters and can be found in the North East Atlantic, from Morocco to southern Norway[7].

They are a temperate species inhabiting shallow coastal rocky reefs and kelp beds where they can live up to 29 years[8]. All individuals are born female and turn into males when the population reaches a certain sex ratio[9] (i.e., protogynous hermaphrodites).

Figure 2. A ballan wrasse (Labrus bergylta)

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[3] Kennedy et al. (2015). Movements of female lumpfish (Cyclopterus lumpus) around Iceland. ICES Journal of Marine Science, 72(3), 880-889.[26] Halal Monitoring Committee, "Homepage," https://halalhmc.org/.

[4] Kennedy et al. (2016). Observations of vertical movements and depth distribution of migrating female lumpfish (Cyclopterus lumpus) in Iceland from data storage tags and trawl surveys. ICES Journal of Marine Science, 73(4), 1160-1169.

[5] Davenport (1985). Synopsis of biological data on the lumpsucker, Cyclopterus lumpus (Linnaeus, 1758) (No. 147). Food & Agriculture Org.

[6] Kennedy et al. (2015). Movements of female lumpfish (Cyclopterus lumpus) around Iceland. ICES Journal of Marine Science, 72(3), 880-889.

[7] Almada et al. (2017). Historical gene flow constraints in a northeastern Atlantic fish: phylogeography of the ballan wrasse Labrus bergylta across its distribution range. Royal Society Open Science, 4(2), 160773.

[8] Villegas-Ríos et al. (2013). Home range and diel behavior of the ballan wrasse, Labrus bergylta, determined by acoustic telemetry. Journal of Sea Research, 80, 61-71.

[9] Grant et al. (2016). Seasonal changes in broodstock spawning performance and egg quality in ballan wrasse (Labrus bergylta). Aquaculture, 464, 505-514.

In reality: Only opportunistic 'cleaners'

Despite being referred to as 'cleaner fish', it is not fully understood whether, or to what extent, lumpfish and wrasse consume sea lice on salmon or other host fish in the wild[10]. In the wild, these fish have various and complex diets. While lumpfish are opportunistic feeders and eat planktonic organisms like amphipods and isopods[11], ballan wrasse primarily eat bivalves and decapod crustaceans, as well as gastropods and algae[12]. Therefore, lumpfish and wrasse used in salmon aquaculture are likely to be opportunistic cleaners whose cleaning behaviour is a consequence of their artificial environment[13].

Figure 3. The fish fans sand to unearth the bivalve (a), takes it into its mouth, swims approximately 5 m to a rock (b), and crushes the mollusc against it (c) [© Bernardi G., 2012]

[10] Brooker et al. (2018). Sustainable production and use of cleaner fish for the biological control of sea lice: recent advances and current challenges. Veterinary Record, 183(12), 383-383.

[11] Davenport (1985). Synopsis of biological data on the lumpsucker, Cyclopterus lumpus (Linnaeus, 1758). FAO Fishery Synopsis. Vol. 147, p. 31.

[12] Deady & Fives (1995). Diet of ballan wrasse, Labrus bergylta, and some comparisons with the diet of corkwing wrasse, Crenilabrus melops. Journal of the Marine Biological Association of the United Kingdom, 75(3), 651-665.

[13] Vaughan et al. (2017). Cleaner fishes and shrimp diversity and a re-evaluation of cleaning symbioses. Fish and Fisheries, 18(4), 698-716.

Sentient and intelligent beings

Lumpfish have unique personalities[14], with evidence showing that individuals can differ in their delousing ability[15] on salmon farms and food preference[16], and that these differences are likely inherited[17].

In addition, members of the wrasse (Labridae) family have been reported to display tool use (i.e., "the use of an external object as a functional extension of mouth or beak, hand or claw, in the attainment of an immediate goal"[18]). For example, using a rock to crush a cockleshell[19] and using anvils to smash food into smaller pieces[20,21] (*Figure 3*). There is also evidence that some species can recognise themselves in a mirror[22], suggesting the fish might be self-aware[23] - or at least more aware than previously thought (this is an ongoing debate[24]).

Wrasse and lumpfish have recently been recognised as sentient beings as part of the Animal Welfare (Sentience) Act[25] (see *"Legal context"* section below).

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[14] Whittaker et al. (2021). Personality profiling may help select better cleaner fish for sea-lice control in salmon farming. Applied Animal Behaviour Science, 243, 105459.

[15] Imsland et al. (2014). Notes on the behaviour of lumpfish in sea pens with and without Atlantic salmon present. Journal of ethology, 32(2), 117-122.

[16] Imsland et al. (2015). Feeding preferences of lumpfish (Cyclopterus lumpus L.) maintained in open net-pens with Atlantic salmon (Salmo salar L.). Aquaculture, 436, 47-51.

[17] Imsland et al. (2016). Is cleaning behaviour in lumpfish (Cyclopterus lumpus) parentally controlled?. Aquaculture, 459, 156-165.

[18] van Lawick-Goodall (1970). Tool-using primates and other vertebrates. In: Lehrman D, Hinde R, Shaw E (eds) Advances in the study of behavior. Academic Press, New York, pp 195–249

[19] Jones et al. (2011). Tool use in the tuskfish Choerodon schoenleinii? Coral Reefs.

[20] Paśko Ł (2010) Tool-like behavior in the sixbar wrasse, Thalassoma hardwicke (Bennett, 1830). Zoo Biol 29:767–773. Reviewed in: Brown et al.. (2011). Fish cognition and behavior (Vol. 21). John Wiley & Sons.

[21] Bernardi, G. (2012). The use of tools by wrasses (Labridae). Coral Reefs, 31(1), 39-39.

[22] Kohda et al. (2022). Further evidence for the capacity of mirror self-recognition in cleaner fish and the significance of ecologically relevant marks. PLoS biology, 20(2), e3001529.

[23] Kohda et al. (2019). If a fish can pass the mark test, what are the implications for consciousness and self-awareness testing in animals?. PLoS biology, 17(2), e3000021.

[24] Gallup & Anderson (2020). Self-recognition in animals: Where do we stand 50 years later? Lessons from cleaner wrasse and other species. Psychology of Consciousness: Theory, Research, and Practice, 7(1), 46.

[25] Animal Welfare (Sentience) Act (2021-2022). UK Parliament.

Lumpfish and wrasse: The invisible victims of the salmon industry

Key numbers

According to the Marine Scotland Directorate, "1.5 million farmed cleaner fish were utilised by the aquaculture sector in Scotland in 2016"[26]. It is specified that "[they] do not currently record or hold information on the number of wild fish caught or purchased by Scottish salmon farm companies", suggesting that more were harvested from the wild.

However, the result of annual survey questionnaires sent to all active authorised fish farmers in Scotland shows that the production of lumpfish and wrasse has increased from 380,000 in 2016 to 15 million in 2020[27] *(Figure 4)*. Although there is no record of the fish harvested from the wild, it was suggested that wild-caught wrasse represented around half of the wrasse used by the industry in 2016[28].

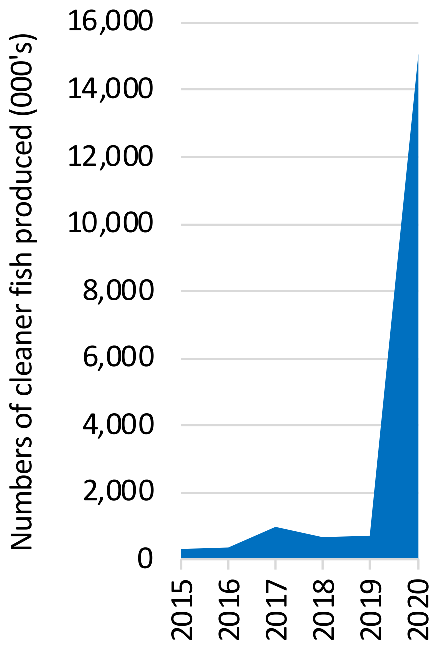

Figure 4. Number (000's) of cleaner fish (lumpfish and wrasse) produced during 2015-2020

[26] Farmed cleaner fish utilised by Scottish aquaculture sector: EIR release. Marine Scotland Directorate. Published: 24 August 2017.
[27] Munro & Wallace (2020). Scottish fish farm production survey 2020. Marine Scotland Science. The Scottish Government, Edinburgh
[28] OpenSeas. Cleaning up the 'cleaner fish' (2017)

Despite these huge numbers, no data is held by the Scottish Government (no official figure). Meanwhile, 51 million cleaner fish were deployed in Norwegian salmon farms in 2020[29]. As a result, lumpfish and wrasse, as 'cleaner fish', represent one of the top three most abundant groups of fish in aquaculture. It is, therefore, crucial to carefully consider their health and welfare.

Lumpfish and wrasse to 'clean' salmon

Hundreds of thousands to millions of fish are kept in our modern salmon farms. The increase of numbers and stock density created and sustain a very challenging situation to protect the health and welfare of the fish, especially when it comes to effective parasite control. In particular, sea lice infestations are one of the biggest issues for the salmon farming industry. Indeed, sea lice are prevalent in the waters of the largest salmon producers[30], i.e., Lepeophtheirus salmonis and various Caligus species in Norway[31], Scotland[32], and Canada[33], and *Caligus rogercresseyi* in Chile[34], threatening the productivity of their farms and the welfare of the salmon (*Figure 5*).

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[29] Norwegian Directorate of Fisheries. Total number of cleaner fish put into cages with Atlantic salmon and rainbow trout (Wild catch and farmed cleaner fish). 2020.

[30] Annual report 2020 - Leading the Blue Revolution, page 32

[31] Liu & Bjelland (2014). Estimating costs of sea lice control strategy in Norway. Preventive veterinary medicine, 117(3-4), 469-477.

[32] Murray (2016). Increased frequency and changed methods in the treatment of sea lice (Lepeophtheirus salmonis) in Scottish salmon farms 2005–2011. Pest management science, 72(2), 322-326.

[33] Krkošek (2010). Sea lice and salmon in Pacific Canada: ecology and policy. Frontiers in Ecology and the Environment, 8(4), 201-209.

[34] Zalcman et al. (2021). Sea lice infestation of salmonids in Chile between 2011 and 2017: use of regulatory data to describe characteristics and identify risk factors. Aquaculture, 530, 735752.

Figure 5. Salmon skin with sea lice

Over the past 40 years, the industry mainly relied on chemotherapeutants (i.e., chemical substances) to remove lice[35], which led to the rapid development of resistance[36] and the decline of their efficacy. For instance, sea lice resistance to hydrogen peroxide (H2O2) treatments has quickly developed and spread[37]. In addition, H2O2 baths are highly irritant and stressful for the salmon, which can result in severe injuries[38] and large-scale mortality[39]. Therefore, the salmon industry has developed mechanical and thermal delousing methods. Mechanical treatments use brushes or water jets (e.g., hydrolicer) to physically remove sea lice from salmon, while thermal treatments expose the salmon to a sudden change in temperature (e.g., thermolicer).

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[35] Overton et al. (2019). Salmon lice treatments and salmon mortality in Norwegian aquaculture: a review. Reviews in Aquaculture, 11(4), 1398-1417.

[36] Aaen et al. (2015). Drug resistance in sea lice: a threat to salmonid aquaculture. Trends in parasitology, 31(2), 72-81.

[37] Overton et al. (2018). Lowering treatment temperature reduces salmon mortality: A new way to treat with hydrogen peroxide in aquaculture. Pest management science, 74(3), 535-540.

[38] Vera & Migaud (2016). Hydrogen peroxide treatment in Atlantic salmon induces stress and detoxification response in a daily manner. Chronobiology International, 33(5), 530-542.

[39] Overton et al. (2018). Lowering treatment temperature reduces salmon mortality: A new way to treat with hydrogen peroxide in aquaculture. Pest management science, 74(3), 535-540. [ref 15]

These treatments involve crowding salmon into a small area, pumping them up into delousing chambers, and then out again, which can stress and physically harm the salmon, threatening their health and welfare[40]. Salmon farms usually use multiple of these methods throughout a production cycle, and sometimes even simultaneously. In response to these invasive and aggressive delousing methods, the salmon industry has heavily invested in 'cleaner fish', which are used as a biological control as they feed (to some extent) on attached lice directly on salmon[41].

Efficacy of the use of lumpfish and wrasse as 'cleaner fish'

Despite the abundant – and increasing – numbers of lumpfish and wrasse used to reduce/eradicate sea lice from salmon farms, their efficacy/effectiveness at fulfilling this role remains unclear[42]. Indeed, many studies have been conducted at a small scale[43], making it challenging to generalise and apply the results to the large commercial environment in which 'cleaner fish' are now used (in terms of number and density of fish, size of the salmon, pen volumes, temperature fluctuation, and locations).

A recent national study conducted at 488 Norwegian farm sites[44] revealed that sites using (more) cleaner fish did not have fewer lice on average, and the effects of delay between delousing treatments and reduction in louse population growth rates were small and highly variable. Besides, louse population growth rates remained positive on average despite the extensive numbers of cleaner fish deployed (tens of thousands per site), and the effects of cleaner fish on louse density were brief. Subsequently, the data suggested widespread suboptimal use of cleaner fish on a national scale.

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[40] Overton et al. (2019). Thermal delousing with cold water: Effects on salmon lice removal and salmon welfare. Aquaculture, 505, 41-46.

[41] Haugland et al. (2020). Application of biological control: use of cleaner fish. In Aquaculture Health Management (pp. 319-369). Academic Press.

[42] Overton et al. (2020). Sea lice removal by cleaner fish in salmon aquaculture: a review of the evidence base. Aquaculture Environment Interactions 12: 31-44.

[43] Imsland et al. (2014). Assessment of growth and sea lice infection levels in Atlantic salmon stocked in small-scale cages with lumpfish. Aquaculture, 433, 137-142.

[44] Barrett et al. (2020). Effect of cleaner fish on sea lice in Norwegian salmon aquaculture: a national scale data analysis. International Journal for Parasitology, 50(10-11), 787-796.

Furthermore, both lumpfish and wrasse are strongly opportunistic feeders with complex diets that depend on their environment. In sea cages with salmon, lumpfish spent only a limited amount of time eating sea lice off salmon (0.2% of recorded behaviour)[45], and gastric lavage revealed that only 28 % of lumpfish[46] and 11% of wrasse[47] had ingested sea lice, questioning their suitability as effective biological control agents in this environment. Moreover, the effectiveness of the 'cleaner fish' is highly diminished by the use of additional sea lice prevention methods. For instance, lice skirts alter the oxygen levels and the water flow leading the salmon to swim deeper, while the wrasse and lumpfish remain closer to the surface, hence limiting occasions for the 'cleaner fish' to encounter the salmon and feed on lice[48].

Millions of 'cleaner fish' are annually used in the salmon industry. Strong well-replicated experiments at a suitable scale are urgently needed to inform the efficacy and suitability of the many fish involved, as well as their needs to better inform legislation and facilitate a more ethical handling of 'cleaner fish' – if they are proven relevant.

[45] Imsland et al. (2014). Notes on the behaviour of lumpfish in sea pens with and without Atlantic salmon present. Journal of ethology, 32(2), 117-122.

[46] Imsland et al. (2014). The use of lumpfish (Cyclopterus lumpus L.) to control sea lice (Lepeophtheirus salmonis Krøyer) infestations in intensively farmed Atlantic salmon (Salmo salar L.). Aquaculture, 424, 18-23.

[47] Gentry et al. (2020). Sea lice prevention strategies affect cleaner fish delousing efficacy in commercial Atlantic salmon sea cages. Aquaculture Environment Interactions, 12, 67-80.

[48] Gentry et al. (2020). Sea lice prevention strategies affect cleaner fish delousing efficacy in commercial Atlantic salmon sea cages. Aquaculture Environment Interactions, 12, 67-80.

Welfare issues

Poor welfare conditions

Poor handling and treatment methods, as well as unsuitable environmental conditions strongly threaten the health and welfare of the lumpfish and wrasse used in the salmon industry. These issues include:

- Starvation and competition for food, with about 33% of lumpfish dying of starvation within the first few months[49]. Therefore, appropriate supplementary feeding is required[50].

- Aggression and predation from salmon can be deadly to the cleaner fish[51], and, in unsuitable conditions, aggression and cannibalism can occur in lumpfish[52] and wrasse[53]. Aggressive interactions with salmon and other fish impacts the stress level and survival of the 'cleaner fish'[54]. It is recommended to feed the salmon before introducing the cleaner fish and provide suitable shelter[55].

- Poor handling during routine site activities such as the lifting of nets during sea lice treatments and salmon transfer can cause the over-inflation of the swimbladder of the wrasse, leading to their death[56]. More considerations towards the biology and needs of the 'cleaner fish' during farm operations should be taken to ensure their health and welfare.

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[49] Powell et al. (2018). Use of lumpfish for sea lice control in salmon farming: challenges and opportunities. Reviews in Aquaculture, 10(3), 683-702.

[50] Leclercq et al. (2015). Development of a water-stable agar-based diet for the supplementary feeding of cleaner fish ballan wrasse (Labrus bergylta) deployed within commercial Atlantic salmon (Salmon salar) net-pens. Animal Feed Science and Technology, 208, 98-106.

[51] Deady et al. (1995). The use of cleaner-fish to control sea lice on two Irish salmon (Salmo salar) farms with particular reference to wrasse behaviour in salmon cages. Aquaculture, 131(1-2), 73-90.

[52] Brooker et al. (2018). Sustainable production and use of cleaner fish for the biological control of sea lice: recent advances and current challenges. Veterinary Record, 183(12), 383-383.

[53] Fish Health Inspectorate. (2013-2018). Publication of Case Information.

[54] Johannesen et al. (2018). Shelters can negatively affect growth and welfare in lumpfish if feed is delivered continuously. PeerJ, 6, e4837.

[55] Leclercq et al. (2018). Application of passive-acoustic telemetry to explore the behaviour of ballan wrasse (Labrus bergylta) and lumpfish (Cyclopterus lumpus) in commercial Scottish salmon sea-pens. Aquaculture, 495, 1-12.

[56] Treasurer & Feledi (2014). The physical condition and welfare of five species of wild caught wrasse stocked under aquaculture conditions and when stocked in Atlantic salmon, Salmo salar, production cages. Journal of the World Aquaculture Society, 45(2), 213-219.

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- High instances of fin damage were reported in both ballan wrasse and lumpfish on salmon farms[57,58].

- Common fungal infection in captive adult lumpfish can cause up to 45% losses in hatchery-reared fish over two years[59]. Secondary bacterial infections can be caused by stress, inadequate nutrition, handling during vaccination, and poor husbandry and/or water quality in the hatchery[60].

- The high prevalence and severity of cataracts on lumpfish used in Norwegian salmon farming, compared to wild ones, are indicative of malnutrition, parasites, or internal imbalance such as problems with osmoregulation (i.e., regulation of salt and water balance in the fish's body)[61].

- High prevalence and severity of sea lice infestation[62]. High numbers (>10) of sea lice were observed on lumpfish at a salmon farm, which might have caused lesions[63].

It should be noted that the vast majority of salmon farms in Scotland are certified by the RSPCA Assured scheme. This scheme has detailed guidelines regarding welfare of cleaner fish, which include provision of feed and provision of shelter/hides for cleaner fish.

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[57] Geitung et al. (2020). Cleaner fish growth, welfare and survival in Atlantic salmon sea cages during an autumn-winter production. Aquaculture, 528, 735623.

[58] Treasurer & Feledi (2014). The physical condition and welfare of five species of wild caught wrasse stocked under aquaculture conditions and when stocked in Atlantic salmon, Salmo salar, production cages. Journal of the World Aquaculture Society, 45(2), 213-219.

[59] Powell et al. (2018). Use of lumpfish for sea lice control in salmon farming: challenges and opportunities. Reviews in Aquaculture, 10(3), 683-702.

[60] Brooker et al. (2018). Sustainable production and use of cleaner fish for the biological control of sea lice: recent advances and current challenges. Veterinary Record, 183(12), 383-383.

[61] Jonassen et al. (2017). An epidemiological study of cataracts in wild and farmed lumpfish (Cyclopterus lumpus L.) and the relation to nutrition. Journal of fish diseases, 40(12), 1903-1914.

[62] Powell et al. (2018). Use of lumpfish for sea lice control in salmon farming: challenges and opportunities. Reviews in Aquaculture, 10(3), 683-702.

[63] Fish Health Inspectorate. (2013-2018). Publication of Case Information.

High mortality rates and end of production mass slaughter

Poor welfare conditions translate into high lumpfish and wrasse mortality rates when used in the salmon industry as 'cleaner fish'. Although mortality rates for lumpfish and wrasses used on Scotland's salmon farms are not reported, they are suggested to be extremely high (up to 100%) and should not be allowed to be ignored anymore[64].

In similar farming situations, Norwegian industries reported mortalities ranging from 18 to 48% for 'cleaner fish', with some farms stating up to 100% mortality or loss[65]. A recent study recorded losses of 27% for lumpfish in 12 weeks and 57% for ballan wrasse in 18 weeks[66], while another study recorded a loss of 14.8% for ballan wrasse in 6 weeks[67]. In addition, a recent industry survey reported 'cleaner fish' mortality of 42%[68], and over 65% (about 193,000 'cleaner fish') during a production cycle in 12 commercial salmon sea cages[69]. Nonetheless, there is no systematic way of evaluating mortality. More studies with a recognised framework are needed to allow for a systematic review and assessment of mortality in 'cleaner fish'.

On top of being ethically questionable, such high mortality rates weaken any efficiency the 'cleaner fish' might have at controlling sea lice in salmon farms on long- and short-time scales, including the cost associated with the regular renewal of the 'cleaner fish' stocks. Additional studies conducted at a commercial scale and through longer periods are crucial to gather industry-relevant data on 'cleaner fish' mortalities and losses, and would surely confirm current concerns about the moral and sustainable use of wrasse and lumpfish in salmon aquaculture[70].

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[64] OneKind Report (2018). Cleaner Fish Welfare on Scotland's salmon farms.

[65] Nilsen et al. (2014). Rensefiskhelse–kartlegging av dødelighet og dødelighetsårsaker. Veterinærinstituttets rapportserie, 12, 74. In: Geitung et al. (2020)

[66] Geitung et al. (2020). Cleaner fish growth, welfare and survival in Atlantic salmon sea cages during an autumn-winter production. Aquaculture, 528, 735623.

[67] Skiftesvik et al. (2013). Delousing of Atlantic salmon (Salmo salar) by cultured vs. wild ballan wrasse (Labrus bergylta). Aquaculture, 402, 113-118.

[68] Stien et al. (2020). Analysis of mortality data from survey on cleaner fish. Rapport fra havforskningen, 6. In: Geitung et al. (2020)

[69] Bui et al. (2018). Assessment of long-term implementation of sea lice prevention technologies: efficiency in reducing infestations and impact on fish welfare.

[70] Geitung et al. (2020). Cleaner fish growth, welfare and survival in Atlantic salmon sea cages during an autumn-winter production. Aquaculture, 528, 735623.

Finally, the wrasse and lumpfish that survived are killed at the end of the salmon production cycle for biosecurity reasons. They are usually slaughtered by an overdose of anaesthetic for the smaller fish and lumpfish, or a percussive blow for bigger wrass[71]. However, slaughter methods of fish are currently excluded from the detailed regulations afforded to terrestrial farmed animals, and there is no legal requirement for pre-stun slaughter.

It is intolerable that such high numbers of animal deaths are being ignored. It is crucial to monitor and assess mortalities and losses, and carefully consider these numbers in the relevant policy-making process. It is time to stop treating lumpfish and wrasse as a disposable resource and question the casual slaughter of millions of sentient beings at the service of the salmon industry. It is understood that after slaughter, these fish do not enter the food chain, nor are used for fishmeal, or by the pet food industry.

Legal context

'Cleaner fish' are protected by the Animal Health and Welfare (Scotland) Act 2006[72] which places a duty of care on those responsible for these animals to safeguard them from needless pain and suffering.

However, despite the extent of wrasse and lumpfish used (and killed) in the salmon industry, there are no stand-alone standards to help safeguard their welfare, and Scottish fish farms are not legally required to report or publish the number of 'cleaner fish' they use, their origin, or provide mortality figures.

Furthermore, the Animal Welfare (Sentience) Act 2022 recognises vertebrate (i.e., animals with a backbone inside their body) and some invertebrate (i.e., cephalopod molluscs and decapod crustacean) animals as sentient beings for the first time in UK law[73]. This includes all fish. Under this new Act, the unique needs of animals – including 'cleaner fish'- will have to be taken into account.

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[71] RSPCA welfare standards for farmed Atlantic salmon (Feb. 2021). P. 54.
[72] Animal Health and Welfare (Scotland) Act 2006
[73] Animal Welfare (Sentience) Bill (2021-2022). UK Parliament.

The way forward

Government commissioned research

There are currently significant gaps in our understanding of the wrasse and lumpfish used in the salmon industry that prevent us from securing their welfare (and even attest to their efficacy as sea lice control methods). Therefore, detailed research into their effectiveness and welfare should be commissioned by the Government (see Recommendations below).

Areas of improvement

It is essential to increase our understanding by conducting species-specific research. The main areas of development include:

- Better understand the causes of mortality of wrasse and lumpfish on salmon farms;
- Identify the essential needs of the wrasse and lumpfish in the wild and captivity to ensure the best environmental and husbandry conditions. For instance, the need for shelter[74] and appropriate substrates, optimised diet[75] (nature and availability), water depth and temperature;
- Evaluate the potential for cohabitation of different 'cleaner fish' species and salmon to inform the development of acclimation and/or conditioning protocols;

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[74] Leclercq et al. (2014). The physiological response of farmed ballan wrasse (Labrus bergylta) exposed to an acute stressor. Aquaculture, 434, 1-4.

[75] Leclercq et al. (2015). Development of a water-stable agar-based diet for the supplementary feeding of cleaner fish ballan wrasse (Labrus bergylta) deployed within commercial Atlantic salmon (Salmon salar) net-pens. Animal Feed Science and Technology, 208, 98-106.

- Focus on domesticating the species by establishing breeding programs and identifying genomic markers for relevant traits that can be selected, such as growth, delousing behaviour, disease resistance, and robustness for better survival in a sea-cage environment[76,77];

- Develop species-specific killing methods that meet the ethical standard for good fish welfare[78,79];

- Develop protocols to re-use wrasse and lumpfish beyond one salmon production cycle to increase the sustainability of the practice[80,81] - that is only if evidence show that their health and welfare can be assured;

- Develop reliable species-specific indicators to closely monitor the welfare of the 'cleaner fish';

- Develop welfare standards that cover the whole life cycle of wrasse and lumpfish (farmed and wild-caught) accounting for species-specific differences between the 'cleaner fish' species.

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[76] Brooker et al. (2018). Sustainable production and use of cleaner fish for the biological control of sea lice: recent advances and current challenges. Veterinary Record, 183(12), 383-383.
[77] Powell et al. (2018). Use of lumpfish for sea lice control in salmon farming: challenges and opportunities. Reviews in Aquaculture, 10(3), 683-702.
[78] Readman et al. (2017). Species specific anaesthetics for fish anaesthesia and euthanasia. Scientific reports, 7(1), 1-7.
[79] Skår et al. (2017). Development of anaesthetic protocols for lumpfish (Cyclopterus lumpus L.): Effect of anaesthetic concentrations, sea water temperature and body weight. PLOS ONE, 12(7), p.e0179344.
[80] Powell et al. (2018). Use of lumpfish for sea lice control in salmon farming: challenges and opportunities. Reviews in Aquaculture, 10(3), 683-702.
[81] Farm Animal Welfare Committee (2014). Opinion on the Welfare of Farmed Fish, 40 pp. Department for Environment, Food & Rural Affairs (DEFRA), London, UK.

Moving towards preventative rather than curative methods against sea lice

Instead of using wrasse and lumpfish as 'cleaner fish', effective, and welfare-friendly alternatives for the prevention of sea lice should be prioritised. Such preventive methods aim at reducing the encounter and/or reducing post-encounter infestation success (review[82]). They include:

- The use of depth-specific louse barrier technologies, such as skirts, snorkels or closed containment, that physically/spatially separate the salmon from the parasites[83];
- Manipulation of the swimming behaviour of the salmon in the absence of barrier technology to reduce encounters with lice that are more abundant closer to the surface. Deep swimming behaviour can be promoted through the use of deep feeding and/or lighting[84];
- Efficient management of the geographic and spatiotemporal conditions and/or careful site selection of the farms could take advantage of specific oceanographic conditions facilitating lower louse infestation rates[85,86];
- Filter-feeding shellfish racks suspended around the cages show the potential to reduce louse abundance[87,88]. In addition, powered filters are successful in avoiding lice and eggs enter the area[89];

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- The breeding of louse-resistant salmon is quickly developing. In particular, the use of genomic selection is a promising tool that can significantly increase the accuracy of selection for sea louse resistanc[90];

- The development of an effective vaccine[91] against sea lice would allow cost-effective production and delivery[92], and therefore, is a key target of the industry[93]. Only one, partially effective, vaccine is currently available (C. rogercresseyi: Providean Aquatec Sea Lice, Tecnovax).

The combination of several of these preventative methods has the potential to make reactive delousing treatments[94], such as the use of millions of wrasse and lumpfish, unnecessary on many Atlantic salmon farms. This is particularly true when coupled with barrier technologies that minimise host-parasite encounter rates[95].

Recommendations

Whilst we understand that at present there are a lack of strong alternatives to the use of cleaner fish, the Conservative Animal Welfare Foundation recommends the following interim actions to ensure that any value added by the use of 'cleaner fish' in the Scottish aquaculture industry is not at the detriment to the welfare of these individual sentient animals.

- That Marine Scotland commissions research and a full review into the use of cleaner fish in the aquaculture industry, with a specific focus on the ability of the industry to effectively meet the welfare needs of 'cleaner fish', the numbers of cleaner fish used and killed per annum by the aquaculture industry in Scotland, and the efficacy of cleaner fish as a tool to tackle sea-lice within the aquaculture industry.

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- That data is collated on an ongoing basis regarding the ability to meet key welfare indicators for cleaner fish, their mortality and escape rates, and the number of 'cleaner fish' slaughtered per annum.

- A suspension of the use of 'cleaner fish' by 2027, unless substantial evidence of the availability to meet the welfare needs of cleaner fish, and their efficacy as a tool to tackle sea-lice within the aquaculture industry, is proven. This timeframe allows for evidence and data to be collected, reviewed and for recommendations to be made and published. Owing to the time required to conduct meaningful research, is critical that this research is commissioned and initiated within two years of this publication. That research should be specific to the environmental conditions and species farmed within the UK aquaculture industry.

Conclusion

The health, welfare, and lives of millions of multiple fish species such as wrasses and lumpfish are threatened in the salmon aquaculture. The number of 'cleaner fish' used has risen exponentially in the last five years and is set to keep increasing, while their efficacy is debated and no strong legislation or enforcement procedures secures their welfare and survival. Instead, huge mortality rates and the absence of official records highlight how highly neglected these intelligent and sentient beings are by the aquaculture industry.

With the introduction of the Animal Welfare (Sentience) Act, it is time to stop treating millions of lumpfish and wrasse as a disposable resource and question their casual slaughter at the service of the salmon industry. Significant breaches in our understanding of the 'cleaner fish' in the salmon industry prevent us from securing their welfare.

Alternative solutions to 'cleaner fish' as sea lice prevention exist, and they should be developed further and prioritised.

Conservative Animal Welfare Foundation