Downstream fish migration
-
state of play in the river Rhine

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Internationale Kommission zum Schutz des Rheins

Commission Internationale pour la Protection du Rhin

Internationale Commissie ter Bescherming van de Rijn

International Commission for the Protection of the Rhine

Outline

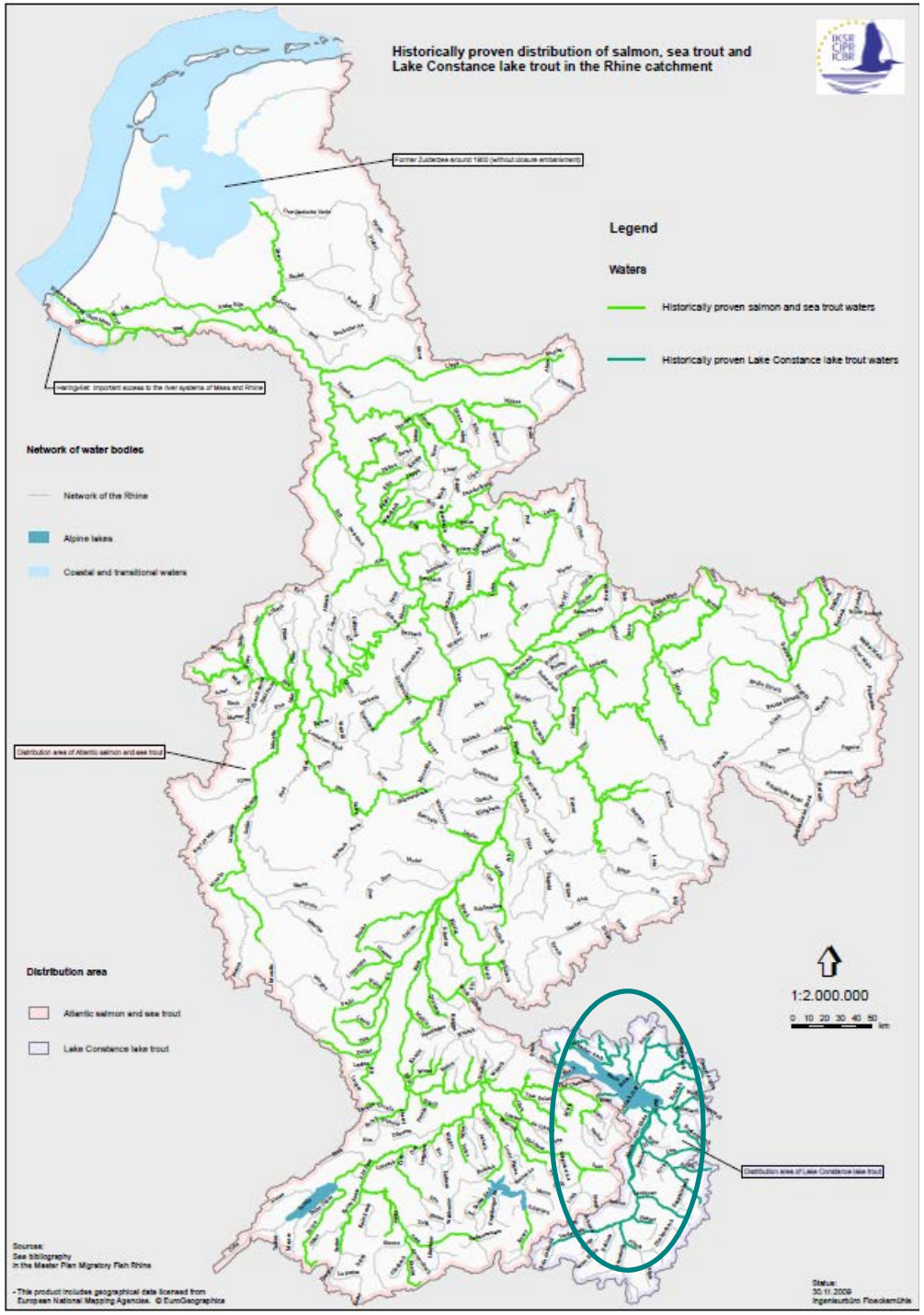
1. Historical overview
2. ICPR programs for salmon and migratory fish
3. Examples of downstream migration facilities
4. Alternative turbine design
5. Research on migration success
6. Conclusions

Historical salmon waters in the Rhine river basin

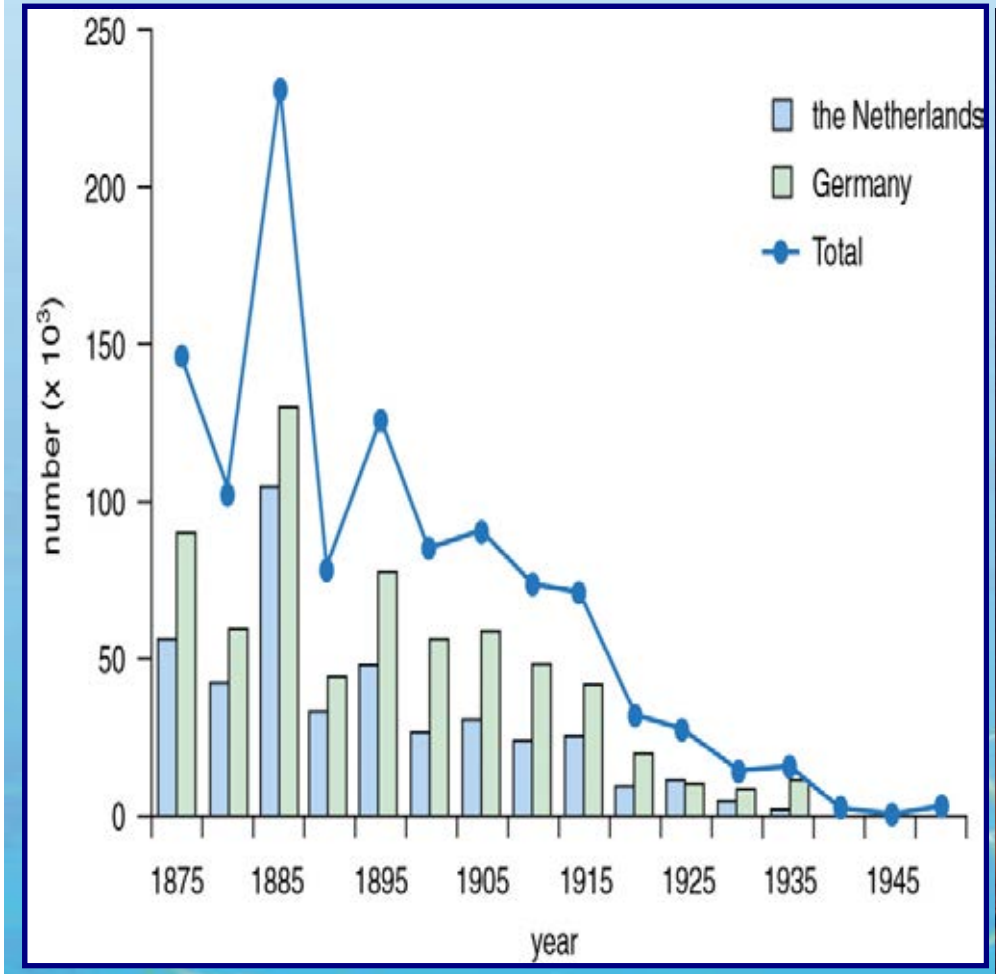
Salmon *Foto: J. Schneider*

Lake Constance trout

Photo: P. Rey



Decline of the salmon population



Sandoz fire 1986

Action Programme Rhine 1987

Salmon as symbol for a healthy Rhine

***Salmo salar* † 1958**

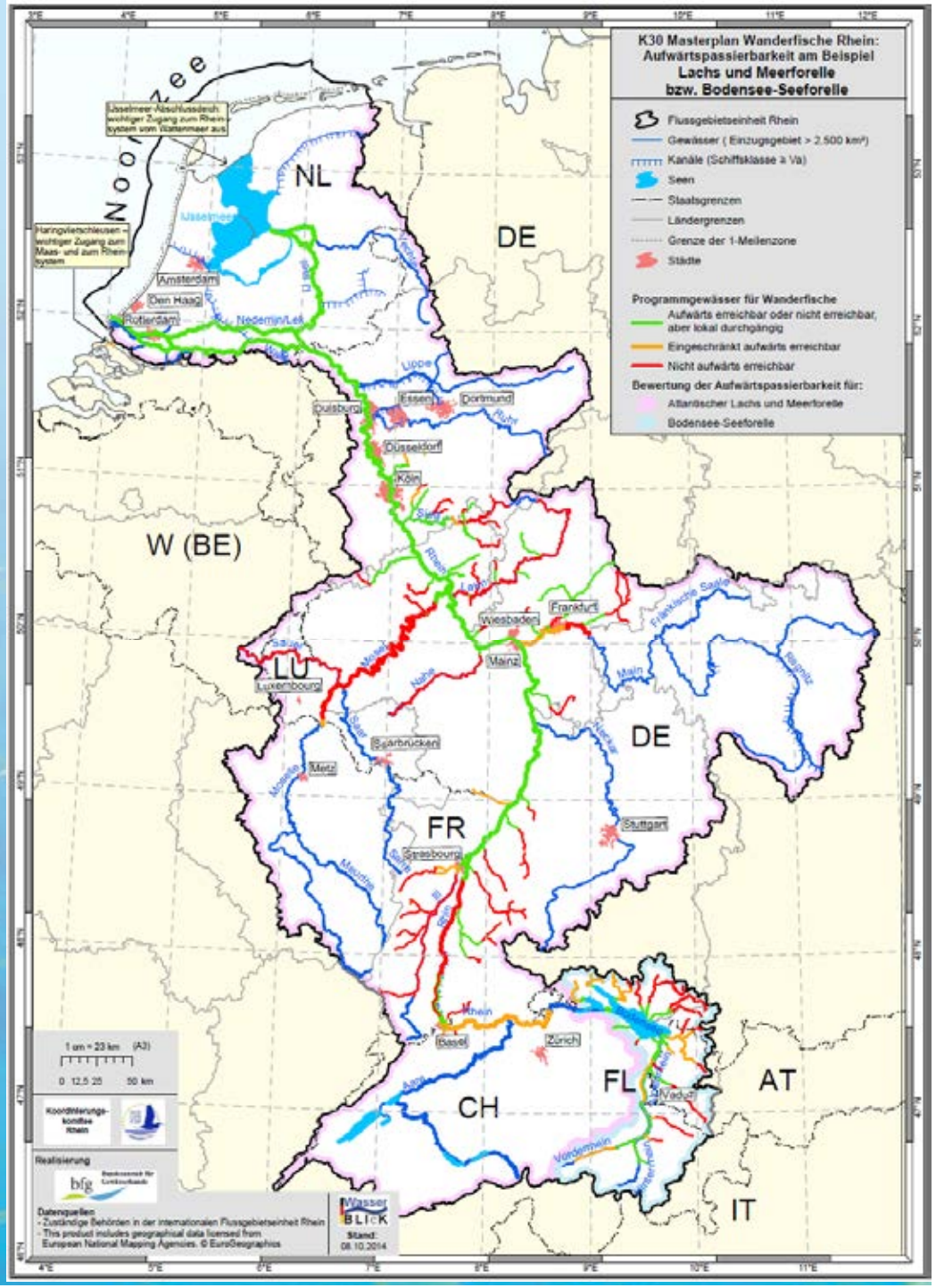
Master Plan Migratory Fish Rhine

River continuity in the program waters

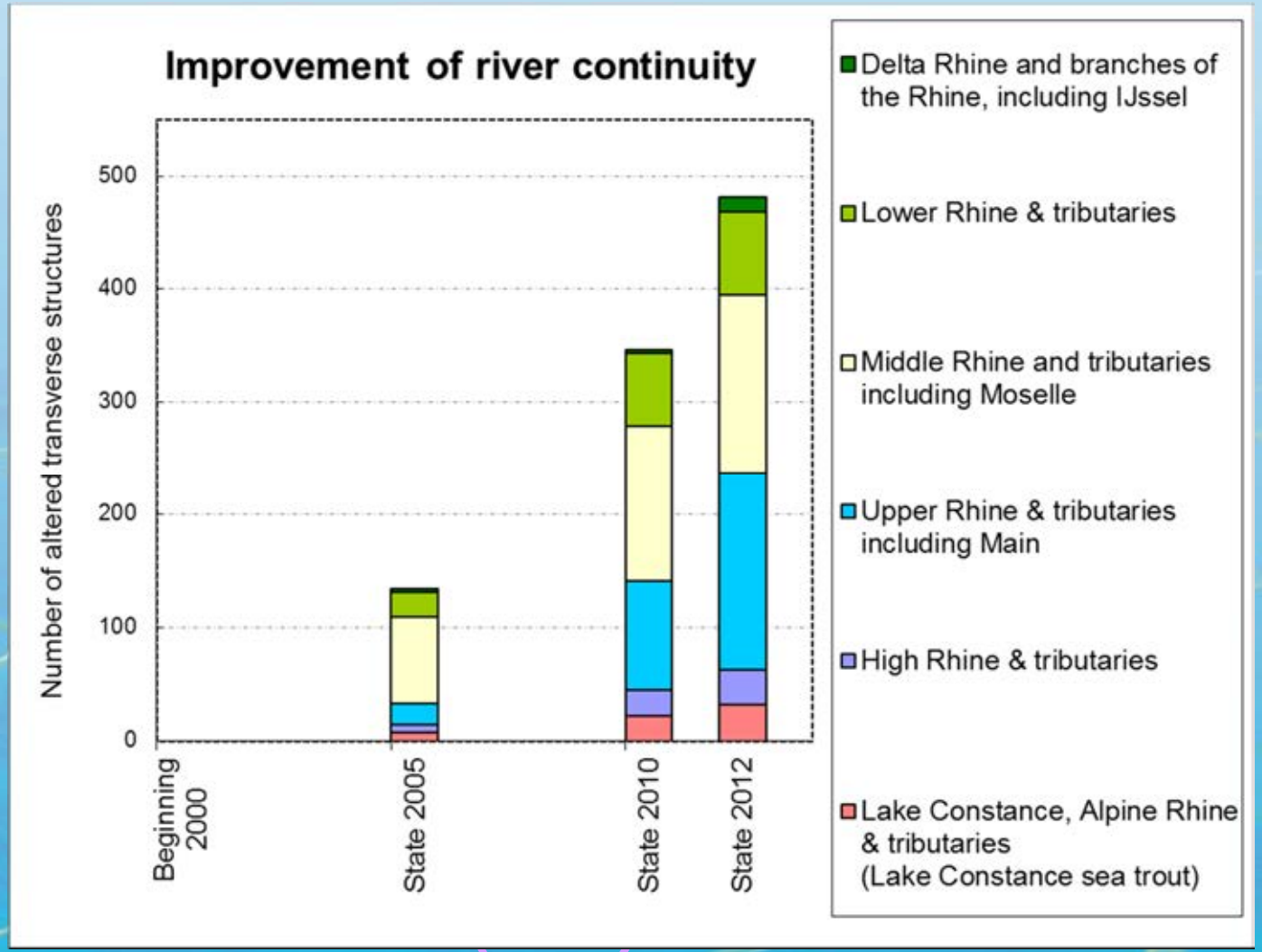
Restoration of habitats

Stocking

Total costs: €560Mln
(data October '14)



Master Plan Migratory Fish Rhine:
- river continuity -



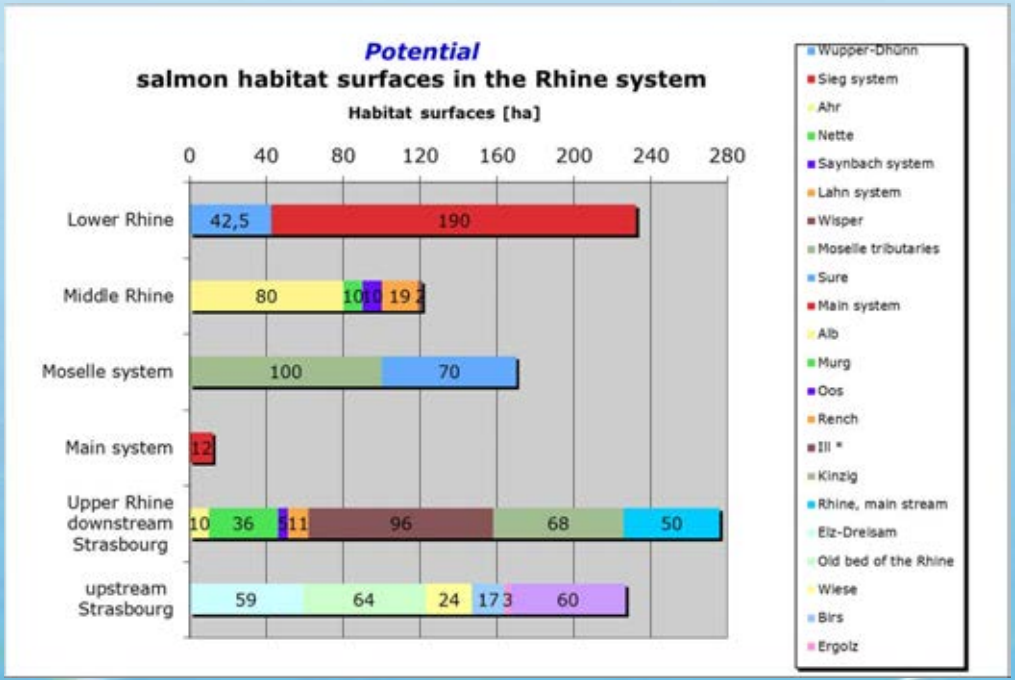
481 barrage weirs were altered between 2000 and 2013

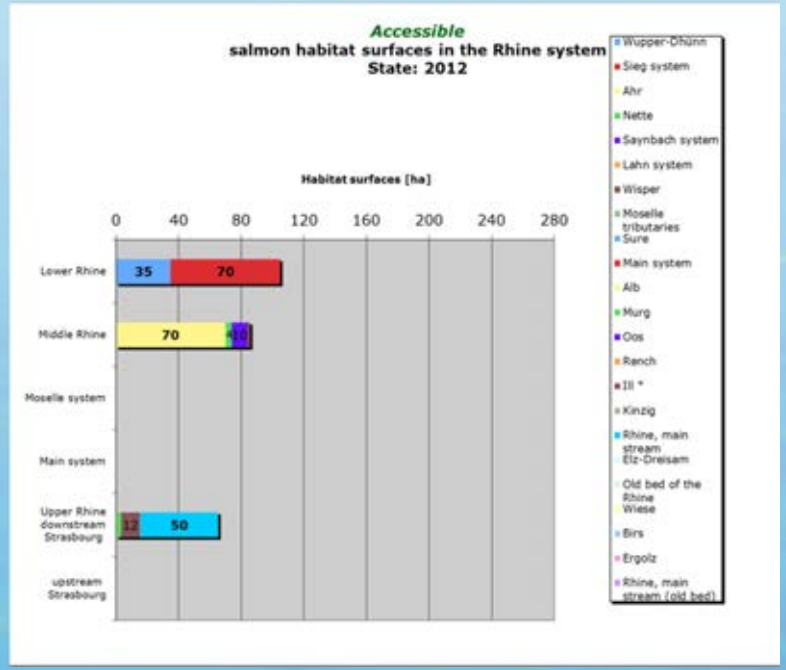
(focus on upstream migration)

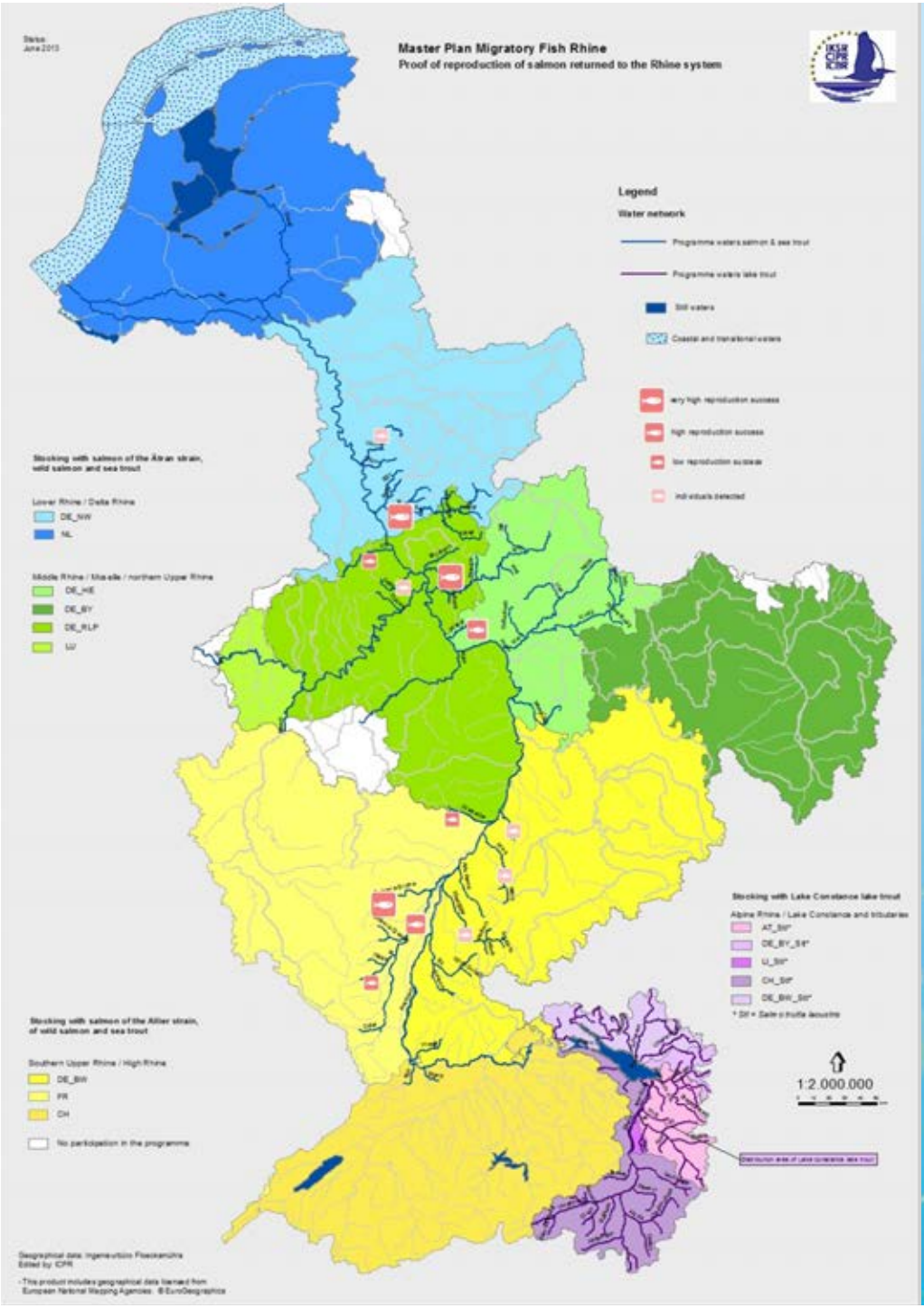
Master Plan Migratory Fish Rhine:
- spawning habitats -

Potential => + 200 ha in Aare (CH)

accessible in 2012



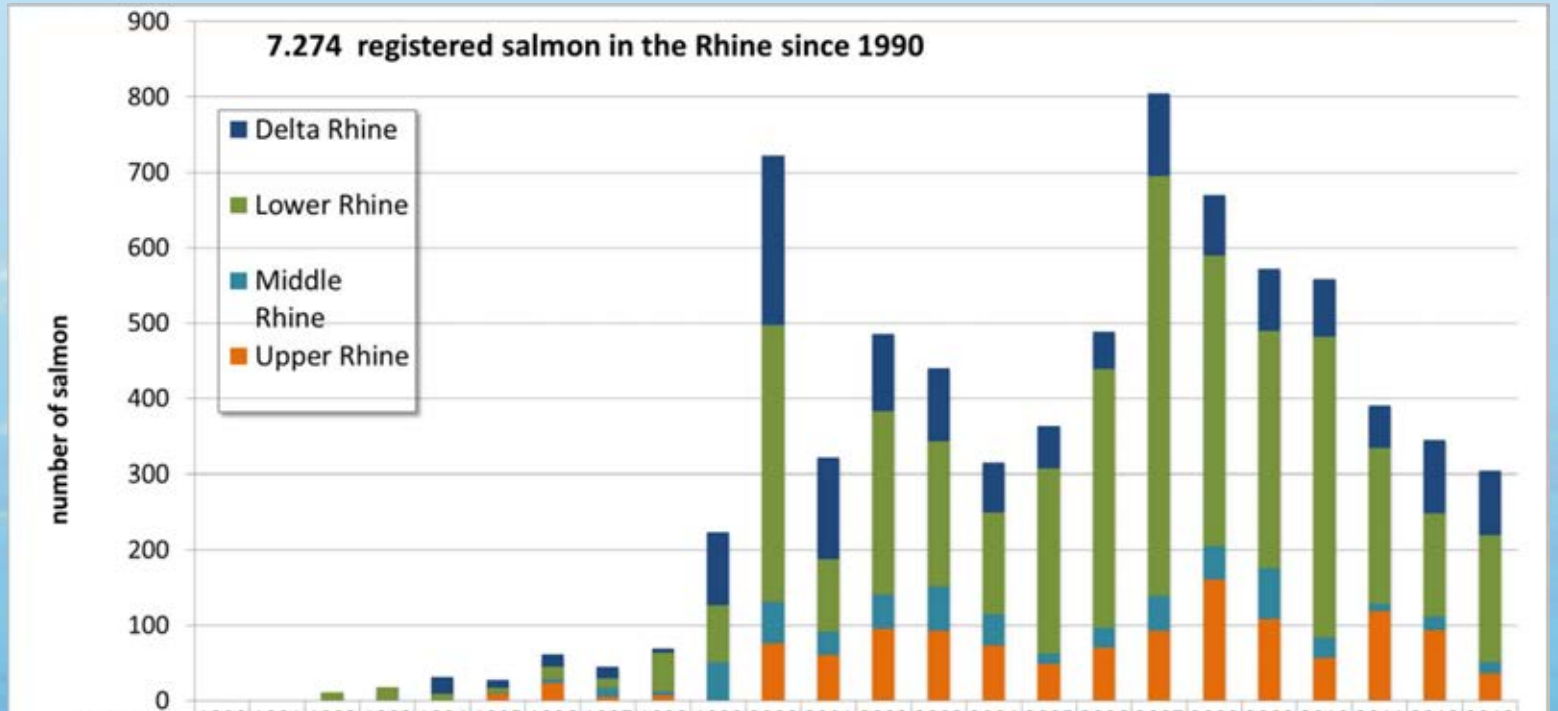




Master Plan Migratory Fish Rhine:

Stocking & natural reproduction of Atlantic salmon in regional coordination units

Current status of salmon



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
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
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
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
Upper Rhine	0	0	0	0	0	9	24	5	7	3	76	61	96	93	73	49	70	93	161	108	57	119	92	36
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

Latest figures of 2014 are showing an upward trend again

Rhine Ministers (2013)

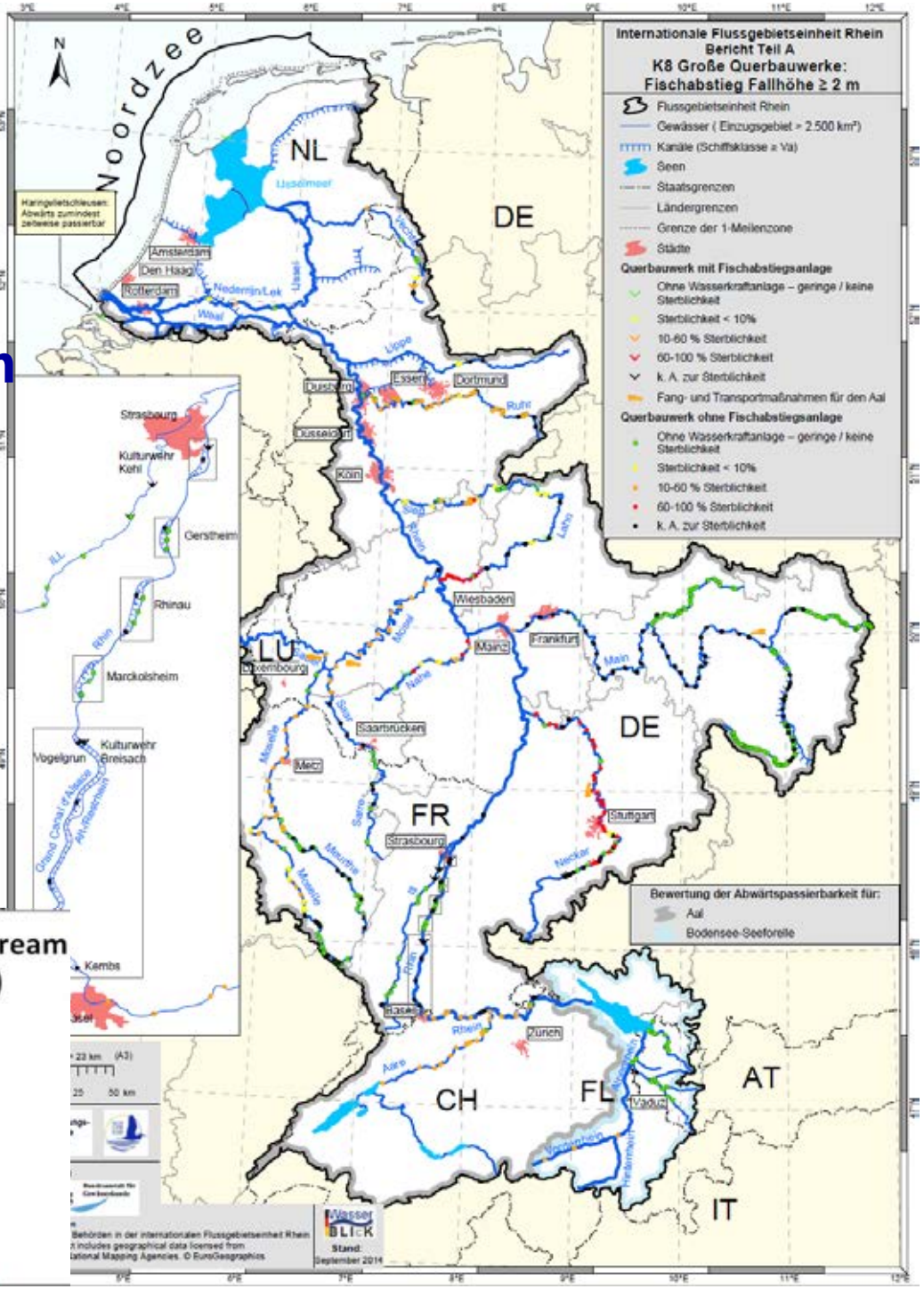
"for juvenile salmon or adult eel, the <u>downstream migration in the turbine areas is critical</u> because of the great danger of injuries, particularly in cases of successive hydro power plants"

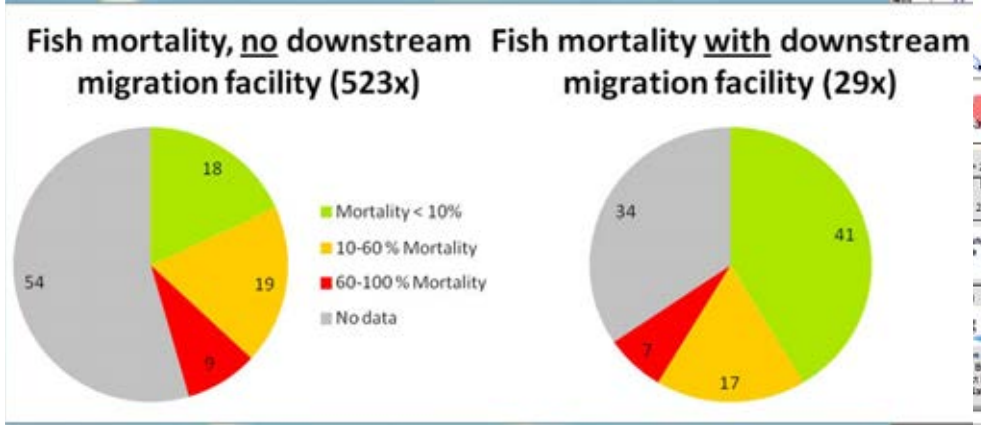
"ask the ICPR to intensively work on the joint determination of <u>innovative techniques of downstream migration</u> at transverse structures"

"as a matter of principle, <u>no new migration obstacles may be constructed</u> in the programme waters and, as far as possible, no obstacles to migration may be constructed in the remaining freely flowing stretches"

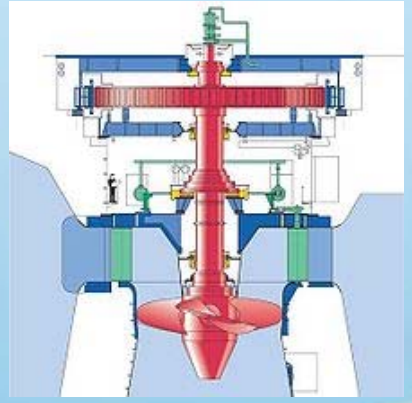
Downstream migration in the Rhine

- Overview of downstream migration bottlenecks
- Little knowledge on effects of downstream migration
- Very few downstream facilities (29 out of 552)

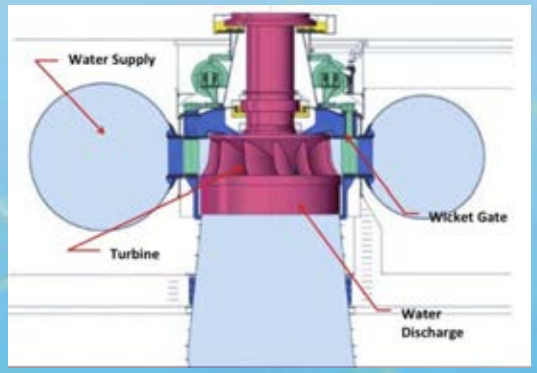




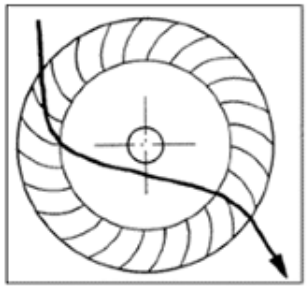
Hydropower in the Rhine

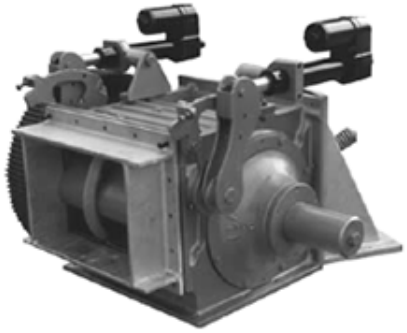


Kaplan



Francis





Banki-Mitchell

Downstream migration facilities

Function control results for Kostheim (Main) 2011

Hydropower station:

- Built 2007-2009
- Horizontal Kaplan
- 2 x 80 m^3/s
- ± 3,5 m head

Fish migration:

- Bypass for upstream + downstream
- Screen (20 mm, 0,5 m/s)
- Eel shaft

Designed mortality < 10%

Function control results for Kostheim (Main) 2011

- About 50 % mortality
- Small fish (< 25-30 cm) & Eels (< 65 cm length) pass the screen (20 mm)
- Injuries by screen, screen cleaning device & turbines
- Different bypasses not accepted (not found?) by eels, smolts or other fish species

Fotos: J. Schneider, BFS

- **vast improvement measures required**

Pilot Hydropower Unkelmühle (Sieg) 2014
Downstream migration and fish protection

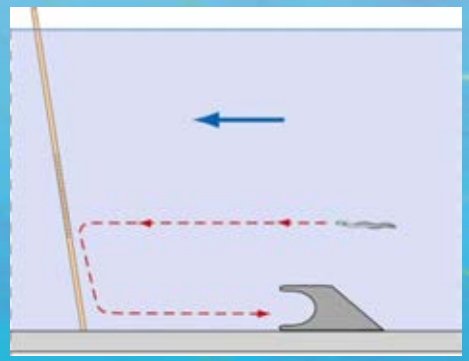
(Cooperation RWE Innogy – Northrhine-Westfalia)

Hydropower station

- 3x Francis
- 28 m^3/s
- Head 3 m

Fish migration measures

- Vertical slot
- Screen (10 mm, max flow 0,5 m/s)
- Eel shafts (3 different depths)
- Bottom Gallery (Eel)

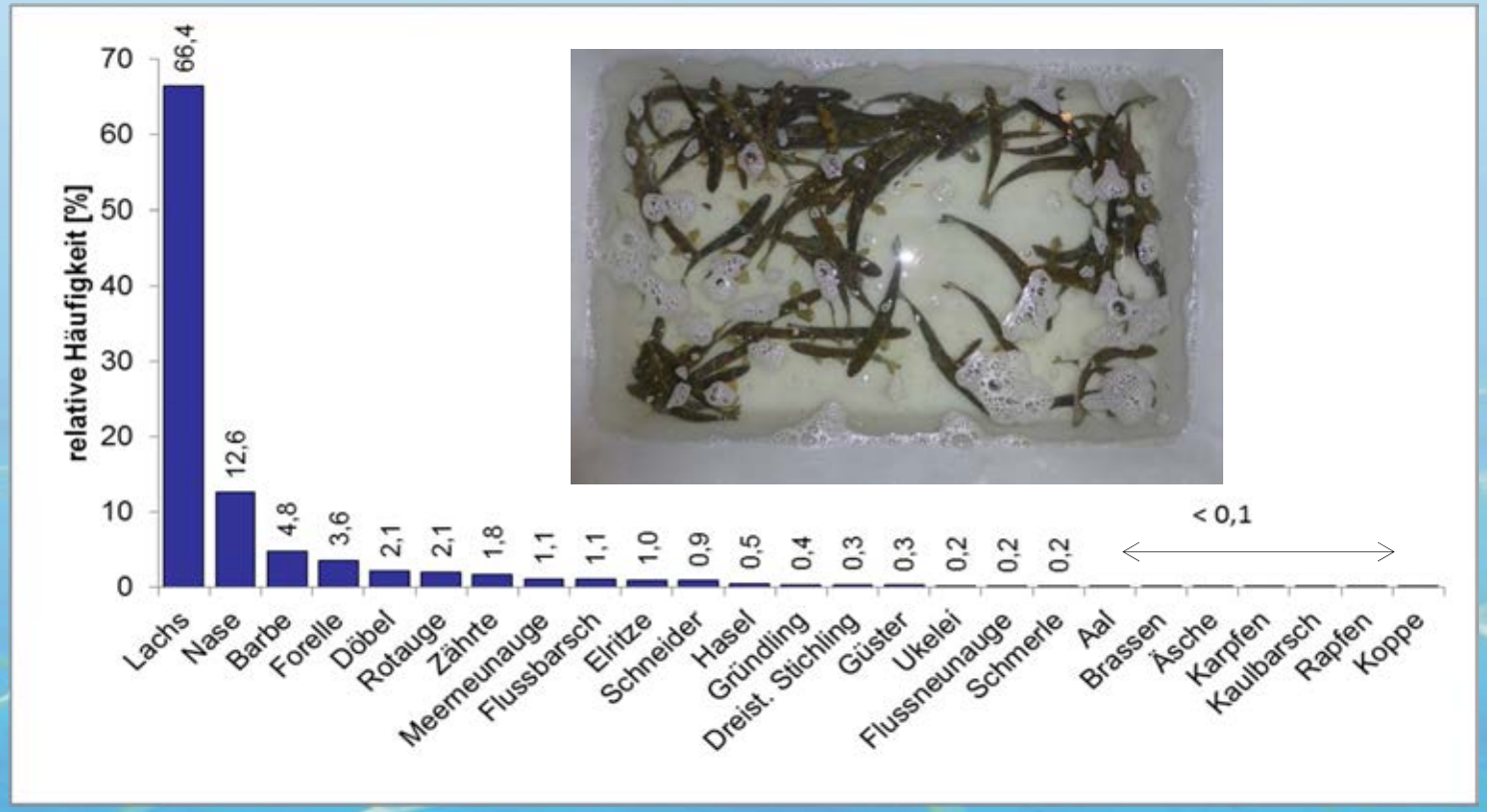


Pilot Hydropower Unkelmühle / Sieg, 2014
Downstream migration and fish protection

(Cooperation RWE Innogy – Northrhine-Westfalia)

First results spring 2014

Catch of 4.404 individuals (from 25 species)
2.923 salmon-smolts (66,4 %)



Evaluation after 3 year biological monitoring
Evaluation of technical and economical data on functioning of hydropower plant

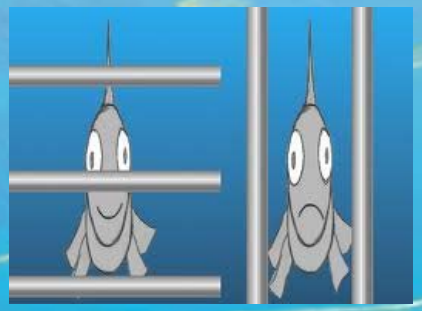
Monitoring approach: using radio telemetry to cover all possible migration routes

Antennas section in front of 10 mm trash rack and at all possible bypass routes

Auer Kotten (Wupper), 2013-2014
Function control results

Hydropower station:
- Kaplan
- 14 m^3/s
- 3 m head

Fish migration
- Vertical slot passage
- Horizontal screen (12mm, 0,5 m/s)
- Bypasses both at surface and floor level



Institut für angewandte Ökologie

Auer Kotten / Wupper, 2013-2014
Fish protection screen; 12 mm horizontal

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lebendigewässer

Auer Kotten / Wupper, 2013-2014
Function control results

Downstream migration facility at hydropower station

- 16 HDX-antennas (half-duplex)
- 1000 tagged Smolts, and
- 300 tagged Silver Eels were released upstream of hydropower station

Questions:

- Functioning of 12 mm trash rack as barrier?
- The use of bypass systems for eel and salmon?
- Results still under analysis

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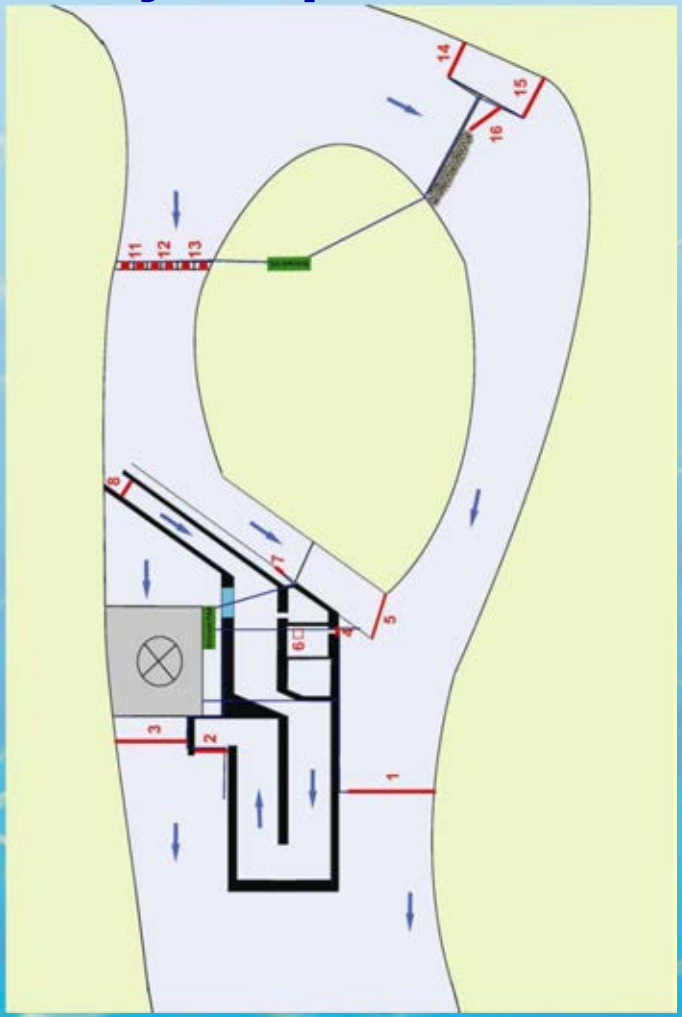
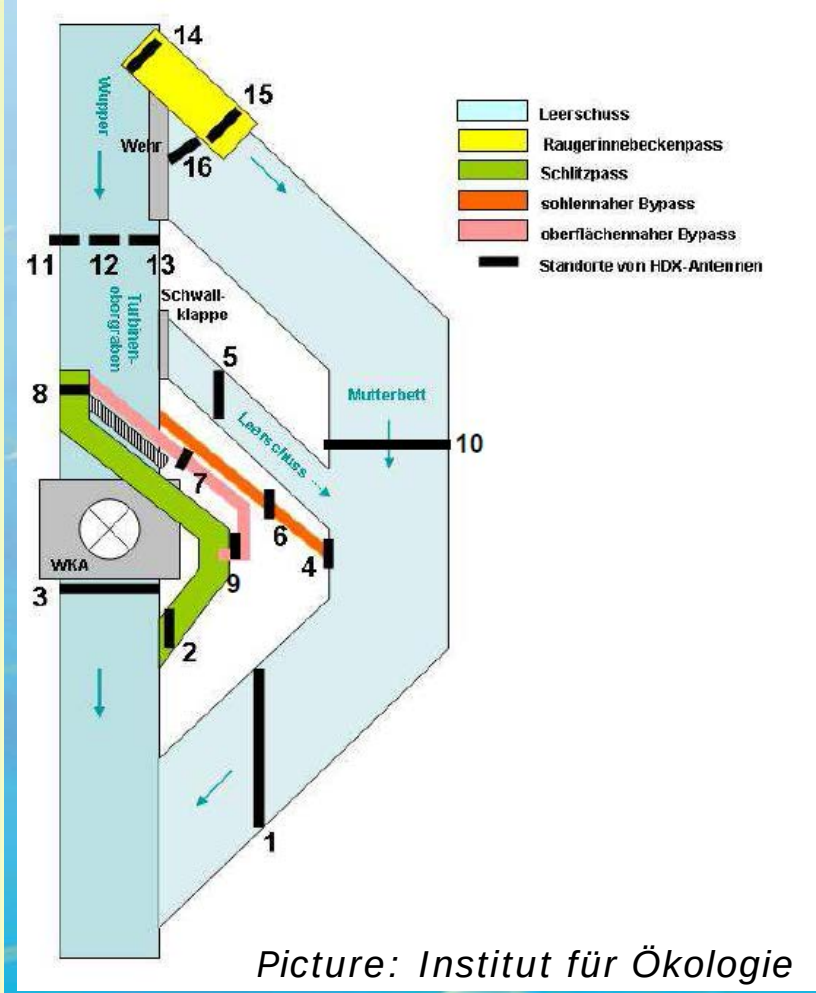
lebendigewässer

Function control results: Auer Kotten / Wupper, 2013-2014

Migration routes and antennas at hydropower station Auer Kotten





Picture: Institut für Ökologie

Alternative turbine design

Archimedes screw turbine

Screw turbine developed in Alsace by the society NSC environnement

- **up to 15 m^3/s**
- **up to 10 m head**
- **up to 500 kW**

- **mortality 0-5%**

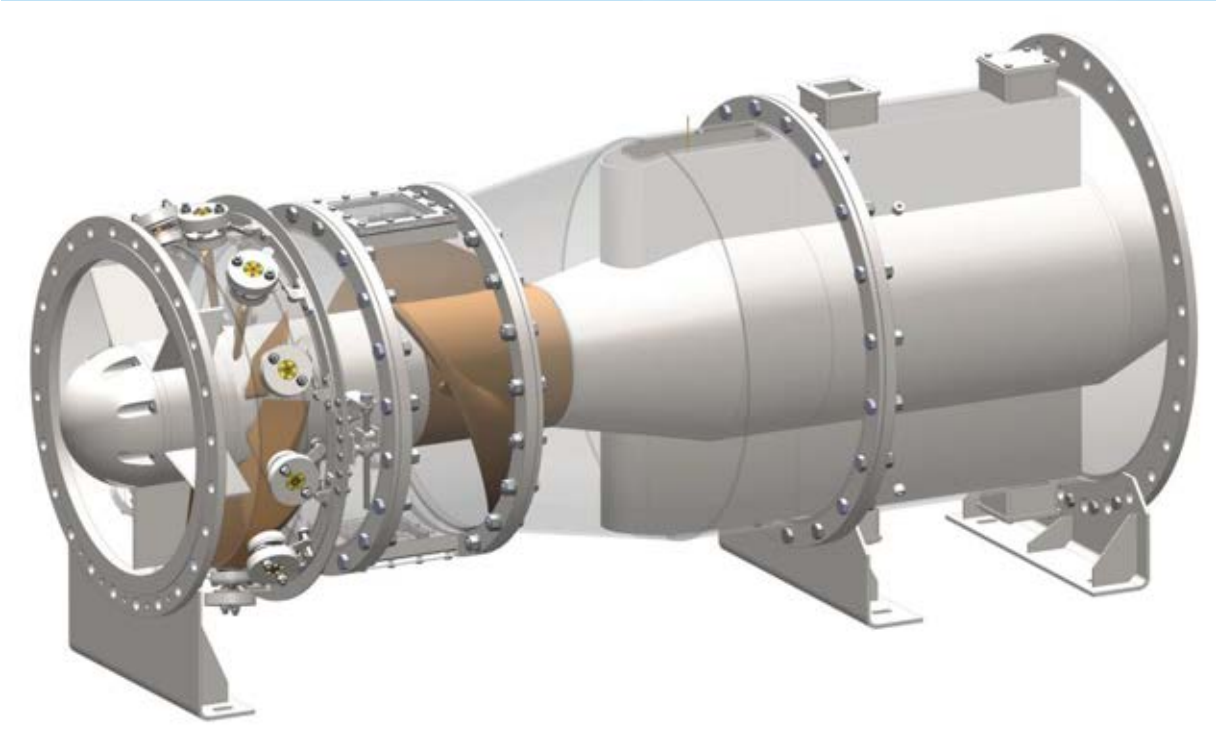
Screw turbine in the Netherlands: study showed no mortality of fish (Foto: VisAdvies)

Very low head

- 10 - 27 m^3/s
- 1,5 – 4,5 m head
- 100 kW – 500 kW

- several tests performed
- mortality 0% (eel, smolts) - 4% (adult salmon)

Pentair Fairbanks Nijhuis

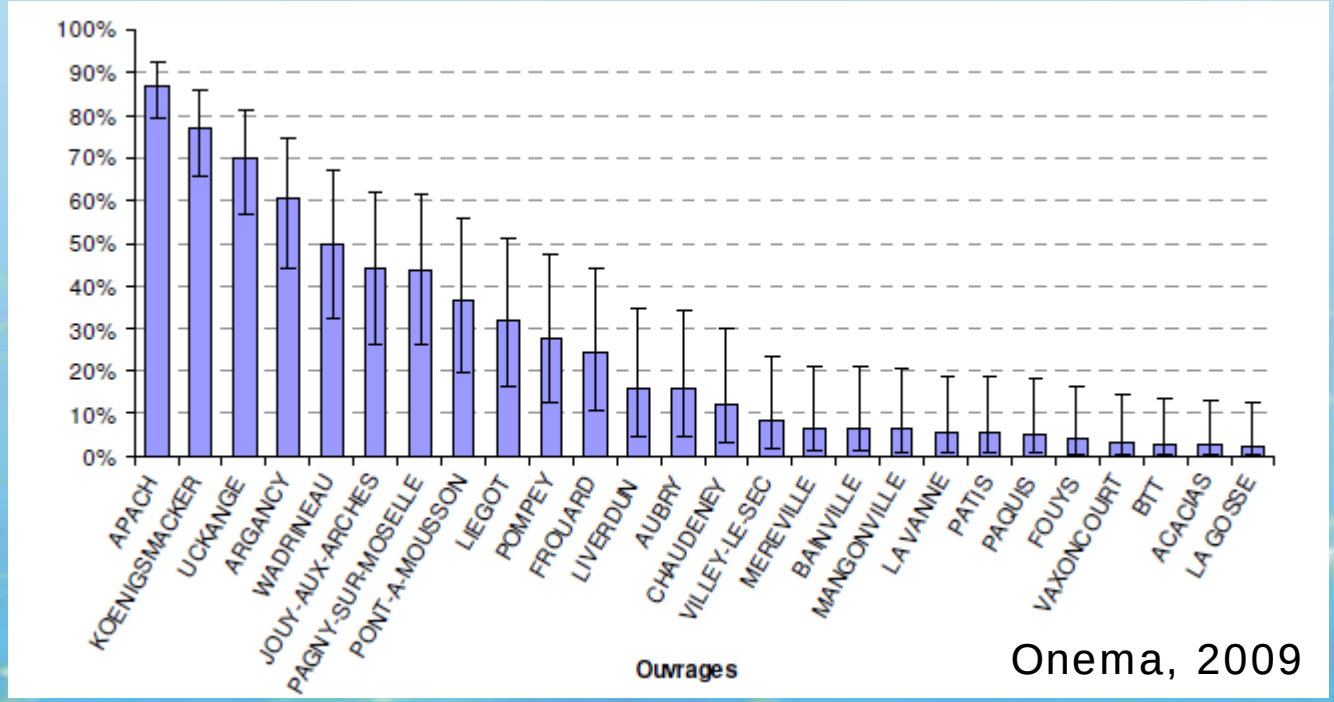


- 1.5 - 150 m^3/s
- 1,5 - 8 m head
- 50 kW – 5 MW

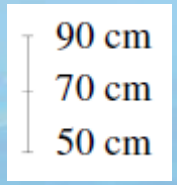
- tests with living Eel
- 3m^3/s, 5.5 m head
- no direct mortality
- no delayed mortality (96 hrs)

Migration success (downstream)

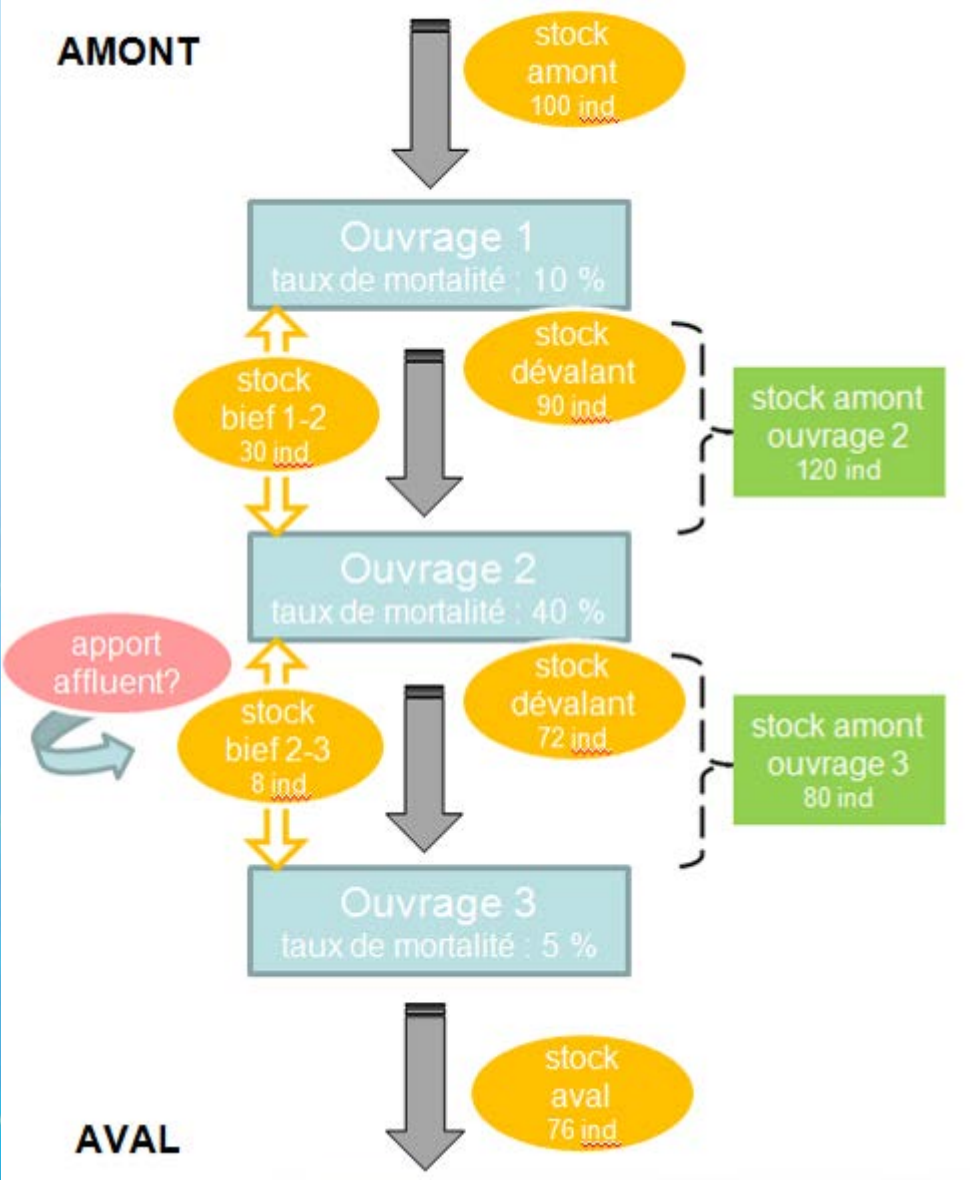
Estimation on ecologic continuity deteriorations for Eel (Mosel river)



Onema, 2009



Estimation on downstream migration: Ill-system (Eel, Smolt)

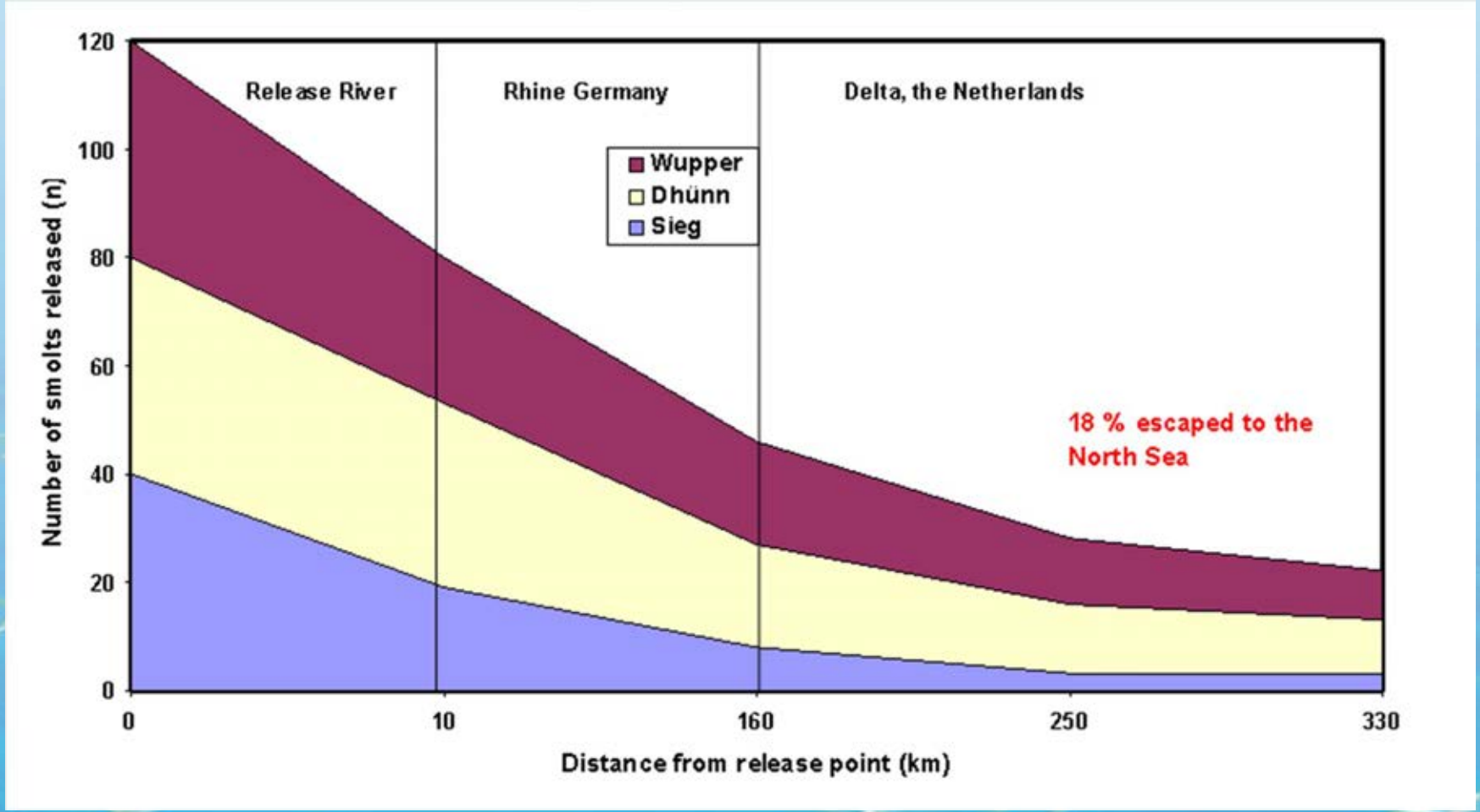


Total estimated reduction of production of Salmon: 26 %

Total estimated reduction of production of Eel: 29 %

Onema, 2014 (in prep)

Telemetry of Smolts from river Sieg (DE) to the North Sea (NL) (2008)



18 % of the Smolts reached the North Sea

NB: hardly hydropower in that stretch of the Rhine!

Conclusions

- After water quality and upstream connectivity, now attention to downstream migration
- Hydropower forms a serious threat to migrating fish
- Both direct (turbines, waste screens) and indirect effects (e.g. increased predation)
- Cumulative effects are significant
- Recent developments on small hydropower installations (≤50m3/s) look promising, but must be checked on site
- Developments on larger installations (up to 350 m3/s) are urgently needed, especially on alternative turbine design

Thank you for your attention

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