Scottish Wildlife Trust

Policy

Finfish Aquaculture

November 2018

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Policy headlines

- The Scottish Wildlife Trust supports sustainable finfish aquaculture and will campaign for effective regulation, monitoring, enforcement and research to achieve a Scottish fish farming industry sold on high quality and unrivalled environmental credentials.
- To be sustainable, the Scottish finfish aquaculture must maintain the quality, health and biodiversity of the waters it occupies, avoiding significant, cumulative, long-term or irreversible damage to the environment. To achieve this, the precautionary principle must be at the core of decision making.
- The sustainable development of the aquaculture industry must be guided by the key principles of the Ecosystem Approach and the achievement of Good Environmental and Ecological Status of our seas and freshwaters as required by the Marine Strategy and Water Framework Directives.
- In line with the Scottish Wildlife Trust's 25-year vision for a network of healthy, resilient ecosystems supporting expanding communities of native species across large areas of Scotland's land, water and seas – fish farms should be sited appropriately, within a strategic framework of spatial planning that directs developers toward locations where significant impacts on biodiversity are avoided. Existing sites that fail to avoid significant impacts on the marine environment should be obligated to apply effective mitigation, be relocated or, when necessary, closed.

Scope

1. The term aquaculture refers to the rearing of aquatic organisms, such as fish, molluscs, crustaceans and aquatic plants, in marine and freshwater environments. The dominant form of aquaculture in Scotland is the farming of finfish (particularly Atlantic salmon – *Salmo salar*), which has seen significant growth over the last 40 years. Atlantic salmon is now the number one food export for the UK, sold in 60 countries and with an estimated value of £579.2m (2016).[1]
2. A growing global population and an increasing dependence on aquaculture as a key source of protein, has caused the global demand for farmed finfish to increase. In response the Scottish Government and the aquaculture industry are planning to significantly increase finfish production over the next 10-15 years. To grow the Scottish finfish industry, the number and size of salmon farms in operation will need to increase.
3. The operation of finfish aquaculture in Scotland has raised several environmental concerns, and any expansion of the industry, using current practices, will exacerbate these concerns. As such, this policy establishes the Scottish Wildlife Trust's position on the future of finfish farming in Scotland.

[1] Food and Drink Federation – 2016 Export Statistics

Context

4. Aquaculture is the fastest growing form of fish production, accounting for 53% of global fish consumption in 2016.[2] With demand for fish set to increase substantially, in line with population growth, and wild fish stocks under threat from over-fishing, it is anticipated that further expansion of aquaculture is required to meet this extra demand.[3]

5. Scotland is the largest producer of farmed Atlantic salmon in the European Union and the third largest globally, behind Norway and Chile. Production expanded rapidly during the 1980s and 90s and over recent decades production has increased significantly, from 32,000 tonnes in 1990 to 162,817 tonnes in 2016.[4] Other species are farmed in Scotland, but their contribution to the total finfish production is small (rainbow trout, brown/sea trout and halibut farms produced a combined 8204 tonnes in 2016). Therefore, this policy will focus mainly on salmon farming.

6. In Scotland, finfish farms are found along the sheltered, inshore waters of the west and northwest coasts, the Western Isles, Orkney and Shetland.

7. Finfish aquaculture has proved important for coastal and island communities, where investment in aquaculture has provided jobs in remote locations where employment opportunities are limited. The trend in Scotland, as elsewhere, has been towards fewer companies operating larger-scale farms. For example, in 2006 there were 44 active salmon farming companies operating 252 sites but in 2016 there were 15 active companies operating 253 sites despite production increasing by approximately 25% during the same 10-year period.[6]

8. Both the Scottish government and the aquaculture industry have clear ambitions to achieve growth in the sector. The Scottish Government targets sustainable production of finfish (including Atlantic salmon) to 210,000t and of shellfish (particularly mussels) to 13,000t by 2020.[5] The aquaculture industry has proposed a more ambitious target for salmon production of 300,000 - 400,000t by 2030.[6]

9. The expansion and intensification of finfish aquaculture has long been associated with environmental degradation. Thus, plans for growth in an industry that is currently unable to deal sufficiently with its environmental impacts must be approached with caution. In 2018, an inquiry by the Scottish Parliament's Environment, Climate Change and Land Reform Committee concluded that:

    - the proposed expansion 'may cause irrecoverable damage to the environment';
    - there are 'significant gaps in knowledge, data, monitoring and research' on the risks to the environment;
    - an ecosystem-based approach to planning industry growth is needed;
    - 'the status quo is not an option'; and
    - 'the current consenting and regulatory regulation, including the approach to sanctions and enforcement, is inadequate to address the environmental issues'.[7]

Legislative drivers

10. The Scottish Wildlife Trust welcomes the Scottish Government's commitment to the Marine Strategy Framework Directive (see Annex) to taking an Ecosystem Approach[8] to marine development and to achieving or maintaining Good Environmental Status of our seas by 2020.

[2] FAO 2018. The State of World Fisheries and Aquaculture 2018 – meeting the sustainable development goals. Rome. Licence: CC BY-NC-SA 3.0 IGO
[3] Foresight. The Future of Food and Farming (2011) Final Project Report. The Government Office for Science, London
[4] Marine Scotland Science – Scottish Fish Farm Production and Scottish Shellfish Farm Production Surveys 2016 - www.gov.scot/Topics/marine/Fish-Shellfish/FHI/surveys
[5] Scotland's National Marine Plan: www.gov.scot/Publications/2015/03/6517
[6] Scotland Food and Drink. 2017. Aquaculture Growth to 2030.
[7] ECCLR Committee: Report on the Environmental Impacts of Salmon Farming 2018

11. The Scottish Government's Strategic Framework for Scottish Aquaculture, renewed in 2009[9], establishes the desired outcomes for the industry within the overall vision for Scotland's marine environment of "clean, healthy, safe, productive and biologically diverse seas managed to meet the long-term needs of nature and people".[10] In response to this framework, the responsibilities of the industry have been set out in the Scottish finfish industry's non-statutory Code of Good Practice.[11]

12. Planning responsibility for aquaculture development lies with the local planning authority under the Town and Country Planning (Scotland) Act 1997 (as amended). Full Environmental Impact Assessment is currently only required where biomass exceeds 100 tonnes, or the farm extends to 0.1 hectares.

13. The Marine (Scotland) Act 2010 (Marine Act) provides a system for guiding the many uses of the marine environment and ensures they occur in the most suitable and least sensitive areas. Under the Marine Act, the Scottish Government published the National Marine Plan[12] (NMP) in 2015, a framework for marine planning that promotes sustainable development and the sustainable use of marine resources.

14. The NMP provides a list of objectives for Scottish aquaculture, which includes:

    - An industry that is sustainable, diverse, competitive, economically viable and which contributes to food security whilst minimising environmental impact.
    - With due regard to the marine environment and carrying capacity, support for the industry's target to grow marine finfish production sustainably to 210,000 tonnes by 2020.
    - A proportionate and transparent regulatory framework within which the industry can achieve these targets.
    - Identification of areas where sustainable aquaculture growth is optimal, taking account of key resource and constraints considerations.
    - Support research and development, including trials and technical innovation, to improve knowledge and understanding of the requirements for sustainability of the industry, with a particular focus on the issues of sea lice, containment and interactions with other activities.

15. The NMP includes plans to develop 11 Regional Marine Plans (RMPs) – smaller, more detailed plans that extend out to 12nm and are implemented at a local level. The plans will be developed by Marine Planning Partnerships, who will be responsible for taking into account local circumstances and smaller ecosystem units. The basic legislative requirements for the RMPs include:

    - Summarising the significant pressures and impact of human activity
    - Setting economic, social, marine ecosystem and climate change objectives
    - Stating policies for sustainable development of the region

16. The RMPs must be guided by clear sustainable development objectives and respect environmental limits. Once implemented, individual planning or licensing authorities must take decisions on planning permission in accordance with the RMP policies.

17. General Policy 9(b) of the NMP states that 'development and use of the marine environment must not result in significant impact on the national status of Priority Marine Features'[13] – a list of habitats and species characteristic

[8] Ecosystem Approach - Convention of Biological Diversity - http://www.cbd.int/ecosystem/principles.shtml
[9] A Fresh Start: A renewed strategic framework for Scottish aquaculture. https://www.gov.scot/Resource/Doc/272866/0081461.pdf
[10] A Fresh Start: The renewed Strategic Framework for Scottish Aquaculture - http://www.scotland.gov.uk/Publications/2009/05/14160104/0
[11] The Code of Good Practice for Scottish Finfish Aquaculture - http://www.thecodeofgoodpractice.co.uk/
[12] National Marine Plan - www.gov.scot/Publications/2015/03/6517
[13] Priority Marine Features in Scotland - https://www.nature.scot/sites/default/files/2018-05/Priority%20Marine%20Features%20in%20Scotlands%20seas.pdf

of the Scottish marine environment, which includes, for example, Atlantic salmon, sea trout, maerl beds and kelp beds.

18. Scottish Planning Policy[14] sets out national planning policies that reflect Scottish Minister's priorities for operation of the planning system, which includes a list of policy principles for supporting aquaculture development:

    - Play a supporting role in the sustainable growth of the finfish and shellfish sectors to ensure that the aquaculture industry is diverse, competitive and economically viable.
    - Guide development to coastal locations that best suit industry needs with due regard to the marine environment.
    - Maintain a presumption against further marine finfish farm developments on the north and east coasts to safeguard migratory fish species.

19. Crown Estate Scotland is responsible for leasing the seafloor out to 12nm and lease approximately 750 sites to fish and shellfish farm operators. Leases are awarded in perpetuity, although the rental rates are reviewed every five years. Crown Estate Scotland has committed to:

    - Leverages sector expertise (in planning, consenting, finance, commercial, legal, and environmental) to ensure the seabed is developed sustainably
    - Shares best practice to help emerging technologies become viable and to address challenges facing new industries[15]

20. Discharges of organic pollutants and other chemicals from salmon farms and wellboats require consent from Scottish Environmental Protection Agency (SEPA) under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR) and Marine Scotland's Licensing and Operations Team (MS-LOT), respectively. In issuing a license, SEPA can place limits on the amount of fish that can be held in the cages (and thus the amount of food used) and limits on the amount of medicines that can be administered. SEPA also requires annual reporting of therapeutant use from each site and these data are available to the public.[16]

21. The Aquaculture and Fisheries (Scotland) Act 2013 provides regulatory control over the aquaculture industry and was intended to ensure farmed and wild fisheries are managed effectively, by maximizing their combined contribution to sustainable economic growth with regard to the wider marine environment. However, much of the governance of fish farms in Scotland is conducted under the Code of Good Practice but, as the code is non-statutory, auditing of compliance with its terms is a matter for industry itself.

22. The health of farmed fish is assessed by the Fish Health Inspectorate (FHI), under two main pieces of legislation: the Aquatic Animal Health (Scotland) Regulations 2009 and the Aquaculture and Fisheries (Scotland) Act 2013. The work covered by the FHI includes fish health surveillance, monitoring cases of disease, assessing farm conditions, monitoring fish escapes, and assessing the level of sea lice on site.

The environmental impacts of finfish aquaculture

23. Finfish aquaculture is typically carried out in suspended net cages sited in inshore waters, like sheltered bays or sea lochs, although the development of larger, offshore facilities is taking place in Norway.

24. Cages are permeable in design; built to contain fish yet allow the free exchange of water to provide clean, oxygenated conditions for the farmed fish and allow the export of waste products into the surrounding

[14] Scottish Planning Policy - www.gov.scot/Resource/0045/00453827.pdf
[15] Crown Estate Scotland website: www.crownestatescotland.com/what-we-do/marine
[16] SEPA Marine Aquaculture - www.sepa.org.uk/water/water_regulation/regimes/aquaculture/marine_aquaculture.aspx

environment. These systems are commonly referred to as open-net fish farms. As there is no physical barrier separating the farmed fish and the surrounding environment, finfish aquaculture is entirely dependent on the surrounding waters being clean and healthy. However, the practice of open-net aquaculture can negatively impact the health of the surrounding environment.

25. The development of salmon farming in Scotland has coincided with a period of decline in wild populations of Atlantic salmon and sea trout, a phenomenon observed across the whole of its native range since the early 70's. While it is likely that multiple factors acting in combination are responsible for this decline, analysis of long-term catch data from Scotland and Norway indicates that areas where intensive salmon aquaculture is conducted have seen declines not replicated in areas where no aquaculture takes place.[17]

26. The Scottish Wildlife Trust considers the following as key environmental impacts:

Sea lice

27. Sea lice (*Lepeophtheirus salmonis* and *Caligus elongatus*) are marine parasites of salmonids, attaching to a host fish as planktonic larvae and growing to adults that feed on fish tissue. They pose risk to the welfare of both farmed and wild fish, causing physiological stress and risk of secondary infection. Fish farms typically keep fish in high densities for long periods of time, which provides perfect conditions for sea lice numbers to expand rapidly to unnaturally high numbers. There is a growing body of evidence that fish farms are a significant source of infestations in wild fish.[18]

28. Open-net salmon farms expose farmed fish to pathogens from wild fish and the surrounding environment. Consequently, clean fish transferred into marine cages from freshwater systems will inevitably become hosts to naturally occurring sea lice. Fish farms that have become infected with sea lice then become sources of planktonic larvae, which disperse into the surrounding waters and infect other farms or wild fish in the adjacent coastal area. Significantly higher infestations of sea lice have been recorded on wild fish in Scottish sea lochs that also contained sea lice-infested farmed salmon compared to non-farmed areas.[19]

29. Sea lice feed on fish skin, tissues and mucus, which can lead to osmotic stress and increased risk of microbial infection. The severity of the effects depends on several factors, such as the life stage of the host fish. For example, adult Atlantic salmon returning to freshwater rivers to breed may pick up sea lice as they swim past a fish farm but will quickly shed them when they enter freshwater – sea lice are intolerant of freshwater. However, the younger, smaller smolts migrating out to sea are at a much greater risk as they are already subject to physiological stress associated with osmoregulation[20], making them particularly vulnerable to the effects of sea lice. Additionally, smolts are unable to shed sea lice in sea water, which prolongs their exposure – female sea lice have been found to live up to 210 days.[21]

30. The problem is not restricted to wild Atlantic salmon; a study in Loch Shieldaig, Torridon, adds to research from both Ireland and Norway that suggest a link between salmon farms and sea lice burdens in wild sea trout (*Salmo trutta*).[22] Sea trout are at much greater risk from sea lice as they migrate multiple times between the sea and

[17] Vøllestad, LA et al. (2009) Divergent trends in anadromous salmonid populations in Norwegian and Scottish rivers. Proc. Roy. Soc. B. 276, 1021–1027

[18] Costello, MJ (2009). How sea lice from salmon farms may cause wild salmonid declines in Europe and North America and be a threat to fishes elsewhere. Proc. R. Soc. B. 276: 3385-3394.

[19] Butler JRA & Watt J. (2003) Assessing and managing the impacts of marine salmon farms on wild Atlantic salmon in western Scotland: identifying priority rivers for conservation. Pp. 93-118 in: Mills D (ed.). Salmon at the Edge. Blackwell Science, Oxford.

[20] Revie C, Dill L, Finstad B, Todd C (2009) Salmon Aquaculture Dialogue Working Group report on sea lice. Commissioned by the Salmon Aquaculture Dialogue. World Wildlife Fund, Washington, DC

[21] Marine Institute – Life cycle of the Salmon louse. https://www.marine.ie/Home/site-area/areas-activity/aquaculture/sea-lice/life-cycle-salmon-louse

[22] Middlemas SJ, Raffell JA, Hay DW, Hatton-Ellis M, Armstrong JD (2010) Temporal and spatial patterns in sea lice levels on sea trout in Western Scotland in relation to fish farm production cycles. Biol Lett 6:548–551

freshwater rivers and remain in coastal waters outside of the breeding season, which increases their exposure time to sea lice larvae from salmon farms. Sea trout sampled from coastal waters within 30km of a salmon farm have been found to have elevated sea lice levels.[23]

31. Sea lice levels are monitored throughout the year and estimated using a sample of fish to calculate an average number of lice per fish across the farm. Thresholds for acceptable levels of sea lice vary; the Fish Health Inspectorate requires salmon farmers to report when their average count is three or more adult females per fish[24], but the industry recommends keeping sea lice levels at 0.5 lice per fish from February 1st to June 30th and one louse per fish from July 1st to January 31st.[25]

32. Salmon farmers have adopted several methods for controlling sea lice infestations, which include chemical therapeutants, cleaner fish (wrasse and lumpsuckers), thermolicers, lasers and husbandry measures, such as fallowing, which breaks the breeding cycle of sea lice. Despite the advancements in technology and treatment techniques, the problems associated with sea lice continue for both farmed and wild fish.

Escapes

33. Escapes from fish farms occur both through recurrent small-scale events and through large scale catastrophic events caused by extreme weather. In 2016, 311,496 salmon escaped from three reported incidents at marine salmon farm sites in Scotland.[26]

34. Farmed salmon are derived from non-local stocks (typically wild Norwegian strains) and are subject to selective breeding to enhance economic traits. Even though the reproductive fitness of farmed fish is low, the high overall numbers of farmed salmon relative to wild salmon mean that even a low rate of escape could result in localised high numbers of escaped fish.[27]

35. Escaped farmed salmon, both as adults and smolts, pose a direct threat to wild populations through competition, spreading disease[28] and interbreeding.[29] Salmon escapes have been identified as the greatest threat to wild salmon in Norway.[30]

36. Human error remains a large factor in escape events and it is important that those installing or operating fish farms are suitably qualified and conform to a consistent professional standard.

Chemical and biological waste

37. Through the application of feed and output of biological waste, finfish aquaculture adds a significant amount of nutrients to sea lochs in Scotland. In addition, a range of antifoulants, pesticides, medicines and disinfectants are authorised for use in fish farming, which pervade into the environment and can be lethal to local fauna.

38. Evidence suggests that nutrient enrichment of the waters surrounding fish farms can promote the growth of algae and aquatic plants – altering the natural balance and quality of the system (eutrophication).[31] Furthermore, uneaten food and biological waste can accumulate in the water and sediments surrounding fish farms. Nutrient

[23] Thorstad, E.B. et al. 2015. Effects of salmon lice Lepeophtheirus salmonis on wild sea trout Salmo trutta—a literature review. Aquacult Env Interac. 7, 91–113
[24] Marine Scotland Topic Sheet 71 – The Regulation of Sea Lice in Scotland
[25] Code of Good Practice for Scottish Finfish Aquaculture
[26] Scottish Fish Farm Production Survey 2016 - https://www.gov.scot/Resource/0052/00524803.pdf
[27] Youngson, Dosdat, Saroglia and Jordan (2001) Genetic interactions between marine finfish species in European aquaculture and wild conspecifics, Journal of Applied Ichthyology 17(4): 153-162
[28] Johnsen, B.O. et al. 1994. The spread of furunculosis in salmonids in Norwegian rivers. J Fish Bio 45, 47-55
[29] Naylor, R. et al. 2005. Fugitive salmon: Assessing the risks of escaped fish from net-pen aquaculture. Bioscience 55, 427-437
[30] Forseth, T. et al. (2017). The major threats to Atlantic salmon in Norway. ICES J Mar Sci doi:10.1093/icesjms/fsx020
[31] Baxter, J.M., Boyd, I.L., Cox, M., Donald, A.E., Malcom, S.J., Miles, H., Miller, B., Moffat, C.F., (editors), (2011) Scotland's Marine Atlas: Information for the national marine plan. Marine Scotland, Edinburgh.

loading on the seafloor can create anoxic conditions, leading to a reduction in species richness and diversity[32] and an increase in organisms resistant to sedimentation and low oxygen levels.[33] Impacts on sensitive benthic habitats and their associated communities is of concern. For example, organic waste build-up on maerl beds has been detected up to 100m from farm sites.[34]

39. Fish farms are susceptible to a range of naturally occurring diseases and parasites, such as sea lice, Infectious Salmon Anaemia, Cardiomyopathy Syndrome and Amoebic Gill Disease. Treatment usually includes the use of therapeutants – medicinal products that are included in fish feed or in bath treatments – and other chemicals[35], many of which are listed as Priority Substances under the Water Framework Directive.[36]

40. The in-feed chemical therapeutant emamectin benzoate (SLICE) is a commonly used treatment for sea lice in Scottish fish farms. This treatment is non-targeted and subsequently released into the environment, through uneaten food and faeces. Knowledge on the environmental and ecological impact of therapeutants is incomplete, but SLICE has been found to cause substantial (60-90%) mortality of wild crustaceans, which include commercially important species such as crabs, lobsters and nephrops.[37,38]

41. Amoebic gill disease (AGD) – gill lesions caused by the amoeba *Paramoeba perurans* – has been widespread in Scottish salmon farming since 2012. One chemical that is commonly used to tackle AGD is hydrogen peroxide as a bath treatment or in well boats. In 2015, the total usage of hydrogen peroxide in Scottish salmon farms was over 19 million litres.[39] The impact hydrogen peroxide baths have on the environment and the salmon being treated is poorly understood[40], yet there are currently no limits on its use.

42. Copper and zinc, present in feed and antifoulant products, have been measured in sediments near aquaculture sites at concentrations exceeding SEPA guidelines. These elements persist in sediments and can also have a detrimental effect on benthic community structure.[41]

Fish feed

43. To ensure the health and growth of farmed salmon, fish feed should contain essential nutrients that would be readily available to wild salmon. These include proteins and fatty acids that wild salmon would source from prey fish. In 1990, approximately 90% of farmed salmon feed came from a marine origin[42], placing pressure on small pelagic fish populations (e.g. anchovy and sandeels).[43] In 2016, the percentage of fishmeal and fish oil derived from wild fish was greatly reduced (approximately 20%), largely replaced by trimmings from commercial fisheries and a range of vegetable proteins and oils.[44]

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[32] Wu, R.S.S. 1995. The environmental impact of fish culture: Towards a sustainable future. Mar Pollut Bull 31, 4-12

[33] Anon. (2002). Review and synthesis of the environmental impacts of aquaculture. The Scottish Association for Marine Science and Napier University. Scottish Executive Central Research Unit, Edinburgh, Scotland.

[34] Hall Spencer, J. et al. 2006. Impact of fish farms on maerl beds in strongly tidal areas. Mar Ecol Prog Ser. 326, 1-9

[35] Including highly toxic substances such as organophosphates, pyrethroids, chitin inhibitors, and neurotoxins

[36] Water Framework Directive Priority Substances - http://ec.europa.eu/environment/water/water-dangersub/pri_substances.htm

[37] SARF Report: Towards understanding of the Environmental Impact of a Sea Lice Medicine - http://www.sarf.org.uk/cms-assets/documents/251503-644637.sarf098---whole-document-aug2016.pdf

[38] Burridge, L., Weis J., Cabello F., Pizarro, J. and Bostick, K. (2010) Chemical use in salmon aquaculture: A review of current practices and possible environmental effects. Aquaculture. 306 (1-4): 7-23.

[39] Freedom of Information request to SEPA made by Global Alliance Against Industrial Aquaculture in 2017

[40] NIVA Report – Freshwater treatment of amoebic gill disease and sea-lice in seawater salmon production: considerations of water chemistry and fish welfare. http://www.fhf.no/media/70950/niva_rapport_6632-2014.pdf

[41] Dean, R.J., Shimmield, T.M. and Black, K.D. (2007). Copper, zinc and cadmium in marine cage fish farm sediments: An extensive survey. Environmental Pollution 145: 84-95.

[42] Ytrestøyl, T. et al. 2015. Utilisation of feed resources in production of Atlantic salmon (*Salmo salar*) in Norway. Aquac 448, 365-374

[43] Naylor, R.L. et al. 2000. Effect of aquaculture on World fish supplies. Nature 405, 1017-1024

[44] In 2016, salmon feed in Norway consisted of 71% vegetable meal and oil, 21% fishmeal and oil, and 8% other raw materials – Marine Harvest Salmon Farming Handbook 2017, pg. 55

44. It is critical that 'forage fisheries' used in fish feeds are well managed and from sustainable stocks. Confidence can be provided by independent certification, using assessments in line with the UN's Food and Agriculture Organisation's Code of Conduct for Responsible Fisheries[45], such as the Marine Stewardship Council[46] that includes wider ecosystem effects in the overall assessment.

45. However, as the aquaculture industry grows, and production increases, the demand for feed will increase and place further pressure on sources of both marine and terrestrial ingredients. To meet this demand, feed suppliers continue to reformulate feeds and look for alternative sources of ingredients, such as insects[47] and microalgae.[48]

Predator control

46. Predators, such as seals and piscivorous birds, are attracted to salmon farms and can cause damage to the farm and loss of fish. Under the Marine Scotland Technical Standard for Scottish Finfish Aquaculture (2015) there is a requirement to ensure 'sufficient tension' in all down-ropes to deter potential predators.[49] Aerial and underwater anti-predator nets are often installed to prevent damage, but seals and birds can become entangled and die in these nets.[50]

47. Fish farm operators can apply for a licence to shoot seals as a 'last resort'. The two native species of seal (grey *Halichoerus grypus* and common *Phoca vitulina*) are targeted, despite being protected by Scottish[51] and EU legislation.[52] In 2017, 245 licences were granted for grey seals and 113 for common seals and 53 and 19 seals were reported to have been shot, respectively.[53]

48. The continued use of seal shooting licences could have important implications for future international trade as one of Scottish salmon key export markets, the USA, will, in 2022, stop importing fish from fish farms where seals have been deliberately shot.[54] Therefore, salmon producers wishing to export to the US will have to provide clear evidence that their product is not associated with seal killing.

49. Acoustic deterrent devices (ADDs) are widely used by the aquaculture industry in Scotland. ADDs emit loud acoustic signals aimed at preventing seal depredation on farmed finfish. However, the effectiveness of ADDs is questionable[55] and seals are frequently seen around facilities actively using these devices. The widespread and unregulated use of ADDs has introduced substantial amounts of underwater noise into the marine environment, the frequency of which overlaps with the audible range of non-target species, such as cetaceans. Even though cetaceans do not pose a threat to aquaculture facilities, they are prone to disturbance and habitat exclusion caused by ADDs and a range of species in Scotland can be affected, including harbour porpoises[56], dolphins[57] and minke whales.[58]

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[45] FAO Code of Conduct for Responsible Fisheries - http://www.fao.org/docrep/005/v9878e/v9878e00.HTM
[46] MSC environmental standard for sustainable fishing - http://www.msc.org/about-us/standards/standards/msc-environmental-standard
[47] Tomberlin, J.K. et al. 2015. Protecting the environment through insect farming as a means to produce protein for use as livestock, poultry and aquaculture feed. J of Insects as Food and Feed 1, 307-309
[48] Taelman, S.E. et al. 2013. The environmental sustainability of microalgae as feed for aquaculture: a lifecycle perspective. Bioresource Technol 150, 513-522
[49] Marine Scotland - A Technical Standard for Scottish Finfish Aquaculture - http://www.gov.scot/Resource/0047/00479005.pdf
[50] Stead, S.M. and Laird, L. 2002. The Handbook of Salmon Farming. 352-353 pp.
[51] Marine (Scotland) Act 2010
[52] Council Directive 92/43/EEC on the conservation of natural habitats and wild fauna and flora (EU Habitats Directive, Annex II)
[53] Marine Scotland seal licencing information - www.gov.scot/Topics/marine/Licensing/SealLicensing/appgraph
[54] Fish and Fish Product Import Provisions of the Marine Mammal Protection Act. United States Federal Register 81(157).
[55] Götz, T. & Janik, V.M. 2013. Acoustic deterrent devices to prevent pinniped depredation: efficiency, conservation concerns and possible solutions. Mar Ecol Prog Ser 492, 285–302.
[56] Northridge, S. P. et al. 2010. Assessment of the impacts and utility of acoustic deterrent devices. Final Report to the Scottish Aquaculture Research Forum, project code SARF044.

50. ADDs cause hearing damage, stress and behavioural disturbance to seals and porpoises.[38] Harbour porpoise are a protected species[59] and it is an offence to harass or disturb them. Likewise, it is an offence to intentionally or recklessly harass or disturb seals at designated haul-out sites.[60] The use of ADDs is not monitored and, therefore, the extent of their use (e.g. frequency, duration and volume) at salmon farm facilities is unknown and unregulated.

Cleaner fish

51. To reduce the number of sea lice in salmon farms, farm operators have increased the use of 'cleaner' fish (e.g. wrasse and lumpsuckers) that live alongside the farmed salmon and feed on sea lice. Cleaner fish are sourced from wild populations and produced in hatcheries. The effectiveness of cleaner fish is still unclear – despite their widespread use, the Scottish salmon farming industry is still unable to control sea lice.

52. In 2016, the salmon farming industry used approximately 1.5 million cleaner fish.[61] In the same year, hatcheries produced 262,000 lumpsuckers and 75,000 wrasse[62], suggesting a significant proportion of cleaner fish used were sourced from wild populations. The unregulated harvesting of wild populations of cleaner fish, in particular wrasse[63], takes place in Scotland and the Southwest of England. It is unknown whether the rate of wrasse removal is sustainable or how their mass removal affects marine ecosystems.

53. When farmed salmon are harvested, after 1-2 years, all cleaner fish in the farm are killed to prevent spreading disease. Therefore, the yearly demand for cleaner fish is consistently high. To meet this demand, and that of a growing industry, the production of cleaner fish from hatcheries will have to increase significantly. However, cleaner fish hatcheries also present environmental concerns: increased resources required for production (e.g. energy and feed), additional medicinal treatments, and genetic divergence and interbreeding risks between farmed and wild fish (similar to those for farmed and wild salmon).

54. The practice of breeding cleaner fish in hatcheries at the scale required by the finfish aquaculture industry is resource-intensive and serves to reduce, rather than eliminate, the problems associated with sea lice. Therefore, the use of wild or hatchery-sourced cleaner fish cannot be considered a long-term, sustainable solution.

Litter

55. To support a growing industry, the number and size of fish farms will have to increase, which will require a greater volume of metal and plastic equipment being placed in the sea. Occasionally, due to storms, poor maintenance, physical degradation, or human error, equipment can be lost at sea and carried long distances by ocean currents. In some cases, lost equipment can wash up on the shoreline. Apart from being an eyesore, lost equipment can pose a threat to marine life.

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[57] Morton, A. B. & Symonds, H. K. 2002. Displacement of *Orcinus orca* (L.) by high amplitude sound in British Columbia, Canada. Ices J Mar Sci 59(1), 71-80.
[58] McGarry, T. et al. 2017. Understanding the effectiveness of acoustic deterrent devices (ADDs) on minke whale (*Balaenoptera acutorostrata*), a low frequency cetacean. ORJIP Project 4, Phase 2. RPS Report EOR0692. Prepared on behalf of The Carbon Trust.
[59] Annex II species to the EU Habitats Directive
[60] Under the Marine (Scotland) Act 2010
[61] Scottish Government EIR release - https://beta.gov.scot/publications/foi-17-01686/
[62] Scottish Fish Farm Production Survey 2016 - http://www.gov.scot/Resource/0052/00524803.pdf
[63] Halvorsen, K.T. et al. 2017. Impact of harvesting cleaner fish for salmonid aquaculture assessed from replicated coastal marine protected areas. Mar Biol Res 13, 359-369

Alternative techniques

Technological

56. Most of the environmental concerns associated with salmon farming in Scotland are the direct result of the open-net design being used. To reduce many of these concerns the salmon farming industry has started investing in alternative farming methods and equipment. These include: fully-closed systems (land or sea based closed-containment systems or Recirculating Aquaculture Systems[64]), semi-closed systems (e.g. the snorkel design[65], lice skirts[66], and waste collection systems[67]), and large offshore salmon farms (e.g. Salmar's Ocean Farm 1[68]).

57. Fully-closed systems present the most effective method for mitigating environmental impacts of salmon farming. The physical, impermeable barrier separating farmed salmon from the surrounding environment would:

    - prevent the transfer of disease, sea lice, and organic and inorganic waste;
    - eliminate the risk of escapes;
    - eliminate the need for cleaner fish; and
    - reduce, if not eliminate, the need for chemical therapeutants.

58. Fully-closed systems are, however, more expensive to operate, have a higher energy demand, and would require the treatment and disposal of waste material on land. Additional concerns over fish survival (due to water filtration and oxygenation) and the economic viability of these systems, indicate that widespread implementation is unlikely in the near future.

59. Until fully-closed systems can be widely implemented, semi-closed systems, offshore farms, and other innovative technologies present immediate, partial solutions to some of the industry's most pressing environmental impacts.

Integrated multi-trophic aquaculture

60. Integrated multi-trophic aquaculture (ITMA) is the practice of farming multiple species at the same site to mimic natural nutrient cycles where the by-products of one species provides food for another. ITMA has the potential to reduce environmental impacts (e.g. sea urchins and seaweeds can feed on nutrient waste from salmon farms), control parasites (e.g. mussels can feed on sea lice larvae, thus reducing the potential for a sea lice outbreak on farmed salmon) and increase the productivity and efficiency of a farm site.

Policy statement – achieving sustainable aquaculture

61. The Scottish Wildlife Trust supports sustainable finfish aquaculture and will campaign for effective regulation, monitoring, enforcement and research to achieve a Scottish fish farming industry based on high quality and unrivalled environmental credentials. To achieve this, the Scottish Wildlife Trust would like to see the strict application of the Precautionary Principle, defined as "where there are threats of serious or irreversible damage,

[64] Murray, F. et al. 2014 Review of Recirculating Aquaculture System Technologies and their commercial application. Highlands and Island Enterprise

[65] Stein, L.H. et al. 2016 'Snorkel' sea lice barrier technology reduces sea lice loads on harvest-sized Atlantic salmon with minimal welfare impacts. Aqua 458, 29-37

[66] www.fishfarmingexpert.com/news/ssf-rolls-out-lice-skirts-after-shetland-success/

[67] Tassal's tarpaulin waste collection system - http://www.abc.net.au/news/2017-05-05/tassal-to-install-salmon-waste-system-in-macquarie-harbour-pens/8500936

[68] www.fishfarmingexpert.com/news/worlds-first-deep-sea-fish-farm-arrives-in-norway/

lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation".[69]

62. The Scottish Wildlife Trust would like to see Scotland become a world leader in sustainable aquaculture production. The reputation of Scottish farmed fish products depends to a considerable degree on the ecological quality of Scotland's marine and coastal environment. Quite apart from the need to minimise impacts on ecological grounds, it makes every sense for the industry to also minimise impacts to mitigate reputational risk. Becoming a world leader in sustainable methods of production and ensuring the highest environmental management and design standards is, we believe, the best way of mitigating this reputational risk. A truly sustainable industry makes good economic as well as good ecological sense. Therefore, the Scottish Wildlife Trust supports fully transparent, science-led labelling schemes, such as the Aquaculture Stewardship Council and the Soil Association's organic standard, which aim to improve the environmental sustainability of aquaculture and allow consumers to make informed choices based on measurable standards.

63. The Scottish Wildlife Trust considers that any further growth of the finfish industry must not be to the detriment of Scotland's environment. Therefore, it is the opinion of the Scottish Wildlife Trust that there should be no further growth of the finfish aquaculture sector using open-net practices. Exceptions should only be granted where the relocation of an existing fish farm results in a significant net environmental benefit, or the applicant proposes to trial innovative new designs and practices that aim to reduce their environmental impact. It is imperative that strict criteria for exceptions are established to provide clear direction for the industry and ensure environmental protection.

64. The Scottish Wildlife Trust believes that, to ensure finfish aquaculture develops sustainably, the Scottish Government should introduce an incentives scheme that provides economic and/or logistical support to the finfish aquaculture industry for the development and trialling of new technology, such as closed and semi-closed systems, aimed at reducing their impact on the environment.

65. The Scottish Wildlife Trust considers that marine spatial planning will play a fundamental role in developing a sustainable aquaculture industry in Scotland. Therefore, the Scottish Wildlife Trust would like to see an Aquaculture Planning Strategy developed to guide the future development of Scotland's finfish aquaculture industry. The Strategy should identify areas where wildlife and habitats are particularly sensitive to aquaculture development, determine the carrying capacity of Scottish waters, and identify a realistic, scientifically-informed growth target for the industry.

66. In alignment with the Aquaculture Planning Strategy, RMPs should incorporate nature conservation sensitivity maps to identify areas for aquaculture development and the relocation of existing farms, to ensure development does not impact sensitive sites.

67. It is the Scottish Wildlife Trust's view that salmon farming should not take place within MPAs that contain protected features (species or habitat) at direct or indirect threat from salmon farming activity. Existing farms located within MPAs that pose a threat to protected features should be required to apply appropriate mitigation measures or be relocated.

68. The Scottish Wildlife Trust considers that salmon farms located outside of MPAs must demonstrate they do not pose an unacceptable impact on the health of Priority Marine Features.

69. The Scottish Wildlife Trust would like to see the adoption of co-ordinated sea lice management measures, through the operation of statutory Farm Management Agreements (FMAs) that facilitate the effective use of synchronised fallowing and chemical treatment regimes within defined areas. Such areas should be defined by boundaries based on ecological grounds and take account of the best available evidence of sea lice dispersal. Where such evidence is

[69] UNEP (1992)

lacking, risk of transfers between management areas should be controlled through setting larger boundaries rather than smaller ones.

70. The Scottish Wildlife Trust considers it essential that a peer-reviewed assessment of the direct and indirect environmental impacts of the chemical therapeutants, treatments, and medicines used by the salmon farming industry is carried out by an independent body. It is essential that all chemicals found to present an unacceptable environmental risk are phased out and where the risks are particularly high, for the chemical to be taken out of use.

71. The Scottish Wildlife Trust believes that, to fully assess strategies for controlling sea lice and gain a broader understanding of the impacts on wild fish, historical data and results of weekly sea lice monitoring from individual farms *and* surrounding wild populations should be made publicly available. Sea lice data from wild fish will identify when the total number of sea lice at a farm, rather than on individual fish, has reached a threshold where the impact on wild fish has become significant and additional farm management action is required.

72. The Scottish Wildlife Trust would like to see the approach for calculating sea lice threshold levels reviewed, as the current method (average lice per fish) does not account for larger farms containing more fish and, therefore, higher total numbers of sea lice. The Scottish Wildlife Trust considers that the sea lice threshold levels should be calculated using the number of fish being held at a site (i.e. an acceptable number of lice per farm), rather than an average number of lice per fish.

73. The Scottish Wildlife Trust considers there should be a ban on use of wild-caught cleaner fish (i.e. wrasse and lumpsuckers). When cleaner fish are required, they should be sourced from hatcheries. However, the Scottish Wildlife Trust considers cleaner fish to be a short-term approach to reducing sea lice numbers and that their use should be phased out as more effective and sustainable alternatives for controlling sea lice become available.

74. The Scottish Wildlife Trust would like to see further investment into research on the potential for integrated multi-trophic aquaculture to reduce the environmental impacts of salmon farming and the potential for sea lice outbreaks.

75. The Scottish Wildlife Trust believes that the siting of farms near important breeding, foraging and haul-out sites for seals is inappropriate. Important breeding and foraging sites for seabirds should also be avoided.

76. The Scottish Wildlife Trust would like to see further efforts made to ensure salmon farming operations do not impact the health of wild salmon populations. The Scottish Planning Policy already acknowledges the impact of salmon farms on wild fish populations, by banning farm development on the North and East coasts of Scotland. However, the same level of protection has not been awarded to wild fish populations in rivers on the West coast of Scotland. As our understanding of salmon migration improves, the Scottish Wildlife Trust would like to see a ban on new salmon farms, and the relocation of existing farms, located along key salmon migration routes.

77. The Scottish Wildlife Trust believes that escapes through system or human failure are not acceptable and that fines should be considered when escapes occur. While events such as extreme weather are difficult to anticipate, it should be the aim of the finfish aquaculture industry to eliminate all escapes through technological means and standards for the construction and operation of facilities. A statutory minimum technical standard, specifying the design, installation and operation of fish farms should be established in Scotland as a matter of urgency. As human error remains a significant factor in escape events, we will also call for those installing or operating fish farms to be suitably qualified and conform to high standards and best practice.

78. The Scottish Wildlife Trust believes that to improve accountability for escapes, regulation to take or require samples from fish farms must be introduced so that escaped fish can be traced back to the farm or company of origin. Such a step would ensure that farm operators are held to account and remedial action can be initiated.

79. The Scottish Wildlife Trust considers that the salmon farming industry and the Scottish Government should be jointly responsible for funding a monitoring programme for wild salmon and sea trout populations in marine regions that contain salmon farms.

80. The Scottish Wildlife Trust considers that the brood stock for salmon farmed in Scotland should come from Scottish waters, and ideally from the surrounding waters of the salmon farm, rather than from non-native salmon stocks (e.g. Norwegian salmon). Therefore, if an escape event occurs, the threat to wild salmon populations from introgression would be reduced as farmed and wild salmon would be genetically more similar.

81. The Scottish Wildlife Trust believes that the rearing of salmon smolts in freshwater open net-cages presents an unacceptable risk of escapes in river catchments containing migratory salmonids. To ensure absolute containment, the rearing of salmon smolts in freshwater should only be carried out in biosecure closed-containment systems.

82. The Scottish Wildlife Trust would like to see the amount of time adult salmon spend in open-net farms should be kept to a minimum, potentially one year, to reduce their impact on the surrounding environment and limit their exposure to disease and parasites.

83. The Scottish Wildlife Trust believes the finfish aquaculture industry must, as a minimum, source all fishmeal and fish oil used in feed from independently certified sustainable stocks.

84. It is the Scottish Wildlife Trust opinion that there should be a ban on seal shooting and will campaign for the use of non-lethal control methods, such as anti-predator netting to be used as standard at fish farm sites.

85. The Scottish Wildlife Trust would like to see better regulation on the use of ADDs and that they should be banned from seal haul out and breeding sites and from SACs and MPAs established for the protection of marine mammals. The Scottish Wildlife Trust would like to see industry-led research on the impact ADDs have on marine life, in particular cetaceans, and for the findings to inform a clear and strict protocol for the future use of ADDs. The Scottish Wildlife Trust believes that alternative measures to prevent predation, such as double netting, should be prioritised and that ADDs should be used as a 'last resort' once other methods have failed, with the aim of phasing out their use completely.

86. The Scottish Wildlife Trust would like to see all large equipment (e.g. feeding pipes, metal frames) used on finfish farms tagged with the operators details to ensure that, in the event of equipment being lost at sea, the costs of removal, once/if found, should be covered by the farm operator.

87. The Scottish Wildlife Trust would like to see applications for new farms and farm extensions, for both planning permission (Local Authority application) and CAR License (SEPA application) adequately publicised to ensure all stakeholders are well informed on new farm developments. The Trust considers that coastal community perspective and participation in salmon farm consultations is essential for capturing the intrinsic value of the marine environment in the decision-making process.

88. The Scottish Wildlife Trust will endeavour to work collaboratively with the aquaculture industry, Government and its Agencies, the research community, coastal communities, and other stakeholders to help ensure that the industry is managed effectively through an efficient and robust regulatory process, and that environmental sustainability is at the core of future decision-making for finfish aquaculture in Scotland.

How the Scottish Wildlife Trust will use this policy

89. The Scottish Wildlife Trust will advocate the principles outlined in this policy statement to Government, the business sector, the wider public and other key stakeholders. In particular, we will advocate for environmental sustainability and the ecosystem-based approach to be central to aquaculture legislation and the implementation of the Marine (Scotland) Act 2010, particularly in relation to marine spatial planning, marine protected areas and the application of Marine Strategy Framework Directive.

90. The Scottish Wildlife Trust will oppose planning applications which pose a significant threat to biodiversity or where biodiversity considerations have not been properly addressed through design or mitigation.

Cross reference to other Scottish Wildlife Trust policies:

Policy Futures 1: Living Landscapes: towards ecosystem-based conservation in Scotland
Policy Futures 2: Living Seas: towards sustainable marine renewable energy in Scotland
The Planning System
Conservation and Management of Seals