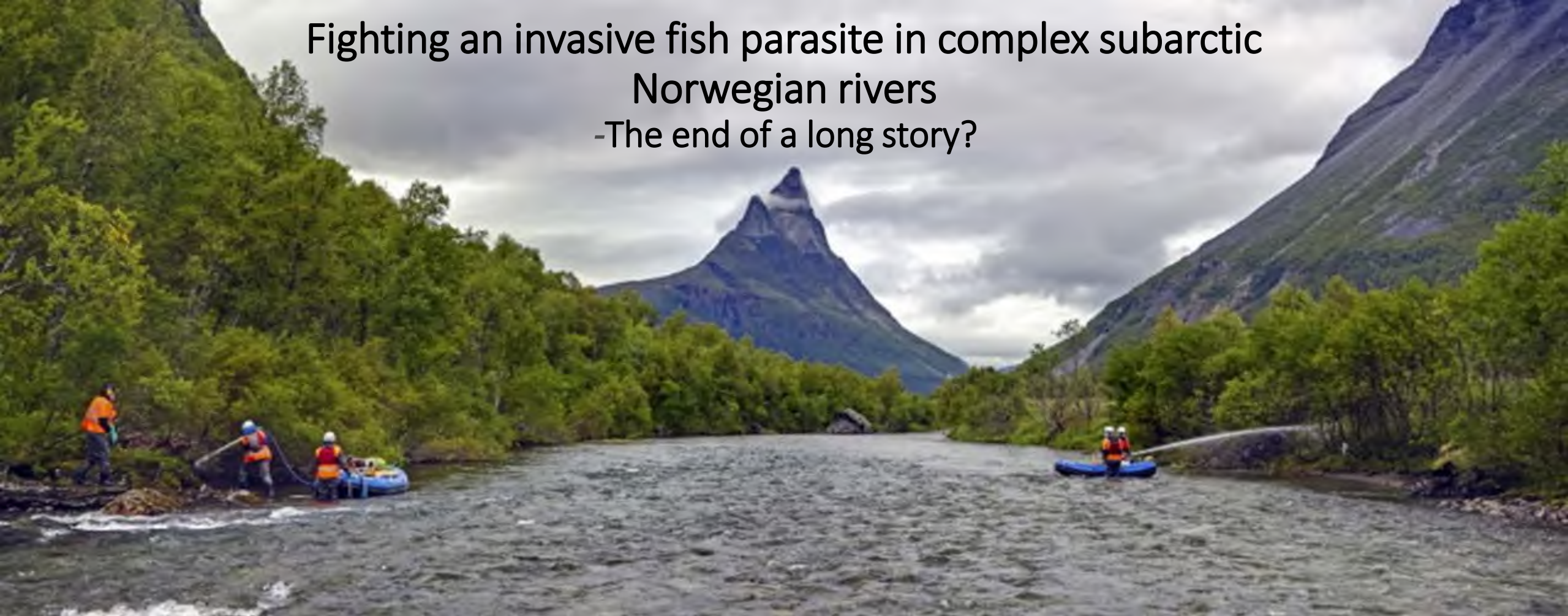


Fighting an invasive fish parasite in complex subarctic Norwegian rivers

-The end of a long story?



Pål Adolfsen and Helge Bardal
Norwegian Veterinary Institute
Section for Environmental and Biosecurity Measures



Veterinærinstituttet
Norwegian Veterinary Institute



The parasite: *Gyrodactylus salaris*, Malmberg 1957.

- Monogenean ectoparasite, alias “salmon fluke”.
- Introduced by import of live infested Atlantic salmon (*Salmo salar*) smolts and Rainbow trout (*Oncorhynchus mykiss*) from Baltic sea rivers.
- Attaches to skin and fins by specialized haptor, feeds on skin.
- Infested Atlantic salmon (*Salmo salar*) and Arctic char (*Salvelinus alpinus*) in totally 50 rivers.
- Norwegian (East Atlantic) strains of Atlantic salmon highly susceptible to the parasite, unlike low susceptible Baltic Sea salmon strains.
- High mortality and catastrophic loss of recruits in infected salmon populations in Norway. Average reduction in densities of young salmon: 86 % (50 – 95 %).
- Asexual reproduction; one single parasite on one single host theoretically can start an epidemic.



The Achilles` heel

- Direct life cycle, no life stages and short survival time without the host.
- Host specific with few alternative permanent host-species in Norwegian freshwaters.
- Limited saltwater tolerance, spreads naturally only by downstream drift and migrating fish in freshwater and brackish fjords.
- Eradication is possible by removing the hosts.
- Rotenone treatment, constructing migration barriers and close fish ladders.
- Sensitive to water chemistry.



Foto: Jannicke Wiik-Nielsen



The battle begins

- Successful eradication projects by rotenone treatments in the 1980`s.
- Treatments failed in «larger» and more complex rivers in the late 1980`s and 1990`s.
- Growing skepticism and resistance to the eradication strategy.
- The future of the rotenone based eradication strategy was uncertain.....
- Alternative strategy: aluminum/sulfuric acid to kill the parasite without killing fish showed the same limitations in complex rivers.

Totally 50 salmon rivers infected



What to do now.....???

- Expert group revised the failed projects and pointed out possible technical and strategic improvements.
- External research projects on the role of alternative hosts (Arctic char and salmon/trout hybrids).
- Reorganization of the eradication projects.
- The Norwegian Veterinary Institute was given the responsibility to plan and implement the eradication projects on behalf of the Norwegian Environmental Agency.
- Internal focus on strategic and technical improvements during several large projects since 2003.
- **In the Skibotn region all the improvements were put to an ultimate test as a third treatment was scheduled for 2015 and 2016**



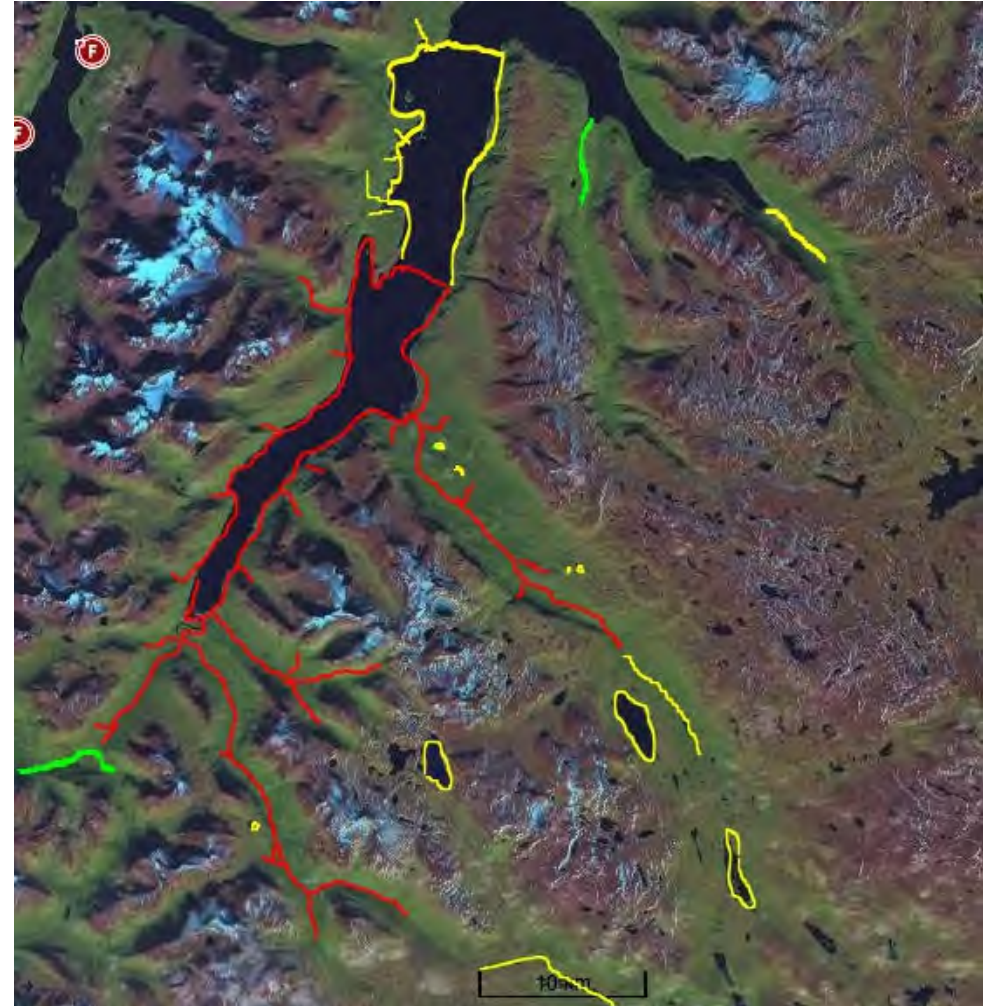
The Skibotn region

- At 69 °N, the northernmost region infected with *G. salaris*
- The Skibotn river infected in the mid - 1970`s, **treated with rotenone in 1988 and 1995. Both treatments failed.**
- Parasite spread to nearby rivers in the same fjord, present in in three main rivers and one large tributary in 2015.
- 3 possible long term hosts: Atlantic salmon, Arctic char and hybrids (Brown trout x Atlantic salmon) abundant in the region.
- Infested fish found in all types of waterbodies permanent or periodically available for anadromous salmonides or their offspring.



Problem #1: Defining the treatment area, to treat or not to treat...

- Infection easy to detect in Atlantic salmon populations, obscure in Arctic char populations.
- National monitoring program for the nearby salmon rivers.
- Resident Arctic char populations upstream, potentially infected by illegal stocking? Monitoring program in the project.
- Electrofishing and screening for parasites on Arctic char in rivers without Atlantic salmon.
- Treatment of **all** small rivers and creeks inside of a defined zone in the fjord as far as salmonides can migrate.
- Treatment of all pounds, marshes and wetlands that are permanent or periodically available for migrating salmonids.



Problem # 2:

Groundwater influx, diluting rotenone treated water

- Temperature mapping (summer) and observation of missing snow and ice cover (winter) to identify groundwater influx.
- Higher rotenone concentrations, robust to dilution.
- Extra dosage stations to compensate for dilution and filtration
- Repeated treatments of the influx areas. Soaking river banks with rotenone/water mix from boat- or backpack mounted pumps
- «Flash flood» of rotenone treated water, reversing the ground water flow.

- **«Heavy rotenone»**

- Vectocarb® (Calciumcarbonate particles) Slurry releases rotenone in the river substrate.

- Cat-sand saturated with CFT- Legumine®, spread manually in smaller groundwater influx areas.

- Bars of soap and CFT- Legumine® Moulded 100 g flat disc, dissolves steady rate in running water. Pocket size «dosage station» for small springs, brooks and seeps.



Problem #3: Arctic char; abundant alternative host.

- Partly neglected as a potential long term host in the 1988 and 1995 treatments.
- Scientific reports from 1990`s and 2000`s confirmed the potential as a long term reservoir host for *G. salaris*.
- New strategy; 100% eradication of Arctic char within the infected rivers.
- Preference for low temperatures, abundant in groundwater fed brooks and ponds.
- Detailed mapping of the watersheds to cover all Arctic char habitats essential.
- Treatment periods extended into the nights to target nocturnal fish hiding in substrate at daytime.



Problem #4:

No good methods for determination of rotenone concentrations during treatments.

- Analyzing lab with high capacity and improved accuracy of rotenone determination at the HQ.
- Water sampling, efficient logistic and fast analyzing during treatment period.
- Possible to detect sublethal concentrations and to implement compensating measures the same day.
- Dedicated teams sampling dead fish and observe for survivors during and directly after the treatment period.



Management of Biological Invasions (2018) Volume 9, Issue 1: 59–65

DOI: <https://doi.org/10.3391/mbi.2018.9.1.06>

© 2018 The Author(s). Journal compilation © 2018 REABIC

Open Access

Research Article

Fast and accurate on-site determination of rotenone in water during fish control treatments using liquid chromatography

Morten Sandvik^{1,*}, Thor Waaler^{1,4}, Thomas Rundberget², Pål Adolfsen³, Helge Bardal³ and Roar Sandodden³

¹Norwegian Veterinary Institute, P. O. Box 750 Sentrum, NO-0106 Oslo, Norway

²Norwegian Institute for water research, Gaustadalléen 21, NO-0349 Oslo, Norway

³Norwegian Veterinary Institute, P. O. Box 5695 Sluppen, NO-7485 Trondheim, Norway

⁴retired

Author e-mails: morten.sandvik@vetinst.no (MS), thor.waaler.@vetinst.no (TW), thomas.rundberget@niva.no (TR), pal.adolfsen@vetinst.no (PA), helge.bardal@vetinst.no (HB), roar.sandodden@vetinst.no (RS)

*Corresponding author

Received: 17 February 2017 / Accepted: 30 September 2017 / Published online: 17 October 2017

Handling editor: Matthew Barnes



Veterinærinstituttet
Norwegian Veterinary Institute



Problem #5: Brackish fjord - potential refuge for infested hosts?

- Migrations of Arctic char between rivers within the maximum survival time of parasite in the brackish water are documented.
- Repeated treatment two following years.
- Extra treatment of lower part of the rivers to kill fish migrating between rivers within the treatment period.
- Treatment period August/September, high fjord temperatures and low freshwater discharge = low survival time for parasites «hitchhiking» in the fjord



Problem #6:

Coordination and assurance of quality in a large field operation

- Two Leaders + staff leading the operation from headquarter each day, alternates with two new leaders the next day
- **Same persons who have mapped the treatment area and planned the operation.**
- Experienced crew in the field, participants from several earlier treatments.
- All teams have VHF communication, maps, GPS receivers and written instructions for every treatment object.
- Team leaders reports to the head quarter during and after treatment.
- The headquarters systematically controls every report at the end of the day to ensure that every task is performed as planned.
- Qualitative fish sampling second year; looking for possible surviving fish from first year treatment and screening for the parasite.



The effort pays off!

Status at the end of this week.....

- 38 previous infected salmon rivers officially declared free from the parasite, (If the Rauma region is declared free at Friday this week...)
- 4 rivers under post - treatment monitoring program.
- **7 rivers still infected.**
- 2 – 3 more years before the result for the Skibotn region is conclusive.
- No parasites found second year of treatment and no parasites are detected in the official post – treatment monitoring program in 2017-18....
- Fish populations successfully reestablished after rotenone treatments.
- No negative long term effects of rotenone treatment detected on the local aquatic fauna, consistent with most international studies



Thank you for your attention!

- Special thanks to the Norwegian Environmental Agency for thrusting us in this!
- Thanks to all the dedicated people, professionals and volunteers who have participated!
- Thanks to all good colleagues!

