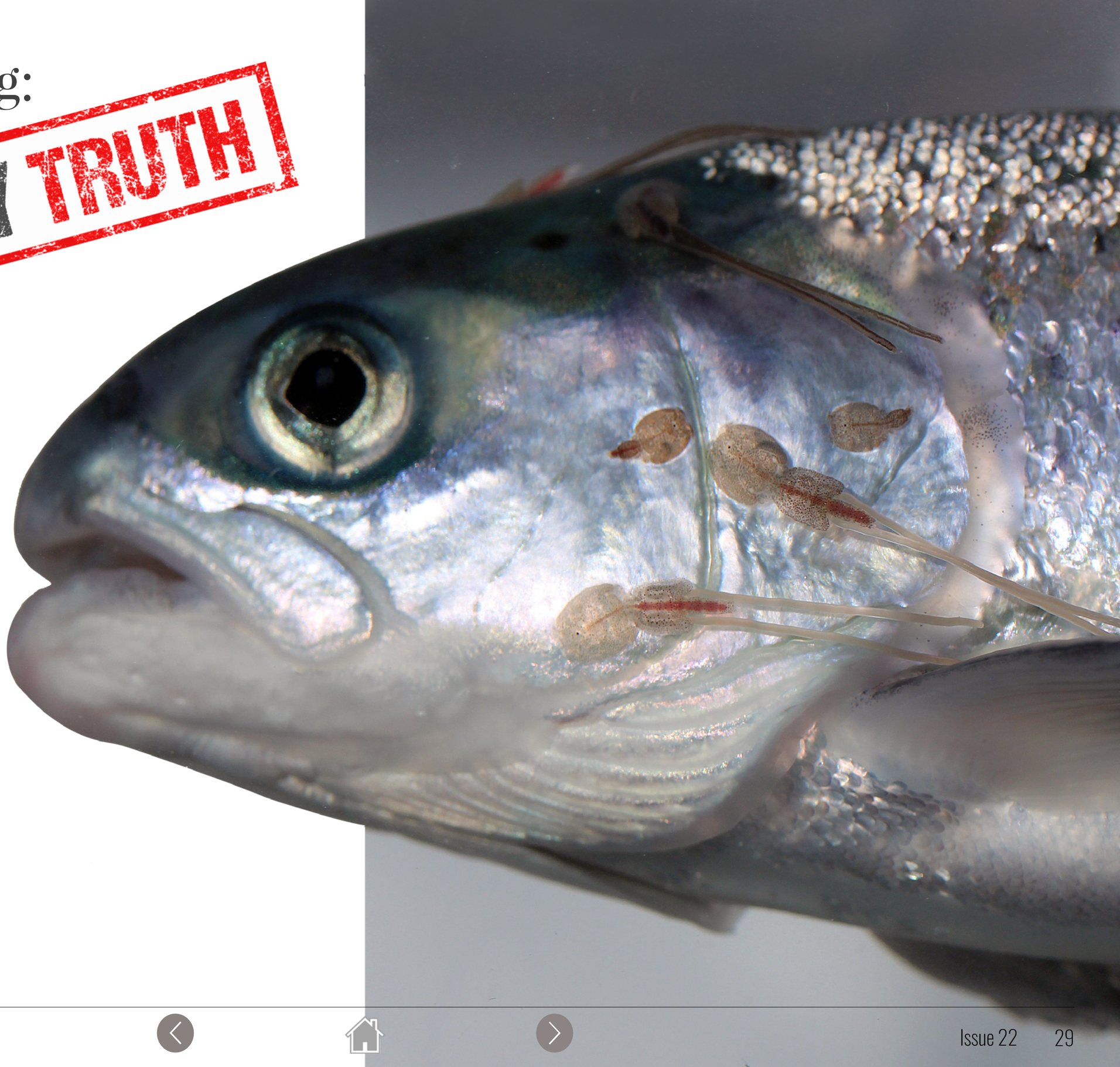
Salmon farming:

THE UGLY TRUTH



The Atlantic salmon (*Salmo salar*) farming industry is big business, not just in Ireland but on a global scale, with harvest volumes for 2018 predicted to rise to some 2.4 million tonnes worldwide. However, despite the economical and alleged dietary benefits for a growing human population, more and more people are realising the lack of sustainability and widespread environmental and ecological damage associated with this industry.

John Murphy, Director of *Salmon Watch Ireland*, dives head first into the fish cages of lies, corruption and corporate greed which are severely impacting, among others, our wild salmon and sea trout stocks...

The advent of salmon farming in the late 1980's in Ireland gave rise to much debate in regard to the negative effects that this new type of practice might mean for our coastal marine environment. Unfortunately the most visible consequence was observed almost immediately in that a strange and unexpected premature sea trout migration back to freshwater took place in areas where salmon farming was being carried out. These fish were early returnees and within a few weeks of their migration as smolts or kelts they had returned in large numbers with varying degrees of injury and infection. Adults and finnock (immature fish at sea) were equally affected with the common denominator being their closeness to salmon farms and the number of sea lice attached to these wild fish, which were many times what was expected in wild fish.

The first wide scale research into the effects of sea lice in Ireland was published by the Department of the Marine in their publication of the Sea Trout Working Group Report in 1992. If one was to fast forward to today it might surprise many people that we are still arguing whether sea lice emanating from salmon farm facilities is causing harm to wild salmonid stocks. This is a period of over 26 years during which the sea lice issue has been researched on a continuous basis by national and international regularity bodies, universities, independent scientists and indeed the aquaculture industry alike. The overall consensus among scientists is that sea lice from aquaculture facilities are a devastating issue for both wild Atlantic salmon and sea trout. Indeed facilities in the Pacific rearing Atlantic salmon are also affecting wild Pacific salmonid species.

The current situation in Ireland, as gleaned from the recent Joint Oireachtas hearing into Aquaculture Licensing records, is that there are 38 licensed facilities to rear finfish which are located from West Cork to Donegal. Not all of these sites are operational but there has been a significant increase in production since 2007 with a 60% increase in production up to 2016 with another as yet unpublished increase in 2017. During this period there has been a substantial increase in the value of Irish farmed salmon with the value in Ireland breaking the €100m barrier. Indeed the price per kg is substantially higher than both Scotland and Norway although, interestingly, less than that for salmon farmed in the Faroe Islands.

In an international context, Ireland (expected 19,000 tonnes in 2017) is a very small player within the industry and is dwarfed by Scotland (180,000 tonnes) and Norway (1.2 million tonnes). Both Scotland and Norway have been relatively static in their production over the last number of years as they are experiencing capacity problems in that there, is in all probability, large scale environmental constraints in their coastal waters associated with anoxic conditions, disease and parasites becoming more prevalent due to large acreage occupied by traditional open-net aquaculture facilities. Very few new licenses in aquaculture regions in Norway are being issued with exceptions for so called "Green Licences" which are for a number of technologies focussed on promoting methods that can solve the environmental and acreage challenges facing the aquaculture sector as a whole.

Despite the scientific studies linking reduced wild salmon survival and indeed an extinction vortex for sea trout in aquaculture regions in Ireland, the political reality is that official policy is to increase salmon farming production by a combination of issuing new licences and amendments to existing licences. Truthfully the industry has only been stopped from expanding to date by virtue of various NGO bodies relying on European law. One of the biggest obstacles to expansion of the industry came about due to a decision by the European Court of Justice in 2007, when a negative judgement against Ireland was handed down for breaches of the EU Birds and Habitats Directives in relation to Natura 2000 sites (Special Areas of Conservation (SAC) & Special Protection Areas (SPA)). There are 71 marine Natura sites in Ireland (where the majority of aquaculture takes place) and the main focus of the judgement related to the failure of the State to put in place a system for data collection, definition of scientific interests and adequate assessment of aquaculture licence applications in the Natura 2000 areas. National legislation was put in place to protect existing licences in these Natura sites so that the aquaculture facilities could continue while negotiations were conducted with EU authorities to ensure compliance with the Birds and Habitats Directives. The process has been concluded and Appropriate Assessments have been conducted in relation to the Marine Natura sites which appear to have given the green light for renewal of licences and the inevitable expansion of the industry in these protected sites.

Has the situation changed from those early days in the 1980s? The simple answer is no; we still have the same arguments regarding sea lice but now we have so many more problems with disease and increased escapement of farmed salmon. All this, and the associated warming of the seas around Ireland's west coast, means we now have an industry which is much more harmful than ever before and is, in essence, an industry which cannot be sustained if Ireland is to preserve its wild salmon and sea trout stocks. The salmon farming industry has by its very nature caused environmental compromise to the marine environment and, more to the point of this article, damaged wild salmonids. The regulatory regime in Ireland is not remotely robust enough, with protocols and guidelines being relied upon to control the industry. The inspection regime in regard to fish health and the monitoring of sea lice levels is carried out by the Marine Institute while the Department of Agriculture, Food & the Marine (DAFM) through its Marine Engineering division is responsible for the inspection of infrastructure associated within the industry.

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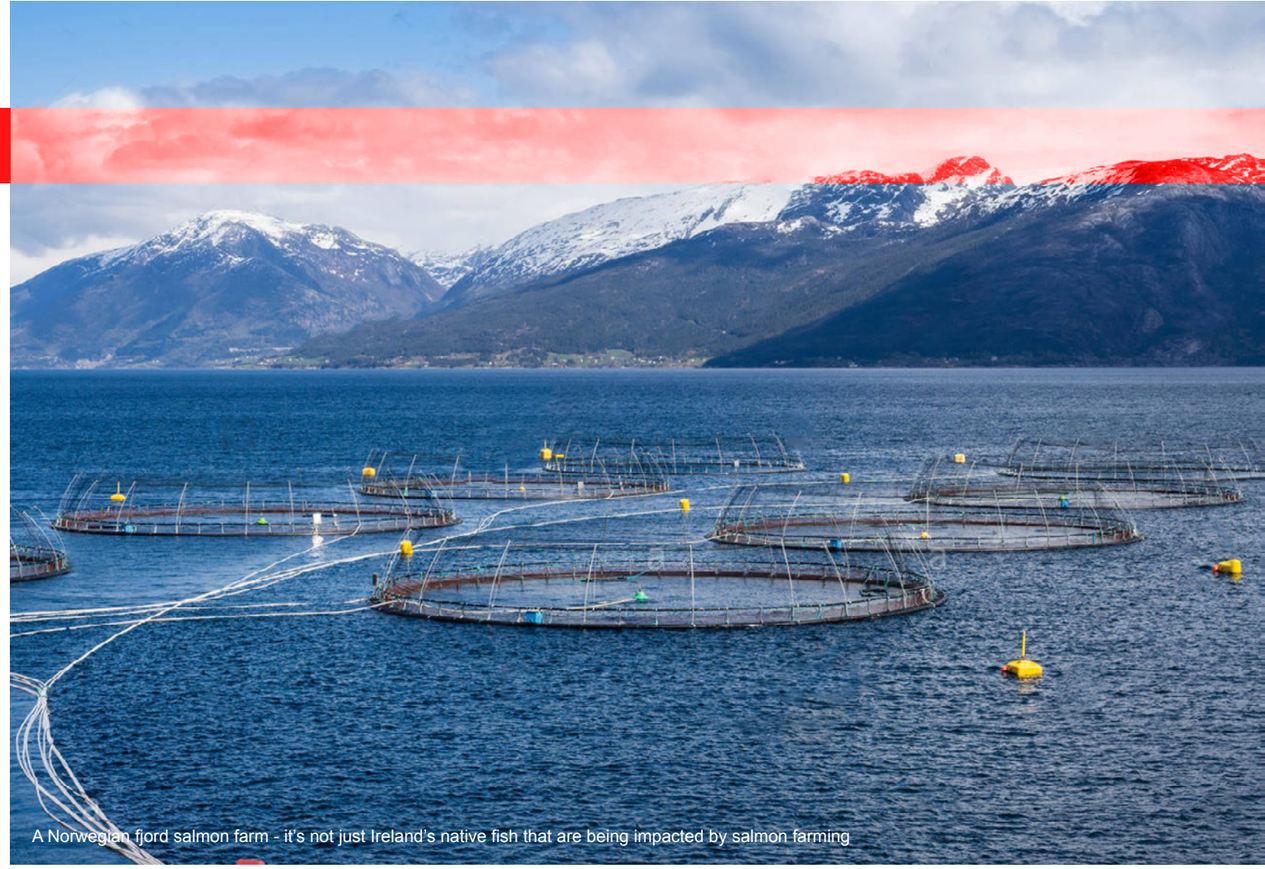

A Norwegian fjord salmon farm - it's not just Ireland's native fish that are being impacted by salmon farming

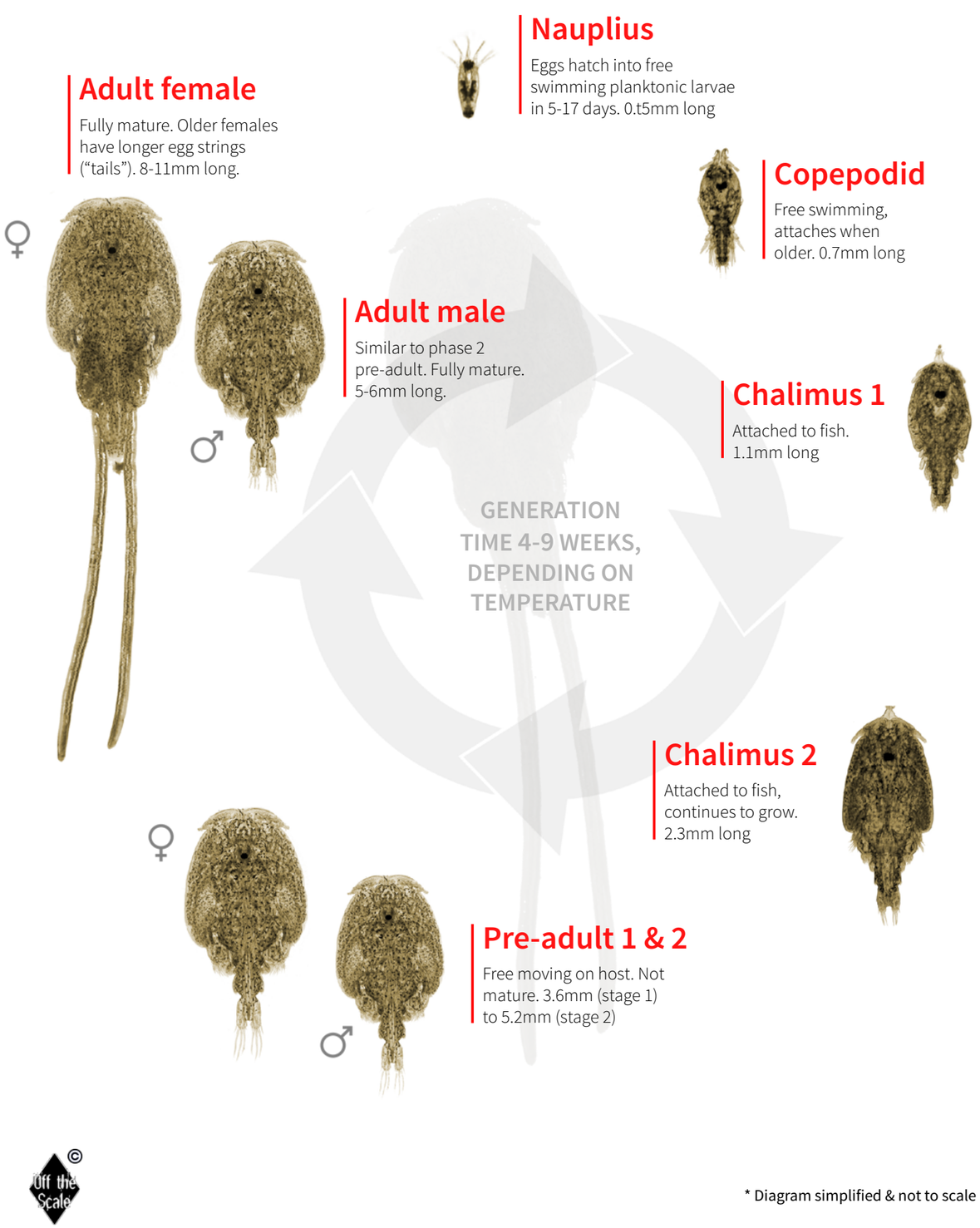
In relation to sea lice the Monitoring Protocol No. 3 for Offshore Finfish Farms lays down specific protocols in relation to their monitoring. Sea Lice inspections are carried out on 14 occasions annually with two inspections per month for March, April and May and monthly inspections outside this period. Only one inspection is carried out during the December / January period due to weather constraints.

The protocol lays down treatment trigger levels for sea lice within the period of March to May, which is referred to as the critical period for wild salmon and sea trout outward migration. This is reflected in lower trigger levels for mandatory treatment at 0.5 ovigerous (egg-bearing) lice per farmed fish but certain licences indicate a lower level of 0.3 lice per fish. The trigger level is also initiated if mobile lice infestation is high even in the absence of ovigerous lice. The lice treatment levels can be relaxed during harvest or by agreement with DAFM. The treatment level is set at 2 ovigerous lice per fish outside the spring period.

While there are 14 physical inspections carried out each year by the Marine Institute regarding sea lice levels, no account has been taken of the effect of biomass on the individual farms and thus the treatment trigger levels are somewhat redundant. For example, a farm of 500 tonnes has the same ovigerous lice treatment level per fish as a farm of 2000 tonnes, with up to four times the number of fish. The very nature of the inspection regime is not robust enough with a very small number of 60 farmed fish being inspected per farm from two net pens, one standard pen and one random choice. With large farms consisting of up to close on a million fish it is highly unlikely that a sample of such order would satisfy any statistical model.

The size of farms and changing environmental factors must be taken into account and effectively a larger farm has more capability in production and distribution of excessive lice larvae in the wider environment. As such, today we are looking at a situation which is quite different to the previous

Salmon louse (*Lepeophtheirus salmonis*) life cycle



* Diagram simplified & not to scale

generation of salmon farms which operated in different environmental and oceanic conditions and with a smaller biomass generally. With warming sea temperatures there is also the spectre of increased production of larval lice through reduced generation time and increased numbers of larval lice surviving which effectively increases the period and range away from a farm that they can remain infective to wild salmonids.

In regard to the sea lice issue there are two species of lice which are important to look at in regard to transfer from farm sources to wild salmon and sea trout. *Lepeophtheirus salmonis* (salmon lice) are host-specific to salmonid species while *Calligus elongates* (sea lice) can infest a large number of marine species but also affect wild salmon and sea trout. Both species have a broadly similar life cycle but *Calligus elongates* can jump host thus providing an increased threat to infestation of farmed salmon from marine fish with a knock on effect to wild salmon and sea trout through larval distribution.

In general, given Ireland's relatively mild sea temperatures, both sea lice species, after hatching on a farmed fish, have a finite period to infect wild fish. However, the number of larval lice released is extremely large as each ovigerous female may release many thousands of eggs over their life span. During the first number of days post-hatching, sea lice are non-feeding and passively drift within the top layer of the water column. Two stages of development are involved before transitioning to a third stage (copepod) where they become infective to wild salmon and sea trout. As copepods they are more active swimmers and are positively phototactic (move towards light) allowing a louse to position itself in the water column in order to give itself the best opportunity of encountering a wild salmonid. The first three planktonic stages of its life cycle can last up to a number of weeks so they can, in areas of strong currents and open coastline, effectively be transported to areas of the ocean which may be up to a 100km from the original source. It is true that the density of the sea lice plume may weaken as they are distributed along the oceanic currents but it is also obvious that natural limits are vastly surpassed in proximity to farms and to some distance from these facilities. The sheltered farms within bays may also contain the larvae in a small geographic area which would compound the situation and effectively allow larvae be dispersed on an on-going basis with each tidal event.

On successful contact with a host the lice go through a process of another number of stages of development during which the damage to the wild host can be devastating if enough individuals infest the fish. Of course sea lice are a natural parasite but the difficulty arises when their larval numbers are increased by the presence of a large number of hosts on a fish farm with opportunity to develop large overall numbers of ovigerous (egg bearing) female lice. If we just think about it, there are upwards of close to a million adult salmon on some individual Irish farms which dwarfs the entire annual wild salmon returns to Ireland by a magnitude of 4:1. Effectively in one bay it is possible to have a situation where available hosts for sea lice infestation could run into the millions, including both adults and post-smolts. The practice and logic of treating the farmed fish is to limit the transition from attachment to maturity of the sea lice but this is more to do with protection of the livestock rather than the protection of wild salmonids. New biological sea lice treatments rather than chemical treatments have been in operation in Ireland over the last number of years but these cleaner fish (wrasse and lumpfish, which graze on sea lice attached to salmon) are becoming more susceptible to disease with a consequent knock-on effect on control of sea lice on farms. There are also growing concerns about the sustainability of (slow growing, late maturing) wild wrasse being captured to act as cleaner fish. This practice may lead to a cascade of effects as yet undetermined.

" With warming sea temperatures there is also the spectre of increased production of larval lice... which effectively increases the period and range away from a farm that they can remain infective to wild salmonids "


Credit: Salmon & Trout Conservation UK

A sea trout (post-smolt) with heavy sea lice infestation

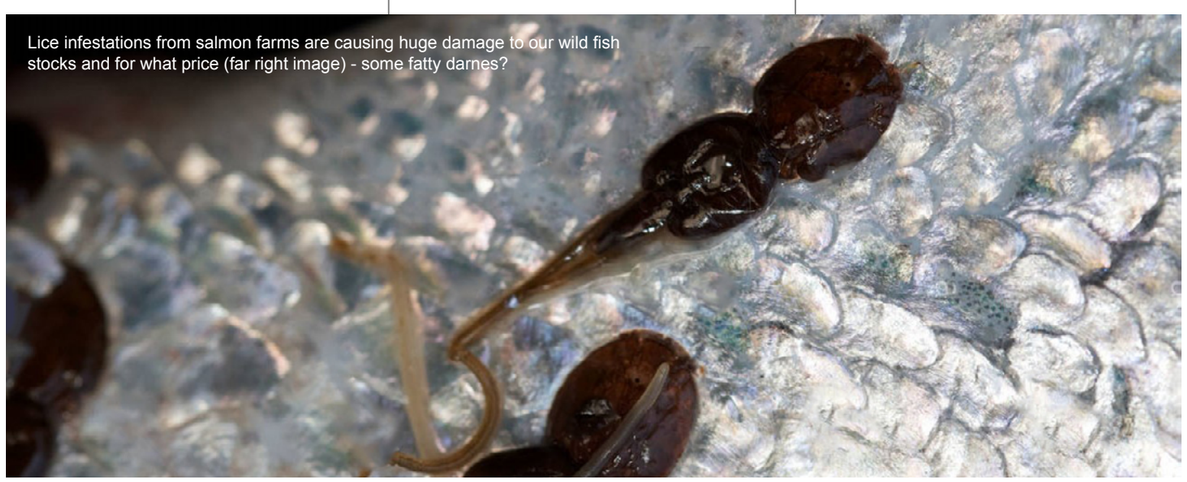
The sea lice which infest wild sea trout and salmon in aquaculture areas cause damage through physical injury which gives rise to physiological changes including elevated plasma cortisol, glucose and reduced osmoregulatory function. All these negative effects may result in death of wild juveniles and indeed adults and it has also been observed that reduced growth, reduced reproduction and impaired swimming ability (increased predation risk) are consequences for wild fish in aquaculture areas, which lead to negative effects at a population level. This results in a reduction in survival which for Atlantic salmon could be up to a 50% decline in returning adults in a year where a large biomass of salmon exists on an adjacent farm. For sea trout this reduction could be up to 90%. Both these percentage reductions are from research in the Erriff River carried out over a long period by Inland Fisheries Ireland (IFI) and are probably similar to all west coastal areas where salmon farming is carried out.

Our own Marine Institute has stated that sea lice are a "minor and irregular" component in overall salmon survival. While agreeing that the effect is irregular this is as a consequence of environmental conditions being negative in certain years for lice larval survival and productivity through reduced salinity in bays after high rainfall (newly hatched larvae do not survive below salinities of 15‰ and poor development of the infective copepodid occurs between 20‰ and 25‰) or low biomass of salmon on farms (generally in the first year of production when farmed post-smolts are on the farm). An anecdotal point here would suggest that recent spring weather patterns in Ireland have been very dry during the April to June period giving excellent survival conditions for the larval stages of sea lice.

We certainly cannot agree that the effects are "minor" as the Marine Institutes own research indicates a loss of up to 20% of adult returnees. The confusion here relates to the Marine Institutes insistence that if 5% of salmon survive to come back as adults in aquaculture areas and 6% return in non-aquaculture areas there is only a 1% difference in overall survival. This is in fact a large reduction in returning adults. If 100,000 smolts were to go to sea from rivers in a fish farming bay with high biomass, 5000 adults may return whereas a bay with no aquaculture would see 6000 fish return, a difference of 1000 fish, which is hardly minor in effect. In relation to sea trout this would in all probability be much more damaging with very few surviving due to their reliance of near shore environments (where the farms are). The research carried out by international bodies and indeed Inland Fisheries Ireland (IFI) is broadly in line with the results and data of the Marine Institute but it is the interpretation of these results by the Marine Institute which is at odds with the vast majority of scientists both nationally and internationally.

One instance which may illustrate an effect due to increased biomass is Kenmare Bay where an amendment to the Deenish Island licence has effectively doubled the amount of fish being stocked at this location with disastrous results for the sea trout populations of Waterville and other catchments within Kenmare Bay and Ballinskelligs Bay in Kerry. Sea lice levels on individual farm fish are generally reported as low at the Deenish site yet premature returning sea trout are evident with a progressive collapse of rod catches of sea trout since 2011. The downward trend in Waterville has continued since, with an alarming collapse of the spawning stock and virtual disappearance of the larger sea trout for which the catchment was internationally famous.

The establishment of larger farms coupled with the ominous trend of increased severe weather patterns primarily involving more intense and destructive storms, increased escapement of salmon from farms is now a reality, with large numbers of farmed salmon turning up in wild salmon rivers in the west of Ireland in 2017. Other factors which also influence escapement involve the increased usage of well boats to treat fish for disease and parasites. Poignantly, the escaped salmon may spawn with wild fish causing a progressive dilution of wild genetics which could effectively destroy the productivity of wild systems.



Lice infestations from salmon farms are causing huge damage to our wild fish stocks and for what price (far right image) - some fatty darnes?

" The establishment of larger farms, coupled with the ominous trend of increased severe weather patterns... means that increased escapement of salmon from farms is now a reality, with large numbers of farmed salmon turning up in wild salmon rivers..."

Whilst not wishing to leave aside the polluting aspects of salmon aquaculture to the marine environment, the scope of this article is more related to direct effects on wild salmonids so we must now look seriously at the probable transmission of disease from salmon farms to wild fish. There are a number of diseases which are notifiable to the Department of Agriculture, Food and Marine under E.U COUNCIL DIRECTIVE 2006/88/EC. Notifiable diseases such as Infectious Salmon Anaemia (ISA), Viral Haemorrhagic Septicaemia (VHS) and Infectious Haematopoetic Necrosis (IHN) are officially absent from Ireland but with expected increases in production there is every reason to believe that these pathogens will eventually arrive at our shores through imported equipment and infrastructure. Ireland is also free from other significant diseases affecting finfish such as *Gyrodactylus salaris* and Bacterial Kidney Disease.

However, other diseases and conditions are prevalent on Irish fish farms and are a very large problem to salmon farming around Ireland, notably Amoebic Gill Disease (AGD), Cardiomyopathy syndrome (CMS) and Pancreas Disease (PD). Amoebic Gill Disease (AGD) primarily affects salmonids and was first described in farmed Atlantic salmon and rainbow trout (*Oncorhynchus mykiss*) in Tasmania in 1993. Other infected species have also been reported including farmed turbot, bass and sea trout. The causative agent is *Paramoeba perurans*, an amoeba which infects the gills of a wide variety of fish species. The main problem with this parasite is that it affects gill filaments and as such is capable of large scale mortality due to secondary infection of compromised tissue. It is contended that farms affected by *Paramoeba perurans* could effectively be acting as large scale environments for the production and distribution (through ocean currents) of vast numbers of this amoeba which, in turn, may affect wild salmonids. The disease has also recently been described in wrasse and lumpfish. The last point is important as both wrasse and lumpfish are, as outlined earlier, used as cleaner fish in the salmon farming industry.

Escapement from fish farms is set to increase into the future.

Sea trout, a species which may spend long periods of time inshore and in vicinity of salmon farming areas, may be at increased risk of being infected. The outbreaks of AGD appear to be more prevalent in Ireland in the period May-July but also in autumn although the diagnosis and manifestation of the disease may be delayed and could be present at other times of the year. Sea trout are present throughout the coastal areas during these periods and it has been noted in a study by the Norwegian Scientific Committee for Food Safety that sea trout in the wild may become infected by *P. perurans* in areas where AGD is present on salmon farms. Indeed other species of fish in the wild may be at risk and are as yet unidentified, principally due to lack of focussed research internationally and in Ireland. The possibility of infection of wild salmonids by the causative agent of AGD, *Paramoeba perurans*, has certainly not been adequately investigated in Ireland.

According to the International Council for the Exploration of the Sea (ICES) "*Piscine myocarditis which is commonly referred to as cardiomyopathy syndrome (CMS) is an economically important disease of Atlantic salmon, Salmo salar in seawater. Characteristic heart lesions primarily involving the myocardium are reported in natural outbreaks with associated mortality. This disease should be regarded as chronic which is associated with a necrotizing severe myocarditis involving the atrium and the spongious region of the heart ventricle and primarily observed in adult or maturing fish after 12 to 18 months in seawater. Piscine myocarditis was originally described from farmed Atlantic salmon, S. salar in 1985 but has subsequently been recorded in wild Atlantic salmon along the Norwegian coast. It is suggested that cardiac function would be impaired and therefore could compromise such migratory fish. Piscine myocarditis is caused by a double-stranded RNA virus named piscine myocarditis virus (PMCV) with structural similarities to the Totiviridae family.*"

The virus PMCV is spread through the water column and as such may now be present in wild salmon and sea trout. Again the salmon farms, with their abnormally high densities of fish, may be acting as a large reservoir for the production and distribution of this virus. Again, no real effort has been made to investigate whether wild salmon and sea trout are being affected.
Another disease which is noteworthy is pancreas disease (PD), caused by the salmonid alphavirus (SAV), which has been evident in Ireland since the early years of the industry. Again there has not been effective research to examine potential impacts on wild salmonids.
Generally it is difficult to quantify what effect these diseases are having on wild fish as most fish affected may die or be compromised to an extent whereby they are at risk of increased predation. If you don't look for a problem you will inevitably not find one and this appears to be the policy of regulatory bodies here and abroad, thus protecting the industry from scrutiny.

Other stressors which also affect salmon farms are harmful algal blooms causing anoxic or toxic conditions for the farmed fish while the threat of jellyfish blooms is now ever-present in our increasingly warming environment, thus causing conditions which may impact on animal welfare regulations.

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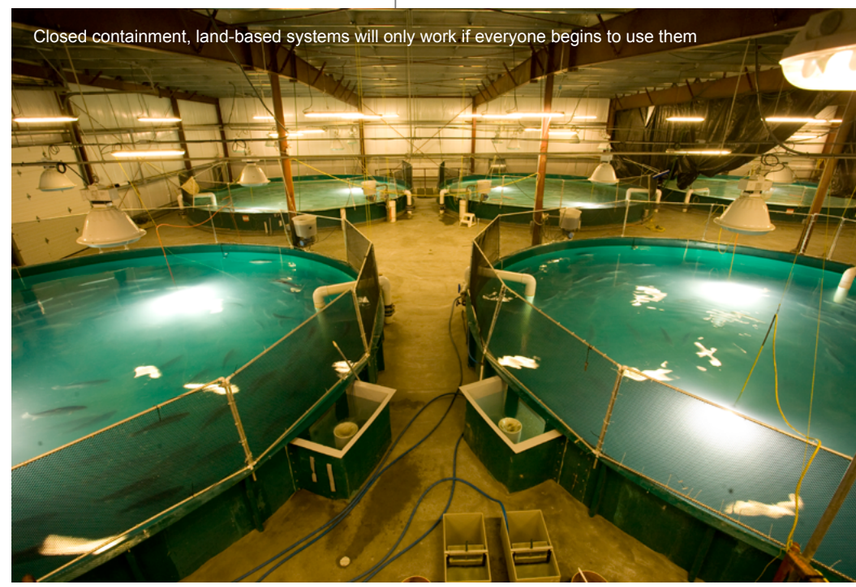
The fish farming industry is operating worldwide and the bottom line really is profit before environmental well-being. This is not unusual in any agricultural activity and all agriculture causes problems to ecosystems at varying degrees. The simple reason why new technologies have not been embraced is that there is a large degree of increased capital outlay involved in closed containment systems which while operating on the world market would not be capable of achieving parity with other countries if this technology was not mandatory in every jurisdiction.

Regarding new technologies, closed containment systems using recirculation systems (RAS) appear to be the great hope but again this technology has proved difficult to scale up to production targets set by open net cages. Many new technologies are being developed to overcome issues with the environment but alas it appears that much of this is to expand the industry rather than replace the open net cages.

Some interesting new technologies include the use of deep ocean technologies including the building of what is essentially


Closed containment, land-based systems will only work if everyone begins to use them

a floating ship which will act as a farm having a capability to keep the salmon at a depth of 10 meters to lessen impact of sea lice. Other technologies include submerged cages at up to 300 meters depth. Indeed Marine Harvest has applied for 14 licenses in Norway towards an egg-shaped, closed farming concept. The use of RAS systems on land to raise salmon smolts to a large size before transfer to open net cages at sea has been proposed which might consist of a regime whereby the smolts could be up to a 1kg in weight before transfer to the sea. This might effectively deal with some of the issues as they would spend a considerably shorter period at sea and could be chemically treated to inhibit lice impact prior to sea introduction and could be stocked so as to avoid the critical period of the wild smolt migration. However, the very important question must also be asked as to the sustainability of an industry which is effectively rearing a salmon; a top, carnivore predator which requires the input of a very substantial amount of protein (fish/shellfish) from a finite marine biomass in order to attain market size. In effect, the input required to rear these fish far outweighs the output and is not in any way sustainable.

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So where do we go from here? Rationally, Ireland has four possible paths to take:

1. **The withdrawal of all licences for open-net pen aquaculture and replacement with green technologies. This may require a transition period but without proper legislation and enforcement damage to wild fish will continue.**
2. **The banning of salmon farming at sea and moving the industry onto land.**
3. **Do nothing and expand the industry at sea.**
4. **Ban salmon farming outright and reclaim our unique coastal ecosystems.**


A wild Atlantic salmon with heavy lice infestation (Credit: EEA)

Unfortunately the third option appears to be the preferred choice of our government and certainly (naturally) the choice of the various companies operating here. With very poor regulatory rules and lack of legally enforceable penalties enshrined in legislation, finfish farming will continue to cause untold damage to Ireland's stocks of wild salmon and sea trout while also contributing to the damage of the wider environment. The fish farming business is also affecting our once considerable but quickly vanishing angling tourism product and if not curtailed and effectively controlled this country will have no economic benefit from salmon and sea trout angling.

Closing or significantly curtailing open-net fish farming at sea will certainly cause hardship to localised economies but there are alternatives through closed containment to protect these jobs and even expand the industry but that decision lies with the large companies which may not feel obliged to invest in new safe technologies due to a lack of Government legislation and enforcement, as well as, always, profitability.

The continued assault on a rapidly dwindling salmon stock and the near extinction of sea trout is immoral in the extreme and is directly as a result of this industry and we need to organise and meet, head-on, the very considerable job

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of changing government policy in regard to this industry. The political and social unrest regarding open-net pen salmon farming on the east and west coast of North America, and indeed Scotland and Norway, must not be ignored by our own politicians. Why would any politician want to continue or for that matter expand an industry which has laid waste to vast areas of oceanic ecosystem and caused the virtual destruction of both wild salmon and sea trout in this jurisdiction and internationally? We must demonstrate that there is another way and show that continuation of farming as it is will not enhance their electoral performance.


Will we ever see an outright ban on salmon farming at sea in Ireland?

We all need to impress upon all our politicians, through direct action if necessary, on the harm these companies are doing to our precious natural ecosystems. We at *Salmon Watch Ireland* can and will help but we need all concerned citizens to organise under one movement and use the very considerable goodwill that exists in our tourism bodies, scientific community and legal sector. I am sure that all anglers, tourism business owners, conservationists, scientists and concerned citizens can be mobilised. To coin a phrase, *Salmon Watch Ireland* needs "eyes and ears" on the ground to monitor and report on the factual situation in aquaculture bays. The spectacle of premature returning sea trout smolts is in all probability happening in many regions and is easily monitored. We would welcome suggestions from the public on how we can highlight what is happening on the ground. We can be contacted by email at:
salmonwatchireland@gmail.com

" The continued assault on a rapidly dwindling salmon stock and the near extinction of sea trout is immoral in the extreme and is directly as a result of this industry "

There are many innovative ways to highlight this manifest immoral industry but we need to work together.

Salmon Watch Ireland, May 2018

Off the Scale

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