THE OCCURRENCE OF SEA LICE (*LEPEOPHTHEIRUS SALMONIS* KRØYER) ON FARMED SALMON IN IRELAND (1995 TO 2000)

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SUMMARY

Lepeophtheirus salmonis is the most frequently recorded ecto-parasite on farmed salmon in Europe, and parasitises only salmonid fish species. It is regarded as being commercially damaging to farmed salmon, with major economic losses to the fish farming community resulting per annum. *Lepeophtheirus salmonis* is a member of the Family Caligidae and has a direct life cycle.

Annual data from around Ireland are analysed, as well as per region and per bay. Data is compiled up to the year 2000 and results are based on lice inspections undertaken bi-monthly for the months March to May inclusive, and monthly for the remainder of the year, with one exception, December/January, when only one sample was taken. Mean ovigerous and mean mobile lice levels are presented. These estimate, respectively, successful breeding females and successful infection.

Results obtained indicate, to some extent, that control methods on different farms differ in the efficacy they have on sea lice infestation, and that depending on which treatment type is used rates of reduction can be different for various life cycle stages. Overall mean ovigerous and mean mobile lice levels were lower in the year 2000 than in 1999. It was apparent that lateral transfer of sea lice during harvesting did occur at a number of sites in the country. It was also apparent that some individual bays appeared to have a greater control over lice infestation levels than others, especially during the critical spring period March to May. The decrease in the control of infestation levels can possibly be attributed to changes in treatments that occurred during the study period, and also to difficulties in achieving effective treatments due to inclement weather and low water temperatures.

Since the initiation of monitoring in 1991, improved control of sea lice infestation has always been one of the goals of the programme. Single Bay Management (SBM), introduced in 1993 by the Marine Institute, implemented new measures to minimise re-infection by these parasites, with protocols agreed by all salmon producers within each bay. These plans were later extended and incorporated in 1998 into the Co-ordinated Local Aquaculture Management System (CLAMS), aiming to optimise environmental conditions within each bay for all users of the bay.

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INTRODUCTION AND METHODOLOGY

There are two species of salmon lice that parasitise cultured salmonid species. The first, *Caligus elongatus*, parasitises over eighty types of marine fishes, whereas the second, *Lepeophtheirus salmonis*, parasitises only salmon and closely related species such as sea trout and rainbow trout. The results contained here concern the larger species *Lepeophtheirus salmonis,* which is the more important parasite of farmed salmon in Ireland, and indeed the most frequently recorded in Europe (Jackson and Minchin, 1992). Levels of *Caligus elongatus* on salmon tend to be highly variable. This is associated with their non specific host requirements, which when combined with the hosts migrating patterns leads to transfers of these parasites occurring when large shoals of pelagic fish pass by the salmon cages.

Lepeophtheirus salmonis is a member of the Family Caligidae and has a direct life cycle (i.e. a single host). This life cycle comprises ten stages as follows. Following hatching from paired egg strings, two free-living nauplius stages are dispersed into the plankton. These stages are followed by a copepodid stage, which must find a host to develop further. The copepodid then moults through four attached chalimus stages before becoming a mobile pre-adult male or female. There are two pre-adult stages separated by a moult, which is then followed by the fully mature adult. 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 (Kabata, 1979; Schram, 1993).

Sea lice are regarded as having the most commercially damaging effect on cultured salmon in the world with major economic losses to the fish farming community resulting per annum (Bristow and Berland, 1991; Jackson and Costello, 1991). They inflict damage to their hosts through their feeding activity on the host's body (Kabata, 1974; Brandal *et al*., 1976; Jones *et al*., 1990; Jonsdottir *et al*., 1992). Sea lice affect salmon in a variety of ways: mainly by reducing fish growth, loss of scales which leaves the fish open to secondary infections (Wootten *et al*., 1982) and damaging of fish which reduces marketability.

All fish farms undergo lice inspections 14 times per year. One lice inspection takes place each month at each site where fish are present, with two inspections taking place each month during the spring period March to May. Only one inspection occurs for December / January. At each inspection two samples are taken for each generation of fish on-site. One from a standard cage (which is sampled at each inspection) and one from a random cage (which is selected on the day of the inspection). Growers are those salmon that have been at sea since spring 1999 (1999 year class fish) and have undergone one winter at sea. Those put to sea in winter 1999 / spring 2000 are referred to as smolts. Thirty fish are examined for each sample. These are anaesthetised in a bin, which at the end of the sample is sieved for any detached lice. Each fish is examined individually for all mobile lice. Lice are removed using forceps and placed in 30ml screw top plastic bottles containing 70% alcohol, one bottle per fish. The results presented in this report refer to mean lice numbers per fish. This was obtained by adding the number of lice taken per fish and the number from the bin, and dividing by the number of fish examined.

There are three regions where salmon farming is carried out, the west (Counties Mayo and Galway), the north-west (Co. Donegal) and the south-west (Counties Cork and Kerry). These are geographically separate from each other with distances between regions of *c.*160km from north-west to west and *c.*200 km from west to south-west. In the year 2000 a total number of 45 sites were inspected for the west coast of Ireland. A breakdown of the numbers of sites per region is given in Table 1.

Results presented are mean ovigerous and mean mobile lice levels for the salmon louse *Lepeophtheirus salmonis*. These terms refer to the mean number of egg bearing adult female lice and the mean number of mobile lice (male or female of any age) that have developed beyond the attached larval stage, respectively. Total mobile levels estimate successful infection, with ovigerous lice levels estimating successful breeding females. The regularity of the sampling protocol outlined above aims to evaluate the levels of lice on growing fish and to bring them under control if necessary by advising treatment. Effective parasite control is characterised by a drop in lice levels in the subsequent inspection.

Table 1. Site names and locations where lice inspections took place in the years 1999 and 2000.

REGION	BAY	SITE
Southwest	*Bantry Bay*	Roancarraig
		Cuan Baoi
	Kenmare Bay	Kealincha - Inishfarnard
		Travara ‡
		Deenish
		Kilmackillogue
West	*Greatman's Bay*	Kerraun Pt.
		Carraroe
		Cuigeal
	Kilkieran Bay	Annaghbhan
		The Gurrig ‡
		Golam
		Lettercallow
		Oilean Iarthach
		Cuanmhuillin/Casheen
		Daonish
		Red Flag
		Inisbarra *
		Ardmore (Eisc Ui Flathartha)
		Ardmore (Emerald) *
		Birbeag
	Bertraghboy Bay	Sealax
		Saltpoint
		Outer Bertragh Buoi
	Mannin Bay	Ardbear Bay *
		Hawk's Nest
		Corhounagh
	Ballinakill Bay	Fraochoilean
		Ballinakill
	Killary Harbour	Rosroe
		Inishdeighil
	Clew Bay	Clare Island (incl. smolt site)
		Seastream
	Bealacragher Bay	Curraun
Northwest	*Donegal Bay*	Eany
		Creevin
		Portside (incl. smolt site)
		Ocean Inver
		Mc Swynes
	Mulroy Bay	Millstone
		Moross
		Cranford
		Milford
		Glinsk
	Lough Swilly	Lough Swilly

‡ Inspections in 2000 only * Inspections in 1999 only

RESULTS

Figures 1 and 2 illustrate the lice levels on one sea-winter salmon during the month of May for the years 1991 to 2000 inclusive. The mean number of egg bearing (ovigerous) lice per fish, and the mean number of mobile lice per fish are examined. The May 2000 levels are lower for both ovigerous and total mobile lice than the previous year and continue the downward trend since 1998. The rate of reduction in the mean mobile number compared to that for mean ovigerous is greater and increasing. This is perhaps indicative of differential efficacy in control methods on the individual farms inspected. Treatment types differ in the way they affect lice stages. Some concentrate on the young juvenile stages while others concentrate on older mobile stages. Therefore, depending on which type of treatment was undertaken, rates of reduction can be different for the different life cycle stages.

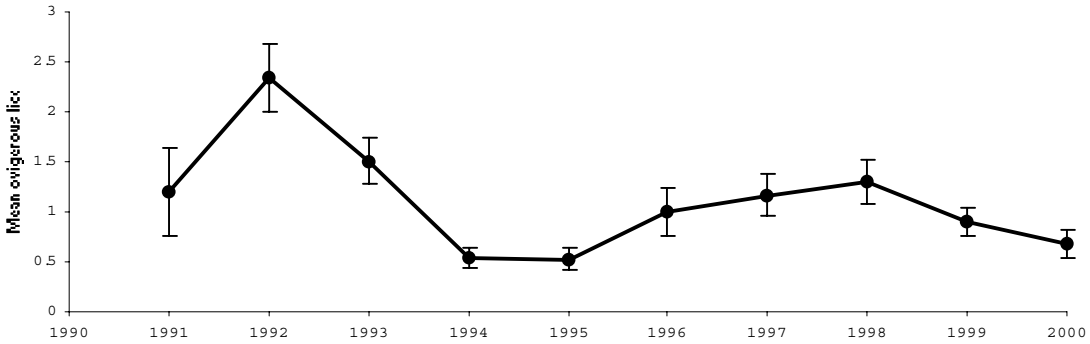

Figure 1 National annual mean (SE) ovigerous *L. salmonis* on one sea-winter salmon for the years 1991 to 2000.

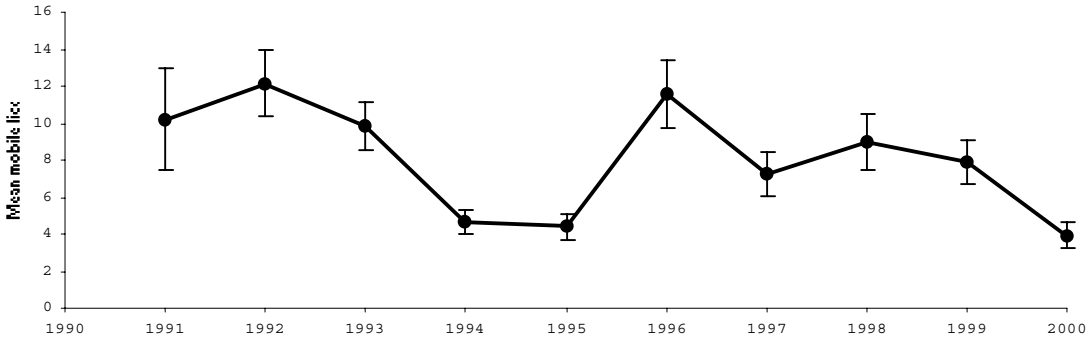

Figure 2 National annual mean (SE) mobile *L. salmonis* on one sea-winter salmon for the years 1991 to 2000.

Mean ovigerous and mean mobile lice levels on one sea-winter salmon for all three regions monitored in the years 1999 and 2000 are shown in Figures 3 and 4. Mean levels are shown for each month that was sampled in the two years. Overall mean ovigerous lice levels were lower in the year 2000 than in 1999, especially during the spring period March to May. Mean ovigerous lice levels for the south-west and west in the year 1999 were generally maintained between 0.5 and 2 until July when levels increased slightly during harvesting. However, in the year 2000 mean ovigerous lice levels were maintained between 0 and 1.5 for the same time period. However, the harvesting period for these two regions extended into October and November. Mean mobile lice levels also followed the

same pattern in both years with those for 2000 being generally lower throughout the year than those in 1999.

Elevated lice levels towards the end of both years can be attributed to harvest practices. Lice level control may appear to lessen at the end of the growing cycle with increasing levels in the ultimate samples before harvest. During harvesting it has been found that lice that detach themselves from the harvest fish attach to the remaining fish still on-site. This has been termed lateral transfer and has been recorded previously on Irish farms by Jackson *et al*. (1997). During the present study less than 10% of initial grower stock remained in all regions by the end of November in both years. Twelve of the sites inspected had persistent control throughout the growing cycle. Five sites had control until the ultimate samples before emptying the site. Eight sites had intermittent control, where the elevated levels persisted longer than the interval between inspections and rising levels were controlled at harvest. Adequate data to determine the levels of control in growers was missing in the case of only one site, Clare Island.

Individual bay analyses (Figures 5 and 6, Table 2) were undertaken on all bays in the west of Ireland where fish farming takes place. Six years data was examined for one sea-winter fish from 1995 to 2000. For a number of years individual farms have had restrictions on lice numbers, imposed on them by their licences or other agreements. From the data given in Figures 5 and 6 and Table 2 it can be seen that lice control has been variable, with some regions having more control than others especially during the March to May period. In the south-west region, Bantry Bay controlled their lice numbers at a low level for the spring period in 4 out of the 6 years examined (averaging the March to May results) and Kenmare Bay in 5 out of the 6 years. Both bays lice levels were higher in 1999, with Bantry Bay having an average of 2 ovigerous lice per fish for the time considered. Mobile levels paralleled those of ovigerous lice for the same period. The bays in the western region of the country controlled ovigerous lice levels in the year 2000 during the March to May period, with approximately 80% of bays being within the range 0.3 to 0.8 for ovigerous lice. This was the same level of control obtained during the year 1999, however previous to that lice levels had been higher during this period with only one bay, Killary Harbour, being within this range (in 4 out of 6 years).

In May 2000 the Lice Monitoring Protocol was introduced by Department of the Marine and Natural Resources (Monitoring Protocol No. 3 for Offshore Finfish Farms – Sea lice Monitoring and Control, DoMNR, May 2000). This protocol sets out treatment trigger levels for all salmonid farms. "*Treatment triggers during the spring period are set close to zero in the range of from 0.3 to 0.5 egg bearing females per fish and are also informed by the numbers of mobile lice on the fish. Where numbers of mobile lice are high, treatments are triggered even in the absence of egg bearing females. Outside of the critical spring period, a level of 2.0 egg bearing lice acts as a trigger for treatments. This is only relaxed where fish are under harvest and with the agreement with the Department of Marine and Natural Resources or its agent".*

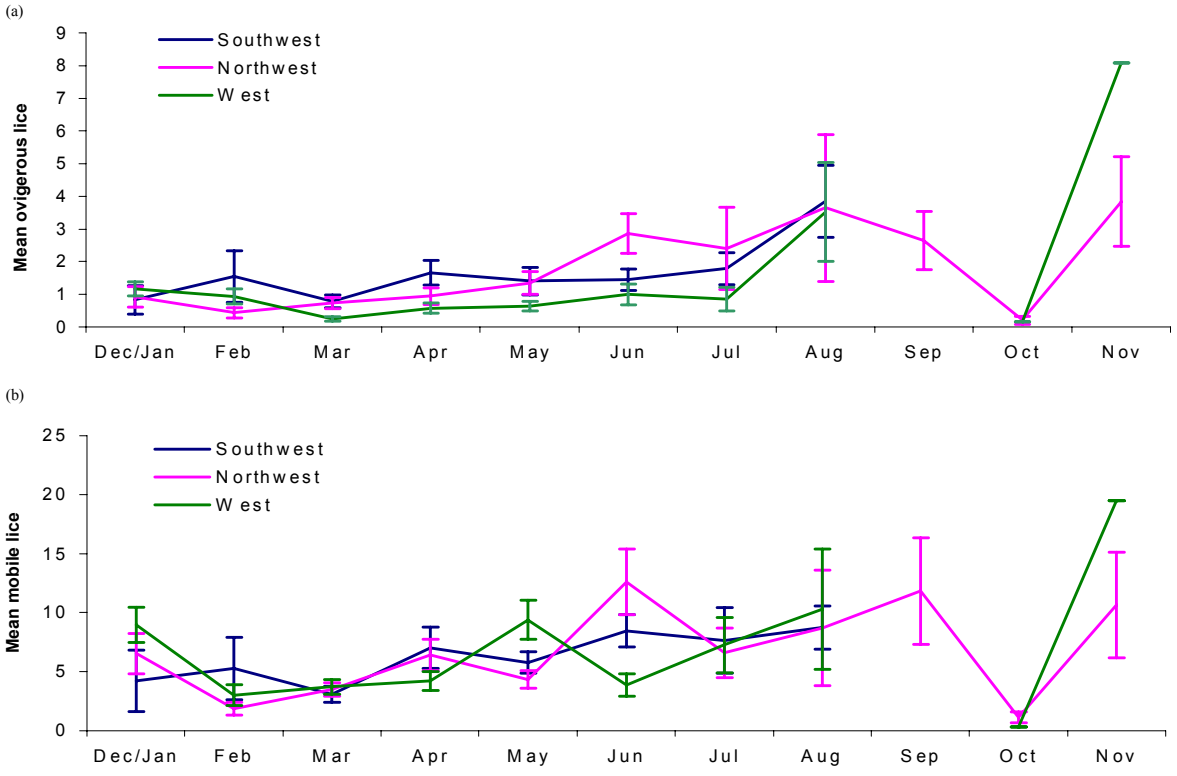

Figure 3 (a) Mean ovigerous lice (SE) and (b) mean mobile lice (SE) on one sea-winter salmon for all three regions in the west coast of Ireland in the year 1999.

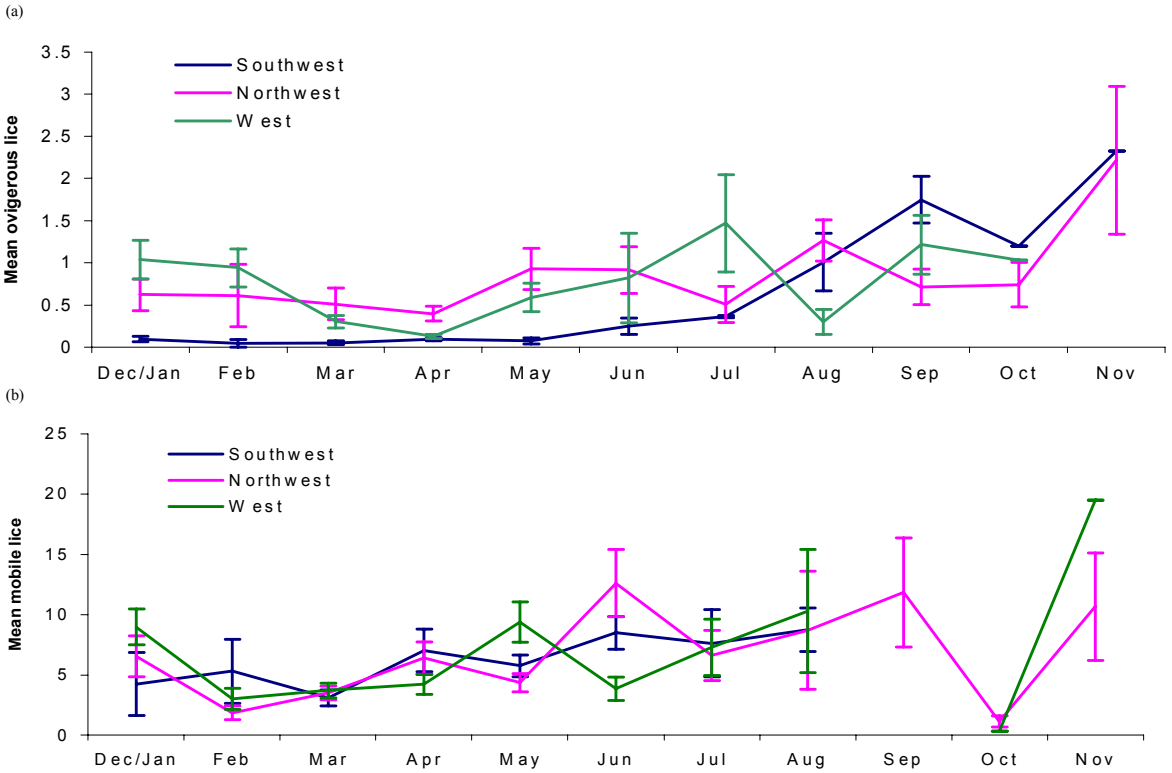

Figure 4 (a) Mean ovigerous lice (SE) and (b) mean mobile lice (SE) on one sea-winter salmon for all three regions in the west coast of Ireland in the year 2000.

Figure 5 Mean ovigerous *L. salmonis* on one sea-winter salmon for each bay inspected since 1995.

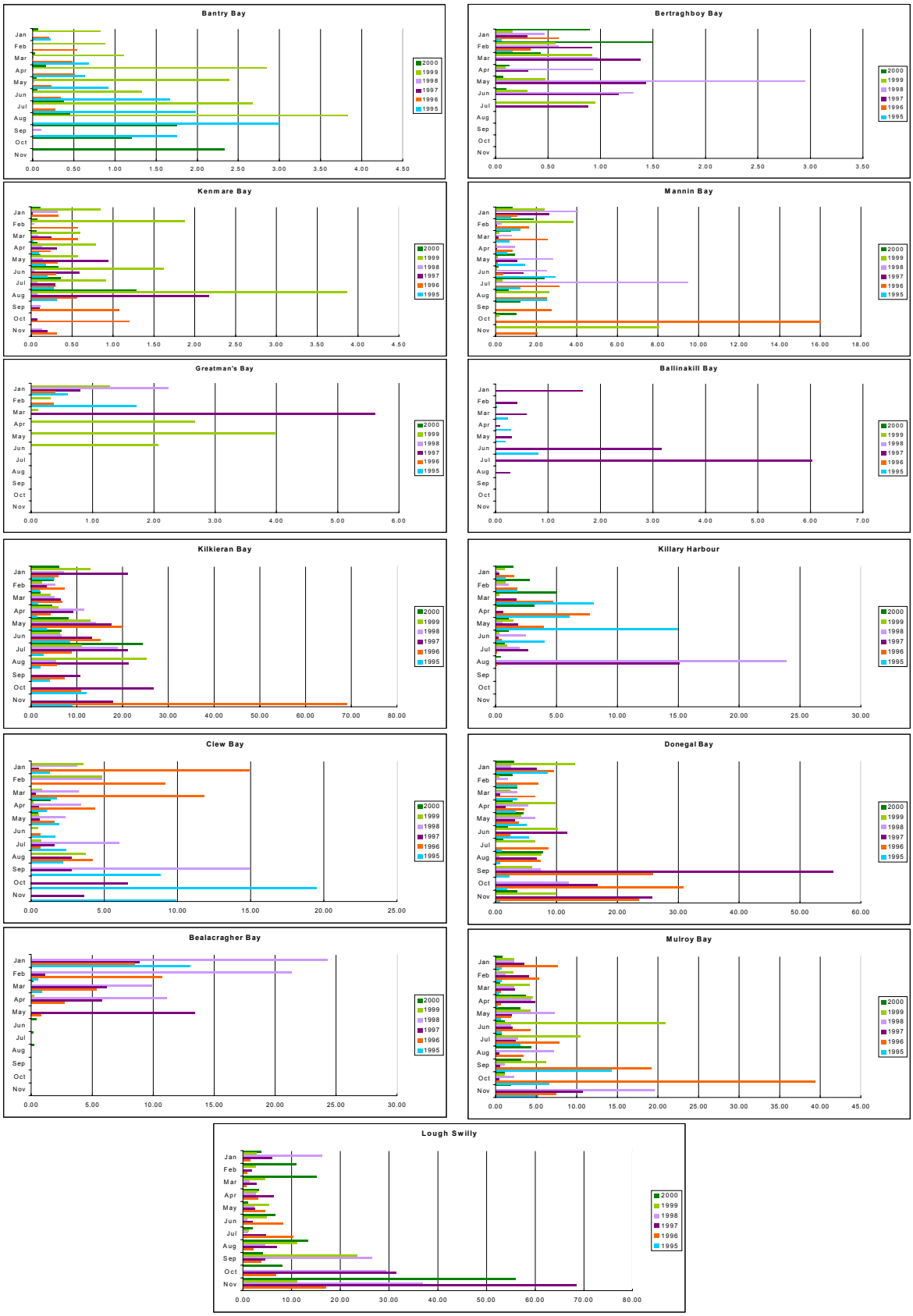

Figure 6 Mean mobile *L. salmonis* on one sea-winter salmon for each bay inspected since 1995.

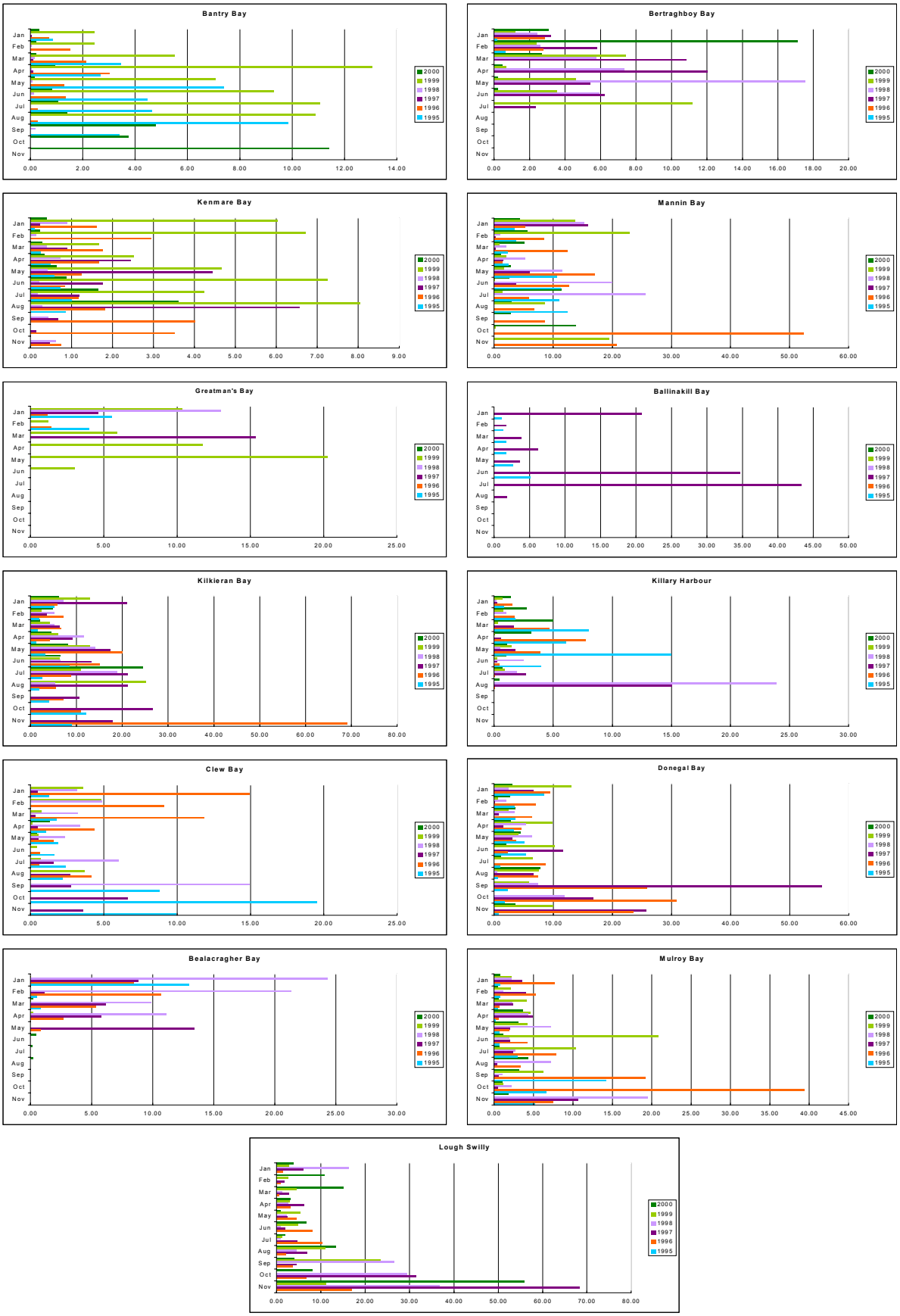

Table 2 Mean ovigerous and mean mobile *Lepeophtheirus salmonis* on one sea winter salmon for all bays inspected during the years 1995 to 2000.

Mean ovigerous lice levels

Bantry Bay	2000	1999	1998	1997	1996	1995
Jan	0.07	0.82	0.00	0.00	0.20	0.22
Feb	0.00	0.88	0.00	MW	0.54	NS
Mar	0.03	1.10	0.01	0.00	0.48	0.68
Apr	0.17	2.85	0.01	0.00	0.51	0.63
May	0.04	2.38	0.02	F	0.23	0.92
Jun	0.05	1.33	0.00	F	0.34	1.67
Jul	0.38	2.67	0.00	F	0.27	1.99
Aug	0.45	3.83	0.00	F	0.00	3.00
Sep	1.75	F	0.10	F	F	1.75
Oct	1.20	F	F	F	F	F
Nov	2.33	F	F	F	F	F

Kenmare Bay	2000	1999	1998	1997	1996	1995
Jan	0.11	0.85	0.32	0.02	0.33	0.01
Feb	0.07	1.88	0.03	MW	0.57	NS
Mar	0.07	0.60	0.09	0.24	0.57	0.02
Apr	0.08	0.79	0.13	0.31	0.24	0.10
May	0.11	0.57	0.14	0.94	0.32	0.18
Jun	0.33	1.62	0.04	0.59	0.30	0.20
Jul	0.36	0.91	0.07	0.30	0.30	0.28
Aug	1.29	3.86	0.07	2.17	0.56	0.32
Sep	F	F	0.12	0.10	1.08	F
Oct	F	F	NS	0.07	1.20	F
Nov	F	F	0.13	0.20	0.32	F

Greatmans Bay	2000	1999	1998	1997	1996	1995
Jan	*	1.28	2.23	0.80	0.39	0.60
Feb	*	0.31	F	NS	0.37	1.72
Mar	*	0.11	F	5.61	F	F
Apr	*	2.67	F	F	F	F
May	*	3.99	F	F	F	F
Jun	*	2.07	F	F	F	F
Jul	*	F	F	F	F	F
Aug	*	F	F	F	F	F
Sep	*	F	F	F	F	F
Oct	*	F	F	F	F	F
Nov	*	F	F	F	F	F

Kilkieran Bay	2000	1999	1998	1997	1996	1995
Jan	1.45	1.58	0.97	1.92	0.50	0.74
Feb	1.01	0.85	1.80	0.59	1.36	0.51
Mar	0.17	0.16	0.73	1.21	1.83	0.39
Apr	0.17	0.75	0.43	1.14	0.71	0.22
May	0.78	0.50	1.48	2.36	1.47	0.37
Jun	2.61	1.43	1.05	4.70	2.31	2.14
Jul	2.84	1.35	6.54	5.19	2.57	0.62
Aug	F	8.00	3.90	7.85	1.80	1.15
Sep	F	F	NS	3.38	1.50	1.05
Oct	F	F	F	3.10	1.66	2.47
Nov	F	F	F	3.54	11.91	3.00

Bertraghboy Bay	2000	1999	1998	1997	1996	1995
Jan	0.90	0.16	0.47	0.30	0.60	0.05
Feb	1.49	0.57	0.60	0.92	0.33	0.16
Mar	0.43	0.92	0.97	1.38	F	F
Apr	0.13	0.09	0.93	0.31	F	F
May	0.07	0.47	2.95	1.43	F	F
Jun	0.10	0.30	1.32	1.17	F	F
Jul	F	0.95	F	0.88	F	F
Aug	F	F	F	F	F	F
Sep	F	F	F	F	F	F
Oct	F	F	F	F	F	F
Nov	F	F	F	F	F	F

Mean mobile lice levels

Bantry Bay	2000	1999	1998	1997	1996	1995
Jan	0.33	2.45	0.00	0.05	0.70	0.84
Feb	0.21	2.45	0.04	MW	1.51	NS
Mar	0.20	5.50	0.14	0.10	2.14	3.45
Apr	0.94	13.05	0.05	0.10	3.02	2.67
May	0.16	7.07	0.08	F	1.29	7.39
Jun	0.83	9.30	0.14	F	1.34	4.47
Jul	1.06	11.05	0.00	F	0.27	4.65
Aug	1.40	10.90	0.00	F	0.27	9.83
Sep	4.78	F	0.17	F	F	3.40
Oct	3.73	F	F	F	F	F
Nov	11.40	F	F	F	F	F

Kenmare Bay	2000	1999	1998	1997	1996	1995
Jan	0.40	6.03	0.90	0.23	1.61	0.09
Feb	0.23	6.72	0.13	MW	2.95	NS
Mar	0.27	1.67	0.39	0.90	1.77	0.24
Apr	0.34	2.52	0.71	2.44	1.67	0.48
May	0.65	4.66	0.41	4.44	1.24	0.58
Jun	0.87	7.25	0.21	1.77	0.83	0.72
Jul	1.66	4.24	0.17	1.19	1.16	1.01
Aug	3.61	8.04	0.28	6.57	1.81	0.85
Sep	F	F	0.43	0.67	4.02	F
Oct	F	F	NS	0.13	3.52	F
Nov	F	F	0.61	0.47	0.75	F

Greatmans Bay	2000	1999	1998	1997	1996	1995
Jan	*	10.37	12.97	4.62	1.17	5.57
Feb	*	1.20	F	NS	1.43	4.00
Mar	*	5.89	F	15.39	F	F
Apr	*	11.76	F	F	F	F
May	*	20.26	F	F	F	F
Jun	*	3.00	F	F	F	F
Jul	*	F	F	F	F	F
Aug	*	F	F	F	F	F
Sep	*	F	F	F	F	F
Oct	*	F	F	F	F	F
Nov	*	F	F	F	F	F

Kilkieran Bay	2000	1999	1998	1997	1996	1995
Jan	6.13	13.01	7.15	21.02	5.86	5.14
Feb	4.86	2.39	5.15	3.45	7.23	1.84
Mar	1.98	4.25	5.12	6.33	6.74	1.54
Apr	4.46	5.97	11.62	9.17	4.22	1.21
May	8.19	12.97	14.13	17.50	20.01	3.26
Jun	6.61	6.24	6.55	13.25	15.04	8.48
Jul	24.40	10.99	18.94	21.14	8.82	2.63
Aug	F	25.20	5.38	21.22	5.53	1.90
Sep	F	F	NS	10.66	7.21	4.11
Oct	F	F	F	26.68	10.95	12.13
Nov	F	F	F	17.94	69.14	9.00

Bertraghboy Bay	2000	1999	1998	1997	1996	1995
Jan	3.06	1.22	2.47	3.21	2.85	0.19
Feb	17.13	2.38	2.60	5.82	2.80	0.63
Mar	2.68	7.42	5.76	10.85	F	F
Apr	0.48	0.67	7.36	12.05	F	F
May	0.20	4.62	17.55	5.42	F	F
Jun	0.23	3.54	5.94	6.24	F	F
Jul	F	11.20	F	2.34	F	F
Aug	F	F	F	F	F	F
Sep	F	F	F	F	F	F
Oct	F	F	F	F	F	F
Nov	F	F	F	F	F	F

Table 2 cont'd

Mannin Bay	**2000**	**1999**	**1998**	**1997**	**1996**	**1995**
Jan	0.83	2.42	4.07	2.62	1.05	0.73
Feb	1.87	3.81	0.31	0.08	1.65	1.22
Mar	0.76	0.17	0.79	0.12	2.54	0.67
Apr	0.02	0.04	0.95	0.08	0.83	0.56
May	0.95	0.10	2.83	1.04	0.10	1.43
Jun	0.13	0.05	2.50	1.35	0.35	2.92
Jul	2.41	0.33	9.47	F	3.13	1.21
Aug	0.62	2.65	F	F	2.54	2.53
Sep	1.22	NS	F	F	2.75	F
Oct	1.03	0.17	F	F	16.04	F
Nov	F	8.08	F	F	2.07	F

Mannin Bay	**2000**	**1999**	**1998**	**1997**	**1996**	**1995**
Jan	4.35	13.72	15.27	15.93	5.29	3.43
Feb	5.67	22.94	1.09	0.29	8.52	3.74
Mar	5.07	0.93	1.99	0.26	12.49	2.29
Apr	1.16	2.09	5.26	1.56	1.43	2.45
May	2.76	1.61	11.51	6.00	17.06	10.63
Jun	2.60	0.19	20.00	3.77	12.73	11.22
Jul	11.43	1.47	25.71	F	5.94	11.03
Aug	2.90	8.62	F	F	6.80	12.46
Sep	2.85	NS	F	F	8.60	F
Oct	13.87	0.33	F	F	52.41	F
Nov	F	19.50	F	F	20.83	F

Ballinakill Bay	**2000**	**1999**	**1998**	**1997**	**1996**	**1995**
Jan	*	*	*	1.67	*	0.00
Feb	*	*	*	0.42	*	0.03
Mar	*	*	*	0.59	*	0.23
Apr	*	*	*	0.08	*	0.30
May	*	*	*	0.31	*	0.19
Jun	*	*	*	3.16	*	0.82
Jul	*	*	*	6.03	*	F
Aug	*	*	*	0.27	*	F
Sep	*	*	*	F	*	F
Oct	*	*	*	F	*	F
Nov	*	*	*	F	*	F

Ballinakill Bay	**2000**	**1999**	**1998**	**1997**	**1996**	**1995**
Jan	*	*	*	20.88	*	1.11
Feb	*	*	*	1.77	*	1.30
Mar	*	*	*	3.81	*	1.66
Apr	*	*	*	6.24	*	1.72
May	*	*	*	3.68	*	2.68
Jun	*	*	*	34.72	*	5.07
Jul	*	*	*	43.30	*	F
Aug	*	*	*	1.80	*	F
Sep	*	*	*	F	*	F
Oct	*	*	*	F	*	F
Nov	*	*	*	F	*	F

Killary Harbour	**2000**	**1999**	**1998**	**1997**	**1996**	**1995**
Jan	0.43	0.09	0.00	0.02	0.19	0.07
Feb	0.27	0.17	0.29	0.00	0.32	0.23
Mar	0.48	0.05	0.01	0.03	0.46	0.62
Apr	0.20	0.01	0.01	0.07	1.25	0.78
May	0.22	0.21	0.02	0.18	0.63	2.17
Jun	0.07	0.16	0.30	0.04	0.11	0.82
Jul	0.61	0.00	0.45	0.81	0.07	F
Aug	0.14	F	0.35	0.60	0.00	F
Sep	F	F	F	NS	F	F
Oct	F	F	F	0.00	F	F
Nov	F	F	F	F	F	F

Killary Harbour	**2000**	**1999**	**1998**	**1997**	**1996**	**1995**
Jan	1.41	0.74	0.21	0.28	1.52	0.81
Feb	2.77	0.78	1.04	0.00	1.75	1.80
Mar	5.01	0.29	0.04	1.68	4.68	8.03
Apr	3.18	0.10	0.03	0.61	7.74	6.06
May	1.08	1.46	0.55	1.83	3.94	14.99
Jun	1.04	0.26	2.47	0.25	0.44	3.96
Jul	0.72	0.90	1.94	2.67	0.09	F
Aug	0.43	F	23.89	15.07	0.10	F
Sep	F	F	F	NS	F	F
Oct	F	F	F	0.00	F	F
Nov	F	F	F	F	F	F

Clew Bay	**2000**	**1999**	**1998**	**1997**	**1996**	**1995**
Jan	NS	0.79	1.24	0.08	1.60	0.22
Feb	NS	2.07	1.88	MW	0.68	NS
Mar	NS	0.32	0.61	0.08	2.92	0.39
Apr	0.00	0.05	0.95	0.10	0.58	0.13
May	0.08	0.11	0.74	0.23	0.24	0.26
Jun	NS	0.27	NS	NS	0.13	0.50
Jul	NS	0.17	2.37	0.70	0.07	0.40
Aug	NS	1.71	NS	0.70	0.87	0.72
Sep	NS	F	2.14	1.62	F	1.72
Oct	NS	F	F	3.07	F	2.89
Nov	NS	F	F	1.25	F	4.17

Clew Bay	**2000**	**1999**	**1998**	**1997**	**1996**	**1995**
Jan	NS	3.56	3.14	0.50	14.93	1.27
Feb	NS	4.80	4.85	MW	9.13	NS
Mar	NS	0.74	3.23	0.31	11.82	1.75
Apr	1.30	0.12	3.39	0.52	4.37	1.05
May	0.47	0.52	2.34	0.55	1.59	1.87
Jun	NS	0.44	NS	NS	0.63	1.63
Jul	NS	0.68	6.01	1.57	0.60	2.40
Aug	NS	3.70	NS	2.73	4.17	2.17
Sep	NS	F	14.93	2.77	F	8.82
Oct	NS	F	F	6.62	F	19.52
Nov	NS	F	F	3.58	F	9.90

Bealacragher Bay	**2000**	**1999**	**1998**	**1997**	**1996**	**1995**
Jan	0.00	0.00	2.51	1.17	0.57	0.75
Feb	0.00	0.00	4.02	0.37	1.32	0.09
Mar	0.02	0.00	2.83	0.81	2.06	0.14
Apr	NS	0.00	4.17	0.91	1.04	F
May	NS	0.00	F	1.98	0.00	F
Jun	0.15	NS	F	F	F	F
Jul	0.03	NS	F	F	F	F
Aug	0.00	NS	F	F	F	F
Sep	F	F	F	F	F	F
Oct	F	F	F	F	F	F
Nov	F	F	F	F	F	F

Bealacragher Bay	**2000**	**1999**	**1998**	**1997**	**1996**	**1995**
Jan	0.00	0.04	24.31	8.85	8.47	13.00
Feb	0.05	0.00	21.34	1.14	10.70	0.56
Mar	0.19	0.05	9.87	6.19	5.34	0.84
Apr	NS	0.20	11.10	5.78	2.69	F
May	NS	0.00	F	13.39	0.83	F
Jun	0.43	NS	F	F	F	F
Jul	0.15	NS	F	F	F	F
Aug	0.20	NS	F	F	F	F
Sep	F	F	F	F	F	F
Oct	F	F	F	F	F	F
Nov	F	F	F	F	F	F

Table 2 cont'd

Donegal Bay	2000	1999	1998	1997	1996	1995
Jan	1.10	1.80	0.11	1.16	1.56	2.80
Feb	1.03	0.28	0.27	0.01	1.23	0.73
Mar	1.09	0.23	0.53	0.13	1.62	0.91
Apr	0.35	0.79	1.40	0.33	1.36	0.44
May	1.42	2.03	1.20	0.36	1.24	0.44
Jun	1.36	1.51	NS	1.97	0.37	0.95
Jul	0.32	4.04	0.02	0.02	2.37	0.31
Aug	1.79	3.86	0.14	3.88	3.11	0.12
Sep	NS	2.98	2.11	12.38	9.20	0.62
Oct	NS	NS	2.76	0.11	7.96	0.59
Nov	1.70	4.03	0.00	7.57	8.29	0.17

Donegal Bay	2000	1999	1998	1997	1996	1995
Jan	3.01	13.04	2.46	6.72	9.53	8.50
Feb	2.73	0.59	2.02	0.12	6.98	3.51
Mar	3.59	2.42	3.49	0.75	6.44	3.56
Apr	2.78	9.83	5.35	1.58	4.63	3.29
May	4.50	4.16	6.48	3.15	3.71	5.07
Jun	2.01	10.28	NS	11.71	2.35	5.44
Jul	1.20	6.49	0.04	0.05	8.68	0.95
Aug	7.75	7.55	0.55	6.67	7.44	0.67
Sep	NS	5.89	7.43	55.45	25.86	2.30
Oct	NS	NS	11.93	16.76	30.86	1.82
Nov	3.57	9.95	0.12	25.73	23.53	0.73

Mulroy Bay	2000	1999	1998	1997	1996	1995
Jan	0.29	0.43	0.17	0.66	0.61	0.04
Feb	0.35	0.50	0.32	0.56	0.89	0.04
Mar	0.03	1.23	0.38	0.39	0.31	0.03
Apr	0.15	1.12	0.17	0.93	0.07	0.02
May	0.55	0.86	1.68	0.97	0.34	0.08
Jun	0.55	5.18	0.00	0.40	0.58	0.08
Jul	0.31	1.43	0.96	0.65	1.80	0.52
Aug	1.22	NS	1.29	0.07	0.75	NS
Sep	0.80	0.43	0.48	0.20	2.21	3.52
Oct	0.36	0.21	1.40	0.25	2.98	1.28
Nov	0.92	NS	1.22	0.37	3.81	2.15

Mulroy Bay	2000	1999	1998	1997	1996	1995
Jan	0.82	2.24	2.23	3.53	7.65	0.75
Feb	0.43	2.10	1.20	4.03	5.29	0.72
Mar	0.54	4.18	2.27	2.41	0.63	0.48
Apr	3.67	4.58	4.34	4.91	0.62	0.24
May	3.04	4.25	7.23	2.00	1.90	0.64
Jun	1.15	20.90	1.89	2.03	4.26	0.69
Jul	0.66	10.42	2.71	2.43	7.87	3.03
Aug	4.35	NS	7.18	0.40	3.38	NS
Sep	3.15	6.22	1.10	0.56	19.19	14.22
Oct	1.07	1.15	2.24	0.47	39.34	6.62
Nov	1.87	NS	19.51	10.65	7.46	5.20

Lough Swilly	2000	1999	1998	1997	1996	1995
Jan	1.05	0.20	3.15	3.61	0.28	*
Feb	0.27	0.42	NS	0.40	0.18	*
Mar	0.92	0.77	0.72	0.62	0.09	*
Apr	0.99	0.90	0.53	0.87	0.68	*
May	0.38	1.20	0.79	0.76	0.36	*
Jun	0.94	2.08	0.44	0.59	1.70	*
Jul	1.08	0.61	0.16	0.55	1.43	*
Aug	0.81	3.24	0.52	3.44	1.30	*
Sep	0.58	3.68	4.22	3.44	2.28	*
Oct	1.31	NS	2.86	6.21	1.84	*
Nov	4.80	3.70	13.23	15.36	4.77	*

Lough Swilly	2000	1999	1998	1997	1996	1995
Jan	3.81	2.83	16.22	6.03	1.48	*
Feb	10.87	2.68	NS	1.82	0.91	*
Mar	15.11	4.60	1.33	2.76	0.66	*
Apr	3.18	2.94	2.65	6.23	3.15	*
May	0.96	5.39	2.23	2.40	4.53	*
Jun	6.71	4.90	0.83	2.04	8.20	*
Jul	2.04	1.19	0.98	4.67	10.34	*
Aug	13.28	11.06	4.59	6.92	2.05	*
Sep	4.03	23.52	26.49	4.57	3.70	*
Oct	8.10	NS	29.47	31.45	6.82	*
Nov	55.95	11.20	36.89	68.43	17.02	*

* no data, smolts only at sea F Fallow NS Not Sampled MW Missed due to adverse weather

DISCUSSION AND CONCLUSIONS

In 1993 the Marine Institute in co-operation with the salmon farming industry initiated a concept called Single Bay Management (SBM). Co-ordinated sea lice treatments were to be undertaken by all fin-fish producers in each bay so that reservoirs for sea lice could be eliminated. Individual treatments on each farm could still be undertaken but combined treatments would minimise re-infection. Each site would also contain only one generation of fish at any given time, to eliminate cross infection and transfer of sea lice from older generation fish to new smolts arriving onsite. Each farm would therefore have at least two sites, a grower site and a smolt site. Fallowing of sites containing older generation fish, for at least one month following the completion of harvest, was to be undertaken before the transfer of new fish onsite could occur. The compulsory harvesting of two sea-winter fish before spring was to be undertaken. The level of sea lice monitoring has increased since 1993 and approximately 20,000 fish are now examined each year. In Norway a national program for controlling sea lice infestations was established by the Norwegian Animal Health Authorities in 1997 (Eithun, 2000). Although having been viewed as a health problem in Norwegian fish farms for many years previously, the sea lice situation was recognised as a potential threat to migrating stocks of smolts from Norwegian rivers. Sampling is undertaken in a similar manner to that carried out in Ireland but not on the same scale. At present in Norway no sampling is required from 15th December to 1st March and inspections are only carried out once a month thereafter (Eithun, 2000). In Ireland that period of time is considered important in terms of controlling sea lice levels before the onset of the critical spring period.

In 1998 a Co-ordinated Local Aquaculture Management System, CLAMS, was initiated in Ireland that was to incorporate and extend the concept of Single Bay Management (SBM) to all aquaculture producers in a bay (Jackson & O'Carroll, 1998). Areas that were highlighted included the control and elimination of disease and parasites, the optimisation of environmental conditions within the bay, the increase of production and the co-operation of all users of the bay. It is hoped that this process will be established countrywide. CLAMS was initiated in November 2000 in Kilkieran Bay, Connemara, Co. Galway. Following on from this the salmon producers in the bay formed a new company, Feirmeoirí Bradáin Cill Chiaráin Teó. (FBCC Teó.). This company is a co-operative venture set up to manage smolt inputs into the bay. Licences will be sought by FBCC Teó. to input smolts into two offshore sites, Birmore Island and Red Flag, each year. Re-distribution of these smolts is to occur the October following input, to the different salmon producers in the bay to ongrow to harvest weight. This plan allows for the separation of fish generations, complete fallowing of the inner bay and an effective Single Bay Management Plan. At present there is an agreed lice control protocol in place for the bay with salmon producers undertaking to co-ordinate treatments both on farm and between farms to maximise their effectiveness.

Fish farms themselves have changed their farming practices over the last number of years. For example in the last three years changes in the stocking protocol of new smolts has occurred. A young salmon is ready to be transferred from freshwater to seawater following the process of smoltification after which it becomes known as a smolt or S1. Smoltification takes place approximately 15 months after eggs hatch. The terms $S^1/_2$ and S0 refer to smolts which have had a faster development than S1 smolts and are ready to go to sea the Winter before their siblings. In the last three years there has been a tendency

by fish farms to stock more $S^1/_2$'s than in previous years and a greater number of sites have contained $S^1/_2$'s. The north-west in particular has stocked 30% to 50% of $S^1/_2$'s during these years. Farms in the west of Ireland stocked more $S^1/_2$'s in the year 2000 than in the previous three years, with six of twenty-three sites being allocated to them.

There have been two fundamental changes in lice control practices on farms in recent years. In early 2000 the use of Ivermectin, which had previously been available as a prescribed treatment under the cascade principle, was no longer permitted. While a new oral treatment, SLICE, was available on a trial basis late in the spring, there was a hiatus in the availability of oral treatments. As a response to this a new strategy for the treatment of *Lepeophtheirus salmonis* on salmonid fish came into effect in the early part of the year 2000. Synchronous bath treatments were carried out early in February before the onset of the critical spring period. This strategy was not in place in 1999 and bath treatments were normally undertaken later in spring, in April and sometimes May. This could possibly account for the lower lice levels in both mean ovigerous and mean mobile levels achieved in the year 2000. It is also possible that higher infestation levels in the spring period in 1999 were due to difficulties in achieving effective treatments because of low water temperatures prior to lice inspections, as reported in other years by Jackson & Minchin (1993), and / or inclement weather. The early part of 1999 saw high gusting winds in most parts of the country, the highest recorded in most meteorological stations since 1990. Low temperatures also extended into April and May 1999.

Over the six years encompassed by this study there is much local variation in the level of lice control. The reasons for these variations range from environmental factors to the availability of treatments. Over the period, there has been a pattern of increasing co-ordination of lice control and the development of a more sophisticated strategic approach to the management of sea lice infestations on farmed salmon in Ireland.

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