Irish Fisheries Bulletin No. 49 2019

National Survey of Sea Lice (*Lepeophtheirus salmonis* Krøyer and *Caligus elongatus* Nordmann) on Fish Farms in Ireland - 2018

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INTRODUCTION

Sea lice are a naturally occurring parasite found on marine fish, including salmonids. They are small ecto-parasitic copepod crustaceans and there are approximately 559 species, made up of 37 genera (Ahyong *et al*., 2011), including 268 *Caligus* species (Boxshall, 2011) and 162 *Lepeophtheirus* species (Chad & Goeff, 2011). The two main species found in Ireland are *Caligus elongatus* (Nordmann, 1832) and *Lepeophtheirus salmonis* (Krøyer, 1837). *C. elongatus* is known to parasitise over 80 different species of marine fish while *L. salmonis* infests only salmonids. *L. salmonis* is the larger of the two species and is regarded as the more damaging parasite. It is endemic at a high prevalence (>90%) within wild populations (Jackson *et al.,* 2013), and occurring frequently on farmed salmonids (Jackson & Minchin, 1992; Jackson *et al.,* 2005). There are two species of salmonids farmed at sea in Ireland on a commercial basis, Atlantic salmon *Salmo salar* (Linnaeus, 1758) and rainbow trout *Oncorhynchus mykiss* (Walbaum, 1792).

L. salmonis is an obligate parasite with a direct lifecycle, with 8 stages, comprising of nauplius 1 and 2, copepodid, chalimus 1 and 2, preadult 1 and 2, and the adult stages. The nauplius 1 stage hatches from paired egg-strings and is dispersed in the plankton. It moults to nauplius 2, also planktonic, which is followed by a copepodid, the infective stage where attachment to the host takes place. The copepodid then moults through the attached chalimus stages before becoming a mobile pre-adult. There are two pre-adult stages before maturing to the adult phase (Figure 1). The adult female can produce batches of paired egg-strings, which in turn hatch into the water column to give rise to the next generation (Hamre *et al.*, 2013; Kabata, 1979; Schram, 1993). The mean length for an adult female is 8mm-11mm and an adult male is 5mm-6mm (Schram, 1993). Under experimental conditions female *L. salmonis* survived up to 210 days, producing as many as 11 pairs of egg strings (Boxaspen, 2006). Jackson and Minchin (1992), in Ireland, found fecundity (mean eggs per pair of egg strings) on wild salmon to be 965 ±30, which was higher than for farmed salmon at 758 ±39. This contrasts to a lower fecundity recorded for wild and farmed salmon in Norway where mean egg numbers have been recorded as 304 ±32 with a range from 246 to 366 at 7.2°C (Heuch *et al*. 2000).

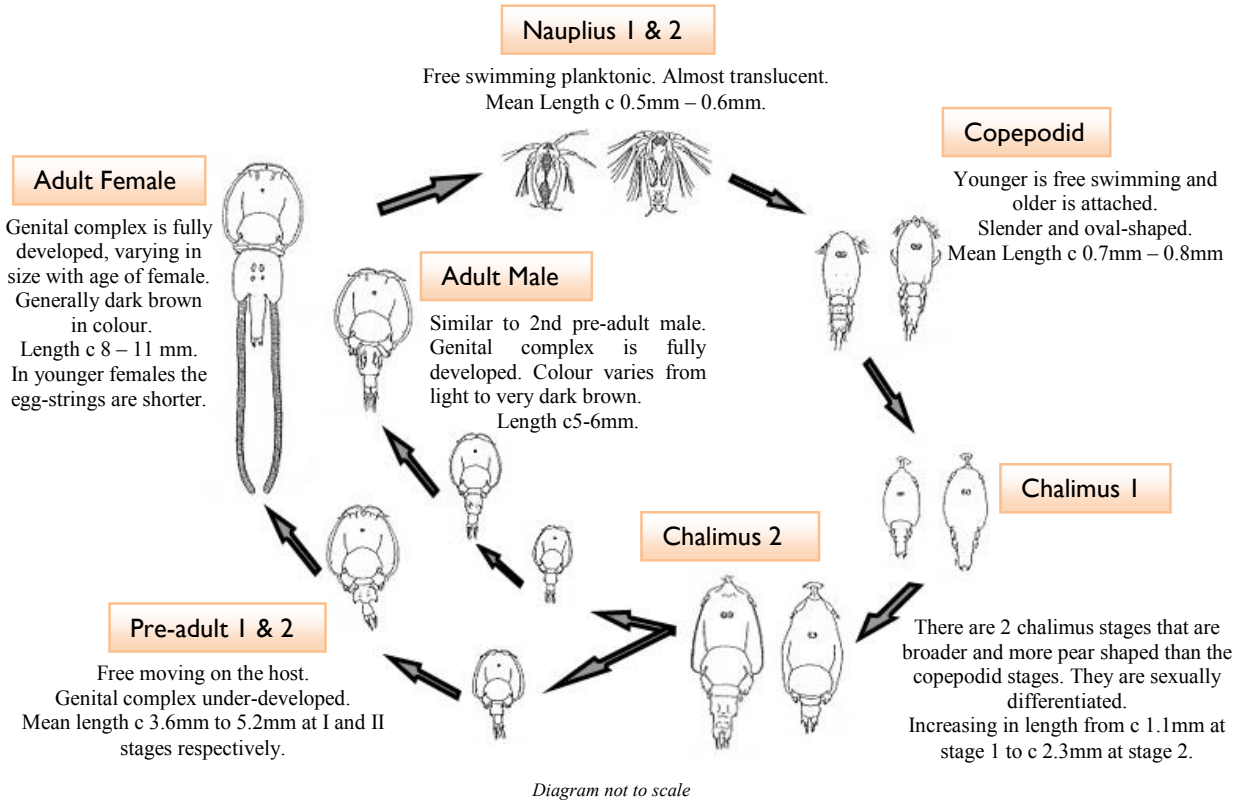

Figure 1 *Life cycle of Lepeophtheirus salmonis (after Schram, 1993 & Hamre et al., 2013).*

C. elongatus is smaller in size than *L. salmonis* averaging approximately 6-8mm in length (Hogans & Trudeau, 1989). The fact that *C. elongatus* is not as host specific as *L. salmonis* (Kabata, 1979) and that the hosts migrate widely is thought to be a factor in the highly variable levels on farmed salmonids at different times of the year.

History of Sea Lice Monitoring in Ireland

In 1991, the Department of the Marine instigated a Sea Lice Monitoring Programme for Finfish Farms in Ireland (Jackson & Minchin, 1993) and in 1993 monitoring was expanded nationwide (Jackson *et al.*, 2002; Jackson *et al.*, 2005). In May 2000, the protocol for sea lice monitoring was formally published (*Monitoring Protocol No.3 for Offshore Finfish Farms – Sea Lice Monitoring and Control*) by the Department of Marine and Natural Resources.

In 2008, the Department of Agriculture, Fisheries and Food (DAFF) published "*A strategy for the improved pest control on Irish salmon farms*". The strategy outlines a comprehensive range of measures to provide for enhanced sea lice control and was developed by a joint DAFF, Marine Institute and Bord Iascaigh Mhara workgroup in response to difficulties experienced by farms in achieving the low levels of infestation required by the national control programme. These measures draw on the on-going Single Bay Management (SBM) process and, through a comprehensive action plan and list of recommendations, seek to advance the suite of tools necessary for improved sea lice control on farms.

The objectives of the National Sea Lice Monitoring Programme are:

- To provide an objective measurement of infestation levels on farms.
- To investigate the nature of infestations.
- To provide management information to drive the implementation of control and management strategies.
- To facilitate further development and refinement of this strategy.

The sea lice control and management strategy has five principal components:

- Separation of generations.
- Annual fallowing of sites.
- Early harvest of two-sea-winter fish.
- Targeted treatment regimes, including synchronous treatments.
- Agreed husbandry practices.

These components combine to reduce the development of sea lice infestations and to ensure the most effective treatment of sea lice. They seek to minimise sea lice levels whilst decreasing reliance on, and reducing the use of, veterinary medicines. Separation of generations and annual fallowing prevent the transmission of infestations from one generation to the next. The early harvest of two-sea-winter fish removes a potential reservoir of sea lice, while the agreed husbandry practises and targeted treatments enhance the efficacy of treatment regimes. One important aspect of targeted treatments is carrying out of synchronised autumn/winter treatments to reduce sea lice burdens to as close to zero as practicable, on all fish which are to be over-wintered. This is fundamental to

achieving near zero egg-bearing sea lice in the spring. The agreed husbandry practises cover a range of related fish health, quality and environmental issues in addition to those specifically related to sea lice control. The Single Bay Management Programme serves to facilitate this and provides a forum for exchange of information between farmers.

In late winter and early spring, seawater temperatures are at a minimum and the development rate of sea lice is slower. Rising water temperatures in spring tend to synchronise the development of sea lice larvae. A strategic treatment at this time can break the cycle of infection. Ovigerous female sea lice are those which produce the infective larvae and treatments are timed to remove adult females before they can release larvae. Setting the treatment trigger at 0.5 ovigerous *L. salmonis* per fish in spring ensures that treatments are carried out when a maximum of half of the fish examined have one ovigerous sea louse. This is a practical time to interrupt sea lice development. Later in the year, the development of new generations is not as synchronised and automatic intervention at a sea lice level of 0.5 ovigerous by way of treatment is not justified. A level of 2.0 ovigerous sea lice per fish has been shown to be a pragmatic level at which intervention by way of treatment is advisable. Levels of mobile and juvenile sea lice are important in advising fish health professionals in developing a sea lice control strategy. However, they are not, of themselves, appropriate measures upon which to trigger mandatory treatments.

Results of the monitoring programme are sent to the relevant farm within 5-10 days of each inspection. A monthly report of results is circulated to relevant parties and the data is published annually (www.marine.ie; Copley *et al.*, 2001; McCarney *et al.*, 2002; O'Donohoe *et al.*, 2003-2018).

Sea Lice Control Methods

The sea lice control and management strategy process includes the use of husbandry, management practises, chemotherapeutants, biological controls and mechanical therapies to control sea lice infestation on farms. Table 1 shows a list of the veterinary medicines authorised to assist in the control of sea lice in Ireland. These are either administered topically or incorporated into the diet. Topical treatments are administered by bathing the fish in specified concentrations of the medicine. Bath treatments can be conducted using well-boats or tarpaulins/skirts to enclose the salmon pens. Medicines incorporated into the diet are a very efficient way to get the required dose to the fish. An over-reliance on any one technique can result in reduced efficacy in the short term and lead to development of resistance over time. A multi-pronged approach to sea lice control is considered more effective in the long-term.

The use of cleaner fish for the control of sea lice is being pursued in Ireland. Various wrasse species were used on salmon farms in the 1990s and their use has grown in recent years with farms typically stocking the five species of wrasse most common in Irish waters, namely, Ballan wrasse *Labrus bergylta* (Ascanius, 1767); Goldsinny wrasse *Ctenolabrus rupestris* (L., 1758); Rock cook wrasse *Centrolabrus exoletus* (L., 1758); Corkwing wrasse *Crenilabrus melops* (L., 1758); Cuckoo wrasse *Labrus mixtus* (L., 1758). Studies in Norway also indicate that lumpfish *Cyclopterus lumpus* (L., 1758) is a suitable cold-water option for biological delousing of Atlantic salmon (Imsland *et al.*, 2014). Lumpfish are currently being used on farms in Ireland as part of a sea lice management plan, with positive results reported.

The use of filtration methods at harvest sites has also proven to be a very successful method for removing all stages of sea lice, including egg-strings; preventing sea lice from re-entering the water column and potentially re-infecting stocks adjacent to the harvest area (O'Donohoe & McDermott, 2014).

Table 1 *Veterinary medicines authorised to assist in the control of sea lice on salmonids in Ireland (www.hpra.ie).*

Compound	*Group*	*Licensing status*	*Delivery Method*	*Mode of action*	*Stages targeted*	*Withdrawal period*
Animal medicines						
Deltamethrin	Pyrethroid	Full MA	Bath	Interferes with nerve transmission by blocking sodium channels in nerve cells	Adults, Preadults. Chalimus unknown	5 degree-days
Emamectin benzoate	Avermectin	Full MA	In-feed	Interferes with neurotranmission disrupting nerve cells causing paralysis and death	All stages	Zero
Hydrogen peroxide	Oxidizer	Full MA	Bath	Gas embolism	Adults, Preadults	Zero

MA - marketing authorisation from the Health Products Regulatory Authority.

METHODOLOGY

Farmed stocks of Atlantic salmon in Ireland are inspected on 14 occasions throughout the year to monitor sea lice levels as part of a national programme. Additional follow-up inspections may be carried out when it is deemed appropriate. Sea lice inspections take place twice per month in March, April and May (the spring period) and then monthly for the remainder of the year. December and January are combined and only one inspection is carried out.

At each inspection two samples are taken for each generation of fish on site, a sample from a standard cage, which is sampled at each subsequent inspection, and a sample from a random cage, which is chosen on the day of the inspection. Thirty fish are examined for each sample after anaesthetising using tricaine methane sulfonate in seawater. The seawater is sieved for any detached lice at the end of each sample. Each fish is examined individually for all mobile sea lice. Sea lice are removed and preserved in 70% ethanol. In the laboratory the species, quantity and life-stage of the sea lice are determined and recorded. The mean number of sea lice per fish is calculated (including the number of detached sea lice from the sieved seawater). Results presented are mean ovigerous sea lice levels and mean total mobile sea lice levels for *L. salmonis* and *C. elongatus* per fish.

Ovigerous sea lice levels are a measure of the breeding female population and total mobile levels measure successful infestation levels. The information gathered aims to evaluate the level of sea lice on the fish and to inform the farmer on a sea lice management strategy. Effective parasite control is characterised by a reduction in sea lice levels on the subsequent inspection.

There are three distinct regions in Ireland where salmonid farming is carried out; the Southwest (Counties Cork and Kerry), the West (Counties Mayo and Galway) and the Northwest (Co. Donegal). These regions are geographically separate from each other with distances between regions of *c.*160 km from Northwest to West and *c.*200 km from West to Southwest (Figure 2).

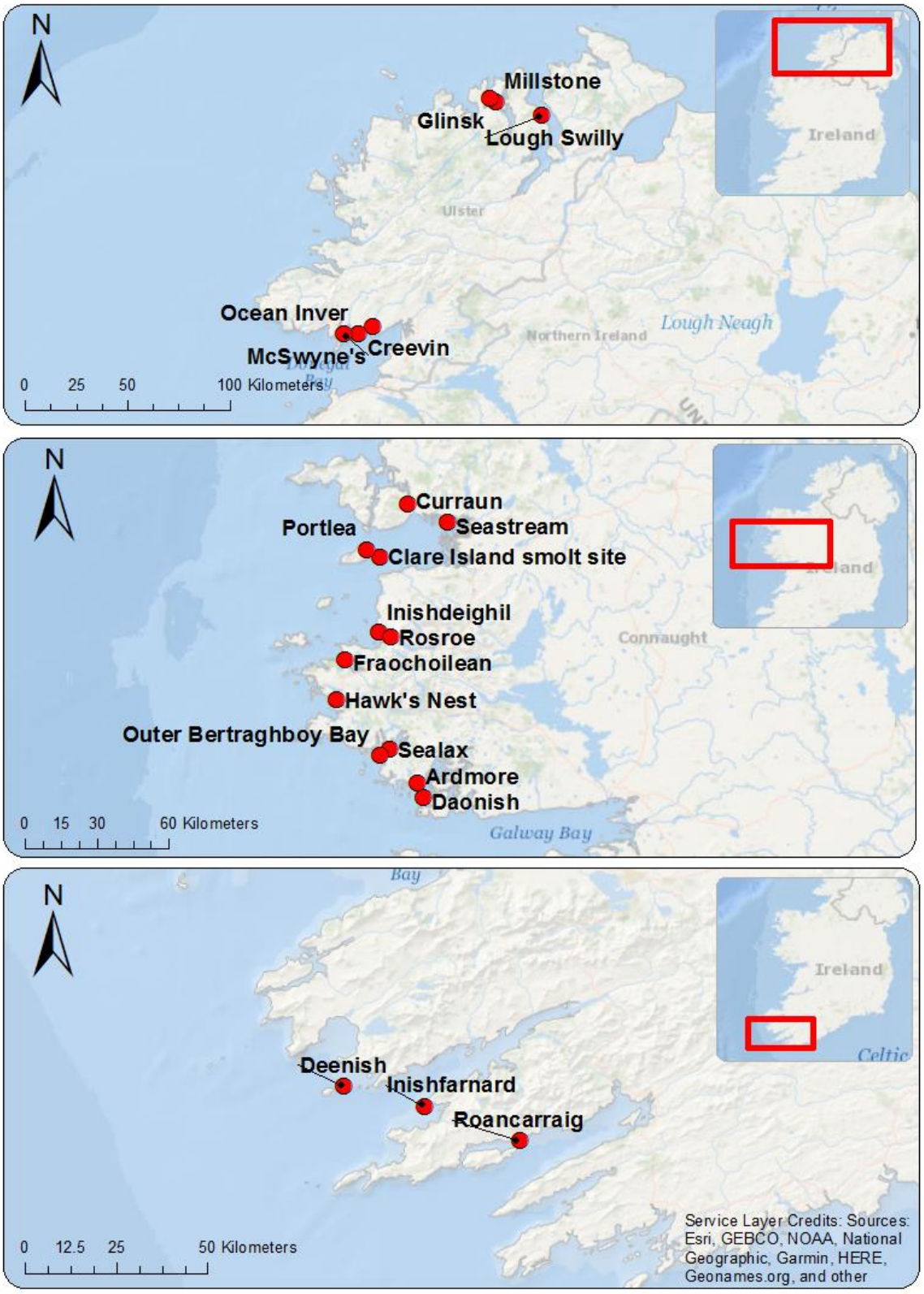

Figure 2 *Locations of fish farm sites*

RESULTS

During 2018 a total of 178 sea lice inspections were carried out on the 21 active farm sites. Over 94% of Atlantic salmon samples were below the Treatment Trigger Levels (TTL) as outlined in the *Monitoring Protocol No.3 for Offshore Finfish Farms – Sea Lice Monitoring and Control,* Department of Marine and Natural Resources (2000). Of the 107 inspections carried out on salmon smolts 100% were below the TTL and 86% of the 71 inspections carried out on one-sea-winter salmon were below the TTL.

Results of monthly sea lice inspections of all active salmonid sites for 2018 are presented in Appendix 1.

Atlantic salmon 2017 (one-sea-winter salmon)

One-sea-winter salmon were stocked in a total of 12 sites in 11 bays in 2018. Seventy-one inspections were undertaken with this generation of fish.

Ovigerous *L. salmonis* levels greater than the TTL were recorded for a total of 10 inspections (14%) on one-sea-winter fish (Table 2). Within the critical spring period sea lice levels were in excess of 0.5 ovigerous females per fish on six inspections (15%) and outside of the spring period four inspections (13%) were in excess of 2.0 ovigerous female *L. salmonis* per fish.

Table 2 *Summary of inspection results on one-sea-winter salmon nationally in 2018.*

	Samples in Spring	Ovigerous > TTL in Spring	Samples outside Spring	Ovigerous > TTL outside Spring	Total Samples	Total Ovigerous > TTL	% over in Spring	% over outside Spring	% over total
National Totals	39	6	32	4	71	10	15%	13%	14%

C. elongatus levels greater than 10 individuals per fish were recorded on one occasion during the year.

Southwest Region

In the Southwest there were no recorded instances of *L. salmonis* levels greater than the TTL (Table 3).

Table 3 *Summary of inspection results on one-sea-winter salmon in the Southwest in 2018*

Company	Site	Samples in Spring	Ovigerous > TTL in Spring	Samples outside Spring	Ovigerous > TTL outside Spring	Total Samples	Total Ovigerous > TTL	% over in Spring	% over outside Spring	% over total
Marine Harvest Ireland	**Roancarraig-Ahabeg**	1	0	2	0	3	0	0%	0%	0%
	Deenish	6	0	4	0	10	0	0%	0%	0%
Southwest	**Totals**	7	0	6	0	13	0	0%	0%	0%

West Region

In the West, *L. salmonis* infestation levels greater than the TTL were recorded on six out of 20 inspections (30%) in the spring period and on three out of 19 inspections (16%) outside the spring period (Table 4).

Table 4 *Summary of inspection results on one-sea-winter salmon in the West in 2018.*

Company	Site	Samples in Spring	Ovigerous > TTL in Spring	Samples outside Spring	Ovigerous > TTL outside Spring	Total Samples	Total Ovigerous > TTL	% over in Spring	% over outside Spring	% over total
Bradan Beo Teo.	**Daonish**	6	0	3	0	9	0	0%	0%	0%
Bifand Ltd./Marine Harvest Ireland	**Sealax**	0	0	1	0	1	0	N/A	0%	0%
	Fraochoileain	6	0	4	1	10	1	0%	25%	10%
Mannin Bay Salmon Company Ltd.	**Hawk's Nest**	1	1	2	0	3	1	100%	0%	33%
Clare Island Seafarms Ltd.	**Smolt site**	2	1	5	0	7	1	50%	0%	14%
	Seastream	4	3	2	1	6	4	75%	50%	67%
Curraun Blue Ltd.	**Curruan**	1	1	2	1	3	2	100%	50%	67%
West	**Totals**	20	6	19	3	39	9	30%	16%	23%

Northwest Region

The TTL were not exceeded for any of the 12 inspections (0%) in the spring period. The TTL were exceeded for one of the seven inspections (14%) outside the spring period in the Northwest (Table 5).

Table 5 *Summary of inspection results on one-sea-winter salmon in the Northwest in 2018.*

Company	Site	Samples in Spring	Ovigerous > TTL in Spring	Samples outside Spring	Ovigerous > TTL outside Spring	Total Samples	Total Ovigerous > TTL	% over in Spring	% over outside Spring	% over total
Ocean Farm Ltd.	**Mc Swynes**	6	0	2	1	8	1	0%	50%	13%
Marine Harvest Ireland	**Glinsk**	0	0	1	0	1	0	N/A	0%	0%
	Lough Swilly	6	0	4	0	10	0	0%	0%	0%
Northwest	**Totals**	12	0	7	1	19	1	0%	14%	5%

Atlantic salmon 2018 (smolts)

A total of 107 inspections were made to 11 sites stocking Atlantic salmon 2018 S1 and S½ smolts during the year 2018. *L. salmonis* levels were below the TTL of ovigerous female lice per fish for all the inspections (100%) carried out in 2018 (Table 6). There was one occasion where the mean total mobile *L. salmonis* were greater than ten. This occurred outside the spring period in the West region.

Table 6 *Summary of inspection results on salmon smolts nationally in 2018*

Company	Site	Samples in Spring	Ovigerous > TTL in Spring	Samples outside Spring	Ovigerous > TTL outside Spring	Total Samples	Total Ovigerous > TTL	% over in Spring	% over outside Spring	% over total
Marine Harvest Ireland	**Inishfarnard**	5	0	6	0	11	0	0%	0%	0%
Southwest	**Totals**	5	0	6	0	11	0	0%	0%	0%
Bradan Beo Teo.	**Ardmore**	6	0	8	0	14	0	0%	0%	0%
Bifand Ltd./Marine Harvest Ireland	**Outer Bertraghboy Bay**	2	0	4	0	6	0	0%	0%	0%
	Sealax	0	0	2	0	2	0	N/A	0%	0%
Rosroe Salmon Ltd.	**Inishdeighil**	0	0	3	0	3	0	N/A	0%	0%
	Rosroe	6	0	5	0	11	0	0%	0%	0%
Clare Island Seafarms Ltd.	**Clare Island Portlea**	3	0	6	0	9	0	0%	0%	0%
West	**Totals**	17	0	28	0	45	0	0%	0%	0%
Ocean Farm Ltd.	**Ocean Inver**	6	0	7	0	13	0	0%	0%	0%
Marine Harvest Ireland	**Creevin**	6	0	7	0	13	0	0%	0%	0%
	Glinsk	6	0	6	0	12	0	0%	0%	0%
	Millstone	6	0	7	0	13	0	0%	0%	0%
Northwest	**Totals**	24	0	27	0	51	0	0%	0%	0%
National Totals		46	0	61	0	107	0	0%	0%	0%

One-sea-winter salmon monthly trend by bay

Bay mean ovigerous and mean mobile *L. salmonis* and *C. elongatus* levels for each bay are shown in Table 7 for one-sea-winter salmon throughout the year. Monthly ovigerous *L. salmonis* levels greater than the spring TTL of 0.5 ovigerous sea lice per fish were recorded on four of the 21 occasions. Of these, two were in Clew Bay, one in Clifden Bay and one in Bealacragher Bay.

Bay mean ovigerous levels of 2.0 ovigerous females per fish or greater were recorded on four out of 32 occasions, outside of the spring period. These occurred on one occasion each at Clew Bay, Bealacragher Bay, Ballinakill Harbour and Donegal Bay.

Mean levels per bay in excess of ten mobile *L. salmonis* per fish were recorded on five occasions, one of these instances had a mean of greater than 20 mobile lice per fish. The maximum bay mean level recorded was 31.90 mobile sea lice per fish, in Ballinakill Harbour in August.

The maximum *C. elongatus* level recorded was 12.3 in the West in October in 2018.

Table 7 *Mean ovigerous and mean mobile Lepeophtheirus salmonis and Caligus elongatus levels per month, for one-sea-winter salmon, for each bay inspected in the year 2018.*

Mean ovigerous *L. salmonis*

	Dec/ Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Bantry Bay	0.17	0.35	0.14	HO							
Kenmare Bay	0.00	0.04	0.05	0.03	0.06	0.13	0.21	HO			
Kilkieran Bay	0.07	0.41	0.36	0.09	0.11	0.00	HO				
Bertraghboy Bay	0.08	TO									
Clifden Bay	0.33	1.78	1.60	HO							
Ballinakill Harbour		0.00	0.04	0.11	0.14	0.51	0.70	4.63	HO		
Clew Bay	0.90	2.01	1.39	0.52	0.32	0.46	0.14	0.07	0.04	0.02	HO
Bealacragher Bay	3.76	0.61	0.57	HO							
Donegal Bay	4.00	0.21	0.25	0.07	0.18	HO					
Mulroy Bay	0.00/TO										
Lough Swilly	0.00	0.00	0.02	0.02	0.08	0.53	0.39	HO			

Mean mobile *L. salmonis*

	Dec/ Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Bantry Bay	0.37	1.52	0.84	HO							
Kenmare Bay	0.04	0.39	0.32	0.12	0.26	0.33	0.43	HO			
Kilkieran Bay	0.72	2.35	1.82	1.39	1.27	0.64	HO				
Bertraghboy Bay	0.25	TO									
Clifden Bay	1.17	3.84	3.77	HO							
Ballinakill Harbour		0.02	0.25	0.39	0.48	3.07	2.45	31.90	HO		
Clew Bay	6.32	15.63	6.94	2.13	2.36	0.81	0.30	0.84	0.21	2.15	HO
Bealacragher Bay	16.09	4.21	2.87	HO							
Donegal Bay	19.64	2.52	3.76	2.74	19.92	HO					
Mulroy Bay	0.00/TO										
Lough Swilly	0.04	0.00	0.08	0.08	0.19	1.56	6.69	HO			

Mean ovigerous *C. elongatus*

	Dec/ Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Bantry Bay	0.04	0.40	0.25	HO							
Kenmare Bay	0.18	2.02	0.35	0.03	0.03	0.05	0.67	HO			
Kilkieran Bay	0.39	0.71	0.01	0.01	0.11	0.13	HO				
Bertraghboy Bay	2.55	TO									
Clifden Bay	0.00	0.00	0.00	HO							
Ballinakill Harbour		0.00	0.03	0.00	0.00	0.02	0.00	1.90	HO		
Clew Bay	2.54	0.05	0.00	0.00	0.01	0.22	0.10	1.55	0.58	6.77	HO
Bealacragher Bay	0.00	0.00	0.00	HO							
Donegal Bay	0.00	0.00	0.00	0.00	0.02	HO					
Mulroy Bay	0.03/TO										
Lough Swilly	0.77	1.16	0.02	0.01	0.07	0.22	1.71	HO			

Mean mobile *C. elongatus*

	Dec/ Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Bantry Bay	0.14	1.23	0.60	HO							
Kenmare Bay	0.57	2.90	0.73	0.08	0.09	0.13	1.44	HO			
Kilkieran Bay	0.52	1.36	0.07	0.05	0.23	0.29	HO				
Bertraghboy Bay	3.59	TO									
Clifden Bay	0.00	0.00	0.07	HO							
Ballinakill Harbour		0.00	0.25	0.02	0.00	0.04	0.02	5.23	HO		
Clew Bay	5.65	0.17	0.00	0.00	0.05	0.31	0.15	3.22	2.18	12.30	HO
Bealacragher Bay	0.03	0.00	0.00	HO							
Donegal Bay	0.10	0.00	0.01	0.05	0.06	HO					
Mulroy Bay	0.03/TO										
Lough Swilly	5.06	2.91	0.02	0.03	0.18	0.60	4.85	HO			

HO = Harvested Out

TO = Transferred Out

Regional monthly means for one-sea-winter salmon

L. salmonis ovigerous and monthly mean mobiles levels per fish for one-sea-winter salmon regionally are shown in Figure 3 and 4. In the spring period of 2018 the ovigerous mean sea lice levels per fish exceeded TTL for March, in the West.

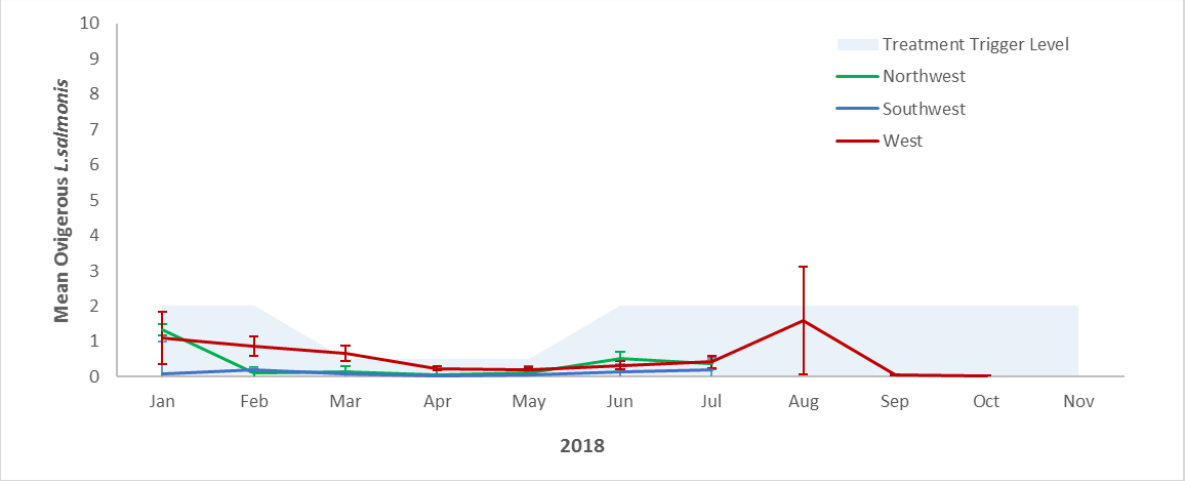

Figure 3 *Mean (±SE) ovigerous L. salmonis per fish per month per region in 2018 on one-sea-winter salmon.*

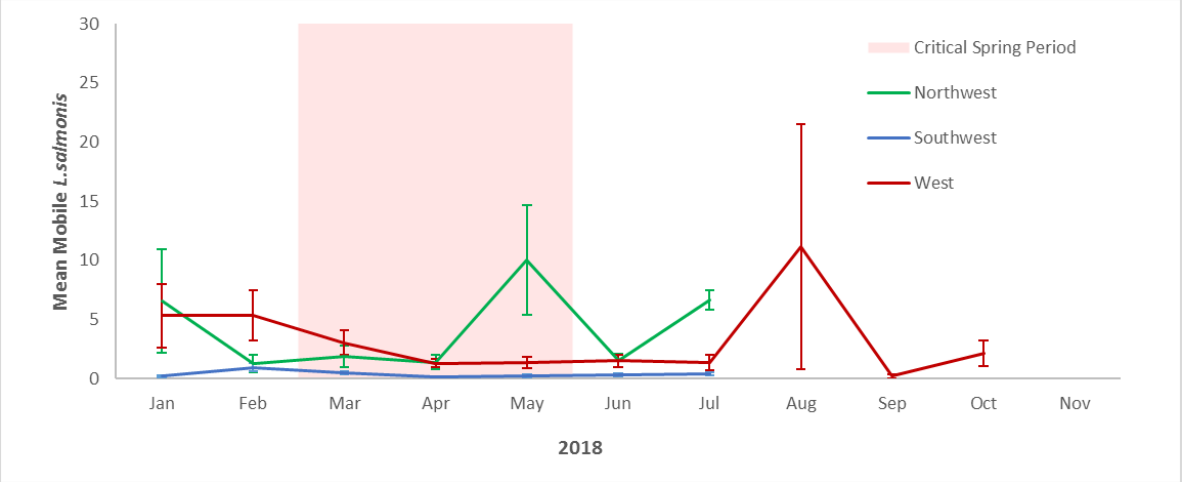

Figure 4 *Mean (±SE) mobile L. salmonis per fish per month per region in 2018 on one-sea-winter salmon.*

Total mobile *L. salmonis* levels exceeded ten sea lice per fish in May in the West, and once in the Northwest region. Total regional mean mobile *L. salmonis* levels peaked at 0.96 mobile sea lice per fish in the Southwest, 11.12 mobile sea lice per fish in the West and at 10.05 mobile sea lice per fish in the Northwest.

Annual trends

The annual trends of *L. salmonis* ovigerous and mobile sea lice levels are compared in Figure 5 and 6 for one-sea-winter salmon for the month of May from 1991 to 2018.

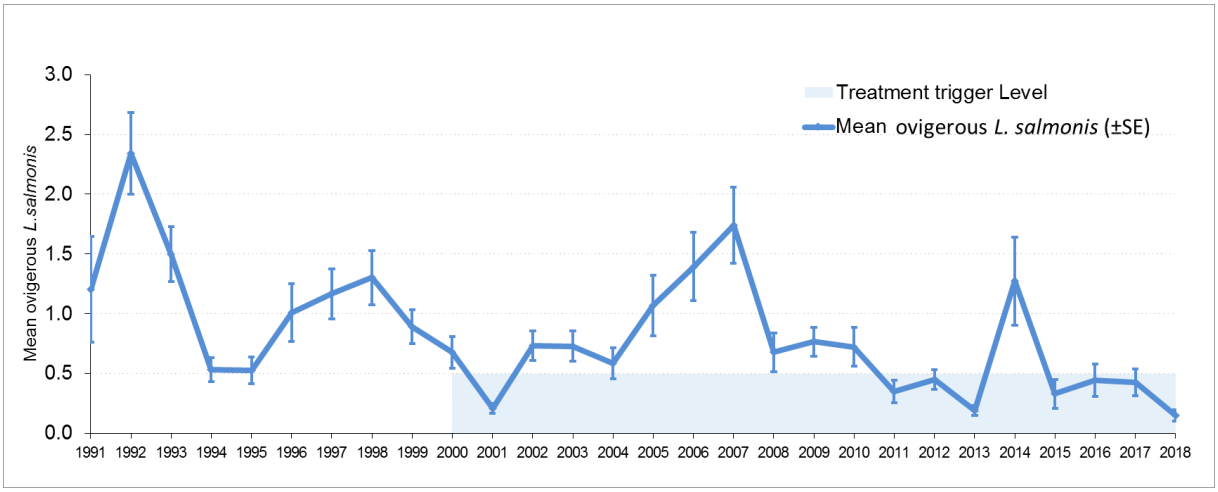

Figure 5 *Annual trend (May mean ±SE) ovigerous L. salmonis on one-sea-winter salmon.*

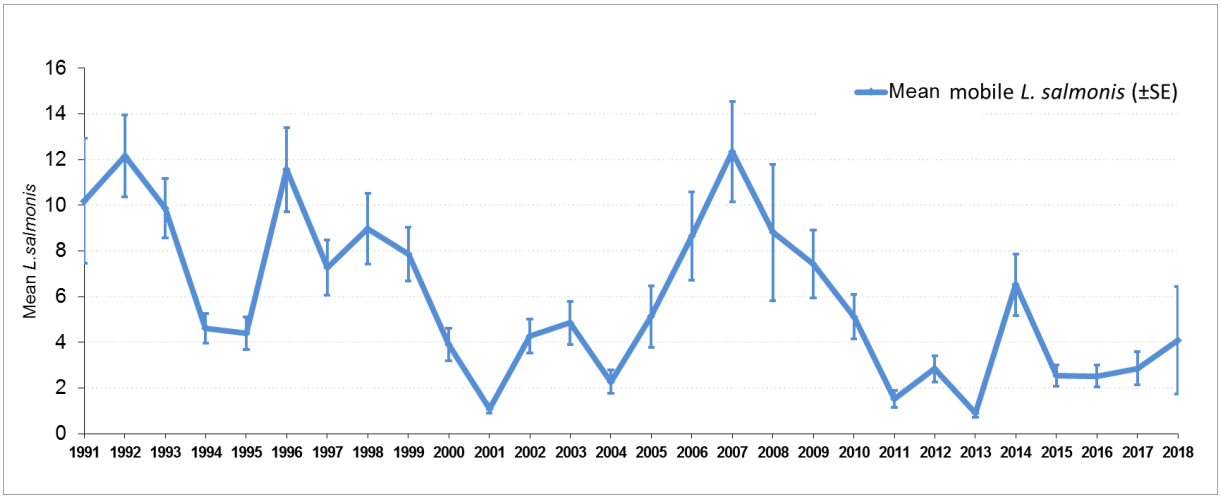

Figure 6 *Annual trend (May mean ±SE) mobile L. salmonis on one-sea-winter salmon.*

Mean ovigerous *L. salmonis* levels in May decreased to 0.15 sea lice per fish in 2018, compared to 0.42 in 2017. Total mobile *L. salmonis* levels increased to 4.08 compared to 2.86 sea lice per fish in May 2017.

DISCUSSION

Sea lice levels on smolts in 2018 were low. All of the sea lice inspections carried out on smolts were below the Treatment Trigger Levels (TTL), these results are similar to the results from 2017.

Nationally, in 2018, 86% of all sea lice inspections on one-sea-winter salmon were below the TTL. The national mean ovigerous *L. salmonis* levels for one-sea-winter salmon in May decreased to 0.15 in 2018 which is the lowest levels on record since 1991. Conversely, the national total mobile *L. salmonis* levels for May have increased marginally for two consecutive years.

During the spring period, 100% of inspections on one-sea-winter-salmon were below the TTL in the Northwest compared to 94% in 2017. In the West, for the same period, 70% were below TTL which is similar to 71% in 2017. All but one sea lice inspections of one-sea-winter salmon undertaken outside of the spring period were below TTL in the Northwest (86%). Similarly, in the West, 84% of inspections on one-sea-winter-salmon were below the TTL outside the spring period. The Southwest continued to have no breaches of protocol levels in 2018.

Sea lice levels in excess of 10 mobile *L. salmonis* per fish on one-sea-winter salmon were recorded on seven occasions, nationally, three of which had means greater than 20 mobile *L. salmonis* per fish. Five of these occasions coincided with ovigerous *L. salmonis* levels in excess of the TTL. This number has fluctuated over the past few years, specifically, there were thirteen occasions in 2017, eight occasions in 2016 and seventeen in 2015. The highest mean mobile sea lice level recorded for one-sea-winter salmon was 31.9 mobile *L. salmonis* per fish, this compares to 53.28 in 2017, 37.6 in 2016 and 71.5 in 2015. There were no high numbers of *Caligus elongatus* recorded in 2018.

The regional data for mean ovigerous *L. salmonis* demonstrates the continued efforts to maintain levels below the TTL for the spring period. Sea lice levels across the country remained similar to previous years. Infestation on smolts was low as is the common annual trend. Sea lice levels on grower fish continued to show a level of control in line with annual trends over the last number of years. Higher sea lice levels were observed in the run up to harvest on larger grower fish which is in keeping with recorded data from sea lice inspections of harvest fish. Control methods including sea lice chemotherapeutants, mechanical and biological delousing methods and Single Bay Management practices continue to have a positive impact on the control of sea lice in Irish salmon farming.

GLOSSARY

Grower:	A fish which has been at sea for one complete year or longer.
Mobile lice:	All sea lice that are mobile – male and female (pre-adult and adult stages) sea lice that have developed beyond the attached larval stages.
n ≤10	Ten fish or fewer were inspected in one or both pens sampled.
Ovigerous lice:	An egg bearing adult female sea lice.
Random (Ran.) Pen:	A pen which is selected by the Inspector on the day of inspection.
Salmonids:	A fish of the family Salmonidae. It includes salmon, trout and charr.
Standard (Std.) Pen:	The selected pen which is sampled at each inspection.
S1 Smolt:	This pertains to a stage in the life cycle of the salmon when it changes from being a freshwater fish to a seawater fish, a process known as smoltification. These fish are transported to the saltwater environment in the spring, which is approximately 15 months after they were hatched.
S½ Smolt (also known as S0):	These fish are put under lights to hasten the onset of smoltification. An S½ smolt is ready to go to sea during the autumn/winter, approximately 11 months after hatching. They are sometimes referred to as S0 (S zero) smolts.
SE:	Standard error (error bars in the graphs) is the standard error of the mean of a sample from a population with a normal distribution, which is equal to the standard deviation of the normal distribution divided by the square root of the sample size.
TTL:	Treatment Trigger Levels

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APPENDIX 1.

Mean sea lice levels on salmonid farms in 2018.

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
BANTRY BAY					
MARINE HARVEST IRL.					
Roancarraig-Ahabeg					
Atlantic Salmon, 2017 S1/2	30/01/2018	0.17	0.37	0.04	0.14
	13/02/2018	0.35	1.52	0.40	1.23
	08/03/2018	0.14	0.84	0.25	0.60
			Harvested Out		
KENMARE BAY					
MARINE HARVEST IRL.					
Deenish					
Atlantic Salmon, 2017	29/01/2018	0.00	0.04	0.18	0.57
	13/02/2018	0.04	0.39	2.02	2.90
	09/03/2018	0.04	0.42	0.44	0.96
	26/03/2018	0.05	0.22	0.27	0.50
	04/04/2018	0.03	0.14	0.02	0.02
	27/04/2018	0.04	0.09	0.04	0.15
	09/05/2018	0.07	0.40	0.07	0.17
	23/05/2018	0.05	0.12	0.00	0.02
	21/06/2018	0.13	0.33	0.05	0.13
	25/07/2018	0.21	0.43	0.67	1.44
			Harvested Out		
Inishfarnard					
Atlantic Salmon, 2018	26/03/2018	0.00	0.00	0.01	0.14
	04/04/2018	0.00	0.00	0.03	0.36
	26/04/2018	0.00	0.04	0.12	0.19
	09/05/2018	0.00	0.04	0.06	0.20
	23/05/2018	0.00	0.03	0.23	0.84
	21/06/2018	0.00	0.05	0.58	0.66
	25/07/2018	0.00	0.03	0.00	0.03
	21/08/2018	0.00	0.02	0.03	0.08
	07/09/2018	0.00	0.00	0.10	0.37
	05/10/2018	0.00	0.02	1.74	3.69
	06/11/2018	0.00	0.04	2.34	3.99

		Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
			F + eggs	**Total**	**F + eggs**	**Total**
KILKIERAN BAY						
BRADAN BEO TEO.						
Ardmore						
	Atlantic Salmon, 2018 S1/2	26/01/2018	0.00	0.00	0.00	0.00
		08/02/2018	0.02	0.18	0.02	0.03
		06/03/2018	0.02	0.25	0.00	0.00
		20/03/2018	0.00	0.87	0.00	0.00
		04/04/2018	0.02	0.47	0.00	0.02
		19/04/2018	0.02	0.31	0.00	0.00
		03/05/2018	0.02	0.34	0.00	0.07
		21/05/2018	0.02	0.46	0.07	0.11
		22/06/2018	0.28	1.33	0.03	0.06
		17/07/2018	1.07	2.10	0.00	0.00
		23/08/2018	0.19	1.75	0.15	0.40
		14/09/2018	0.70	3.47	0.08	0.16
		18/10/2018	0.09	8.07	0.89	1.48
		21/11/2018	1.62	23.52	2.89	7.38
Daonish						
	Atlantic Salmon, 2017 S1/2	23/01/2018	0.07	0.72	0.39	0.52
		12/02/2018	0.41	2.35	0.71	1.36
		06/03/2018	0.45	2.52	0.02	0.05
		21/03/2018	0.28	1.13	0.00	0.09
		03/04/2018	0.05	0.77	0.02	0.04
		18/04/2018	0.13	2.02	0.00	0.07
		02/05/2018	0.20	2.39	0.15	0.32
		16/05/2018	0.02	0.15	0.07	0.15
		22/06/2018	0.00	0.64	0.13	0.29
				Harvested out		

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	**Total**	**F + eggs**	**Total**
BERTRAGHBOY BAY					
BIFAND LTD. / MARINE HARVEST IRL.					
Outer Bertraghboy Bay					
Atlantic Salmon, 2017		Transferred to Sealax			
Atlantic Salmon, 2018	14/05/2018	0.00	0.01	0.00	0.05
	25/05/2018	0.00	0.00	0.02	0.03
	20/06/2018	0.00	0.05	0.30	0.57
	11/07/2018	0.02	0.09	0.50	0.80
	30/08/2018	0.02	0.04	0.08	0.13
	05/09/2018	0.03	0.19	0.02	0.11
		Transferred to Sealax			
Sealax					
Atlantic Salmon, 2017	25/01/2018	0.08	0.25	2.55	3.59
		Transferred to Fraochoilean			
Atlantic Salmon, 2018	17/10/2018	0.00	0.09	0.00	0.43
	20/11/2018	0.00	0.46	3.20	6.90
CLIFDEN BAY					
MANNIN BAY SALMON COMPANY LTD.					
Hawk's Nest					
Atlantic Salmon, 2017 S1/2	05/12/2017	0.33	1.17	0.00	0.00
	22/02/2018	1.78	3.84	0.00	0.00
	08/03/2018	1.60	3.77	0.00	0.07
		Harvested Out			

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	**Total**	**F + eggs**	**Total**
BALLINAKILL HARBOUR					
BIFAND LTD. / MARINE HARVEST IRL.					
Fraochoilean					
Atlantic Salmon, 2017	19/02/2018	0.00	0.02	0.00	0.00
	05/03/2018	0.07	0.26	0.03	0.12
	26/03/2018	0.02	0.25	0.03	0.38
	10/04/2018	0.11	0.44	0.00	0.04
	20/04/2018	0.10	0.34	0.00	0.00
	11/05/2018	0.24	0.87	0.00	0.00
	17/05/2018	0.04	0.10	0.00	0.00
	07/06/2018	0.51	3.07	0.02	0.04
	12/07/2018	0.70	2.45	0.00	0.02
	28/08/2018	4.63	31.90	1.90	5.23
		Harvested Out			
KILLARY HARBOUR					
ROSROE SALMON LTD.					
Inishdeighil					
Atlantic Salmon, 2018 S1/2	13/07/2018	0.11	0.61	0.00	0.02
	29/08/2018	0.19	0.80	0.02	0.09
	06/09/2018	0.32	1.14	0.04	0.04
		Transferred to Rosroe			
Rosroe					
Atlantic Salmon, 2018 S1/2	10/01/2018	0.00	0.00	0.04	0.07
	09/02/2018	0.00	0.07	0.00	0.10
	08/03/2018	0.02	0.08	0.05	0.22
	21/03/2018	0.00	0.05	0.04	0.17
	13/04/2018	0.00	0.08	0.00	0.00
	27/04/2018	0.00	0.09	0.00	0.00
	04/05/2018	0.00	0.05	0.00	0.00
	24/05/2018	0.00	0.10	0.00	0.02
	19/06/2018	0.04	0.17	0.04	0.09
		Transferred to Inishdeighil			
Atlantic Salmon, 2018 S1/2	24/10/2018	0.10	1.20	0.02	0.17
	16/11/2018	1.27	9.39	0.30	0.66

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
CLEW BAY					
CLARE ISLAND SEAFARMS LTD.					
Clare Island Smolt Site					
Atlantic Salmon, 2017	08/05/2018	0.62	4.42	0.00	0.07
	28/05/2018	0.03	0.30	0.02	0.04
	26/06/2018	0.46	0.81	0.22	0.31
	18/07/2018	0.14	0.30	0.10	0.15
	29/08/2018	0.07	0.84	1.55	3.22
	12/09/2018	0.04	0.21	0.58	2.18
	15/10/2018	0.02	2.15	6.77	12.30
		On Starve for Harvest			
Portlea					
Atlantic Salmon, 2018	23/04/2018	0.00	0.00	0.00	0.00
	08/05/2018	0.00	0.07	0.00	0.00
	28/05/2018	0.00	0.02	0.08	0.19
	26/06/2018	0.00	0.02	0.05	0.11
	18/07/2018	0.02	0.14	0.04	0.13
	21/08/2018	0.00	0.00	0.00	0.03
	12/09/2018	0.00	0.01	0.05	0.21
	15/10/2018	0.00	0.14	0.82	1.88
	23/11/2018	0.00	0.00	0.02	0.06
Seastream					
Atlantic Salmon, 2017	30/01/2018	0.90	6.32	2.54	5.65
	21/02/2018	2.01	15.63	0.05	0.17
	13/03/2018	2.13	11.55	0.00	0.00
	29/03/2018	0.65	2.34	0.00	0.00
	11/04/2018	0.41	1.00	0.00	0.00
	23/04/2018	0.63	3.27	0.00	0.00
		Transferred to Clare Island Smolt Site			
BEALACRAGHER BAY					
CURRAUN BLUE LTD.					
Curraun					
Atlantic Salmon, 2017 S1/2	30/01/2018	3.76	16.09	0.00	0.03
	27/02/2018	0.61	4.21	0.00	0.00
	13/03/2018	0.57	2.87	0.00	0.00
		Harvested Out			

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	**Total**	**F + eggs**	**Total**
DONEGAL BAY					
MARINE HARVEST IRL.					
Creevin					
Atlantic Salmon, 2018 S1/2	13/02/2018	0.02	0.60	0.29	0.97
	15/03/2018	0.13	1.77	0.00	0.00
	29/03/2018	0.11	1.36	0.00	0.00
	12/04/2018	0.36	1.36	0.00	0.00
	24/04/2018	0.15	0.89	0.12	0.44
	01/05/2018	0.09	0.78	0.02	0.20
	18/05/2018	0.18	3.02	0.09	0.29
	21/06/2018	0.04	1.40	0.25	0.40
	20/07/2018	0.33	2.75	1.05	2.46
	14/08/2018	0.00	0.10	0.00	0.00
	25/09/2018	0.08	2.66	0.36	0.58
	24/10/2018	1.03	2.45	0.20	0.27
	07/11/2018	1.48	6.15	0.53	0.88
OCEAN FARM LTD.					
McSwyne's					
Atlantic Salmon, 2017 S1/2	05/12/2017	4.00	19.64	0.00	0.10
	22/02/2018	0.21	2.52	0.00	0.00
	15/03/2018	0.06	1.62	0.00	0.00
	29/03/2018	0.45	5.90	0.00	0.02
	12/04/2018	0.07	1.66	0.00	0.00
	24/04/2018	0.07	3.82	0.00	0.10
	02/05/2018	0.14	12.45	0.02	0.02
	17/05/2018	0.22	27.39	0.02	0.10
			Harvested Out		
Ocean Inver					
Atlantic Salmon, 2018 S1/2	13/02/2018	0.02	1.37	0.19	0.48
	15/03/2018	0.06	0.52	0.41	0.66
	29/03/2018	0.02	0.90	0.49	0.73
	12/04/2018	0.10	1.05	0.02	0.09
	24/04/2018	0.00	0.52	0.00	0.12
	02/05/2018	0.04	0.58	0.21	0.94
	18/05/2018	0.03	2.25	0.03	0.19
	21/06/2018	0.47	1.98	0.31	0.53
	20/07/2018	0.06	0.32	0.05	0.18
	14/08/2018	0.20	0.52	0.00	0.00
	25/09/2018	0.21	1.30	0.00	0.00
	24/10/2018	0.68	1.24	0.14	0.17
	07/11/2018	1.03	3.40	0.47	0.63

		Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
			F + eggs	Total	F + eggs	Total
MULROY BAY						
MARINE HARVEST IRL.						
Glinsk						
	Atlantic Salmon, 2017	05/12/2017	0.00	0.00	0.03	0.03
			Transferred to Lough Swilly			
	Atlantic Salmon, 2018	14/03/2018	0.00	0.00	0.00	0.00
		28/03/2018	0.00	0.03	0.02	0.04
		11/04/2018	0.00	0.00	0.00	0.06
		25/04/2018	0.00	0.00	0.00	0.03
		01/05/2018	0.00	0.05	0.03	0.17
		16/05/2018	0.00	0.07	0.03	0.10
		19/06/2018	0.00	0.07	0.04	0.06
		18/07/2018	0.08	0.52	0.05	0.09
		30/08/2018	0.00	0.05	0.00	0.00
		26/09/2018	0.00	0.05	0.02	0.05
		23/10/2018	0.00	0.00	0.00	0.04
		08/11/2018	0.00	0.12	0.03	0.05
			Transferred to Lough Swilly			
Millstone						
	Atlantic Salmon, 2018 S1/2	12/02/2018	0.00	0.00	0.22	0.30
		14/03/2018	0.00	0.08	0.22	0.27
		28/03/2018	0.00	0.02	0.20	0.24
		11/04/2018	0.00	0.00	0.06	0.07
		25/04/2018	0.00	0.06	0.11	0.23
		01/05/2018	0.00	0.07	0.26	0.32
		16/05/2018	0.02	0.06	0.05	0.10
		19/06/2018	0.02	0.14	0.02	0.03
		18/07/2018	0.11	2.76	0.34	0.62
		30/08/2018	0.03	0.99	0.09	0.37
		26/09/2018	0.00	1.16	0.14	0.33
		23/10/2018	0.00	0.22	0.05	0.09
		08/11/2018	0.00	1.44	0.21	0.47

		Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
			F + eggs	**Total**	**F + eggs**	**Total**
	LOUGH SWILLY					
Lough Swilly						
	Atlantic Salmon, 2017	22/01/2018	0.00	0.04	0.77	5.06
		21/02/2018	0.00	0.00	1.16	2.91
		14/03/2018	0.02	0.07	0.00	0.00
		28/03/2018	0.02	0.09	0.04	0.04
		11/04/2018	0.00	0.05	0.00	0.00
		25/04/2018	0.04	0.12	0.02	0.07
		02/05/2018	0.07	0.18	0.00	0.05
		17/05/2018	0.09	0.20	0.14	0.32
		20/06/2018	0.53	1.56	0.22	0.60
		19/07/2018	0.39	6.69	1.71	4.85
				Harvested Out		

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ISSN 1649-5055

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