BFS

Bürogemeinschaft
für Fisch- & Gewässerökologische Studien
Frankfurt – Marburg

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

Restocking – Current and future practices

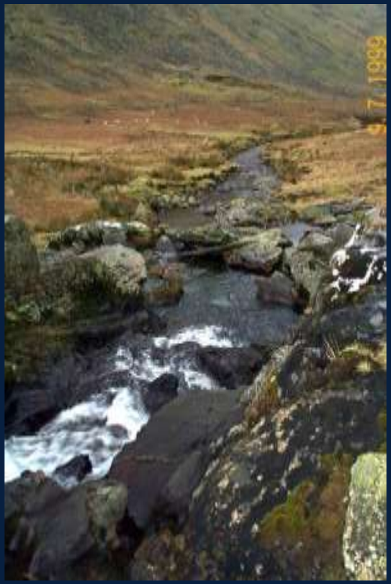
Experience in Germany, success and failure

Presentation by: **Dr. Jörg Schneider, BFS Frankfurt, Germany**

Contents

- The donor strains
- Survival rates, growth and densities as indicators
- Natural reproduction as evidence for success
  - suitability of habitat
  - ability of the source
- Return rate as evidence for success
- Genetics and quality of stocking material as evidence for success
- Known and unknown factors responsible for failure
  - barriers
  - mortality during downstream migration
  - poaching
  - ship propellers
    - mortality at sea
- Trends and conclusion

Criteria for the selection of a donor-strain



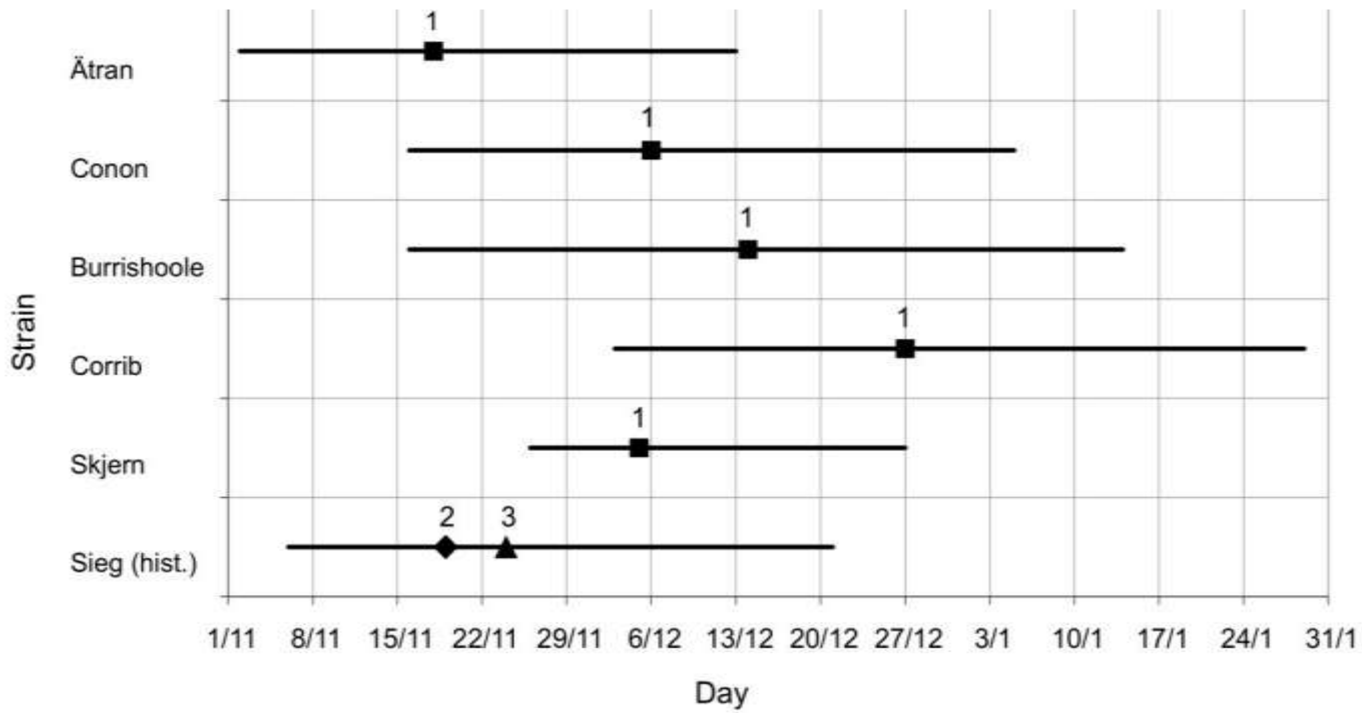
yesterdays environment dictates tomorrows adaptations (G. de LEANIZ)

- Geographic (and genetic) distance to the donor stream
- Spawning time of the donor stock
- Length of donor river
- Timing of return of the donor stock
- Availability of the source
- Health status and restrictions

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

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Spawning time of non-native stocks in river Gudenau (Denmark) (G. Holdensgaard, DCV, unpublished data) and spawning time of the extirpated Sieg salmon (hist.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

Performance of the donor strains is promising

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), since 13-17 years (!), followed by Wieslauter, Murg and Kinzig (5-6 years)

Natural reproduction

Natural reproduction has been recorded in almost all *accessible* tributaries:
- Sieg-system
- Wupper, Dhünn
- Ahr, Nette, Saynbach
- Wisper
- Wieslauter
- Murg, Kinzig

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

Reproduction is recorded over more than 16 years

In the rivers Sieg and Saynbach 10 - 30% of the returners originate from natural reproduction (estimation)

Reproduction in the Rhine system

Land	System	Projektgewässer - Auswahl wichtigster Zuflüsse (* kein Besatz)	Erstbesatz Lachs	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
				Jahr der Brutnachweise (Reproduktion im vorangegangenen Herbst/Winter)																				
D	Wupper-Dhünn	Wupper	1993	/	/	/	/	/	/	/	/	0	/	/	/	/	/	(X)	/	/	/	/	/	
		Dhünn		/	/	/	/	/	/	/	/	0	/	/	X	X	/	/	/	/	/	/	/	
		Eifgenbach		/	/	/	/	/	/	/	/	/	/	/	/	0	/	/	/	/	/	/	/	
D	Sieg	Rheinische Sieg NRW	Lachsbesatz im Rheinischen Siegsystem seit 1988, seit 1998 zusätzlich zu den klassischen Äschen- und oberen Barbenregionen auch in ausgesuchten kleineren und mittelgroßen Bächen	X	/	/	/	/	/	/	X	0	XX	/	/	/	/	/	/	/	/	XX	/	
		Agger (untere 30 km)		X	/	/	/	/	/	/	0	0	XXX	XXX	XXX	XX	XXXX	XXXX	XXXX	/	/	XXX	XXX	
		Naafbach		/	/	/	/	/	/	/	XX	0	/	XXX	XXX	XXX	XXXX	XXXX	XXXX	/	/	XXX	XXX	
		Pleisbach		/	/	/	/	/	/	/	0	/	/	0	/	/	X	/	X	/	/	/	/	
		Hanfbach		/	/	/	/	/	/	/	/	0	/	0	X	/	/	/	/	/	/	/	/	
		Bröl		X	/	/	X	/	/	/	0	0	XX	XX	0	XX	XXX	/	XXX	/	/	/	XX	
		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	/	/	/	/	/	/	
		Irsenbach		/	/	/	/	/	/	/	/	0	/	/	/	/	/	/	/	/	/	/	/	
		Sülz		/	/	/	/	/	/	/	0	0	/	/	/	XX	/	/	/	/	/	XXX	/	
		Schlingenbach		/	/	/	/	/	/	/	/	0	/	/	/	/	X	XXXX	XXX	/	/	XXX	0	
		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	X	X	X
		Wisserbach	1991	/	/	/	/	/	/	XXX	XX	XX	0	X	XX	XXX	XX	XXXX	0	X	0	0	0	0
		Elbbach	1995	/	/	/	/	/	/	/	/	0	X	0	/	/	XX	XX	0	0	0	/	/	/
		Heller-Daade	1998	/	/	/	/	/	/	/	/	0	0	/	/	/	X	X	x	0	0	0	0	0
		Asdorf	1997	/	/	/	/	/	/	/	/	0	0	/	/	/	/	/	/	0	/	/	/	0
D	Ahr	Ahr	1995	/	/	/	/	/	/	X	0	0	X	X	0	0	0	?	0	XX	XX	0	XX	XX
D	Nette	Nette *	-	/	/	/	/	/	/	/	X	0	XX	X	X	X	0	X	0	X	0	X	0	XX
D	Saynbach	Saynbach	1994	/	/	/	/	/	/	XX	XX	XX	XXX	XXXX	XXXX	XX	XXXX	XXXX	XX	XX	XXX	X	X	XX
		Brexbach	1994	/	/	/	/	/	/	XXXX	XX	X	X	0	0	0	0	XXX	XX	XX	0	0	0	0
D	Mosel	Elzbach	2005	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
		Kyll	1996	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
		Prümsystem	1996	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Lux/D		Sauer	1992	/	/	/	/	/	/	/	/	/	0	/	/	/	/	/	/	/	/	/	/	/
		Our	1992	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
D	Lahn	Mühlbach	1994	/	/	/	/	/	/	(X)	0	/	/	/	/	/	/	/	/	/	/	/	/	/
		Weil	1995	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	0
		Dill	1995	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
D	Nahe	Nahe	2004 / 2013	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	0
D	Wisper	Wisper	1999	/	/	/	/	/	/	/	/	0	XX	XX	0	0	XX	XXXX	0	X	XX	0	0	XX
D	Main	Schwarzbach	2009	/	/	/	/	/	/	/	/	/	/	/	/	/	/	0	0	0	0	0	0	0
		Kinzigsystem (Hessen)	2001	/	/	/	/	/	/	/	/	/	/	/	/	0	/	/	/	/	/	/	?	0
D	Alb	Alb	2001	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	X	X	X	
D/F	(Wies)Lauter	(Wies)Lauter	1991	/	/	/	/	/	/	/	/	/	/	/	/	/	/	?	X	X	X	X	X	X
D	Murg	Murg	2001	/	/	/	/	/	/	/	/	/	/	/	X	X	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	XXX	XX	
		Fecht	1991	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	XX	X	XX	0	
		oberes Illsystem**	1991	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	X	X	X	0	
		Moder	2005	/	/	/	/	/	/	/	/	/	/	/	X	X	X	X	X	X	X	X	0	
D	Kinzig	Kinzig (Baden-Württemberg)	2001	/	/	/	/	/	/	/	/	/	/	X	/	/	/	/	/	X	X	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	2012	2013	2014

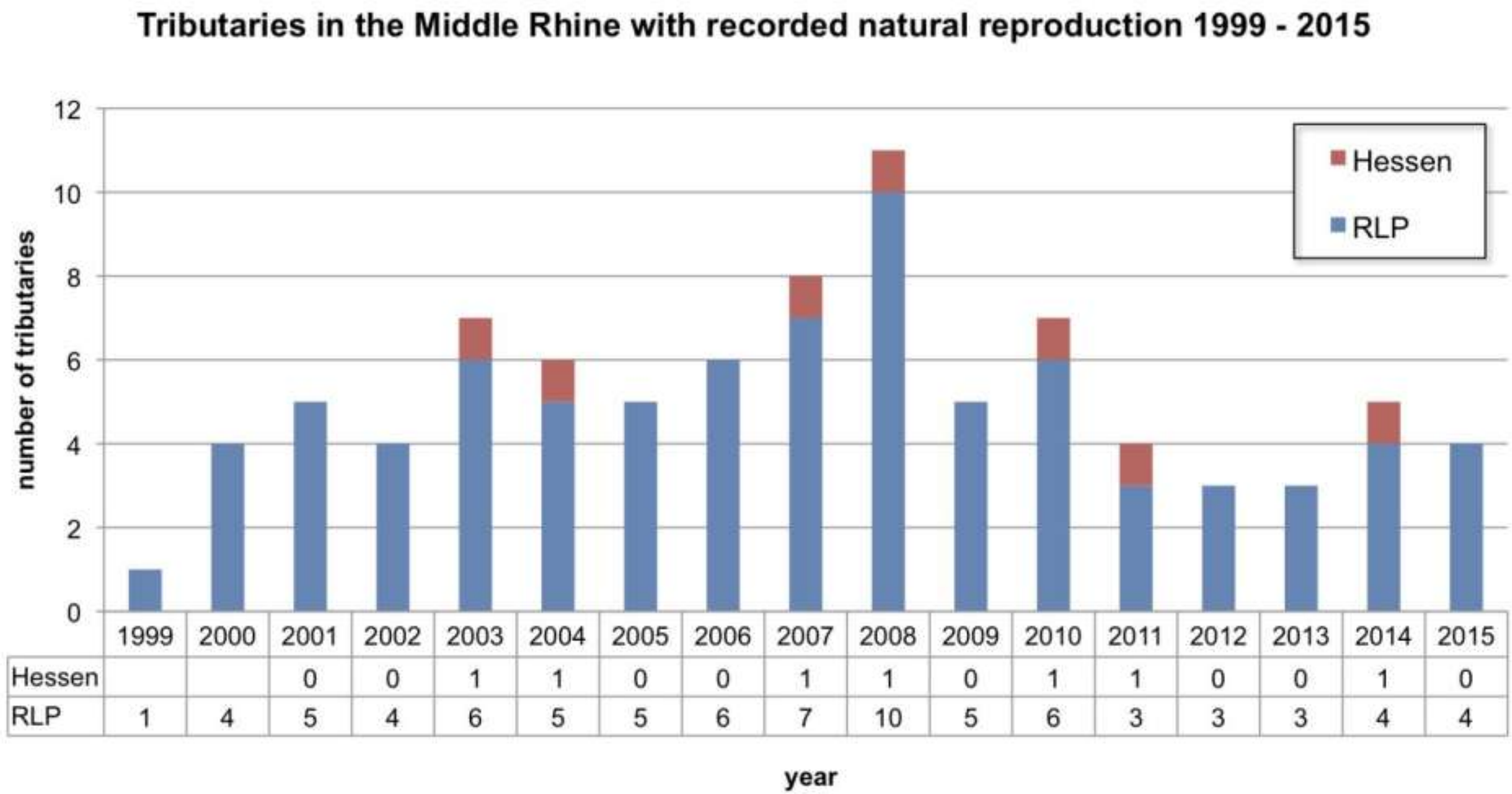
LEGENDE

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

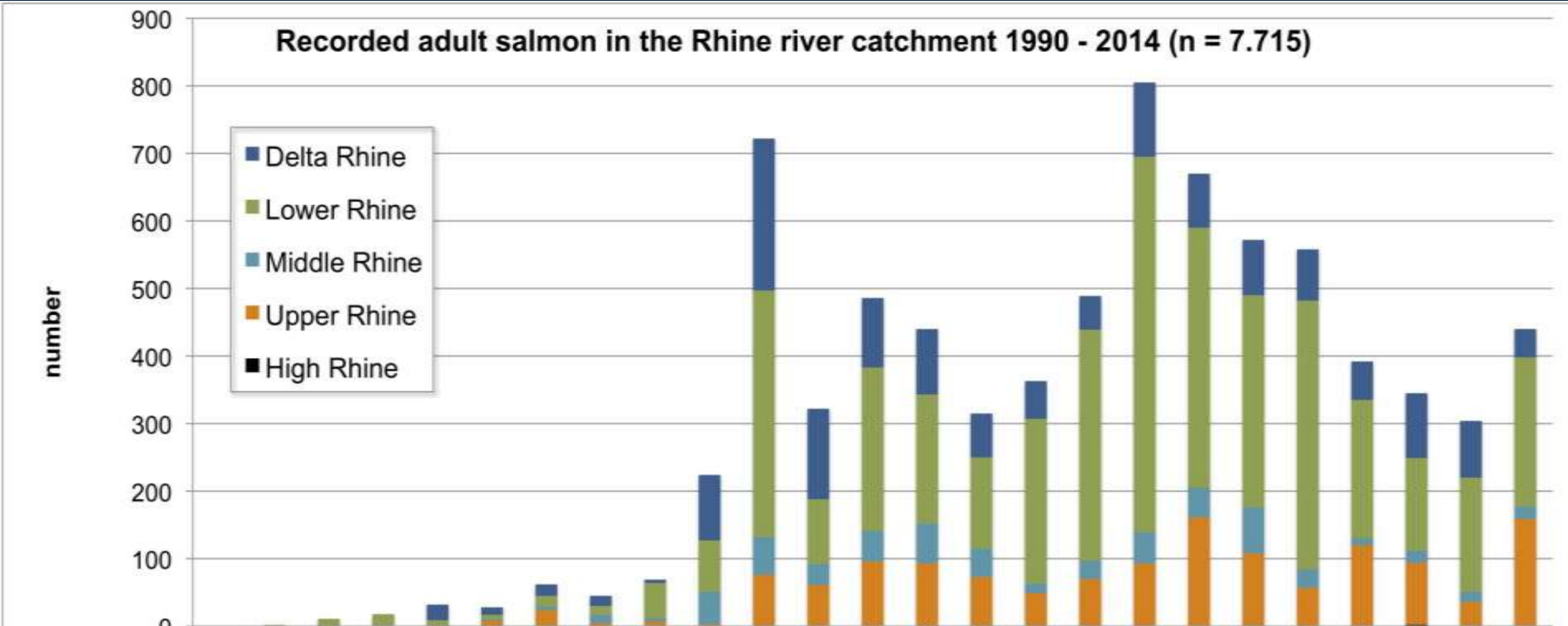
In the Middle Rhine a decline of events of natural reproduction is experienced since 2008



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Hessen			0	0	1	1	0	0	1	1	0	1	1	0	0	1	0
RLP	1	4	5	4	6	5	5	6	7	10	5	6	3	3	3	4	4

Statistics by ICPR

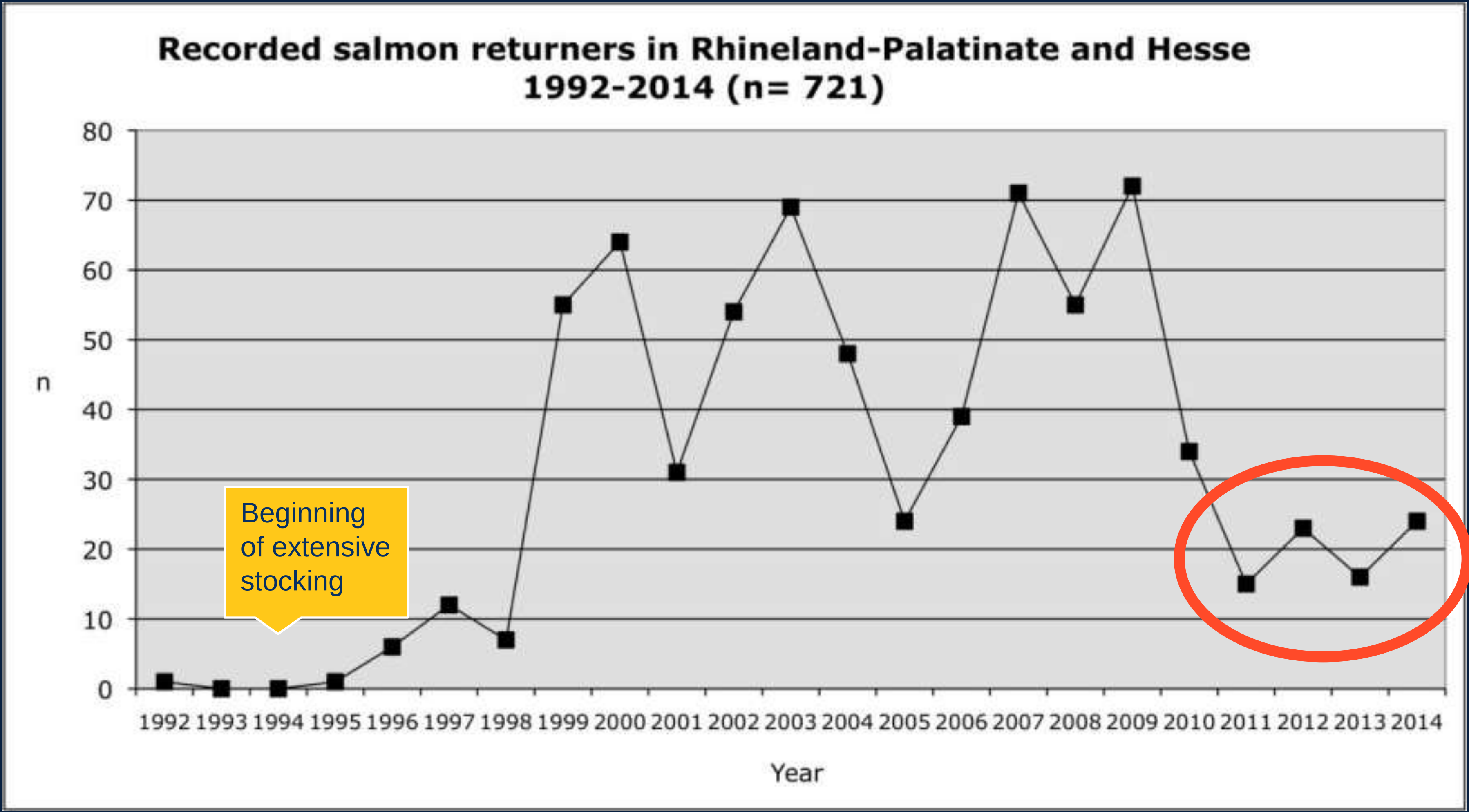
Returners



year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Delta Rhine	0	0	0	0	23	11	17	15	5	97	225	134	103	97	65	56	50	110	80	82	76	57	96	84	42
Lower Rhine	1	2	10	18	9	7	16	13	52	76	365	96	242	191	135	244	342	556	385	314	398	205	137	169	221
Middle Rhine	0	0	1	0	0	1	5	12	5	48	56	31	45	59	42	14	27	46	44	68	27	10	18	15	18
Upper Rhine	0	0	0	0	0	9	24	5	7	3	76	61	96	93	73	49	70	93	161	108	57	120	92	36	159
High Rhine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0

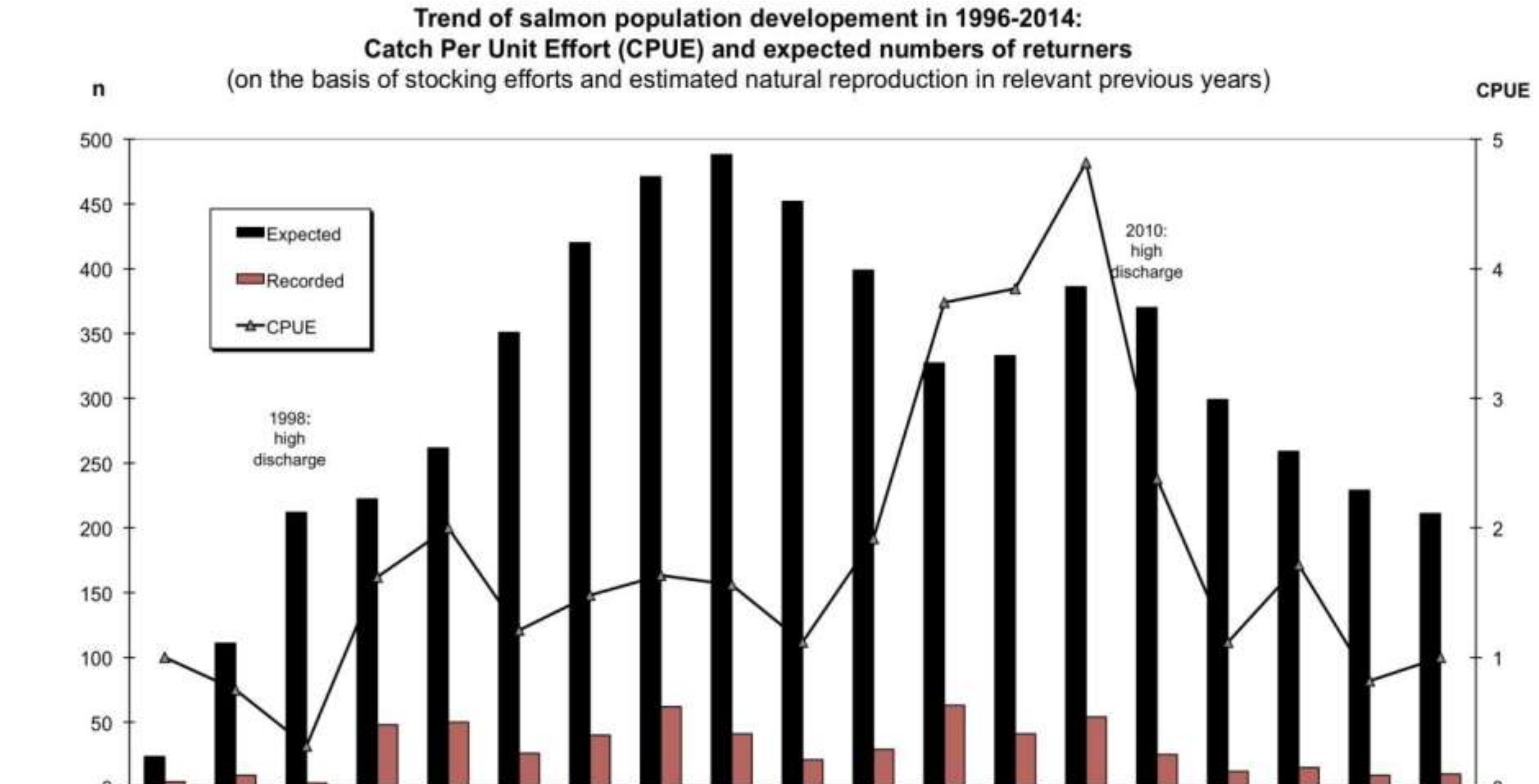
Returners

Returners



Returners

Returners

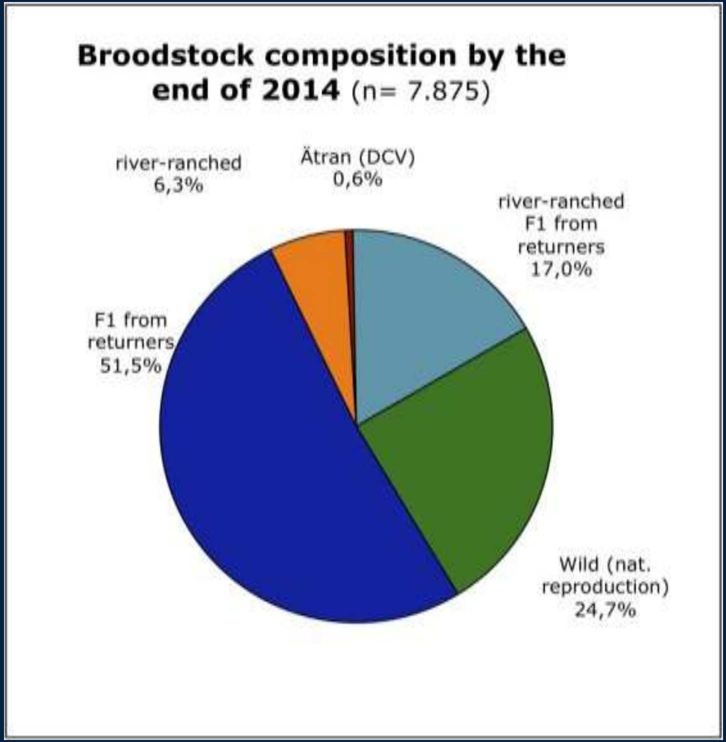


	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Expected	23	111	212	222	262	351	420	471	488	452	399	327	333	386	370	299	259	229	211
Recorded	4	9	3	48	50	26	40	62	41	21	29	63	41	54	25	12	15	9	10
CPUE	1	0,75	0,32	1,62	2,00	1,21	1,48	1,63	1,56	1,12	1,92	3,74	3,85	4,82	2,38	1,12	1,71	0,82	1,00

Year

Genetics and brood-stock (Hesse & Rhineland-Palatinate)

Returners



Brood-stock at „Salmon Center Hasper Talsperre“

Genetic analysis at Agri-Food & Biosciences Institute Northern Ireland (AFBINI) in Belfast:

79 YOY generation F1 from brood-stock were analysed. Results:

- Mostly Ätran origin (almost no indication of straying and or former stocking pratice with Irish, Scottish and French strains)
- High genetic variability – no bottle-neck

ENSING, D. (2014): Genetics study on Atlantic salmon (*Salmo salar*)
from the broodstock in the „Lachszentrum Hasper Talsperre“ hatchery on the River Rhine

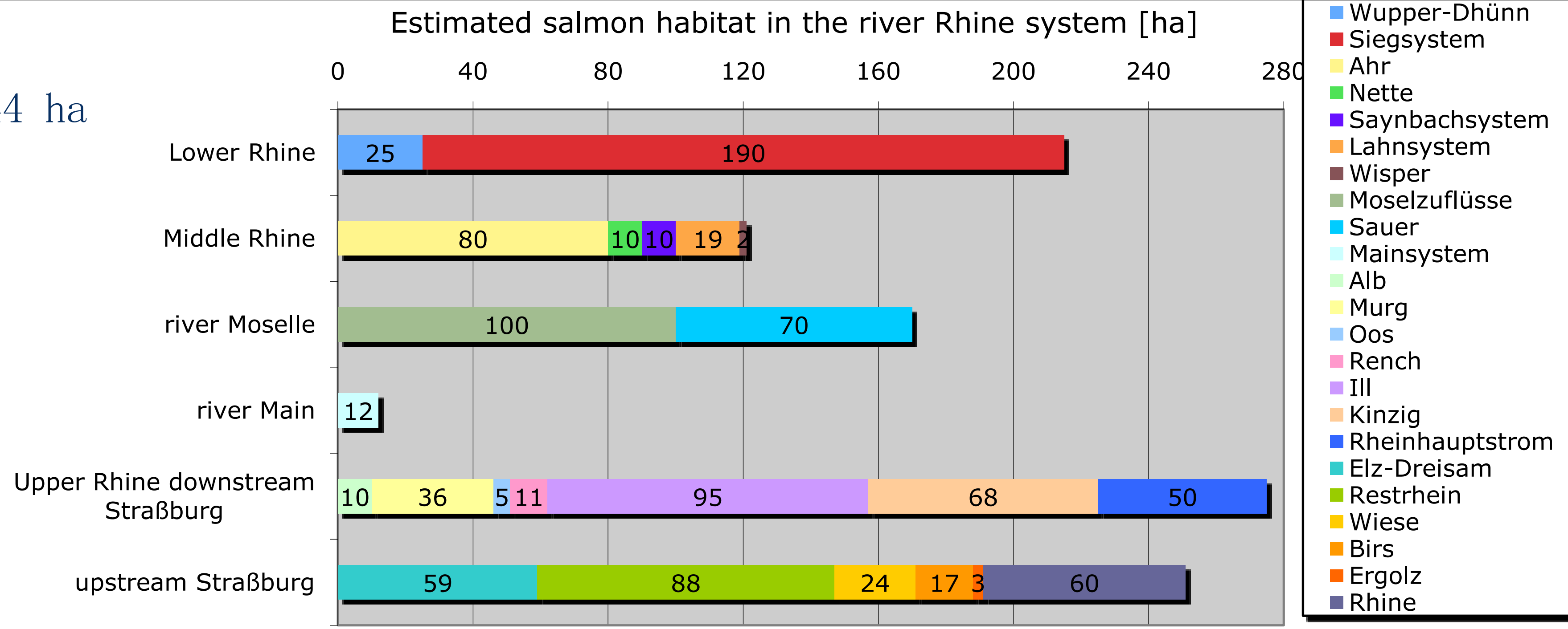
1.044 ha

Known and unknown factors responsible for failure

218 ha

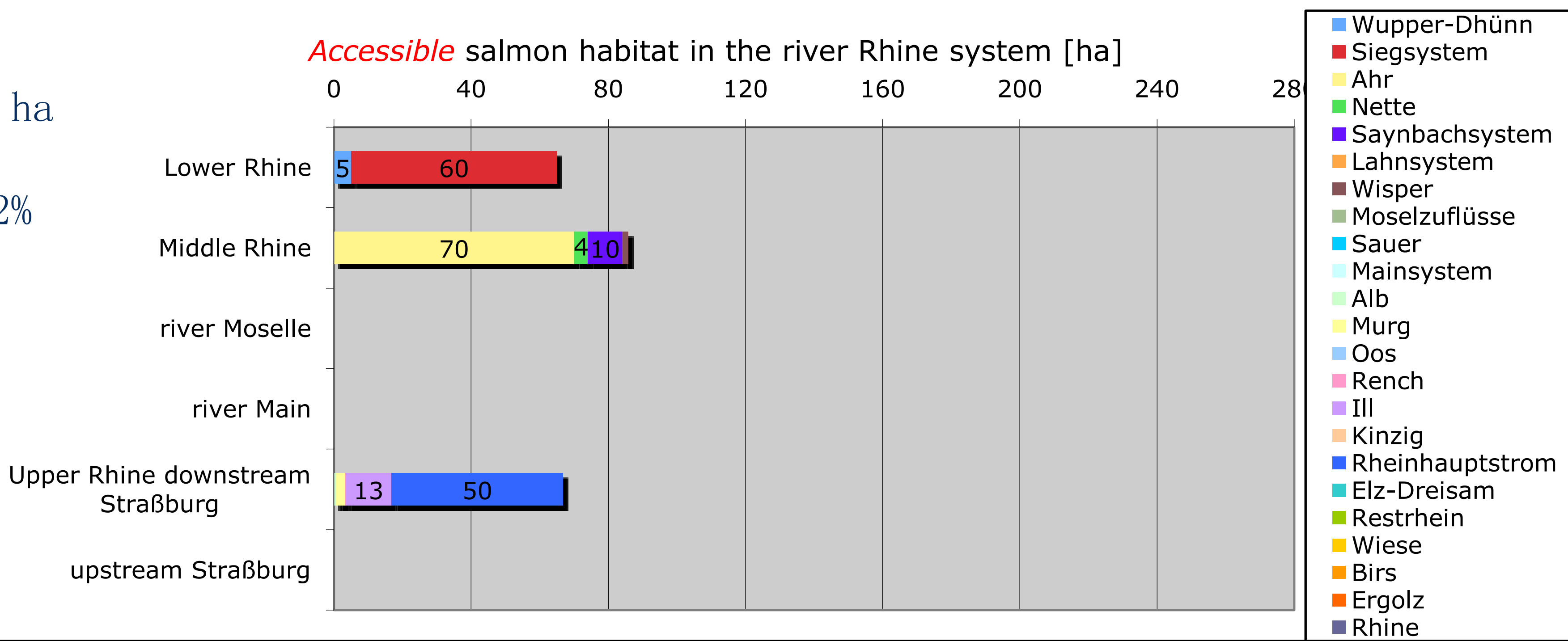
= 22%

1. 044 ha

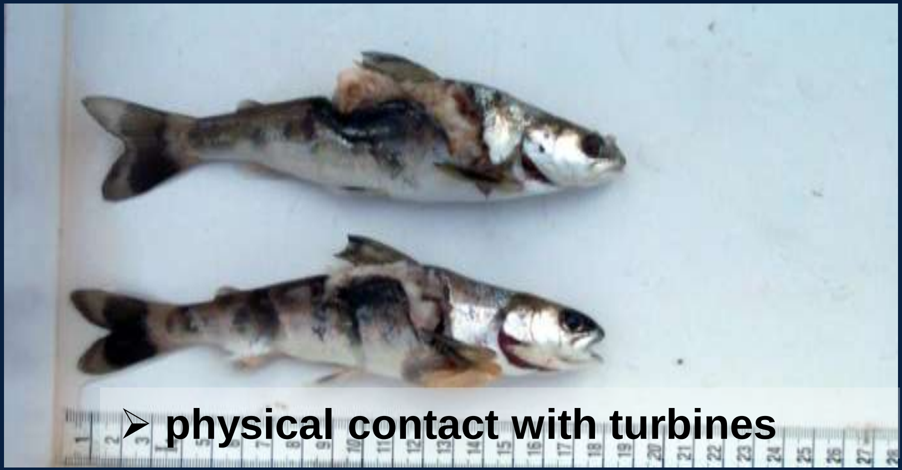


218 ha

= 22%



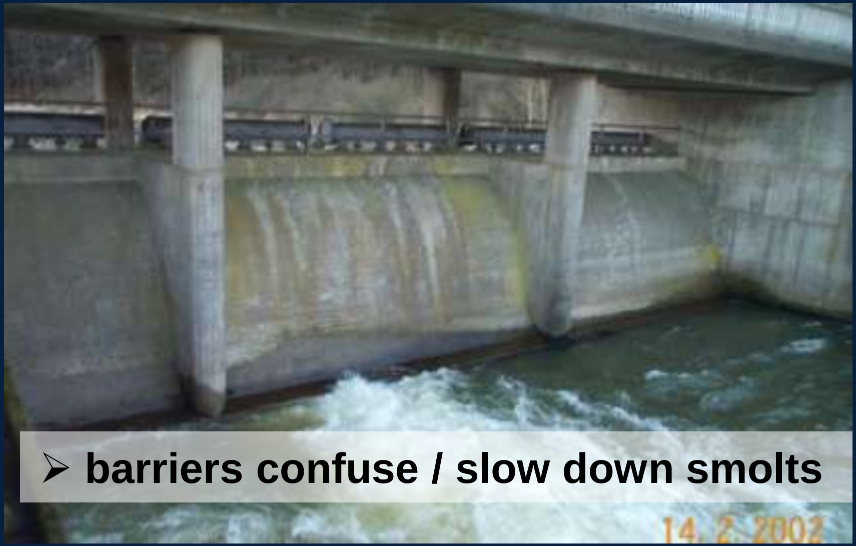
Factors responsible for failure



➢ **physical contact with turbines**

➢ **high predation in stagnating water**

The negative human impact in tributaries is often linked with **hydro-energy plants** – *politicians want it, salmons don't …*

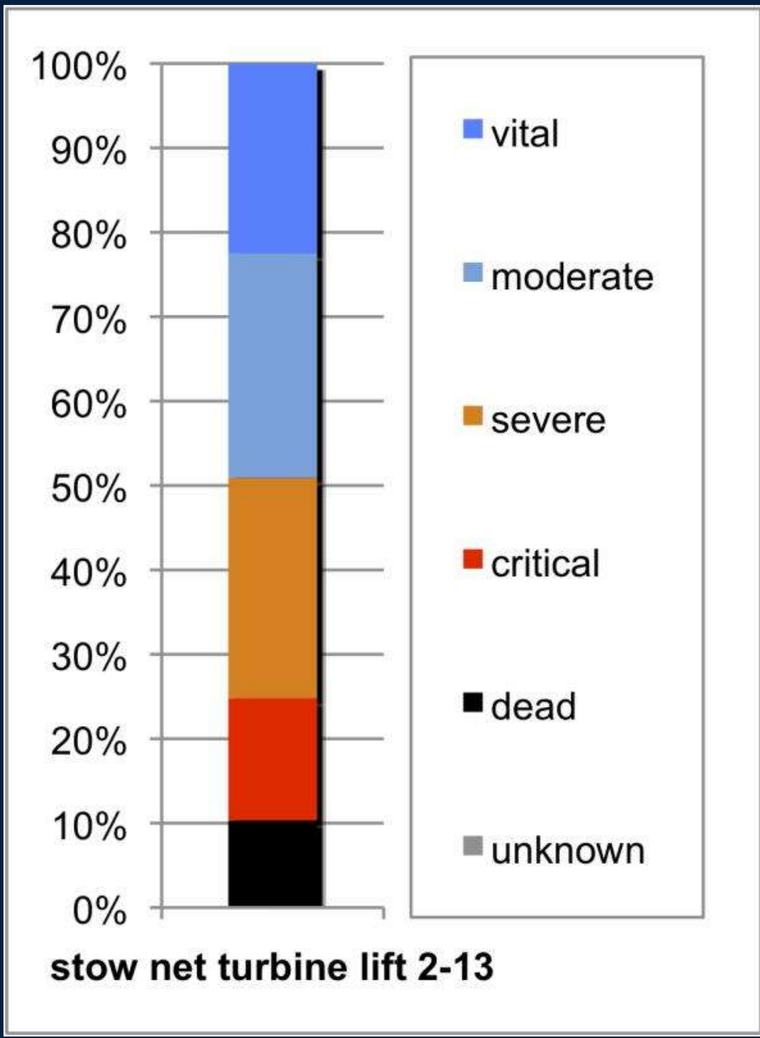


➢ **barriers confuse / slow down smolts**

➢ **alteration of flow**

Downstream migration: a trial with salmon smolts at Kostheim hydroplant (river Main) in April 2011

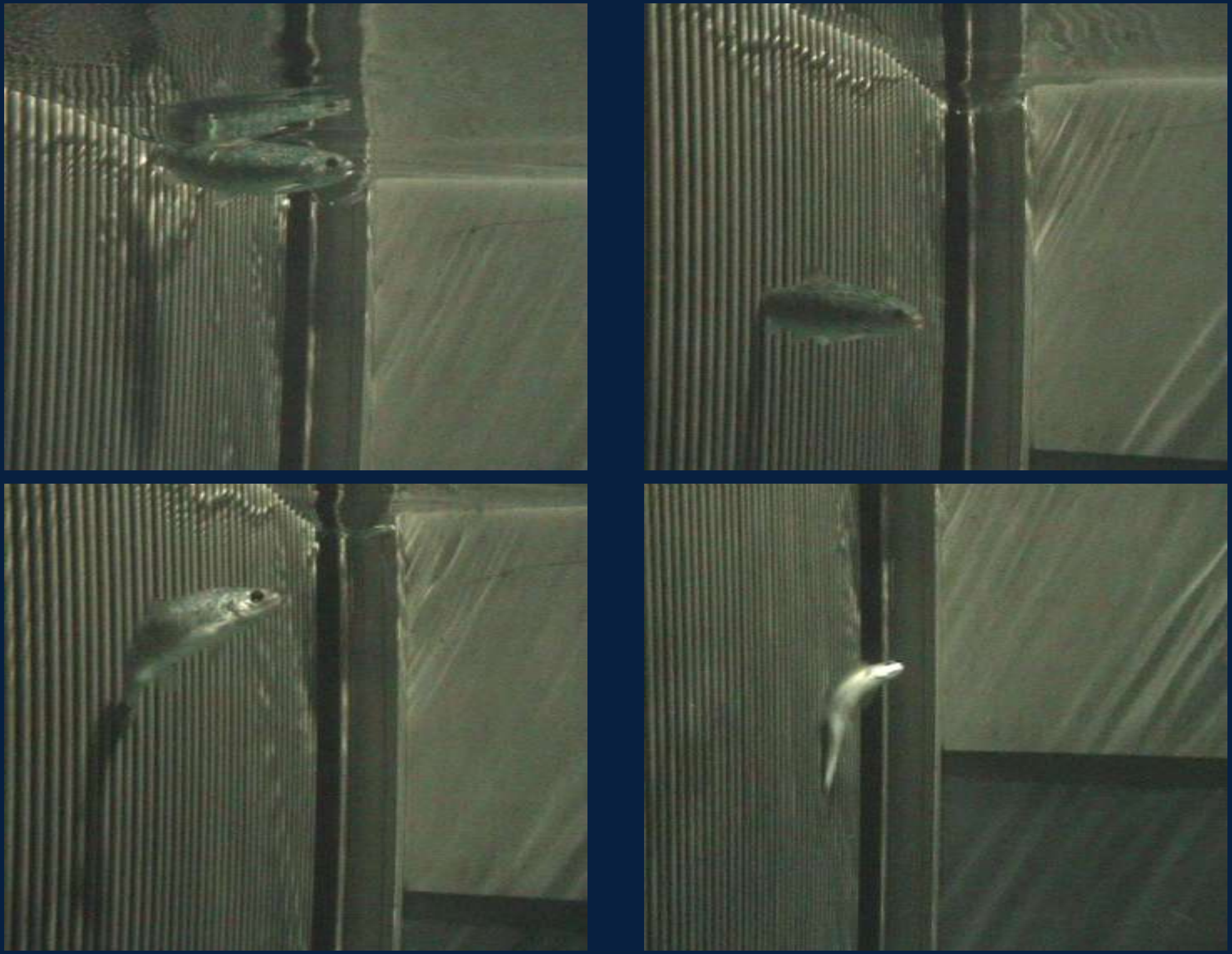
50% of the smolts were dead or not capable of surviving, due to scale loss, haematoma at the basis of caudal fins and internal bleeding.



Most individuals displayed injuries characteristic for contact with the 20 mm bar space trash rack

Behaviour of salmon smolts encountering a vertical rack equiped with 10 mm bar space, velocity 0,5 m/s

Lab study by DIRK HÜBNER (BFS-Marburg)



Factors responsible for failure

The “cumulative effect”

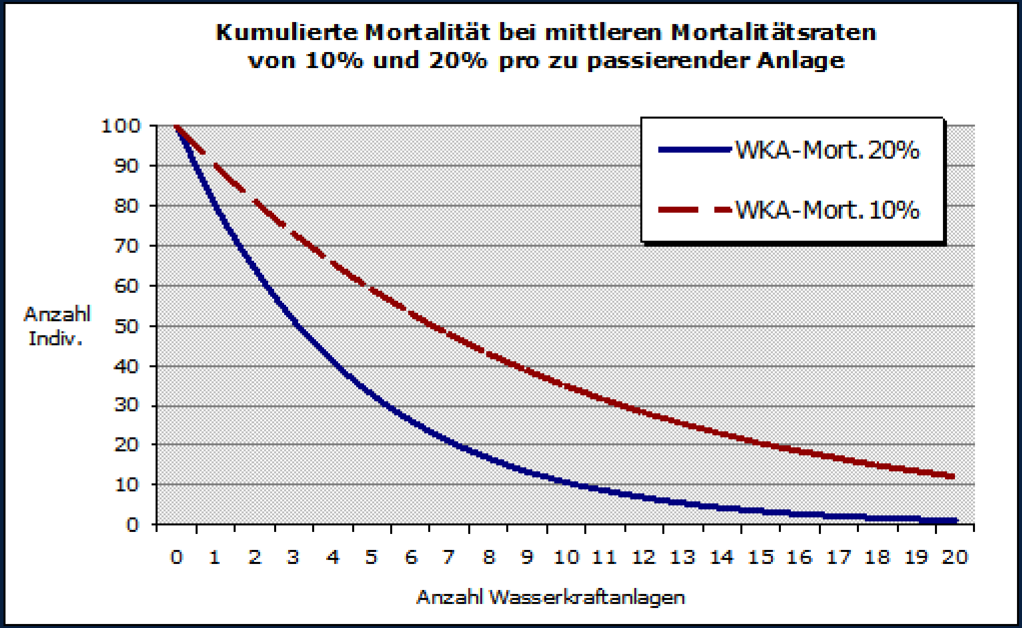
Downstream migration, smolts

The graph illustrates the cumulative mortality of migrating salmon smolts in relation to the number of hydro plants for mortality rates of 10% and 20%.

Upstream migration, returners

The rate of failing to find even „well-designed“ fishpasses“ in large rivers is most certainly more than 10%

The cumulative effect therefore is even doubled in a full life-cycle of Atlantic salmon



Graph according to IKSR

Factors responsible for failure

More very large container ships operating with some thousands horsepower (an under-estimated factor ?!)

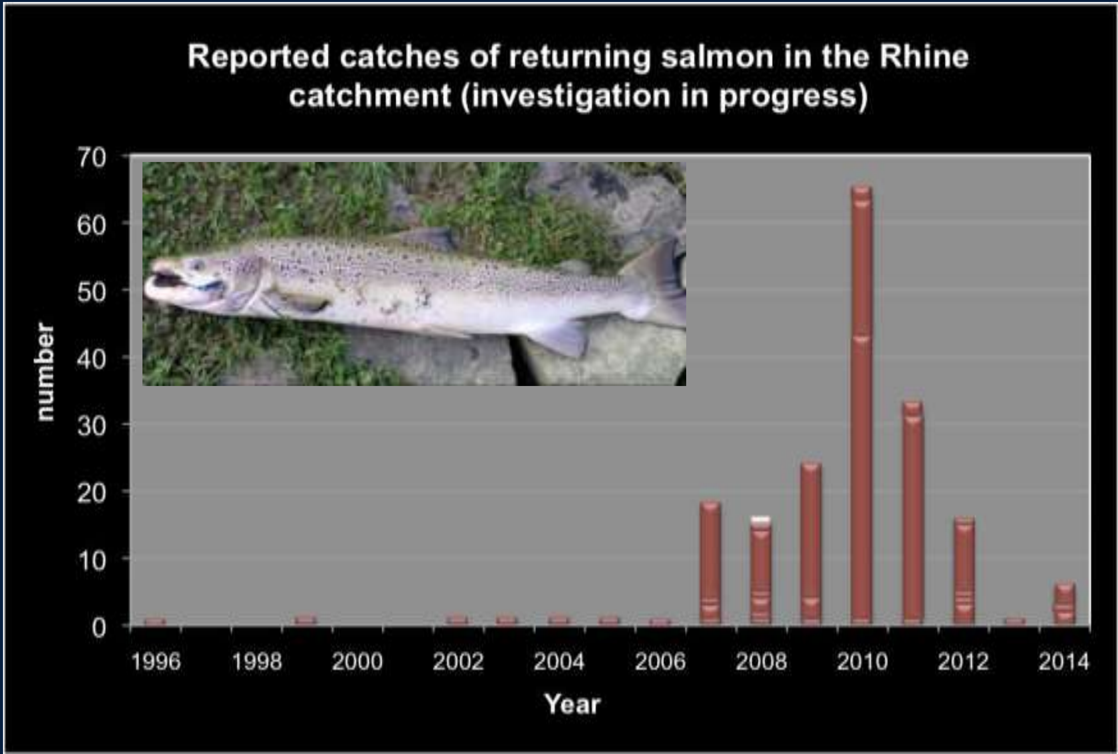
Factors responsible for failure

Salmon are physically able to enter **turbine chutes** from the tailwater at low head hydro-power plants:

Max. swimming speed indiv. 75 – 85 cm: 4,3 – 6,0 m/s (5,8 – 8,4 body length/s) under lab conditions. In the wild up to 10 m/s are suggested !

Factors responsible for failure

Poaching and „by-catch“
seem to be a substantial problem ...



Factors responsible for failure

Other factors

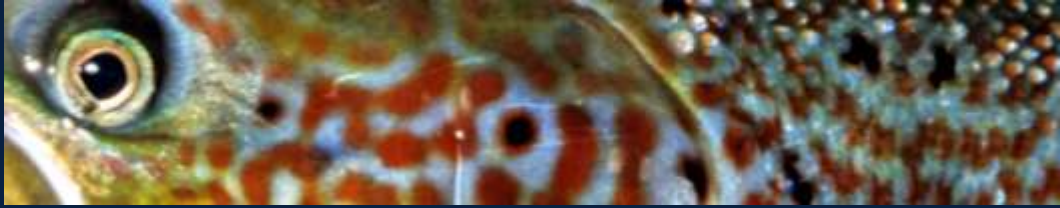
More predators, such as
cormorants, asp, catfish, sander inhabiting the migration routes;
sculpin and cormorants in the rearing habitats

Climate change, more dry years, like the drought of the century in autumn 2011 (picture), hot summers like this year or even 2003 with water temperature of 30° C in the Rhine

Factors responsible for failure

Mortality at sea is very high – the reasons are unknown

Conclusions 1



The return rate to the spawning rivers is insufficient and most probably even decreasing

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 doing very well (because of spawning time?). Allier salmon so far do not have access to high quality spawning grounds, but successful reproduction has been documented.

River-specific problems, like dams, weirs, hydroelectric power stations, navigation, habitat quality, temperature, have not improved significantly in the past years – some got worse ....

Predator abundance is significantly higher than 10 years ago: cormorant, asp, catfish, sculpin …

Poaching and “by-catch” are seen as a new challenge to authorities and project managers

Conclusions 2

- 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
- Established populations are adapted to these environmental factors

yesterdays environment dictates tomorrows adaptations (G. de Leaniz)

We have to give our emerging populations time for adaptation and stock differentiation !

Using wild fish for brood-stocks may be beneficial

Reintroduction is a process of adaptation – nobody knows, how many generations it will take ...

Thank you very much for your attention

Foto: P. Tigges

Foto: F. Steinmann

Merci beaucoup pour votre attention