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National Survey Of Sea Lice (*Lepeophtheirus salmonis* Krøyer and *Caligus elongatus* Nordmann) on Fish Farms in Ireland – 2023

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Contents

INTRODUCTION

Sea lice are a naturally occurring parasite found on marine fish, including salmonids. They are small ecto-parasitic copepod crustaceans, of the family Caligidae which comprises of over 500 valid species (Boxshall & Özak, 2022). The two main species of interest in Ireland are *Caligus elongatus* and *Lepeophtheirus salmonis* (the salmon louse). *C. elongatus* is known to parasitise over 100 distinct marine species while *L. salmonis* primarily infests salmonids. *L. salmonis* is endemic at a prevalence of over 90% within wild populations (Jackson *et al.,* 2013), and occurs frequently on farmed salmonids (Jackson & Minchin, 1992; Jackson *et al.,* 2005). Atlantic salmon *Salmo salar* (Linnaeus, 1758) were the only species of salmonid farmed at sea in Ireland on a commercial basis, in 2023.

L. salmonis is an obligate parasite with a direct lifecycle, which has 8 stages, comprising of nauplius 1 and 2, copepodid, chalimus 1 and 2, pre-adult 1 and 2, and the adult stage. The nauplius 1 stage hatches from paired egg-strings and is dispersed in the plankton, where it moults to the next planktonic stage, nauplius 2. This is followed by the infective copepodid stage where attachment to the host takes place. The time it takes for a newly hatched nauplii to develop into an infective copepodid varies from approximately 7.2 days in March (March average temp = 7±1°C) to 2.4 days in May (May average temp = 13±1°C). 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 rate of this development through the stages is dependent upon sea water temperature (Figure 2; Hamre *et al*., 2019; Samsing *et al*., 2016). There are notable variations in the development time for female *L. salmonis* to reach maturity and produce egg strings from the beginning of the spring period (*c.* 90 days) to the end of the spring period (*c.* 30 days).

From a single mating event, the adult female can produce several batches of paired egg-strings, which in turn hatch from the distal end of the egg strings into the water column to give rise to the next generation (Hamre *et al.*, 2013; Kabata, 1979; Schram, 1993). The number of days in between batches of eggs is dependent on temperature and can vary from 17.1 days at 6 °C to 5.7 days at 14 °C (Hamre, *et al*., 2019). 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). Fecundity is also seasonally affected with peaks observed in spring (Ritchie, *et al.*, 1993).

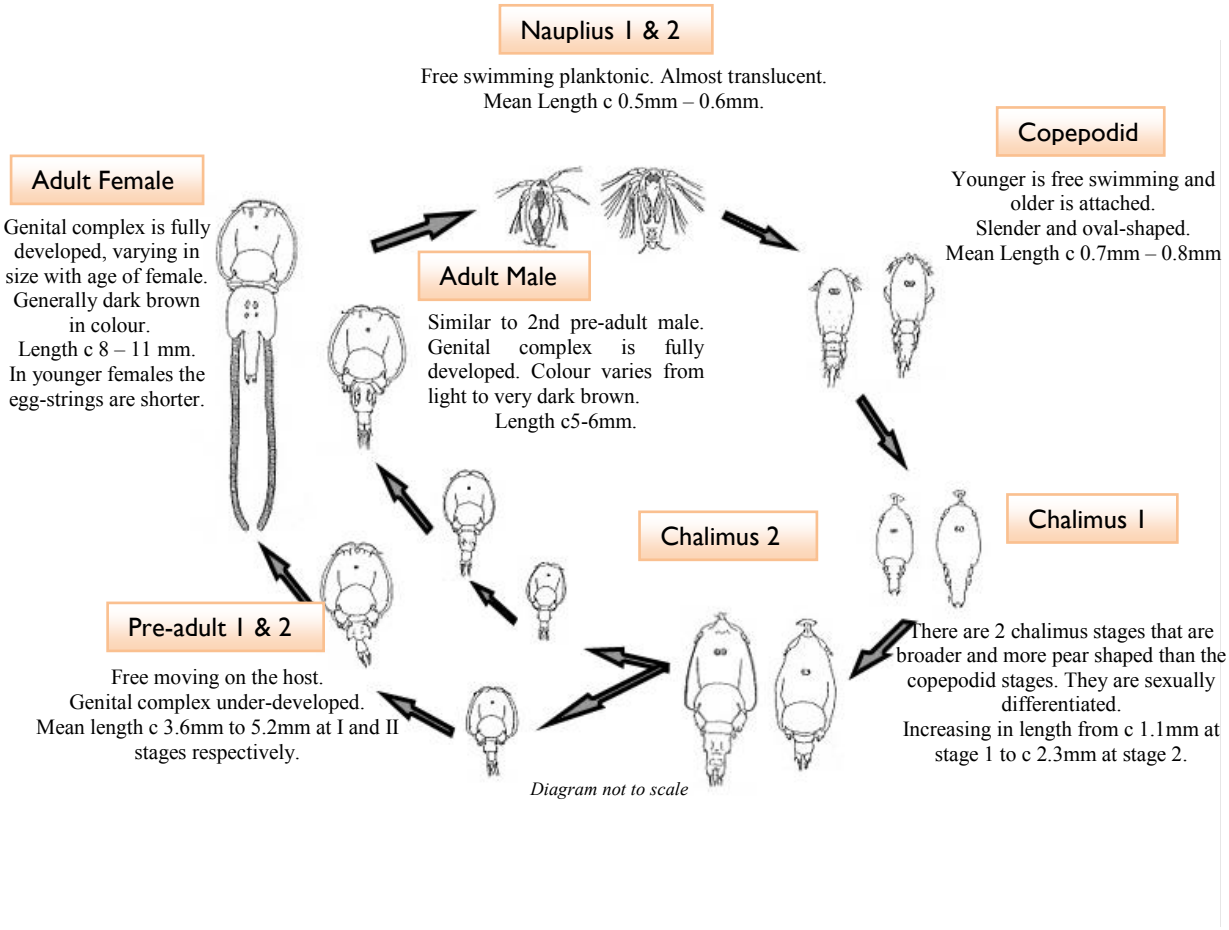

Figure 1 *Life cycle of Lepeophtheirus salmonis (after Schram, 1993 & Hamre et al., 2013).*

C. elongatus is smaller in size than *L. salmonis* averaging 6-8mm in length and has a slightly different documented life cycle to *L. salmonis*, with four chalimus stages and no pre-adult stage (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 various times of the year (Jackson *et al.*, 2000; Hemmingsen *et al.*, 2020).

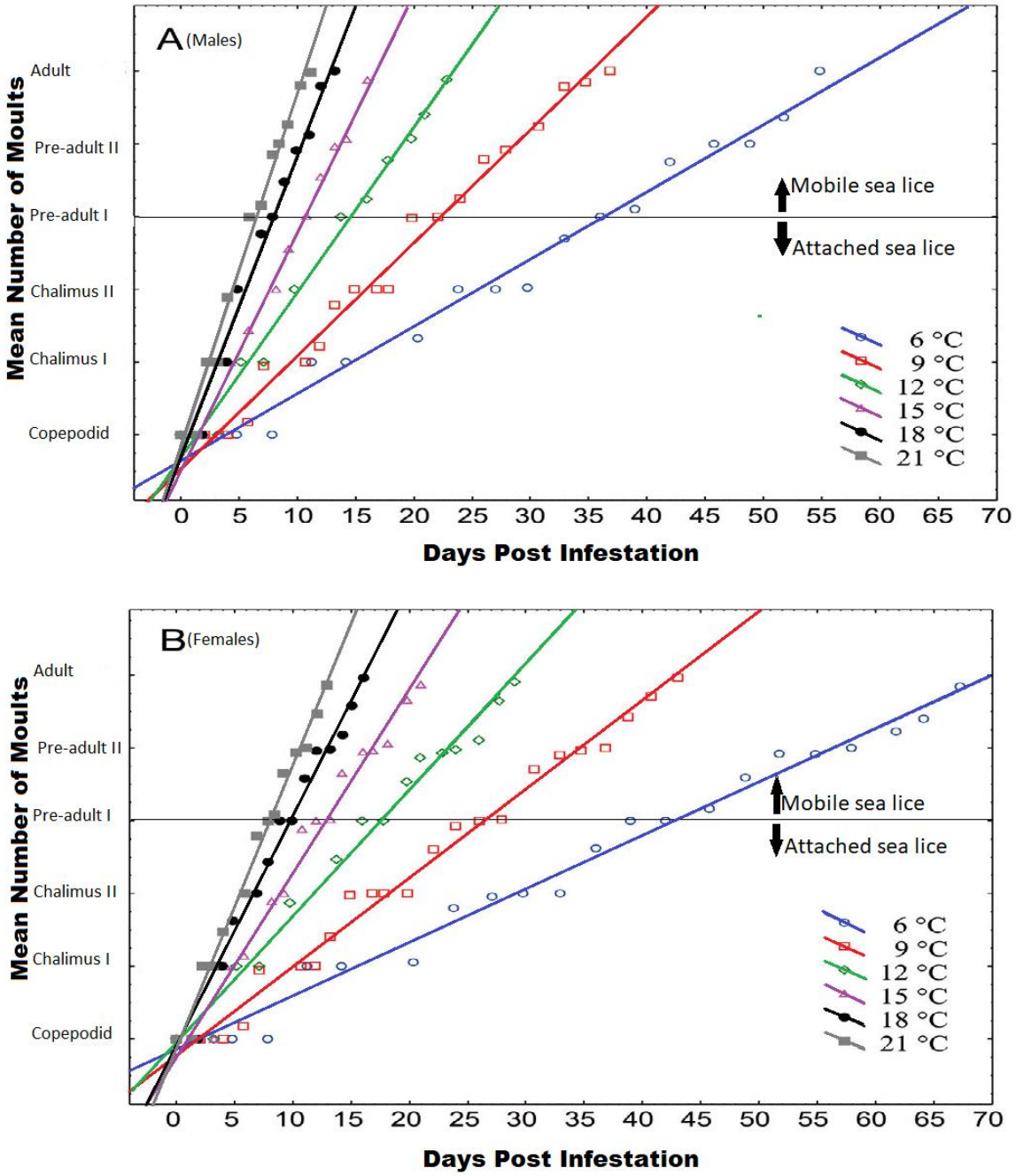

Figure 2 Mean number of moults vs. days post infestation for *L. salmonis* (A) males and (B) females. (Adapted from Hamre, *et al.*, 2019)

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 as the *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*". This 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 monitoring 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.
- Provide management with 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 infestations and to ensure the most effective treatment. They seek to minimise infestation 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. A synchronised, targeted, late winter/early spring treatment is useful to break the cycle of salmon lice infestation. It is important to reduce the salmon lice burden when seawater temperatures are at a minimum given the development rate of salmon lice is slower (Figure 2). This is fundamental to achieving near zero egg-bearing salmon lice in the spring. The agreed husbandry practices cover a range of related fish health, quality, and environmental issues in addition to those specifically related to salmon lice control. The Single Bay Management Programme serves to facilitate this control and management strategy, in addition to providing a forum for exchange of information between farmers.

Ovigerous female salmon lice are those which produce the infective 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 salmon 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 salmon lice level of 0.5 ovigerous by way of treatment is not justified. A level of 2.0 ovigerous salmon 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 salmon lice are important in advising fish health professionals in developing a control strategy. However, they are not, of themselves, appropriate measures upon which to trigger mandatory treatments. Subject to review under the National Strategic Plan for Sustainable Aquaculture Development.

Results of the monitoring programme are sent to the relevant farm within 5-10 days of each inspection. Salmon lice levels of 2.0 ovigerous (0.5 ovigerous in spring period) are used as Treatment Trigger Levels (TTL) to inform management to take action to reduce levels, as outlined in the *Monitoring Protocol No.3 for Offshore Finfish Farms – Sea Lice Monitoring and Control,* Department of Marine and Natural Resources (2000). A monthly report of results is circulated to relevant parties and the data is published annually (https://www.marine.ie/; Marine Institute Annual Sea Lice Reports) (Appendix 1).

Sea Lice Management

The sea lice management strategy on farms includes the use of husbandry, management practices, prescription-only veterinary medicines, and non-medicinal measures to control sea lice infestation. All veterinary medicines require prior authorisation from the Health Products Regulatory Authority (HPRA) before being placed on the market in Ireland. Table 1 shows a list of the veterinary medicines authorised to assist in the control of sea lice in Ireland. In exceptional circumstances, national and EU legislation allows for the use of veterinary medicinal products authorised for use in another EU member state excluding Ireland. This process, known as the 'cascade-system' is under the direction of the Department of Agriculture, Food, and the Marine (DAFM). Veterinary medicines for the control of sea lice can be 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 net-pens. In-feed medicines are incorporated into the diet to get the required dose to the fish. An over-reliance on any one veterinary medicine can result in reduced efficacy in the short term and lead to development of resistance over time. For this and other reasons, current management practices are migrating away from veterinary medicines and are moving toward non-medicinal removal of sea lice. A multi-pronged approach to sea lice control is considered more effective in the long-term and includes biological, mechanical, thermal, and freshwater/hyposaline measures.

Cleaner fish as a control method of sea lice continue to be used in Ireland. These include the use of wild-caught and hatchery reared ballan wrasse (*Labrus bergylta)*. These have played a key role in maintaining the low salmon lice levels recorded on all farms in 2023. Farms typically stock the five species of wrasse most common in Irish waters (Bolton-Warberg, 2018):

- 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*) and*
- Cuckoo wrasse *Labrus mixtus* (L., 1758).

Lumpfish *Cyclopterus lumpus* (L., 1758) are considered a more suitable cold-water option for biological delousing of Atlantic salmon (Imsland *et al.*, 2014) and continue to be deployed with positive effects on farms in Ireland as part of sea lice management plans.

The use of filtration methods at harvest sites have also proven to be a successful method of preventing sea lice from re-entering the water column and potentially re-infesting stocks adjacent to the harvest area (O'Donohoe & McDermott, 2014).

Thermal and mechanical delousing methods continue to be used and are successful at removing the mobile stages, however, they are known to be less successful at removing the attached stages (Grøntvedt, *et al.*, 2015; Overton, *et al.*, 2019). In addition, the use of hyposaline water bathing for control of *Neoparamoeba perurans (*the aetiological agent of amoebic gill disease) continues to be an effective tool in the control of sea lice (Mc Dermott, *et al.*, 2021).

Table 1 *Prescription-only veterinary medicines authorised for use in the control of sea lice on salmonids in Ireland* in 2023*(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

MA: Marketing authorisation from the Health Products Regulatory Authority.

METHODOLOGY

Farmed stocks of Atlantic salmon in Ireland are inspected monthly to monitor sea lice levels as part of the national programme, and twice per month in March, April, and May (the spring period), up to 14 occasions throughout the year. December and January are combined and only one inspection is carried out. Follow-up inspections may be carried out when deemed appropriate. At each inspection 2 samples are taken for each generation of fish on site, a sample from a standard pen, which is sampled at each subsequent inspection, and a sample from a random pen, which is chosen on the day of the inspection. Thirty fish are examined for each sample after anaesthetising using tricaine methanesulfonate in seawater. Fish are examined individually for all mobile sea lice. Sea lice are removed and preserved in 70% ethanol. The seawater the fish were held in is also sieved for any detached sea lice. 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 those in the sieve). The mean ovigerous sea lice levels and mean total mobile sea lice levels for *L. salmonis* and *C. elongatus* per fish are reported.

Ovigerous sea lice levels are a measure of the breeding female population, and total mobile levels provide an indication of current 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 3 distinct regions 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 (Figure 3) are geographically separate, with distances between regions of *c.*160 km from Northwest to West and *c.*200 km from West to Southwest.

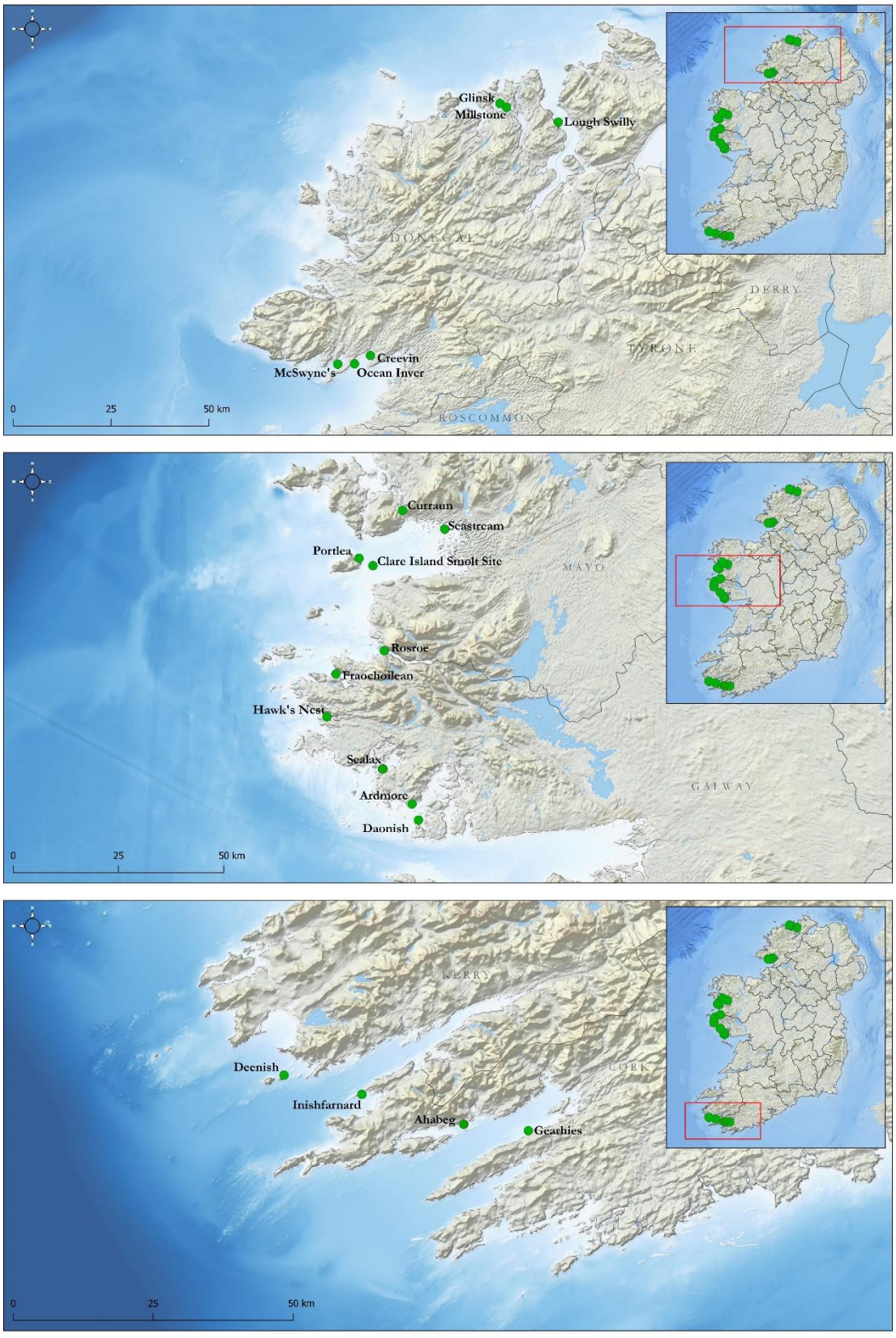

Figure 3 *Locations of active marine fish farm sites in 2023*

RESULTS

During 2023, a total of 181 sea lice inspections were carried out on 20 active farm sites. 100% of Atlantic salmon sea lice inspections 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). There were 120 inspections on salmon smolt sites, 100% of which were below the TTL. Of the 61 inspections from one-sea-winter salmon sites 100% were below the TTL.

Results of monthly sea lice inspections of all active salmonid sites for 2023 are presented in Appendix 2.

Atlantic salmon 2022 (one-sea-winter salmon)

One-sea-winter salmon were present in 9 sites in 7 bays in 2023. Sixty-one inspections were carried out on this generation of fish. Ovigerous *L. salmonis* levels greater than the TTL were not recorded on one-sea-winter fish. For details on the numbers of inspections at each site see Table 2.

Table 2 *Summary of inspection results on one-sea-winter salmon nationally in 2023.*

Company	Site	Samples in Spring	Ovigerous >TTL in Spring	Samples outside Spring	Ovigerous >TTL outside Spring	Total Samples	Total Ovigerous >TTL	% over TTL in Spring	% over TTL outside Spring	Total % over TTL
Mowi Irl.	Inishfarnard	6	0	6	0	12	0	0%	0%	0%
Southwest	**Totals**	6	0	6	0	12	0	0%	0%	0%
Bradan Beo Teo.	Ardmore	6	0	2	0	8	0	0%	0%	0%
Bifand Ltd./Mowi Irl.	Sealax	0		1	0	1	0		0%	0%
Clare Island Seafarms Ltd.	Clare Island Smolt Site	2	0	2	0	4	0	0%	0%	0%
	Seastream Innishcorragh	4	0	2	0	6	0	0%	0%	0%
Rosroe Salmon Ltd.	Rosroe	6	0	2	0	8	0	0%	0%	0%
West	**Totals**	18	0	9	0	27	0	0%	0%	0%
Ocean Farm Ltd.	Ocean Inver	6	0	3	0	9	0	0%	0%	0%
Mowi Irl.	Creevin	4	0	2	0	6	0	0%	0%	0%
	Lough Swilly	5	0	2	0	7	0	0%	0%	0%
Northwest	**Totals**	15	0	7	0	22	0	0%	0%	0%
National Totals		39	0	22	0	61	0	0%	0%	0%

Mean levels more than 10 mobile *L. salmonis* per fish were recorded on one occasion. It was the maximum mean mobile *L. salmonis* level recorded at 11.8 per fish in Killary Harbour during March.

C. elongatus levels greater than 10 individuals per fish were recorded on one occasion, during the year. The highest total mobile *C. elongatus* level recorded was 14.4 per fish in Lough Swilly Harbour during February.

Atlantic salmon 2023 (smolts)

A total of 120 inspections were undertaken at 11 sites stocking Atlantic salmon 2023 S1 and S½ smolts during the year 2023. *L. salmonis* levels were below the TTL for all inspections (100%) throughout 2023 (Table 3).

Table 3 *Summary of inspection results on salmon smolts nationally in 2023.*

Company	Site	Samples in Spring	Ovigerous >TTL in Spring	Samples outside Spring	Ovigerous >TTL outside Spring	Total Samples	Total Ovigerous >TTL	% over TTL in Spring	% over TTL outside Spring	Total % over TTL
Mowi Irl.	Ahabeg	6	0	2	0	8	0	0%	0%	0%
	Gearhies	0		6	0	6	0		0%	0%
	Deenish	3	0	6	0	9	0	0%	0%	0%
Southwest	**Totals**	9	0	14	0	23	0	0%	0%	0%
Bradan Beo Teo.	Daonish	6	0	8	0	14	0	0%	0%	0%
Bifand Ltd.	Fraochoilean	6	0	8	0	14	0	0%	0%	0%
Mannin Bal Salmon Company Ltd.	Hawks Nest	6	0	8	0	14	0	0%	0%	0%
Curraun Blue Ltd.	Curraun	6	0	8	0	14	0	0%	0%	0%
Clare Island Seafarms Ltd.	Portlea	2	0	6	0	8	0	0%	0%	0%
West	**Totals**	26	0	38	0	64	0	0%	0%	0%
Ocean Farm Ltd.	Mc Swynes	6	0	7	0	13	0	0%	0%	0%
Mowi Irl.	Glinsk	4	0	6	0	10	0	0%	0%	0%
	Millstone	4	0	6	0	10	0	0%	0%	0%
Northwest	**Totals**	14	0	19	0	33	0	0%	0%	0%
National Totals		49	0	71	0	120	0	0%	0%	0%

There were no instances when the mean total mobile *L. salmonis* per fish was greater than 10. The maximum mean level recorded was 9.02 mobile salmon lice per fish, in Clifden Bay in October.

Sampling record

All samples were collected in 2023.

One-sea-winter salmon monthly trend by bay

Mean ovigerous and mean mobile *L. salmonis,* and *C. elongatus* levels for each bay are shown in Table 4 for one-sea-winter salmon throughout the year. Monthly ovigerous *L. salmonis* levels greater than the spring TTL of 0.5 ovigerous salmon lice per fish, on a bay level, were not recorded in 2023.

Table 4 *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 2023.*

Mean ovigerous *L. salmonis*

	Dec/Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Kenmare Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.27	HO	
Kilkieran Bay	0.10	0.02	0.03	0.23	0.27	HO					
Bertraghboy Bay	0.00	HO									
Killary Harbour	0.31	0.27	0.23	0.20	0.22	HO					
Clew Bay	0.00	0.03	0.02	0.01	0.01	0.02	0.02	HO			
Donegal Bay	0.00	0.03	0.04	0.01	0.12	0.10	HO				
Lough Swilly	0.17	0.15	0.04	0.02	0.20	HO					

Mean mobile *L. salmonis*

	Dec/Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Kenmare Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.40	0.50	HO	
Kilkieran Bay	0.48	0.18	1.71	2.27	1.28	HO					
Bertraghboy Bay	0.00	HO									
Killary Harbour	1.13	2.65	7.69	1.75	1.80	HO					
Clew Bay	0.04	0.12	0.12	0.14	0.23	0.08	0.09	HO			
Donegal Bay	0.03	0.06	0.07	0.10	0.42	0.29	HO				
Lough Swilly	0.52	0.90	0.34	0.55	2.30	HO					

Mean ovigerous *C. elongatus*

	Dec/Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Kenmare Bay	1.73	0.73	1.22	1.70	0.42	1.16	0.22	2.00	0.73	HO	
Kilkieran Bay	0.02	0.02	0.05	0.06	0.00	HO					
Bertraghboy Bay	0.05	HO									
Killary Harbour	0.19	0.52	0.25	0.06	0.06	HO					
Clew Bay	0.09	0.35	2.21	2.22	1.05	0.13	0.14	HO			
Donegal Bay	0.05	1.16	0.41	1.21	1.58	2.09	HO				
Lough Swilly	3.74	6.80	0.23	1.13	0.97	HO					

Mean mobile *C. elongatus*

	Dec/Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Kenmare Bay	2.87	1.20	3.70	4.33	0.90	2.97	0.3	3.30	1.20	HO	
Kilkieran Bay	0.02	0.02	0.10	0.13	0.00	HO					
Bertraghboy Bay	0.10	HO									
Killary Harbour	0.24	0.83	0.67	0.44	0.19	HO					
Clew Bay	0.41	0.81	4.48	4.61	2.33	0.21	0.19	HO			
Donegal Bay	0.15	2.47	0.98	2.81	3.88	3.62	HO				
Lough Swilly	5.22	14.37	0.47	2.13	1.37	HO					

HO = Harvested out

Regional monthly means for one-sea-winter salmon and smolts

L. salmonis ovigerous and monthly mean mobile levels per fish for one-sea-winter salmon regionally are shown in Figures 4 and 5. In 2023, the mean regional ovigerous salmon lice levels per fish did not exceed the TTL. The highest mean regional ovigerous salmon lice levels per fish (0.30) occurred in the Southwest in August.

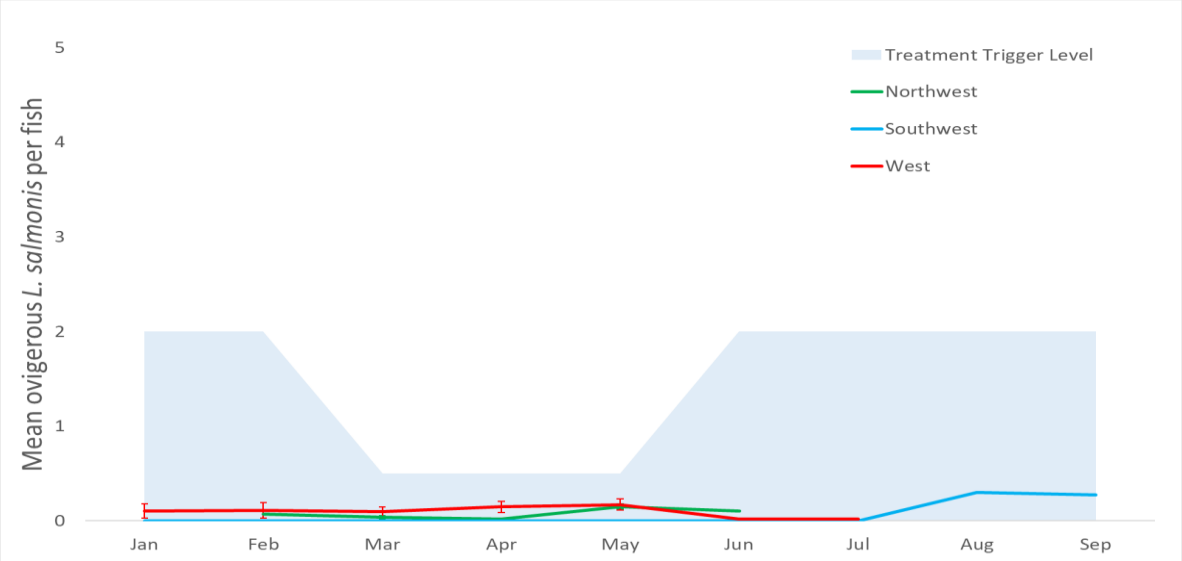

Figure 4 *Mean (±SE) monthly ovigerous L. salmonis per fish per region in 2023 on one-sea-winter salmon.*

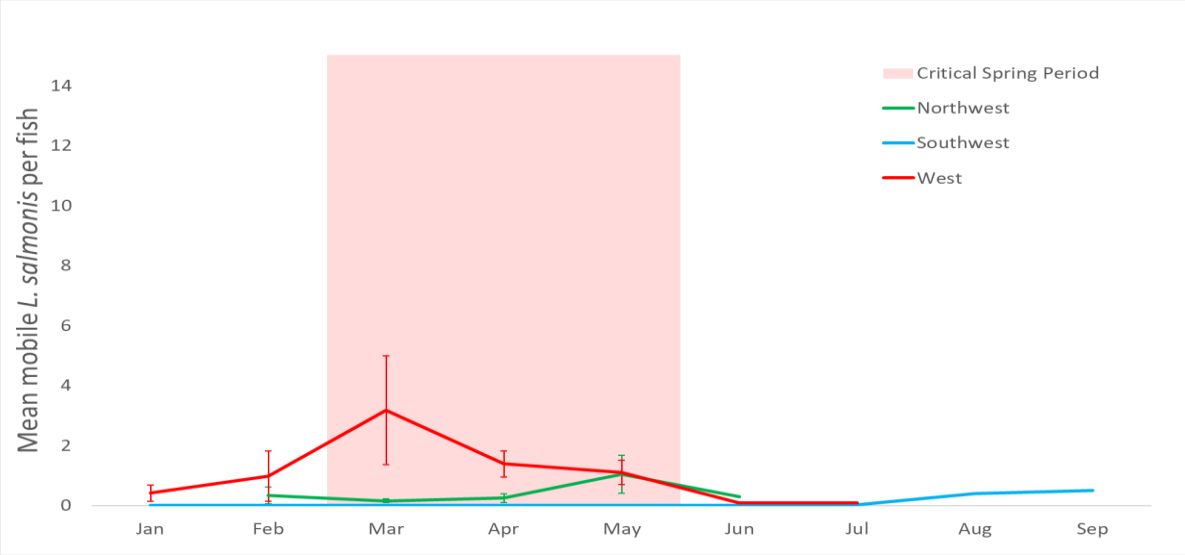

Figure 5 *Mean (±SE) monthly mobile L. salmonis per fish per region in 2023 on one-sea-winter salmon.*

Total regional mean mobile *L. salmonis* levels peaked at 3.18 mobile sea lice per fish in the Western region in March, 0.50 in the Southwest in September, and 1.05 in the Northwest in May.

L. salmonis ovigerous and monthly mean mobile levels per fish for smolts regionally are shown in Figures 6 and 7. In 2023, the mean regional ovigerous salmon lice levels per fish did not exceed the TTL. The highest mean regional mobile salmon lice levels per fish (0.42) occurred in the Northwest in October.

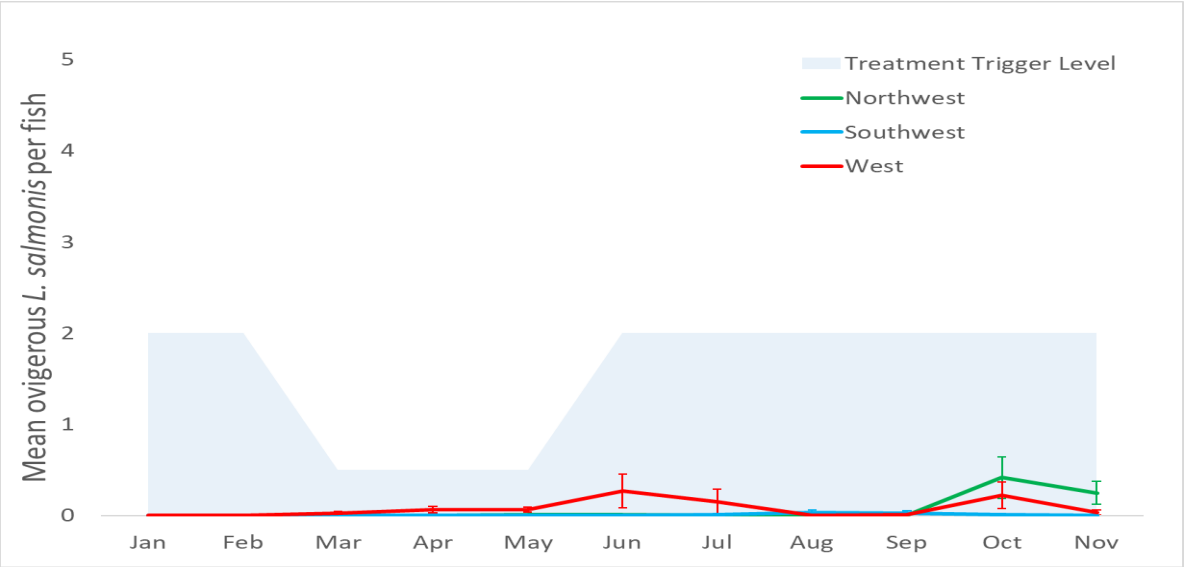

Figure 6 *Mean (±SE) monthly ovigerous L. salmonis per fish per region in 2023 on smolts.*

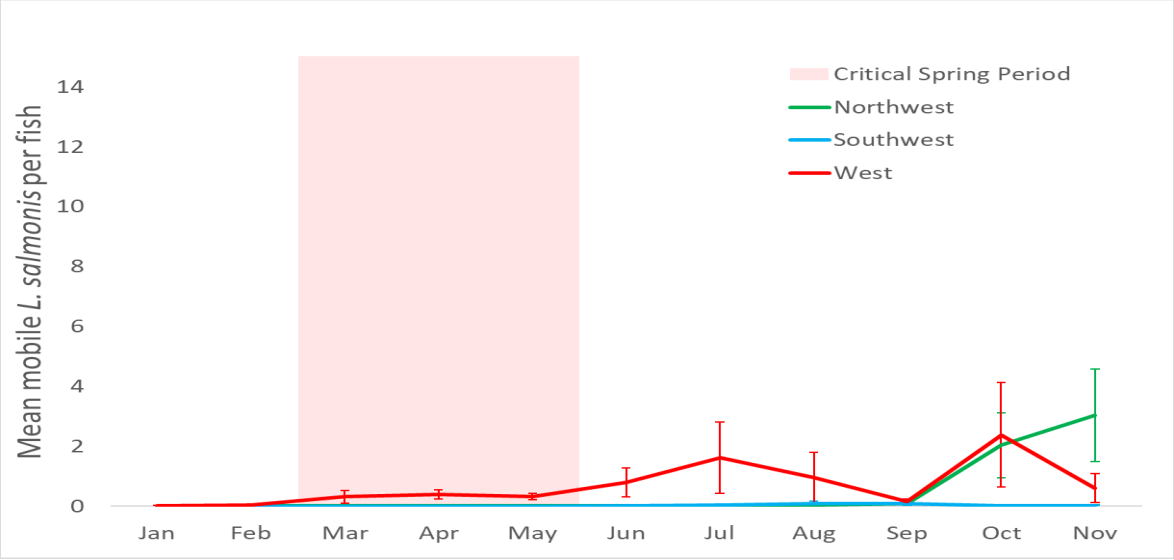

Figure 7 *Mean (±SE) monthly mobile L. salmonis per fish per region in 2023 on smolts.*

Total regional mean mobile *L. salmonis* levels for smolts peaked at 2.38 mobile salmon lice per fish in the Western region in October, 0.09 in the Southwest in August and 3.03 in the Northwest in November.

Annual trends (One-sea-winter salmon)

The annual trends of *L. salmonis* ovigerous and mobile salmon lice levels are compared in Figures 8 and 9 for one-sea-winter salmon for the month of May from 1991 to 2023.

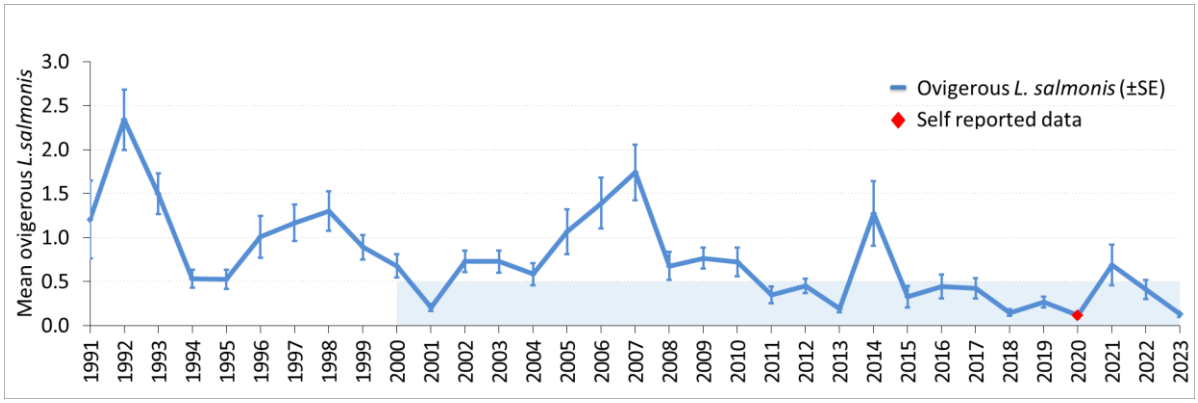

Figure 8 *Annual trend (May mean ±SE) ovigerous L. salmonis on one-sea-winter salmon.*

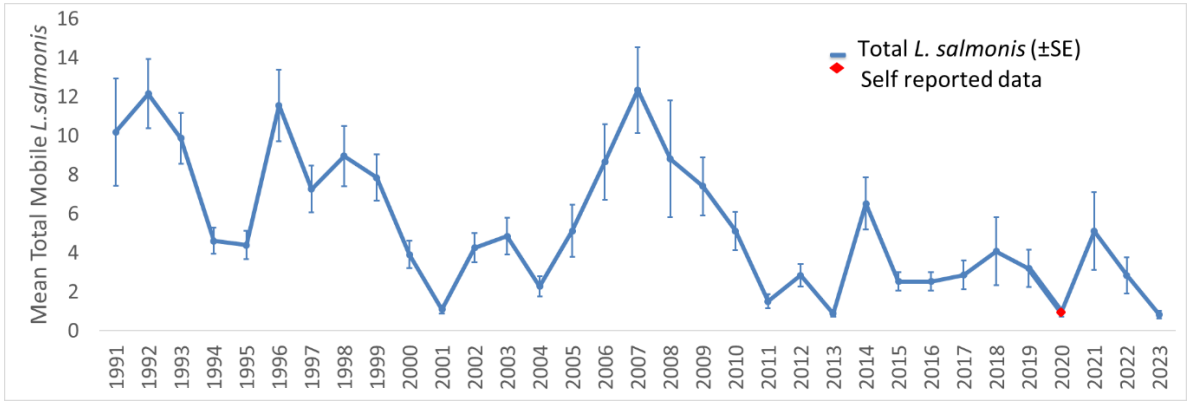

Figure 9 *Annual trend (May mean ±SE) mobile L. salmonis on one-sea-winter salmon.*

Mean ovigerous *L. salmonis* levels in May decreased to 0.13 salmon lice per fish in 2023. The 5-year May mean ovigerous *L. salmonis* from 2018-2022 was 0.33 ±0.10 (S.E.) per fish. Total mobile *L. salmonis* levels decreased to 0.82 per fish which is lower than the 5-year May mean total *L. salmonis* from 2018-2022 of 3.23 ±0.69 (S.E.) per fish.

Regional Spring trends of salmon lice in Ireland

A regional assessment of the spring period (March, April, and May) means of ovigerous *L. salmonis* levels over the previous five years show levels were typically lower than the TTL. Salmon lice levels are higher in one-sea-winter salmon than in smolts. The Southwest region has had consistently low salmon lice levels among all salmon cohorts. The West and Northwest are regions where elevated salmon lice levels have occasionally occurred in spring over the previous 5 years (Figures 10 and 11).

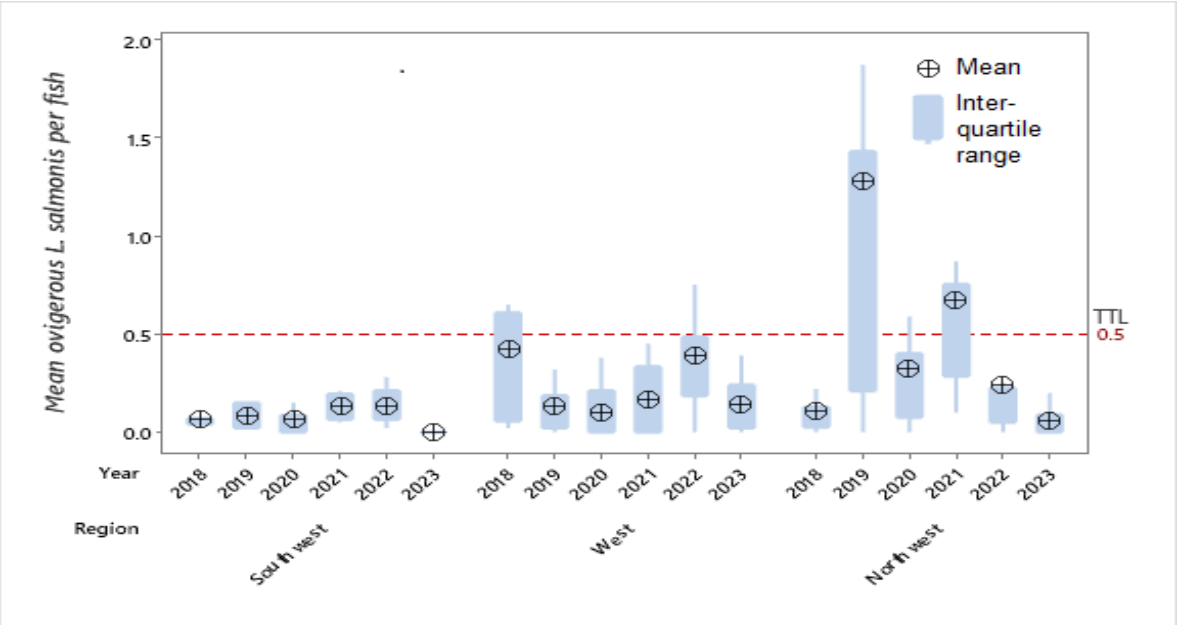

Figure 10 *Spring mean ovigerous L. salmonis per fish for one sea winter salmon, 2018-2023*

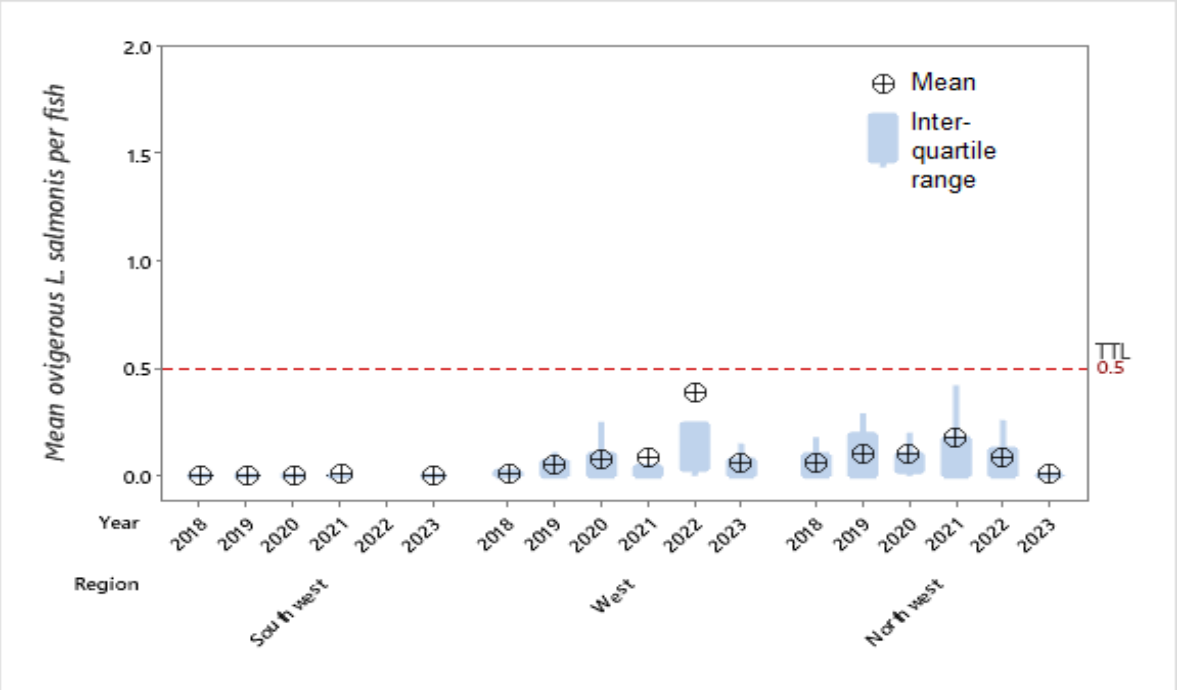

Figure 11 *Spring mean ovigerous L. salmonis per fish for smolt, 2018-2023*

DISCUSSION

For the first time since the inception of the national sea lice monitoring programme, no breaches of the treatment trigger levels (TTL) were recorded in 2023. This continues a trend of decreasing salmon lice levels on Irish salmon farms since monitoring commenced in 1991.

The national mean ovigerous salmon lice per fish for one-sea-winter salmon in May (0.13) decreased from 0.41 in 2022 (D'Arcy, *et al*., 2023). The 5-year May mean ovigerous salmon lice per fish from 2018-2022 was 0.33. The national total mobile salmon lice per fish for May (0.82) decreased in 2023 to the lowest since records began. The 5-year May mean total salmon lice per fish from 2018-2022 was 3.23.

As with 2022, the regional graphs demonstrate a similar pattern of low salmon lice levels for both smolts and one-sea-winter-salmon throughout 2023. These graphs show that infrequent incidents of increased levels of infestation are followed by successful efforts to reduce overall salmon lice levels.

All the sites that harvested one-sea-winter-salmon in 2023 had low salmon lice levels in the inspection prior to harvest. All but one of these sites had consistently low salmon lice levels throughout 2023. This is a positive shift away from previous years when it was not unusual for levels to increase prior to harvest. Protracted harvests which involve the early harvest of larger grade fish were observed at several sites in 2023 and this practice may have reduced salmon lice infestation pressure at those sites.

Although official data on the methods used to control salmon lice are not collected in Ireland, non-medicinal treatments/husbandry practices increasingly play a significant role in the management of infestation levels. It is worth highlighting that most of the sites that had consistently low salmon lice levels frequently bathed the salmon in fresh/hyposaline water and were stocked with cleaner fish. On the occasions when salmon lice levels rose at a site the availability of a thermolicer vessel has enabled the operators to maintain low salmon lice levels especially in the spring period.

In summary, every inspection was below the mandatory trigger levels for action throughout 2023 (see Appendix 2 for details). This is the first year this has occurred since the inception of the sea lice monitoring programme and elevated salmon lice levels continue to be the exception rather than the rule. The fact that levels have been below the TTL since July 2022 demonstrates a high degree of adherence to the pest management strategy and proactive

salmon lice management. The continued use of non-medicinal delousing practices such as cleaner fish, hyposaline/fresh water bathing and thermal delousing methods as well as effective husbandry, timely use of authorised veterinary medicines and implementation of Single Bay Management practices is proving to be effective in maintaining low salmon lice levels on all marine Atlantic salmon farms in Ireland.

GLOSSARY

Mobile lice	All sea lice (*C. elongatus* and *L. salmonis*) that are mobile – male and female (pre-adult and adult stages) sea lice that have developed beyond the attached larval stages.
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 char.
Standard (Std.) Pen	The selected pen which is sampled at each inspection.
S1 Smolt	Smolt pertains to a stage in the salmon life cycle when it changes from being a freshwater fish to a seawater fish, a process known as smoltification. S1 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 2.

Mean sea lice levels on salmonid farms in 2023.

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
BANTRY BAY					
MOWI IRL.					
Ahabeg					
Atlantic Salmon, 2023 S 1/2	17/01/2023	0.00	0.00	0.18	0.34
	03/02/2023	0.00	0.00	0.32	0.42
	03/03/2023	0.00	0.00	0.31	0.66
	21/03/2023	0.00	0.00	0.25	0.63
	06/04/2023	0.00	0.00	0.07	0.07
	27/04/2023	0.00	0.00	0.11	0.21
	10/05/2023	0.00	0.00	0.26	0.60
	23/05/2023	0.00	0.00	0.04	0.04
		Transferred to Gearhies			
Gearhies					
Atlantic Salmon, 2023 S 1/2	09/06/2023	0.00	0.00	0.00	0.00
	26/07/2023	0.00	0.07	0.20	0.34
	22/08/2023	0.06	0.18	0.85	2.19
	06/09/2023	0.05	0.18	1.60	3.38
	09/10/2023	0.02	0.03	0.12	0.14
	07/11/2023	0.00	0.05	2.25	4.00

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
KENMARE BAY					
Deenish					
Atlantic Salmon, 2023	28/04/2023	0.00	0.00	0.02	0.05
	09/05/2023	0.00	0.00	0.16	0.57
	22/05/2023	0.00	0.00	0.17	0.37
	07/06/2023	0.00	0.02	1.69	2.49
	25/07/2023	0.02	0.03	1.71	4.25
	23/08/2023	0.00	0.00	0.02	0.02
	07/09/2023	0.00	0.00	0.06	0.14
	10/10/2023	0.00	0.00	0.00	0.04
	07/11/2023	0.00	0.00	0.37	0.97
Inishfarnard					
Atlantic Salmon, 2022	17/01/2023	0.00	0.00	1.73	2.87
	03/02/2023	0.00	0.00	0.73	1.20
	03/03/2023	0.00	0.00	0.76	2.85
	21/03/2023	0.00	0.00	1.69	4.56
	06/04/2023	0.00	0.00	3.14	8.09
	27/04/2023	0.00	0.00	0.25	0.58
	10/05/2023	0.00	0.00	0.29	0.79
	23/05/2023	0.00	0.00	0.56	1.01
	08/06/2023	0.00	0.00	1.16	2.97
	25/07/2023	0.00	0.02	0.22	0.30
	23/08/2023	0.30	0.40	2.00	3.30
	06/09/2023	0.27	0.50	0.73	1.20
		Harvested Out			

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*		
		F + eggs	Total	F + eggs	Total	
KILKIERAN BAY						
BRADAN BEO TEO.						
Ardmore						
Atlantic Salmon, 2022 S 1/2	23/01/2023	0.10	0.48	0.02	0.02	
	03/02/2023	0.02	0.18	0.02	0.02	
	13/03/2023	0.00	1.10	0.06	0.11	n<10
	23/03/2023	0.05	2.32	0.05	0.09	
	14/04/2023	0.36	2.38	0.02	0.02	
	24/04/2023	0.10	2.15	0.10	0.24	
	11/05/2023	0.16	0.44	0.00	0.00	
	16/05/2023	0.39	2.13	0.00	0.00	
		Harvested Out				
Daonish						
Atlantic Salmon, 2023 S 1/2	23/01/2023	0.00	0.05	0.00	0.00	
	03/02/2023	0.00	0.07	0.00	0.00	
	13/03/2023	0.00	0.40	0.00	0.02	
	23/03/2023	0.15	1.76	0.00	0.00	
	14/04/2023	0.03	0.84	0.00	0.00	
	25/04/2023	0.11	0.31	0.00	0.02	
	11/05/2023	0.03	0.31	0.00	0.00	
	23/05/2023	0.05	0.32	0.00	0.00	
	28/06/2023	0.02	0.55	0.00	0.00	
	27/07/2023	0.00	0.12	0.00	0.00	
	17/08/2023	0.00	0.02	0.00	0.00	
	26/09/2023	0.03	0.40	0.00	0.00	
	27/10/2023	0.72	2.76	0.04	0.04	
	17/11/2023	0.15	0.33	0.00	0.02	

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
BERTRAGHBOY BAY					
BIFAND LTD./MOWI IRL.					
Sealax					
Atlantic Salmon, 2022 S 1/2	19/01/2023	0.00	0.00	0.05	0.10
		Harvested Out			
CLIFDEN BAY					
MANNIN BAY SALMON COMPANY LTD.					
Hawks Nest					
Atlantic Salmon, 2023 S 1/2	17/01/2023	0.00	0.00	0.00	0.02
	21/02/2023	0.00	0.00	0.00	0.00
	01/03/2023	0.00	0.00	0.02	0.02
	24/03/2023	0.00	0.00	0.00	0.00
	05/04/2023	0.00	0.00	0.00	0.02
	17/04/2023	0.00	0.00	0.04	0.04
	04/05/2023	0.00	0.02	0.00	0.00
	26/05/2023	0.00	0.00	0.00	0.00
	16/06/2023	0.00	0.00	0.00	0.00
	26/07/2023	0.05	0.47	0.00	0.00
	29/08/2023	0.00	4.33	0.00	0.00
	18/09/2023	0.00	0.29	0.00	0.02
	10/10/2023	0.37	9.02	0.00	0.00
	15/11/2023	0.03	2.52	0.10	0.19

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
BALLINAKILL HARBOUR					
BIFAND LTD.					
Fraochoilean					
Atlantic Salmon, 2023 S 1/2	17/01/2023	0.00	0.00	0.05	0.06
	08/02/2023	0.00	0.00	0.10	0.10
	03/03/2023	0.00	0.08	0.20	0.26
	21/03/2023	0.00	0.10	0.11	0.14
	06/04/2023	0.02	0.97	0.26	0.29
	21/04/2023	0.29	0.83	0.00	0.00
	05/05/2023	0.27	0.80	0.00	0.04
	18/05/2023	0.20	1.04	0.00	0.00
	09/06/2023	0.95	2.58	0.00	0.00
	10/07/2023	0.70	6.29	0.00	0.02
	01/08/2023	0.03	0.05	0.00	0.00
	12/09/2023	0.02	0.06	0.00	0.00
	03/10/2023	0.02	0.02	0.02	0.02
	10/11/2023	0.00	0.03	0.11	0.18

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	**Total**	**F + eggs**	**Total**
KILLARY HARBOUR					
ROSROE SALMON LTD.					
Rosroe					
Atlantic Salmon, 2022 S 1/2	20/01/2023	0.31	1.13	0.19	0.24
	16/02/2023	0.27	2.65	0.52	0.83
	07/03/2023	0.11	3.60	0.16	0.73
	21/03/2023	0.35	11.79	0.34	0.61
	04/04/2023	0.27	2.37	0.10	0.78
	28/04/2023	0.13	1.13	0.02	0.09
	03/05/2023	0.23	2.43	0.12	0.32
	17/05/2023	0.22	1.17	0.00	0.07
		Harvested Out			

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
CLEW BAY					
CLARE ISLAND SEAFARMS LTD.					
Clare Island Smolt Site					
Atlantic Salmon, 2022	12/05/2023	0.00	0.15	0.92	1.98
	19/05/2023	0.02	0.32	1.18	2.68
	08/06/2023	0.02	0.08	0.13	0.21
	13/07/2023	0.02	0.09	0.14	0.19
		Harvested Out			
Portlea					
Atlantic Salmon, 2022		Transferred to Seastream Innishcorragh			
Atlantic Salmon, 2023	12/05/2023	0.00	0.04	0.10	0.29
	19/05/2023	0.00	0.16	0.17	0.41
	08/06/2023	0.00	0.00	0.00	0.03
	13/07/2023	0.00	0.02	0.00	0.00
	24/08/2023	0.00	0.00	0.00	0.00
	15/09/2023	0.00	0.00	0.00	0.00
	19/10/2023	0.00	0.00	0.02	0.02
	14/11/2023	0.00	0.00	0.03	0.15
Seastream Innishcorragh					
Atlantic Salmon, 2022	27/01/2023	0.00	0.04	0.09	0.41
	09/02/2023	0.03	0.12	0.35	0.81
	02/03/2023	0.02	0.15	2.27	4.56
	27/03/2023	0.03	0.10	2.15	4.40
	11/04/2023	0.00	0.12	2.01	4.06
	18/04/2023	0.02	0.16	2.43	5.17
		Transferred to Clare Island Smolt Site			

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*		
		F + eggs	Total	F + eggs	Total	
BEALACRAGHER BAY						
CURRAUN BLUE LTD.						
Curraun						
Atlantic Salmon, 2023 S 1/2	27/01/2023	0.00	0.03	0.00	0.00	
	09/02/2023	0.00	0.12	0.00	0.00	
	02/03/2023	0.02	0.07	0.02	0.27	n<10
	27/03/2023	0.02	0.10	0.03	0.07	
	11/04/2023	0.08	0.14	0.04	0.06	
	18/04/2023	0.00	0.05	0.05	0.05	
	09/05/2023	0.05	0.33	0.21	0.27	
	19/05/2023	0.07	0.30	0.18	0.25	
	08/06/2023	0.37	0.83	0.00	0.02	
	13/07/2023	0.00	1.18	0.00	0.00	
	09/08/2023	0.00	0.37	0.00	0.00	
	15/09/2023	0.00	0.02	0.00	0.00	
	19/10/2023	0.00	0.09	0.00	0.00	
	14/11/2023	0.00	0.15	0.00	0.00	

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	**Total**	**F + eggs**	**Total**
DONEGAL BAY					
MOWI IRL.					
Creevin					
Atlantic Salmon, 2022 S 1/2	05/12/2022	0.00	0.02	0.03	0.11
	07/02/2023	0.04	0.06	0.66	1.45
	09/03/2023	0.09	0.09	0.09	0.12
	31/03/2023	0.00	0.04	0.09	0.32
	14/04/2023	0.00	0.00	0.26	0.54
	19/04/2023	0.00	0.04	0.89	2.58
		Harvested Out			

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
OCEAN FARM LTD.					
Mc Swynes					
Atlantic Salmon, 2023 S 1/2	08/02/2023	0.00	0.02	0.91	1.93
	08/03/2023	0.00	0.02	1.82	2.51
	31/03/2023	0.00	0.00	0.62	1.34
	05/04/2023	0.00	0.00	0.80	1.97
	18/04/2023	0.00	0.06	1.73	5.54
	03/05/2023	0.00	0.06	2.25	5.24
	17/05/2023	0.00	0.02	0.00	0.00
	02/06/2023	0.00	0.02	0.05	0.31
	04/07/2023	0.00	0.00	0.08	0.24
	08/08/2023	0.00	0.00	0.00	0.00
	12/09/2023	0.00	0.00	0.00	0.00
	17/10/2023	0.00	0.00	0.00	0.00
	29/11/2023	0.00	0.00	0.00	0.00
Ocean Inver					
Atlantic Salmon, 2022 S 1/2	05/12/2022	0.00	0.05	0.06	0.18
	07/02/2023	0.02	0.07	1.66	3.49
	08/03/2023	0.00	0.04	0.63	1.16
	31/03/2023	0.05	0.10	0.84	2.34
	05/04/2023	0.00	0.07	0.95	2.74
	18/04/2023	0.05	0.29	2.75	5.40
	03/05/2023	0.11	0.57	2.12	4.13
	17/05/2023	0.14	0.27	1.04	3.64
	02/06/2023	0.10	0.29	2.09	3.62
			Harvested Out		

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
MULROY BAY					
MOWI IRL.					
Glinsk					
Atlantic Salmon, 2023	06/04/2023	0.00	0.00	0.00	0.00
	19/04/2023	0.00	0.05	0.08	0.09
	04/05/2023	0.00	0.00	0.08	0.18
	18/05/2023	0.00	0.00	0.07	0.09
	01/06/2023	0.00	0.02	0.02	0.05
	05/07/2023	0.00	0.00	0.00	0.00
	09/08/2023	0.00	0.02	0.05	0.12
	13/09/2023	0.00	0.22	0.00	0.00
	18/10/2023	0.47	2.39	0.04	0.04
	10/11/2023	0.41	5.13	0.03	0.05
		Transferred to Creevin			
Millstone					
Atlantic Salmon, 2023	06/04/2023	0.00	0.00	0.00	0.02
	19/04/2023	0.02	0.03	0.04	0.04
	04/05/2023	0.02	0.02	0.07	0.11
	18/05/2023	0.02	0.06	0.04	0.05
	01/06/2023	0.02	0.02	0.00	0.00
	05/07/2023	0.00	0.05	0.02	0.04
	09/08/2023	0.00	0.09	0.02	0.06
	13/09/2023	0.00	0.02	0.00	0.00
	18/10/2023	0.78	3.72	0.13	0.15
	10/11/2023	0.33	3.97	0.02	0.02
		Transferred to Lough Swilly			

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
LOUGH SWILLY					
Lough Swilly					
Atlantic Salmon, 2022	06/12/2022	0.17	0.52	3.74	5.22
	08/02/2023	0.15	0.90	6.80	14.37
	09/03/2023	0.05	0.39	0.29	0.35
	30/03/2023	0.03	0.30	0.16	0.60
	06/04/2023	0.03	0.17	0.56	1.53
	19/04/2023	0.02	0.93	1.71	2.74
	04/05/2023	0.20	2.30	0.97	1.37
		Harvested Out			

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