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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. There are 37 genera (Ahyong *et al*., 2011) made up of approximately 559 species, including 268 *Caligus* species (Boxshall, 2011) and 162 *Lepeophtheirus* species (Chad & Goeff, 2011). The two main species of interest in Ireland are *Caligus elongatus* and *Lepeophtheirus salmonis* (the salmon louse). *C. elongatus* is known to parasitise over 80 distinct species of marine fish while *L. salmonis* infests only 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 2022.

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, preadult 1 and 2, and the adult stage. The nauplius 1 stage hatches from paired egg-strings and is dispersed in the plankton. It moults to nauplius 2, also planktonic. This is followed by the infective copepodid 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 rate of this development through the stages is dependent upon sea water temperature (Figure 2; Hamre *et al*., 2019; Samsing *et al*., 2016). 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).

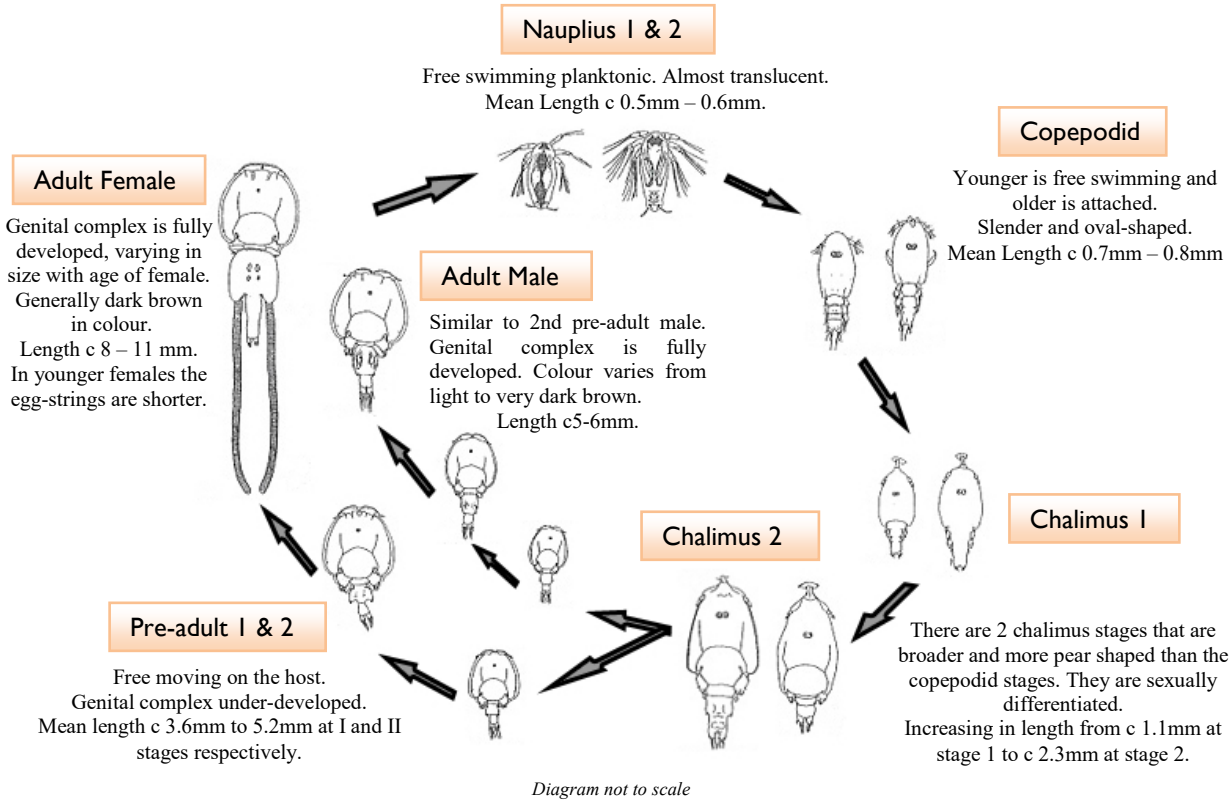

Figure 1 *Life cycle of Lepeophtheirus salmonis (after Schram, 1993 & Hamre et al., 2013).*

C. elongatus is smaller in size than *L. salmonis* averaging 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 (Hemmingsen *et al.*, 2020).

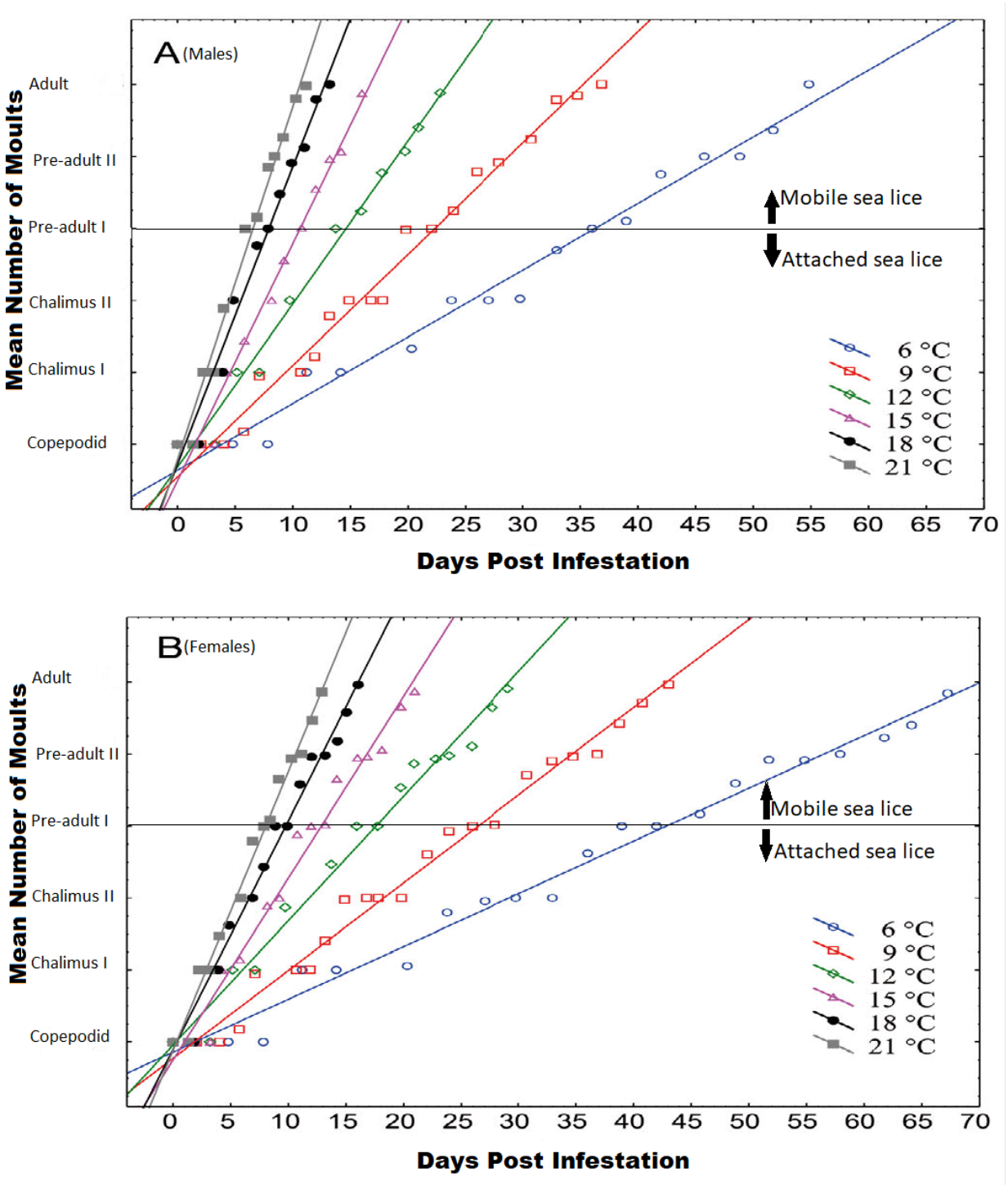

Figure 2 Mean number of moults vs. days post infestation for *L. salmonis* (A) males and (B) females. (Adapted from Hamre, *et al.*, 2019)

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 and to reduce the burden to as close to zero as practicable, as when seawater temperatures are at a minimum 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 sea 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.

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)

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. Farms typically stock the five species of wrasse most common in Irish waters (Bolton-Warberg, 2017):

- 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 for removing all stages of sea lice, including egg-strings, preventing sea lice from re-entering

the water column and potentially re-infesting stocks adjacent to the harvest area (O'Donohoe & McDermott, 2014).

In addition to mechanical de-lousing methods, thermal de-lousing is now used on several farms in Ireland as part of their sea lice management plan. The use of hyposaline water to control both sea lice numbers and *Neoparamoeba perurans (*the aetiological agent of amoebic gill disease) on salmon farms during the warmer summer months has also proved successful (Mc Dermott, *et al.* 2022).

Table 1 *Prescription-only veterinary medicines authorised for use in the control of sea lice on salmonids in Ireland* in 2022*(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 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 (Fig. 3) are geographically separate, with distances between regions of *c.*160 km from Northwest to West and *c.*200 km from West to Southwest.

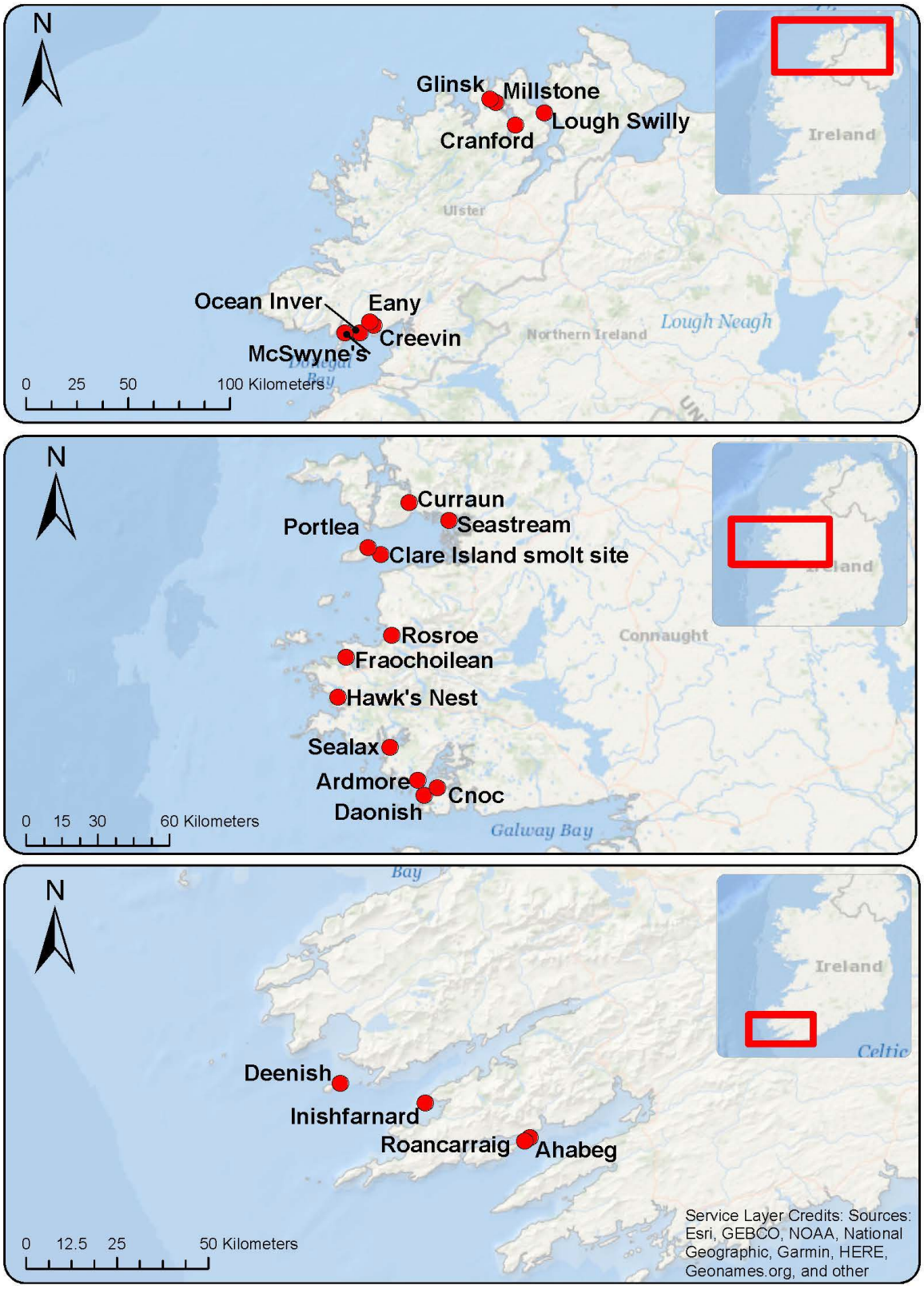

Figure 3 *Locations of active marine fish farm sites in 2022*

RESULTS

During 2022, a total of 190 sea lice inspections were carried out on 23 active farm sites. Over 93% 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 112 inspections on salmon smolt sites, 96% of which were below the TTL. Of the 78 inspections from one-sea-winter salmon sites 90% were below the TTL.

Results of monthly sea lice inspections of all active salmonid sites for 2022 are presented in Appendix 1.

Atlantic salmon 2021 (one-sea-winter salmon)

One-sea-winter salmon were present in 13 sites in 9 bays in 2022. Seventy-eight inspections were carried out on this generation of fish.

Ovigerous *L. salmonis* levels greater than the TTL were recorded for a total of 8 inspections (10%) on one-sea-winter fish (Table 2). Within the critical spring period sea lice levels were greater than 0.5 ovigerous females per fish on 7 occasions (15%).

Table 2 *Summary of sea lice reports on one-sea-winter salmon nationally in 2022.*

Company	Samples in Spring	Over in Spring	Samples outside Spring	Over outside Spring	Total Samples	Total Over	% over in Spring	% over outside Spring	% over total
National Totals	48	7	30	1	78	8	15%	3%	10%

Southwest Region

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

Table 3 *Summary of sea lice reports on one-sea-winter salmon in the Southwest in 2022.*

Company	Site	Samples in Spring	Over in Spring	Samples outside Spring	Over outside Spring	Total Samples	Total Over	% over in Spring	% over outside Spring	% over total
Mowi Irl.	**Ahabeg**	0		1	0	1	0		0%	0%
	Deenish	6	0	4	0	10	0	0%	0%	0%
Southwest	**Totals**	6	0	5	0	11	0	0%	0%	0%

West Region

In the West, there was 1 out of 17 inspections (6%) of *L. salmonis* infestation levels greater than the TTL outside the spring period and 5 out of 25 inspections (20%) within the spring period. (Table 4).

Table 4 *Summary of sea lice reports on one-sea-winter salmon in the West in 2022.*

Company	Site	Samples in Spring	Over in Spring	Samples outside Spring	Over outside Spring	Total Samples	Total Over	% over in Spring	% over outside Spring	% over total
Bradan Beo Teo.	**Cnoc**	2	1	2	0	4	1	50%	0%	25%
	Daonish	6	3	2	1	8	4	50%	50%	50%
Bifand Ltd.	**Fraochoilean**	2	1	2	0	4	1	50%	0%	25%
Clare Island Seafarms Ltd.	**Clare Island smolt site**	1	0	5	0	6	0	0%	0%	0%
	Seastream Innishcannon	5	0	2	0	7	0	0%	0%	0%
	Seastream Innishcorragh	5	0	2	0	7	0	0%	0%	0%
Curraun Blue Ltd.	**Curruan**	4	0	2	0	6	0	0%	0%	0%
West	**Totals**	25	5	17	1	42	6	20%	6%	14%

Northwest Region

In the Northwest, the TTL was exceeded on 2 out of 17 inspections (12%) in the spring period (Table 5). There were no instances when the TTL was exceeded outside the spring period.

Table 5 *Summary of sea lice reports on one-sea-winter salmon in the Northwest in 2022.*

Company	Site	Samples in Spring	Over in Spring	Samples outside Spring	Over outside Spring	Total Samples	Total Over	% over in Spring	% over outside Spring	% over total
Ocean Farm Ltd.	**Mc Swynes**	6	2	1	0	7	2	33%	0%	29%
Mowi Irl.	**Cranford B**	0		2	0	2	0		0%	0%
	Millstone	5	0	2	0	7	0	0%	0%	0%
	L.Swilly	6	0	3	0	9	0	0%	0%	0%
Northwest	**Totals**	17	2	8	0	25	2	12%	0%	8%

Mean levels in excess of 10 mobile *L. salmonis* per fish were recorded on 5 occasions, 2 of these instances had a mean of greater than 20 mobile sea lice per fish. The maximum mean mobile *L. salmonis* level recorded was 49.0 per fish in Ballinakill Harbour in February.

C. elongatus levels greater than 10 individuals per fish were recorded on 8 occasions, during the year. The highest total mobile *C. elongatus* recorded were 22.2 per fish in Clew Bay in February.

Atlantic salmon 2022 (smolts)

A total of 112 inspections were undertaken at 11 sites stocking Atlantic salmon 2022 S1 and S½ smolts during the year 2022. *L. salmonis* levels were below the TTL of 0.5 ovigerous female salmon lice per fish for 41 of 45 inspections (91%) during the spring period. Sixty-six out of 67 (98.5%) inspections outside the spring period were below the TTL of 2 ovigerous female salmon lice per fish. (Table 6).

Table 6 *Summary of sea lice reports on salmon smolts nationally in 2022.*

Company	Site	Samples in Spring	Over in Spring	Samples outside Spring	Over outside Spring	Total Samples	Total Over	% over in Spring	% over outside Spring	% over total
Mowi Irl.	**Roancarraig**	**4**	**0**	**5**	**0**	9	0	0%	0%	0%
	Inishfarnard	1	0	6	0	7	0	0%	0%	0%
Southwest	**Totals**	5	0	11	0	16	0	0%	0%	0%
Bradan Beo Teo.	**Ardmore**	6	3	8	0	14	3	50%	0%	21%
Bifand Ltd. / Mowi Irl.	**Sealax**	6	0	8	1	14	1	0%	13%	7%
Rosroe Salmon Ltd.	**Rosroe**	6	0	8	0	14	0	0%	0%	0%
Clare Island Seafarms Ltd.	**Portlea**	1	0	6	0	7	0	0%	0%	0%
West	**Totals**	19	3	30	1	49	4	16%	3%	8%
Ocean Farm Ltd.	**Ocean Inver**	6	0	8	0	14	0	0%	0%	0%
Mowi Irl.	**Creevin**	6	0	8	0	14	0	0%	0%	0%
	Eany	6	1	4	0	10	1	17%	0%	10%
	Glinsk	3	0	4	0	7	0	0%	0%	0%
	L. Swilly	0	0	2	0	2	0		0%	0%
Northwest	**Totals**	21	1	26	0	47	1	5%	0%	2%
		Samples in Spring	**Over in Spring**	**Samples outside Spring**	**Over outside Spring**	**Total Samples**	**Total Over**	**% over in Spring**	**% over outside Spring**	**% over total**
National Totals		45	4	67	1	112	5	9%	1%	4%

There were 2 instances when the mean total mobile *L. salmonis* per fish was greater than 10. These occurred inside the spring period in Kilkieran Bay and one of these instances coincided with mean ovigerous levels above the TTL. The maximum mean level recorded was 10.7 mobile salmon lice per fish, in Kilkieran Bay in March.

Sampling record

One inspection was not undertaken due to weather at McSwyne's Bay in February.

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 7 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 recorded on 4 out of 21 occasions, in Kilkieran Bay and Donegal Bay.

There were no occasions outside of the spring period for which the bay mean was above the TTL of 2.0 ovigerous females per fish.

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 2022.*

Mean ovigerous *L. salmonis*

	Dec/Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
BANTRY BAY	0.03	HO									
KENMARE BAY	0.05	0.02	0.16	0.05	0.18	0.13	0.40	HO			
KILKIERAN BAY	0.38	1.90	0.63	0.84	0.63	HO					
BALLINAKILL HARBOUR	0.75	0.45	0.35	HO							
CLEW BAY	0.02	0.12	0.08	0.26	0.38	0.18	1.01	0.90	0.16	0.10	HO
BEALACRAGHER BAY	0.00	0.08	0.15	0.24	HO						
DONEGAL BAY	0.88	HO	0.31	0.38	1.06	HO					
MULROY BAY	0.00	0.01	0.05	0.00	0.02	HO					
LOUGH SWILLY	0.02	0.12	0.08	0.18	0.18	0.27	HO				

Mean mobile *L. salmonis*

	Dec/Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
BANTRY BAY	0.21	HO									
KENMARE BAY	0.26	0.05	0.29	0.34	1.32	0.60	2.77	HO			
KILKIERAN BAY	7.12	20.29	3.94	3.26	2.83	HO					
BALLINAKILL HARBOUR	4.47	49.04	3.63	HO							
CLEW BAY	0.10	0.57	0.82	1.05	1.52	0.99	3.59	3.58	1.85	2.67	HO
BEALACRAGHER BAY	0.17	0.45	2.04	2.97	HO						
DONEGAL BAY	3.97	HO	3.39	10.35	10.47	HO					
MULROY BAY	0.00	0.08	0.12	0.12	1.32	HO					
LOUGH SWILLY	0.05	0.49	1.16	0.78	1.09	1.05	HO				

Mean ovigerous *C. elongatus*

	Dec/Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
BANTRY BAY	0.06	HO									
KENMARE BAY	0.36	0.54	0.89	0.05	1.06	1.70	6.17	HO			
KILKIERAN BAY	0.00	0.03	0.01	0.00	0.00	HO					
BALLINAKILL HARBOUR	0.07	0.09	0.01	HO							
CLEW BAY	8.20	7.97	4.24	0.01	0.00	0.02	0.93	0.72	0.38	0.67	HO
BEALACRAGHER BAY	0.07	0.08	0.18	0.19	HO						
DONEGAL BAY	0.00	HO	0.03	0.04	0.14	HO					
MULROY BAY	0.01	0.23	0.17	0.13	0.27	HO					
LOUGH SWILLY	1.08	2.69	2.35	1.24	0.88	0.18	HO				

Mean mobile *C. elongatus*

	Dec/Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
BANTRY BAY	0.17	HO									
KENMARE BAY	1.81	1.19	1.69	0.21	1.79	4.33	19.94	HO			
KILKIERAN BAY	0.01	0.12	0.02	0.00	0.00	HO					
BALLINAKILL HARBOUR	0.10	0.22	0.03	HO							
CLEW BAY	14.69	17.25	11.12	0.03	0.02	0.05	1.16	1.19	0.69	1.00	HO
BEALACRAGHER BAY	0.07	0.15	0.36	0.42	HO						
DONEGAL BAY	0.00	HO	0.10	0.33	0.90	HO					
MULROY BAY	0.02	0.39	0.28	0.24	0.85	HO					
LOUGH SWILLY	2.12	5.38	5.37	2.38	2.18	0.30	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 2022, the mean regional ovigerous salmon lice levels per fish did not exceed the TTL. The highest mean regional ovigerous salmon lice levels per fish (1.0) occurred in the West in July.

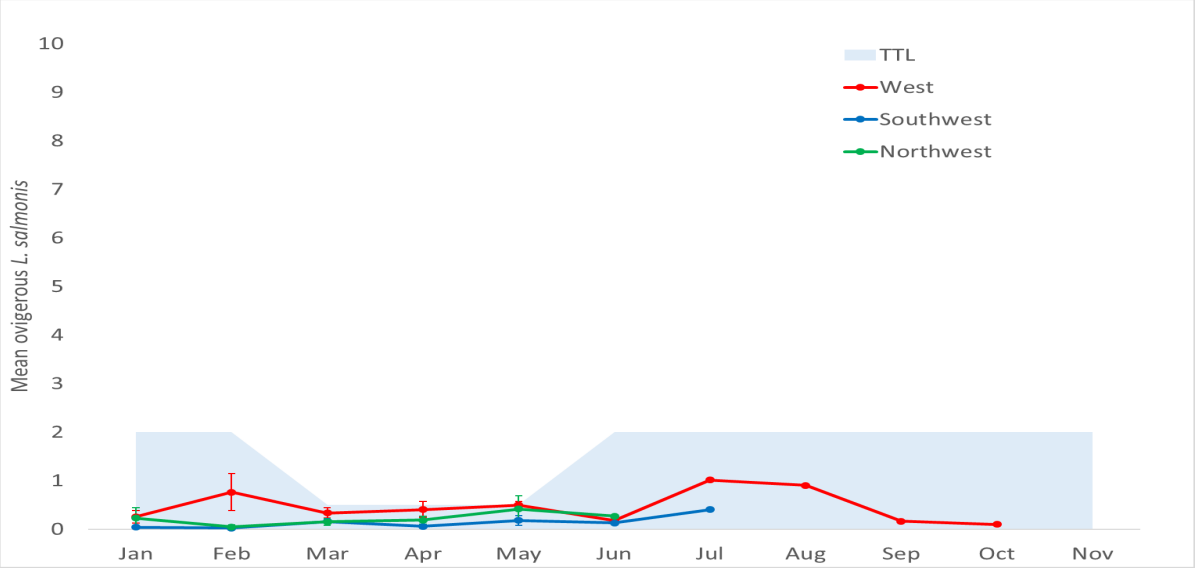

Figure 4 *Mean (±SE) monthly ovigerous L. salmonis per fish per region in 2022 on one-sea-winter salmon.*

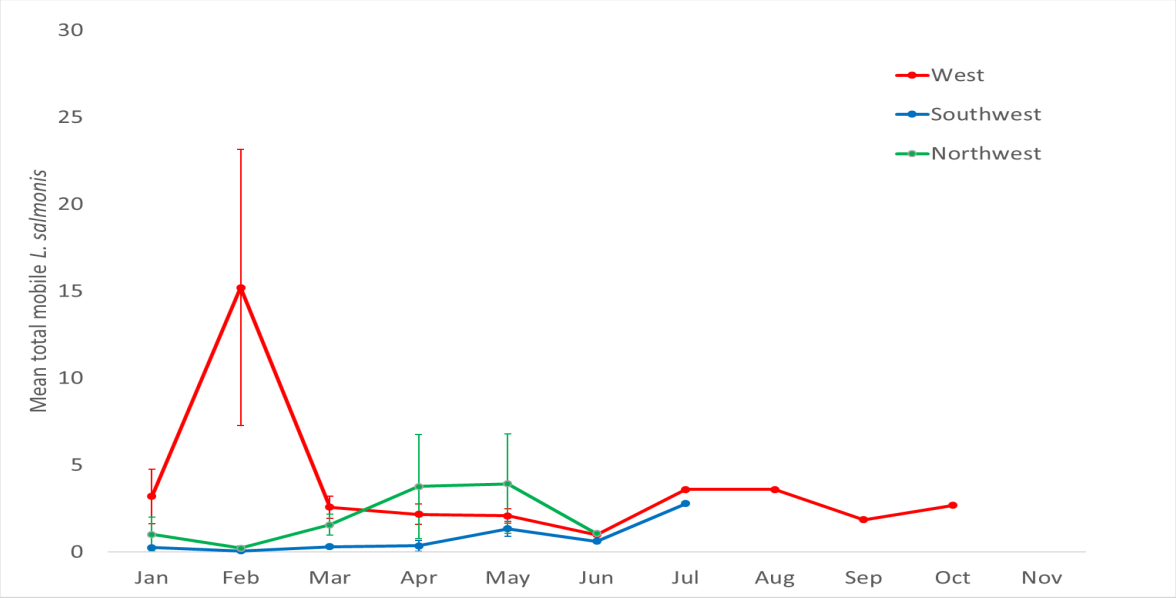

Figure 5 *Mean (±SE) monthly mobile L. salmonis per fish per region in 2022 on one-sea-winter salmon.*

Total regional mean mobile *L. salmonis* levels peaked at 15.2 mobile sea lice per fish in the Western region in February, 2.8 in the Southwest in July, and 3.9 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 the spring period of 2022, the mean regional ovigerous salmon lice levels per fish exceeded the TTL once in the West in May. This was attributed to one sea lice inspection in Kilkieran Bay.

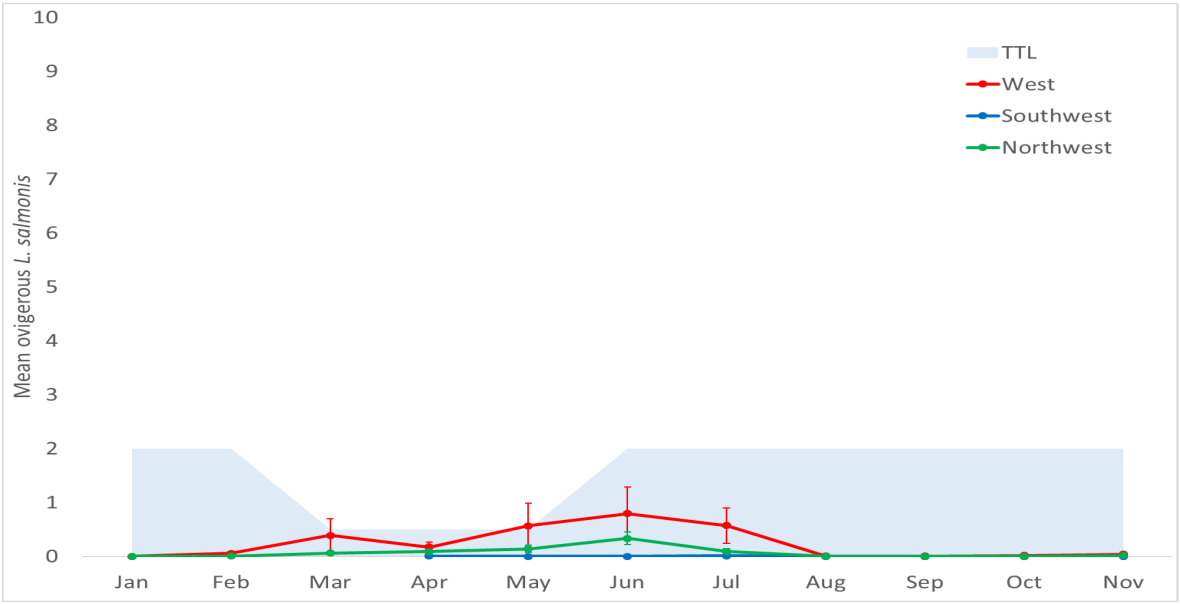

Figure 6 *Mean (±SE) monthly ovigerous L. salmonis per fish per region in 2022 on smolts.*

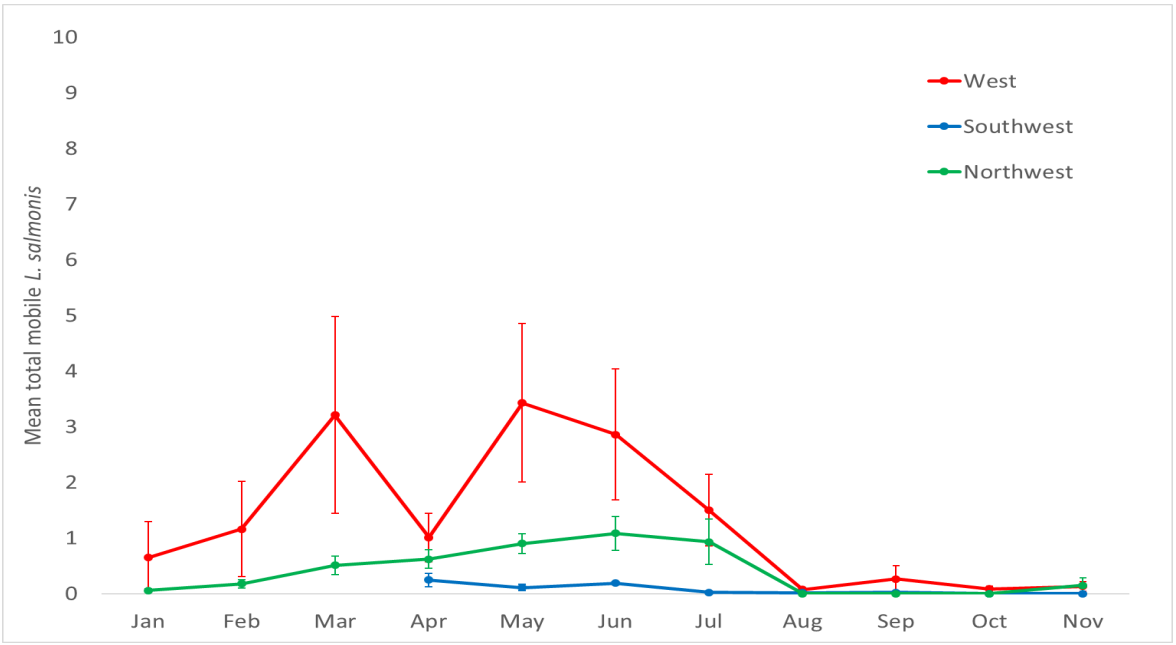

Figure 7 *Mean (±SE) monthly mobile L. salmonis per fish per region in 2022 on smolts.*

Total regional mean mobile *L. salmonis* levels for smolts peaked at 3.4 mobile salmon lice per fish in the Western region in May, 0.3 in the Southwest in April and 1.1 in the Northwest in June.

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 2022.

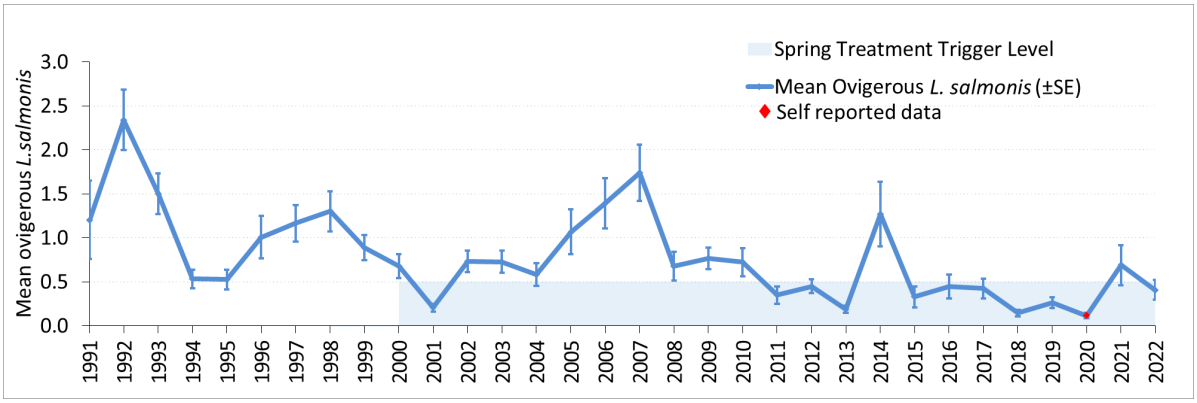

Figure 8 *Annual trend (May mean ±SE) ovigerous L. salmonis on one-sea-winter salmon.*

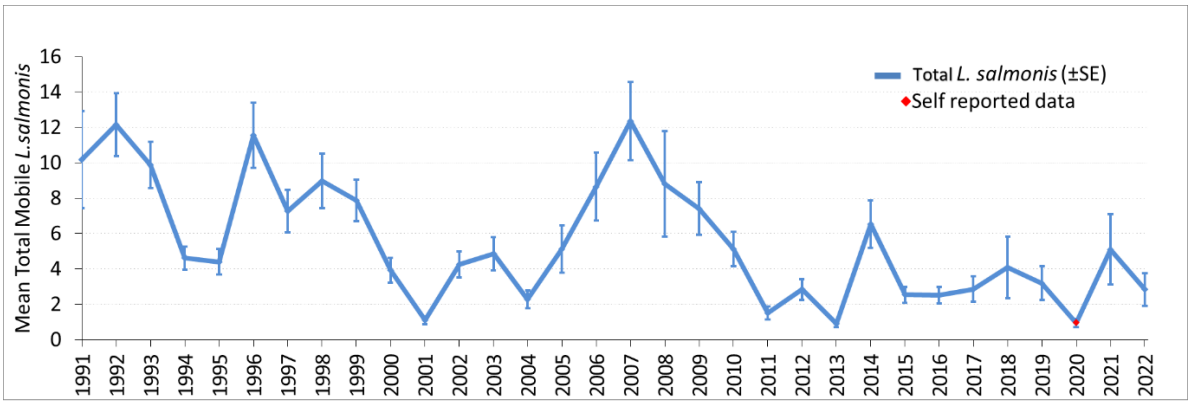

Figure 9 *Annual trend (May mean ±SE) mobile L. salmonis on one-sea-winter salmon.*

Mean ovigerous *L. salmonis* levels in May decreased to 0.41 salmon lice per fish in 2022. The 5-year May mean ovigerous *L. salmonis* from 2017-2021 was 0.32 ±0.06 (S.E.) per fish. Total mobile *L. salmonis* levels decreased to 2.84 per fish which is similar to the 5-year May mean total *L. salmonis* from 2017-2021 of 2.82 ±0.64 (S.E.) per fish.

DISCUSSION

In 2022, 93% of all salmon lice inspections were below the TTL, in detail 96% of smolt inspections and 90% of one-sea-winter salmon inspections were below TTL. This is a decrease from the 95% reported in 2021 (D'Arcy *et al*., 2022), but higher than the 91% reported for 2019 (O'Donohoe *et al*., 2020).

The national mean ovigerous *L. salmonis* levels for one-sea-winter salmon in May (0.41) decreased below the TTL. The 5-year May mean ovigerous *L. salmonis* from 2017-2021 was 0.32 per fish. The national total mobile *L. salmonis* levels for May decreased in 2022 to 2.84 per fish compared to 5.1 per fish in May 2021. The 5-year May mean total *L. salmonis* from 2017-2021 was 2.82 per fish.

As with 2021, the regional graphs demonstrate a similar pattern of salmon lice levels for both smolts and one-sea-winter-salmon in 2022. These results demonstrate how, in general, management efforts continue to maintain low salmon lice levels in line with the strategy for improved pest control on Irish salmon farms. Salmon lice levels remained typically low in the South-western region throughout the year and in the North-western region, apart from McSwyne's Bay in the Spring period. These patterns show that increased levels of infestation are followed by successful efforts to reduce overall salmon lice levels. They also highlight when these efforts were not sufficient during the spring period in the Western region. In the case of the one-sea-winter-salmon in Kilkieran Bay, it is apparent that the rough seas in February and lack of weather-independent lice control measures, e.g. cleaner fish, resulted in infestation levels which proved difficult to reduce below the TTL over the following months. In the case of the smolts in Kilkieran Bay, the regional trend highlights how continued efforts to reduce salmon lice levels using hyposaline water eventually resulted in near zero *L. salmonis* per fish (ovigerous and mobile).

Of the 10 sites that harvested one-sea-winter-salmon in 2022, 9 had low salmon lice levels in the inspection prior to harvest. Seven out of those 10 sites had consistently low salmon lice levels throughout 2022. This is a positive shift away from previous years when it was not unusual for levels to increase prior to harvest. It is worth noting that the one-sea-winter-salmon sites that had consistently low salmon lice levels were consistently stocked with cleaner fish. The use of cleaner fish was widespread on marine salmon farms in 2022, including the use of hatchery reared wrasse (*L. bergylta)* for the first time in Ireland. These have played a key role in maintaining the low salmon lice levels recorded on all farms in 2022, especially during the second half of the year. Although official data on the methods

used to control salmon lice are not collected in Ireland, non-medicinal treatments continue to play an important role in the management of infestation levels. 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 salmon lice levels continues to be an effective tool in the control of sea lice (Mc Dermott, *et al*., 2021). Co-operation between the salmon farming companies to plan and carry out mechanical treatments has further enhanced the co-ordinated approach to salmon lice control on salmon farms in Ireland, as evidenced by many inspections being below the mandatory trigger levels for action (see Appendix 1 for details).

In keeping with previous year's results, elevated salmon lice levels have been the exception rather than the rule. The fact that levels have been below the TTL since July 2022 demonstrates a significant level of adherence to the pest management strategy and proactive salmon lice management. The continued use of non-medicinal delousing systems such as cleaner fish, hyposaline water bathing, thermal and mechanical 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 1.

Mean sea lice levels on salmonid farms in 2022.

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*		
		F + eggs	Total	F + eggs	Total	
BANTRY BAY						
MOWI IRL.						
Ahabeg						
Atlantic Salmon, 2021 S1/2	15/12/2022	0.03	0.21	0.06	0.17	
			Harvested Out			
Roancarraig						
Atlantic Salmon, 2021 S1/2	02/12/2022		Transferred to Ahabeg			
Atlantic Salmon, 2022	13/04/2022	0.00	0.37	0.00	0.04	
	26/04/2022	0.01	0.12	0.01	0.04	
	04/05/2022	0.00	0.12	0.09	0.12	
	24/05/2022	0.00	0.21	0.14	0.14	
	23/06/2022	0.00	0.19	1.28	3.53	
	13/07/2022	0.02	0.02	0.02	0.04	
	26/08/2022	0.00	0.00	0.00	0.00	
	14/09/2022	0.00	0.00	0.02	0.02	
	12/10/2022	0.00	0.00	0.03	0.03	
			Transferred to Creevin			
KENMARE BAY						
Deenish						
Atlantic Salmon, 2021	15/12/2022	0.05	0.26	0.36	1.81	
	25/02/2022	0.02	0.05	0.54	1.19	
	02/03/2022	0.12	0.21	1.04	2.24	
	16/03/2022	0.19	0.38	0.74	1.15	
	13/04/2022	0.02	0.04	0.00	0.05	
	26/04/2022	0.09	0.65	0.10	0.37	
	04/05/2022	0.08	1.76	0.45	1.14	
	24/05/2022	0.28	0.88	1.66	2.45	
	23/06/2022	0.13	0.60	1.70	4.33	
	14/07/2022	0.40	2.77	6.17	19.94	n<10
			Harvested Out			

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*		
		F + eggs	Total	F + eggs	Total	
Inishfarnard						
Atlantic Salmon, 2022	25/05/2022	0.00	0.00	0.05	0.05	
	23/06/2022	0.00	0.19	0.72	2.00	
	13/07/2022	0.00	0.03	0.00	0.03	
	25/08/2022	0.00	0.04	0.00	0.00	
	13/09/2022	0.00	0.05	0.04	0.04	
	11/10/2022	0.00	0.00	0.00	0.00	
	29/11/2022	0.00	0.00	0.25	0.33	
KILKIERAN BAY						
BRADAN BEO TEO.						
Ardmore						
Atlantic Salmon, 2022 S 1/2	21/12/2022	0.00	1.95	0.00	0.02	
	15/02/2022	0.12	2.84	0.00	0.00	
	04/03/2022	0.24	10.71	0.00	0.00	
	30/03/2022	1.92	6.29	0.00	0.00	
	08/04/2022	0.65	1.89	0.00	0.00	
	28/04/2022	0.16	2.77	0.00	0.00	
	12/05/2022	0.23	7.02	0.00	0.00	
	31/05/2022	3.09	10.24	0.03	0.05	
	24/06/2022	0.25	1.86	0.00	0.07	
	19/07/2022	0.43	0.78	0.08	0.08	
	15/08/2022	0.02	0.02	0.00	0.00	
	23/09/2022	0.00	0.04	0.00	0.00	
	12/10/2022	0.07	0.15	0.03	0.06	
	29/11/2022	0.15	0.38	0.12	0.12	
Cnoc						
Atlantic Salmon, 2021	21/12/2022	0.21	9.70	0.00	0.00	
	15/02/2022	1.48	15.53	0.00	0.00	n<10
	18/03/2022	0.42	5.40	0.00	0.00	n<10
	25/03/2022	1.31	4.20	0.02	0.04	
			Transferred to Daonish			

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
Daonish					
Atlantic Salmon, 2021 S1/2	21/12/2022	0.54	4.55	0.00	0.02
	15/02/2022	2.31	25.04	0.07	0.25
	18/03/2022	0.49	4.84	0.02	0.03
	25/03/2022	0.32	1.34	0.00	0.00
	15/04/2022	0.13	0.90	0.00	0.00
	28/04/2022	1.56	5.63	0.00	0.00
	11/05/2022	0.52	3.58	0.00	0.00
	31/05/2022	0.75	2.08	0.00	0.00
			Harvested Out		

BERTRAGHBOY BAY

BIFAND LTD./MOWI IRL.

Sealax

Atlantic Salmon, 2022 S 1/2	17/12/2022	0.00	0.00	0.05	0.07
	03/02/2022	0.00	0.03	0.81	0.92
	03/03/2022	0.06	0.85	1.34	1.97
	29/03/2022	0.03	0.22	0.00	0.00
	05/04/2022	0.03	0.24	0.00	0.00
	21/04/2022	0.02	0.44	0.00	0.00
	04/05/2022	0.04	1.02	0.00	0.00
	18/05/2022	0.25	2.49	0.00	0.02
	21/06/2022	2.21	4.92	0.07	0.20
	05/07/2022	1.52	2.50	0.02	0.07
	17/08/2022	0.00	0.12	0.00	0.00
	09/09/2022	0.00	0.02	0.00	0.00
	25/10/2022	0.00	0.00	0.00	0.00
	28/11/2022	0.00	0.00	0.00	0.00

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
BALLINAKILL HARBOUR					
BIFAND LTD.					
Fraochoilean					
Atlantic Salmon, 2021 S1/2	28/01/2022	0.75	4.47	0.07	0.10
	08/02/2022	0.45	49.04	0.09	0.22
	11/03/2022	0.62	6.65	0.02	0.05
	22/03/2022	0.07	0.61	0.00	0.00
			Harvested Out		
KILLARY HARBOUR					
ROSROE SALMON LTD.					
Rosroe					
Atlantic Salmon, 2022 S 1/2	16/12/2022	0.00	0.00	0.00	0.07
	25/02/2022	0.04	0.61	0.06	0.09
	09/03/2022	0.05	0.68	0.11	0.14
	28/03/2022	0.02	0.50	0.00	0.00
	07/04/2022	0.12	0.45	0.00	0.00
	22/04/2022	0.04	0.26	0.00	0.00
	05/05/2022	0.16	1.01	0.00	0.08
	19/05/2022	0.18	2.23	0.00	0.02
	13/06/2022	0.71	4.66	0.02	0.12
	18/07/2022	0.34	2.66	0.02	0.02
	18/08/2022	0.00	0.08	0.00	0.00
	14/09/2022	0.02	0.97	0.25	0.55
	17/10/2022	0.00	0.20	0.02	0.07
	08/11/2022	0.00	0.13	0.22	0.37

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
CLEW BAY					
CLARE ISLAND SEAFARMS LTD.					
Clare Island Smolt Site					
Atlantic Salmon, 2021	26/05/2022	0.30	1.62	0.00	0.04
	14/06/2022	0.18	0.99	0.02	0.05
	21/07/2022	1.01	3.59	0.93	1.16
	23/08/2022	0.90	3.58	0.72	1.19
	08/09/2022	0.16	1.85	0.38	0.69
	10/10/2022	0.10	2.67	0.67	1.00
			Harvested Out		
Portlea					
Atlantic Salmon, 2020			Harvested Out		
Atlantic Salmon, 2022	26/05/2022	0.00	0.00	0.05	0.09
	14/06/2022	0.00	0.00	0.00	0.13
	21/07/2022	0.00	0.05	0.04	0.13
	23/08/2022	0.00	0.07	0.02	0.09
	08/09/2022	0.00	0.02	0.00	0.02
	10/10/2022	0.00	0.00	0.00	0.07
	03/11/2022	0.00	0.02	0.08	0.13
Seastream Innishcannon					
Atlantic Salmon, 2021	14/01/2022	0.03	0.13	8.94	16.71
	14/02/2022	0.20	1.00	11.13	22.17
	02/03/2022	0.23	0.61	5.58	12.68
	23/03/2022	0.24	1.88	3.82	9.03
	13/04/2022	0.18	1.94	0.03	0.06
	26/04/2022	0.43	1.25	0.00	0.00
	13/05/2022	0.48	1.70	0.00	0.03
			Transferred to Clare Island Smolt Site		
Seastream Innishcorragh					
Atlantic Salmon, 2021	14/01/2022	0.00	0.07	7.45	12.66
	14/02/2022	0.03	0.13	4.81	12.32
	02/03/2022	0.00	0.27	4.54	11.72
	23/03/2022	0.00	0.95	3.49	10.78
	13/04/2022	0.19	0.77	0.02	0.05
	26/04/2022	0.29	0.79	0.00	0.02
	13/05/2022	0.42	1.32	0.00	0.00
			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, 2021 S1/2	14/01/2022	0.00	0.17	0.07	0.07
	14/02/2022	0.08	0.45	0.08	0.15
	02/03/2022	0.04	0.68	0.06	0.09
	23/03/2022	0.27	3.40	0.30	0.63
	13/04/2022	0.26	2.94	0.12	0.23
	26/04/2022	0.20	3.03	0.33	0.80
			Harvested Out		

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
DONEGAL BAY					
MOWI IRL.					
Creevin					
Atlantic Salmon, 2022 S1/2	05/01/2022	0.00	0.01	0.00	0.07
	25/02/2022	0.02	0.10	0.16	0.40
	08/03/2022	0.00	0.10	0.15	0.32
	30/03/2022	0.06	0.43	0.02	0.05
	07/04/2022	0.03	0.33	0.00	0.00
	19/04/2022	0.00	0.17	0.00	0.00
	06/05/2022	0.05	0.51	0.00	0.02
	23/05/2022	0.05	1.05	0.00	0.04
	15/06/2022	0.47	1.30	0.00	0.03
	20/07/2022	0.25	1.10	0.00	0.00
	24/08/2022	0.00	0.00	0.00	0.00
	22/09/2022	0.00	0.00	0.00	0.00
	13/10/2022	0.00	0.00	0.00	0.00
	14/11/2022	0.02	0.03	0.00	0.02
Eany					
Atlantic Salmon, 2022 S1/2	05/01/2022	0.00	0.11	0.10	0.29
	25/02/2022	0.00	0.11	0.13	0.43
	08/03/2022	0.00	0.00	0.20	0.30
	30/03/2022	0.13	1.02	0.00	0.02
	07/04/2022	0.14	0.89	0.00	0.00
	19/04/2022	0.12	0.73	0.02	0.02
	06/05/2022	0.10	1.18	0.00	0.03
	23/05/2022	0.58	1.35	0.00	0.04
	15/06/2022	0.35	1.68	0.15	0.18
	20/07/2022	0.06	2.03	0.00	0.00
			Transferred to Creevin		

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
OCEAN FARM LTD.					
Mc Swynes					
Atlantic Salmon, 2021 S1/2	17/01/2022	0.88	3.97	0.00	0.00
	25/02/2022		Missed due to weather		
	09/03/2022	0.49	3.19	0.00	0.08
	30/03/2022	0.14	3.60	0.07	0.12
	08/04/2022	0.55	18.63	0.09	0.60
	27/04/2022	0.20	2.07	0.00	0.07
	04/05/2022	1.49	15.32	0.21	1.35
	30/05/2022	0.20	0.77	0.00	0.00
			Harvested Out		
Ocean Inver					
Atlantic Salmon, 2022 S1/2	17/01/2022	0.00	0.06	0.16	0.30
	25/02/2022	0.00	0.33	0.60	1.45
	09/03/2022	0.02	0.56	0.87	1.41
	30/03/2022	0.14	0.94	1.34	2.43
	08/04/2022	0.26	1.15	1.23	2.54
	27/04/2022	0.06	1.05	0.00	0.06
	04/05/2022	0.09	1.31	0.07	0.13
	23/05/2022	0.23	1.33	0.00	0.00
	15/06/2022	0.51	1.13	0.02	0.03
	20/07/2022	0.02	0.25	0.02	0.02
	23/08/2022	0.00	0.00	0.00	0.00
	22/09/2022	0.00	0.00	0.00	0.02
	13/10/2022	0.00	0.00	0.00	0.00
	14/11/2022	0.00	0.00	0.00	0.00

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
MULROY BAY					
MOWI IRL.					
Cranford B					
Atlantic Salmon, 2021	17/12/2022	0.00	0.00	0.02	0.02
	17/02/2022	0.02	0.10	0.14	0.29
			Harvested Out		
Glinsk					
Atlantic Salmon, 2022	19/04/2022	0.00	0.04	0.00	0.00
	05/05/2022	0.00	0.12	0.00	0.05
	24/05/2022	0.02	0.35	0.02	0.03
	14/06/2022	0.00	0.22	0.00	0.03
	21/07/2022	0.02	0.35	0.02	0.04
	24/08/2022	0.00	0.00	0.02	0.04
	21/09/2022	0.00	0.00	0.19	0.42
			Transferred to Lough Swilly		
Millstone					
Atlantic Salmon, 2021	17/12/2022	0.00	0.00	0.00	0.02
	17/02/2022	0.00	0.05	0.32	0.50
	15/03/2022	0.05	0.10	0.16	0.19
	31/03/2022	0.05	0.14	0.19	0.37
	13/04/2022	0.00	0.19	0.14	0.32
	20/04/2022	0.00	0.06	0.13	0.16
	05/05/2022	0.02	1.32	0.27	0.85
			Harvested Out		

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
LOUGH SWILLY					
Lough Swilly					
Atlantic Salmon, 2021	17/12/2022	0.02	0.05	1.08	2.12
	17/02/2022	0.12	0.49	2.69	5.38
	15/03/2022	0.07	1.03	2.11	5.20
	31/03/2022	0.09	1.30	2.58	5.54
	13/04/2022	0.20	0.89	1.70	3.18
	20/04/2022	0.17	0.67	0.78	1.59
	05/05/2022	0.11	1.31	1.43	3.90
	24/05/2022	0.25	0.87	0.33	0.47
	14/06/2022	0.27	1.05	0.18	0.30
				Harvested Out	
Atlantic Salmon, 2022	12/10/2022	0.00	0.00	0.13	0.34
	09/11/2022	0.02	0.42	3.20	6.70

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