

THE NEED TO MANAGE SALMONID INVASIONS IN EUROPE TO PROTECT NATIVE BIODIVERSITY



POLICY BRIEF

SUMMARY OF RECOMMENDATIONS

- Stocking of non-native species and populations of salmonids should be avoided
- Monitoring, reporting and evaluation of stocking and transfer activities in countries such as Germany, France, Norway and Sweden are generally lacking or insufficient, and therefore should be improved
- Local and regional authorities should be empowered to enforce national fisheries regulations and to evaluate practices for salmonid stocking
- Science – policy – public cooperation and dialogue is strongly encouraged to achieve more sustainable conservation practices for native salmonids. This involves increased outreach and public information about the downsides of non-native salmonids and joint undertaking of impact assessments involving practitioners, scientists and authorities
- The recommendations of the SalmoInvade project aid the implementation of the [European Water Framework Directive \(2000/60/EG\)](#) which states that exposure to foreign species and strains degrade the ability to achieve good ecological status. These recommendations also aid in fulfilling several targets of the [EU 2020 biodiversity strategy \(COM \(2011\) 244\)](#), e.g.: “combat invasive alien species” (target 5), “improve management of EU fish stocks” (target 4), and “protect aquatic ecosystems and their services” (target 2).

KEY RESULTS

- Non-native salmonid species, as well as non-native populations of native salmonid species, can have negative ecological effects on native biodiversity across all levels of biological organization, from individuals (e.g. displacement) to ecosystems (e.g. primary production)
- The spread of non-native salmonid populations is generally perceived as undesirable judging from contemporary stocking policies in countries such as Germany, France, Norway or Sweden, but still continues to be common throughout Europe, with few exceptions
- The release of non-native salmonids, such as rainbow trout or brook trout is widespread in central European countries, such as France and Germany, and is legally allowed there, while such releases are more controlled through legal constraints in Scandinavian countries
- The spread of domesticated non-native fish, such as rainbow trout, can to some degree be controlled by intensive fishing given their high vulnerability to angling
- The public awareness of non-native salmonids and their potential effects on biodiversity is low in the surveyed countries (France, Germany, Sweden and Norway). However, citizens intuitively prefer river conditions and management actions that benefit wild salmonids
- The perceived potential negative genetic or ecological effects of fish stocking hardly affected stocking decisions of local angling clubs in France and Germany, which were rather 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.

CONTEXT

Salmonids are among the economically and culturally most important fish in Europe, for recreational and commercial fishing, as key species for a viable and growing aquaculture industry, and part of the European cultural heritage. They are also flagship species for river restoration and water quality. Due to their unique value, salmonids (e.g. rainbow trout (*Oncorhynchus mykiss*), brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), Atlantic salmon (*Salmo salar*) have been introduced and translocated widely outside their natural range (Fig. 1).

Variable ecological conditions in Europe affect both the natural distribution of native salmonids and the current invasion potential of non-native salmonids. Differences across countries are also reflected in varying legislation, management practices and stakeholder perceptions. Furthermore, salmonids migrate (naturally or artificially) across administrative, legislative and geographical boundaries. Thus, an integrated Pan-European approach is needed to establish the knowledge base required for effective management of invasive salmonids in Europe.

This policy brief reports the conclusions of the BiodivERsA-funded [SalmoInvade project](#). The policy recommendations have been developed in dialogue with European and national-level stakeholders, including a reference group from France, Germany, Sweden and Norway (see [SalmoInvade website](#)). The recommendations have been reviewed by Peter Hutchinson of *The North Atlantic Salmon Conservation Organization (NASCO)*, and Johan Dannewitz of *The International Council for the Exploration of the Sea (ICES)*.



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Fig. 1: Rainbow trout (first) and Brook trout (second) are non-native species which are common in Europe whereas brown trout (third) is native in many European countries.

RESEARCH HIGHLIGHTS

IMPACTS OF NON-NATIVE SALMONIDS

Results from a meta-analysis of published scientific data (Buoro *et al.* 2016) demonstrated that invading salmonids have overall negative ecological effects on native biodiversity (Fig. 2). **The release of non-native individuals from the same species (e.g. hatchery-produced) has overall stronger effects at lower levels of biological organisation** (e.g. fitness of native salmonids) than the release of non-native individual from other species.

A comparison (Sundt-Hansen *et al.*, in prep) of native Atlantic salmon performance under different invasion scenarios (i.e. farmed Atlantic salmon, native brown trout and non-native rainbow trout) showed no important effects on the native Atlantic salmon. However, introducing growth-enhanced native salmonids could have different outcomes. Indeed, **the introduction of growth-enhanced native salmonids caused cascading ecological effects, suggesting more diverse ecological effects than previously recognized** (Cucherousset *et al.*, in prep).

Using a novel approach combining field and laboratory measurements, research (Zavorka *et al.* 2017) showed that **the non-native brook trout can reduce the fit-**

ness of co-existing native brown trout in headwater streams. This is possibly due to the disruption of adaptive trait associations in native brown trout by the “evolutionarily novel” brook trout, although this hypothesis requires further testing.

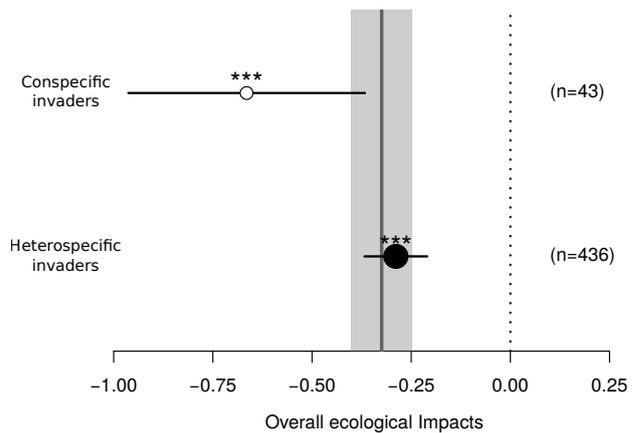


Fig. 2: Overall ecological impacts of conspecific (white circle) and heterospecific (black circle) Salmonid invaders (adapted from Buoro *et al.* 2016).

EFFECTS OF ANGLING ON THE FITNESS OF SALMONID INVADERS

Using angling experiments in collaboration with the Swedish Anglers Association (*SportFiskarna*), it was found that invasive fishes are often characterized by a “bolder” behaviour; results demonstrated that non-native rainbow trout are more likely to be caught by angling than native brown trout, although depending strongly on the angling methods (Koeck *et al.*, in preparation; Fig. 3).

Similarly, bolder rainbow trout individuals 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**, although the ecological relevance of this approach and the impact of fishing intensity require further analysis.

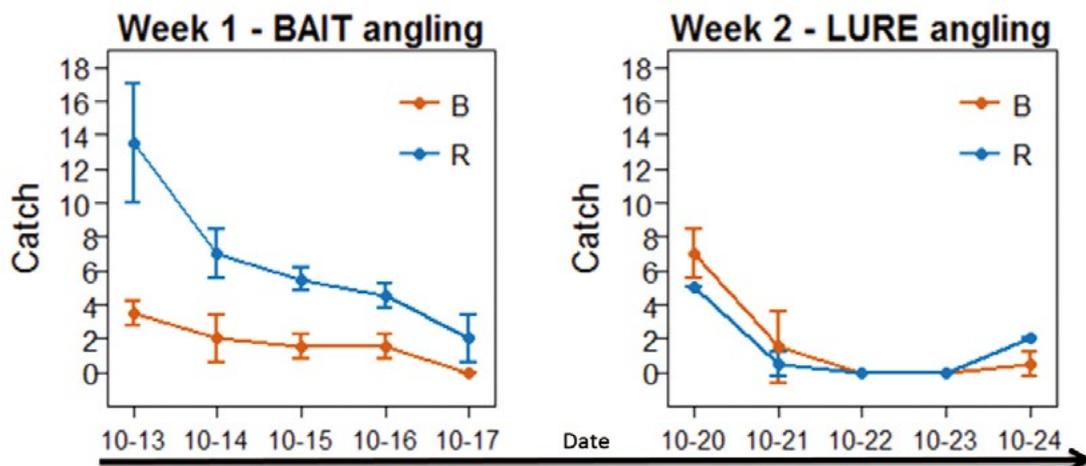


Fig. 3: Non-native rainbow trout (R) are caught more frequently than native brown trout (B) when bait angling, whereas no species difference is found in catchability on a lure.

PUBLIC PERCEPTION OF BIODIVERSITY AND CONSERVATION

A survey of French, German, Swedish and Norwegian citizens' views on non-native salmonids showed that the **majority of the public did not feel well informed about fish biodiversity and the potential threats resulting from the introduction of non-native fishes** to domestic rivers (Fig. 4), despite an intuitive concern about the introduction of non-native fishes (Kochalski *et al.*, in preparation). At the same time, citizens of all four countries expressed a positive attitude toward the historic introduction of non-native salmonids as economically important fish species. Conservation -and in some countries restoration- of native salmonids was supported despite uncertainties as to whether these species are truly native to central Europe (e.g. Atlantic salmon).

We also studied respondents' hypothetical willingness to pay an annual fee (WTP) to a river development fund over a 10-year period. The WTP served as a measure of well-being received by the public from the implementation of alternative hypothetical river basin management plans. These plans would affect most rivers within a distance of about 50 km around citizens' homes. Analyses revealed **preferences for salmonid-friendly river conditions** (high native biodiversity, few hydropower dams, good bathing water quality) (Table 1). **Restoration of natural river functioning would thus promise to generate substantial economic benefits to society** (Riepe *et al.*, in preparation).

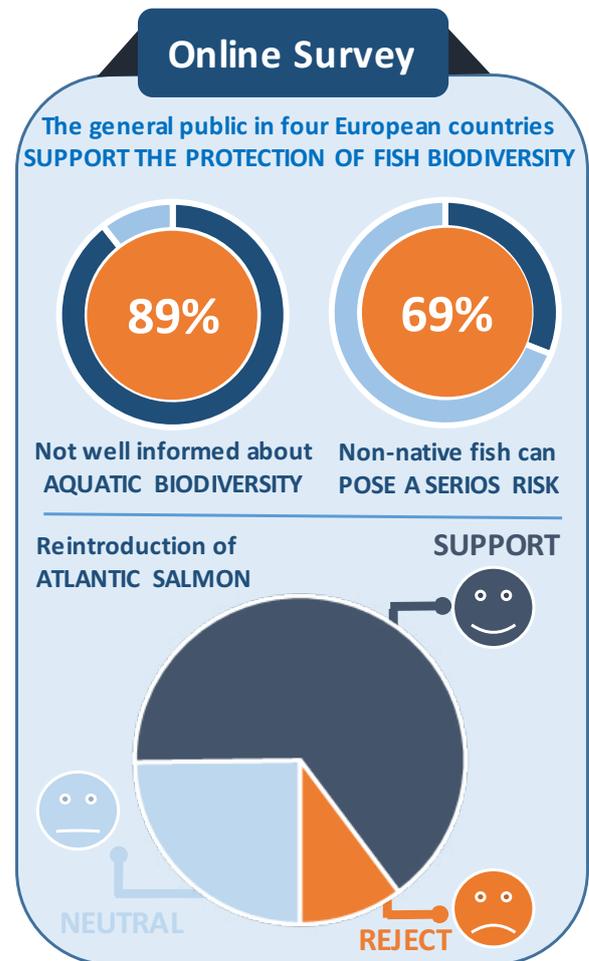


Fig. 4: The general public supports the protection of fish biodiversity, but is not well informed about it.

GOVERNANCE EFFECTS ON TRANSFER OF NON-NATIVE SALMONIDS

Comparing governance systems for fisheries in Canada, France, Germany, Sweden and Norway revealed important differences in overall goals and objectives, sectorial organization and levels of decision-making (Aas *et al.*, in preparation). All countries had a century-long period which emphasized stocking of non-native and native sal-

monids. Current salmonid stocking policies and practices varied significantly among the jurisdictions; the degree of policy change varied from rapid changes in Atlantic Canada and Norway to incremental, so far limited changes in France and Germany.

STOCKING IN ANGLING CLUBS AS VECTORS OF NON-NATIVE FISHES

In France and Germany, angling clubs were found to be major vectors of salmonid introductions to natural watersheds (Riepe *et al.*, 2017). Of the clubs surveyed in both countries, 22 % stocked primarily native salmonids and 27 % primarily non-native salmonids. The perceived

potential negative genetic or ecological effects of fish stocking hardly affected stocking decisions, which were rather 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.

Table 1: Willingness-to-pay (WTP) estimates (€ per year) by country for six alternative hypothetical river basin management plans affecting most rivers within 50 km around citizens' homes.

| 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 | 197.5*a | 155.2*a | 189.0*a | 218.1*a | 77.6*a | 226.4*a |
| Germany | 425.9*ab | 328.8*ab | 488.2*ab | 675.9*b | 75.6ab | 685.6*b |
| Norway | 284.2*ab | 149.7*a | 285.9*ab | 303.7*ab | 67.0*a | 284.3*ab |
| Sweden | 578.7*b | 482.6*b | 574.6*b | 657.8*b | 245.4*b | 699.6*b |

Note. WTP values in a column with the same subscript do not differ ($p \geq .05$). * $p < .05$.

POLICY RECOMMENDATIONS

IMPROVE MONITORING, REPORTING AND EVALUATION OF SALMONID STOCKING AND TRANSFER

- European countries are recommended to conduct systematic evaluation and reporting of existing salmonid stocking practices (species, quantity, life-stages, origin and location) in light of national and international objectives and obligations
- To facilitate monitoring, released salmonids need to be identifiable as such, which might involve fish marking

or genetic monitoring. Exceptions might involve the release of non-native salmonids in completely enclosed small water bodies where native salmonids are absent (e.g. put-and-take fisheries) where recaptures might be sufficient for monitoring

IMPLEMENT STRICT GUIDELINES FOR STOCKING OF NON-NATIVE SALMONID SPECIES AND POPULATIONS TO MEET BIODIVERSITY GOALS

- Invest in habitat protection and habitat restoration to boost natural stocks and buffer invasion risks
- Engage in stocking with native salmonids only after documenting strong declines and risks of losing the population, and when doing so, use local strains to reduce genetic risks

- Engage in stocking of non-native salmonids only in agreement with national law, after running a risk assessment protocol and in ecosystems where the risk of spread is null
- Manage problems with escapes, for example by engaging with recreational and other fisheries to quickly organize removals

EMPOWER AND SUPPORT LOCAL AND REGIONAL DECISION-MAKERS AND AUTHORITIES TO ENFORCE REGULATIONS AND TO EVALUATE PRACTICES FOR SALMONID STOCKING

- In jurisdictions where management of fish stocking and transfer is de-centralized, networks of local actors, scientists and regional authorities should be strengthened to assess and adjust current stocking practices
- Influence stocking decisions by local actors by transferring new scientific knowledge to angler communities

and by providing support to local decision-makers. Improved collaboration of science and local practice through adaptive management is strongly encouraged

CONSIDER THE VARIATION IN PUBLIC PERCEPTION OF NATIVE SALMONIDS WITHIN EUROPE WHEN DEVISING STRATEGIES FOR THEIR CONSERVATION

- In countries with a high awareness of native salmonids, like for Atlantic Salmon in Norway and Sweden, conservation messages could focus on the benefits for these native salmonids to improve public buy-in and link with restoration of the general ecological status of rivers. An increased public outreach and knowledge transfer is however needed for currently positively valued non-native salmonid species.

- In countries where there is less awareness of native salmonids, like Germany and France, public messaging should focus on improving the general ecological status of rivers, such as free-flowing conditions or high water quality, which benefits native salmonids. In addition, increased outreach would improve the knowledge base and awareness of the general public about native salmonids.

IMPROVE SCIENCE – POLICY – PUBLIC COOPERATION AND DIALOGUE TO FACILITATE BIODIVERSITY CONSERVATION

- To achieve more sustainable use of aquatic biodiversity, including salmonids, governments and the EU are encouraged to support programs strengthening science – policy – public cooperation and dialogue at national and European levels.

- Future management of non-native salmonids calls for a cross-sectorial integration to address conflicting interests and avoid a parochial approach to management.

SalmoInvade



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The present briefing is a result of this project and was produced by the SalmoInvade researchers. It does not necessarily reflect the views of BiodivERsA partners.