

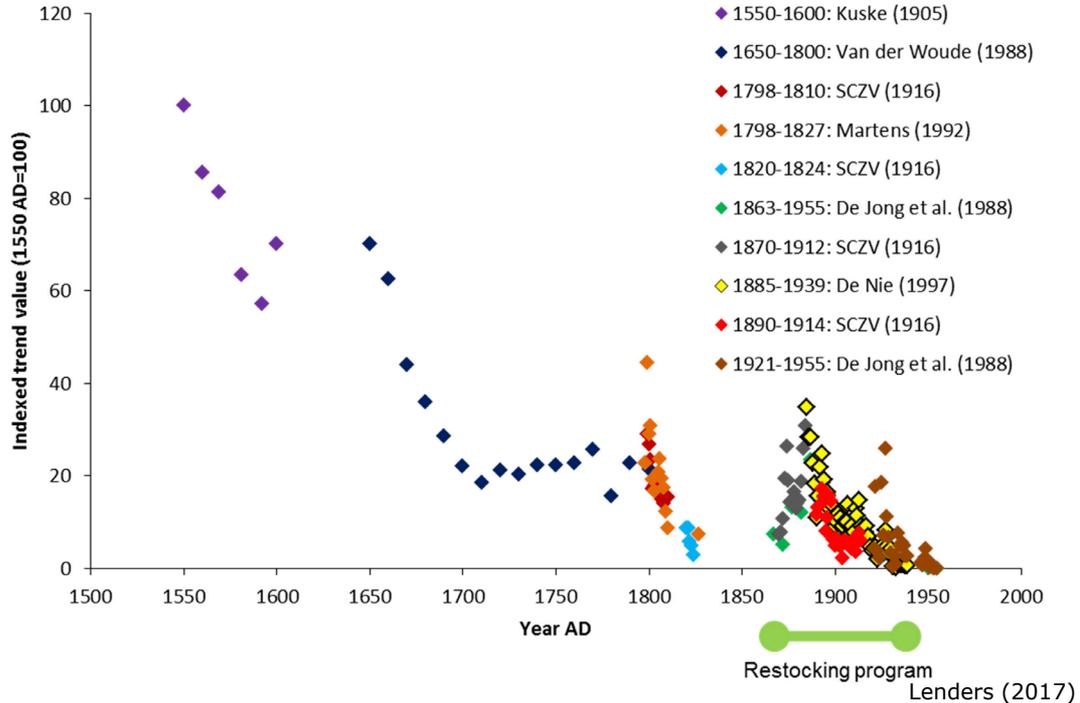
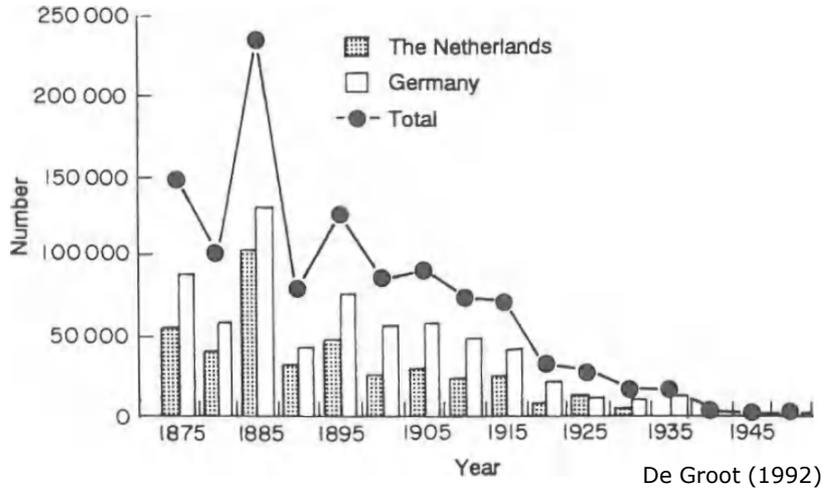
Why does the Atlantic salmon (*Salmo salar*) population from the River Rhine not recover?

Salmon conference Landau

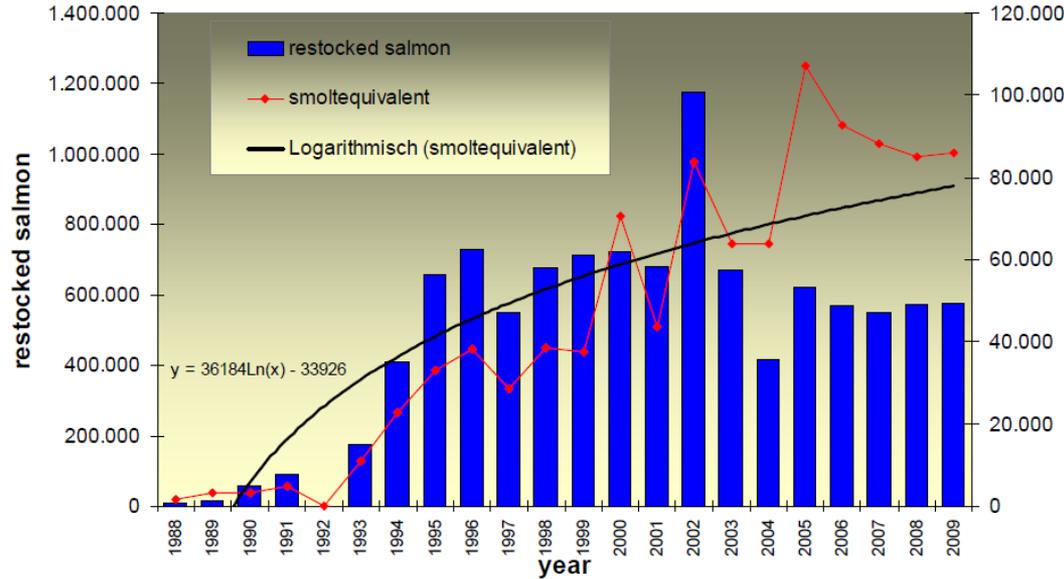
12-05-2023 **Jacco van Rijssel (Wageningen Marine Research, NL)**



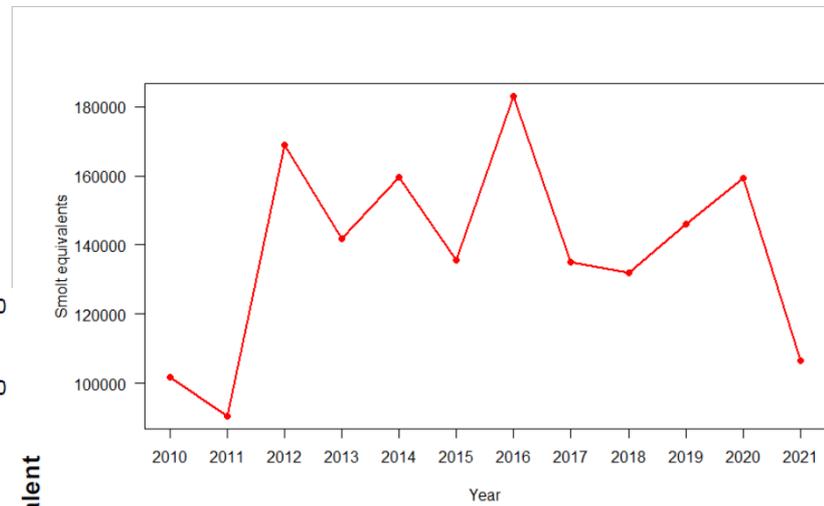
Rhine salmon extinct in the 1950s



Reintroduction



Data: LANUV (NRW, Germany), assembled by Armin Nemitz (Rhineland Fishery-Association)

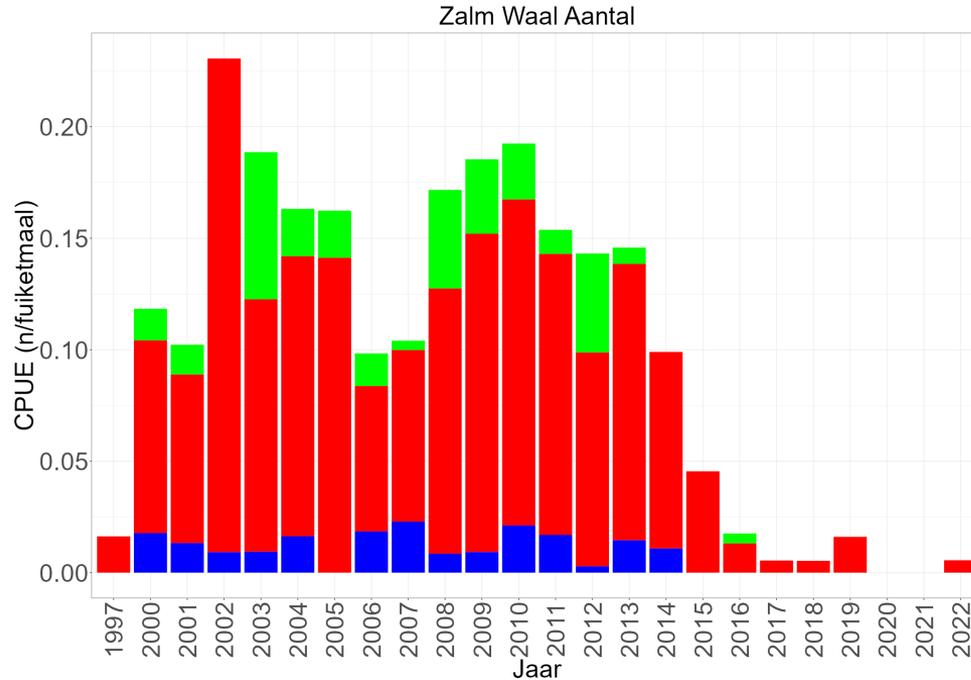


Data: ICPR, smolt equivalents calculated based on ICPR (2009)



Photo: Armin Nemitz

Salmon trend (river Waal)



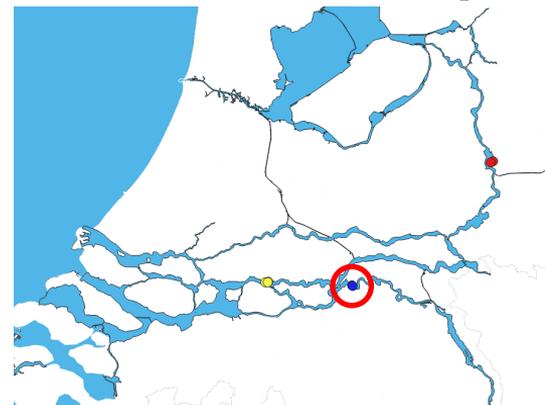
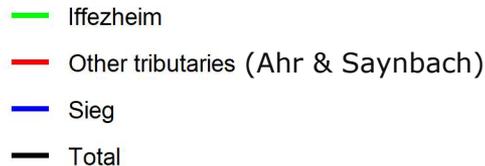
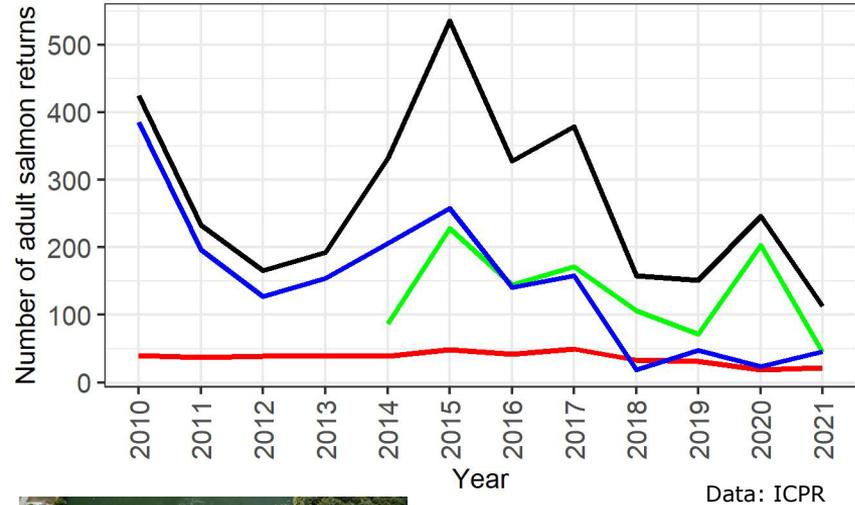
Lengteverdeling (cm)

- 80-120 (terugkerende adult)
- 50-80 (terugkerende adult)
- 25-50 (sub-adult)

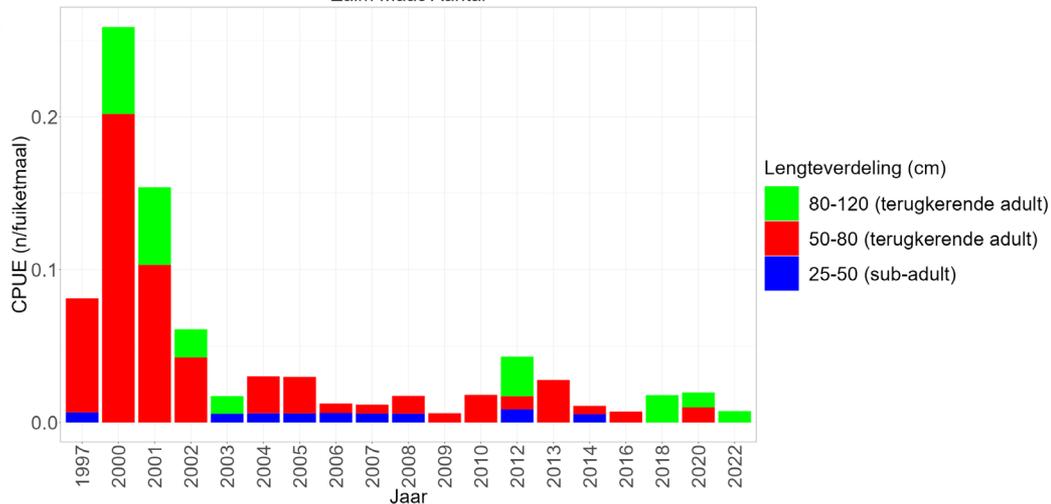
Data: WMR



Salmon trend (German tributaries and Meuse)



Zalm Maas Aantal



Methods (fish tracking)



- Adults: 926 sea trout, 195 salmon (2001-2016)

@Haringvliet sluices

- Smolts: 1305 salmon (2006-2016)

@Sieg, Dhünn, and Wupper



Results

Smolts



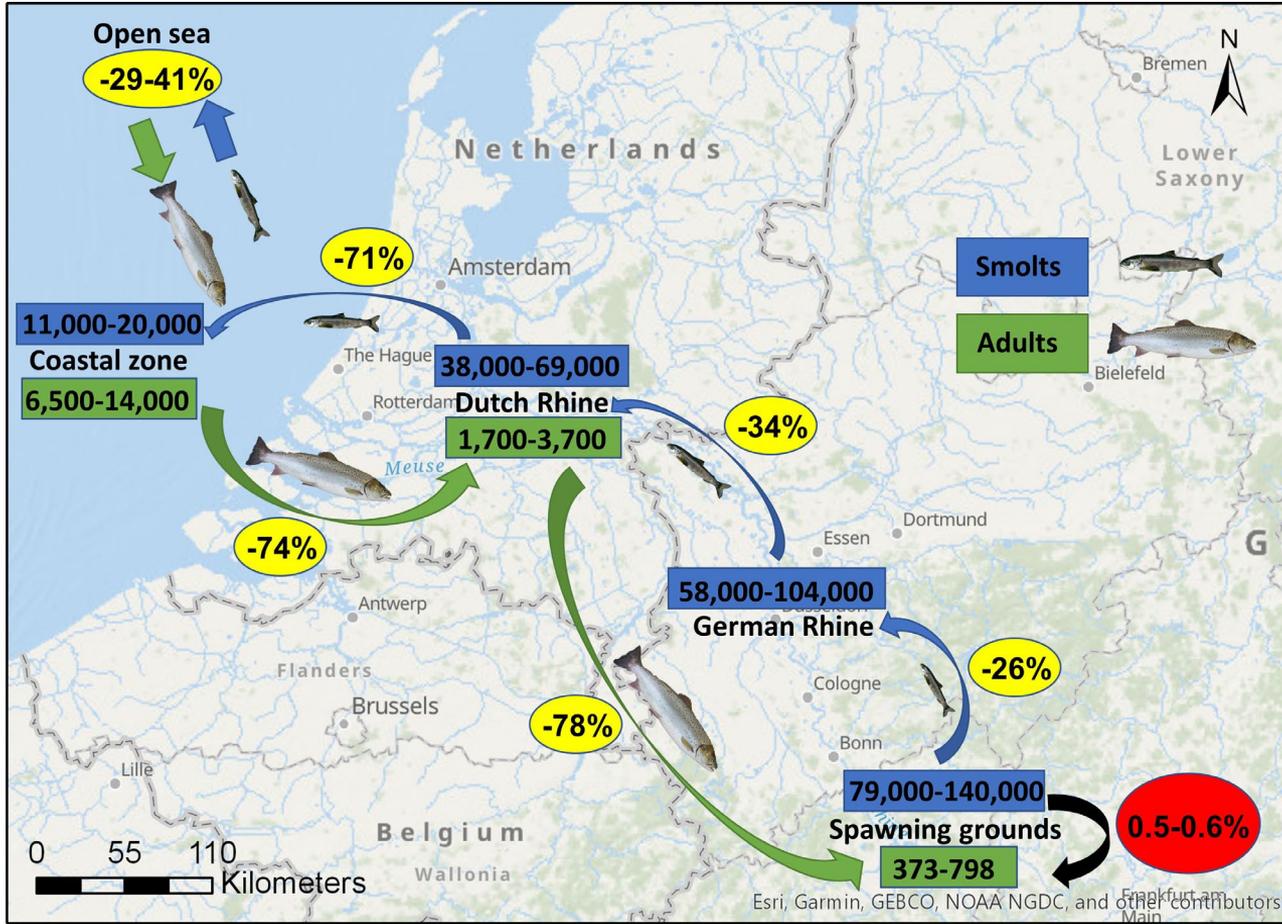
- Average number of reintroduced smolts ~138.000 (2010-2021)
- Average natural production ~2000 smolts (2010-2021) Data: Jörg Schneider
- Average total 140.000 smolts

Adults



- Average number of returning adults 279
- 35%-75% is estimated to be observed Armin Nemitz (personal communication)
- 373-798 returning adults per year

Results



56% of tagged smolts reach mouth of river Wupper, equals minimum estimate

Discussion

- Return rate of 0.5-0.6%, while $\sim 3\%$ is assumed to be needed for self-sustaining population Schneider (2009)
- Losses are very high in freshwater (26%-78%), marine “only” (29-41%)
- However, large (29 cm), 2+, hatchery reared smolts used
- Adult data mainly based on sea trout, which forage along the coast and can and do enter at other freshwater entry points, disappearance percentage before salmon reach Dutch lower Rhine (74%) overestimation?

Discussion – probable causes? – Weirs/turbines

- Dutch part of Rhine, 3 weirs (1 active hydropower station) in Nederrijn/Lek
- However, most salmon migrate through river Waal
- Still many weirs/hydropower stations in tributaries Germany, how many?
- Several studies in Germany show smolt mortality of 5-25% per hydropower station Havn et al. (2018, 2020); Thorstad et al. (2017)

Discussion – probable causes? – Reduced discharge and ship navigation

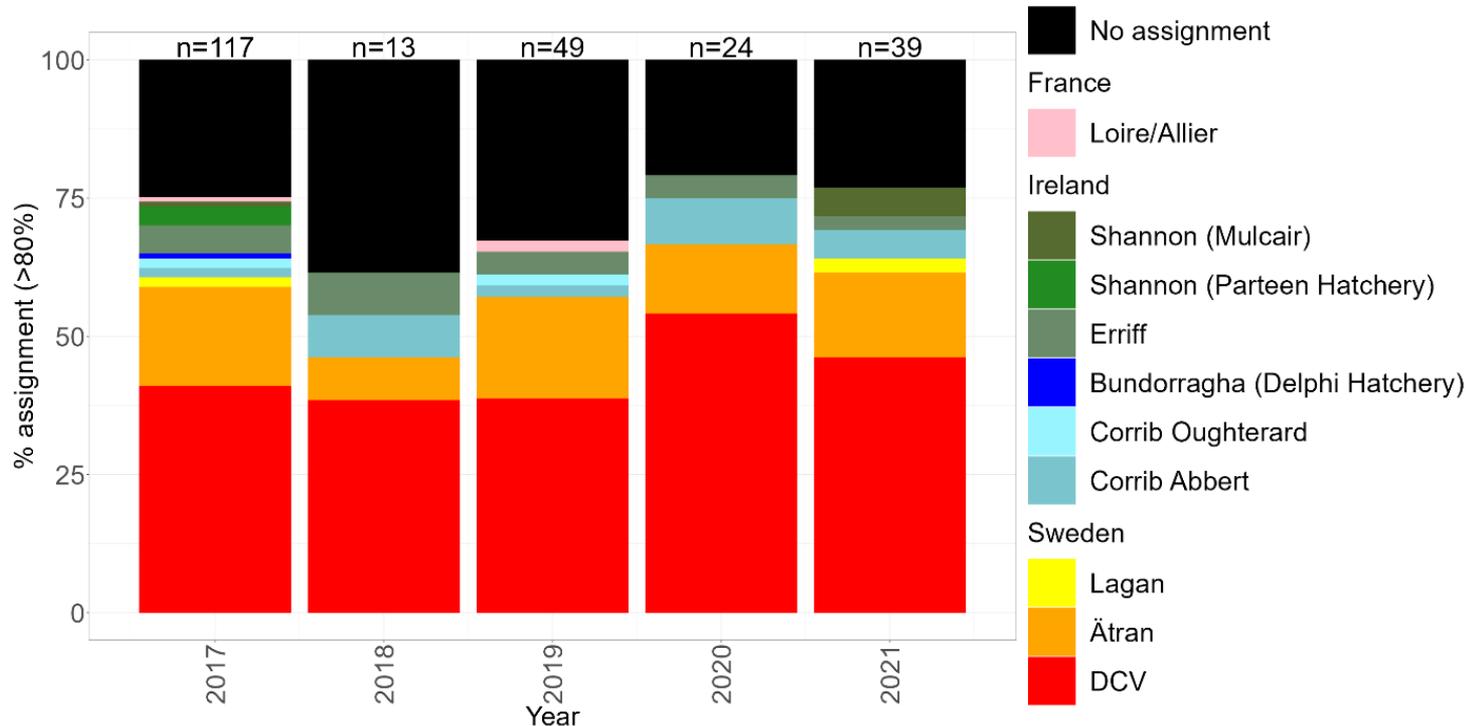
- ~1900 ships on the Dutch and German part of the Rhine, daily
- Droughts and reduced discharge, navigation depth = 2.5 m
- Average ship draft = 2.2 m
- Suction force is 1-4 m
- You do the math...
- Number of returners is indeed higher 1-2 years after high discharge

Schneider (2009), Schneider & Seufert (2021), van de Ven et al. (2021)

Discussion – probable causes? – Predation

- Cormorants → 10-20% of smolts were predated in rivers Sieg, Wupper and Dhünn ICPR (2018)
- Seals → So far no quantitative evidence for Rhine salmon. In Scotland diet of harbour seal consisted for 0-64% of salmon but varied strongly on a fine spatial and temporal scale Sharples et al. (2009)
- Wels catfish → Only anecdotal evidence so far, probably a high predation rate close to weirs, e.g. in France 35% of salmon were predated by catfish in a fishway Boulêtreau et al. (2018)
- Other predators → 70% of tagged smolts predated in Denmark near hydropower station (pikeperch, pike, grey heron) Koed et al. (2002)

Discussion – probable causes? – Genetic (un)suitability



Anne Schrimpf, unpublished data

Discussion – probable causes? – Fisheries

- Fisheries at
- No salmon in
- Previous dec
- Haringvliet s
- Bycatch at N
- Probably low
- Fisheries ba
- 2nd quarter 20



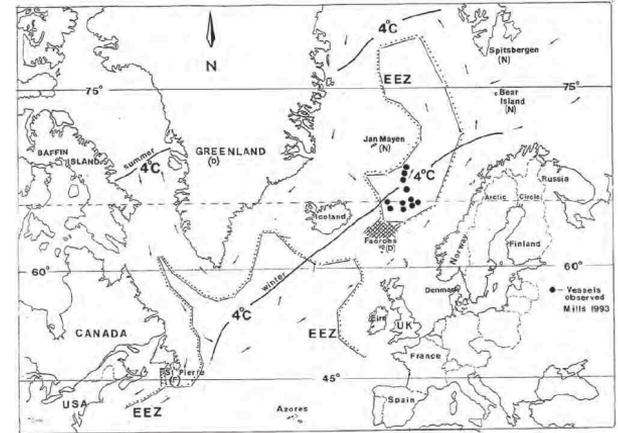
021

the data)

- Soort
- Atlantische zalm
- Bultrugzalm
- Zeeforel
- Regenboogforel
- Noordzeehouting
- Fint
- Zeeprik
- Rivierprik
- Siberische steur

Other threats

- Reduced body condition
- Food availability (in the ocean)
- Warmer ocean and river temperatures
- Illegal, unreported & unregulated (IUU) fisheries
- Insufficient spawning/nursery habitat quality
- Pink salmon?



Dadswell et al. (2021)



Conclusions



...tive effects?

...nvironment →

...ers! Einum & Nislow (2010),

... discharge

...o-called human

...ter
...arine zone

Outlook / Food for thought

- Join forces, share data
 - e.g. overview of weirs/hydropower stations in tributaries
 - many data/reports/research done by local governments in native language, not accessible
- Rethink stocking methods?

PNAS

RESEARCH ARTICLE

ECOLOGY

 OPEN ACCESS

Intentional release of native species undermines ecological stability

Akira Terui^{a,1} , Hirokazu Urabe^b , Masayuki Senzaki^c , and Bungo Nishizawa^d

Thank you!

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Anne Schrimpf (RPTU Kaiserslautern-Landau)

