Irish Fisheries Bulletin

No. 46 2016

National Survey of Sea Lice (*Lepeophtheirus salmonis* Krøyer and *Caligus elongatus* Nordmann) on Fish Farms in Ireland - 2015

Pauline O'Donohoe

Frank Kane

Suzanne Kelly

Tom McDermott

Alan Drumm

Pat Nixon

Dave Jackson

Marine Institute
Foras na Mara

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Pauline O'Donohoe, Frank Kane, Suzanne Kelly,
Tom McDermott, Alan Drumm, Pat Nixon and Dave Jackson.

Aquaculture Section,
Marine Environment and Food Safety Services,
Marine Institute,
Rinville,
Oranmore,
Co. Galway.

www.marine.ie

http://www.marine.ie/Home/site-area/areas-activity/aquaculture/sea-lice

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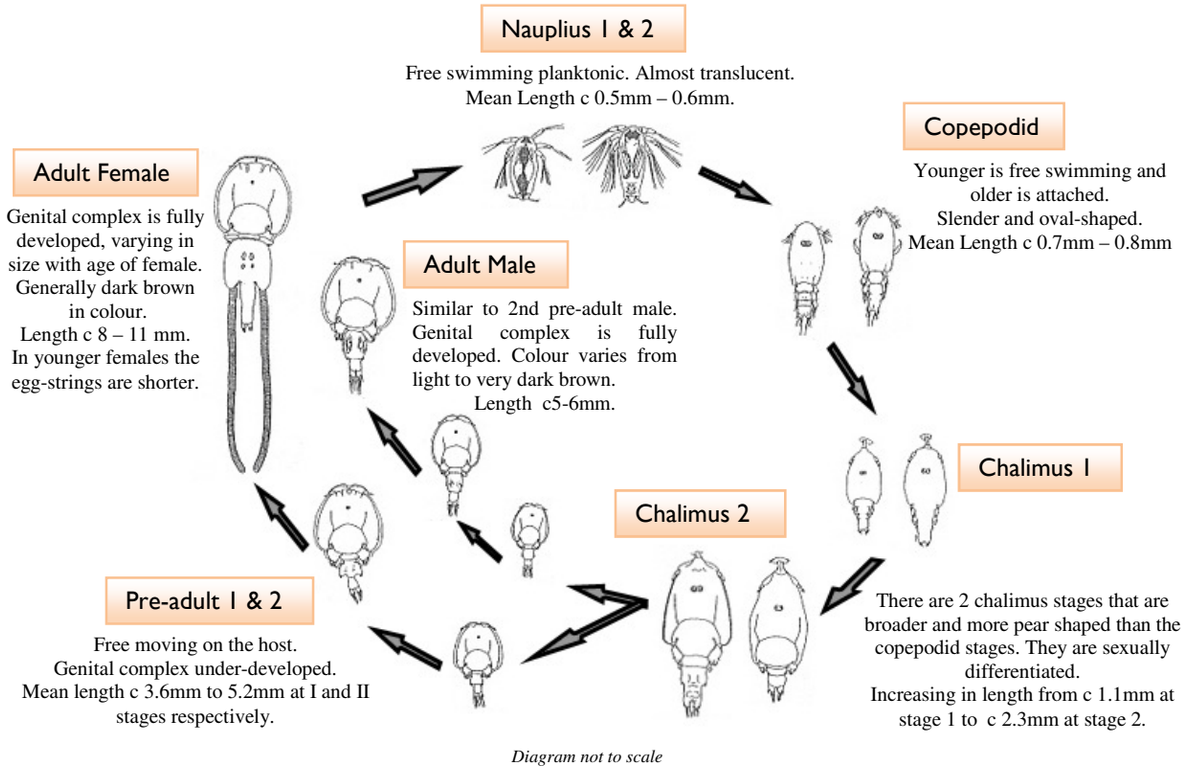
INTRODUCTION

Sea lice are found on wild and cultured salmonids, the two main species found in Ireland are *Caligus elongatus* and *Lepeophtheirus salmonis*. They are small ectoparasitic copepod crustaceans which occur on several species of fish. There are estimated to be approximately 559 species made up of 37 genera (Ahyong *et al*., 2011), including 162 *Lepeophtheirus* species (Chad & Goeff, 2011) and 268 *Caligus* species (Boxshall, 2011). *L. salmonis* infests only salmonids, while *C. elongatus* is known to parasitise over 80 different species of marine fish. *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 in Ireland on a commercial basis, Atlantic salmon *Salmo salar* L. and rainbow trout *Oncorhynchus mykiss* Walbaum.

The lifecycle of *L. salmonis* has 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. The adult female can produce a number of batches of paired egg-strings, which in turn hatch into the water column to give rise to the next generation (Hamre, 2013; Kabata, 1979; Schram, 1993). *L. salmonis* has a single host species in its lifecycle. 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 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 practises.

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 vertical 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 synchronized 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 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 are 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.*, 2003-2015).

Sea Lice Control Methods

The sea lice control and management strategy process includes the use of husbandry, management practices and chemotherapeutants to control the numbers of sea lice on farms. Table 1 shows a list of the veterinary medicines authorised to assist in the control of sea lice in Ireland. These can either 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 by using tarpaulins or skirts to enclose the salmon net-pens, or by use of well-boats. Medicines incorporated into the diet are a very efficient way to get the required dose to the fish. Inappetence and the natural hierarchy that exist within a cage can lead to reduction in efficacy of treatments. This may act as a source of re-infestation in the short term and lead to development of resistance in time.

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 but recent interest has mainly been in stocking ballan wrasse *Labrus bergylta* (Treasurer, 2013). Studies in Norway indicate that lumpfish *Cyclopterus lumpus* is a suitable cold-water option for biological delousing of Atlantic salmon (Imsland, 2014). Lumpfish are currently being trialed on farms in Ireland as part of a sea lice management plan.

Mechanical delousing devices have been used at a number of sites. Results have been optimistic, these devices may become important in sea lice management in the future. 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). A surface skimmer for removing dislodged sea lice from the water following a treatment is also in use in some locations.

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
Teflubenzuron	Insect Growth Regulator	Full MA	In-feed	Inhibits chitin synthesis preventing moulting and growth. Limited efficacy beyond medication period. Not authorized for use below 9°C	Moulting stages - Chalimus, Preadults only	45 degree-days
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 and rainbow trout 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 estimate the breeding female population and total mobile levels estimate 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 drop in sea lice levels on the subsequent inspection.

In 2015, salmonid farms were producing 2 different stocks of fish: 2014 Atlantic salmon (one-sea-winter salmon) and 2015 Atlantic salmon (smolts). Rainbow trout were not stocked in this period.

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. In 2015 a total number of 20 sites were inspected around Ireland, see Figure 2.

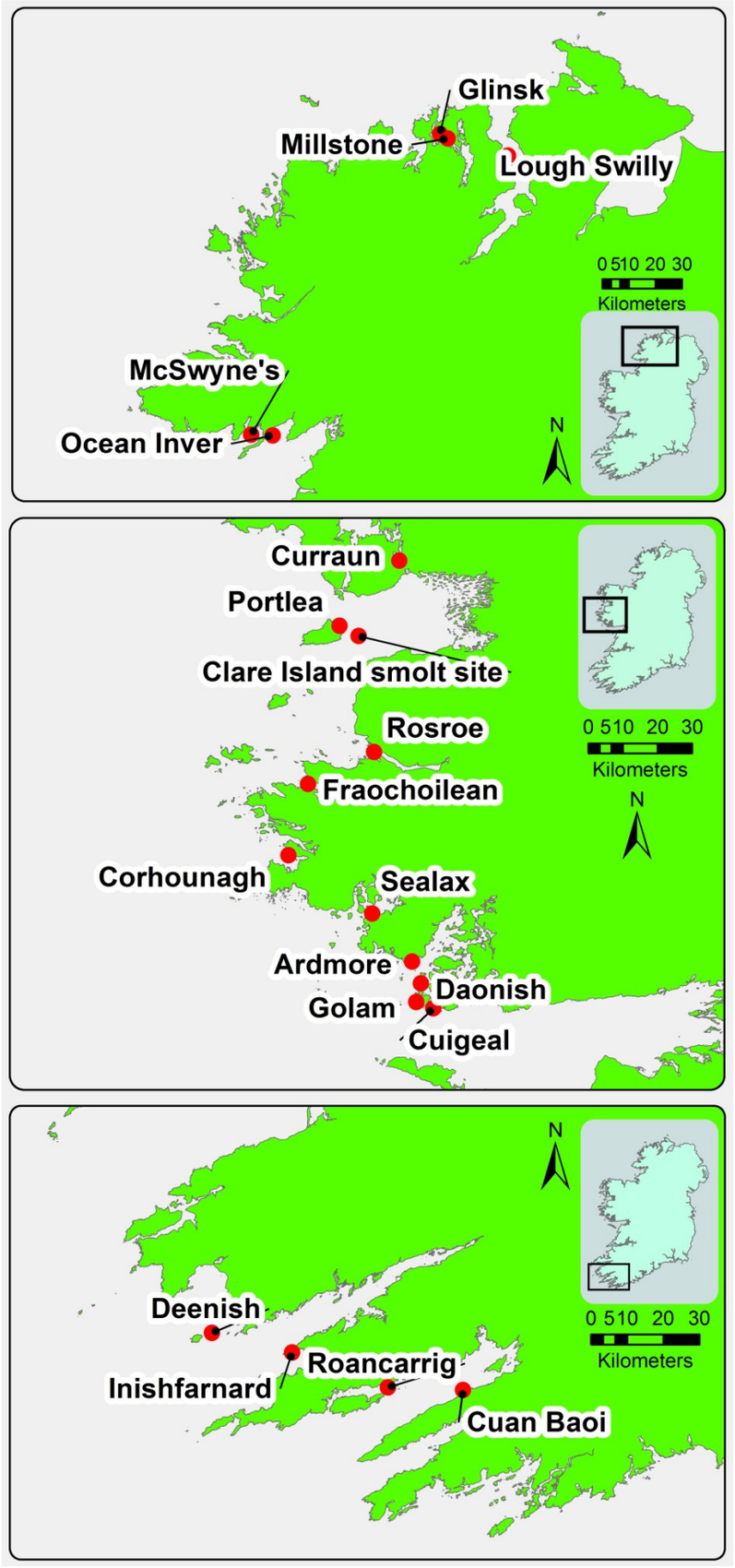


Figure 2. *Locations of fish farm sites.*

RESULTS

During 2015 a total of 212 sea lice inspections were carried out on the 20 active farm sites. Over 86% 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 98 inspections carried out on salmon smolts, 97% were below the TTL and 78% of the 113 inspections carried out on one-sea-winter salmon were below TTL. Neither two-sea-winter salmon nor rainbow trout were stocked in 2015.

Results of 2015 sea lice inspections of all active salmonid sites for each month are presented in Appendix 1.

Atlantic salmon 2014 (one-sea-winter salmon)

One-sea-winter salmon were stocked in a total of 13 sites in 9 bays in 2015. One hundred and thirteen visits were undertaken to this generation of fish. Two sites continued to stock one-sea-winter salmon in November 2015.

Ovigerous *L. salmonis* levels greater than the TTL were recorded in a total of 25 inspections (22%) 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 12 inspections (19%) and outside of the spring period 13 inspections (27%) were in excess of 2.0 ovigerous female *L. salmonis* per fish.

Table 2. *Summary of inspections results on one-sea-winter (1SW) salmon nationally in 2015.*

	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	64	12	49	13	113	25	19%	27%	22%

C. elongatus levels greater than 10 individuals per fish were not recorded at any site throughout the year.

Southwest Region

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

Table 3. *Summary of inspections results on 1SW salmon in the Southwest in 2015.*

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
Murphy's Irish Seafood Ltd	**Cuan Baoi**	6	0	4	0	10	0	0%	0%	0%
Marine Harvest Ireland	**Roancarraig- Ahabeg**	6	0	2	0	8	0	0%	0%	0%
	Inishfarnard	6	0	8	0	14	0	0%	0%	0%
Southwest	**Totals**	18	0	14	0	32	0	0%	0%	0%

West Region

In the West, *L. salmonis* infestation levels greater than the treatment trigger were recorded on 10 out of 28 inspections (36%) in the spring period and on 9 out of 23 inspections (39%) outside the spring period (Table 4).

Table 4. *Summary of inspections results on 1SW salmon in the West in 2015.*

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
Marine Harvest Ireland	**Ardmore**	7	3	2	0	9	3	43%	0%	33%
Bradan Beo Teo	**Daonish**	6	0	3	0	9	0	0%	0%	0%
Mannin Bay Salmon Co Ltd	**Corhounagh**	2	2	2	2	4	4	100%	100%	100%
Rosroe Salmon ltd	**Corhounagh**	1	1	4	3	5	4	100%	75%	80%
	Rosroe	6	3	4	1	10	4	50%	25%	40%
Clare Island Seafarms Ltd	**Portlea**	6	1	8	3	14	4	0%	38%	29%
West	**Totals**	28	10	23	9	51	19	36%	39%	37%

At Corhounagh in Mannin Bay, *L. salmonis* exceeded treatment trigger levels for all of the 3 inspections in the spring and 5 of the 6 inspection outside the spring period.

Levels at Rosroe, Killary Harbour, were above treatment trigger levels for 3 of the 6 inspections in the spring and 1 of the 4 inspections outside the spring. Portlea, Clew Bay, exceeded levels for 1 of the 6 spring inspections and for 3 of the 8 inspections outside the spring period. Ardmore, Kilkieran Bay reached TTLs for 3 of the 7 spring inspections but none of the 2 inspections outside spring.

Northwest Region

The treatment trigger levels were exceeded on 2 of the 18 inspections in the spring and 4 of the 13 inspections outside the spring period in the Northwest (Table 5).

Table 5. *Summary of inspections results on 1SW salmon in the Northwest in 2015.*

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.	**Ocean Inver**	6	2	4	3	10	5	33%	75%	50%
Marine Harvest Ireland	**Glinsk**	2	0	2	0	4	0	0%	0%	0%
	Millstone	6	0	4	0	10	0	0%	0%	0%
	Lough Swilly	4	0	3	1	7	1	0%	33%	14%
Northwest	**Totals**	18	2	13	4	31	6	11%	31%	19%

OceanInver, Donegal Bay, exceeded treatment trigger levels on 2 of the 6 spring inspections, and also on 3 of the 4 inspections outside the spring period.

Atlantic salmon 2015 (smolts)

A total of 98 inspections were made to 11 sites stocking Atlantic salmon 2015 S1 and S½ smolts during the year 2015. *L. salmonis* levels were below the TTL of 0.5 ovigerous female lice per fish for all of the 36 inspections in the spring period and for 59 of the 62 samples outside of this period (Table 6).

Table 6. *Summary of inspections results on salmon smolts nationally in 2015.*

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
Marine Harvest Ireland	**Roancarraig-Ahabeg**	6	0	8	0	14	0	0%	0%	0%
	Deenish	6	0	6	0	12	0	0%	0%	0%
Southwest	**Totals**	12	0	14	0	26	0	0%	0%	0%
Bradan Beo Teo	**Cuigeal**	0	0	4	0	4	0	0%	0%	0%
	Daonish	0	0	2	0	2	0	0%	0%	0%
	Golam	6	0	2	0	8	0	0%	0%	0%
Comhlucht Bradain Chonamara Teo	**Sealax**	3	0	6	0	9	0	0%	0%	0%
Bifand Ltd	**Fraochoilean**	6	0	8	1	14	1	0%	13%	7%
Clare Island Seafarms Ltd	**Clare Island smolt site**	0	0	6	1	6	1	0%	17%	17%
Curraun Blue Ltd	**Curraun**	6	0	8	0	14	0	0%	0%	0%
West	**Totals**	21	0	36	2	57	2	0%	6%	4%
Ocean Farm Ltd	**McSwyne's**	1	0	6	0	7	0	0%	0%	0%
Marine Harvest Ireland	**Glinsk**	2	0	6	1	8	1	0%	17%	13%
Northwest	**Totals**	3	0	12	1	15	1	0%	8%	7%
National Totals		36	0	62	3	98	3	0%	5%	3%

C. elongatus levels were greater than 10 individuals per fish on one occasion in July on these fish.

Sampling record

One sample was missed due to fish health issues in the 2015 sampling year.

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 7 of the 25 occasions. Of these there were 2 in Mannin Bay, 2 in Killary Harbour and one each in Kilkieran bay, Clew Bay and Donegal Bay.

Bay mean ovigerous levels of 2.0 ovigerous females per fish or greater were recorded on 12 out of 43 occasions, outside of the spring period, These occurred in Mannin Bay on 5 occasions, Clew Bay on 3, Donegal Bay on 2 and in Killary Harbour and Lough Swilly on one occasion each.

Mean mobile levels per bay in excess of 10 *L. salmonis* per fish were recorded on 10 occasions, 4 of these instances had means of greater than 20 mobile lice per fish. The maximum bay mean level recorded was 71.5 mobile sea lice per fish, in Mannin Bay in September.

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 2015.*

Mean ovigerous *L. salmonis*

	Dec/ Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Bantry Bay	0.06	0.29	0.25	0.16	0.13	0.71	HO		0.12	HO	
Kenmare Bay	0.02	0.03	0.10	0.21	0.02	0.00	0.00	0.18	0.00	0.08	0.07
Kilkieran Bay	0.98	1.17	0.82	0.43	0.22	0.57	HO				
Mannin Bay	8.28	10.00	8.47	HO	3.19	1.05	4.27	4.33	16.67	HO	
Killary Harbour	0.97	1.81	1.43	0.66	0.39	1.80	4.71	HO			
Clew Bay	0.20	0.17	0.28	0.57	0.44	0.43	0.77	3.23	14.31	2.66	0.40
Donegal Bay	2.78	4.00	1.46	0.35	0.09	0.48	HO				
Mulroy Bay	0.02	0.00	0.04	0.02	0.07	0.40	1.06	HO			
Lough Swilly	HO			0.02	0.03	0.45	0.53	6.52	HO		

Mean mobile *L. salmonis*

	Dec/ Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Bantry Bay	0.39	1.50	1.50	1.35	3.29	1.81	HO		0.16	HO	
Kenmare Bay	0.26	0.45	0.46	1.95	0.02	0.04	0.00	0.35	0.09	0.34	0.24
Kilkieran Bay	3.07	3.11	3.37	1.41	2.92	1.44	HO				
Mannin Bay	16.55	15.95	15.82	HO	6.97	3.84	27.10	8.76	71.50	HO	
Killary Harbour	7.45	9.56	9.28	8.16	8.15	10.54	15.62	HO			
Clew Bay	0.70	1.17	1.02	3.90	1.38	1.31	2.18	14.01	37.02	10.16	1.60
Donegal Bay	8.97	7.02	3.28	3.03	0.48	0.87	HO				
Mulroy Bay	0.07	0.02	0.08	0.06	0.25	0.91	4.87	HO			
Lough Swilly	HO			0.07	0.22	1.04	1.64	21.27	HO		

Mean ovigerous *C. elongatus*

	Dec/ Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Bantry Bay	0.34	0.69	0.62	0.42	0.92	0.33	HO		0.12	HO	
Kenmare Bay	0.09	0.07	0.01	0.00	0.00	0.00	0.33	0.20	0.04	0.02	0.04
Kilkieran Bay	0.00	0.02	0.01	0.00	0.01	0.00	HO				
Mannin Bay	0.04	0.04	0.04	HO	0.00	0.00	0.00	0.00	0.13	HO	
Killary Harbour	0.00	0.00	0.00	0.00	0.00	0.05	0.00	HO			
Clew Bay	0.94	3.52	0.45	0.98	0.02	0.00	0.49	4.23	0.12	0.00	0.00
Donegal Bay	0.41	0.00	0.05	0.11	0.01	0.16	HO				
Mulroy Bay	0.06	0.01	0.03	0.00	0.01	0.10	0.33	HO			
Lough Swilly	HO			0.03	0.05	0.00	0.03	0.23	HO		

Mean mobile *C. elongatus*

	Dec/ Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Bantry Bay	0.90	1.90	1.76	1.02	2.43	0.76	HO		0.28	HO	
Kenmare Bay	0.18	0.20	0.06	0.02	0.01	0.07	0.67	0.48	0.04	0.10	0.04
Kilkieran Bay	0.00	0.02	0.01	0.00	0.01	0.00	HO				
Mannin Bay	0.04	0.04	0.04	HO	0.00	0.00	0.00	0.00	0.19	HO	
Killary Harbour	0.00	0.00	0.00	0.00	0.00	0.05	0.03	HO			
Clew Bay	1.99	7.61	0.64	2.15	0.02	0.00	1.12	8.03	0.12	0.00	0.00
Donegal Bay	0.81	0.00	0.14	0.20	0.02	0.16	HO				
Mulroy Bay	0.11	0.11	0.08	0.02	0.02	0.13	0.60	HO			
Lough Swilly	HO			0.03	0.16	0.02	0.03	0.48	HO		

HO = Harvested out

Regional monthly means for one-sea-winter salmon

L. salmonis ovigerous and mobile monthly mean levels per fish for one-sea-winter salmon regionally are shown in Figures 3 and 4. In the spring period of 2015 the ovigerous mean sea lice levels per fish exceeded TTLs for March, April and May in the West, and for March in the Northwest.

Outside the spring regional mean ovigerous *L. salmonis* levels per fish were in excess of TTL in January, February, July, August, September and October in the West and August in the Northwest.

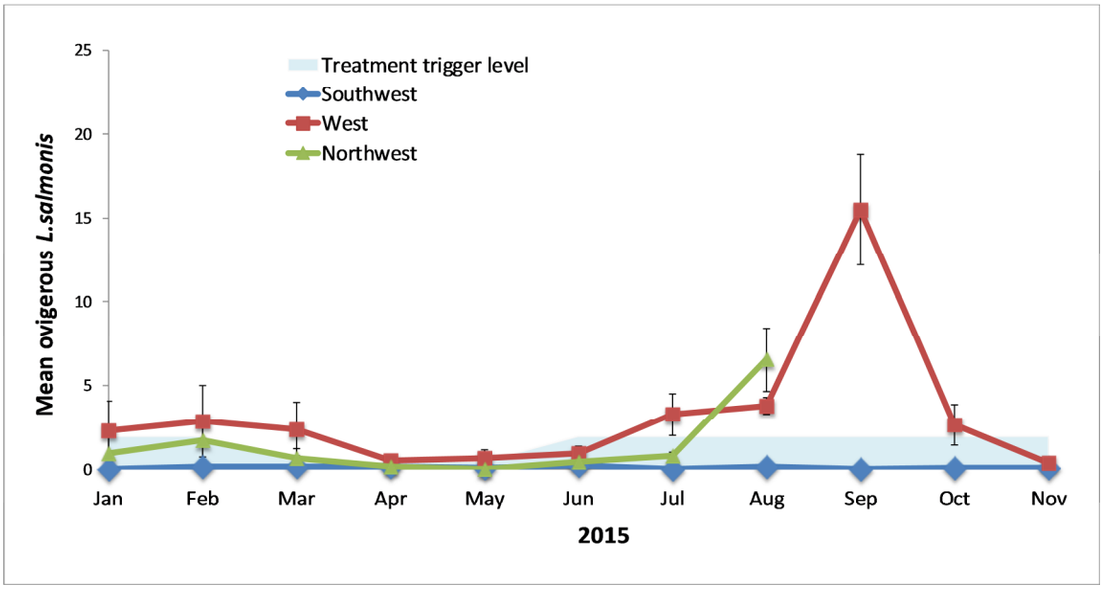


Figure 3. *Mean (SE) ovigerous L. salmonis per fish per month per region in 2015 on one-sea-winter fish.*

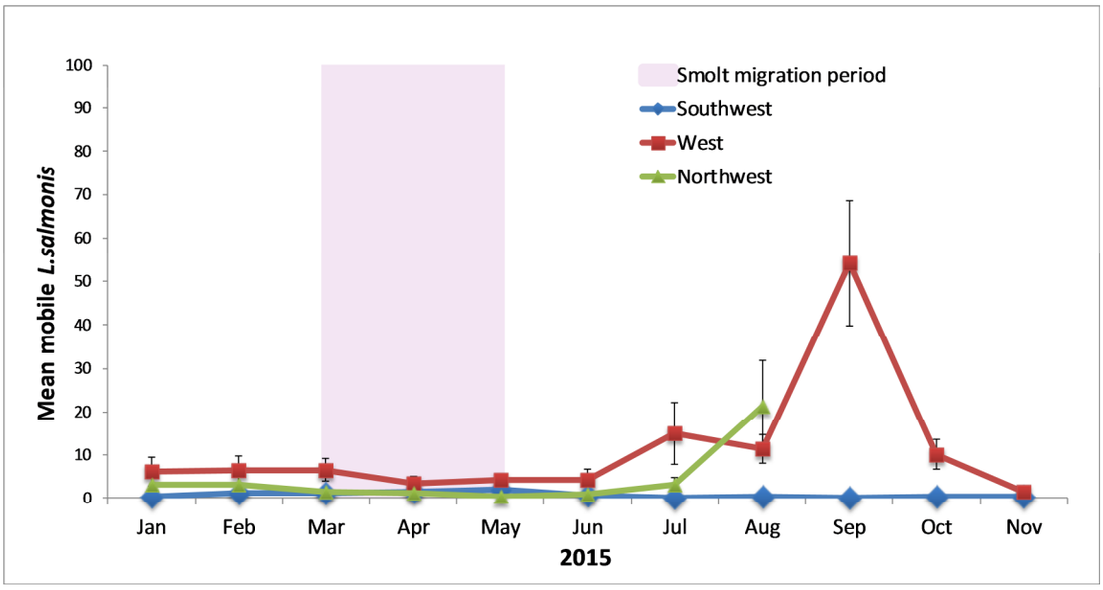


Figure 4. *Mean (SE) mobile L. salmonis per fish per month per region in 2015 on one-sea-winter fish.*

Total mobile *L. salmonis* levels exceeded 10 sea lice per fish in July, August, September and October in the West, in August in the Northwest but on no occasion in the Southwest. Total regional mean mobile *L. salmonis* levels peaked at 1.98 mobile sea lice per fish in the Southwest, 54.26 mobile sea lice per fish in the West and at 21.27 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 Figures 5 and 6 for one-sea-winter salmon in the month of May from 1991 to 2015.

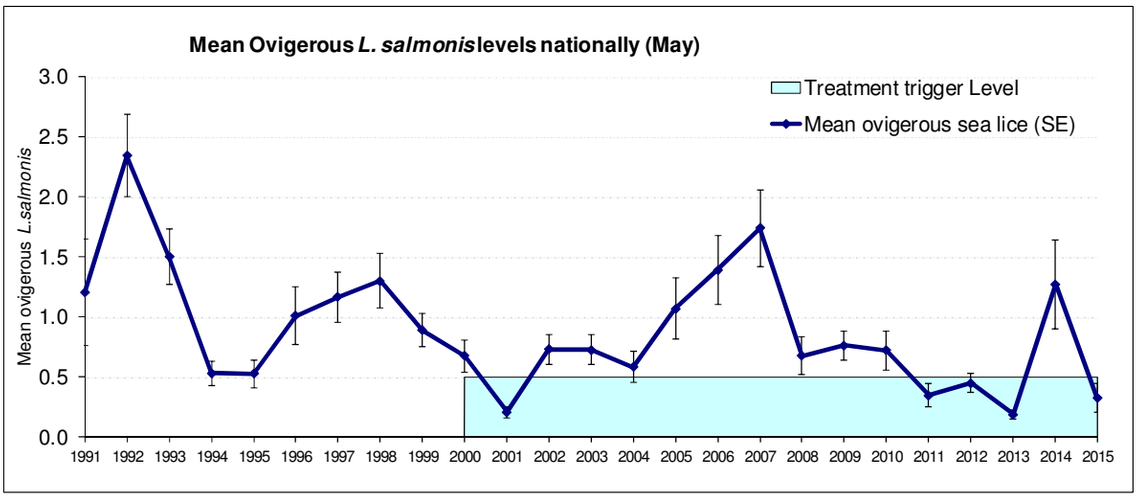


Figure 5. *Annual trend (May mean) (SE) ovigerous L. salmonis on one-sea-winter salmon.*

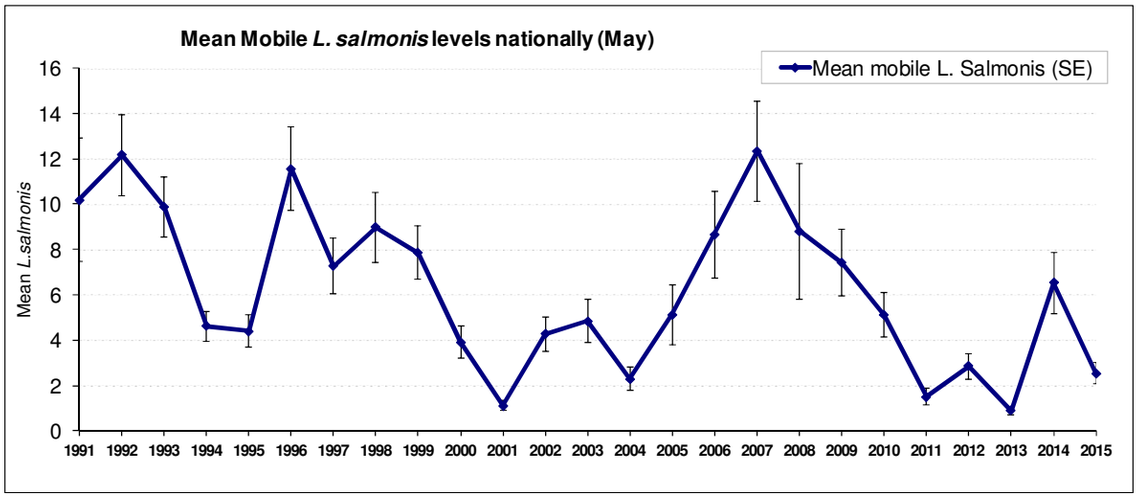


Figure 6. *Annual trend (May mean) (SE) mobile L. salmonis on one-sea-winter salmon.*

Mean ovigerous *L. salmonis* levels in May of 2015 dropped to 0.33 sea lice per fish, compared to 1.27 in 2014 and 0.19 in 2013 which were the lowest on record. Total mobile levels also decreased from 6.25 sea lice per fish in 2014 to 2.53 sea lice per fish in May of 2015.

DISCUSSION

As has been the case in previous years, sea lice levels on smolts in 2015 were low. Ninety seven percent of sea lice inspections on smolts were below the Treatment Trigger Levels (TTL), this compares with 94% in 2014 and 100% in 2013.

Sea lice levels on one-sea-winter salmon decreased in 2015 compared to 2014. In 2015 78% of inspections were below TTL compared to 71% in 2014 and 82% in 2013. During the spring period in the Northwest 81% of inspections were below the TTL compared to 61% in 2014. In the West, for the same period, 63% were below TTL which is a slight increase from 61% on 2014. The Southwest continued to have no breaches of protocol levels in 2015. Outside of the spring period the sea lice levels for one-sea-winter salmon show that 69% of inspections were below TTL in the Northwest, 61% were below in the West and 100% in the Southwest. These compare to 48% in the Northwest, 62% below in the West, and 100% in the Southwest during 2014.

Sea lice levels in excess of 10 *L. salmonis* mobiles per fish on one-sea-winter salmon nationally were recorded on 13 occasions, compared to 23 occasions in 2014 and 13 in 2013, 4 of these inspections had means of greater than 20 mobile *L. salmonis* per fish which was less than 2014, when 11 inspection recorded sea lice levels in excess of 20 mobile *L. salmonis* per fish. One of these inspections had levels greater than 40 *L. salmonis* per fish, compared to 4 in 2014. The highest mean sea lice level recorded for one-sea-winter salmon was 71.5 mobile *L. salmonis* per fish, this compares to 137.6 mobile *L. salmonis* per fish in 2014 and 84.02 mobile *L. salmonis* per fish in 2013. There were no unusually high numbers of *Caligus elongatus* recorded in 2015.

The greatest improvement in sea lice numbers in 2015 was on grower fish in the Northwest; in spring the number of inspections below TTLs increased from 61% in 2014 to 81%, and from 48% to 69% outside spring. The regional plot shows that sea lice numbers did not increase in the autumn for 2015, as it had done in 2014.

Continuous on-farm sea lice checks have facilitated early intervention resulting in better sea lice control generally. The use of alternative approaches to complement husbandry and medicinal treatments, coupled with rigorous pro-active regulatory oversight, has led to improved sea lice levels over all in Ireland during 2015.

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 less were inspected in one or both cages sampled.
Ovigerous lice:	An egg bearing adult female sea lice.
Random (Ran.) Cage:	A cage 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.) Cage:	The selected cage 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 exposed to manipulated photoperiods to hasten the onset of smoltification. Hence 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.

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APPENDIX 1. MEAN SEA LICE LEVELS ON SALMONID FARMS IN 2015.

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
BANTRY BAY					
MARINE HARVEST IRL.					
Roancarraig-Ahabeg					
Atlantic Salmon, 2014 S1/2	19/01/2015	0.08	0.46	0.19	0.87
	04/02/2015	0.41	2.16	0.95	2.63
	10/03/2015	0.31	1.74	0.82	2.01
	18/03/2015	0.35	2.26	0.77	2.23
	10/04/2015	0.34	2.97	0.96	2.49
	30/04/2015	0.00	0.02	0.00	0.00
	15/05/2015	0.00	1.15	0.12	1.68
	27/05/2015	0.00	6.41	1.73	3.80
			Harvested Out		
Atlantic Salmon, 2015 S1/2	19/01/2015	0.00	0.05	0.09	0.40
	04/02/2015	0.00	0.10	0.14	0.92
	10/03/2015	0.00	0.23	0.06	0.12
	18/03/2015	0.00	0.21	0.13	0.95
	10/04/2015	0.02	0.18	0.00	0.07
	22/04/2015	0.00	0.23	0.00	0.00
	15/05/2015	0.02	0.78	0.04	0.10
	27/05/2015	0.04	0.74	0.11	0.28
	17/06/2015	0.02	0.08	0.00	0.02
	14/07/2015	0.09	0.55	1.05	2.32
	12/08/2015	0.05	0.22	2.44	5.30
	16/09/2015	0.00	0.00	0.05	0.46
	30/10/2015	0.00	0.33	0.04	0.06
	24/11/2015	0.17	0.42	0.31	0.45

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
MURPHY'S IRISH SEAFOOD LTD.					
Cuan Baoi					
Atlantic Salmon, 2013			Harvested Out		
Atlantic Salmon, 2014 S1/2	20/01/2015	0.03	0.27	0.63	0.97
	05/02/2015	0.07	0.17	0.17	0.43
	10/03/2015	0.14	0.43	0.36	1.43
	19/03/2015	0.07	0.57	0.17	0.67
	10/04/2015	0.14	1.03	0.24	0.48
	20/04/2015	0.16	1.10	0.35	0.68
	14/05/2015	0.37	1.53	1.17	2.30
	27/05/2015	0.42	3.10	0.65	1.32
	16/06/2015	0.71	1.81	0.33	0.76
	14/07/2015		On starve for harvest		
	14/08/2015		On starve for harvest		
	28/09/2015	0.12	0.16	0.12	0.28
			Harvested Out		
KENMARE BAY					
MARINE HARVEST IRL.					
Deenish					
Atlantic Salmon, 2015 S1/2	13/03/2015	0.00	0.03	0.10	0.24
	19/03/2015	0.00	0.04	0.07	0.24
	09/04/2015	0.02	0.03	0.16	0.21
	21/04/2015	0.00	0.04	0.14	0.33
	14/05/2015	0.00	0.01	0.21	0.34
	26/05/2015	0.00	0.03	0.38	0.66
	18/06/2015	0.00	0.15	0.08	0.22
	15/07/2015	0.00	0.00	0.62	1.18
	11/08/2015	0.02	0.04	1.07	2.16
	15/09/2015	0.00	0.02	0.09	0.15
	29/10/2015	0.11	0.18	0.00	0.02
	23/11/2015	0.10	0.49	0.21	0.44

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
Inishfarnard					
Atlantic Salmon, 2014	19/01/2015	0.02	0.26	0.09	0.18
	05/02/2015	0.03	0.45	0.07	0.20
	13/03/2015	0.02	0.13	0.00	0.04
	18/03/2015	0.19	0.78	0.02	0.09
	09/04/2015	0.04	1.70	0.00	0.04
	21/04/2015	0.39	2.21	0.00	0.00
	15/05/2015	0.03	0.03	0.00	0.00
	26/05/2015	0.00	0.00	0.00	0.02
	17/06/2015	0.00	0.04	0.00	0.07
	14/07/2015	0.00	0.00	0.33	0.67
	12/08/2015	0.18	0.35	0.20	0.48
	16/09/2015	0.00	0.09	0.04	0.04
	29/10/2015	0.08	0.34	0.02	0.10
	23/11/2015	0.07	0.24	0.04	0.04
GREATMAN'S BAY					
BRADAN BEO TEO.					
Cuigeal					
Atlantic Salmon, 2015 S1/2	25/06/2015	0.04	0.22	0.02	0.17
	21/07/2015	0.05	0.22	0.10	0.39
	18/08/2015	0.02	0.05	0.00	0.00
	08/09/2015	0.06	0.08	0.02	0.05
			Transferred to Daonish		
KILKIERAN BAY					
Daonish					
Atlantic Salmon, 2014 S1/2	27/01/2015	1.23	3.91	0.00	0.00
	17/02/2015	0.98	2.66	0.04	0.04
	10/03/2015	0.39	1.55	0.00	0.00
	23/03/2015	0.32	1.81	0.00	0.00
	09/04/2015	0.37	2.65	0.00	0.00
	30/04/2015	0.12	1.27	0.00	0.02
	15/05/2015	0.27	3.49	0.00	0.00
	25/05/2015	0.27	2.27	0.03	0.03
	25/06/2015	0.57	1.44	0.00	0.00
			Harvested Out		
Atlantic Salmon, 2015 S1/2	06/10/2015	0.00	0.05	0.00	0.14
	04/11/2015	0.00	0.04	0.09	0.22

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
Golam					
Atlantic Salmon, 2015 S1/2	27/01/2015	0.05	1.02	0.00	0.00
	17/02/2015	0.05	0.70	0.00	0.00
	10/03/2015	0.05	2.47	0.00	0.00
	23/03/2015	0.00	0.09	0.00	0.00
	09/04/2015	0.00	0.43	0.00	0.00
	30/04/2015	0.00	0.14	0.00	0.00
	15/05/2015	0.00	0.37	0.00	0.00
	25/05/2015	0.00	0.41	0.00	0.00
			Transferred to Cuigeal		
MARINE HARVEST IRL.					
Ardmore					
Atlantic Salmon, 2014 S1/2	27/01/2015	0.73	2.24	0.00	0.00
	12/02/2015	1.36	3.55	0.00	0.00
	13/03/2015	1.16	4.72	0.02	0.02
	27/03/2015	1.42	5.40	0.00	0.00
	07/04/2015	1.23	2.17	0.00	0.00
	17/04/2015	0.16	0.39	0.00	0.00
	21/04/2015	0.27	0.60	0.00	0.00
	07/05/2015	0.02	1.45	0.00	0.00
	26/05/2015	0.31	4.47	0.00	0.00
			Harvested Out		
BERTRAGHBOY BAY					
COMHLUCHT BRADAIN CHONAMARA TEO					
Sealax					
Atlantic Salmon, 2013			Harvested Out		
Atlantic Salmon, 2015	24/04/2015	0.00	0.40	0.00	0.03
	13/05/2015	0.00	0.42	0.00	0.00
	29/05/2015	0.00	0.01	0.00	0.00
	17/06/2015	0.00	0.00	0.02	0.02
	06/07/2015	0.00	0.19	0.02	0.20
	25/08/2015	0.00	0.02	0.02	0.15
	17/09/2015	0.00	0.02	0.02	0.03
	07/10/2015	0.00	0.03	0.10	0.51
	20/11/2015	0.00	0.00	0.13	0.20

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
MANNIN BAY					
MANNIN BAY SALMON COMPANY LTD.					
Corhounagh					
Atlantic Salmon, 2014 S1/2	26/01/2015	8.28	16.55	0.04	0.04
	11/02/2015	10.00	15.95	0.04	0.04
	16/03/2015	10.85	16.80	0.04	0.06
	26/03/2015	6.10	14.84	0.03	0.03
			Harvested Out		
ROSROE SALMON LTD.					
Atlantic Salmon, 2014	27/05/2015	3.19	6.97	0.00	0.00
	12/06/2015	1.05	3.84	0.00	0.00
	24/07/2015	4.27	27.10	0.00	0.00
	26/08/2015	4.33	8.76	0.00	0.00
	17/09/2015	16.67	71.50	0.13	0.19
			Harvested Out		
BALLINAKILL HARBOUR					
BIFAND LTD.					
Fraochoilean					
Atlantic Salmon, 2015 S1/2	03/12/2014	0.00	0.02	0.02	0.52
	05/02/2015	0.02	0.12	0.34	0.59
	09/03/2015	0.03	0.90	0.23	0.39
	18/03/2015	0.14	1.26	0.12	0.25
	08/04/2015	0.16	1.59	0.02	0.03
	22/04/2015	0.06	0.56	0.00	0.00
	12/05/2015	0.00	1.24	0.00	0.00
	28/05/2015	0.22	5.59	0.04	0.09
	24/06/2015	0.31	1.50	0.18	0.52
	14/07/2015	0.20	5.91	0.16	0.90
	19/08/2015	1.14	18.40	0.96	1.74
	28/09/2015	0.72	5.21	0.00	0.00
	06/10/2015	2.45	17.67	0.02	0.09
	23/11/2015	0.96	4.17	0.00	0.00

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
KILLARY HARBOUR					
ROSROE SALMON LTD.					
Rosroe					
Atlantic Salmon, 2014	19/01/2015	0.97	7.45	0.00	0.00
	25/02/2015	1.81	9.56	0.00	0.00
	13/03/2015	1.58	8.72	0.00	0.00
	31/03/2015	1.29	9.85	0.00	0.00
	15/04/2015	0.88	11.50	0.00	0.00
	30/04/2015	0.45	4.83	0.00	0.00
	15/05/2015	0.38	8.16	0.00	0.00
	28/05/2015	0.40	8.14	0.00	0.00
	26/06/2015	1.80	10.54	0.05	0.05
	29/07/2015	4.71	15.62	0.00	0.03
			Harvested Out		
CLEW BAY					
CLARE ISLAND SEAFARMS LTD.					
Clare Island Smolt Site					
Atlantic Salmon, 2015	11/06/2015	0.00	0.14	0.08	0.23
	09/07/2015	0.17	0.91	6.94	14.52
	14/08/2015	0.10	1.30	0.09	0.10
	25/09/2015	1.47	5.55	0.00	0.00
	28/10/2015	2.49	10.86	0.02	0.08
	11/11/2015	0.00	0.75	0.02	0.02
Portlea					
Atlantic Salmon, 2014	23/01/2015	0.20	0.70	0.94	1.99
	06/02/2015	0.17	1.17	3.52	7.61
	10/03/2015	0.23	0.87	0.48	0.61
	19/03/2015	0.34	1.17	0.42	0.68
	02/04/2015	0.65	2.76	0.89	1.71
	22/04/2015	0.49	5.05	1.07	2.59
	14/05/2015	0.44	1.47	0.00	0.00
	27/05/2015	0.45	1.28	0.04	0.04
	11/06/2015	0.43	1.31	0.00	0.00
	09/07/2015	0.77	2.18	0.49	1.12
	14/08/2015	3.23	14.01	4.23	8.03
	25/09/2015	14.31	37.02	0.12	0.12
	28/10/2015	2.66	10.16	0.00	0.00
	26/11/2015	0.40	1.60	0.00	0.00

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
BEALACRAGHER BAY					
CURRAUN BLUE LTD.					
Curraun					
Atlantic Salmon, 2015 S1/2	23/01/2015	0.00	0.20	0.02	0.02
	20/02/2015	0.00	0.07	0.05	0.07
	16/03/2015	0.00	0.02	0.00	0.00
	23/03/2015	0.05	0.07	0.02	0.02
	09/04/2015	0.02	0.13	0.00	0.00
	21/04/2015	0.00	0.15	0.02	0.02
	22/05/2015	0.02	0.21	0.00	0.02
	29/05/2015	0.02	0.11	0.00	0.00
	25/06/2015	0.15	0.81	0.00	0.00
	22/07/2015	0.37	0.83	0.00	0.00
	05/08/2015	0.26	3.66	0.00	0.00
	15/09/2015	1.55	5.57	0.00	0.00
	06/10/2015	1.57	6.52	0.00	0.00
	23/11/2015	0.68	5.19	0.00	0.00
DONEGAL BAY					
OCEAN FARM LTD.					
Mc Swynes					
Atlantic Salmon, 2015	26/05/2015	0.00	0.00	0.29	0.50
	17/06/2015	0.02	0.12	0.38	0.38
	07/07/2015	0.00	0.06	1.36	2.49
	26/08/2015	0.02	0.04	0.14	0.27
	10/09/2015	0.04	0.09	0.02	0.02
	14/10/2015	0.02	0.07	0.04	0.04
	11/11/2015	0.23	0.83	0.13	0.17
Ocean Inver					
Atlantic Salmon, 2014	19/01/2015	2.78	8.97	0.41	0.81
	11/02/2015	3.76	6.93	0.00	0.00
	20/02/2015	4.50	7.21	0.00	0.00
	13/03/2015	2.34	4.35	0.04	0.08
	27/03/2015	1.02	2.74	0.06	0.17
	15/04/2015	0.32	3.42	0.08	0.18
	21/04/2015	0.43	2.25	0.18	0.25
	15/05/2015	0.16	0.75	0.00	0.03
	26/05/2015	0.05	0.35	0.02	0.02
	17/06/2015	0.48	0.87	0.16	0.16
				Harvested Out	

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
MULROY BAY					
MARINE HARVEST IRL.					
Glinsk					
Atlantic Salmon, 2014	18/12/2014	0.00	0.06	0.06	0.14
	10/02/2015	0.00	0.04	0.02	0.22
	10/03/2015	0.00	0.05	0.04	0.11
	26/03/2015	0.00	0.04	0.08	0.19
			Transferred to Lough Swilly		
Atlantic Salmon, 2015	08/05/2015	0.00	0.00	0.00	0.00
	20/05/2015	0.00	0.09	0.05	0.24
	16/06/2015	0.00	0.05	0.03	0.07
	08/07/2015	0.00	0.98	0.21	0.45
	27/08/2015	0.55	9.96	0.00	0.02
	29/09/2015	0.83	15.78	0.00	0.00
	14/10/2015	2.58	8.13	0.02	0.02
	11/11/2015	0.00	0.34	0.02	0.04
Millstone					
Atlantic Salmon, 2014	18/12/2014	0.03	0.08	0.07	0.08
	10/02/2015	0.00	0.00	0.00	0.00
	10/03/2015	0.00	0.02	0.00	0.00
	26/03/2015	0.25	0.31	0.00	0.00
	08/04/2015	0.03	0.10	0.00	0.02
	24/04/2015	0.02	0.02	0.00	0.02
	08/05/2015	0.02	0.15	0.00	0.00
	20/05/2015	0.12	0.36	0.02	0.04
	16/06/2015	0.40	0.91	0.10	0.13
	08/07/2015	1.06	4.87	0.33	0.60
	27/08/2015		Missed due to fish health issues		
			Harvested Out		

	Date	*Lepeophtheirus salmonis*		*Caligus elongatus*	
		F + eggs	Total	F + eggs	Total
LOUGH SWILLY					
Lough Swilly					
Atlantic Salmon, 2014	08/04/2015	0.03	0.09	0.02	0.02
	24/04/2015	0.02	0.06	0.04	0.04
	07/05/2015	0.04	0.14	0.04	0.14
	20/05/2015	0.02	0.30	0.07	0.18
	16/06/2015	0.45	1.04	0.00	0.02
	08/07/2015	0.53	1.64	0.03	0.03
	27/08/2015	6.52	21.27	0.23	0.48
			Harvested Out		

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ISSN 1649-5055

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HEADQUARTERS & LABORATORIES

MARINE INSTITUTE
Rinville
Oranmore
Co. Galway
Tel: +353 91 387 200
Fax: +353 91 387 201
Email: institute.mail@marine.ie

MARINE INSTITUTE REGIONAL OFFICES

MARINE INSTITUTE
Wilton Park House,
Wilton Place,
Dublin 2.
Tel: +353 1 7753900
Fax: +353 91 387201

MARINE INSTITUTE
Furnace
Newport
Co. Mayo
Tel: +353 98 42300
Fax: +353 98 42340