Executive Summary

The Impact of Salmon Aquaculture on Our Native Fisheries and the Aquatic Environment.

Aquaculture has the potential to be a sustainable source of seafood, which could help to alleviate some of the pressures on the world's oceans. However, the current stewardship of fish farms is in question, due to the impact of aquaculture on wild fish and the surrounding environment.

In 1980, commercial wild fisheries harvested 99% of salmon consumed worldwide. By 2003, approximately 60% of marketed salmon was from aquaculture. Salmon is now farmed in 24 countries, with Norway, Chile, Scotland and Canada being responsible for 71% of global production. The Atlantic salmon is the most economically important species, representing 89% of salmon production. The industry has become more technologically advanced, but full-time employment at farms has decreased.

This paper focuses on the scientific evidence of the impact of current stewardship of salmon farms on the surrounding environment and, in particular, wild salmon and sea trout.

Impacts of salmon farming on wild salmon and the surrounding environment

Salmon farms pose a threat to wild salmon and the environment in several ways. These include; spreading of parasites – particularly sea lice - and diseases; interbreeding of wild and farmed salmon; chemical waste; biological waste and eutrophication.

Sea lice

The sea louse is an ocean parasite of Atlantic salmon, which easily transfers from farmed to wild populations as open cage systems allow its planktonic larval stage to disperse into the surrounding water. This can be detrimental to migrating fish populations, especially juvenile salmon and sea trout, which are most vulnerable during and immediately after smoltation. Sea lice may also spread microbial and bacterial diseases.

Laboratory dose-response studies on wild salmon smolts found infection of 0.75 lice per gram of fish weight would cause death, while monitoring in the Norwegian sea found no live post smolts with more than 10 adult lice. Other experiments have found that 30-50 sea lice larvae can cause death in juvenile salmonids. Sea trout have been captured from fish farming areas with between 3-20 times the natural infestation rate of adult female lice per fish. In Norway, specialists recommend less than 10 lice per wild salmonid to ensure no impact on wild salmonid populations.

Salmon farms alter the natural relationship between lice and wild salmonids. For example, wild salmon infested with sea lice would typically suffer from reduced foraging efficiency, thus increasing host mortality, while this is overcome by artificial feeding in aquaculture. Fish farms also expose salmonids to the parasites at an abnormally young period of development, and studies have shown wild salmon and sea trout numbers declining more significantly in areas with fish farms than areas without. Research from two Norwegian fjords found 86% of wild migrating juvenile salmon died as a direct result

of sea lice infestations whilst migrating past salmon farms, and Canadian scientists calculated a 99% collapse in one local native pink salmon population within four generations if lice infestation continued.

Disease transfer
The high density of fish at fish farms functions as a reservoir for pathogens and diseases, providing an ideal breeding ground and facilitating movement into nearby wild populations. In addition, escapees may transmit disease to wild stocks which have no natural defences. Wild fish can also transfer disease to fish farm populations, allowing pathogens to multiply rapidly and exacerbate natural levels.

Escapee salmon: Interbreeding of wild and escaped (genetically engineered) salmon
Farmed salmon escape practically everywhere there is aquaculture, often in large numbers compared to wild stocks. In Norway, it is estimated that 1.3 million salmon escape each year and, in 2000, an estimated 500,000 fish escaped in Scotland. There is growing evidence that these escapees are establishing significant populations in the wild. It is estimated that on the west coast of Scotland, 22% of 'wild' caught salmon were farmed escapees and, within Norwegian rivers in close proximity to fish farms, up to 80% of the spawning fish in one season were from fish farms. Experimental ocean fishing off the Faroe Islands during the mid 1990s found 20-40% of salmon caught was from farmed origins.

Farmed salmon typically show lower genetic variability than wild salmon, leading to farmed fish diluting gene pools and local adaptability in wild populations. Farmed salmon differ from wild salmon both morphologically and physically, which can affect behaviour, spawning success and competitive ability. Experiments have shown that farmed fish have survival rates as low as 16% of native fish in the wild.

The use of sterile fish in aquaculture has been found to reduce return rates of escaped farmed salmon to both estuaries and freshwater. This, coupled with their inability to produce viable offspring, could reduce the ecological impact of escapee farm fish.

Chemical wastes
Antibiotic and insecticide medication for diseases and parasites in aquaculture can expose the surrounding environment to chemical wastes, which can be toxic to other aquatic organisms.

Outputs from fish farms are controlled by discharge consents. However, the number of drugs permitted by the Veterinary Medicines Directorate for use in fish farms has grown with the scale of the industry, expanding from three drugs in 1989 to 40 in 2002. Between 1985 and 1987 in Norway, antibiotic use increased from 17 to 48 mt per year, exceeding the combined use by humans and terrestrial animals in the country during the same period. The incautious and profligate use of these antibiotics can lead to the development of drug-resistant strains of diseases in both wild and farmed populations.

Elevated levels of zinc, copper and cadmium have been found in fish farm sediments as a result of feed and faecal outputs, and the anti-foulant products used in aquaculture. A survey of metal concentrations in surface sediments at 70 sites around fish farms in Loch Craignish, on the west coast of Scotland, found maximum concentrations of 921, 805 and 3.5 $\mu g\ g^{-1}$ of zinc, copper and cadmium, respectively. Elevated levels of sediment metals can have a wide range of impacts on the benthos, including altering community structure and reproductive success.

Biological Waste and Nutrient Loading
Sediments from faeces and uneaten food beneath fish cages have been found to be enriched in phosphorus, nitrogen, organic carbon and zinc, posing a major threat to water quality and environmental integrity. The wastes can also smother animal and plant communities beneath cages, disrupting benthic communities and impacting sediment nutrient cycling.

Summary
Despite some common perceptions to the contrary, the scientific literature unequivocally demonstrates that, to varying degrees, fish farms are having a detrimental impact on native fisheries, the wider environment and the many public benefits associated with it. In order to make aquaculture a viable and sustainable industry, these threats must be addressed as an urgent priority.