A review of sea lice monitoring of wild sea trout in the WRFT area in 2007 and 2008

Peter Cunningham,

Wester Ross Fisheries Trust

16 April 2009

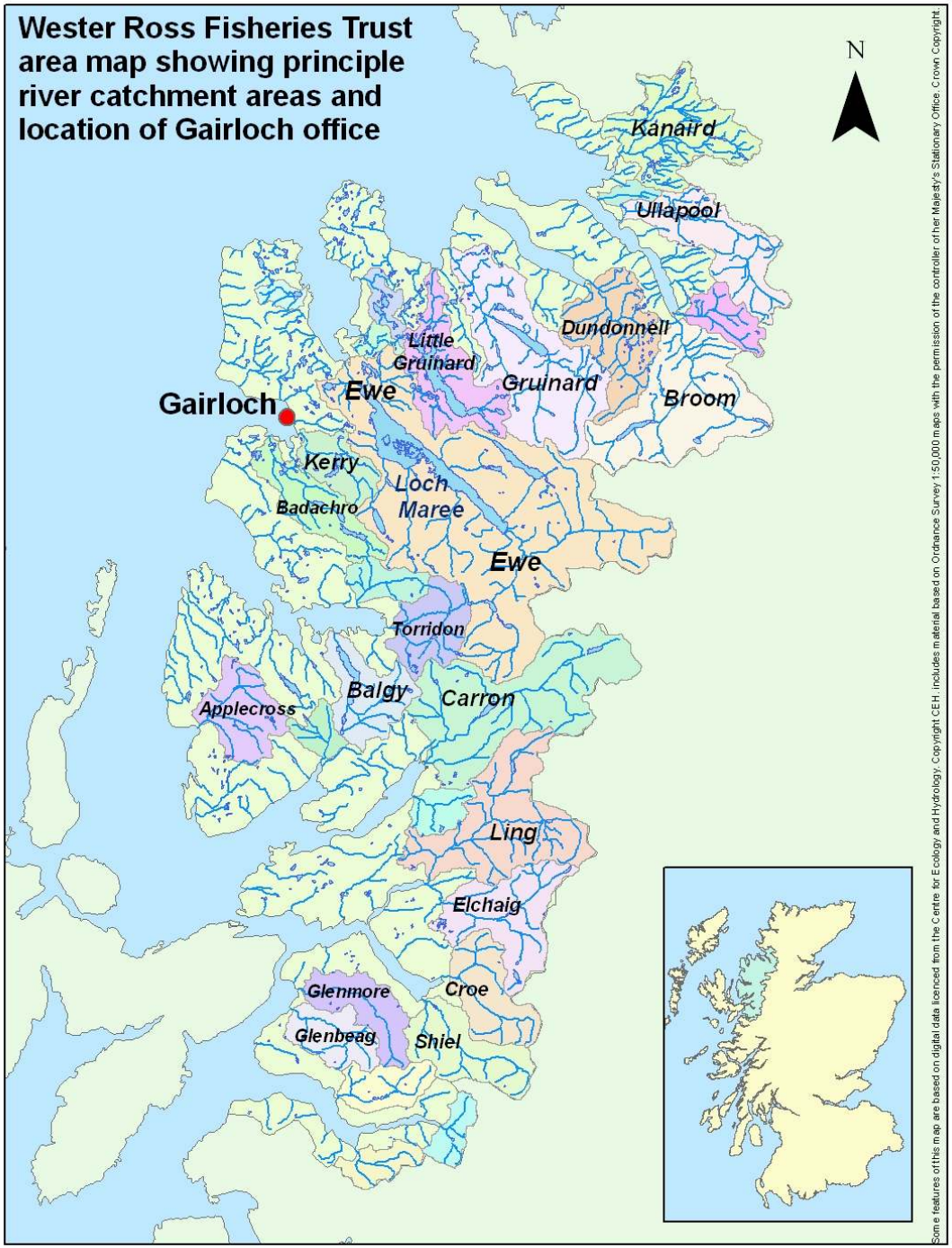
RAFTS

Tripartite Working Group

The Scottish Government

The overall **Purpose** of the Trust is to

maximise and sustain the natural productivity of wild salmonid fisheries in the rivers and lochs of Wester Ross.



Fisheries Co-management

State agencies and
Research institutions

Local Fishery Trust

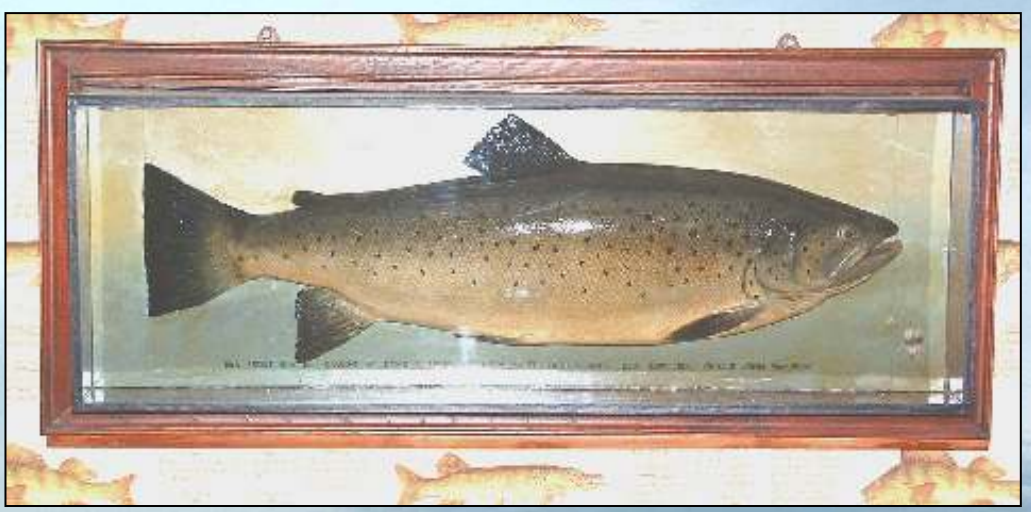
Fisheries managers, anglers . . .

Fish, habitats and fisheries

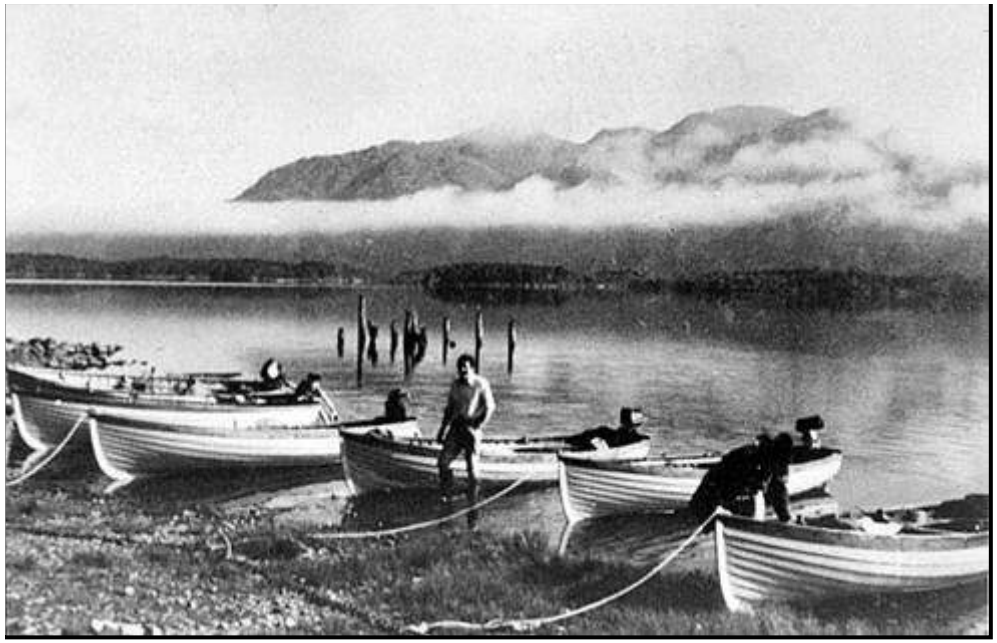
•FMP Objective 2

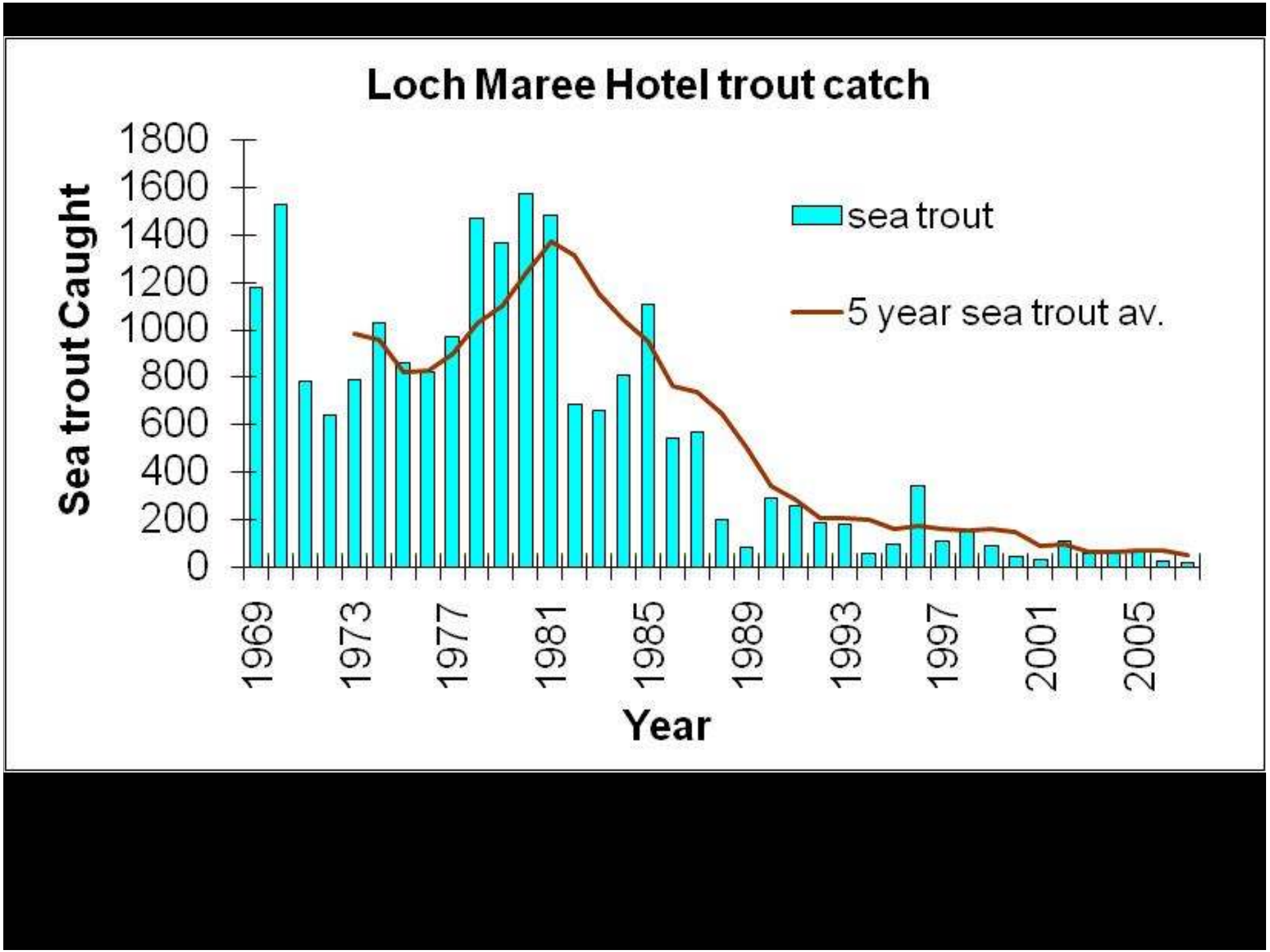
Restoration of the Loch Maree sea trout Fishery


The art of dapping
was developed on
Loch Maree. . .

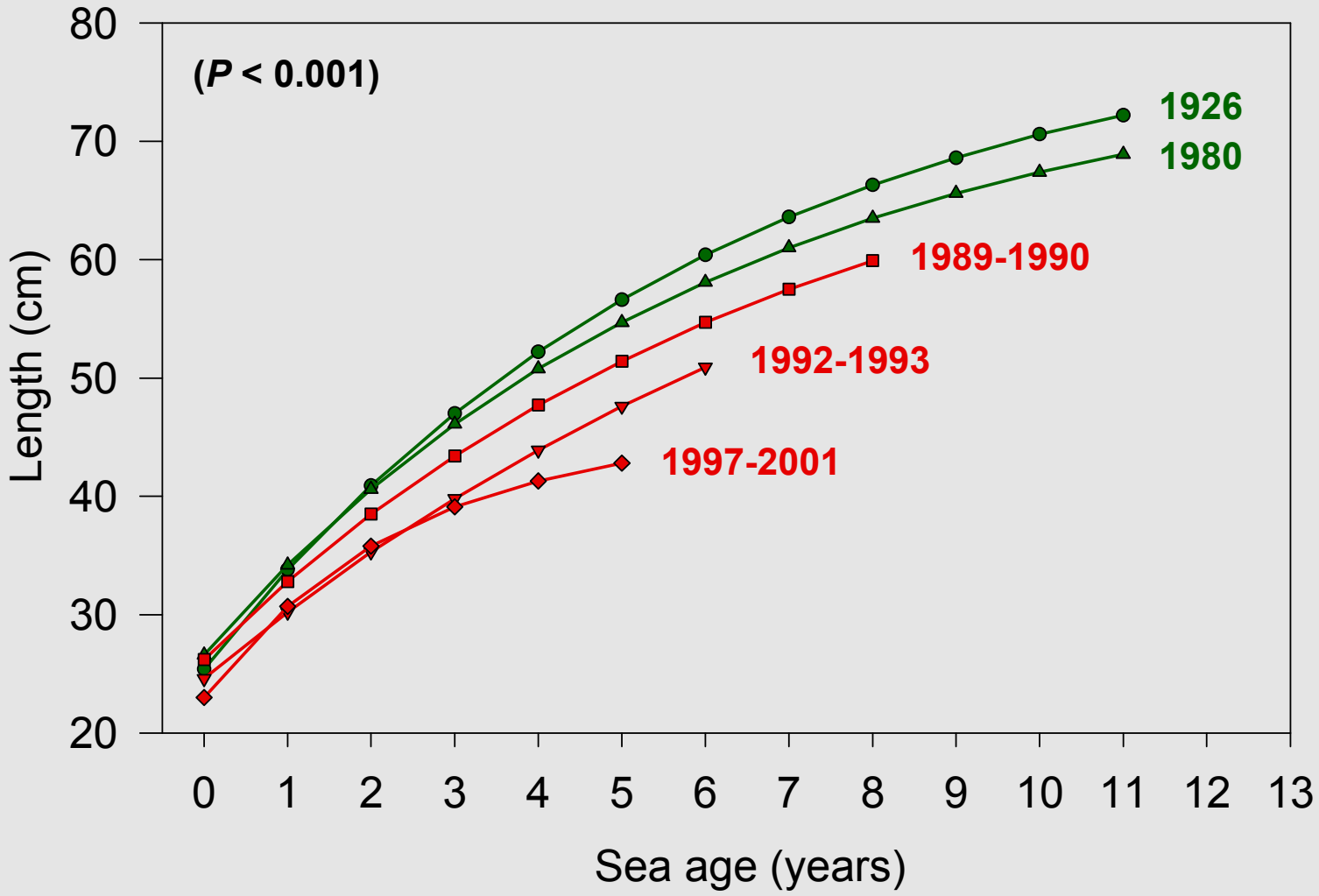


Former British record rod caught sea trout



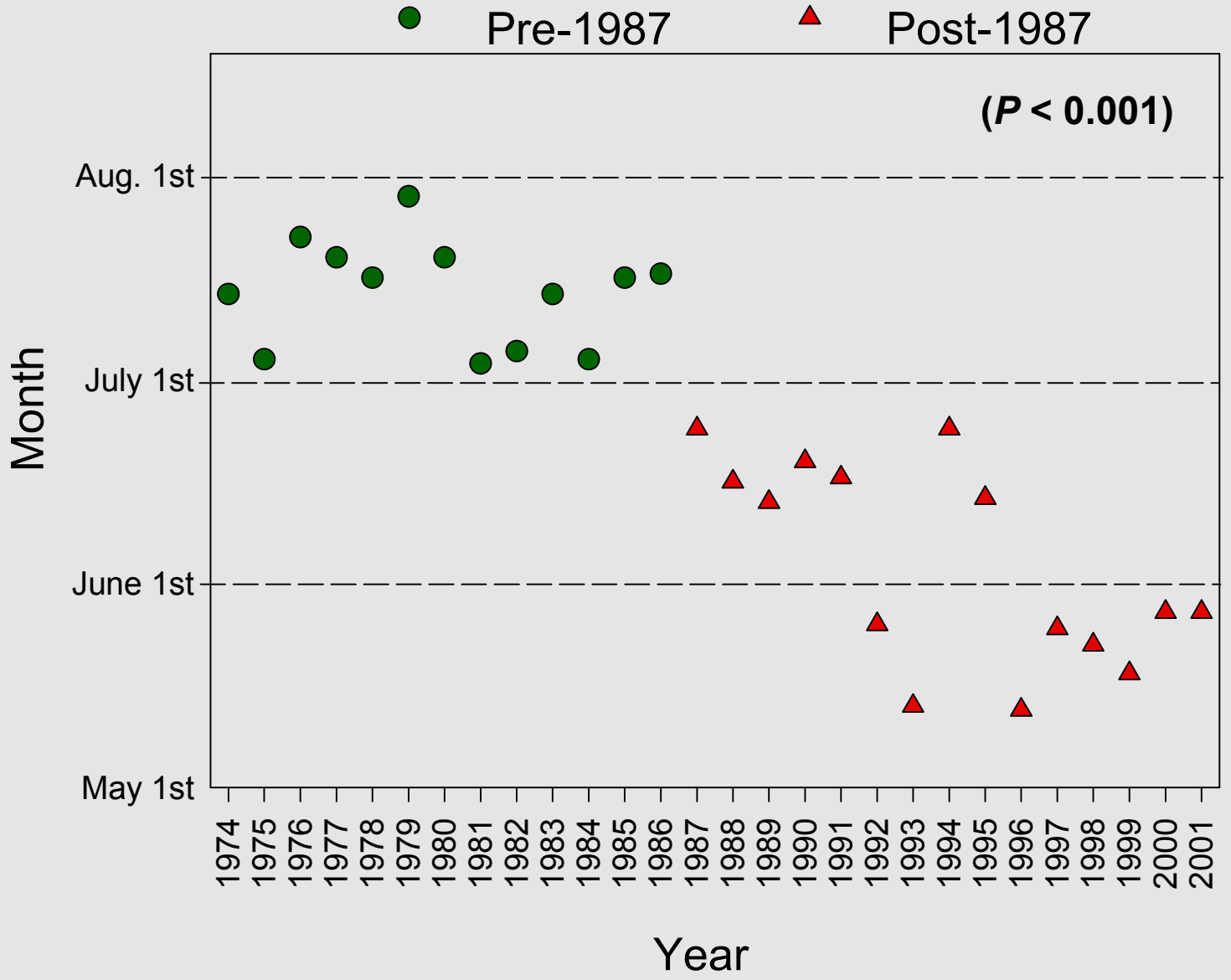

Loch Maree Hotel trout catch
Sea trout Caught
1800
1600
1400
1200
1000
800
600
400
200
0
sea trout
5 year sea trout av.
1969
1973
1977
1981
1985
1989
1993
1997
2001
2005
Year

Marine Ages and Growth

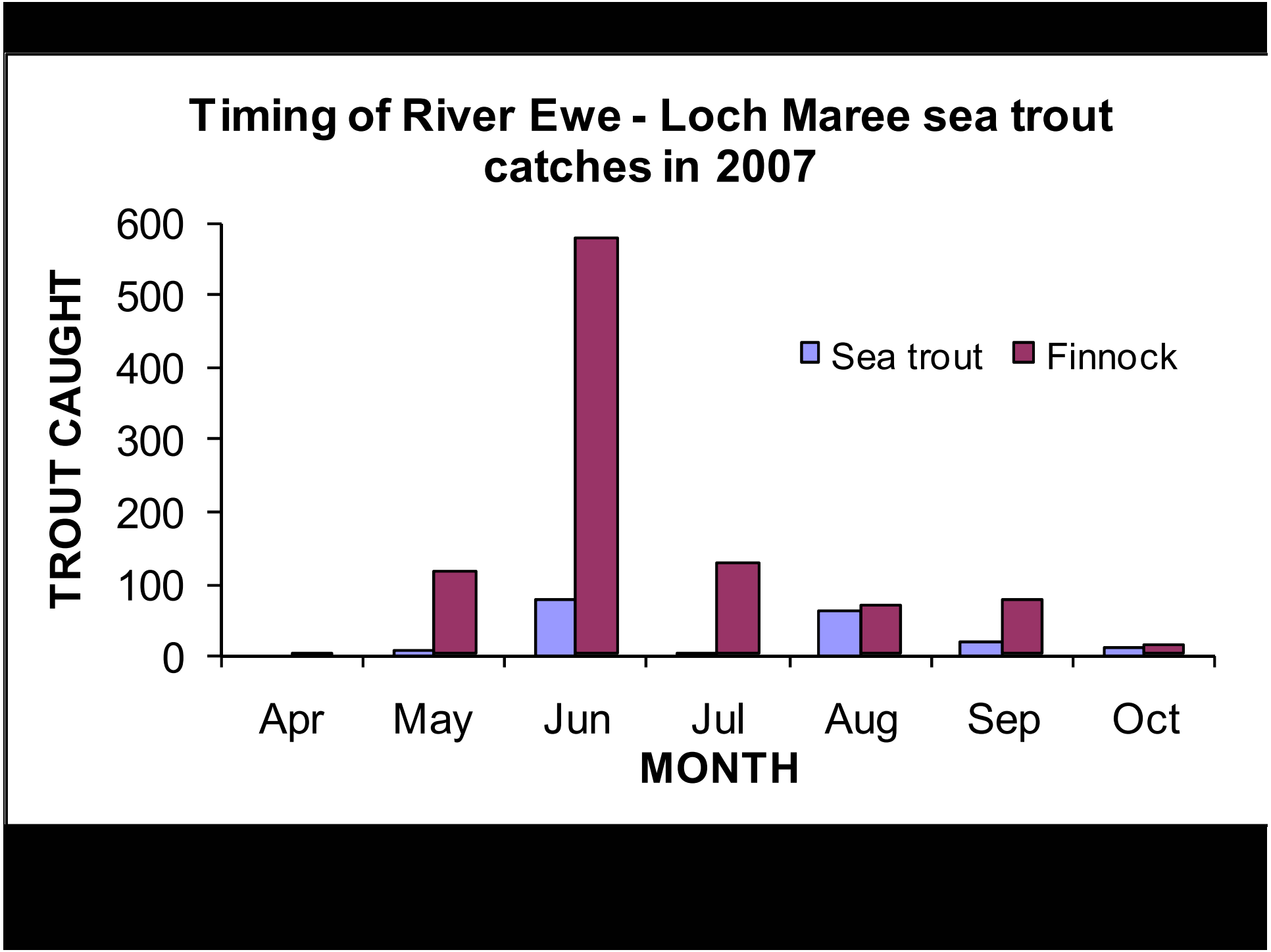


from Butler, 2002

Date of First River Ewe Finnock, 1974-2001

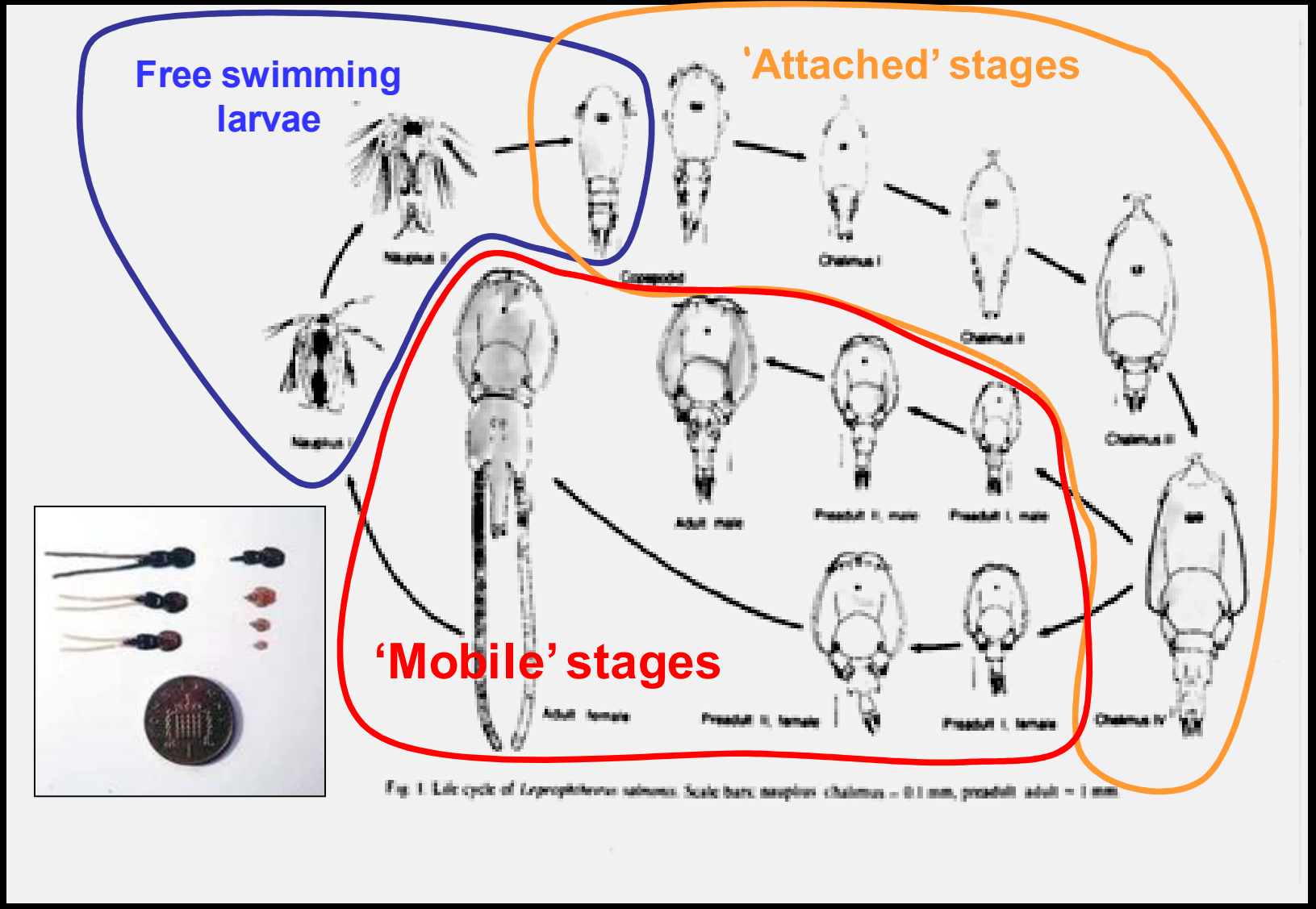


from Butler, 2002

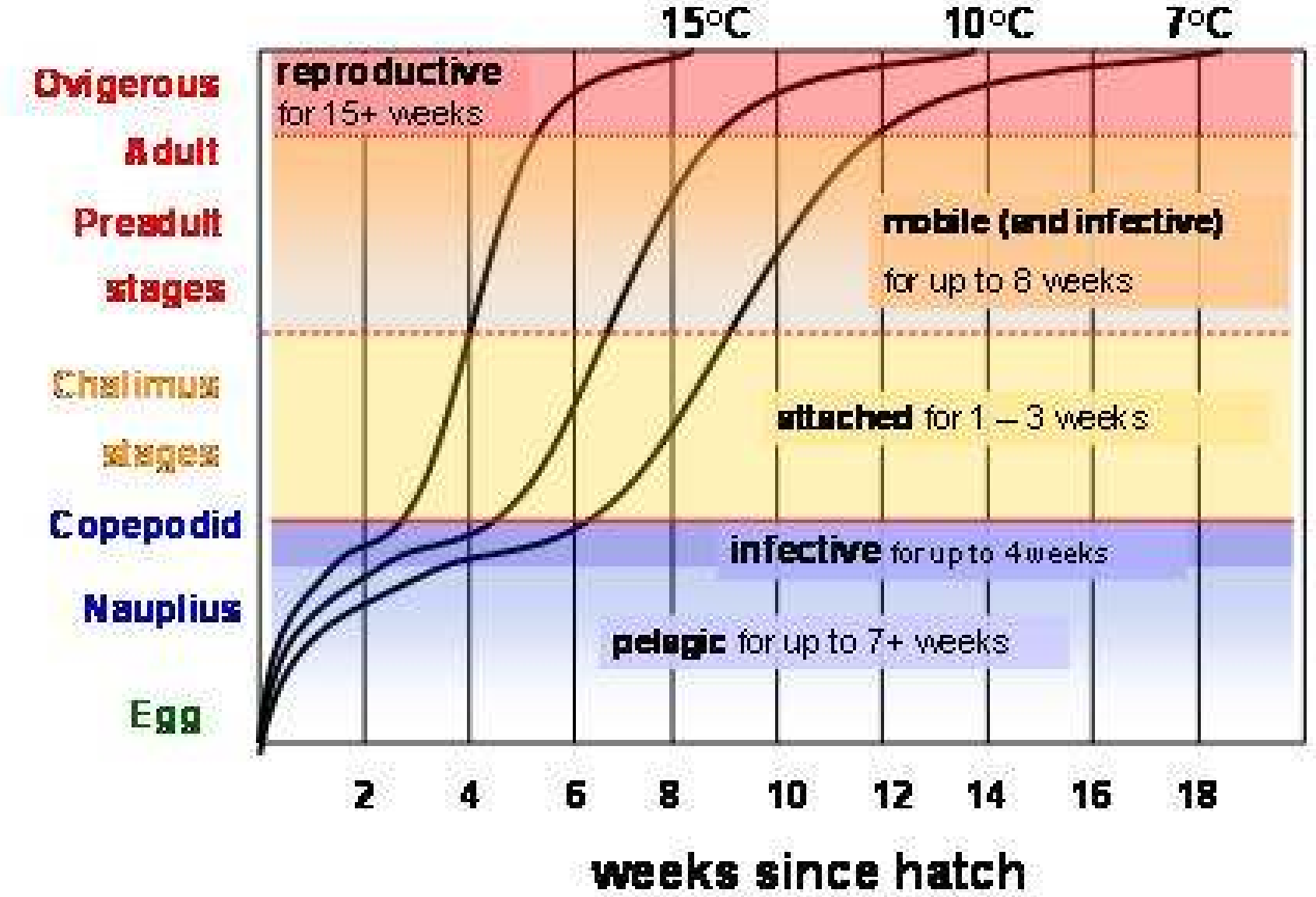

Timing of River Ewe - Loch Maree sea trout catches in 2007
TROUT CAUGHT
600
500
400
300
200
100
0
Sea trout
Finnock
Apr
May
Jun
Jul
Aug
Sep
Oct
MONTH

Sea lice monitoring

Lepeophtheirus salmonis : life cycle



Lepeophtheirus salmonis : rates of development

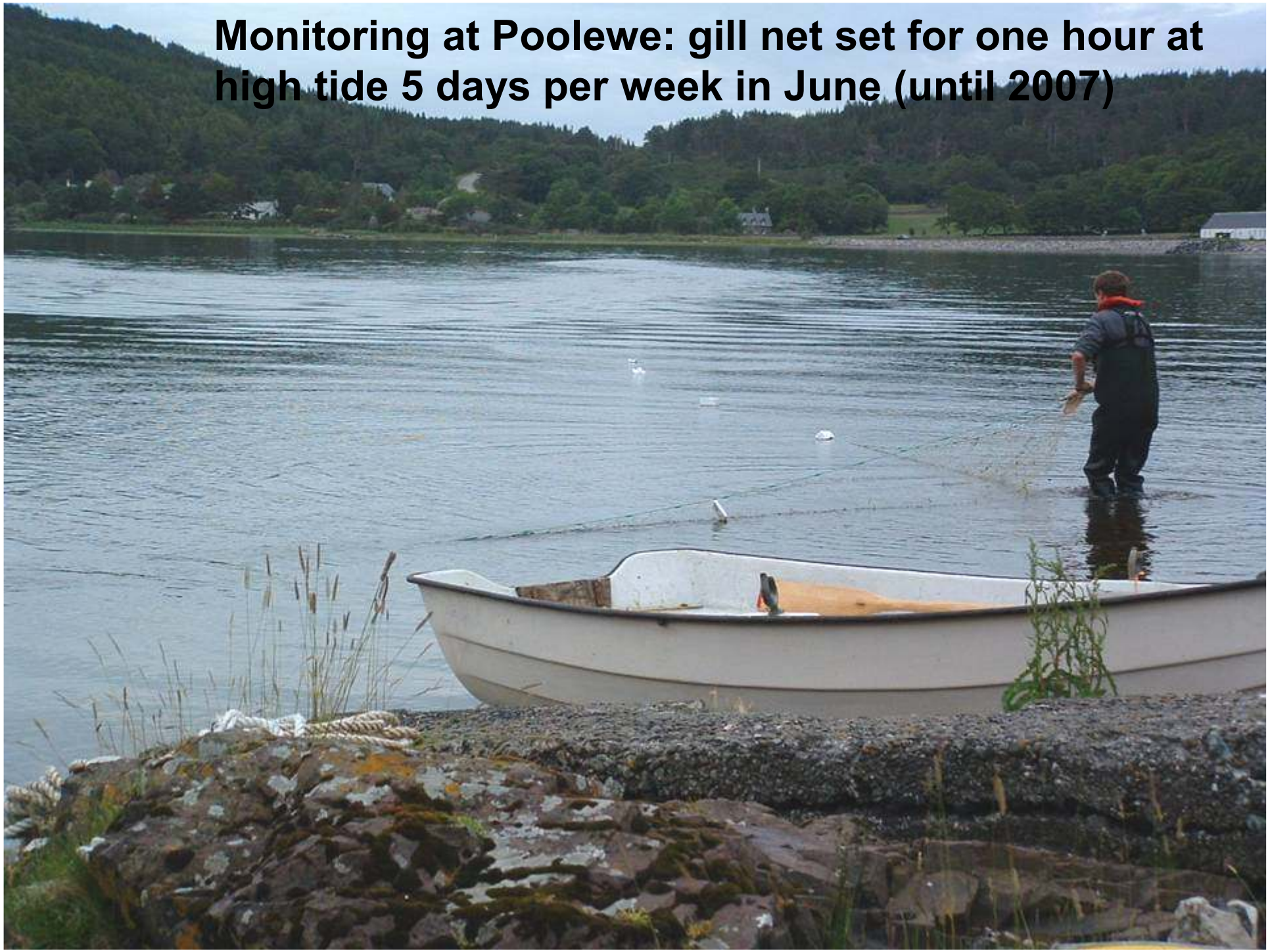


Based on 'EWOS guide', Heuch et al. (2005), Boxaspen (2006), Revie et al (2009)

Objectives

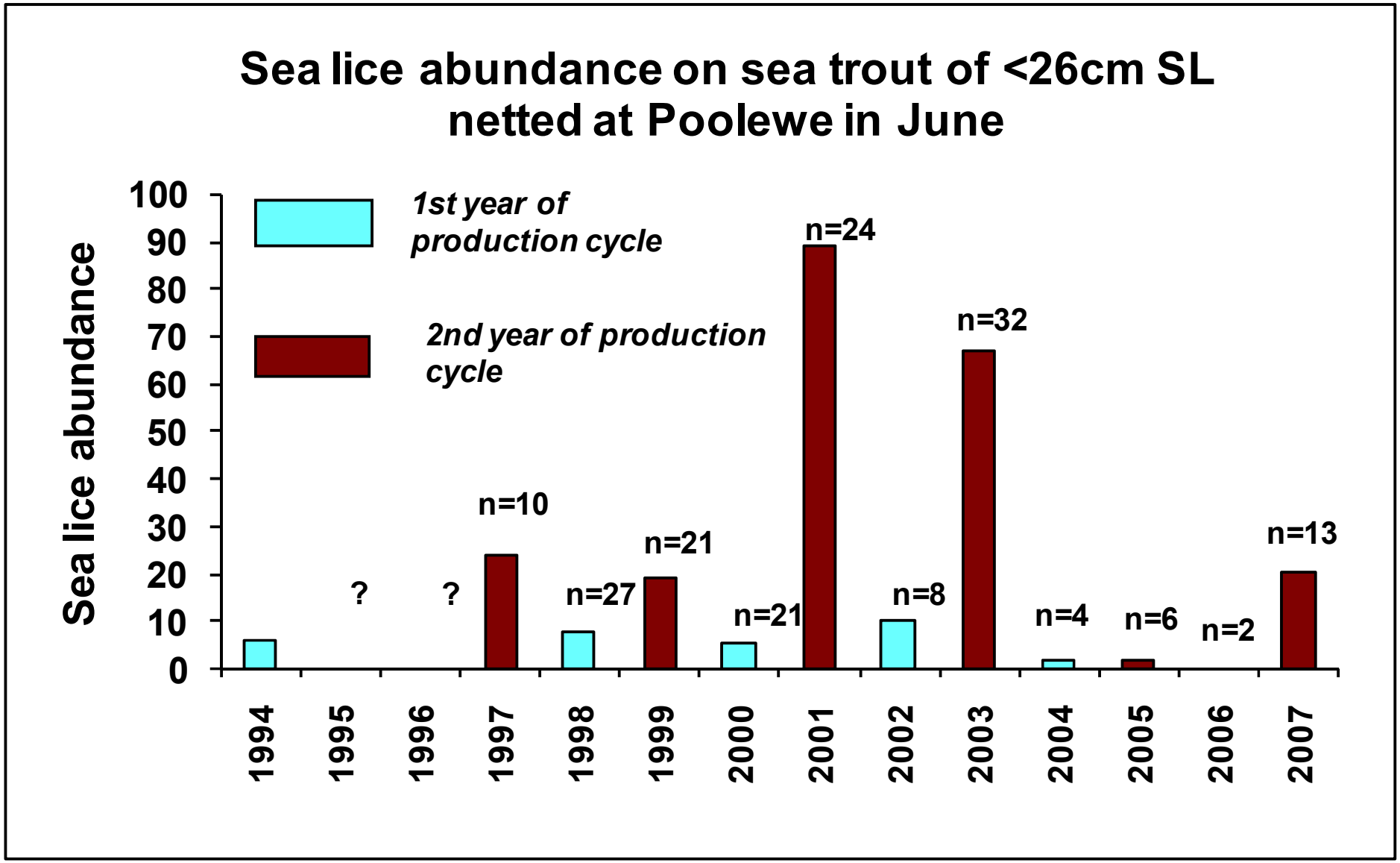
1. to continue to develop a clearer understanding of year to year patterns of lice infection of sea trout, in relation to local geography, climate, and salmon farming activities in nearby areas = Monitoring

2. to gather additional information by responding to reports of high levels of sea lice infection, in order to investigate the severity of an epizootic, its extent, distribution, and possible causes = Surveillance.


Monitoring at Poolewe: gill net set for one hour at high tide 5 days per week in June (until 2007)

Protocol

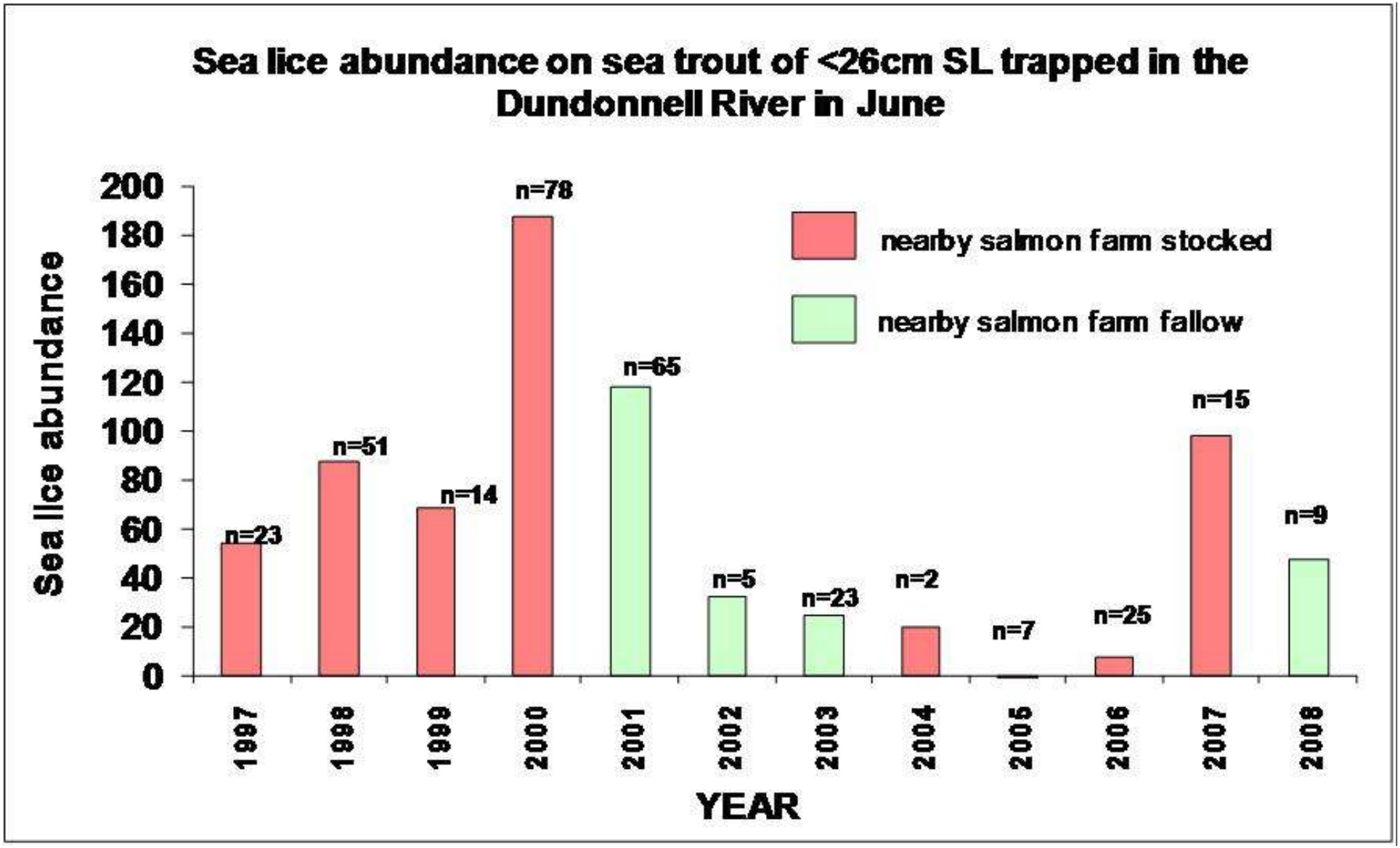
1. Anaesthetise fish
2. Measure length
3. Take scale sample
4. Count lice
   - attached
   - mobiles
6. Return fish to water after recovery
7. Contact FRS Fish Health if >30 lice recorded on consecutive fish (i.e. if epizootic suspected)


Sea lice abundance on sea trout of <26cm SL netted at Poolewe in June
Sea lice abundance
100
90
80
70
60
50
40
30
20
10
0
1st year of production cycle
2nd year of production cycle
?
?
n=10
n=27
n=21
n=21
n=24
n=8
n=32
n=4
n=6
n=2
n=13
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007

Dundonnell – fyke net fished near top of tide

Alastair Macdonald emptying the fyke net, July 2008


Dundonnell finnock, July 2008
TESCO
SUPEKFLEX


Sea lice abundance on sea trout of <26cm SL trapped in the Dundonnell River in June
Sea lice abundance
200
180
160
140
120
100
80
60
40
20
0
n=23
n=51
n=14
n=78
n=65
n=5
n=23
n=2
n=7
n=25
n=15
n=9
nearby salmon farm stocked
nearby salmon farm fallow
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
YEAR

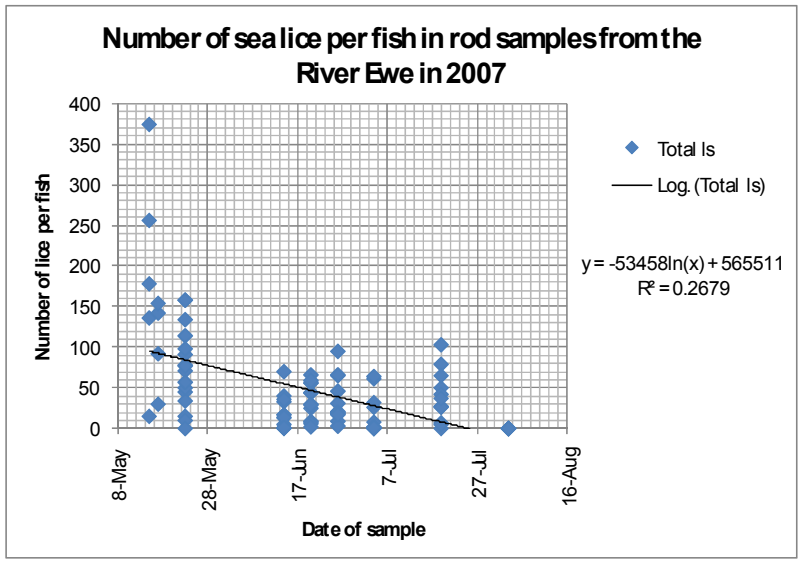
Rod and line sampling – River Ewe

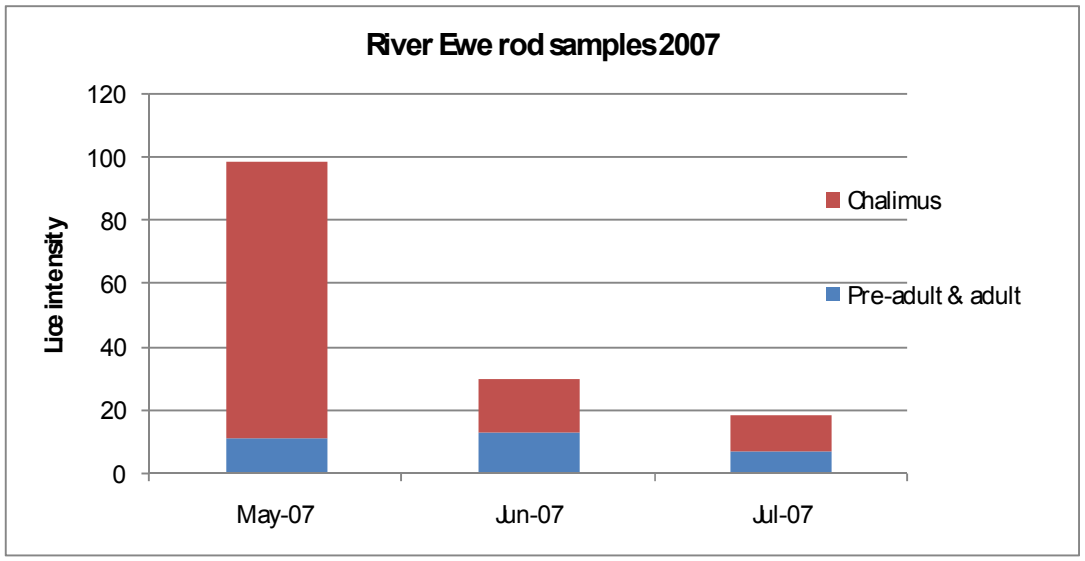
- A fast way to obtain a sample of fish in order to assess severity of an epizootic

- An efficient way of gaining a supplementary sample of sea trout in River Ewe

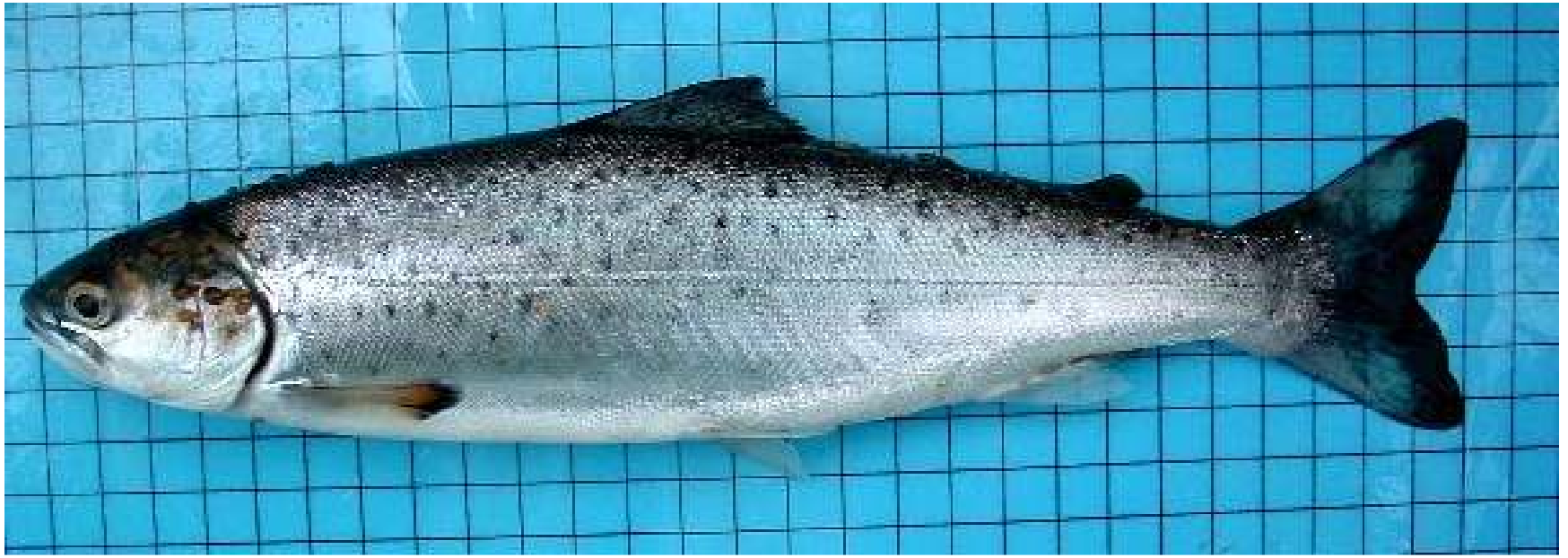
River Ewe May 2007

River Ewe May 2007


Number of sea lice per fish in rod samples from the River Ewe in 2007
Number of lice per fish
400
350
300
250
200
150
100
50
0
8-May
28-May
17-Jun
7-Jul
27-Jul
16-Aug
Date of sample
Total ls
Log. (Total ls)
y = -53458ln(x) + 565511
R² = 0.2679

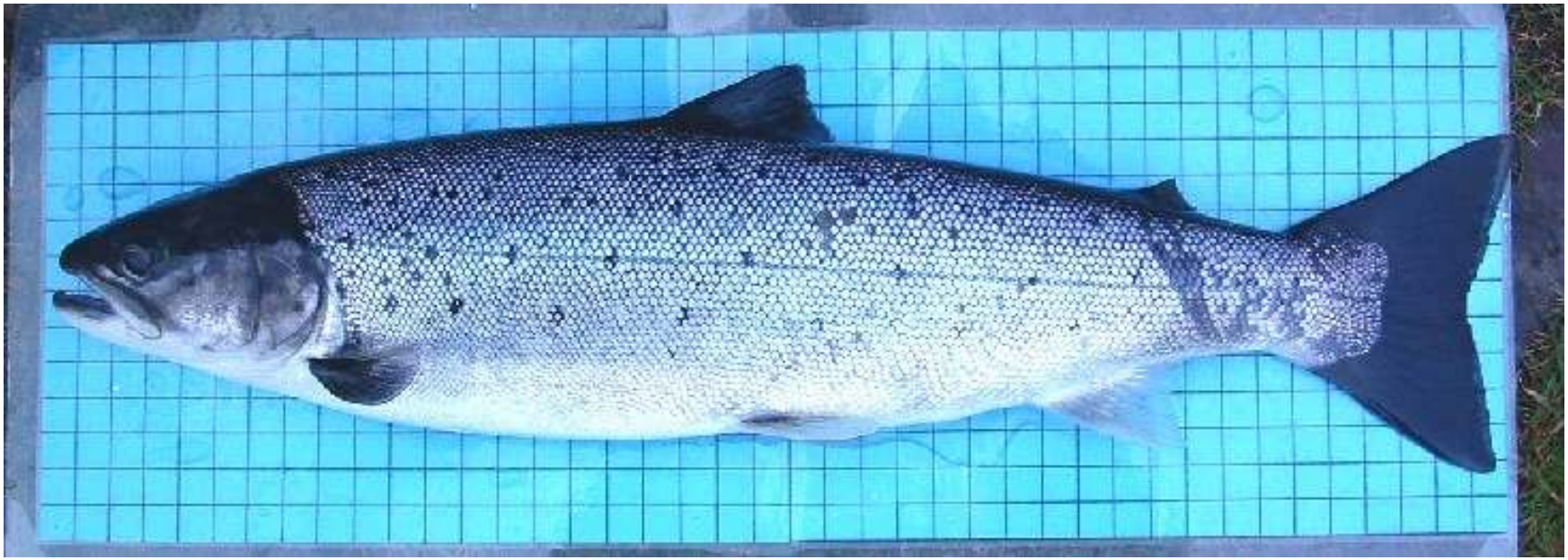

River Ewe rod samples 2007
Lice intensity
120
100
80
60
40
20
0
May-07
Jun-07
Jul-07
Chalimus
Pre-adult & adult

River Ewe, July 2008

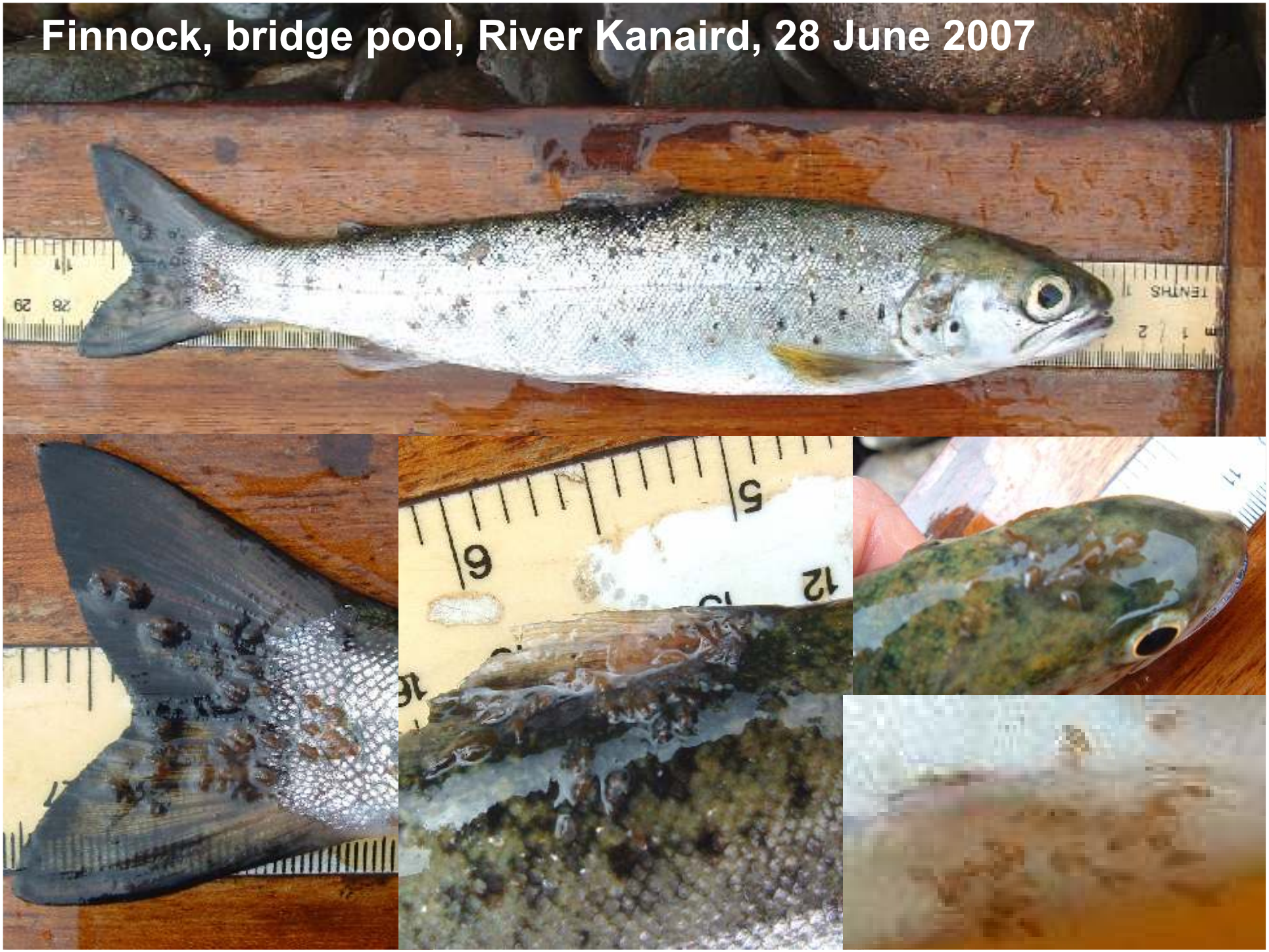


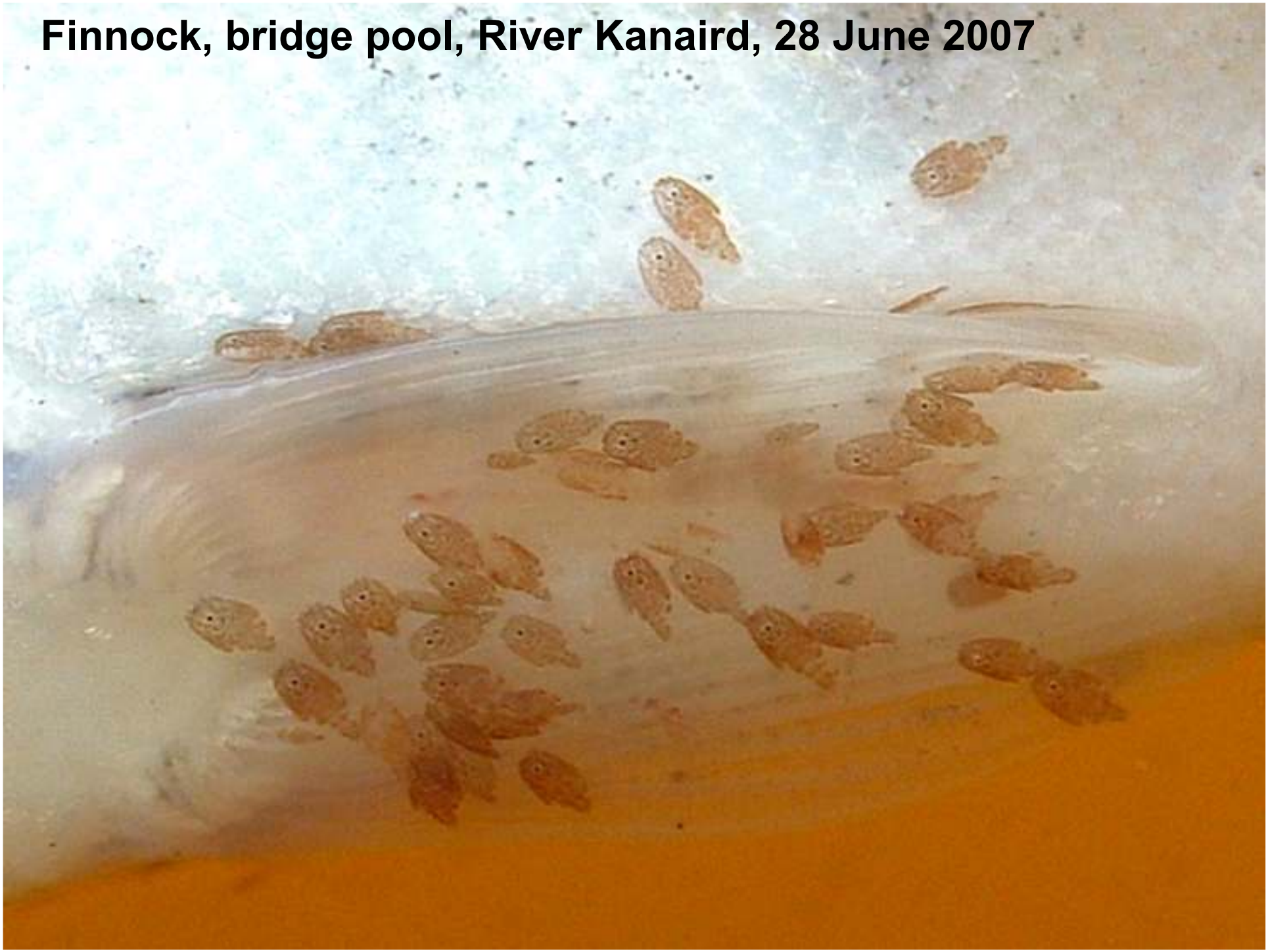
River Ewe, July 2008

River Ewe, July 2008



Finnock, bridge pool, River Kanaird, 28 June 2007




Finnock, bridge pool, River Kanaird, 28 June 2007


Sea trout, bridge pool, River Kanaird, 28 June 2007

River Kanaird rod and line 28 June 2007: 10 sea trout in sample

At request of Andy Aitken

Fish #	Length	*Sea lice (See note)*				**Dorsal Dar**	Predator Dama	Spots	Photos?	Comment
	mm	chal	PrA /A	Ov Fem	total					
1	**215**	0	2	0	**2**	**1**	N	Y	3	healing scars on dorsal; fin
2	**228**	9	0	0	**9**	**1**	N	Y	1	not too bad - fatter than fish#1
3	**380**	0	0	0	**0**	**2**	N	Y	2	dorsal fimn badly eroded and raw bloody ulcer
4	**232**	0	0	0	**0**	**0.5**	N	light	1	a few scars
5	**218**	7	2	0	**9**	**1**	N	Y	1	dorsal scars indicative of 20+ lice earlier
6	**213**	0	1	0	**1**	**0.5**	Y	Y	1	scale loss on flanks - possible bird attack
7	**199**	0	2	0	**2**	**1**	N	Y	1	
8	**220**	90	9	0	**99**	**1.5**	N	Y	2	dorsal fin eroded to ray bones
9	**184**	40	0	0	**40**	**1**	N	Y	1	
10	**233**	170	10	0	**180**	**2+**	N	Y	10	very tatty: fish retained

Note: sea lice were assumed to be *Lepeophtheirus salmonis*; a voucher speciment has been retained and frozen for subsequent

An epizootic is defined as a disease which affects animals as an epidemic does mankind (Chambers 20th Century Dictionary). In the context of sea trout and sea lice, we refer to the occurrence of sea trout with high levels of sea lice infection (average of 30 or more lice per fish in a sample of 3 or more consecutive sea trout), or ‘early-returned’ sea trout with evidence of high level of sea louse infection (scarring and eroded fins).

Sweep netting for sea trout (May to September 2008)

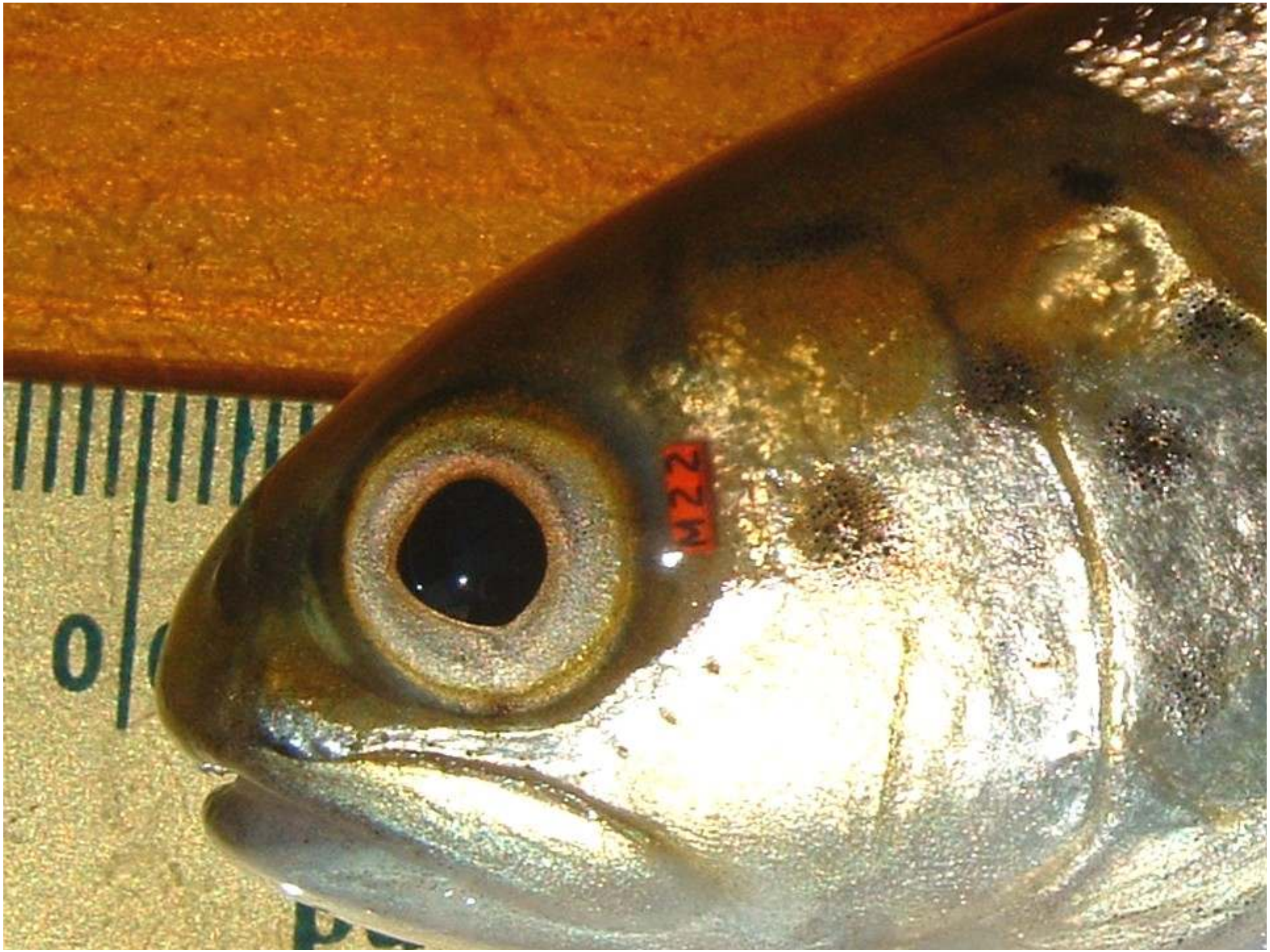
The Scottish Government

Tripartite Working Group

Kildonan Bay,

Little Loch Broom


OCEAN


M22

(photo by Ben Rushbrooke)

(photo by Ben Rushbrooke)

(photo by Ben Rushbrooke)

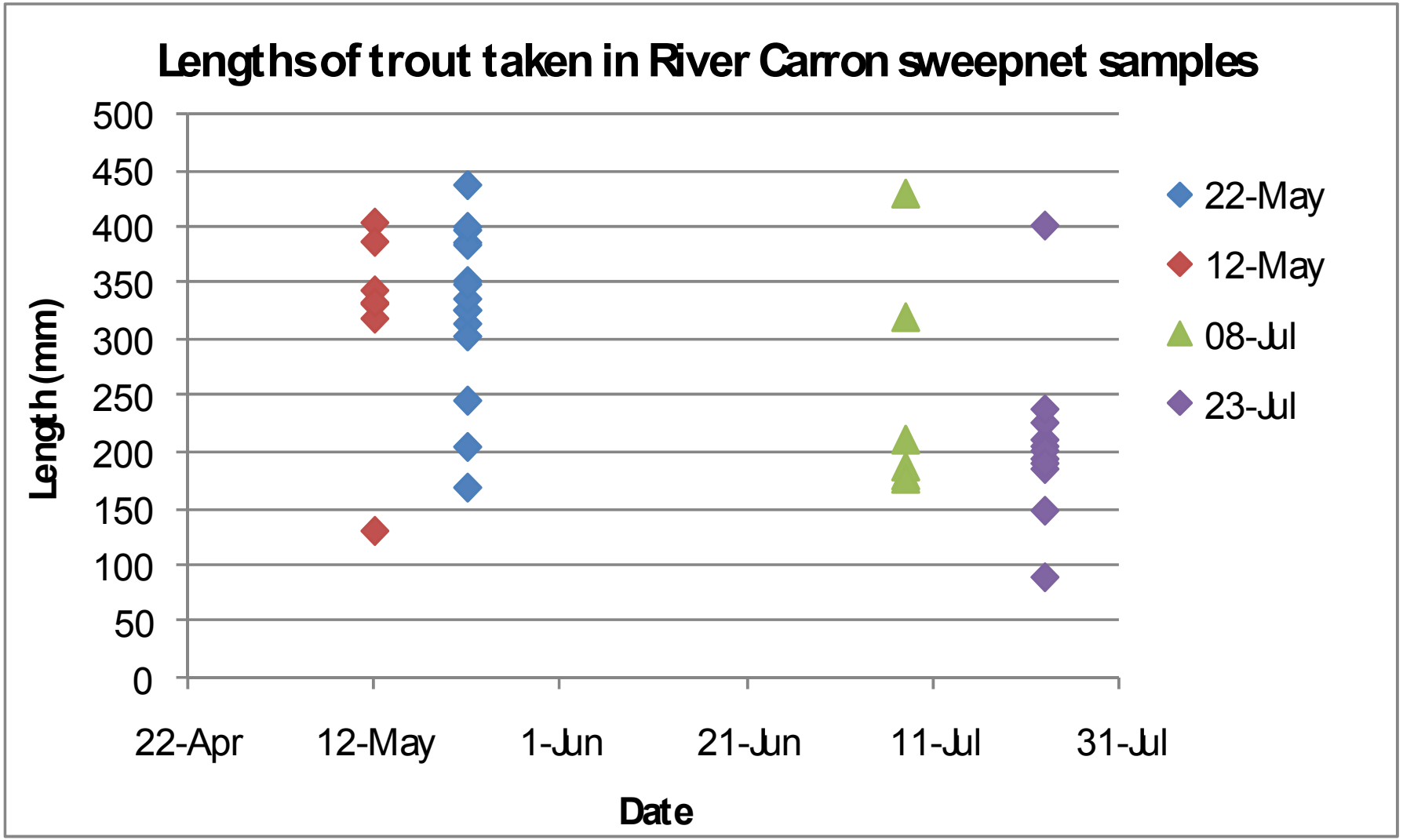

(photo by Ben Rushbrooke)

Small sea trout, Boor Bay, 28 May 2008

(photo by Ben Rushbrooke)

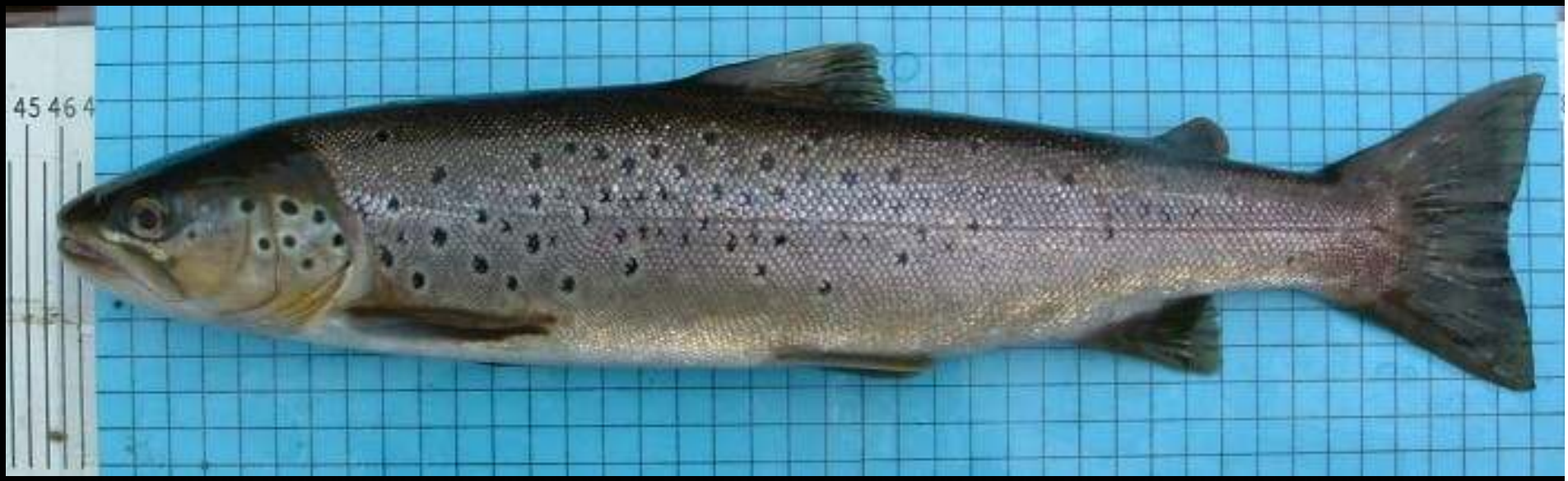
Kerry Bay 2008

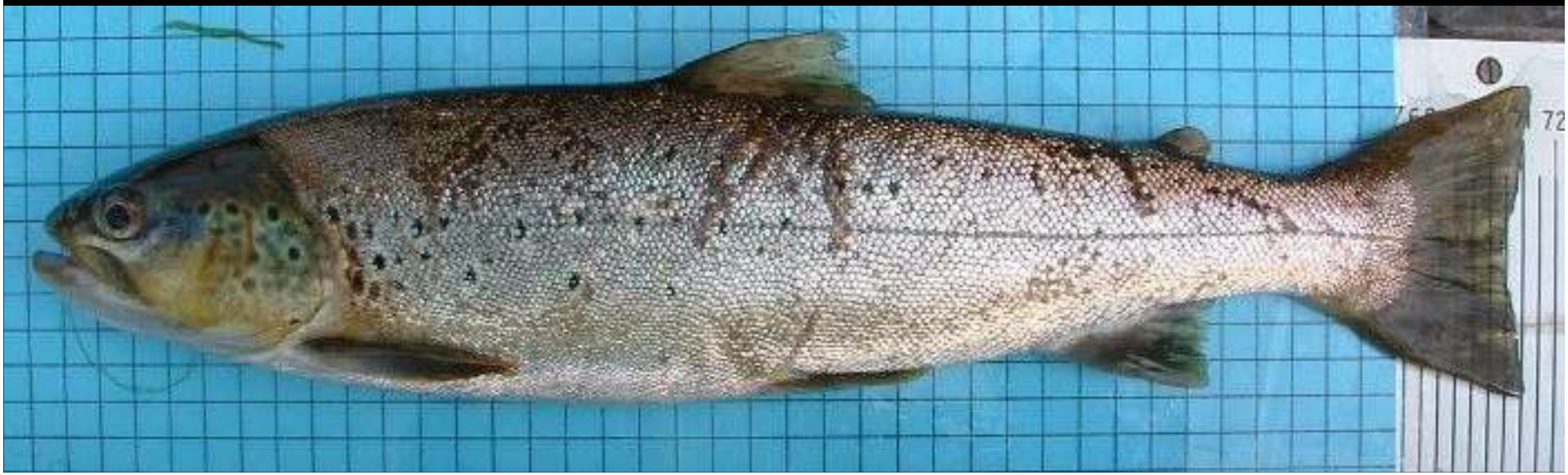
River Carron, June 2009


Lengths of trout taken in River Carron sweepnet samples
Length (mm)
500
450
400
350
300
250
200
150
100
50
0
22-Apr
12-May
1-Jun
21-Jun
11-Jul
31-Jul
Date
22-May
12-May
08-Jul
23-Jul

Carron post-smolt, 22nd May 2008

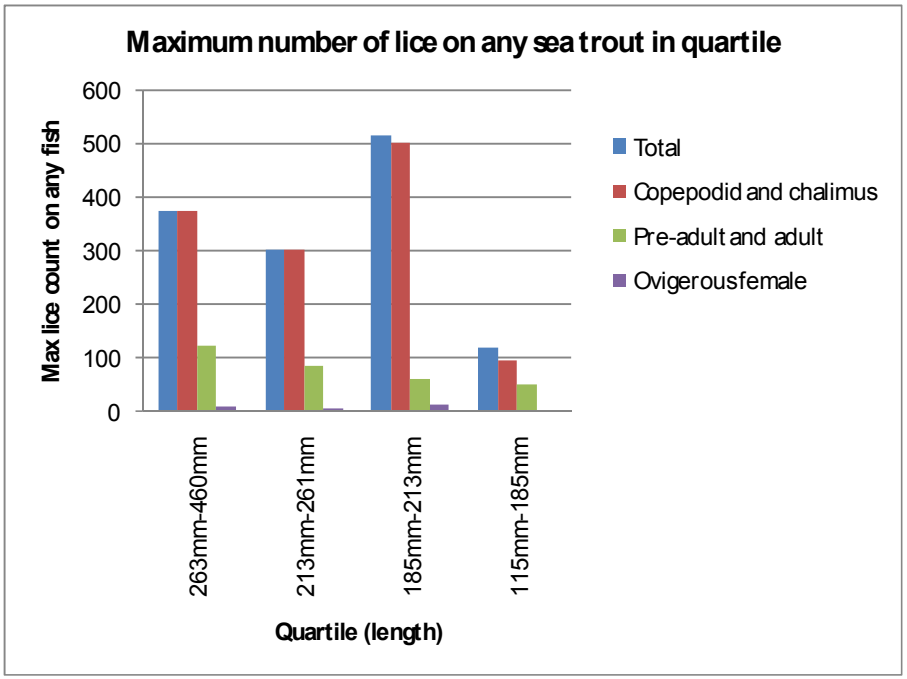
Carron estuarine trout, 22nd May & 22 July 2008

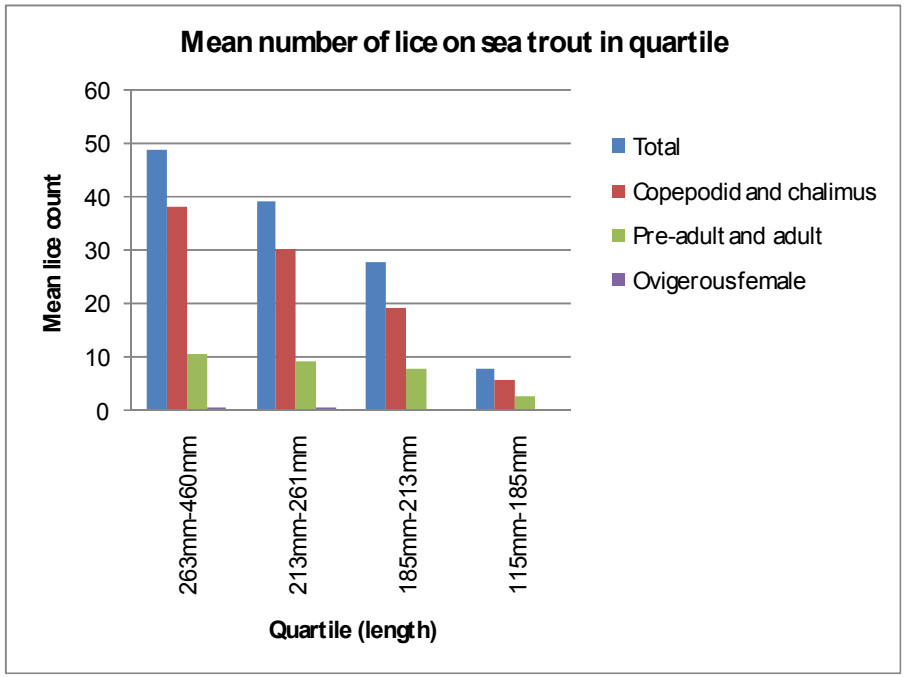




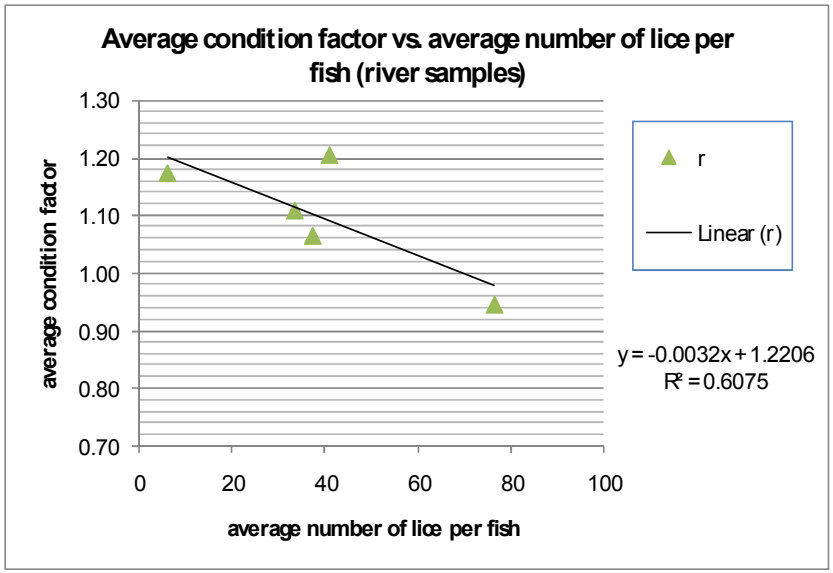
What can we learn from sea lice observation and data?

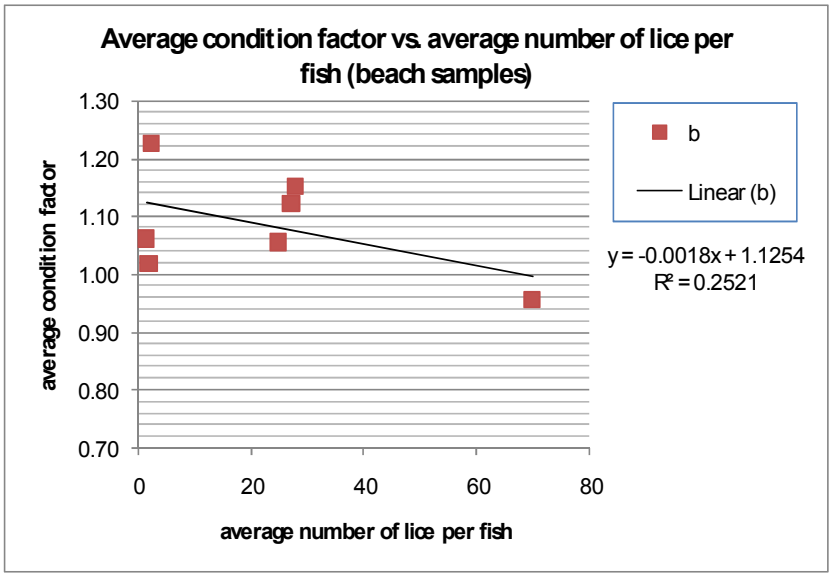
Whether larger fish have more lice on average than smaller fish(?)

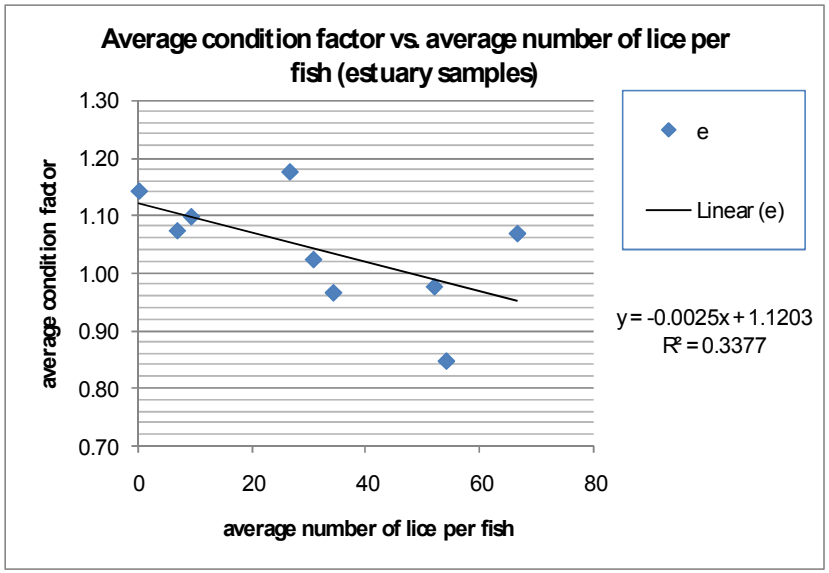


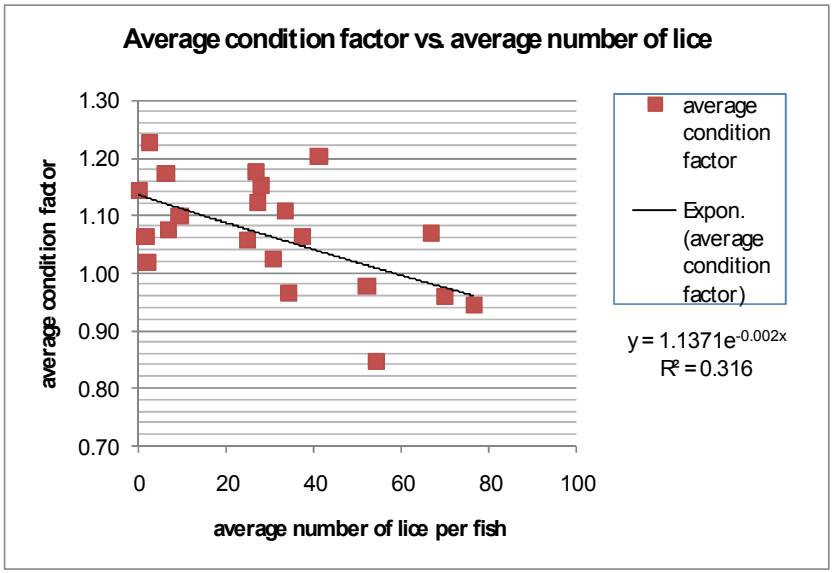


Whether fish with higher lice burdens are in poorer condition (?)

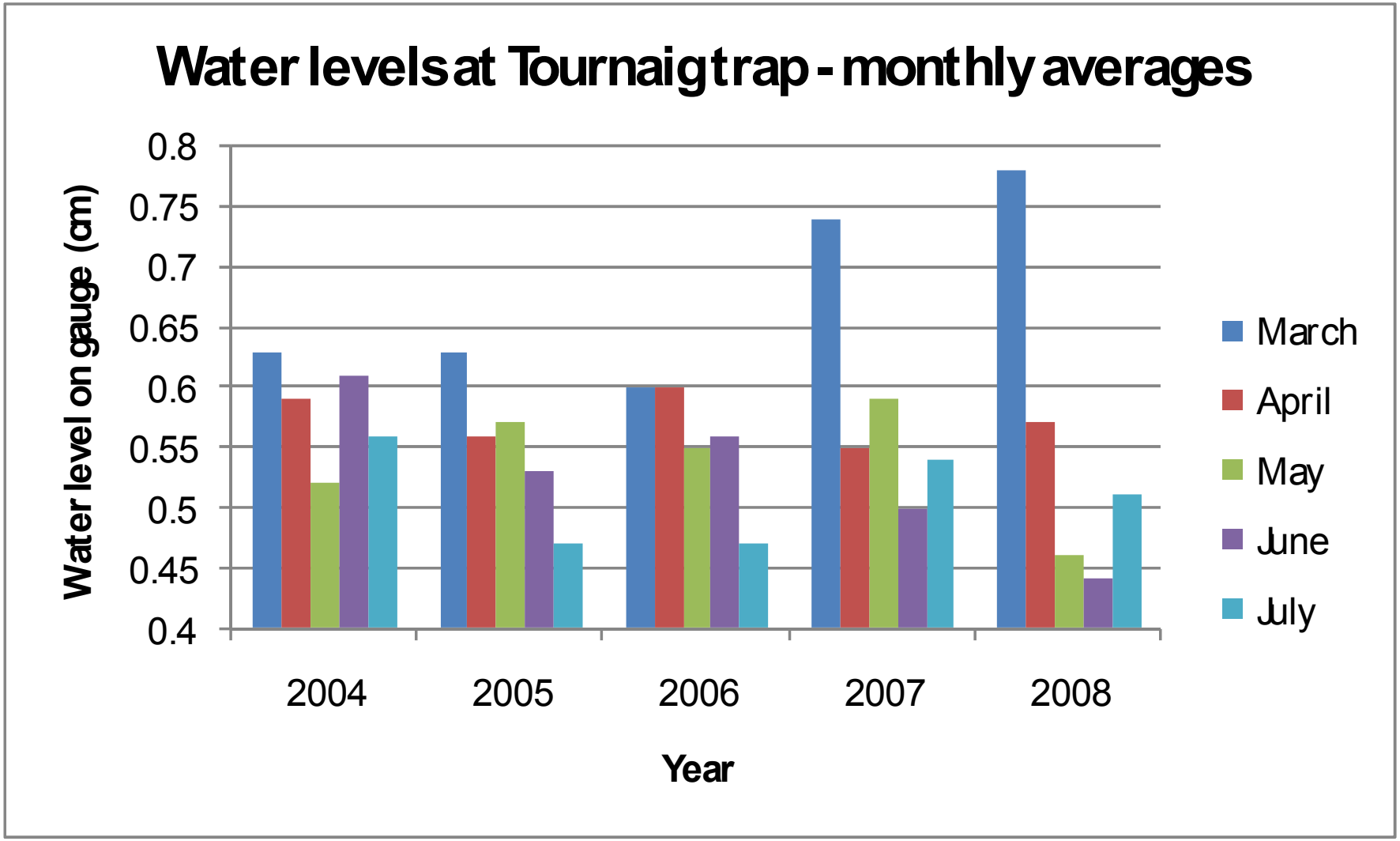






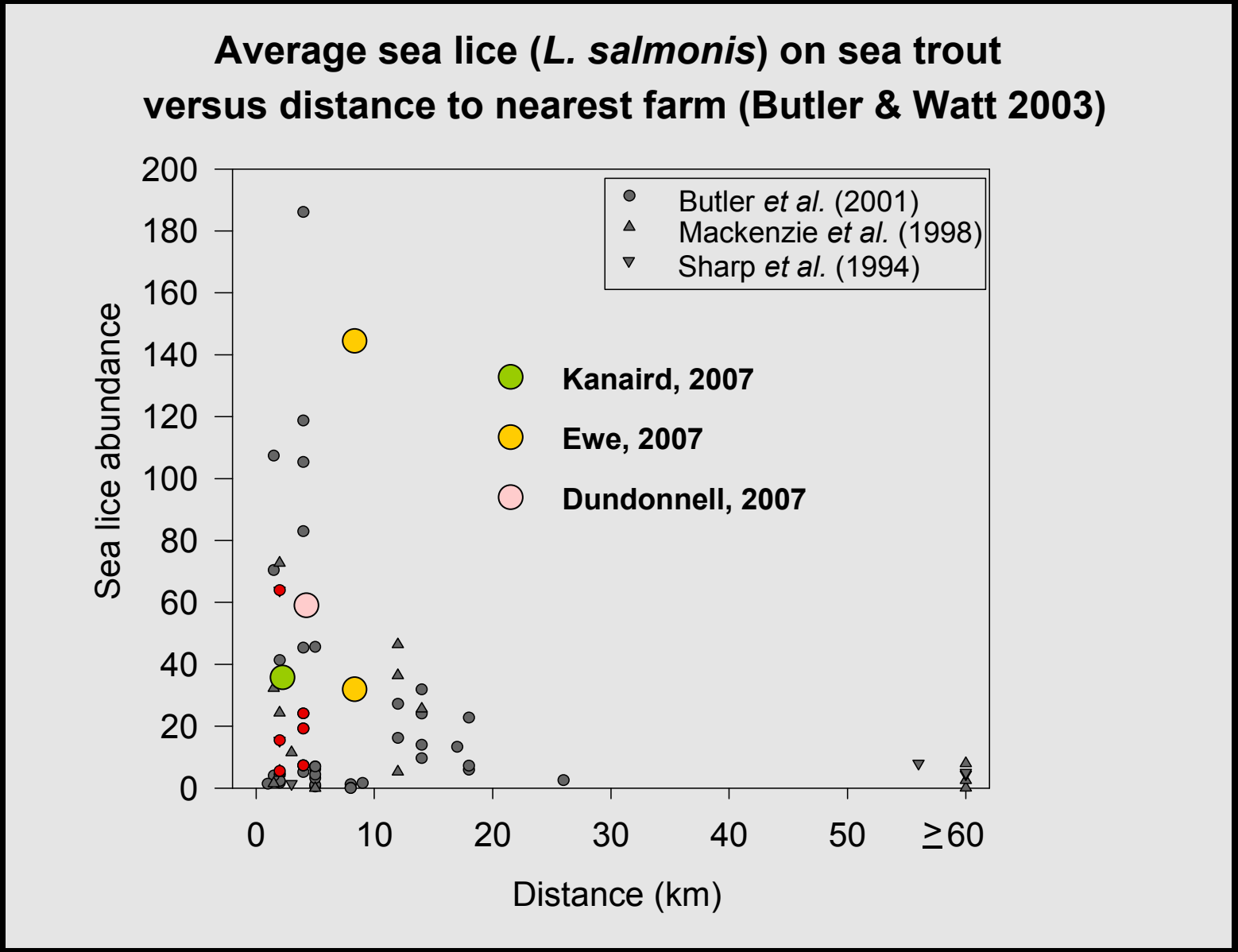


Whether infection is highest when there is little freshwater in lochs(?)



Tournaig trap project supported in 2008-9 & 2009-2010 by Marine Harvest

Whether infection levels relate to salmon farming (?)



Relationship . . . in Ireland (1992 -2001), from Gargan *et al* (2003)

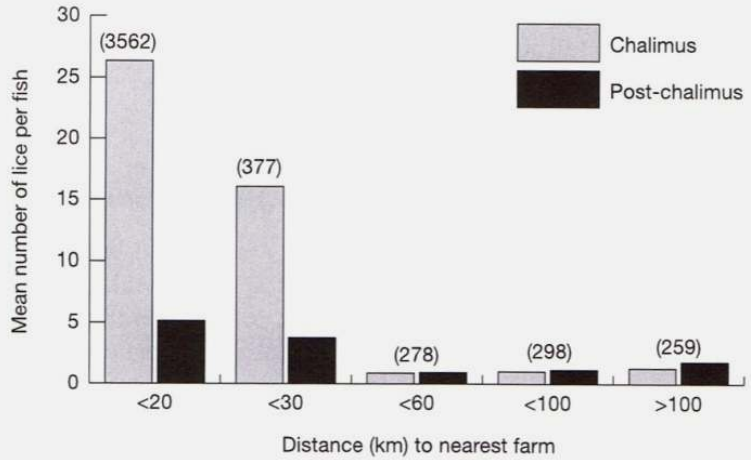


Fig. 10.3 Mean number of lice juveniles (chalimus) and adults (post-chalimus) infesting sea trout smolts in relation to distance categories to the nearest farm. Number of fish in each category is given in parentheses.

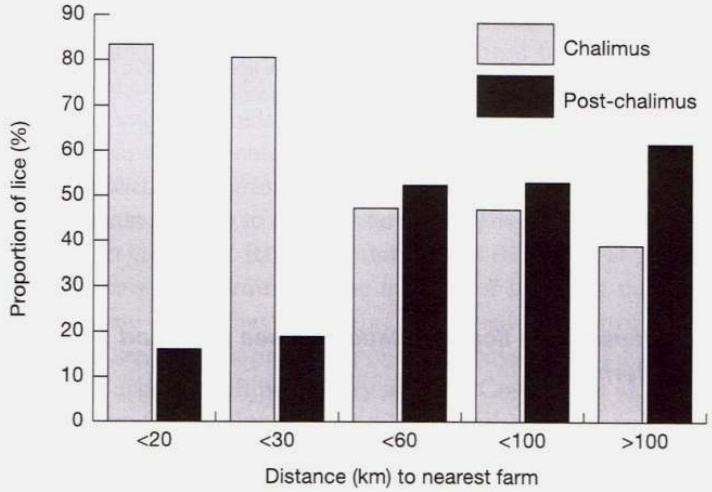
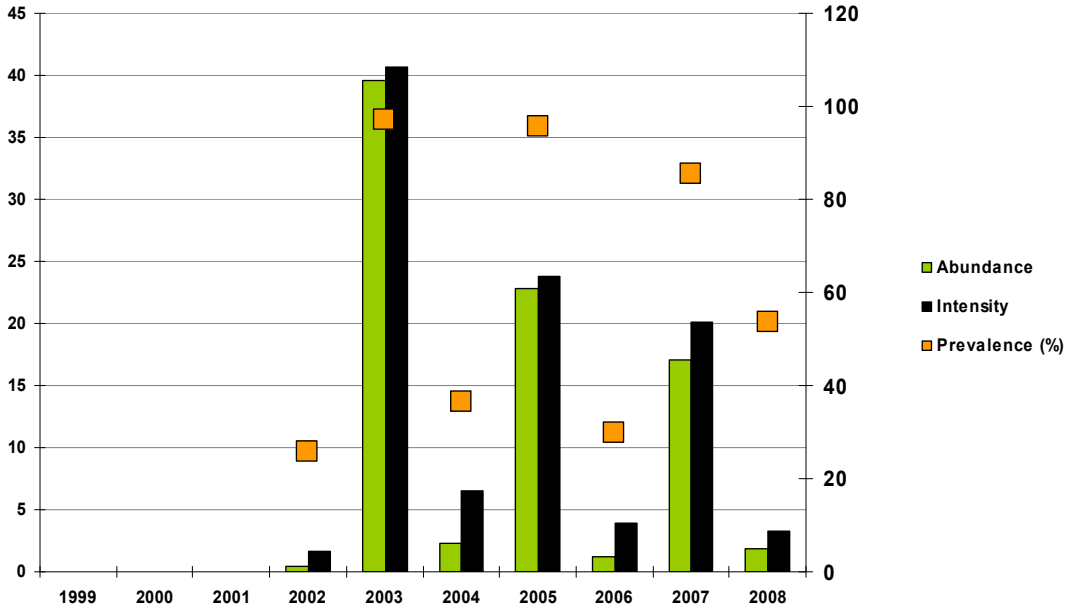


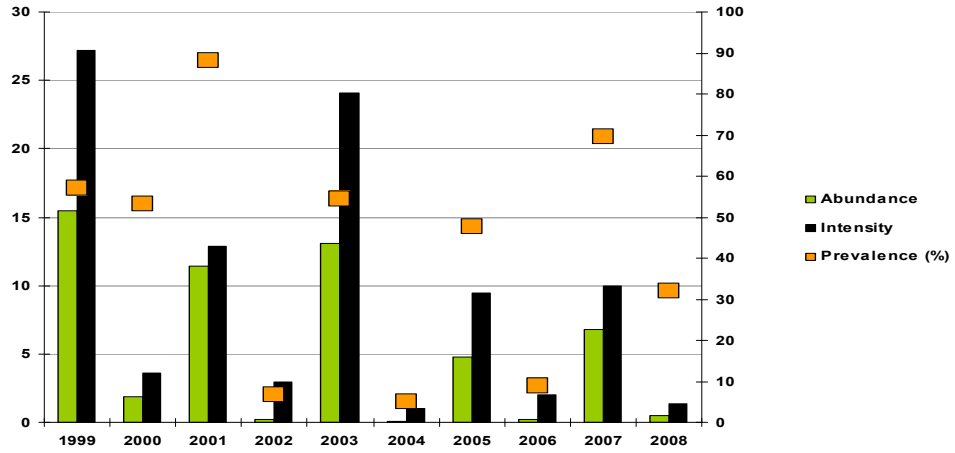
Fig. 10.4 Proportion of chalimus in the lice population infesting sea trout as a function of distance to the nearest farm.

Sea lice levels on wild post-smolt sea trout from upper Loch Linnhe

Kinlocheil (Lochaber Fisheries Trust data)



Camus na Gual (Lochaber Fisheries Trust data)



Hypotheses:

1. *sea trout were infected with higher burdens of sea lice at sites closest to active salmon farms*
(null hypothesis: there was no difference in lice burdens on sea trout in relation to distance from active salmon farms)

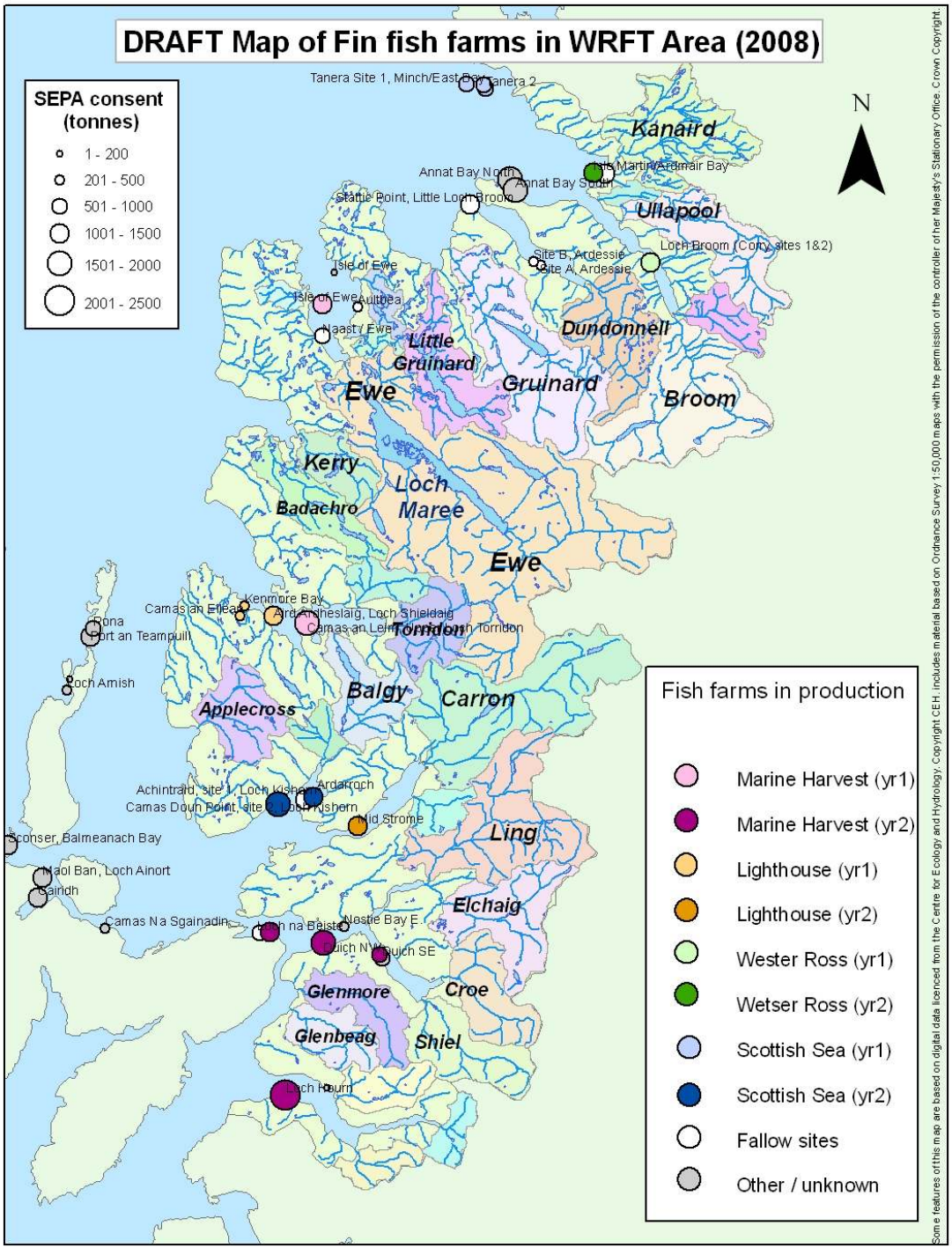
1a. *sea trout were infected with higher burdens of sea lice at sites closest to salmon farms in the second year of the production cycle*

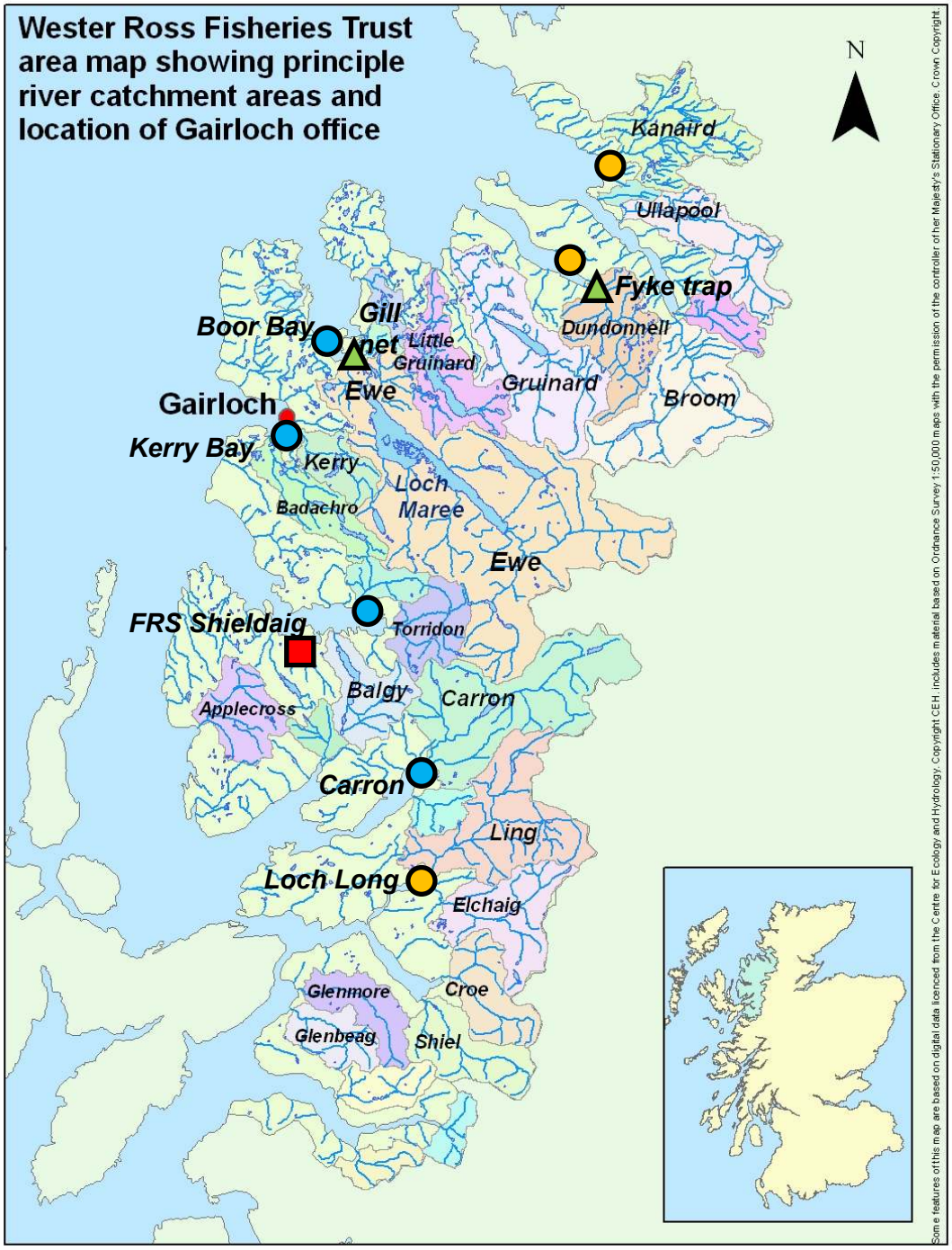
1b. *sea trout were infected with higher burdens of chalimus sea lice at sites closest to salmon farms in the second year of the production cycle.*

1c. *sea trout were infected with higher burdens of pre-adult and adult sea lice at sites closest to salmon farms in the second year of the production cycle*

Method of data analyses

1. All data compiled into excel spreadsheet.
2. ‘Abundance’, ‘prevalence’ and ‘intensity’ calculated
3. Distance to nearest active fish farm ‘as the fish swims’ from sampling locations calculated from map.
4. Data plotted on excel spreadsheet.
5. Trend line and r^2 (goodness of fit) value plotted automatically
6. No further statistical analyses undertaken yet . . .


DRAFT Map of Fin fish farms in WRFT Area (2008)
SEPA consent (tonnes)
1 - 200
201 - 500
501 - 1000
1001 - 1500
1501 - 2000
2001 - 2500
N
Tanera Site 1, Minch/East Bay
Tanera 2
Kanaird
Annat Bay North
Annat Bay South
Isle Martin/Ardmair Bay
Stattic Point, Little Loch Broom
Ullapool
Loch Broom (Corry, sites 1&2)
Site B, Ardessie
Site A, Ardessie
Isle of Ewe
Isle of Ewe Aultbea
Naast / Ewe
Dundonnell
Little Gruinard
Gruinard
Broom
Ewe
Kerry
Loch Maree
Badachro
Ewe
Kenmore Bay
Camas an Eilean
Ard Ardheslaig, Loch Shieldaig
Camas an Lein
Torridon
Dona
Port an Teampuill
Loch Amish
Balgy
Carron
Applecross
Achintraid, site 1, Loch Kishorn
Ardaroch
Camas Doun Point, site 2, Loch Kishorn
Mid Strome
Ling
Sconser, Balmeanach Bay
Maol Ban, Loch Ainort
Gairidh
Elchaig
Camas Na Sgainadin
Nostie Bay E
Loch na Beiste
Duich NW
Duich SE
Glenmore
Croe
Glenbeag
Shiel
Loch Hourn
Fish farms in production
Marine Harvest (yr1)
Marine Harvest (yr2)
Lighthouse (yr1)
Lighthouse (yr2)
Wester Ross (yr1)
Wetser Ross (yr2)
Scottish Sea (yr1)
Scottish Sea (yr2)
Fallow sites
Other / unknown
Some features of this map are based on digital data licenced from the Centre for Ecology and Hydrology. Copyright CEH. includes material based on Ordnance Survey 1:50,000 maps with the permission of the controller of her Majesty's Stationary Office. Crown Copyright.


Wester Ross Fisheries Trust area map showing principle river catchment areas and location of Gairloch office
N
Kanaird
Ullapool
Fyke trap
Dundonnell
Gill net
Boor Bay
Little Gruinard
Gruinard
Broom
Ewe
Gairloch
Kerry Bay
Kerry
Loch Maree
Badachro
Ewe
FRS Shieldaig
Torridon
Balgy
Carron
Applecross
Carron
Ling
Loch Long
Elchaig
Glenmore
Croe
Glenbeag
Shiel
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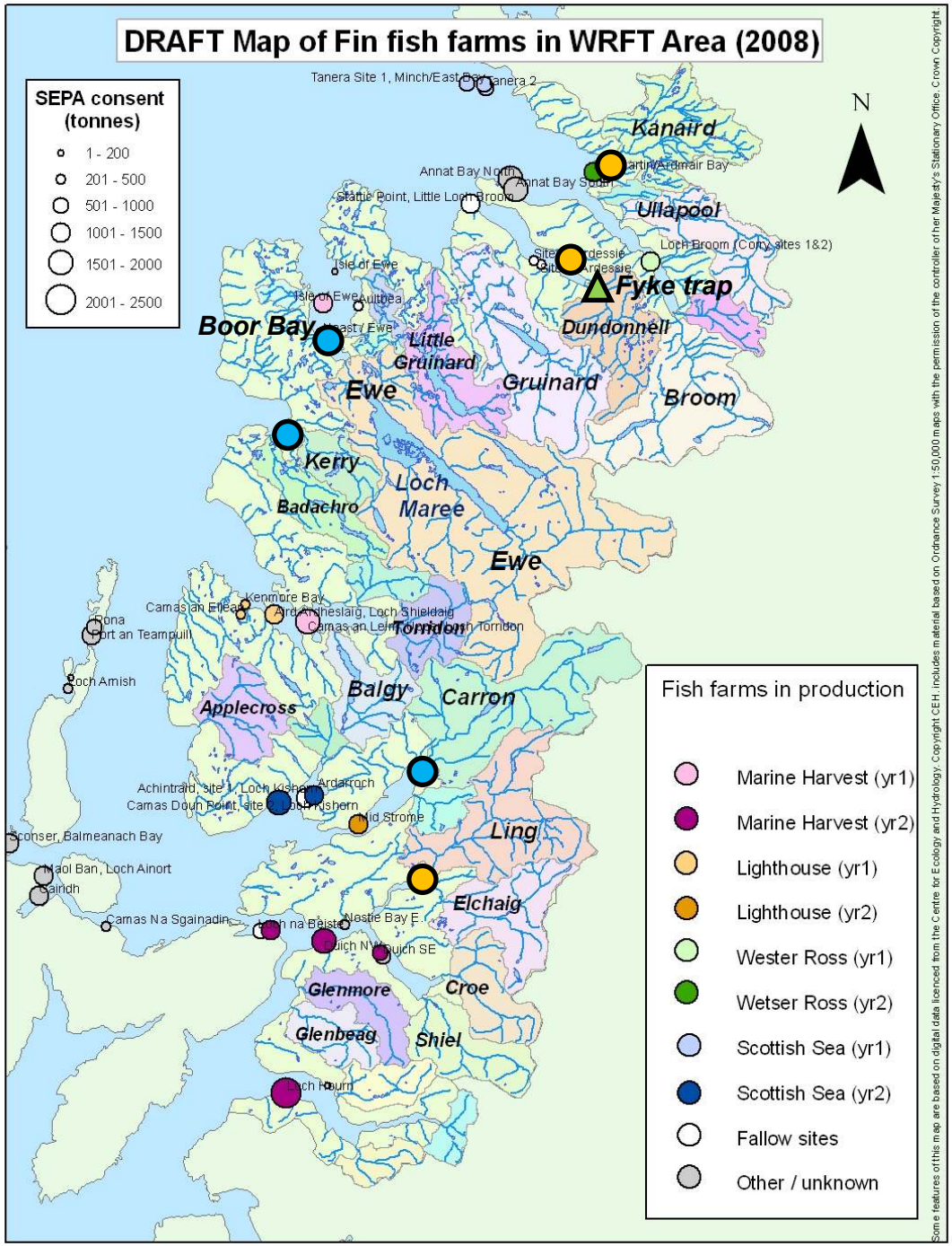
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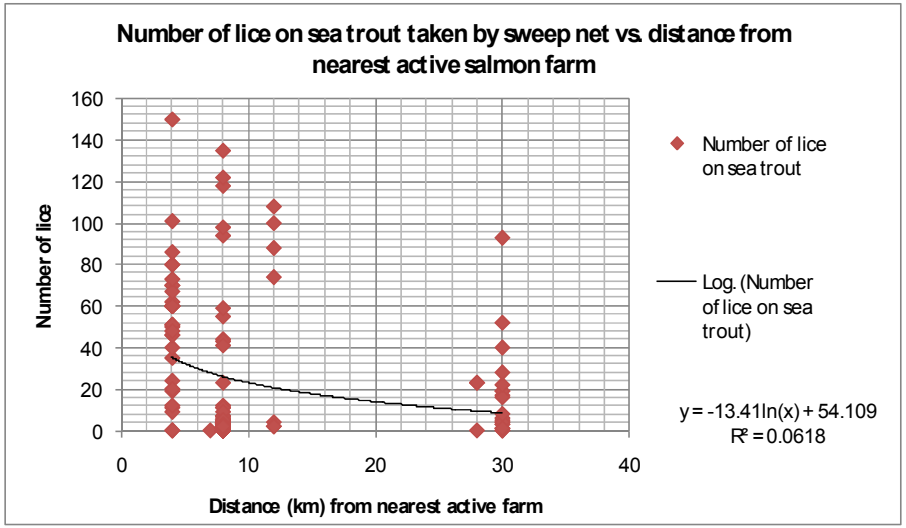
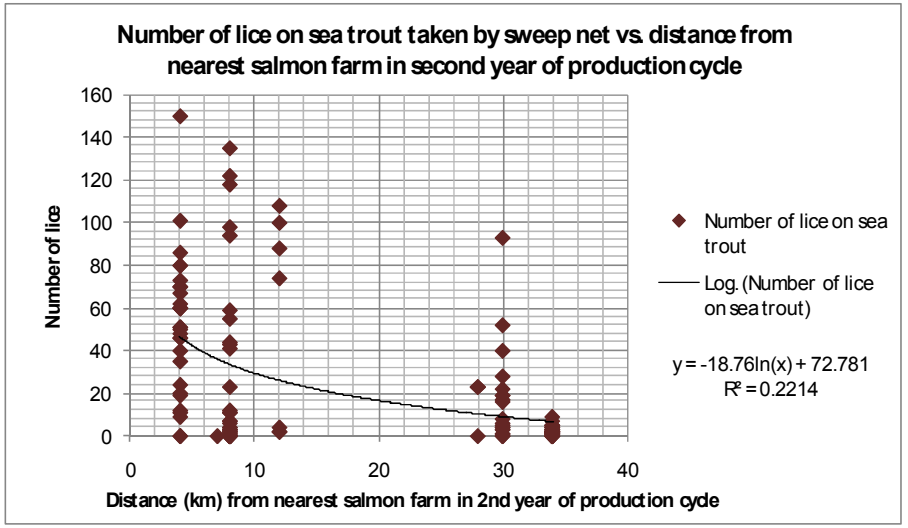
Results 1: Individual sea trout caught in sweep nets

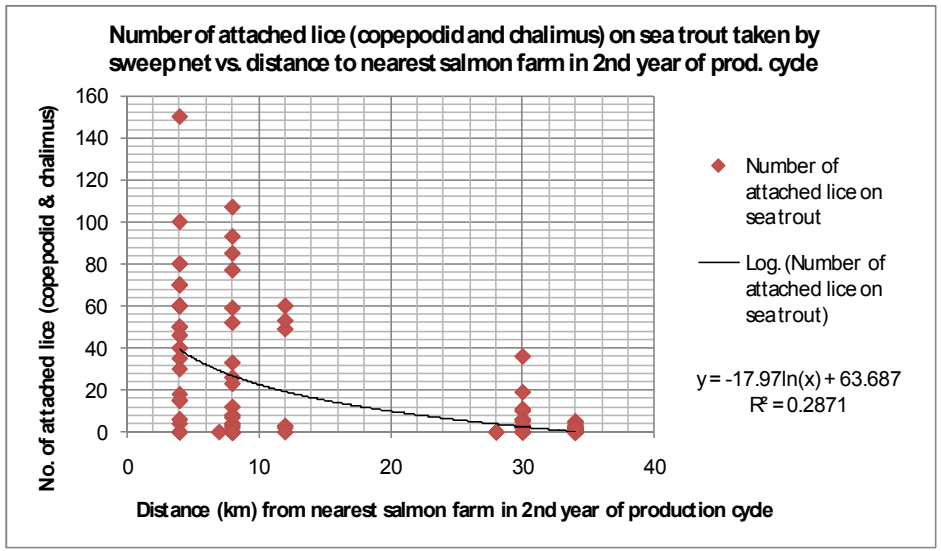
When total numbers of lice per fish are plotted against distance to nearest active fish farm, the trendline has weak goodness of fit.

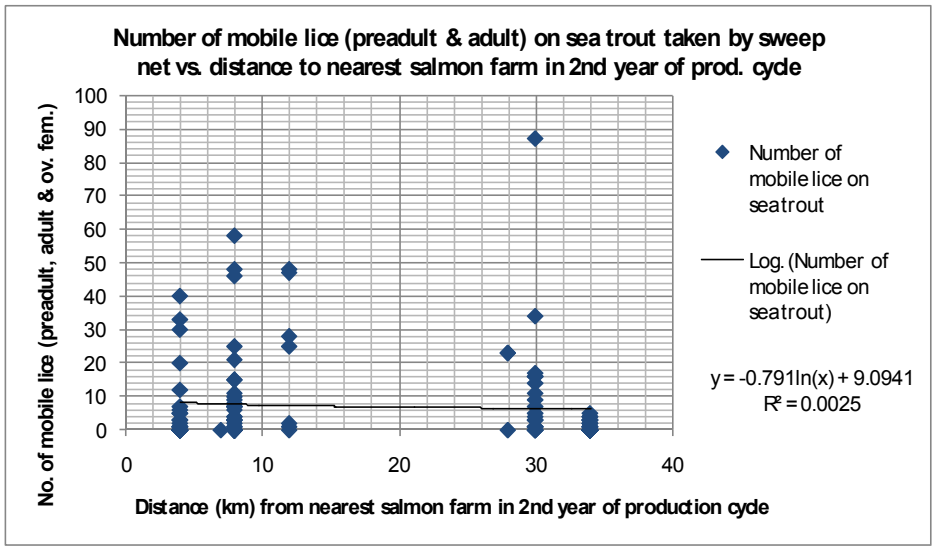




**Excludes fish taken in Kanaird sample on 8th May 2008; a sea trout with 500 lice taken in the Carron in May 2008. Boor Bay samples have been limited to a random 20 fish per sample.*

If ‘attached’ lice (chalimus and copepodids) are plotted separately from ‘mobile’ lice (adult and pre-adult lice, trendlines are very different.





**Excludes fish taken in Kanaird sample on 8th May 2008; a sea trout with 500 lice taken in the Carron in May 2008. Boor Bay samples have been limited to a random 20 fish per sample.*

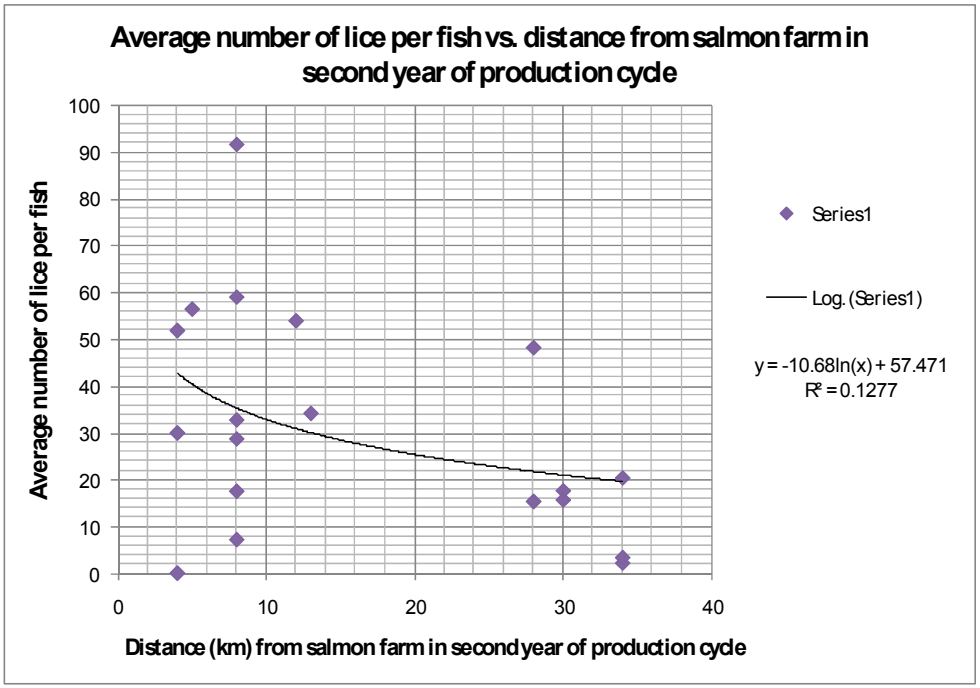
Fish were grouped into ‘samples’ ranging in size from three fish to 38 fish, and *intensity of infection calculated for each sample . . . .

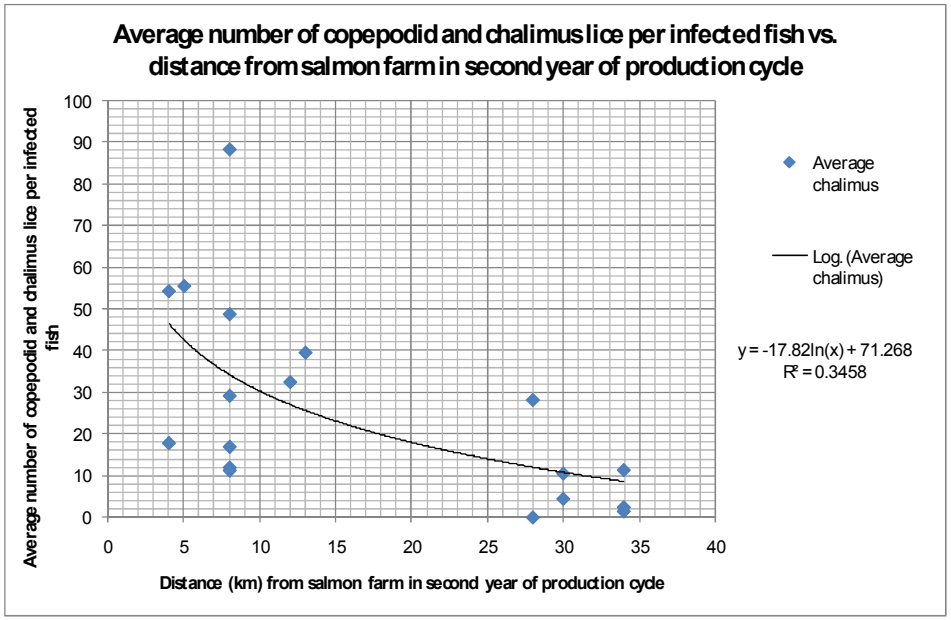
Location	Method	Date	Number of fish		*Lepeophtheirus salmonis*								Distance (km) to nearest farm in 2nd year
					All lice				Copepodid & chalimus		Pre-adult and adult		
			Total	Infected	Total	Abundance	Prevalence	Intensity	Total	Intensity	Total	Intensity	
Dundonnell	Fyke net	Jun-07	20	17	1130	56.50	85.00	66.47	943	55.47	187	11.00	5
Dundonnell	Fyke net	Jun-Jul 2008	20	18	965	48.25	90.00	53.61	507	28.17	458	25.44	28
Ewe	Gill	Jun-07	24	22	787	32.79	91.67	35.77	641	29.14	146	6.64	8
Ewe	Rod	May-07	28	26	2569	91.75	92.86	98.81	2293	88.19	276	10.62	8
Ewe	Rod	Jun-07	38	37	1092	28.74	97.37	29.51	626	16.92	466	12.59	8
Ewe	Rod	Jul-07	38	37	666	17.53	97.37	18.00	416	11.24	250	6.76	8
Kanaird	Rod and line	28-Jun-07	10	8	342	34.20	80.00	42.75	316	39.50	26	3.25	13
River Ewe	Rod and line	Jul-Aug 2008	19	17	387	20.37	89.47	22.76	193	11.35	194	11.41	34
River Carron	Sweep	May-08	22	21	1300	59.09	95.45	61.90	1023	48.71	277	13.19	8
River Carron	Sweep	Jul-08	17	6	122	7.18	35.29	20.33	72	12.00	50	8.33	8
Loch Long	Sweep	May to July 08	7	7	378	54.00	100.00	54.00	227	32.43	151	21.57	12
Kanaird	Sweep net	08 May 2008	37	0	0	0.00	0.00	0.00	0	0.00	0	0.00	4
Kanaird	Sweep net	28 May 2008	33	31	1713	51.91	93.94	55.26	1681	54.23	32	1.03	4
Kanaird	Sweep net	19 June 2008	7	6	210	30.00	85.71	35.00	107	17.83	103	17.17	4
LLoch Broom	Sweep net	May-08	3	2	46	15.33	66.67	23.00	0	0.00	46	23.00	28
Kerry	Sweep net	May-Jun 2008	14	11	247	17.64	78.57	22.45	49	4.45	198	18.00	30
Kerry	Sweep net	Jul-Aug 2008	6	6	94	15.67	100.00	15.67	63	10.50	31	5.17	30
Boor Bay	Sweep net	May-08	40	26	86	2.15	65.00	3.31	63	2.42	23	0.88	34
Boor Bay	Sweep net	Jul-Aug 2008	15	13	50	3.33	86.67	3.85	19	1.46	31	2.38	34

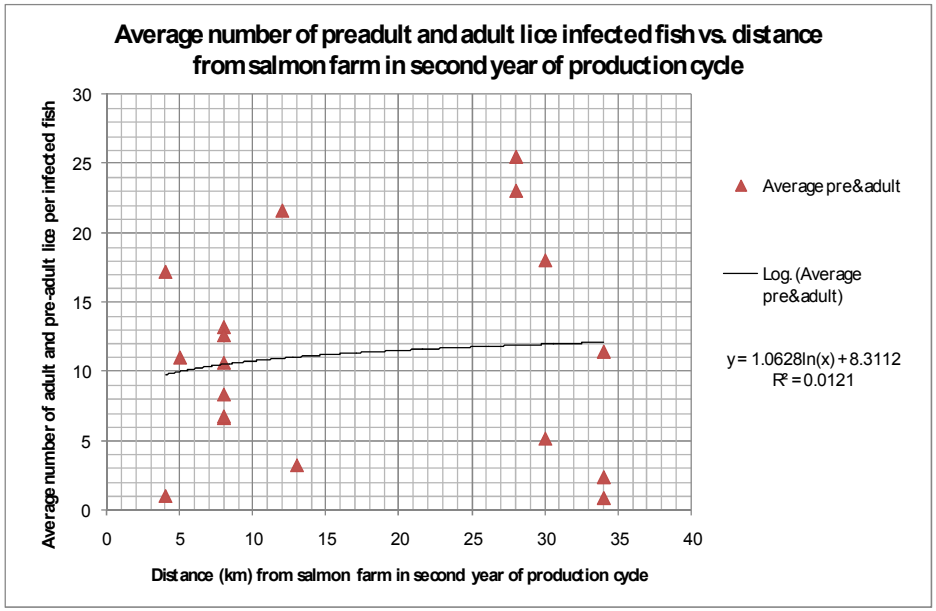
*intensity is the average number of lice per infected fish in the sample.

Results 2: Sea trout from all methods grouped as ‘samples’

The trendline for the number of copepodid and chalimus lice per infected fish vs. distance to salmon farm in second year of production cycle shows strongest fit.

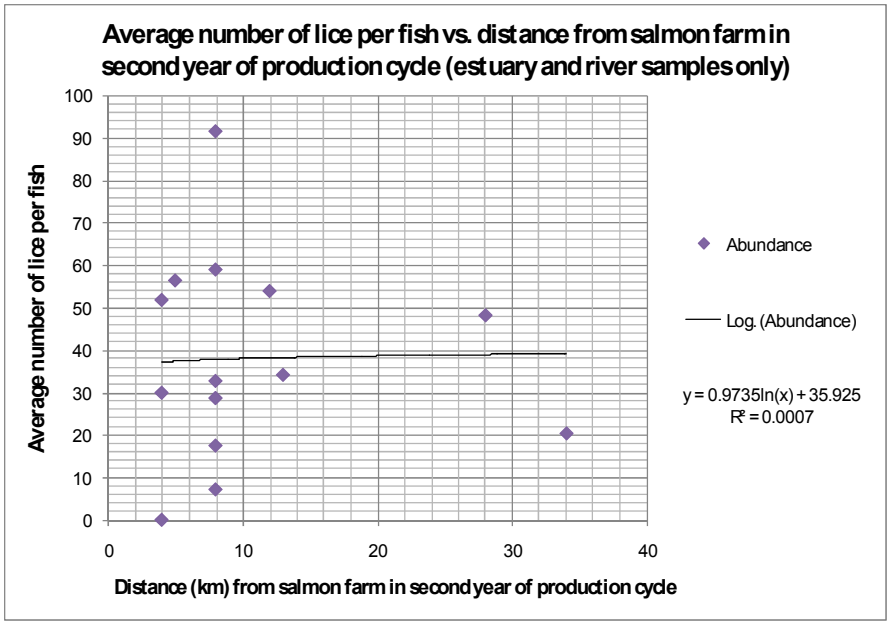




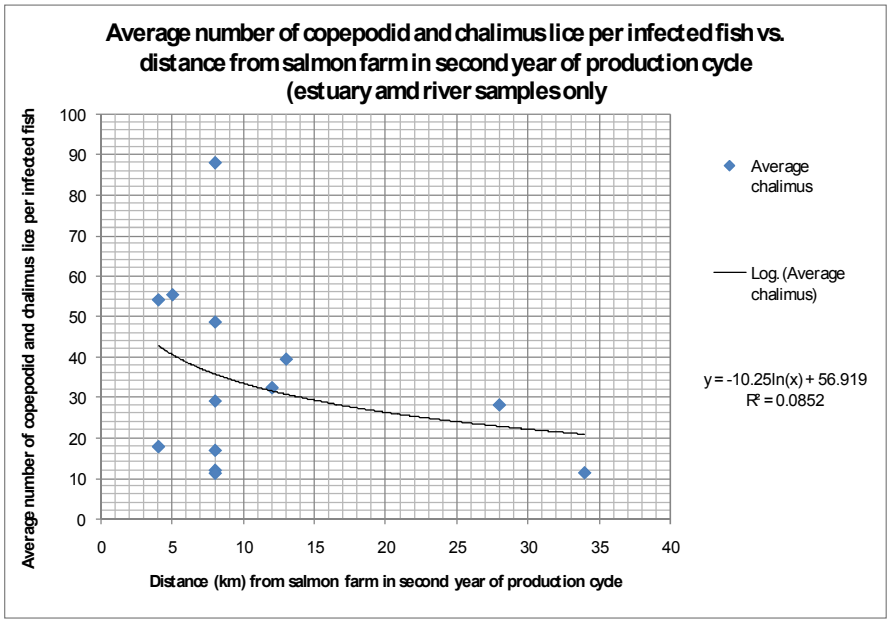


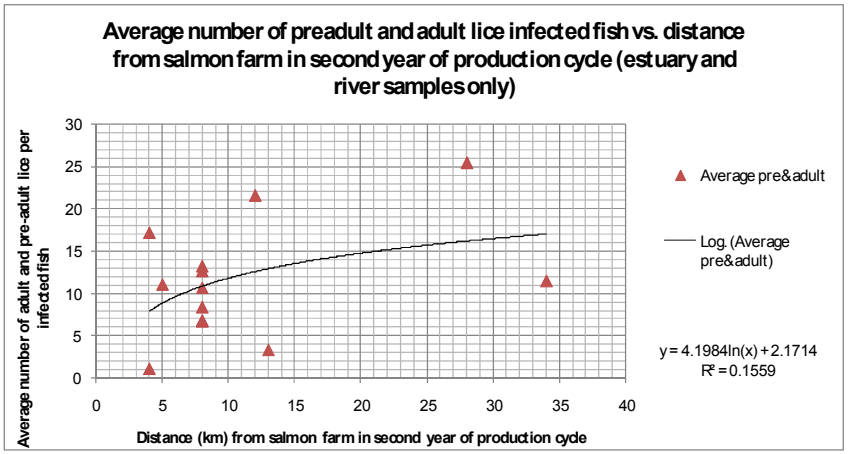
•Out of all the samples (398 fish), of the 73 sea trout with 50 or more copepodid or chalimus (attached) lice, only 5 were more than 20km from a salmon farm in the 2nd year of the production cycle.

•Out of all the samples, of 162 infected sea trout with 10 or less copepodid or chalimus lice, 62 were more than 20km from a salmon farm in the second year of its production cycle.



However, if the beach sweep samples are removed from the analyses, relationships become very weak:
only two samples remain more than 20km from a salmon farm in the second year of the production cycle.





Bias and error

1.Sampling method (sweep vs. fyke vs. gill vs. rod and line)

2.Sampling site characteristic (estuary [early returns] vs. beach [feeding fish])

3.Sampling time (May [just entered sea] – August [lice already off if early-returned in June])

4.Miscounting of lice (counting method [live or preserved fish], good vs. poor light)

5.Misidentification of lice (Lepeophtheirus vs. Caligus)

6.Small sample size (not enough samples at varying distances from salmon farm, river estuary, etc).

The relative importance of each of these depends upon the objectives of the monitoring programme and the question(s) you are trying to answer.

Conclusions 1

- *Within the WRFT area, sea lice infection levels of sea trout reached 'epizootic' levels in Loch Kanaird in 2008, Little Loch Broom in 2007, Loch Ewe in 2007, (Loch Torridon in 2007), Loch Carron in 2008 and Loch Loch (by Loch Duich) in 2008. Observations indicated that lice epizootics also occurred in Loch Kanaird in 2007 (rod sample data), and Loch Duich in 2007.*

- *However, lice levels on sea trout were not uniformly high within the WRFT area especially in 2008. Samples of sea trout from Loch Ewe had low sea lice abundance in 2008. Sea trout in good condition were caught in the River Ewe in August 2008.*

Conclusions 2

- *Levels of chalimus lice on sea trout tended to be highest at sites nearest salmon farms in the second year of their production cycle, though the small sample size probably means that no firm conclusion can be reached without additional data. In contrast, there was no clear trend in the numbers of pre-adult and adult lice with distance from salmon farms.*

- *Levels of chalimus lice infection of sea trout were generally greatly reduced at distances over 20km from the nearest salmon farm in the second year of the production cycle.*

Conclusions 3

- *Lice levels were highest on samples taken from river estuary sites.*

- *Sweep net sampling at beach sites in Loch Ewe (Boor Bay) and Loch Gairloch (Kerry bay) were less productive with fewer fish caught.*

- *All methods of sampling caught fish with more than 100 lice and fish with less than 10 sea lice.*

- *Lice epizootics may have been exacerbated in 2008 by unusually warm, dry sunny weather. Bright, sunny conditions with low rainfall are typical of April and May in Wester Ross.*

Conclusions 4

- *This study also hints that some areas are naturally more prone to sea lice epizootics than others (e.g. Little Loch Broom).*

- *Catch returns at the FRS Shieldaig trap in 2007 support the hypothesis that a majority of sea trout which become very heavily infected do not survive.*

- *Sea lice data collected in the WRFT area in 2007 and 2008 is consistent with the hypothesis that salmon farms in the second year of the production cycle are the primary source of sea lice which infect sea trout within the area.*

Recommendations 1

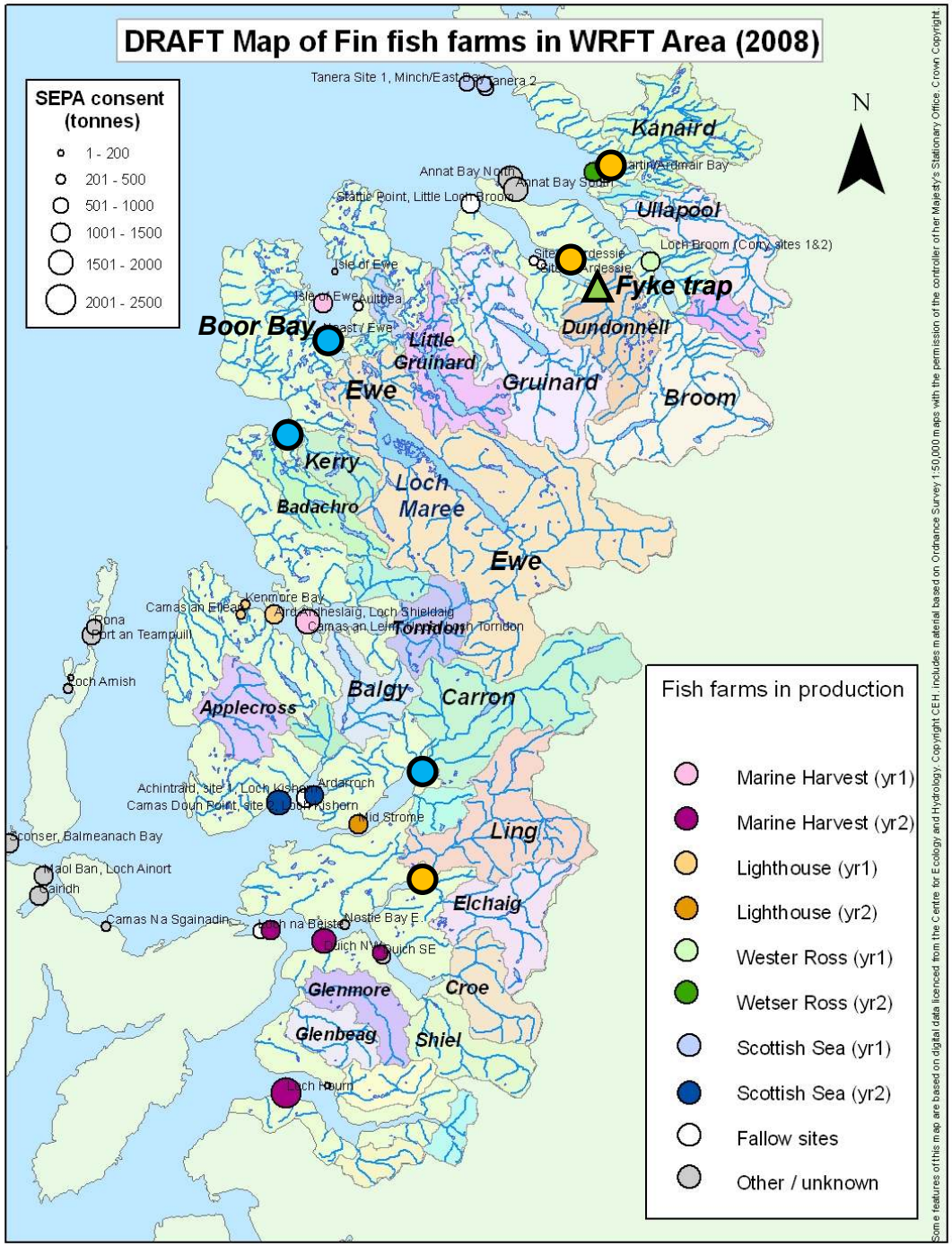
- *With the inclusion of additional existing data sets and more complex testing, a clearer understanding of patterns of infection could be developed for sea lice infection of wild sea trout in 2007 and 2008 for the WRFT area. More usefully, the study should address patterns of infection across the west of Scotland??*

- *From 2009, additional monitoring sites within the WRFT area particularly at sites further than 20km from the nearest salmon farm in the second year of the production cycle would provide further clarification of contemporary relationships between sea lice infection of sea trout and salmon farming cycle in local waters??*

Recommendations 2

- *A GIS mapping system could be developed to analyse sea lice abundance and infection pressures on both wild fish and farmed fish in the west of Scotland to inform management at both the local and regional scale. Fisheries trust biologists, FRS biologists and RDOs should work together to develop such a system. The SFCC may be able to provide support.*

- *From samples which do not fit a general pattern (e.g. samples with mean abundance of L. salmonis chalimus stage lice >30 more than 30km from a salmon farm in second year of production cycle; or samples with mean abundance of L. salmonis chalimus stage lice <30 within 10km of a salmon farm in the second year of the production cycle), it may be possible to identify areas which are 'naturally' more prone or less prone to sea lice epizootics.*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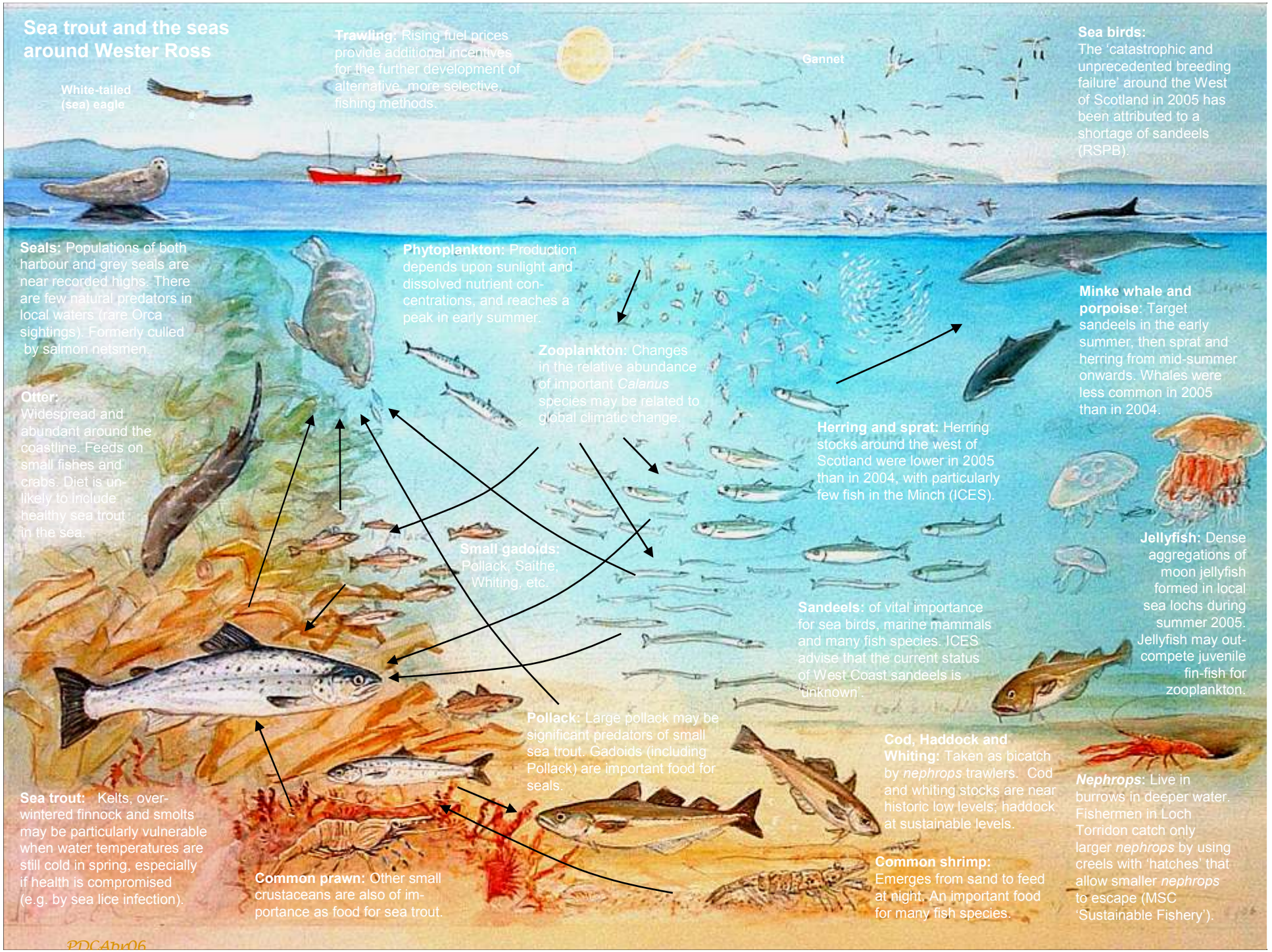
Recommendations 3

- *This study further highlights the need for additional measures to be taken to reduce the production of larval sea lice further on salmon farms particularly in the second year of their production cycle in all areas if populations of wild sea trout are to recover.*

- *Because of the numbers of salmon present on salmon farms within the area, this will invariably mean reducing on-farm ovigerous lice levels to much less than the recommended 0.5 ovigerous lice per fish during the period February – June as stated in the Code of Good Practice.*

Sea trout and the seas around Wester Ross



White-tailed (sea) eagle

Trawling: Rising fuel prices provide additional incentives for the further development of alternative, more selective, fishing methods.

Gannet

Sea birds: The 'catastrophic and unprecedented breeding failure' around the West of Scotland in 2005 has been attributed to a shortage of sandeels (RSPB).

Seals: Populations of both harbour and grey seals are near recorded highs. There are few natural predators in local waters (rare Orca sightings). Formerly culled by salmon netsmen.

Phytoplankton: Production depends upon sunlight and dissolved nutrient concentrations, and reaches a peak in early summer.

Zooplankton: Changes in the relative abundance of important *Calanus* species may be related to global climatic change.

Minke whale and porpoise: Target sandeels in the early summer, then sprat and herring from mid-summer onwards. Whales were less common in 2005 than in 2004.

Herring and sprat: Herring stocks around the west of Scotland were lower in 2005 than in 2004, with particularly few fish in the Minch (ICES).

Otter: Widespread and abundant around the coastline. Feeds on small fishes and crabs. Diet is unlikely to include healthy sea trout in the sea.

Small gadoids: Pollack, Saithe, Whiting, etc.

Jellyfish: Dense aggregations of moon jellyfish formed in local sea lochs during summer 2005. Jellyfish may outcompete juvenile fin-fish for zooplankton.

Sandeels: of vital importance for sea birds, marine mammals and many fish species. ICES advise that the current status of West Coast sandeels is 'unknown'.

Pollack: Large pollack may be significant predators of small sea trout. Gadoids (including Pollack) are important food for seals.

Cod, Haddock and Whiting: Taken as bicatch by *nephrops* trawlers. Cod and whiting stocks are near historic low levels; haddock at sustainable levels.

Sea trout: Kelts, overwintered finnock and smolts may be particularly vulnerable when water temperatures are still cold in spring, especially if health is compromised (e.g. by sea lice infection).

Common prawn: Other small crustaceans are also of importance as food for sea trout.

Common shrimp: Emerges from sand to feed at night. An important food for many fish species.

Nephrops: Live in burrows in deeper water. Fishermen in Loch Torridon catch only larger *nephrops* by using creels with 'hatches' that allow smaller *nephrops* to escape (MSC 'Sustainable Fishery').

PDCApr06

Marine Seminar: 29th May 2009, Poolewe

Sea trout and the seas around Wester Ross

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Acknowledgements

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Thank you to TWG and Ailsa McLellan for support for sea lice monitoring in 2007 and 2008, to Diane Baum (Lochaber FT) for permission to copy results of sea lice monitoring in Lochaber, to Prof Barry Blake for reviewing the first draft of this report.

Thank you!

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