

# Insights from SalmoInvade: policy recommendations based on biological and social findings



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# Project - Background & Timeline

- **Salmonids** are among the most important fish in Europe. They are targets for recreational and commercial fishery, part of our cultural heritage, and serve as flagship species for river restoration
- Because of their value, salmonids have been translocated widely outside their native range since the 19<sup>th</sup> century. Ecological conditions vary considerably within Europe, which has affected both the natural distribution of native salmonids, and the current invasion potential for non-native salmonids
- Differences across countries are also reflected in e.g. varying legislation, governance, stakeholder perceptions, type of fishing and stocking rights
- Thus, a pan-European approach is needed to integrate the knowledge required for managing invasive salmonids in Europe
- **SalmoInvade** was funded under the BiodivERsA call 2012-2013:  
*Invasive species and Biological Invasions*
- **Project duration:** 31 Dec 2013 – 31 March 2017





The **SalmoInvade** consortium covers Scandinavia and continental Europe, and insights from North American Salmonid invasions.

#### Partner institutions

- University of Gothenburg (Sweden)
- Leibniz-Institute of Freshwater Ecology and Inland Fisheries in the Forschungsverbund Berlin e.V. (Germany)
- Norwegian Institute for Nature Research, NINA (Norway)
- CNRS/University Paul Sabatier (France)
- Memorial University (Canada)



## Project participants



#### Steering group

- Jörgen Johnsson, Sweden (coordinator)
- Robert Arlinghaus, Germany
- Julien Cucherousset, France
- Kjetil Hindar, Norway
- Ian Fleming, Canada



# Salmolnvade stakeholder meetings



Stakeholder ref group r

er meeting Sep 2016



Visit by the Swedish King  
Carl Gustaf XVI Nov 2015



Stakeholder meeting Germany Oct 2016

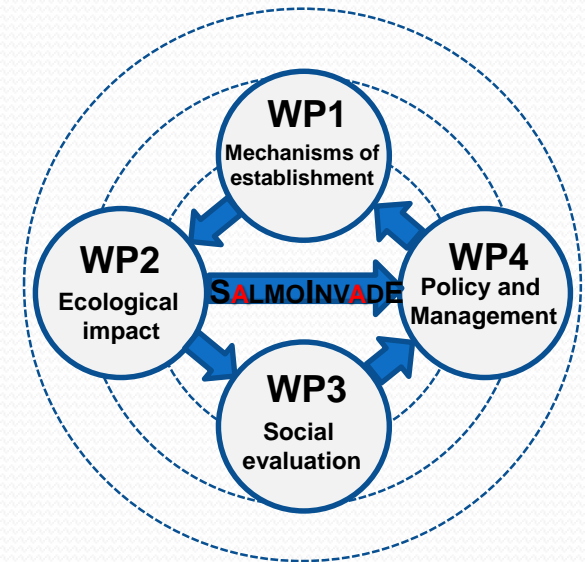


Stakeholder meeting France Nov 2016

# Project - Objectives

The main objectives of Salmolnvade are:

1. to evaluate current releases of non-native salmonids in Europe and the social, economic and ecological mechanisms underlying their invasion potential,
2. to investigate the ecological and evolutionary impacts of biological invasions by salmonids,
3. to evaluate how salmonid invasions are perceived by the public and by key stakeholders and
4. to provide integrated recommendations for policy and management of salmonid invasions.



Salmolnvade will integrate novel eco-evolutionary and socio-economic hypotheses to evaluate the impacts and consequences of non-native salmonid invasions. The results are expected to influence policy and management of this economically important group of fish.

# Project Outputs

## Research Highlights I. Biological studies



# *I. Synthesis: impacts of non-native salmonids*

Buoro et al. 2016. *Ecology Letters* 19: 1363–1371.

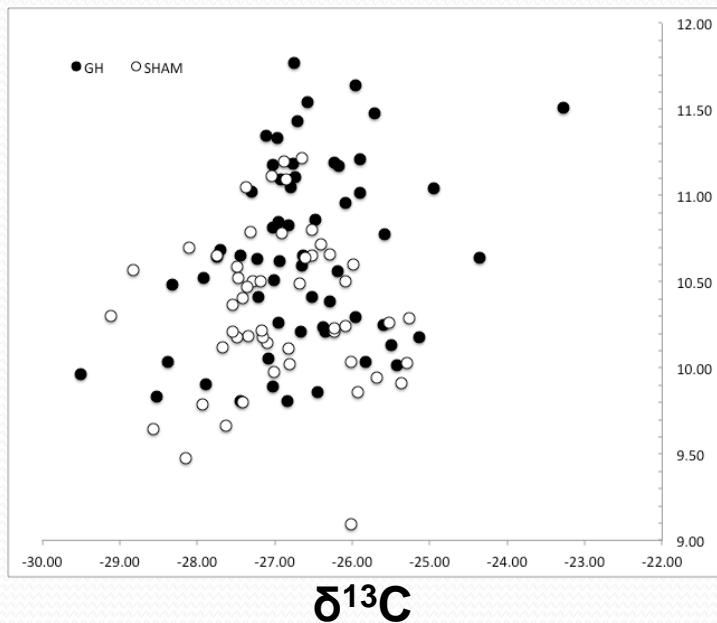
- Using a meta-analytic approach we reviewed published scientific data to investigate the ecological impacts of salmonid invaders at the global scale
- Results demonstrated that invading salmonids have, overall, negative ecological effects on native biodiversity
- Furthermore, the release of non-native conspecific individuals (e.g. hatchery) have strong effects at lower levels of biological organisation, whereas the introduction of non-native species have stronger effects at higher levels of biological organisation
- A knowledge gap was identified regarding the effects of introduced non-native populations of conspecifics on recipient communities and ecosystems



## II. Growth-enhanced Salmon modify ecosystem functioning

Cucherousset et al. *In prep.*

- Growth hormone (GH) implants was used to simulate the phenotypic effects of growth-enhanced salmon (e.g. aquaculture-selected, GH-transgenic)
- We found that native growth enhanced salmon invaders can have cascading ecological effects, disrupting the functioning of headwater streams
- This novel result suggests that releases or escapes of growth-enhanced fish can have more diverse ecological effects than previously recognized





### III. *Effects of non-native brook trout on native brown trout*

Závorka et al. 2017. *Functional Ecology* 31: 1582-1591.

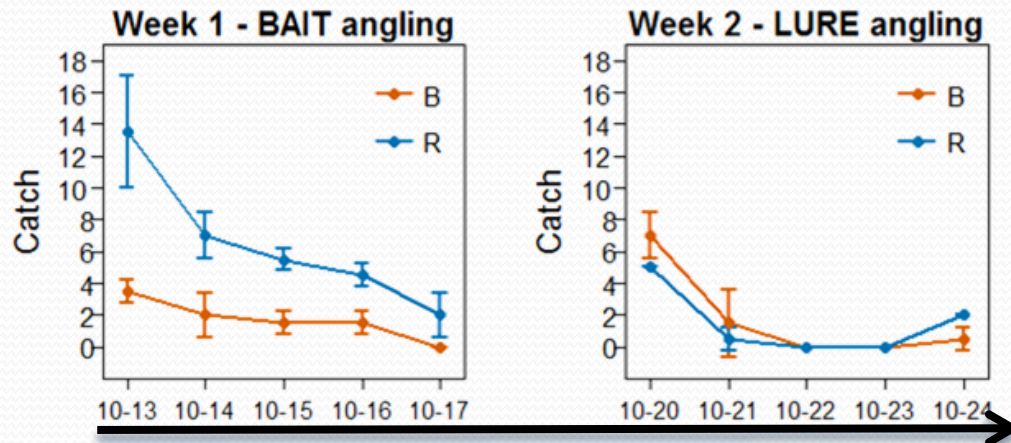
- We studied the ecological interactions between non-native brook trout and native brown trout combining field and laboratory measurements of phenotypic traits and ecological niche traits
- We found that non-native brook trout can reduce the fitness (i.e. growth) of co-existing brown trout in headwater streams.
- The mechanism behind this appears to be that coexistence with the “evolutionary novel” brook trout disrupts adaptive trait associations in native brown trout



## IV. Effects of angling on the fitness of salmonid invaders

Koeck et al. *In revision. Journal of Applied Ecology*

- In collaboration with the Swedish Anglers Association we investigated to what extent angling can be used to mitigate the invasiveness of non-native salmonids
- We found that non-native rainbow trout are more likely to be caught by angling than native brown trout, but the effect is strongly dependent on the angling methods. Furthermore, in rainbow trout, bolder individuals, as estimated from activity scoring prior to angling, were more likely to be caught by anglers.
- These results suggest that angling could be tailored to mitigate the effects of bold non-native salmonid species and bold invasive phenotypes, but the ecological relevance of this approach requires further investigation



# Project Outputs

## Research Highlights II. Social studies

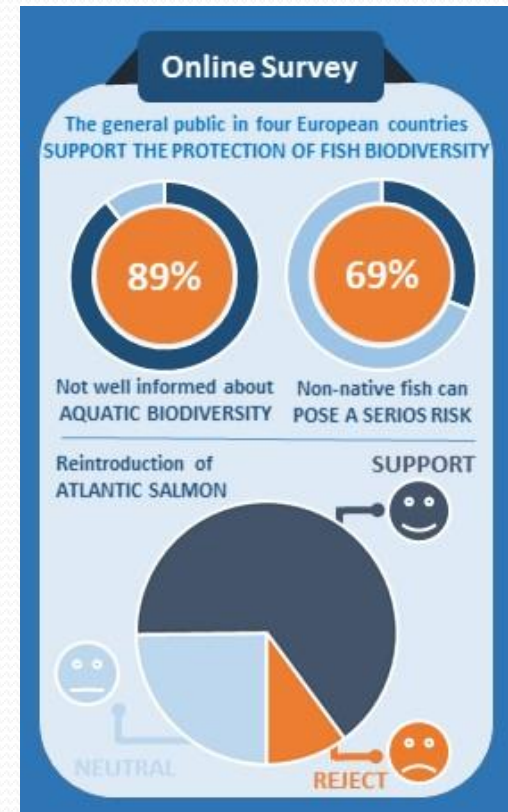


# I. Public perception of biodiversity and conservation

Kochalski et al. (In revision). *Conservation Biology*.

## Online survey

- Citizens of four countries (France, Germany, Sweden, Norway) were surveyed as to their views about non-native salmonids
- The majority of the public did not feel well informed about fish biodiversity and the potential threats from the introduction of non-native fishes
- Despite this lack of knowledge, vast majorities of the citizens in all countries were intuitively concerned about risks associated with the introduction of non-native fishes



# I. Public perception of biodiversity and conservation

Riepe et al. (*In revision*).

## Willingness to pay

- In general respondents preferred salmonid-friendly river conditions (high native biodiversity, few hydropower dams, good bathing water quality)
- In the Scandinavian countries, the presence of wild native salmonids were preferred over the presence of other riverine fish species

Table 1. Willingness-to-pay (WTP) estimates (€ / year) by country for six alternative river basin management plans.

Country	Scenario 1 Fisheries (native salmonids)	Scenario 2 Fisheries (nonnative salmonids)	Scenario 3 Conservation oriented (native salmonids)	Scenario 4 Holistic ecosystem conservation	Scenario 5 Hydropower (Green Energy)	Scenario 6 Hydropower (Green Energy) AND fisheries (native salmonids)
France	238.7 <sub>a</sub>	168.9 <sub>a</sub>	235.0 <sub>a</sub>	261.8 <sub>a</sub>	106.7 <sub>a</sub>	238.5 <sub>a</sub>
Germany	246.6 <sub>a</sub>	182.0 <sub>a</sub>	286.0 <sub>a</sub>	395.5 <sub>b</sub>	60.2 <sub>b</sub>	382.7 <sub>b</sub>
Norway <sup>a</sup>	667.8 <sub>b</sub>	370.2 <sub>b</sub>	683.5 <sub>b</sub>	729.6 <sub>c</sub>	147.1 <sub>a</sub>	655.2 <sub>c</sub>
Sweden <sup>a</sup>	731.0 <sub>b</sub>	582.1 <sub>c</sub>	741.7 <sub>b</sub>	832.5 <sub>c</sub>	316.6 <sub>c</sub>	834.6 <sub>c</sub>

Note. All WTP values  $p < .05$ . WTP values in each column that share subscripts do not differ significantly ( $p \geq .05$ ). <sup>a</sup>WTP values in NOK and SEK, respectively, were converted to €.

## II. Governance effects on transfer of non-native salmonids

Aas Ø et al. *In revision. Aquatic Conservation.*

- Governance differences were found among the countries in overall goals and objectives, sectorial organization and levels of decision-making
- In France and Germany stocking is commonly based on local decision making (e.g. in angling clubs) whereas Sweden, Norway (and Canada) are more characterized by top-down legislative control of stocking and introductions
- In Scandinavia, particularly Norway, negative ecological impacts of stocking (e.g. escapes from aquaculture, *Gyrodactylus*) have been more evident than in central Europe which may partly explain differences in governance



### *III. Understanding stocking in angling clubs as vectors of non-native fishes* Riepe et al. *Fisheries Research* 194 (Suppl. C): 173-187.

- In France and Germany, angling clubs were found to be major vectors of salmonid introductions to natural watersheds. Of the clubs surveyed in both countries, 22 % stocked primarily native salmonids and 27 % primarily non-native salmonids
- The potential negative genetic or ecological effects of fish stocking, as perceived by the decision-maker, hardly affected stocking decisions for either native or nonnative salmonids
- By contrast, stocking decisions were strongly influenced by the economic and social contexts of the clubs (e.g., type of water body under management or economic resources) and by social norms



# Summary and Policy Recommendations

## KEY RESULTS

- *Non-native salmonid species, as well as non-native populations of native salmonid species, can have substantial negative ecological effects on native biodiversity across all levels of biological organization, from individuals to populations, communities and ecosystems*
- *Domesticated non-native fish, such as rainbow trout, can to some degree be controlled by intensive fishing given their high vulnerability to angling*
- *There are substantial differences in governance and management of salmonid stocking and transfer between and within European countries, in particular in terms of levels of decision-making, as well as in trends and volume of salmonid stocking*
- *The public awareness of non-native salmonids and their potential effects on biodiversity is low. However, citizens of the four European countries surveyed intuitively prefer river conditions and management actions that have positive effects on wild salmonids*
- *Decisions by local-level fisheries decision-makers to stock non-native salmonids are rather influenced by the attitude toward fish stocking governed by social and economic contextual factors and social norms rather than by potential negative biological effects*



# Summary and Policy Recommendations

## RECOMMENDATIONS

- *Stocking of non-native species and populations of salmonids should be avoided*
- *Monitoring, reporting and evaluation of stocking and transfer activities in European jurisdictions are generally lacking. Local and regional authorities should be empowered to enforce regulations and to evaluate practices for salmonid stocking*
- *Within the framework of international conservation agreements, strategies for the conservation of native salmonids should be devised in accordance with the variation in national regulations, existing governance practices and public perception of native and non-native salmonids across European countries*
- *Science – policy – public cooperation and dialogue is strongly encouraged to achieve more sustainable conservation practices for native salmonids*

# RDI Gaps for the Future

- *The biological effects of invasive non-native species and populations appear to be more complex than previously recognized. More research studying effects at multiple levels of biological organization, and also at longer time scales, is required*
- *Biological and social science studies need to be better integrated to understand how knowledge of biodiversity and its values, and the consequences of spread of non-native species/populations, can be transferred most effectively to the public and stakeholders*
- *The EU is recommended to initiate and support multidisciplinary European research programs further examining the links between science, policy and public awareness of biodiversity conservation*

# Link to SRIA Themes

- **Theme 1: Improving Ecosystem Sustainability and Human Well-being**
  - 1.1.- Developing approaches for assessing and optimising the value of ecosystem services
    - 1.1.1. Developing approaches for assessing the ecological functioning of ecosystems
    - 1.2.2. Managing the risks caused by invasive species and options for remediation



# Project – Contact Details



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SalmoInvade web page: <http://bioenv.gu.se/english/salmoinvade>

