Salmon and People in a Changing World – Edinburgh 29/3/2019

Salmon Farming

Learning from International best practice on regulation, new technologies and innovation to manage impacts on wild fish – the Irish context

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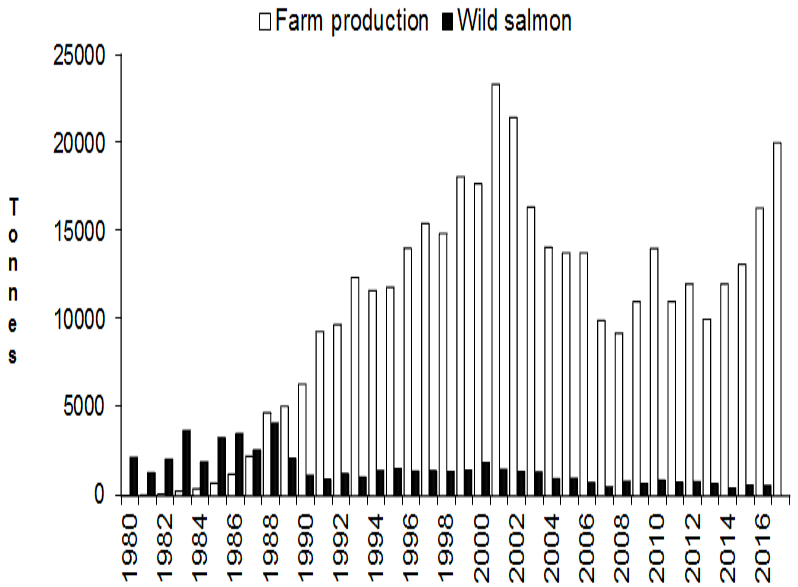
Irish Salmon Aquaculture Industry

- Currently ~ 20,000 Tonnes
- Mostly based on organic fish
- About 17 sites, along Western seaboard
- Large increase in production planned
- However, difficulty in acquiring new sites



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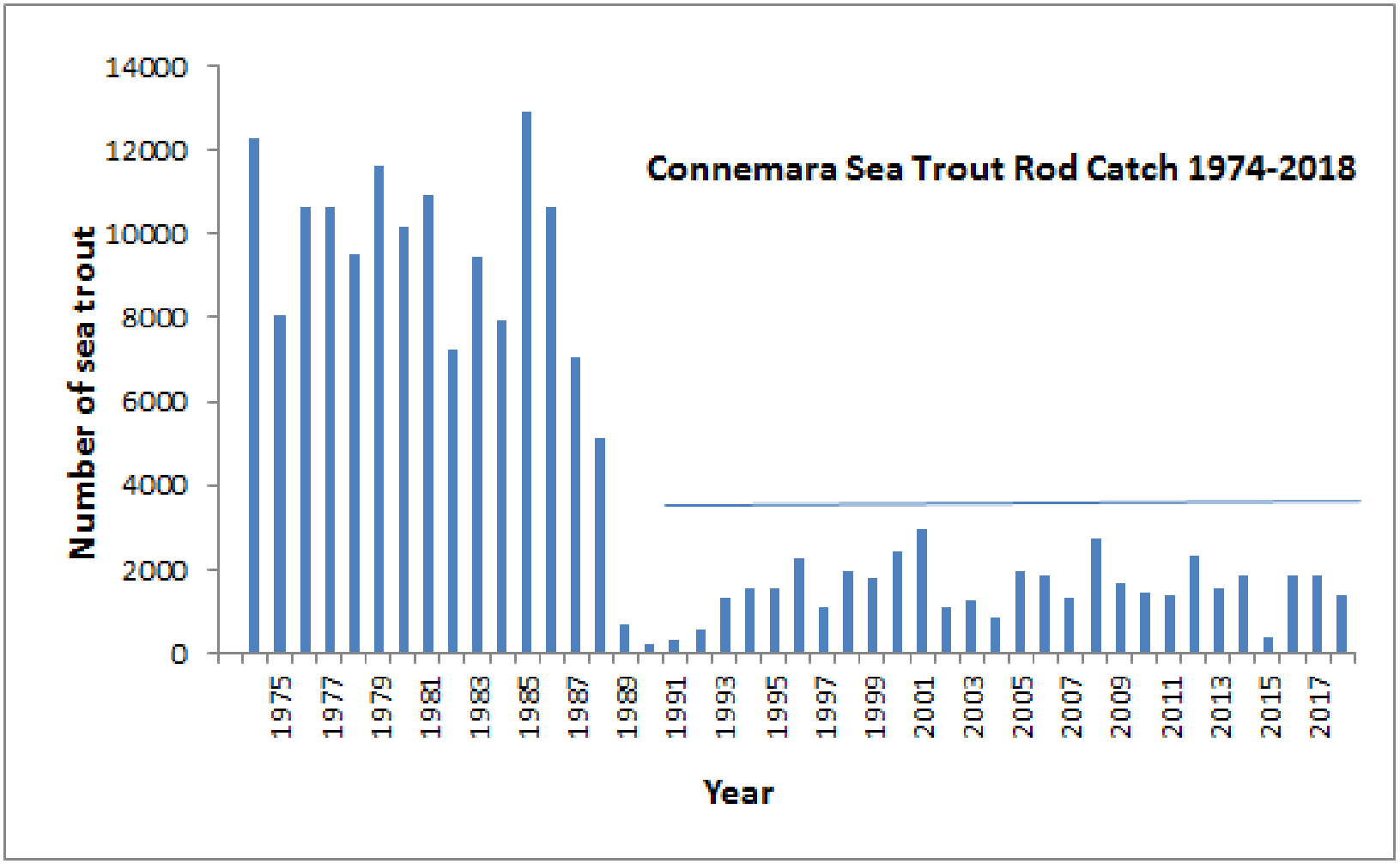
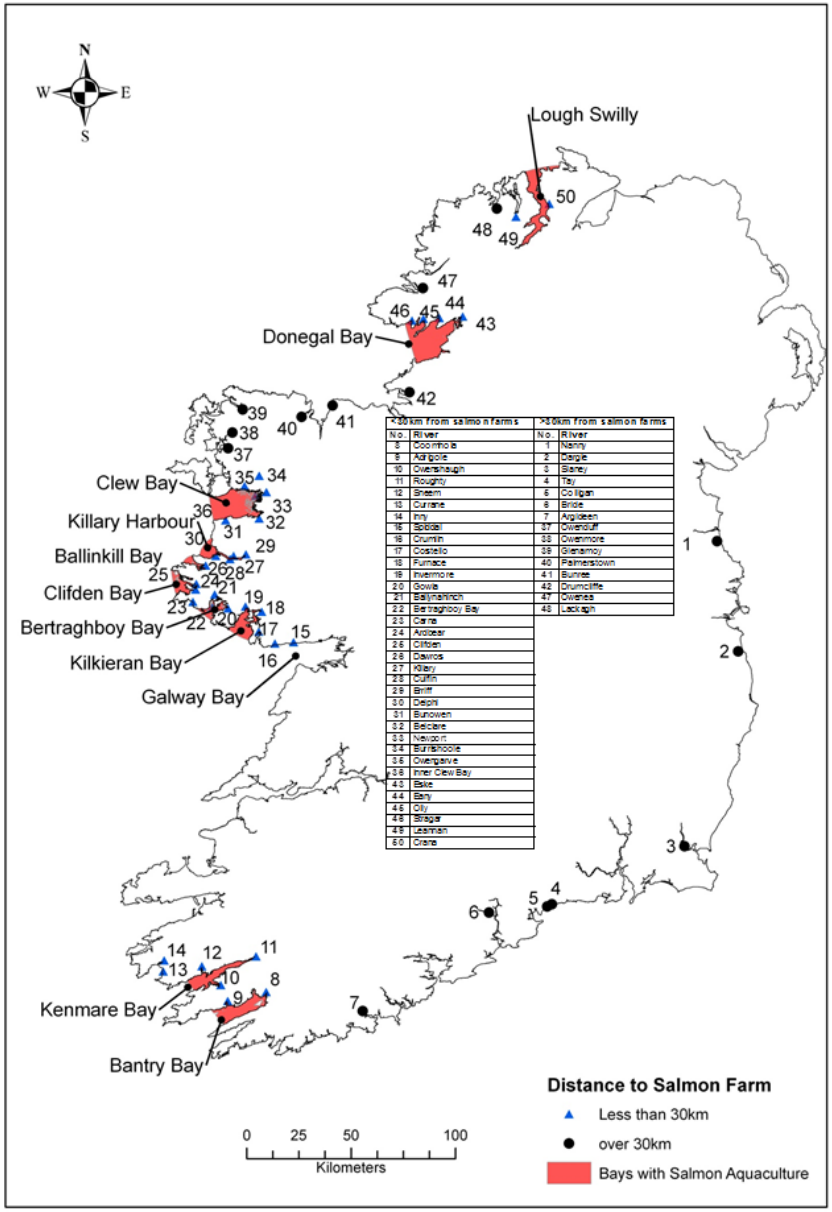

Connemara Sea Trout Rod Catch 1974-2018
Number of sea trout
14000
12000
10000
8000
6000
4000
2000
0
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
Year

Sampling for lice infested Sea trout in Ireland 1992-2016



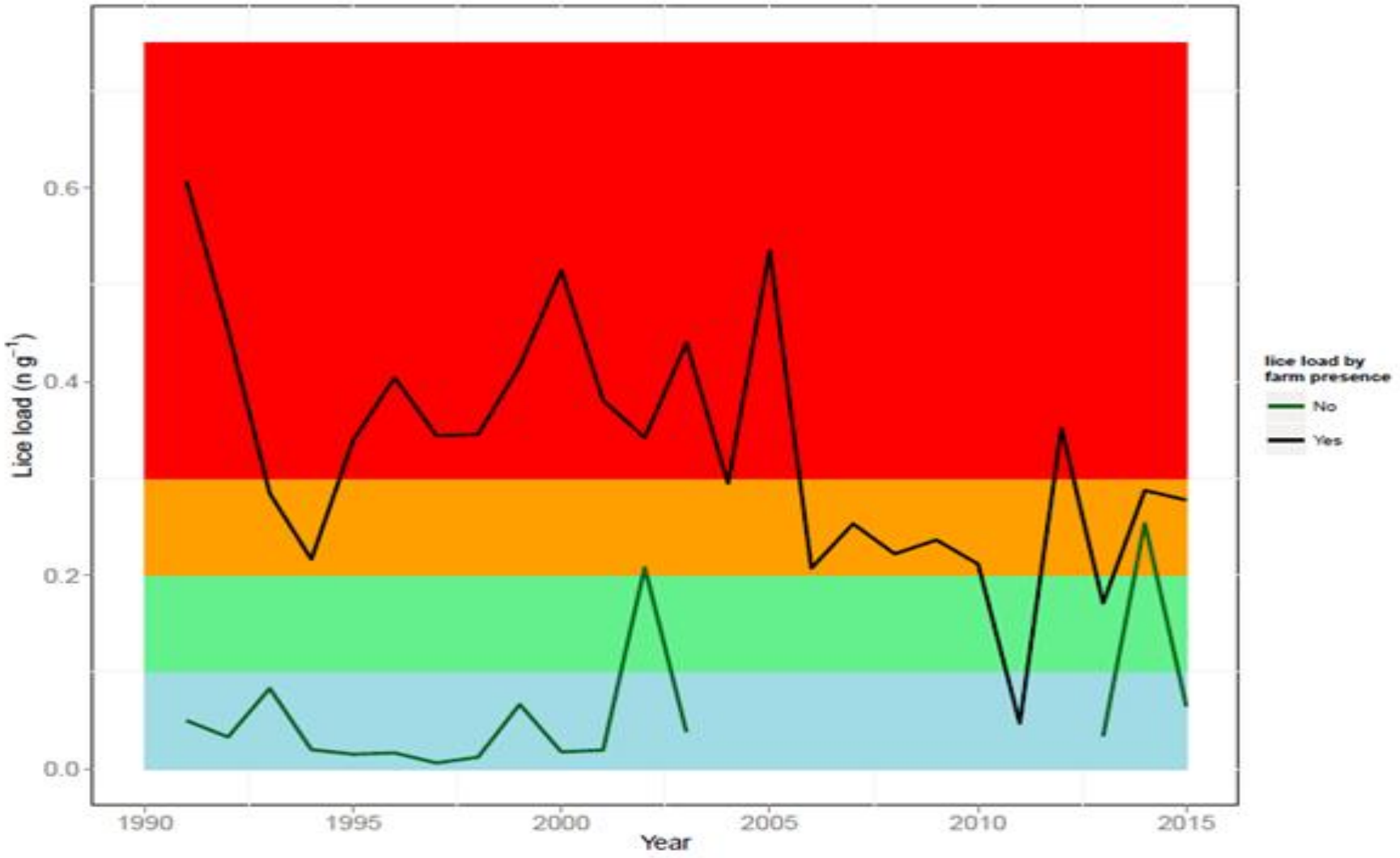
Taranger et al. 2015 - Risk assessment of sea lice on wild salmonids applied to Irish sea trout data

Assessment on **Stock regulating effects** of salmon lice on wild salmon and sea trout populations

Infection group (number of lice/fish weight, g)	Proportion of population (%)	Expected mortality	Index
< 0,1	50	0%	0
0,1 - 0,2	20	20%	4
0,2 - 0,3	20	50%	10
> 0,3	10	100%	10
Estimated stock reduction (%)			24

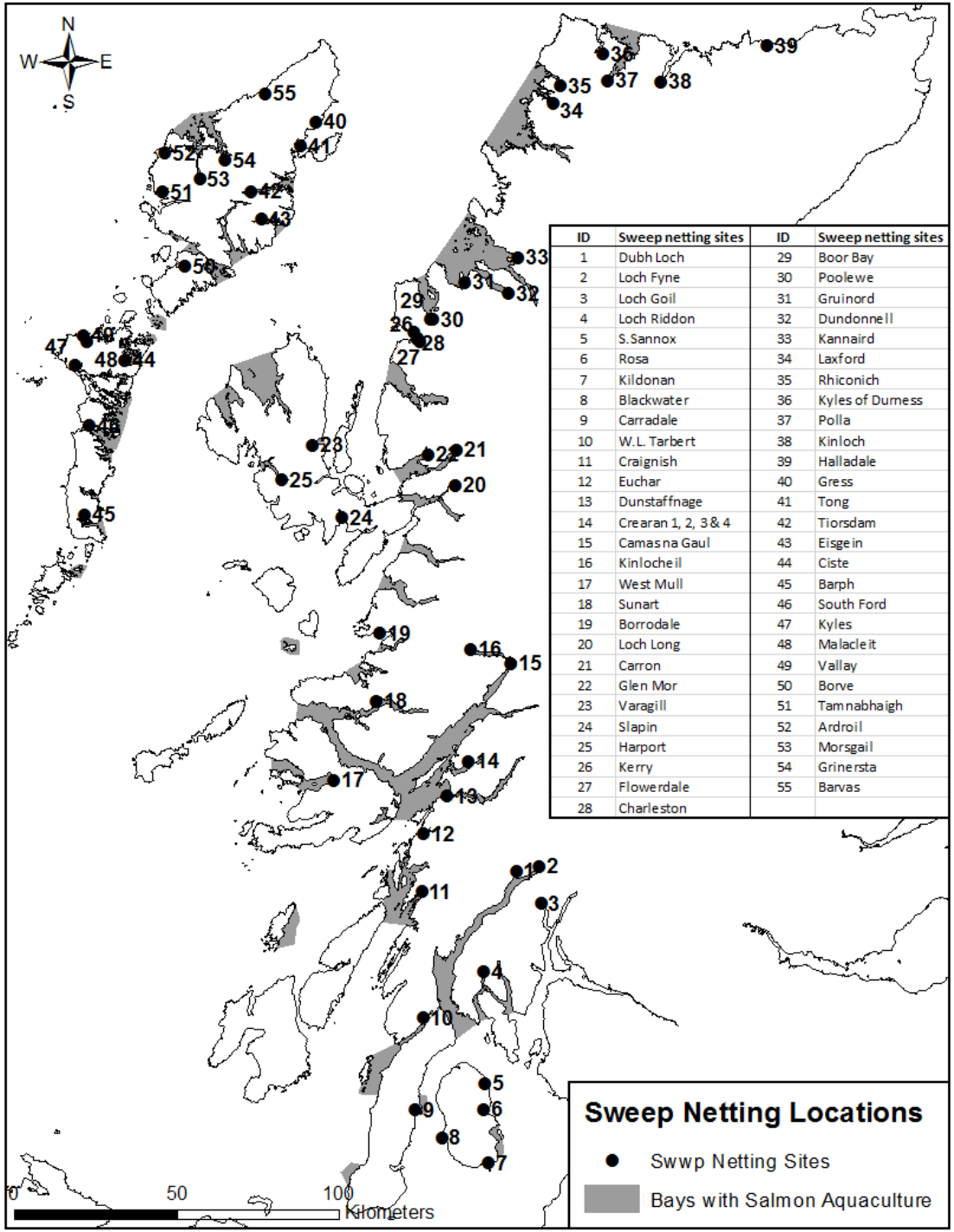
Increased Mortality Risk at Population Level	Stock Regulating Effect
>30%	High
10%-30%	Moderate
<10%	Low

Lice impact on Sea Trout in Ireland 1992-2016 (Gargan *et al*. 2017)



The population-level increase in mortality risk due to salmon lice infections at individual Irish locations (Gargan *et al*. 2017)

Location	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Bantry Bay			31	75	77	0			66																
Kenmare Bay	64	46	27	23	7	21	4	1	15	0	72	23		30											
Galway Bay			39	16	2		33	0																	
Cashla Bay	44	37	65	0	0	33	44	33	40	0	0			7	60		19		0					0	
Kilkieran Bay			72	79	56	84	63	73	78	94	69	50	46	11	100	28	80	67	83		20		25		
Bertraghboy Bay	77	14	87	20	60	100	43	71	73	41	0	100	33	71	22	25	66	0	14		50			33	
Clifden Bay	55	70		59	3	42	40	29	30	18															
Ballinakill Bay	60	53	35	29	38	10	46	31	38	18	28	40	19	27	53	16	21	50		69	0		29	56	75
Killary Harbour	63	34	29	15	50	77	32	18	57	46	1		50	43	65	42	32	90	0		0		40		71
Clew Bay	26	67	12	7	14	8	15	48	18	13		54		41	81	38	52	34		33			46		
Donegal Bay			26	4	36	13	19	36	45	50	44	64	60	19	50	0	28	26	21	13	0		0	33	0
Lough Swilly			24	0	45	27	43	5	61	17	35	41	50		38	10	28	11	65	20	13	47	1	46	6
East Coast			4		9	3	0	3	0		5		0												
Courtmacsherry Bay		3	5		0	0	0	11																	
Tullaghan Bay		33		0	6	5	0	1	15	3		26	1				0								
North Mayo/Sligo	20	0	14	0	0	6	0	2	13																
Loughros More Bay			7	0	0	0	1		0	0	0		14		0										
Sheep Haven Bay			0	0	0	2	0	0		3															0



ID	Sweep netting sites	ID	Sweep netting sites
1	Dubh Loch	29	Boor Bay
2	Loch Fyne	30	Poolewe
3	Loch Goil	31	Gruinord
4	Loch Riddon	32	Dundonnell
5	S.Sannox	33	Kannaird
6	Rosa	34	Laxford
7	Kildonan	35	Rhiconich
8	Blackwater	36	Kyles of Durness
9	Carradale	37	Polla
10	W.L. Tarbert	38	Kinloch
11	Craignish	39	Halladale
12	Euchar	40	Gress
13	Dunstaffnage	41	Tong
14	Crearan 1, 2, 3 & 4	42	Tiorsdam
15	Camas na Gaul	43	Eisgein
16	Kinlocheil	44	Ciste
17	West Mull	45	Barph
18	Sunart	46	South Ford
19	Borrodale	47	Kyles
20	Loch Long	48	Malacleit
21	Carron	49	Vallay
22	Glen Mor	50	Borve
23	Varagill	51	Tamnabhaigh
24	Slapin	52	Ardroil
25	Harport	53	Morsgail
26	Kerry	54	Grinersta
27	Flowerdale	55	Barvas
28	Charleston		

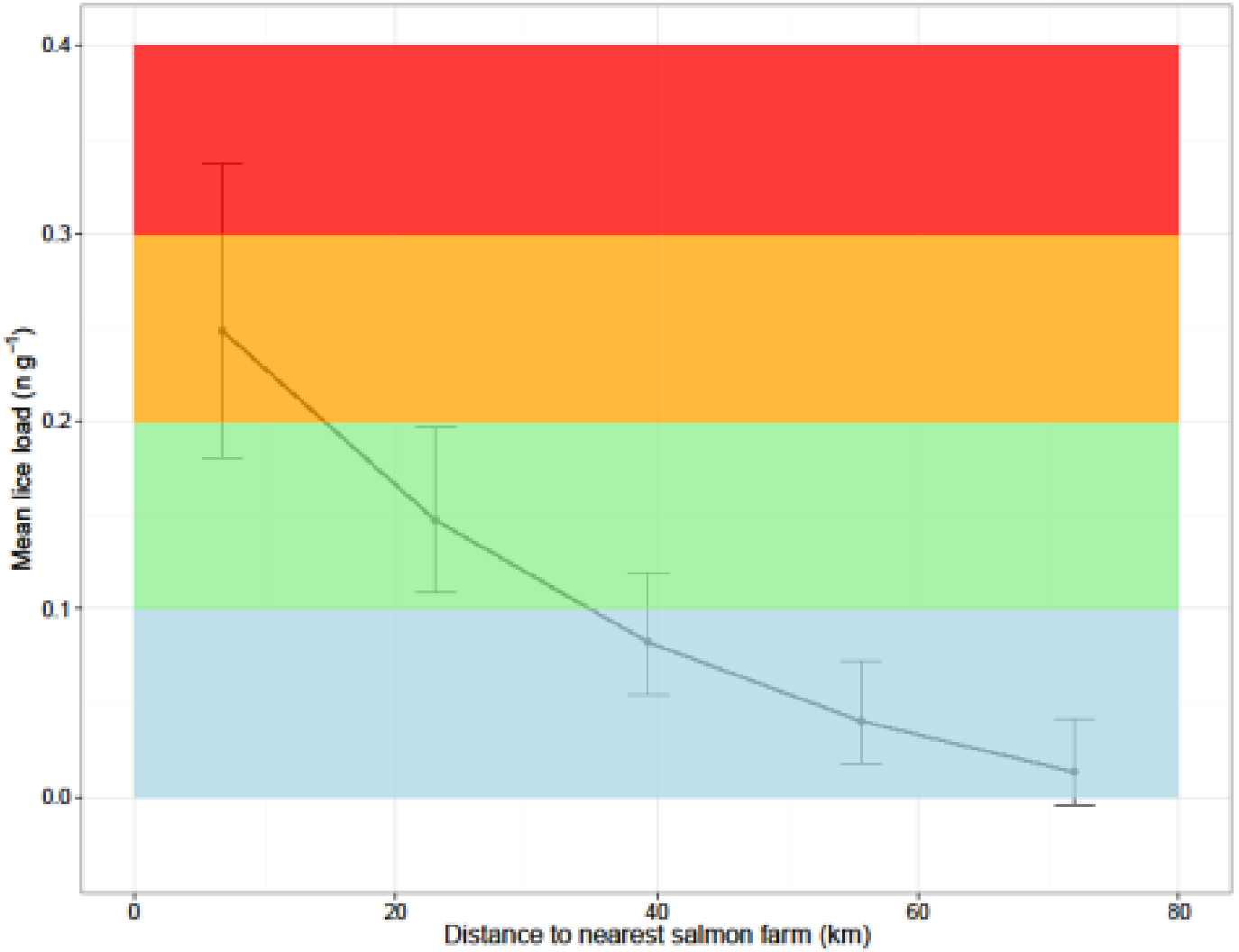
The population-level increase in mortality risk due to salmon lice infections at individual Scottish locations (Gargan *et al*. 2017)

	Location	Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
West Sutherland	Rhiconich	SCO			0	6															
West Sutherland	Kyle of Durness																			0	
West Sutherland	Dionard	SCO									38			1	2						
West Sutherland	Kinloch	SCO																	0	1	
West Sutherland	Laxford	SCO	5		3	12	2	1	7	6	1	13	3	20	1		55	1	30	0	13
West Sutherland	Polla	SCO			5	7	0	0	3	13	1	22	0	5	4		4	0	0	0	19
West Sutherland	Halladale	SCO											100		47						
Wester Ross	L.L.Broom	SCO												0							
Wester Ross	Poolewe	SCO						14	85	0	0	0	43								
Wester Ross	Kerry	SCO												11	28						
Wester Ross	Ewe	SCO	16	6	22	0			90		13		45	15	5						
Wester Ross	Flowerdale	SCO															22	0	0	0	49
Wester Ross	Glen Mor	SCO					56	34	4	3		22									
Wester Ross	Carron	SCO												15	0						
Wester Ross	Charleston	SCO													7						
Wester Ross	Dundonnell	SCO	49	83	67	94	80	31	33	14	0	6	44	66							
Wester Ross	Boor Bay	SCO												0	19		0	22	0		3
Wester Ross	Gruinard	SCO	26	34	22	8															
Wester Ross	Kannaird	SCO	79		0								30	21			47	37	42	24	
Skye	Varagill	SCO																			0
Skye	Slapin	SCO															14		16	35	0
Skye	Harport	SCO															11		5		
Lochaber	Sunart	SCO										56		93	0						
Lochaber	Camus na Gaul								75	1	54	0	45	2	15		51.5	0.2	47.5	0.0	23.1
Lochaber	Borrodale	SCO																10	0	3	0
Lochaber	Kinlocheil	SCO			23	0	26		33	0	15	0	13	0	1		9.0	14	12	0	0
Argyll	Kildonan	SCO	38	50	80	20	8														
Argyll	Carradale	SCO											6	0	6			0	0	1	0
Argyll	Craignish	SCO												33	0						
Argyll	Creran1	SCO									2										

The population-level increase in mortality risk due to salmon lice infections at individual Scottish locations (Gargan *et al*. 2017)

	Location	Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Argyll	Creran2	SCO			5	0	25	2	90		7						
Argyll	Creran3	SCO					64			0							
Argyll	Creran4	SCO			29	0	17	2	49	9	22						
Argyll	Dunstaffnage	SCO		47	34	17	17	16	77	10	51		13.8	3	54	0	43
Argyll	Loch Fyne	SCO					3	0	4	4	2			1	1	0	0
Argyll	Dubh Loch	SCO	14	5	9	1	4	0	3	6	5						
Argyll	Loch Goil	SCO												49	1.3	35.0	
Argyll	Loch Long	SCO								53							
Argyll	Loch Riddon	SCO					37	2	8	1	7			50	0	33	0
Argyll	Rosa	SCO							0		27						
Argyll	S.Sannox	SCO							10	0							
Argyll	W.Tarbert	SCO							24	71	13						
Argyll	Euchar	SCO				50		1	18	15	3						
West Mull	Ba Mouth	SCO			8	5	1	0	11	0	16						
Arran	Blackwater	SCO			38	88		0	34								
Outer Hebrides	Borve	SCO			0			10	9	0	0		7	31	5	2	12
Outer Hebrides	Barvas	SCO							22	0	13						
Outer Hebrides	Ardroil	SCO							0		0						
Outer Hebrides	Eisgean	SCO									28		0	14	19	12	22
Outer Hebrides	South Ford	SCO															29
Outer Hebrides	Tamnabhaigh	SCO							1								
Outer Hebrides	Tiorsdam	SCO				82		43	97	100	18						
Outer Hebrides	Tong	SCO									0		0	0	9	9	2
Outer Hebrides	Vallay	SCO						5									
Outer Hebrides	Gress	SCO					0	0	0	0							
Outer Hebrides	Grimersta	SCO		93	15	70		53	48	0	0						
Outer Hebrides	Kyles	SCO							21				14	0	0	18	5
Outer Hebrides	Malacleit	SCO											10	1	11	14	12
Outer Hebrides	Morsgail	SCO							100								27
Outer Hebrides	**Barph**							62	78		56						
Outer Hebrides	**Ciste**							80	32		17						

A strong negative effect of distance to the nearest salmon farm on lice load in Ireland



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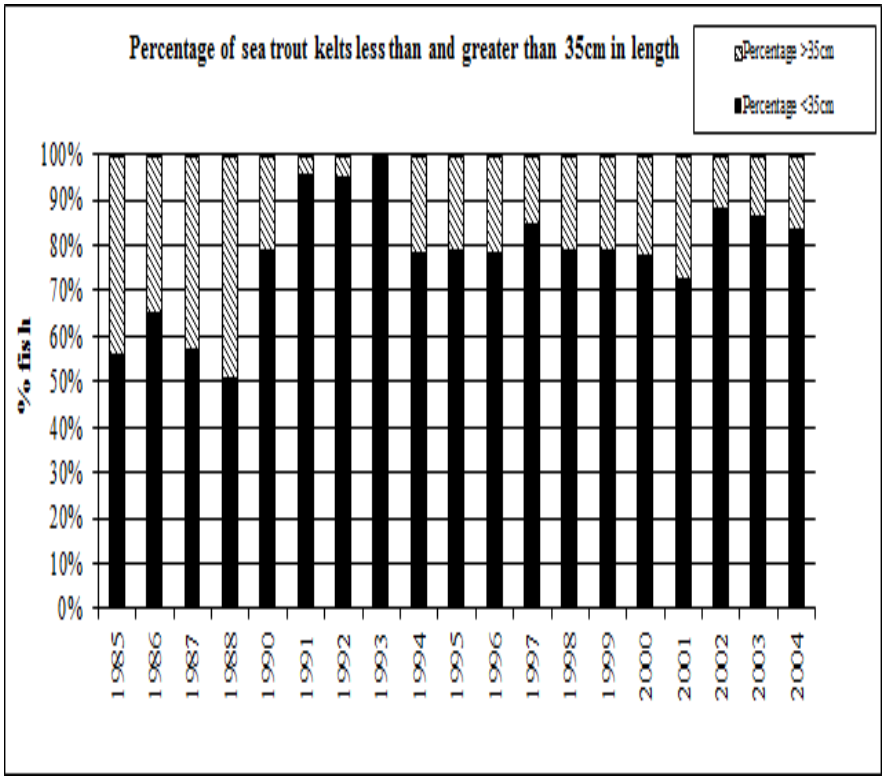
Long-term Sea Trout Monitoring 1985 – 2004
Tawnyard kelt & smolt trap

Temporal variation in sea trout *Salmo trutta* life history traits in the Erriff River, western Ireland

P. G. Gargan[1,*], F. L. Kelly[1], S. Shephard[1], K. F. Whelan[2]



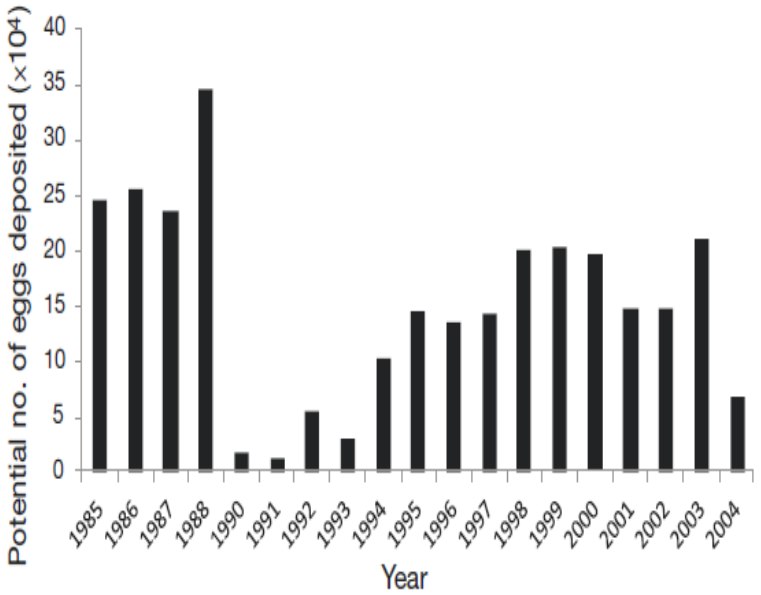


Fig. 6. Estimated potential sea trout *Salmo trutta* egg deposition, Tawnyard catchment, 1985–2004

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International Review of impact of sea lice

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AQUACULTURE ENVIRONMENT INTERACTIONS
Aquacult Environ Interact

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REVIEW

Effects of salmon lice *Lepeophtheirus salmonis* on wild sea trout *Salmo trutta*—a literature review

Eva B. Thorstad[1,*], Christopher D. Todd[2], Ingebrigt Uglem[1], Pål Arne Bjørn[3], Patrick G. Gargan[4], Knut Wiik Vollset[5], Elina Halttunen[3], Steinar Kålås[6], Marius Berg[1], Bengt Finstad[1]

Lice infestation pressure- Potential for sea trout or salmon smolts to be impacted?

Lice infestation pressure - the Extent of any impact depends on;

- Location (long Norwegian fjords & short coastal bays in Ireland)
- Production strategy (multiple sites, single generation sites, fallowing)
- Lice burden in spring
- Local topography
- Environment (salinity, freshwater influence, temperature etc)

- If a combination of circumstances exist, even in short coastal bays, there is potential for impact of lice from farms to impact out-migrating wild salmonids

- Critical to consider the cumulative effect of lice infestation on the migration route

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Long-term Studies on Impact of Sea Lice in Ireland

Erriff Upstream Trap

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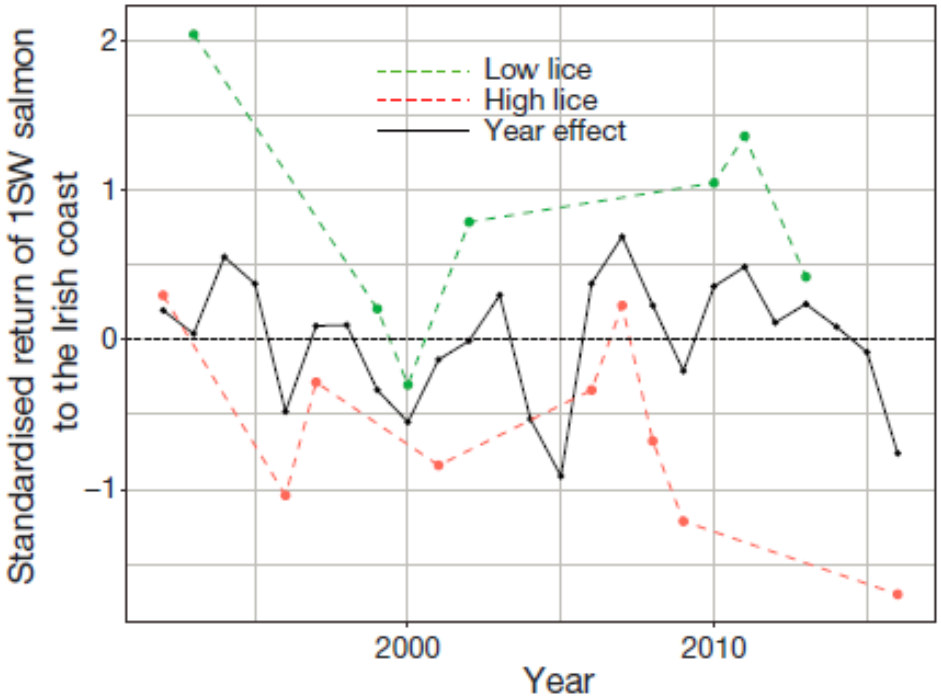
Erriff Fishery - Long-term Studies on sea lice impact on salmon



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AQUACULTURE ENVIRONMENT INTERACTIONS
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Quantifying the contribution of sea lice from aquaculture to declining annual returns in a wild Atlantic salmon population

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Sea Lice Regulation in Ireland

- Monthly sea lice monitoring (twice/month March – May)
- March – May ovigerous lice thresholds (0.3 – 0.5)
- Thresholds not related to size of farms
- High mobile sea lice may also trigger treatments
- If lice thresholds breached, a Notice to Treat is issued
- If lice levels not brought under control before spring, Early Harvesting may be ordered
- Early harvesting by mid-March enforced four times since 2012
- Not enforced consistently where lice levels not brought under control in spring

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Strategies contributing to ineffective lice control

- farm sites located too close to salmonid rivers;
- mixed year-class production (smolt and grower fish reared in close proximity);
- rearing two-sea-winter fish with difficulty of controlling lice;
- lack of sea lice control due to protracted harvesting;
- lack of synchronised sea lice treatments between sites;
- insufficient fallowing;
- fallowing not aligned with wild smolt runs.

Problems with Current Lice Regulation

- Sampling programme does show farm lice levels monthly
- However, no link between lice levels on farms and lice levels sea trout
- Sea Lice regulation not linked to hydrodynamic / lice dispersal modelling
- Farmed fish move from offshore smolt sites to inshore grow out sites – often there is prolonged harvesting during wild smolt migration
- Spring lice trigger levels (0.5 ovigerous) not related to farm size & may not be sufficiently low at all sites to ensure no lice induced mortality of wild fish.

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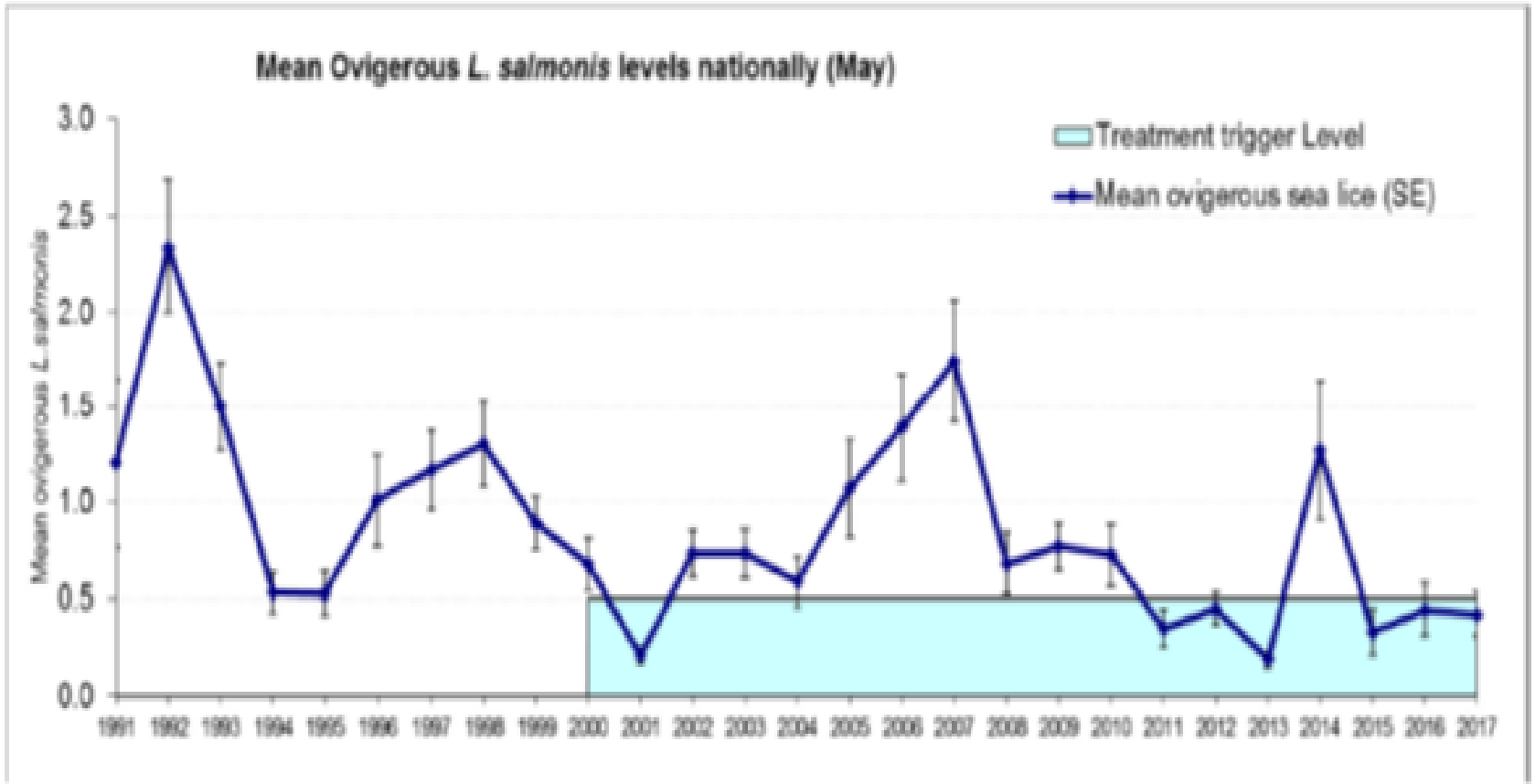
Annual trend in May of ovigerous *L.salmonis* lice on 1-sea winter salmon in Ireland 1991-2017 (Source – Marine Institute).



Management lessons learnt re: effective lice control

- Single generation sites since 2000, often in separate bays, (*sites one tidal excursion apart)*
- Annual Fallowing before re-stocking; 4-6 weeks
- Whole bay spring fallowing
- Harvesting carried out remote from the grower sites.
- Annual synchronous "winter" lice treatment for all adjacent sites
- Where there is a persistent problem with sea lice control, an incremental series of actions occurs; Management Cell Approach

Monitoring & Research on Sea Lice Impacts in Ireland

- Annual monitoring of lice levels on sea trout in aquaculture bays
- Erriff Index catchment –monitoring smolt/kelt and upstream runs – PIT tagging, acoustic tagging etc
- Release of Slice treated & control groups of hatchery smolts
- Sampling lice in the water column - Lice pumping – eDNA
- Licetrack Project - Using hydrodynamic & particle tracking models, environmental variables, sea lice production on farms
- Will contribute to developing best management practice for sea lice control aimed at reducing the presence of sea lice

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