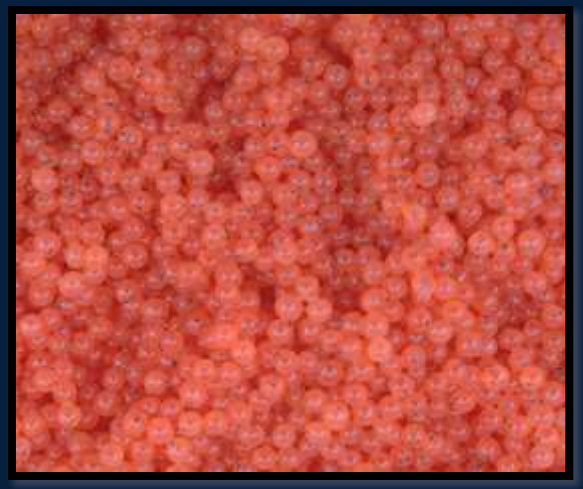
BFS

Bürogemeinschaft
Für Fisch- & Gewässerökologische Studien
Frankfurt - Rastatt - Lörrach

Fische - Makrozoobenthos - Makrophyten - Gewässerökologie - FFH - EG-WRRL
Beratung – Konzeption – Planung

Selection of donour stocks to start with

Salmon 2020 - Reintroduction of Atlantic Salmon in the river Rhine system



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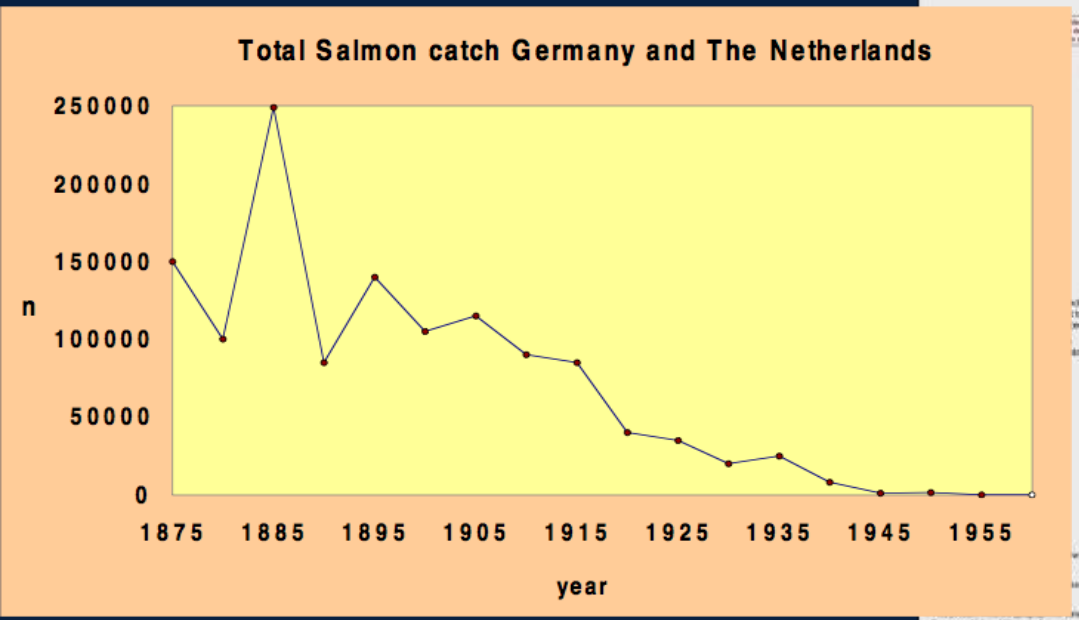
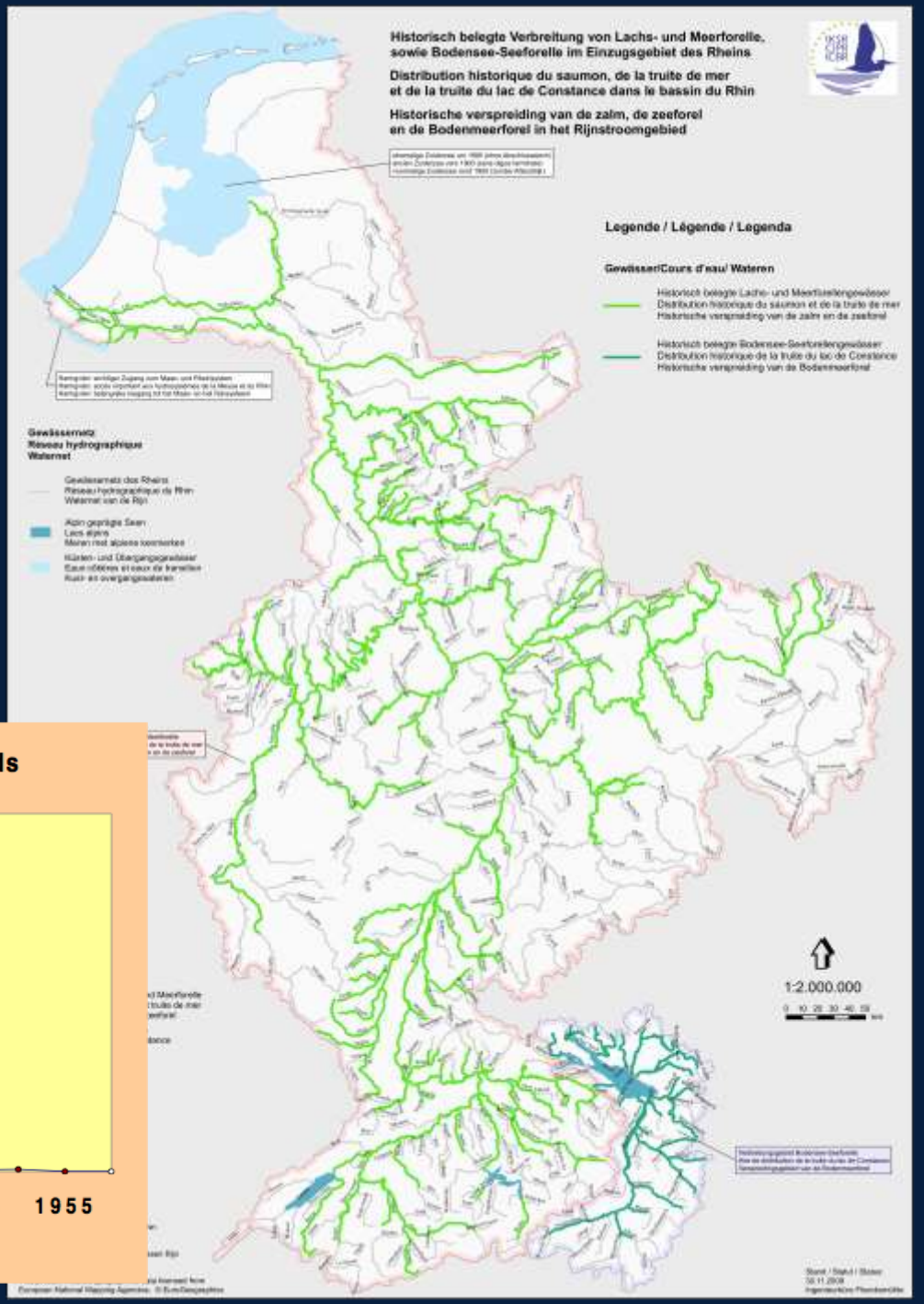
Contents

- Historical distribution
- Stocking - which source ?
- Reproduction
- Trends and conclusion

Historical distribution of salmon in the Rhine system





Juvenile habitat suitable for stocking various juvenile life-stages

Salmon stocking

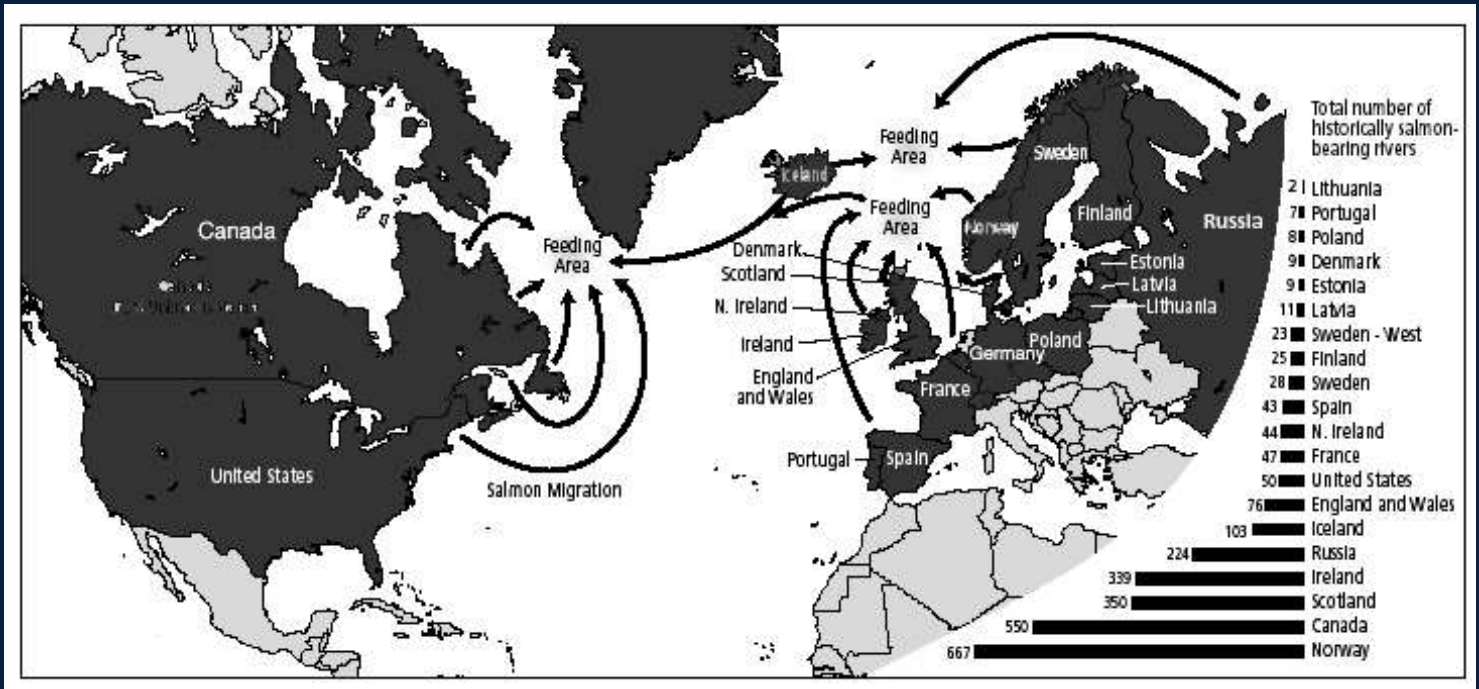
During the past 15 years, more than 16 million juvenile salmon have been released into the Rhine catchment.

Sources: Ireland, France, Sweden, Denmark, Scotland, Spain, Norway

Partly, stocked salmon are the descendants of adult returners

Artificial rearing already supplements the import of eggs and juveniles

Salmon stocking – what source ?



Map by WWF

- **Distribution in North America** from Labrador to New England and Maine
- **Distribution in Europe f**rom Arctic Russia to Portugal (incl. Baltic region)

=> Significant differences in biotic and abiotic factors affecting freshwater life

All tested strains demonstrated similar life-history patterns in the freshwater phase - comparable to the ancient Rhine salmon

Absolute growth of salmon (standard length)
- age 0+ (autumn): 6.2 - 11.0 cm
- age 1+ (spring): 6.8 - 11.0 cm
- age 2+ (spring) 12.1 - 18.0 cm (SCHNEIDER, 1998)

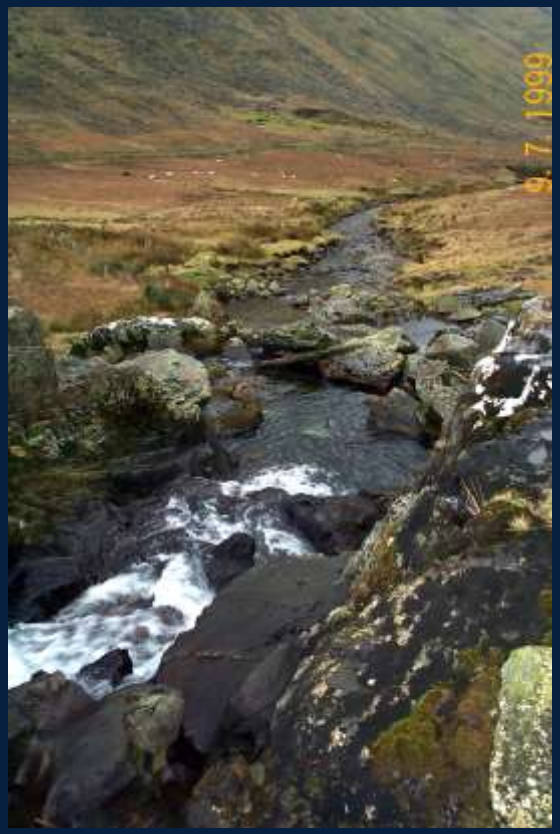
The Upper Modal Group incorporates between 15 - 72% of the age class 1 (SCHNEIDER, 1998)

Smolts are commonly 1 and 2 years old (rarely 3 years)

Emigration of smolts starts in March and ends in May (tributaries)

Proportion of precocious parrs in age classes
age 0+: 0-13%; 1+: 8-60%, 2+ (resident): > 95%
(SCHNEIDER, 1998)

Generation time is relatively short - the age of returners commonly varies between 2+ and 5+
(but the proportion of MSW is stock specific)



Adaptation and stock differentiation

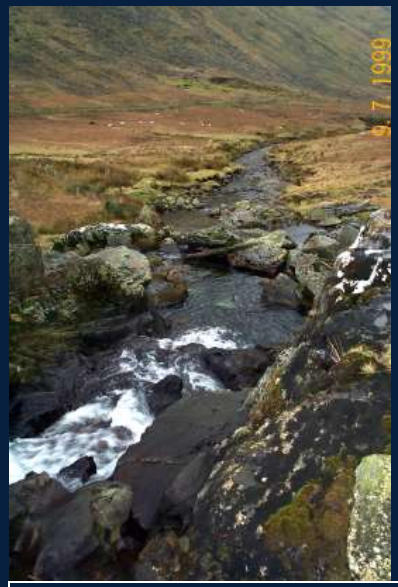
yesterdays environment dictates tomorrows adaptations
(G. de Leaniz)

- Genetic differentiation is based on homing to natal rivers (isolation of populations)

- Natal rivers vary in size, gradient, temperature regime, water chemistry, flow, and many other environmental factors

Spawning time is stock specific and under genetic control…

Spawning time and the selection of a donor-strain



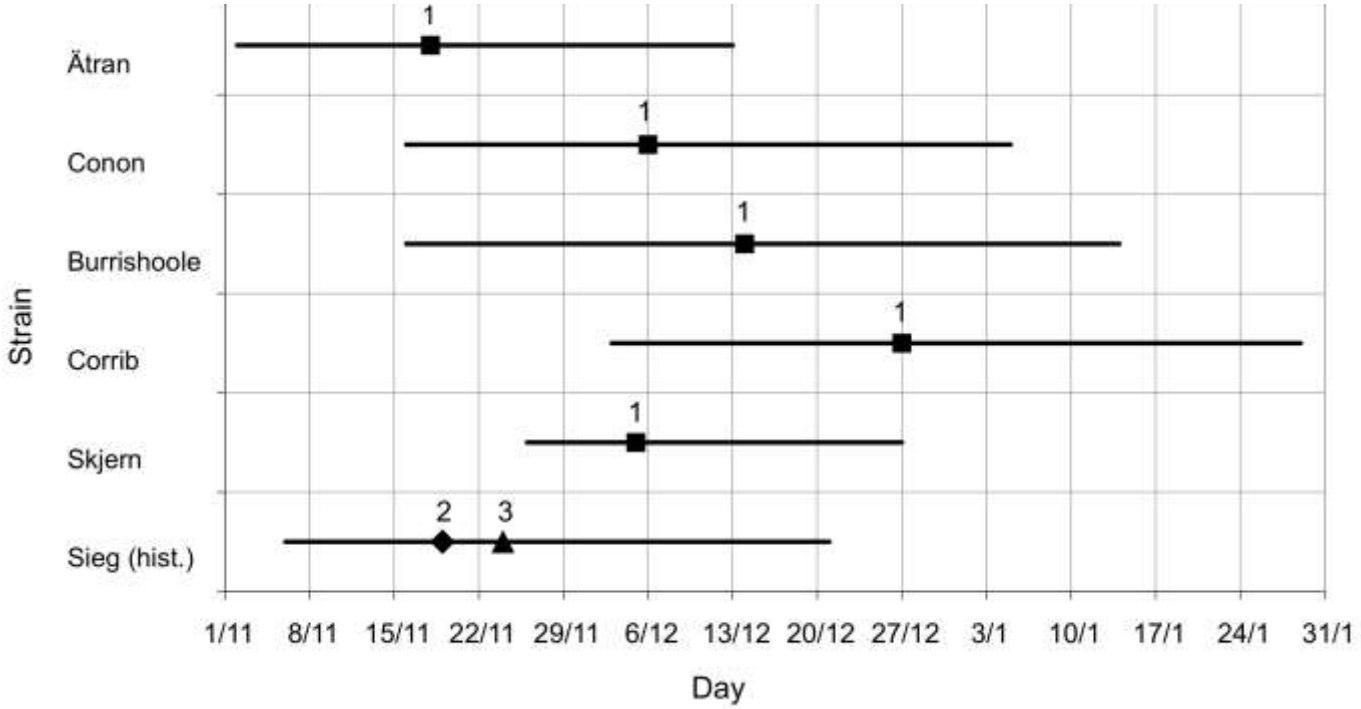
Salmon spawn at different times in different environments

- Spawning time has a high heritability in salmonid fishes
- The timing correlates with water temperature during incubation - spawning time between „cold river“ and „warm river“ populations differs by 5-6 months (Pechora river; Russia: September, Iberian populations: January-February
- In large river systems spawning in upper (colder) reaches may occur earlier than in lower reaches
- The timing of reproduction ensures optimal timing of hatching and initial feeding for the offspring

  Bad timing leads to mass mortality in the first weeks after emergence (starvation, predation, drift…)

Transplanted strains keep their inherited spawning time in the new environment for many generations - spawning time is stock specific. The timing of reproduction ensures optimal timing of hatching and initial feeding for the offspring (Heggberget 1988) and is of selective importance

Spawning time of non-native stocks in river Gudenau (Denmark) (G. Holdensgaard, DCV, unpublished data) and spawning time of the extirpated Sieg salmon (hist. records)



A common garden experiment - spawning period (lines) and peak-spawning (boxes) of five introduced (= allochthonous) stocks returning to river Gudenau (Denmark) (n= 443) => the Ätran strain demonstrates the closest consistency with the ancient Sieg strain (Middle Rhine).

In 2003/2004 the strategy of introducing mixed stocks in single tributaries was abandoned in favour of using the Ätran strain (Middle Rhine) and Allier (Upper Rhine) only.

Selective importance of timing

Atlantic salmon fry and co-existing trout and charr fry have overlapping habitat requirements and compete for territories and food after emergence from the gravel. Early emerging fry is having an advantage in establishing territories and high growth performance

top: brown trout (*Salmo trutta*)

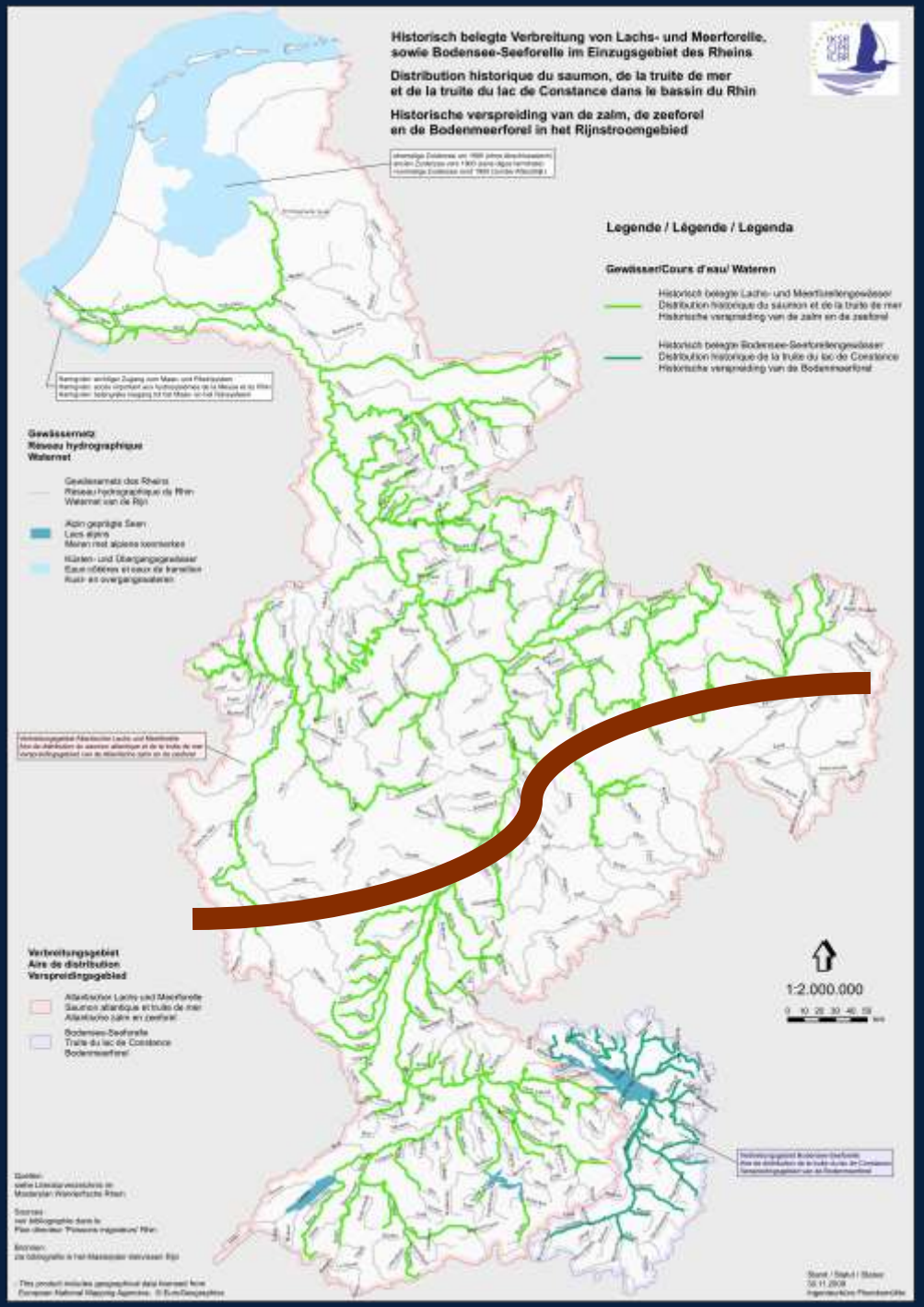
below: Atlantic salmon (*Salmo salar*)

- A female‘s spawning time will dictate the thermal regime her embryos experience during development and to a large extent, their hatching and emergence time from gravel as fry (Fleming & Petersson 2001)
- The timing of reproduction ensures optimal timing of hatching and initial feeding for the offspring (Heggberget 1988)
- Optimal timing of hatching depends on flow conditions, temperature (limit ≥ 7˚C), prey abundance, predator abundance, inter- and intra-specific competition (prior residence effect)
- “Bad” timing leads to mass mortality in the first weeks after emergence (starvation, predation, displacement…)
- Early juvenile life is thus a period of intense selection - which explains the high heritability of population-specific spawning periods.

Donour stocks used in the Rhine system

Ätran (Sweden)

Allier (France)



Collection of data via electro-fishing

Survival rates of stocked fish, natural reproduction, smolt-ratios, and returning salmon are assessed in most river systems using the method of electro-fishing.

Results:

Survival rates, growth and juvenile densities are good, sometimes excellent.

Natural reproduction has been successful in various river-systems (e.g. Dhünn, Sieg, Saynbach, Nette, Ahr (Germany), Bruche, Ill (France) since 9-13 years (!)

Natural reproduction

Natural reproduction has been recorded in almost all *accessible* tributaries:

- Sieg-system
- Wupper, Dhünn
- Ahr, Nette, Saynbach
- Wisper
- Wieslauter
- Upper Rhine
- Ill, Bruche

In rivers Sieg (system) and Saynbach densities where particular high in some years.

Reproduction is recorded over more than 12 years

In the rivers Sieg and Saynbach 10 - 30% of the returners are allready 2nd generation (= „wild“)

Reproduction in the Rhine system

Land	System	Projektgewässer - Auswahl wichtigster Zuflüsse (* kein Besatz)	Erstbesatz Lachs	Jahr der Brutnachweise (Reproduktion im vorangegangenen Herbst/Winter) 1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
D	Wupper-Dhünn	Wupper	1993	/	/	/	/	/	/	/	/	0	/	/	/	/	/	(X)	/	/	/
		Dhünn		/	/	/	/	/	/	/	/	0	/	/	X	X	/	/	/	/	/
		Eifgenbach		/	/	/	/	/	/	/	/	/	/	/	/	0	/	/	/	/	/
D	Sieg	Rheinische Sieg NRW	Laichbesatz im Rheinischen Siegsystem seit 1988, seit 1998 zusätzlich zu den klassischen Aachen- und oberen Barbenregionen auch in ausgesuchten Klemeren und mittelgroßen Bächen	X	/	/	/	/	/	/	X	0	XX	/	/	/	/	/	/	/
		Agger (unters 30 km)		X	/	/	/	/	/	/	0	0	XXX	XXX	XXX	XX	XXXX	XXXX	XXXX	/	/
		Naafbach		/	/	/	/	/	/	/	XX	0	/	XXX	XXX	XXX	XXXX	XXXX	XXXX	/	/
		Pleisbach		/	/	/	/	/	/	/	0	/	/	0	/	/	X	/	X	/	/
		Hanfbach		/	/	/	/	/	/	/	/	0	/	0	X	/	/	/	/	/	/
		Bröl		X	/	/	X	/	/	/	0	0	XX	XX	0	XX	XXX	/	XXX	/	/
		Homburger Bröl		/	/	/	/	/	/	/	0	0	/	XX	XXX	XX	X	/	/	/	/
		Waldbröl		/	/	/	/	/	/	/	0	0	/	0	0	XXX	XXX	/	0	/	/
		Derenbach		/	/	/	/	/	/	/	/	/	/	/	/	0	/	/	/	/	/
		Steinchesbach		/	/	/	/	/	/	/	/	/	/	/	/	0	/	/	/	/	/
		Krabach		/	/	/	/	/	/	/	/	/	/	/	X	/	/	/	/	/	/
		Gierzhagener Bach		/	/	/	/	/	/	/	/	0	/	/	/	/	X	/	/	/	/
		Inserbach		/	/	/	/	/	/	/	/	0	/	/	/	/	/	/	/	/	/
		Sülz		/	/	/	/	/	/	/	0	0	/	/	/	XX	/	/	/	/	/
		Schlingenbach		/	/	/	/	/	/	/	/	0	/	/	/	/	X	XXXX	XXX	/	/
		mittlere Sieg RLP	1994	/	/	/	/	/	/	/	X	0	0	0	X	X	X	XXXX	X	0	?
		Nistersystem	1991	/	/	/	/	/	XX	0	X	X	X	X	X	XXX	XX	XXXX	X	X	X
		Wisserbach	1991	/	/	/	/	/	/	XXX	XX	XX	0	X	XX	XXX	XX	XXXX	0	X	0
		Elbbach	1995	/	/	/	/	/	/	/	/	0	X	0	/	/	XX	XX	0	0	0
		Heller-Daade	1998	/	/	/	/	/	/	/	/	0	0	/	/	/	X	X	x	0	0
		Asdorf	1997	/	/	/	/	/	/	/	/	0	0	/	/	/	/	/	/	0	/
D	Ahr	Ahr	1995	/	/	/	/	/	/	X	0	0	X	X	0	0	0	?	0	XX	XX
D	Nette	Nette *	-	/	/	/	/	/	/	/	X	0	XX	X	X	X	0	X	0	X	0
D	Saynbach	Saynbach	1994	/	/	/	/	/	/	XX	XX	XX	XXX	XXXX	XXXX	XX	XXXX	XXXX	XX	XX	XXX
		Brexbach	1994	/	/	/	/	/	/	XXXX	XX	X	X	0	0	0	0	XXX	XX	XX	0
D	Mosel	Elzbach	2005	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
		Kyll	1996	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
		Prümsystem	1996	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Lux/D		Sauer	1992	/	/	/	/	/	/	/	/	/	0	/	/	/	/	/	/	/	/
		Our	1992	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
D	Lahn	Mühlbach	1994	/	/	/	/	/	/	(X)	0	/	/	/	/	/	/	/	/	/	/
		Weil	1995	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
		Dill	1995	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
D	Nahe	Nahe	2004 (einmalig)	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
D	Wisper	Wisper	1999	/	/	/	/	/	/	/	/	0	XX	XX	0	0	XX	XXXX	0	X	XX
D	Main	Schwarzbach	2009	/	/	/	/	/	/	/	/	/	/	/	/	/	/	0	0	0	0
		Kinzigsystem (Hessen)	2001	/	/	/	/	/	/	/	/	/	/	/	/	0	/	/	/	/	X
D	Alb	Alb	2001	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	X
D/F	(Wies)Lauter	(Wies)Lauter	1991	/	/	/	/	/	/	/	/	/	/	/	/	/	/	?	X	X	X
D	Murg	Murg	2001	/	/	/	/	/	/	/	/	/	/	/	X	X	X	/	/	/	X
F/D	Rhein	Rhein unterh. Iffezheim *	-	/	/	/	/	/	/	/	/	/	/	X	/	/	/	/	/	/	/
D	Rench	Rench	2001	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
F	Ill	Bruche	1991	/	X	X	X	X	X	X	X	X	X	X	X	X	X	X	XXX	XXX	XXX
		Moder	2005	/	/	/	/	/	/	/	/	/	/	/	X	X	X	X	X	X	X
		oberes Illsystem**	1991	/	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
D	Kinzig	Kinzig (Baden-Württemb	2001	/	/	/	/	/	/	/	/	/	/	X	/	/	/	/	/	/	/
D	Elz-Dreisam	Elz	2005	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
		Dreisam	2008	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
F/D	Rhein	Restrhein (Altrhein)	1991	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
CH	Wiese	Wiese	1984	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
CH	Birs	Birs	1995	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
CH	Ergolz	Ergolz	1995	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
				1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011

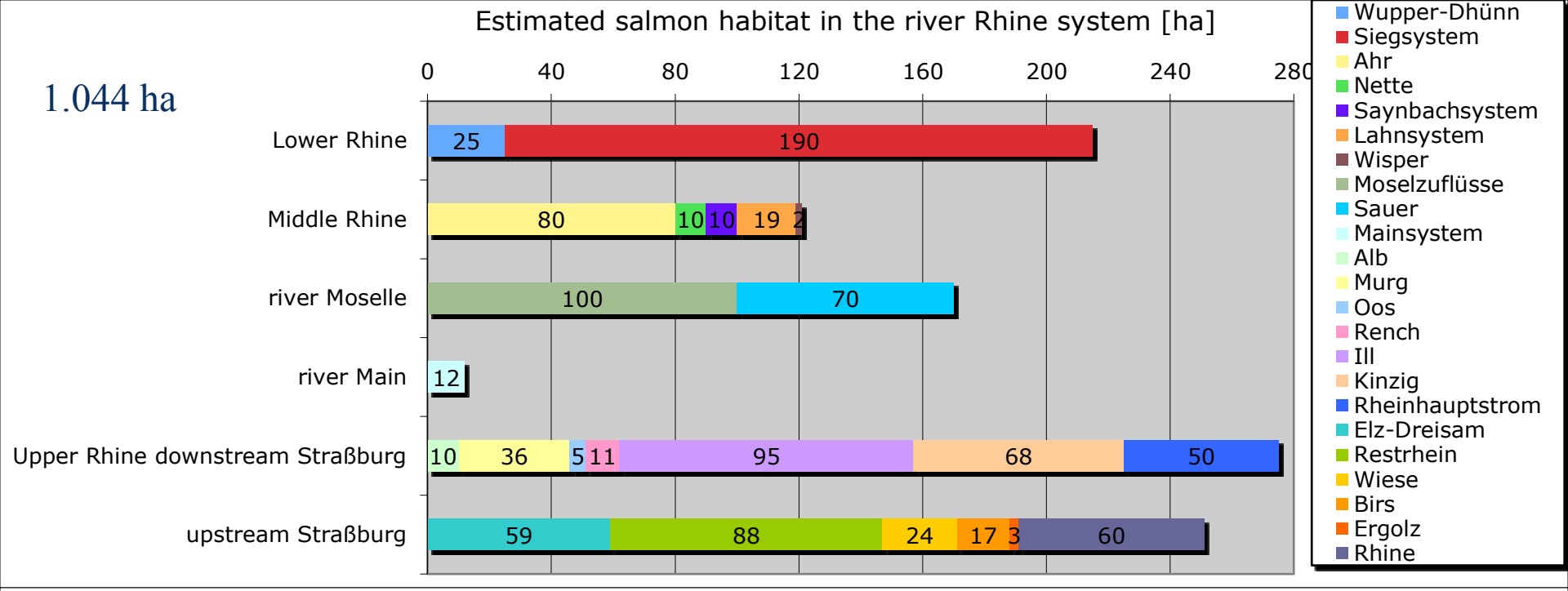
LEGENDE

qualitative Nachweise / Einzelnachweise / Einzellokalitäten beprobt	X
qualitative Nachweise / Rückkehrer oberhalb Wanderhindernis eingesetzt	(X)
geringer Reproduktionserfolg (1 bis ± 5 Parrs/100 m2)	XX
hoher Reproduktionserfolg (> 5 - 50 Parrs/100 m2)	XXX
sehr hoher Reproduktionserfolg (> 50 Parrs/100 m2)	XXXX
Untersuchung durchgeführt, keine Nachweise	0
nicht untersucht	/
Nachweis unsicher	?

Laichgründe (größtenteils) erreichbar	
Laichgründe partiell eingeschränkt erreichbar	
Laichgründe nicht/ausnahmsweise erreichbar	

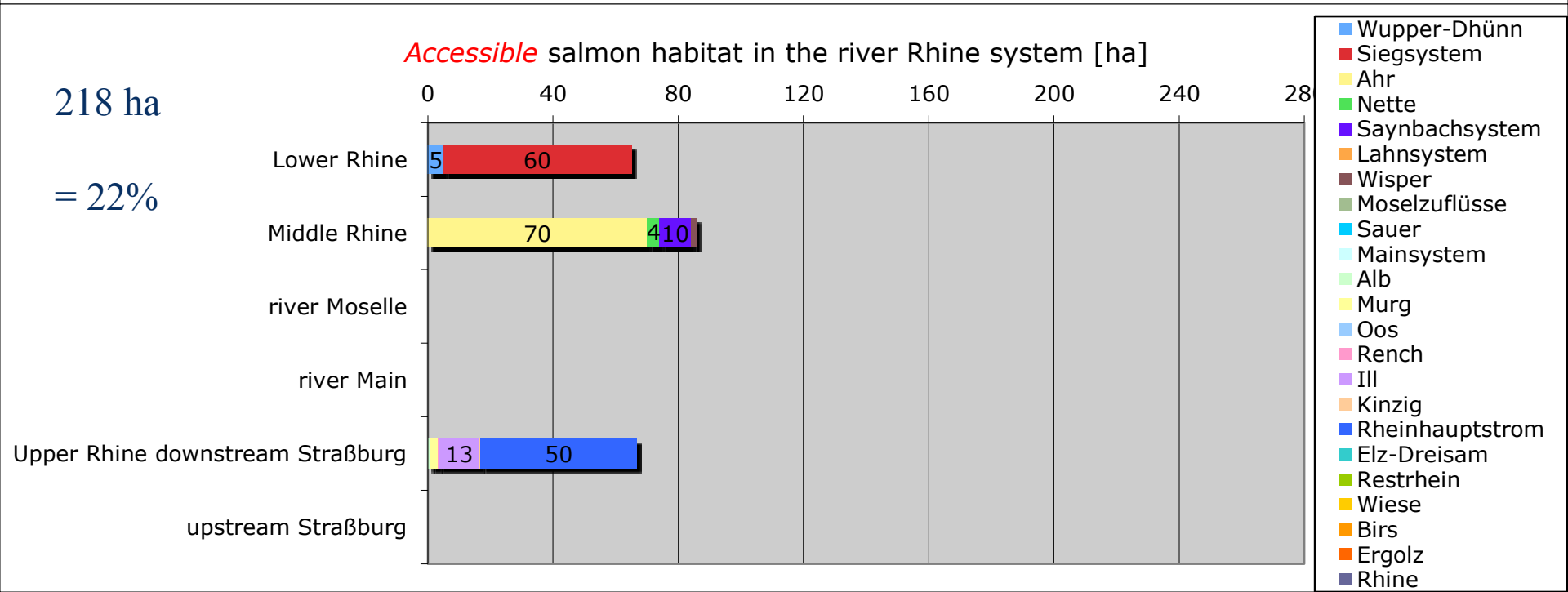
** Illsystem ohne Thur und Lauch

1.044 ha



218 ha

= 22%



Conclusions

Reintroduction is a process of adaptation – nobody knows, how many generations it takes …

The documented natural reproduction (some years showed high densities of wild YOY) is a clear indicator, that the reintroduction can be achieved.

The Swedish strain Ätran is reproducing successfully in many streams - because of spawning time matching with the environmental condtions?.

Allier salmon so far do not have access to high quality spawning grounds. Data of the performance are insufficient.

The return rate to the spawning rivers is still insufficient, but should improve with the adaptation / evolution of new stocks.

Thank you very much for your attention

Merci beaucoup pour votre attention