Lice and wild salmonids – effects on individuals and populations in Norwegian fjord systems

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NINA
Norwegian Institute for Nature Research

Background levels - natural infection systems for salmon lice

- Very few hosts were available for salmon lice along the coastline in the winter period:
  - -Atlantic salmon feeding in the open ocean
  - -Sea trout and Arctic charr mostly spending the winter in
  - freshwater

- The infection pressure on fjord migrating post smolts were therefore very limited, and were mostly derived from ascending adult salmon

- In a natural system, salmon lice slowly and gradually aggregate on coastal feeding salmonids, and the infection usually peaks at 4-8 lice late in the autumn

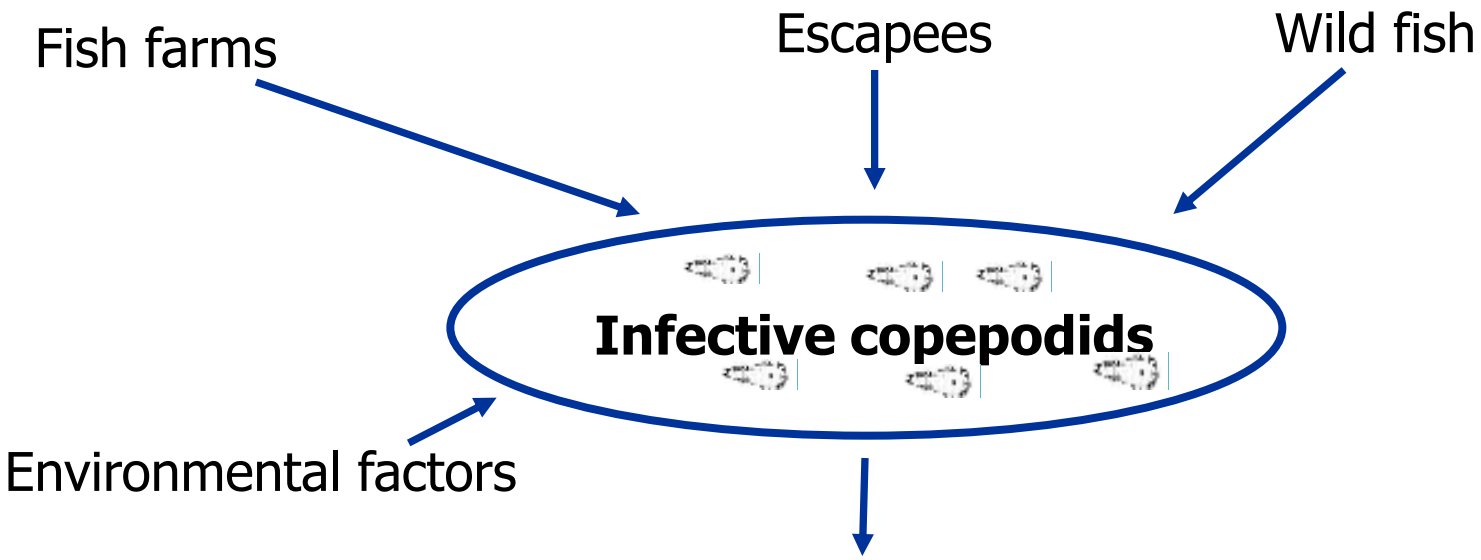
Changed infection system for salmon lice

- Salmon lice rapidly became a problem when salmon farming began

- All the new hosts changed the salmon lice population dynamic fundamentally (numbers from Norway):
  - - Total stock of wild salmonids at sea approx. 2.5 million
  - Total number of farmed salmonids at sea approx. 1 306 678 tonnes (approx. 400 mill salmonids) and 1006 marine farms licenced in 2012

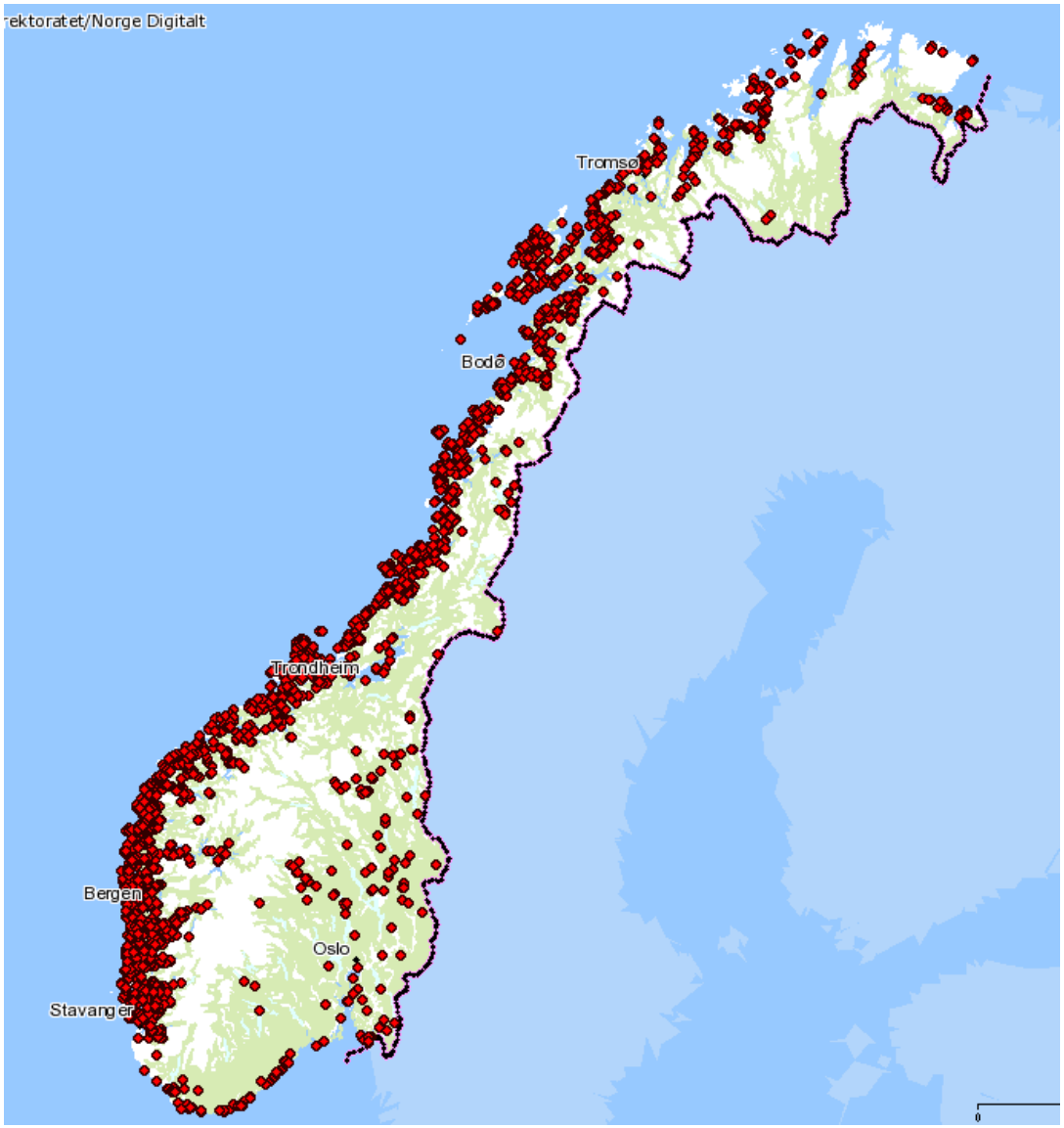
- *This means that there are almost 200 times more hosts available for salmon lice now compared to the situation before salmon farming began*

Sources for salmon lice



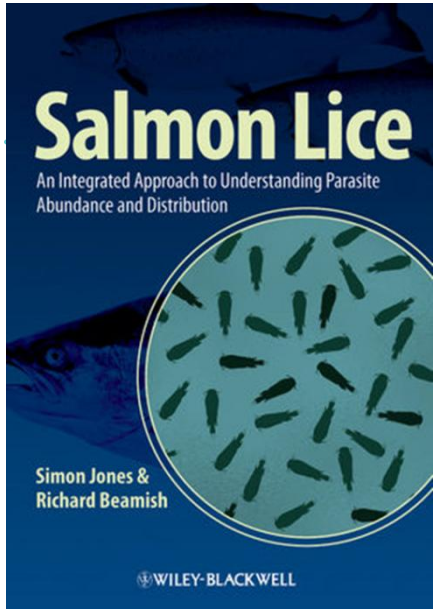
Postsmolts

Sea sites for salmonid fish farming in Norway in 2012: c. 1 300 000 tons; approx. 400 mill. fish; 1006 licenced fish farms



Salmon lice - effects

- Physiological effects
- Monitoring in field
- Mortality and stock reducing effects
- Model sites for salmon lice research in Norway



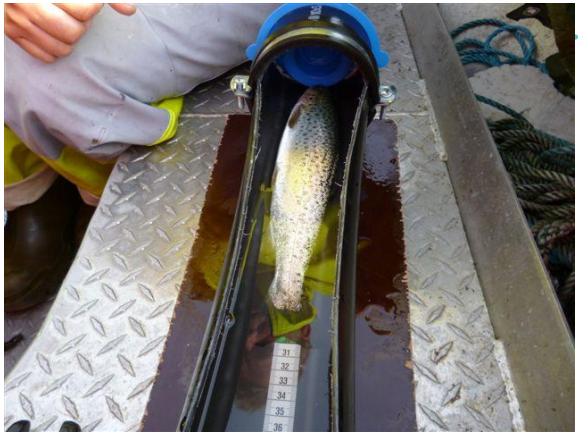
Salmon lice - effects

- Physiological effects on salmonids

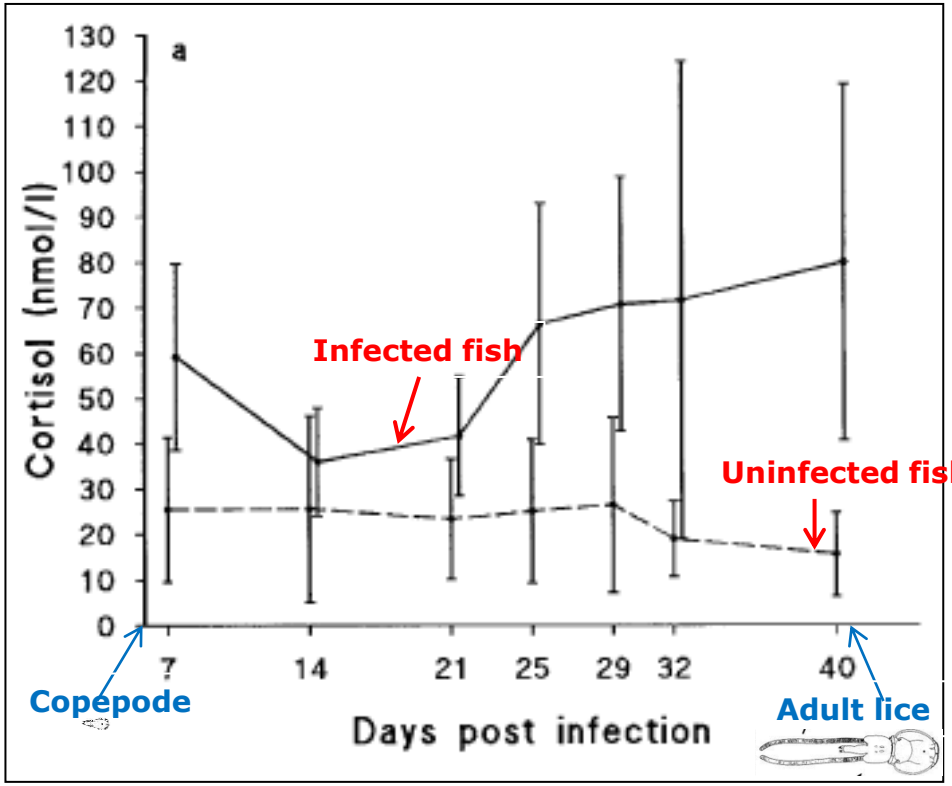
Premature return to freshwater to get rid of salmon lice

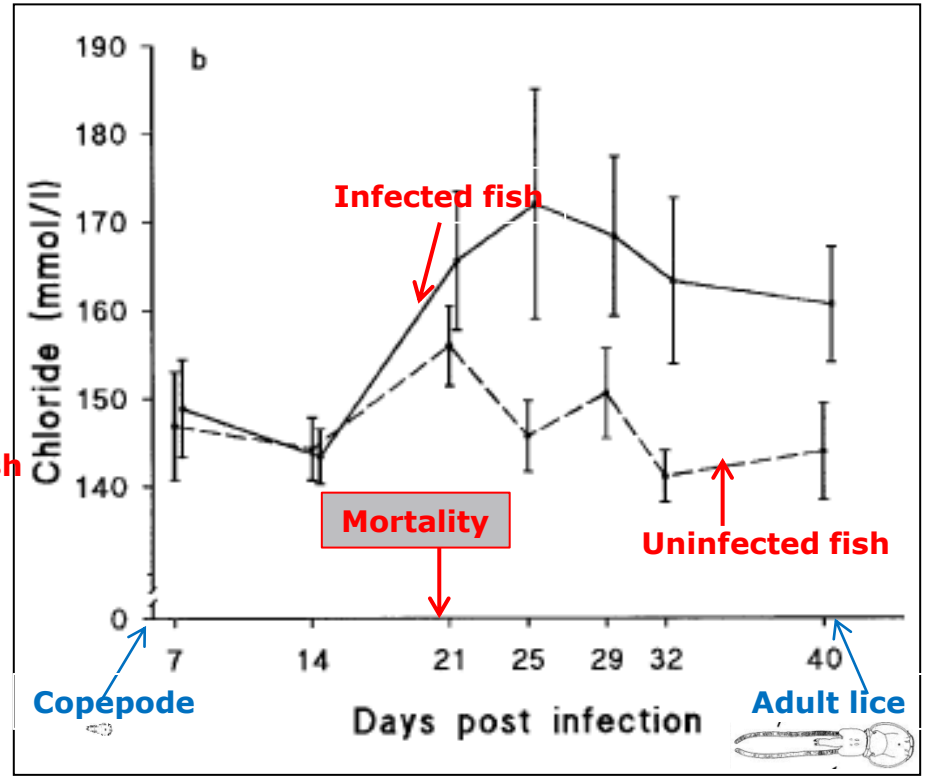
Each eggstring >250 eggs*2, with 2. prod. cycles per month

Estimating tolerance levels for sea lice in wild captured sea trout



Physiological responses for sea lice – stress, seawater tolerance, mortality





0,1 lice per fish weight initiates negative physiological processes in salmonids

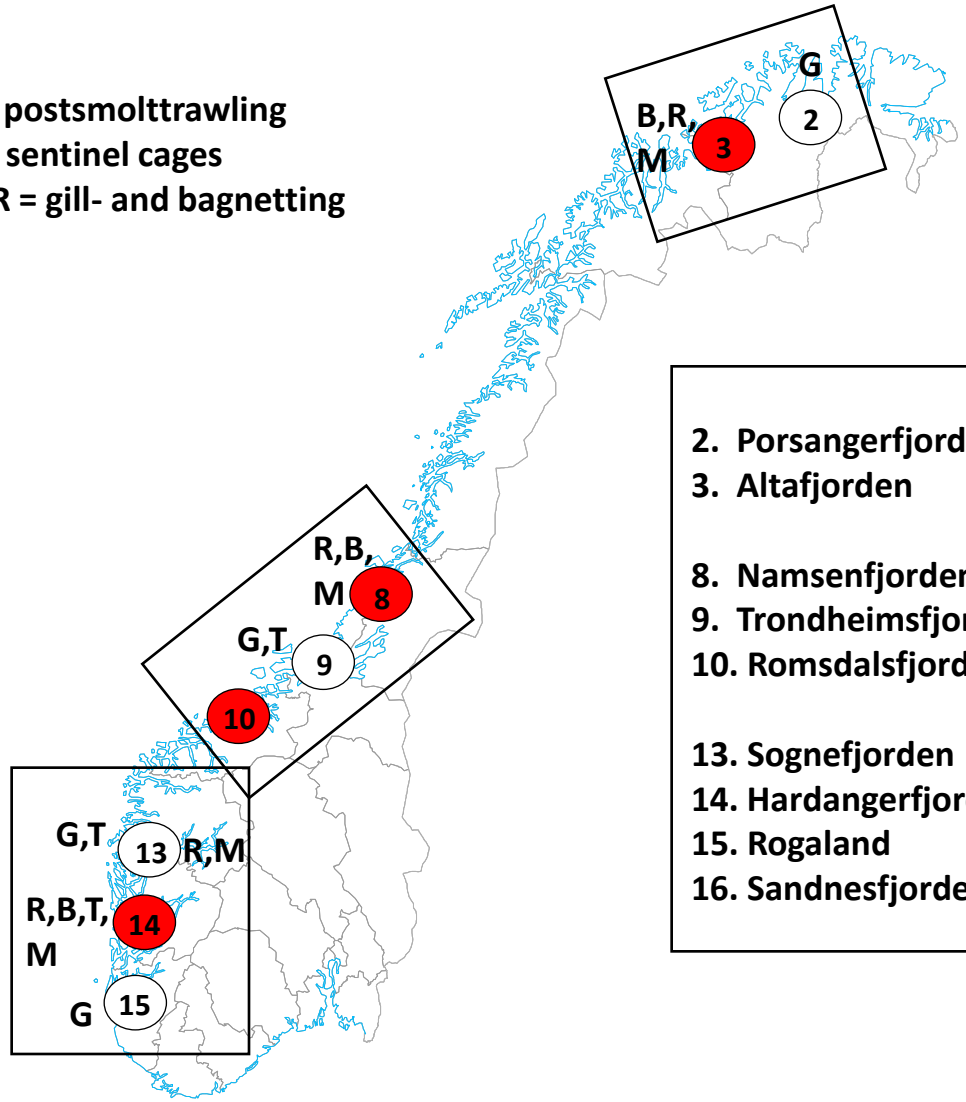
Finstad et al. 2000, Aquacult. Res. 31

Salmon lice - effects

- Monitoring in field

National sea lice monitoring - 2013

T = postsmolttrawling
B = sentinel cages
G/R = gill- and bagnetting

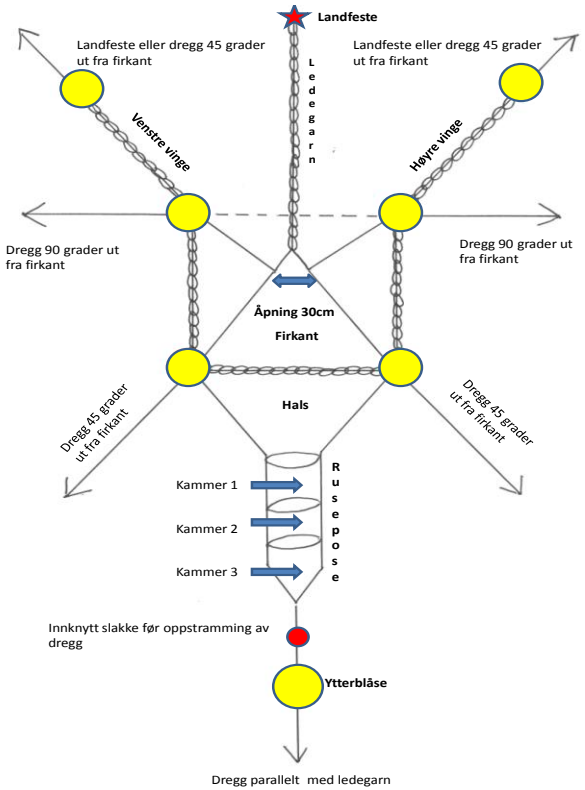


2. Porsangerfjorden
3. Altafjorden

8. Namsenfjorden
9. Trondheimsfjorden
10. Romsdalsfjorden

13. Sognefjorden
14. Hardangerfjorden
15. Rogaland
16. Sandnesfjorden

Capture method – bag netting



Live capture of fish


Photo: Arne Kvalvik, M.H


Photo: Arne Kvalvik, M.H

Field analyses – lice counting

Photo: Bengt Finstad, NINA

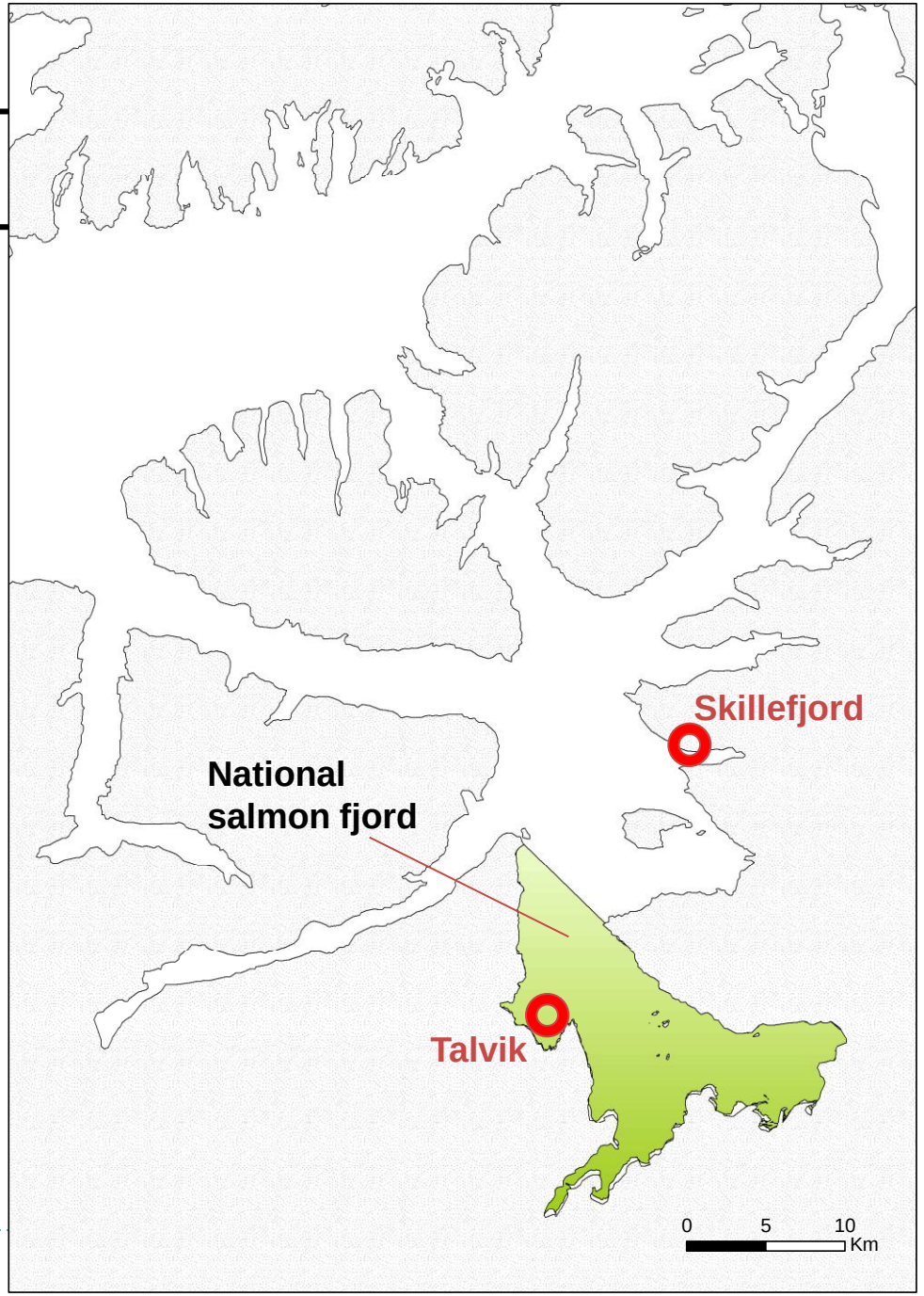
Photo: Raumafisk

Photo: Bengt Finstad, NINA

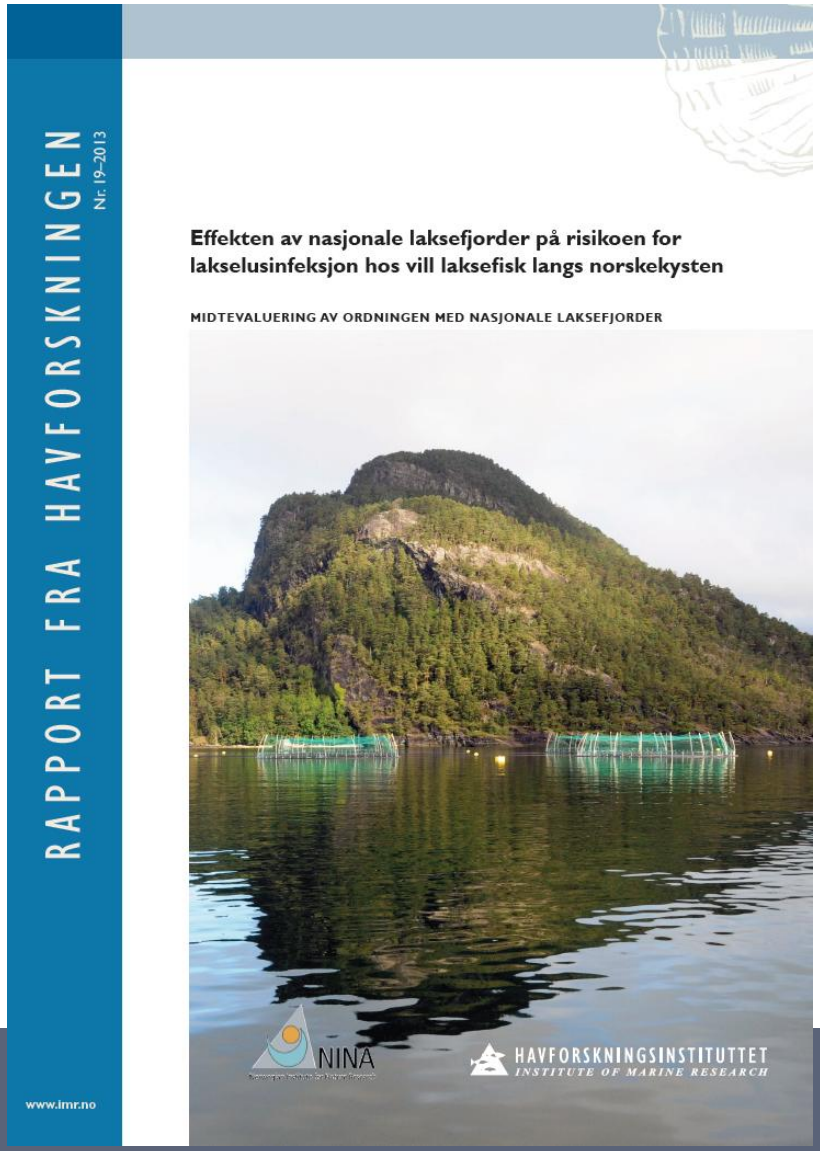
Alta 2013 (bagnetting)

Skillefjord						
Week	n	Weight (mean±SD)	Prev (%)	Intensity (mean±SD)	Max	% >0.1 rel int
28	28	462 ± 361	82	14,9 ± 16,1	59	11
29	15	114 ± 120	60	39,2 ± 24,0	**89**	**53**
33	41	254 ± 224	88	27,5 ± 14,5	**58**	**54**

Talvik						
Week	n	Weight (mean±SD)	Prev (%)	Intensity (mean±SD)	Max	% >0.1 rel int
28	36	466 ± 507	58	13,2 ± 13,0	46	3
29	44	441 ± 463	91	16,8 ± 13,4	59	18
33	40	246 ± 377	78	8,9 ± 7,4	24	13

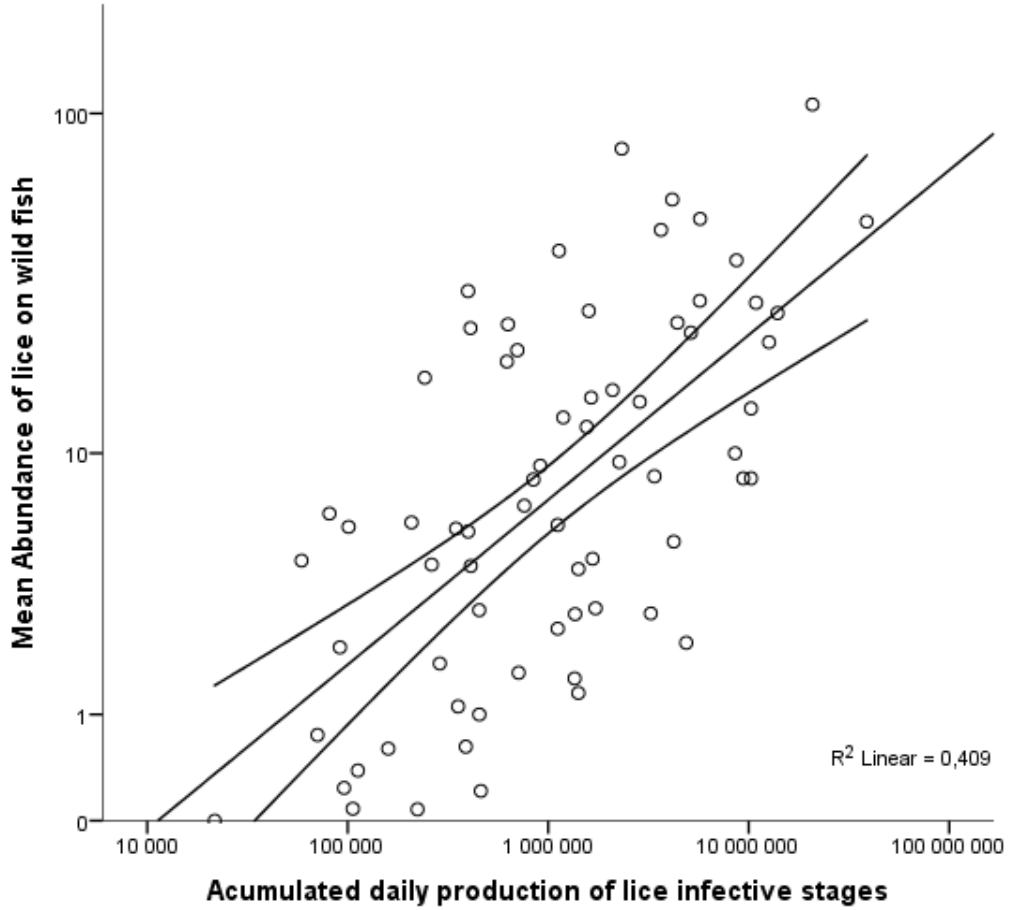


Midevaluation of «Norwegian national salmon fjords»



NINA

Midevaluation of «Norwegian national salmon fjords»



Serra-Llinares et al. 2014, Aquacult. Env. Interact. 5

Salmon lice - effects

- Mortality and stock reducing effects

Mortality and stock reducing effects

Table used for estimation of lice index related to suggested effects of salmon lice on postsmolts of Atlantic salmon, sea trout and Arctic charr <150 g. The material is divided into infection groups based on the number of lice/gram fish weight. The sum of all groups gives an estimated stock reduction (%) and is classified as minor (<10%), moderately (10-30%) and high (>30%). * Calculated as an example.

Infection group (number of lice/gram fish weight)	**Percentage of population (%)**	**Expected mortality**	**Index**
< 0,1	0,6	0 %	0
0,1 - 0,2	0,1	20 %	2
0,2 - 0,3	0,1	50 %	5
> 0,3	0,2	100 %	20
		Estimated reduction in population (%)	**27***

May

County	Fjord	Site	2010	2011	2012	2013
Aust-Agder	Sandnesfjord	Sandnes	0	0	0	
Rogaland	Ryfylke	Hellvik		0	0	0
		Vikedal*2012		36	20	
		Nedstrand				3
		Forsand		0	0	
Hordaland	Hardanger	Granvin	0	0		
		Ålvik		54	51	0
		Rosendal	0	69	53	13
		Etne	0	0	16	1
Sogn og Fjordane	Sognefjorden	Balestrand	0	0	2	0
		Vik				0
		Brekke / Dingja	0	35	23	0
Møre og Romsdal	Romsdal	Eresfjord	0	0	0	
		Sandnesbukta				22
		Isfjord	0	0	0	0
		Bolsøy *2010-2012	2	10	22	15
		Vatnefjorden				0
		Frænfjorden				7
	Storfjord	Sylte	0	0	37	
		Sykkylven	0	0	0	
		Ørsta	0	5	9	
Sør-Trøndelag	Trondheimsfjorden	Skatval *2010	6	0	2	0
		Agdenes	0	90	94	0
		Hitra	0	5	0	0
Nord-Trøndelag	Namsen	Tøtdal	0	0	0	0
		Sitter *2010-2011	32	24	71	15
		Vikna			7	98
Nordland	Eidsfjord	Vik *alle	0	32	50	
	Folda	Ballkjosen	0	25	13	
		Sagfjord	0	7	7	
	Vefsn	Fagervika	0	3		
		Leirfjord	0	0		
	Velfjord	Indre Velfjord *			4	
		Ytre Velfjord *			4	
Troms	Salangen	Løksa *2012		0	4	
Finnmark	Altafjord	Talvik *2012	0	0	1	12
		Skillefjord	5	0	3	26
	Bugøyfjord	Bugøyfjord				
	Porsanger	Handelsbukt	0	0		0
		Kåfjord/Repvåg *2013	0	0		0

June

County	Fjord	Site	2010	2011	2012	2013
Aust-Agder	Sandnesfjord	Sandnes	0	2	2	
Rogaland	Ryfylke	Hellvik		0	0	0
		Vikedal		15	0	
		Nedstrand				7
		Forsand		3	0	
Hordaland	Hardanger	Granvin	0	14		
		Ålvik		17	40	32
		Rosendal	55	67	87	38
		Etne	54	3	74	32
Sogn og Fjordane	Sognefjorden	Balestrand	1	0	3	0
		Vik				
		Brekke / Dingja	46	19	72	19
Møre og Romsdal	Romsdal	Eresfjord	0	21	8	
		Sandnesbukta				71
		Isfjord	7	15	25	26
		Bolsøy	14	13	32	73
		Vatnefjorden				98
		Frænfjorden				81
	Storfjord	Sylte	0	0	0	
		Sykkylven	3	10	34	
		Ørsta	25	16	35	
Sør-Trøndelag	Trondheimsfjorden	Skatval	0	13	2	11
		Agdenes	26	40	34	35
		Hitra	8	47	88	41
Nord-Trøndelag	Namsen	Tøtdal	0	9	14	55
		Sitter	65	40	59	62
		Vikna			57	60
Nordland	Eidsfjord	Vik	34	54	59	
	Folda	Ballkjosen	52	45	66	
		Sagfjord	4	52	32	
	Vefsn	Fagervika	19	4		
		Leirfjord	3	0		
	Velfjord	Indre Velfjord			34	
		Ytre Velfjord			28	
Troms	Salangen	Løksa		22	20	
Finnmark	Altafjord	Talvik	3	47	5	18
		Skillefjord	4	55	24	51
	Bugøyfjord	Bugøyfjord		10		
	Porsanger	Handelsbukt	0	0		5
		Kåfjord/Repvåg	0	0		27

Mortality and stock reducing effects – recent publications

- Gargan P.G., Forde G., Hazon N., Russell D.J.F. & Todd C.D. 2012. Evidence for sea lice-induced marine mortality of Atlantic salmon (*Salmo salar*) in western Ireland from experimental releases of ranched smolts treated with emamectin benzoate. Can. J. Fish. Aquat. Sci. 69:343-353.
- Jackson D., Cotter D., Newell J., McEvoy S., O'Donohoe P., Kane F., McDermott T., Kelly S. & Drumm A. 2013. Impact of *Lepeophtheirus salmonis* infestations on migrating Atlantic salmon, *Salmo salar* L., smolts at eight locations in Ireland with an analysis of lice-induced marine mortality. J. Fish. Dis. 36: 273-281.
- Krkošek M., Crawford W.R., Patrick G., Gargan P.G, Skilbrei, O.T., Finstad, B & Todd, C.D. (2012). Impact of parasites on salmon recruitment in the Northeast Atlantic Ocean. Proc. R. Soc. B. 280. doi: 10.1098/rspb.2012.2359.
- Skilbrei O.T., Finstad B., Urdal K., Bakke G., Kroglund F. & Strand R. 2013. Impact of early salmon louse, *Lepeophtheirus salmonis*, infestation and differences in survival and marine growth of sea-ranched Atlantic salmon, *Salmo salar* L., smolts 1997–2009. J. Fish Dis. 36: 249-260
- Vollset, K.V., Barlaup, B.T., Skoglund, H., Normann, E.S. & Skilbrei, O.T. 2014. Salmon lice increase the age of returning Atlantic salmon. Biol. Lett. 10: 20130896. http://dx.doi.org/10.1098/rsbl.2013.0896

Journal of Fish Diseases 2013 doi:10.1111/jfd.12157

Mortality and stock reducing effects

Short Communication

Comment on Jackson *et al.* 'Impact of *Lepeophtheirus salmonis* infestations on migrating Atlantic salmon, *Salmo salar* L., smolts at eight locations in Ireland with an analysis of lice-induced marine mortality'

M Krkošek[1], C W Revie[2], B Finstad[3] and C D Todd[4]

1 Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, ON, Canada
2 Atlantic Veterinary College, University of Prince Edward Island, Charlottetown, PE, Canada
3 Norwegian Institute for Nature Research, Trondheim, Norway
4 Scottish Oceans Institute, University of St Andrews, St Andrews, UK

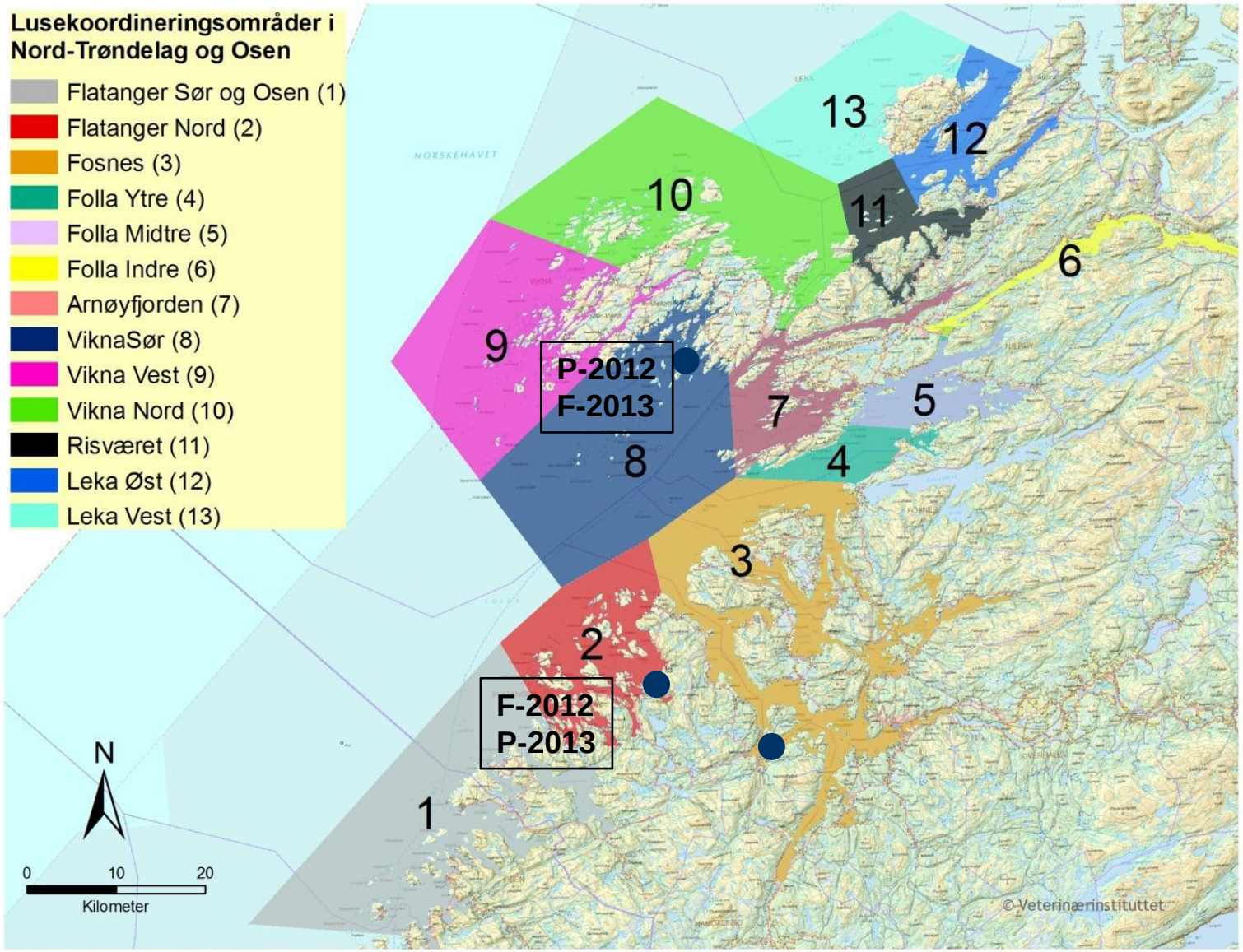
"…a one-third loss of overall adult recruitment".

"…parasites can and, in this case, do have a large effect on fisheries recruitment, irrespective of apparent changes in overall marine mortality over time, and with important implications for the management and conservation of wild salmon stocks».

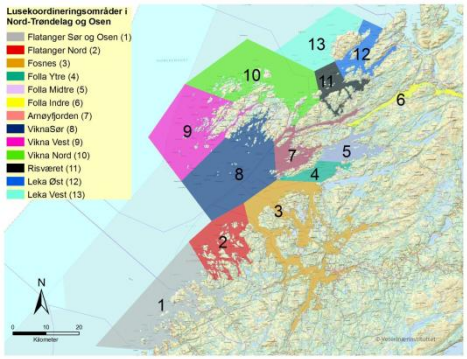
Salmon lice - effects

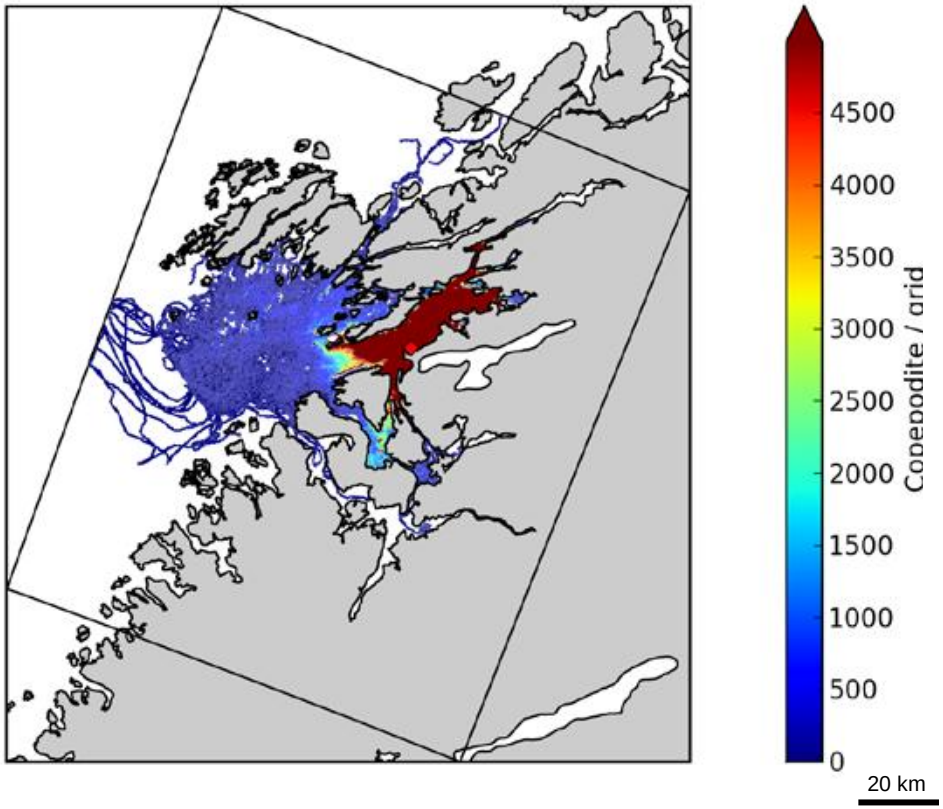
- Model sites for salmon lice research in Norway

Research activity, Namsenfjord, Romsdalsfjord and Hardangerfjord

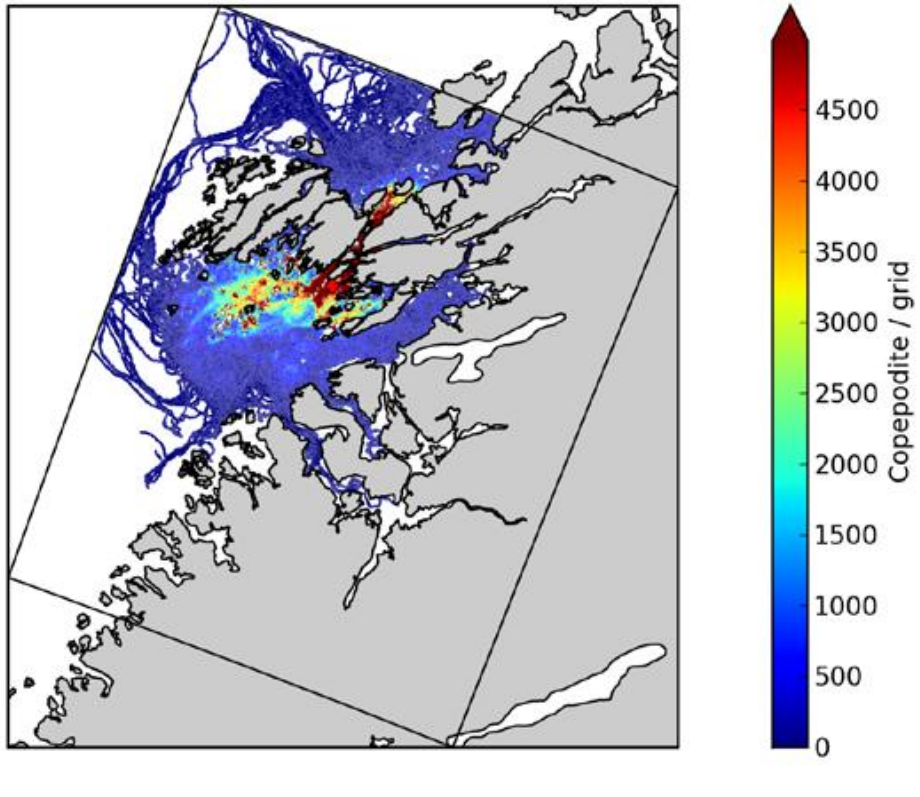

Lusekoordineringsområder i Nord-Trøndelag og Osen
Flatanger Sør og Osen (1)
Flatanger Nord (2)
Fosnes (3)
Folla Ytre (4)
Folla Midtre (5)
Folla Indre (6)
Arnøyfjorden (7)
ViknaSør (8)
Vikna Vest (9)
Vikna Nord (10)
Risværet (11)
Leka Øst (12)
Leka Vest (13)
NORSKEHAVET
13
12
10
11
6
9
P-2012
F-2013
7
5
8
4
3
2
F-2012
P-2013
1
N
0
10
20
Kilometer
© Veterinærinstituttet

Densityplot –coordinating areas 60 days simulation – April-May 2010



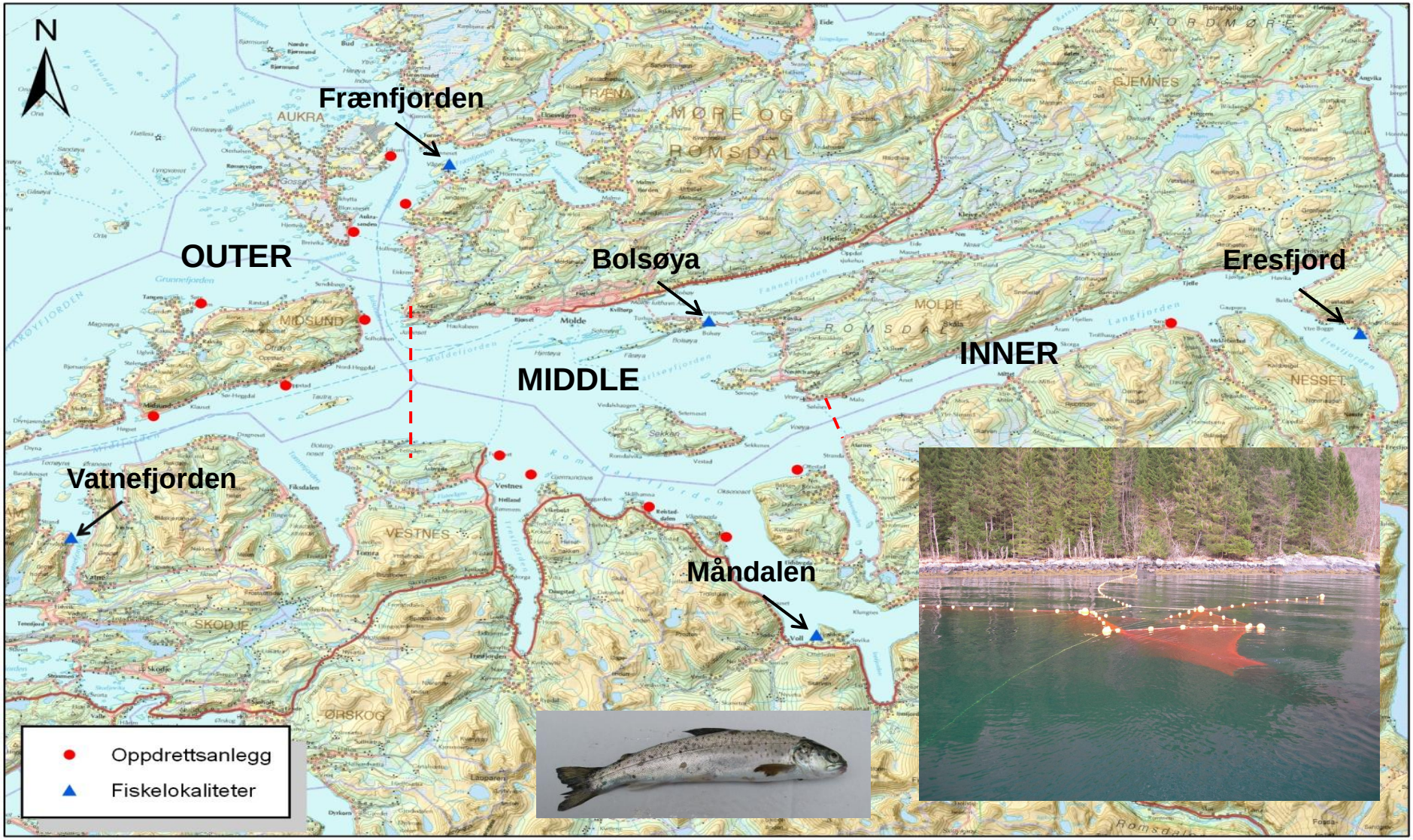


Releases at Folda. Big local conc. in areas 4, 5 and partly 6 and some spread south in the fjord systems in area 3

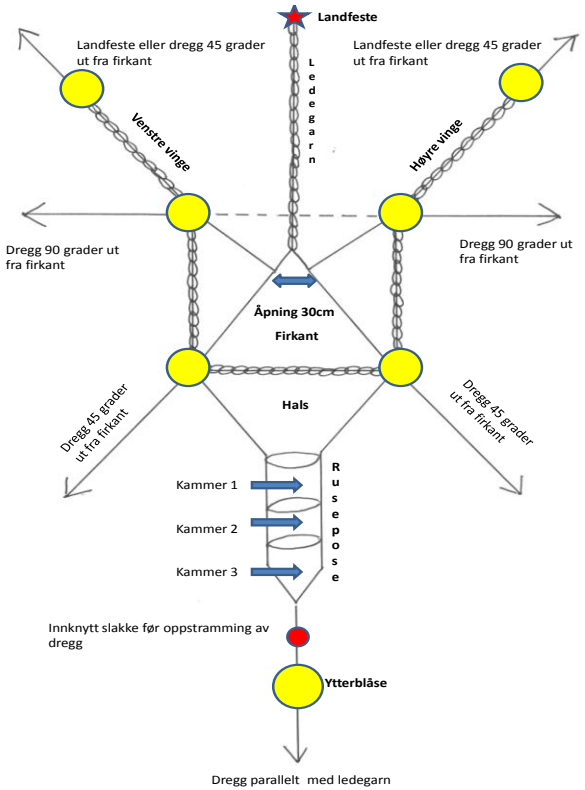


Releases in the Folda area. Spread west in area 8 and north towards Nærøysundet into area 10.

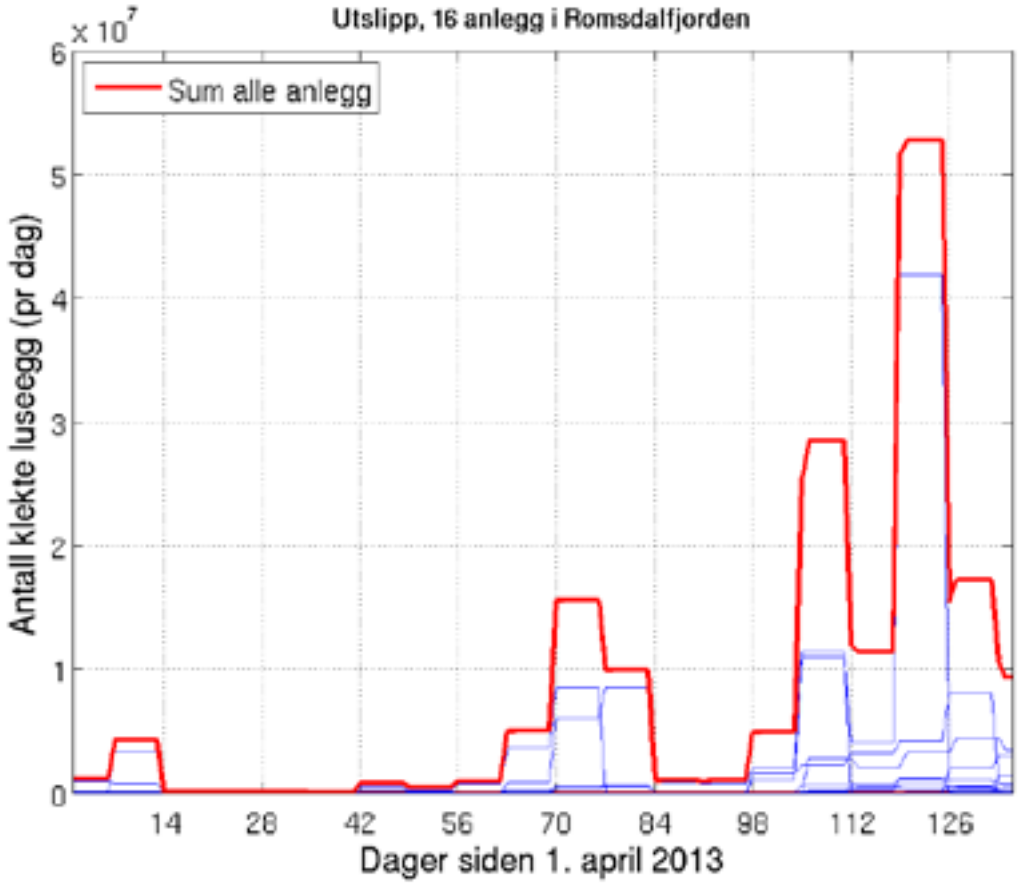
Fish farms and monitoring sites - Romsdalsfjord



Capture method – bag netting



Estimated production of copepodites from fish farms in the Romsdalsfjord - 2013



Taranger et al. 2014. Risikovurdering norsk fiskeoppdrett, Fisken og havet, særnummer 2-2014

NINA

Telemety –sea trout, Etne (Hardangerfjord with Norways largest aquaculture activity)– this area is fallowed each second year

Listening stations (hydrophones) VR2W

Listening stations in river

Outer recapture- and release area

Inner recapture- and release area

0 1 2 Km

Sea lice studies in Norway - what do we know?

Fish farms - effects

- The number of hosts in the farm is more than 200 times greater than wild stocks

- The relationship between intensive farming areas and sea lice infestation on wild salmonids (salmon, trout and charr) is shown

Sea lice studies in Norway - what do we know?

Individual

- Lice causing physiological disorders in salmonids (salmon, trout and charr)
- Tolerance studies on farmed smolts of salmon, trout and charr has provided us with an approach to estimate tolerance levels
- Louse infestations of individual fish affect fish behavior in a negative direction

Sea lice studies in Norway - what do we know?

Populations

- Release experiments with individual tagged smolts protected fish have better return migration and growth than unprotected fish

- Premature (early) return migration detected in trout and charr that has lice infestation

- But – still we need more information on population effects and behavior of lice infested wild salmonids

A model for management advices related to environmental sustainable production for the industry and management authorities

Step 1

Step 2

LICE PRODUCTION FARMS

INFECTION LEVELS WILD FISH

EFFECT OF INFECTIONS ON WILD STOCKS

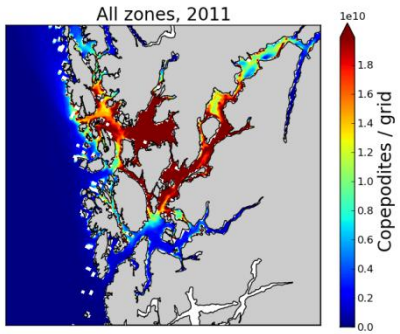
Regulation (NFSA)

MANAGEMENT ADVICE FOR SUSTAINABLE LICE PRODUCTION

Limits

Step 3

Model for sustainable production



Important issues for Iceland

- Collect «historical data» of sea lice on salmonids and other pathogens in relevant fjords – a «before- and after study» related to fish farming – IMPORTANT!

- Establish relevant monitoring stations as we do in Norway to monitor these effects and relate this to fish farming activity

- Methods as gill netting, bag nets, sentinel cages, plankton towing, FISH-lift trawling, hydrography


Thank you for your attention!