



# Smolt run: Experiences from research projects and the North Rhine-Westphalian migratory fish program

01.03.2019 – Dipl.-Biol. Karin Camara

Location: Landgoed Altembrouck, 's Gravenvoeren, Belgium

# Content

- What is LANUV NRW?
- Main tasks / key figures
- Applied Research & investigations on smolts
- The „HDX-Project“
- Migrating fish program – special investigations



Species protection (fish, crabs, shells), water development and special information systems



Aquaculture, species-appropriate fish farming resource efficiency  
(NRW = third largest producer country in Germany)



Biomonitoring, river & lake fishing

## Core tasks LANUV NRW Fisheries Ecology



Training center for fisheries & environmental education as well as training location in the teaching profession Fischwirt  
(one of three locations in Germany for inter-company training of fish farmers; largest training location in NRW)



fish health, animal welfare



# LANUV NRW Fisheries Ecology

## A few key figures

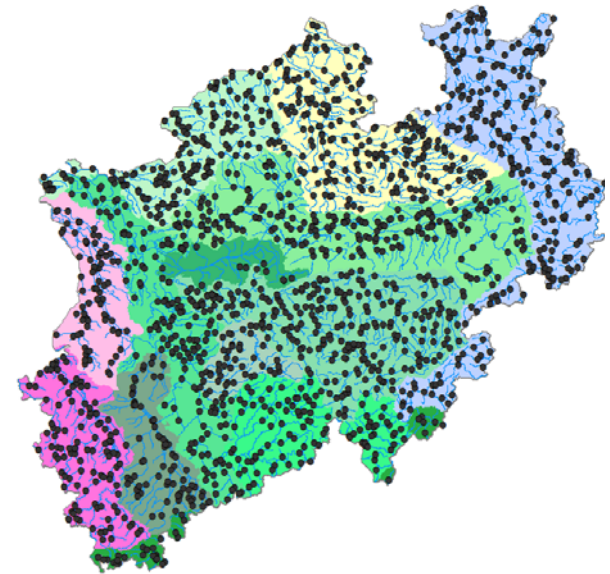


Recording and evaluation of fish fauna in 1.500 river water sampling sites in NRW in the 3-year cycle (EU-WFD & FFH)

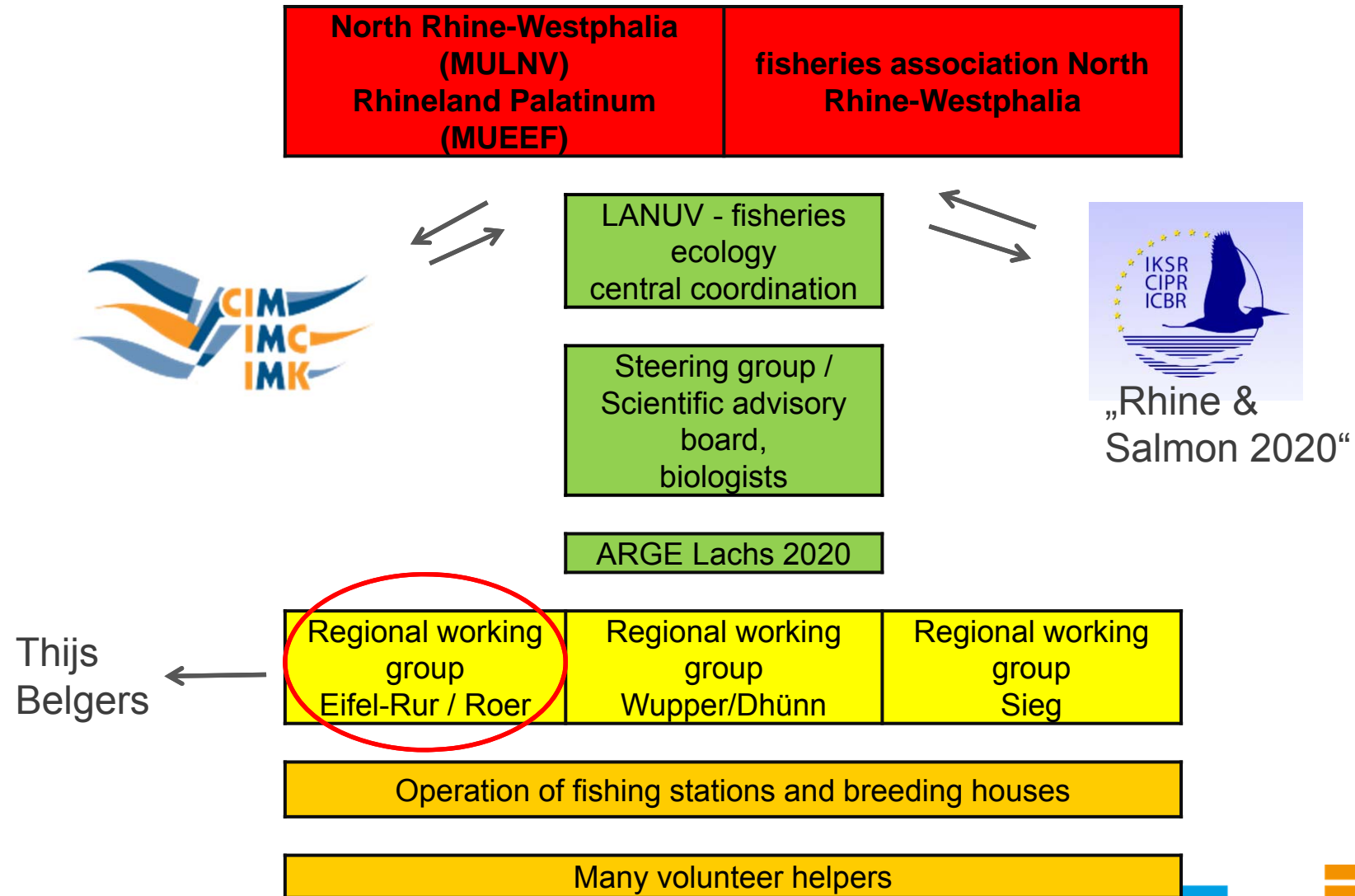


Extraction & breeding of up to one million salmon eggs / year & application in suitable rivers (migratory fish program NRW)

Procurement of 1 million eels / year and restocking in suitable rivers (EU Eel Regulation)



# Migrating fish program NRW - Organization



# The “HDX-Project”:

Bezirksregierung  
Düsseldorf



# The “HDX-Project”: How far do fish migrate in the river Wupper?

## Some results from the HDX fish monitoring 2013-2018

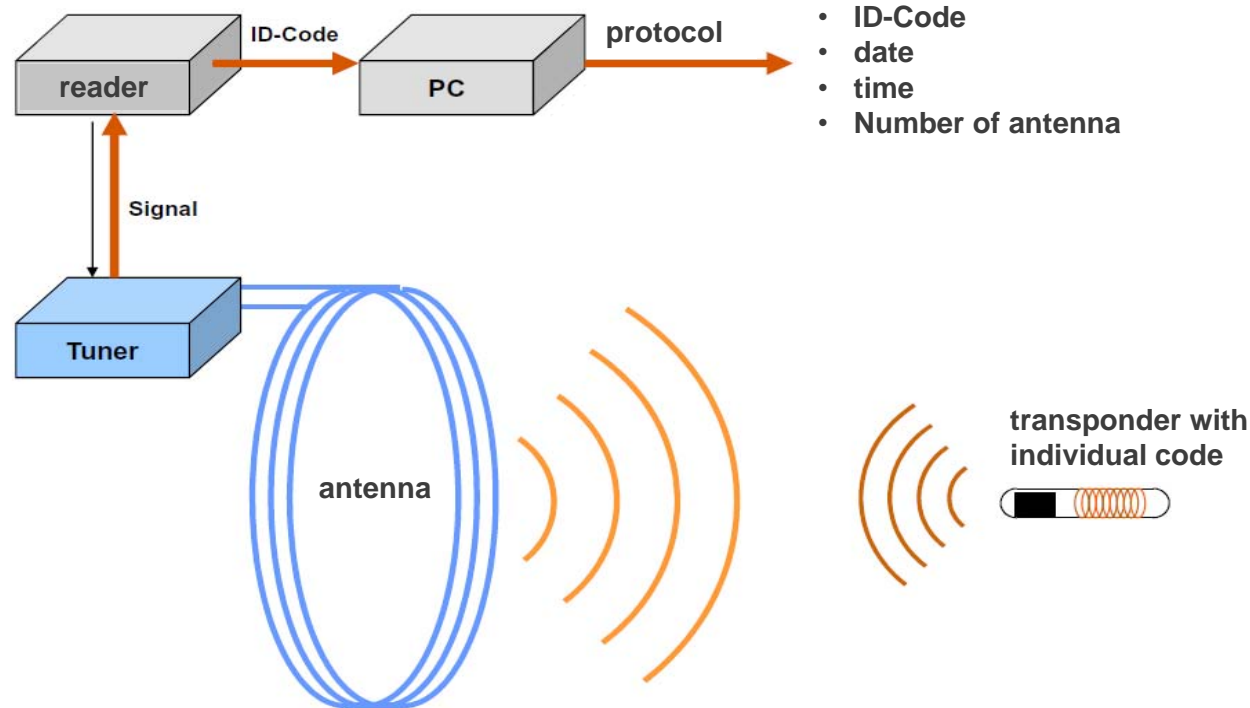
### Background:

- 1) Fish-monitoring as a condition for the extension of the water right to operate the hydroelectric power station at the location Auer Kotten (Wupper)
  - 2) Comprehensive information about the effectiveness of restoration measures that have been implemented over the last 20 years in the river Wupper.
- Besides Auerkotten, five more hydropower plants and parts of the river were equipped with 31 HDX antennas, covering a river stretch of 70 km.
  - A total of 3.088 wild fish from below and above the WKA locations were caught and tagged with HDX-transponders and restocked,
  - as well as a total of 564 silver eels (river Mosel) and 3.500 salmon smolts (aquaculture).



# How does HDX technology work?

HDX = HalfDuplex- Radio Frequency Identification



*When the transponder is activated by electromagnetic coupling*

*the transponder transmits its ID code, which the antenna receives*



LANUV 01.03.2019

Figure:  
Institut für angewandte Ökologie,  
changed by LANUV)



# How were the fish individually recorded in the Wupper?



„swimm through“  
HDX-antenna  
at turbine spout

# How were the fish individually recorded in the Wupper?



„swim over“  
HDX-Antenne in  
main river  
channel

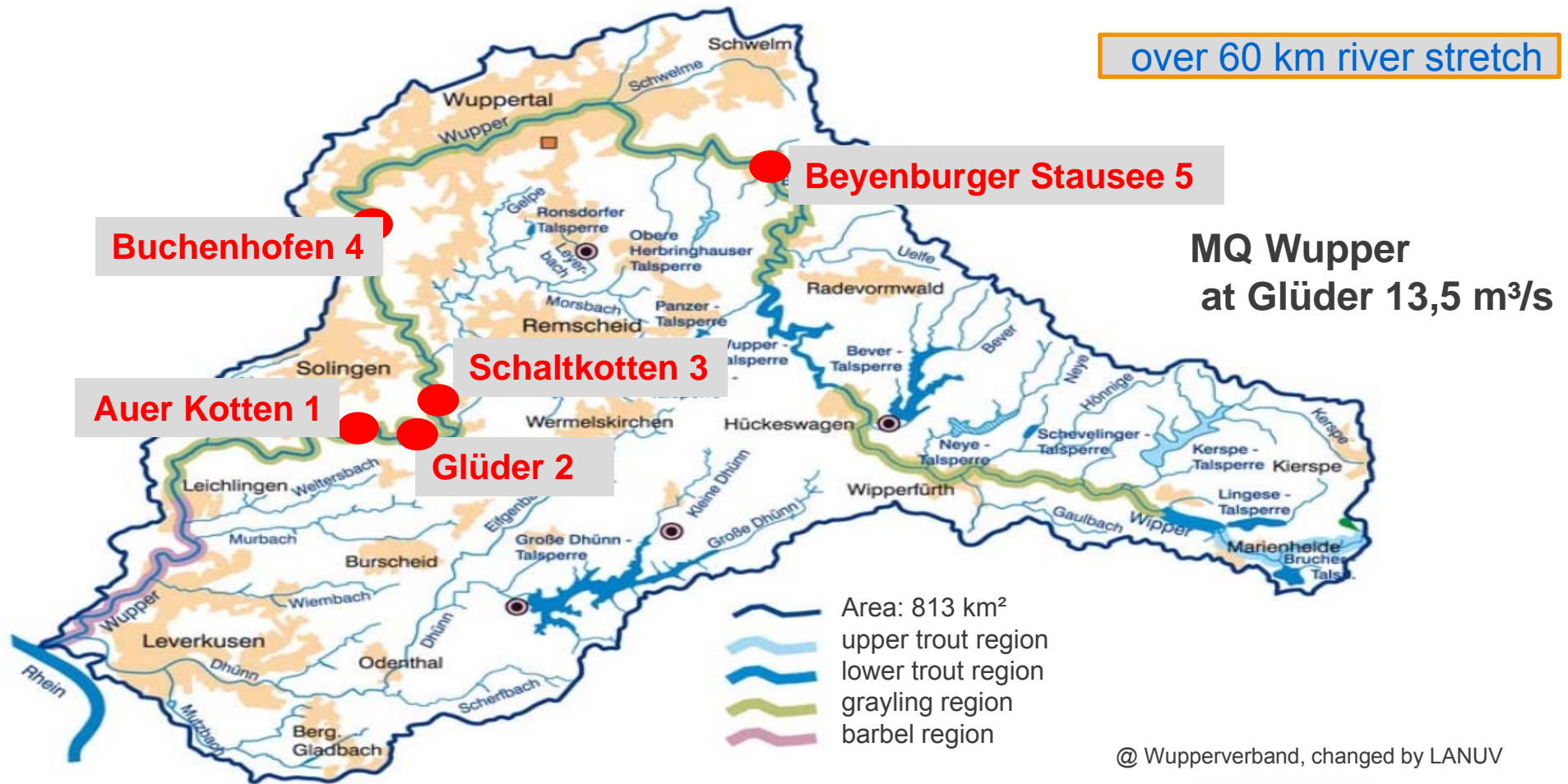
# fishes released in the project area

year	silver eels		salmon smolts		13 more anadromous and potamodromous fish species	
	restocking location	number	restocking location	number	restocking location	number
2013/14	Brücke Glüder & OWK Auer Kotten	269	Brücke Glüder & OWK Auer Kotten	999	Reuschenberger M.	88
2015	-	-	Brücke Glüder & Kohlfurth	500	divers	1.528
2016	Brücke Glüder	295	-	-	divers	1.472
Summe		564		1.499		3.088

In March 2018, a total of 2000 marked salmon smolts were again distributed to locations above each hydropower plant to test how far they find their way down the Wupper.

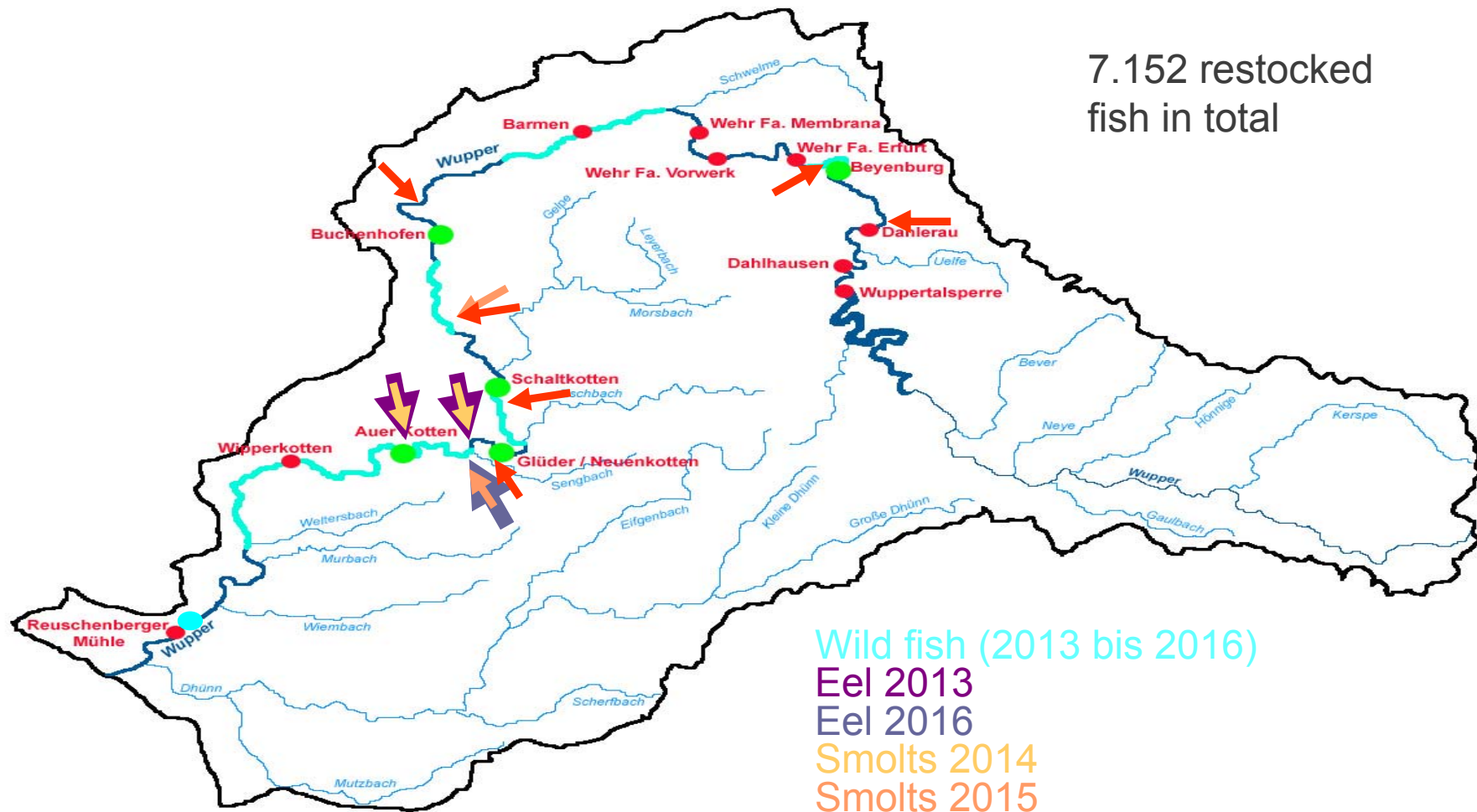


# HDX-antenna Locations





# HDX-antenna locations und restocking



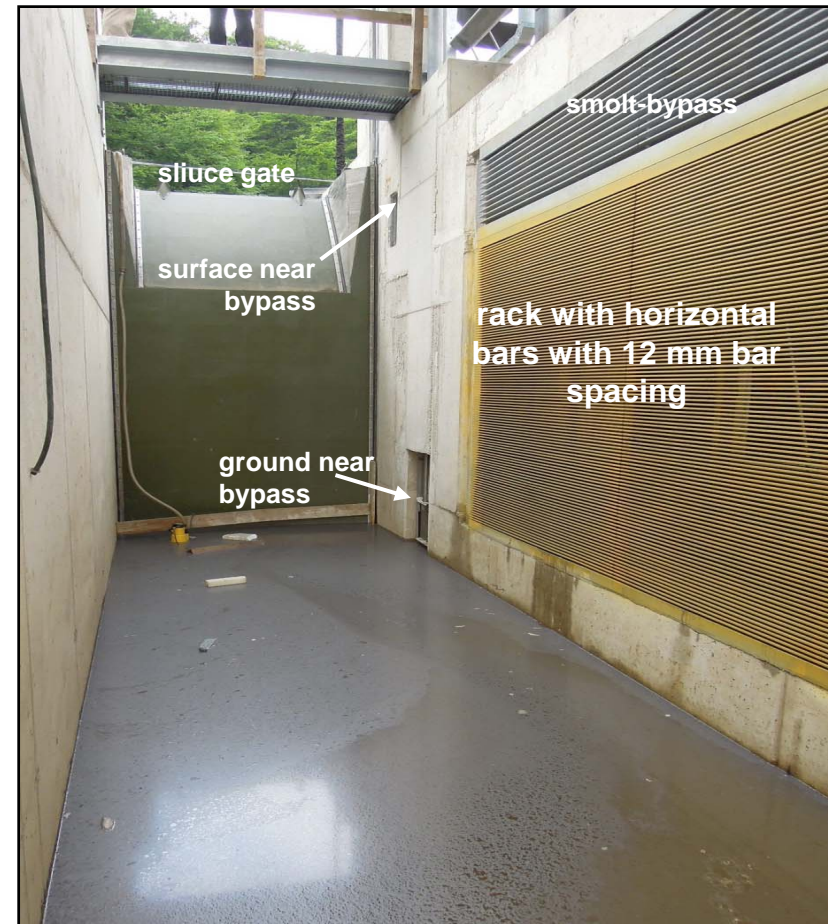
# Hydro power @ (1) Auer Kotten



# Hydro power @ (1) Auer Kotten

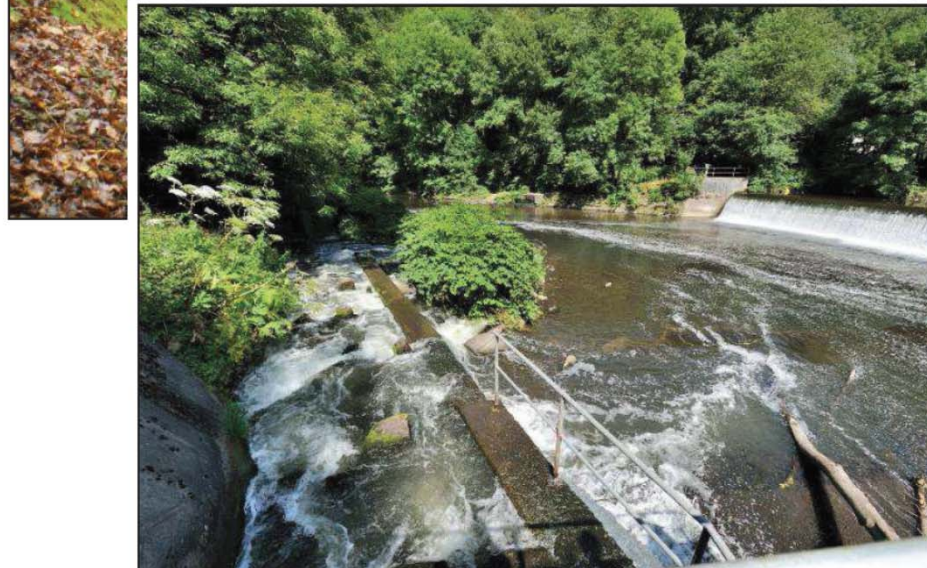
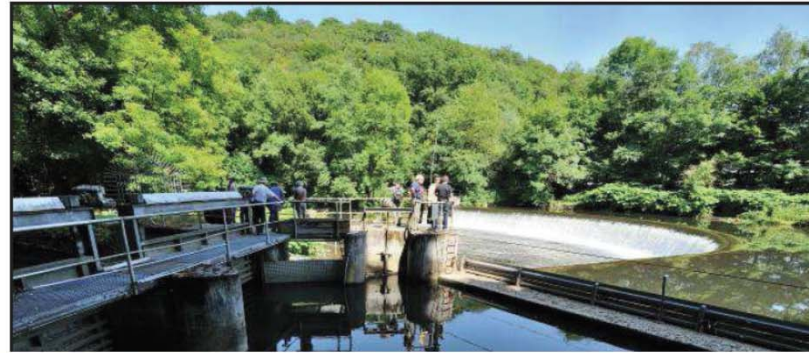
## Passability of the 12 mm horizontal rack

- no salmon smolt or eel migrated across the turbine outlet throughout the study period
- 12 mm horizontal rake is considered to be impassable for these target species



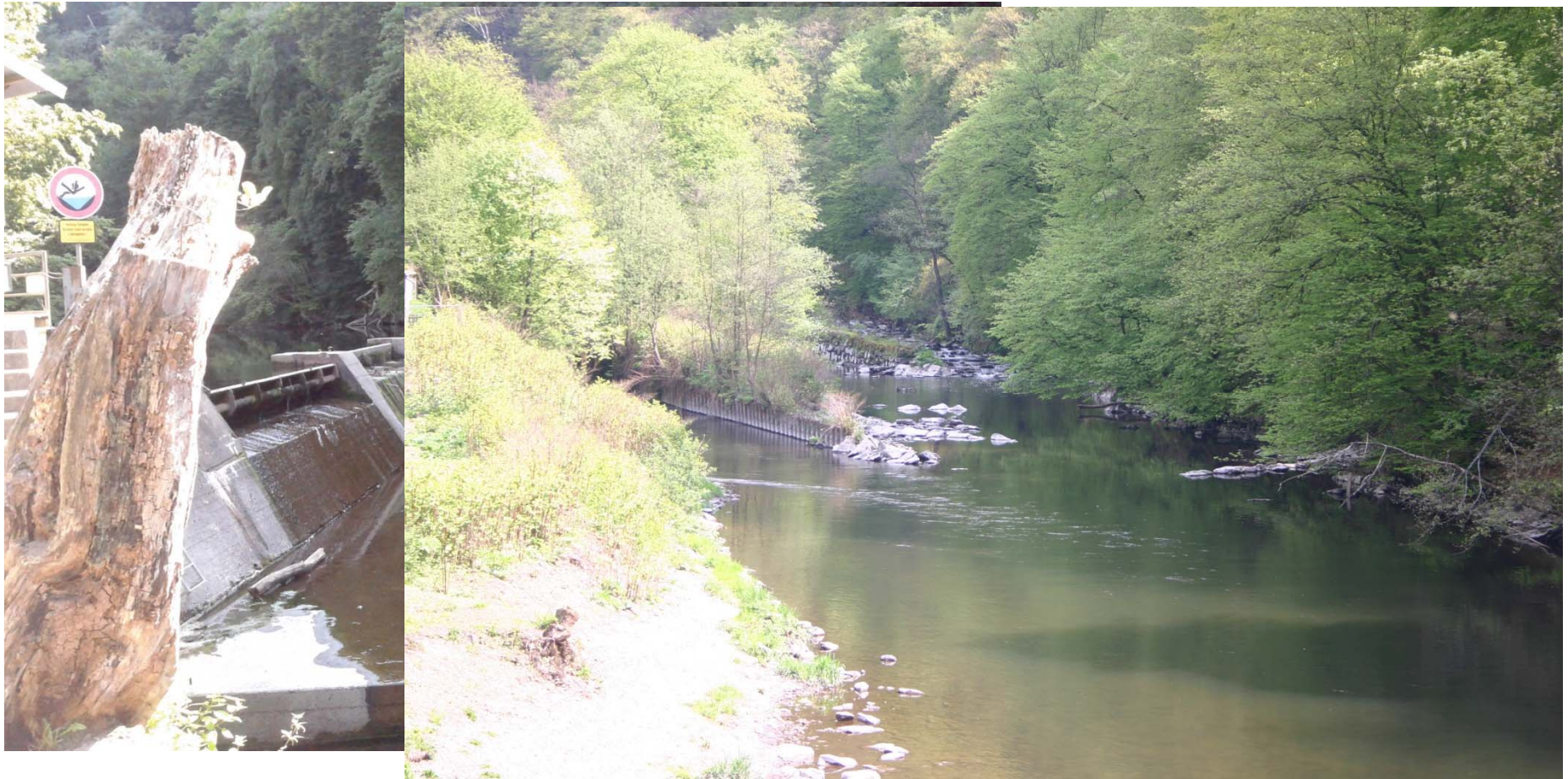


# Hydropower @ (2) Glüder/Neuenkotten (km 25)



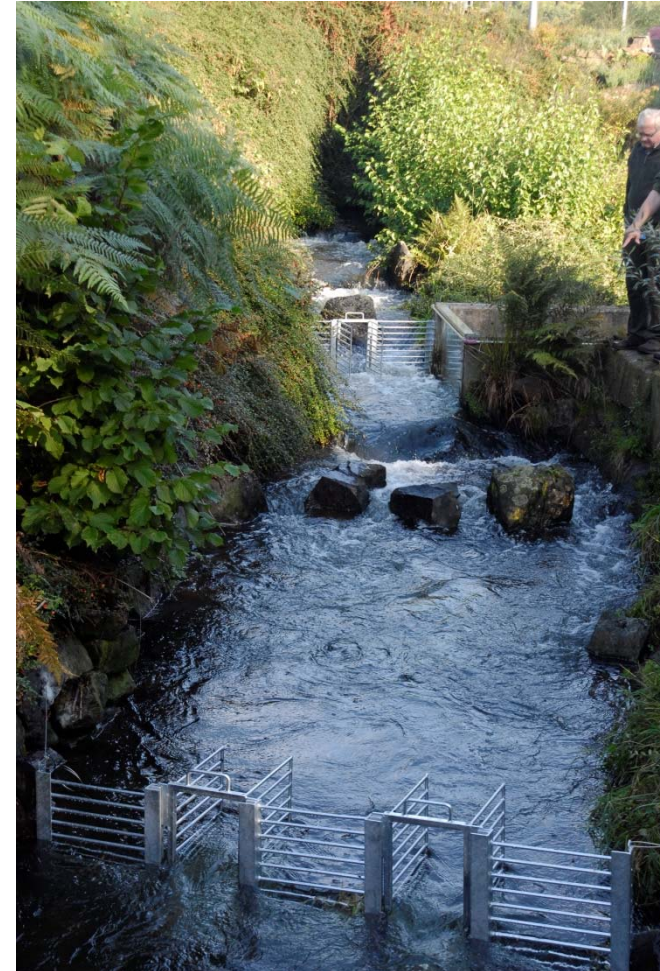


# Hydropower @ (3) Schaltkotten (km 32)





# Hydropower @ (4) Buchenhofen (km 40)



# Fishway @ (5) Lake Beyenburg (km 65)



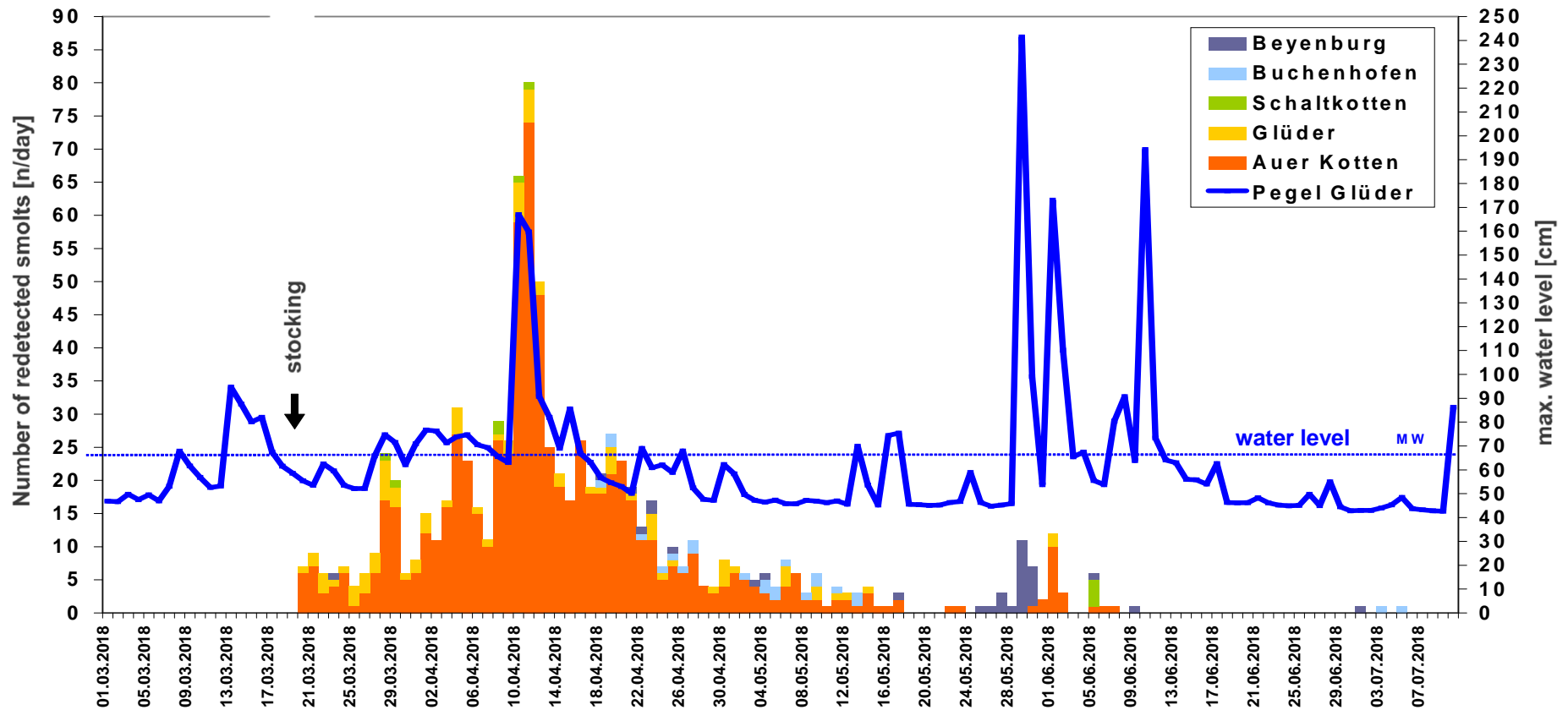


# migrating behavior of restocked smolts

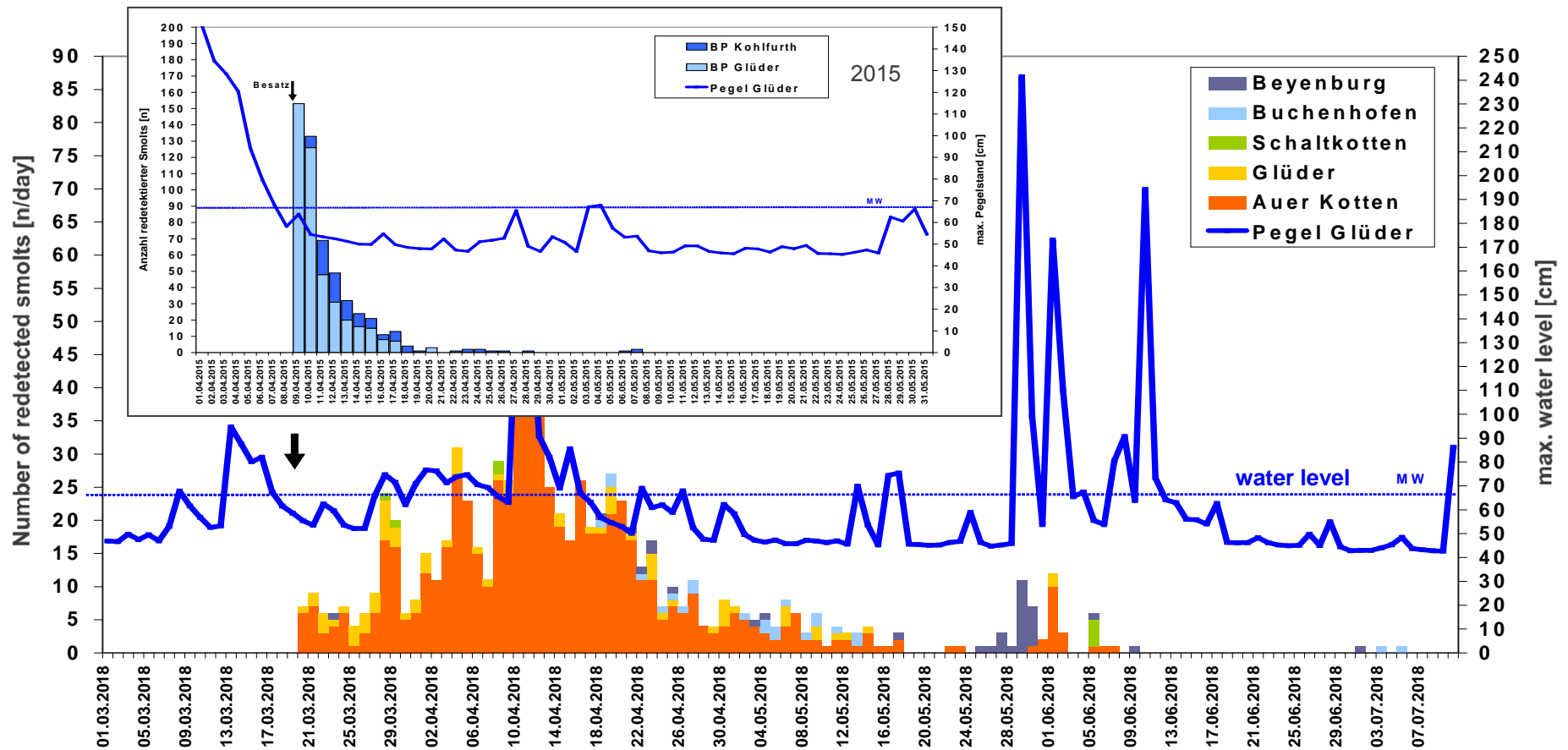




# Redetection rates, smolts 2018

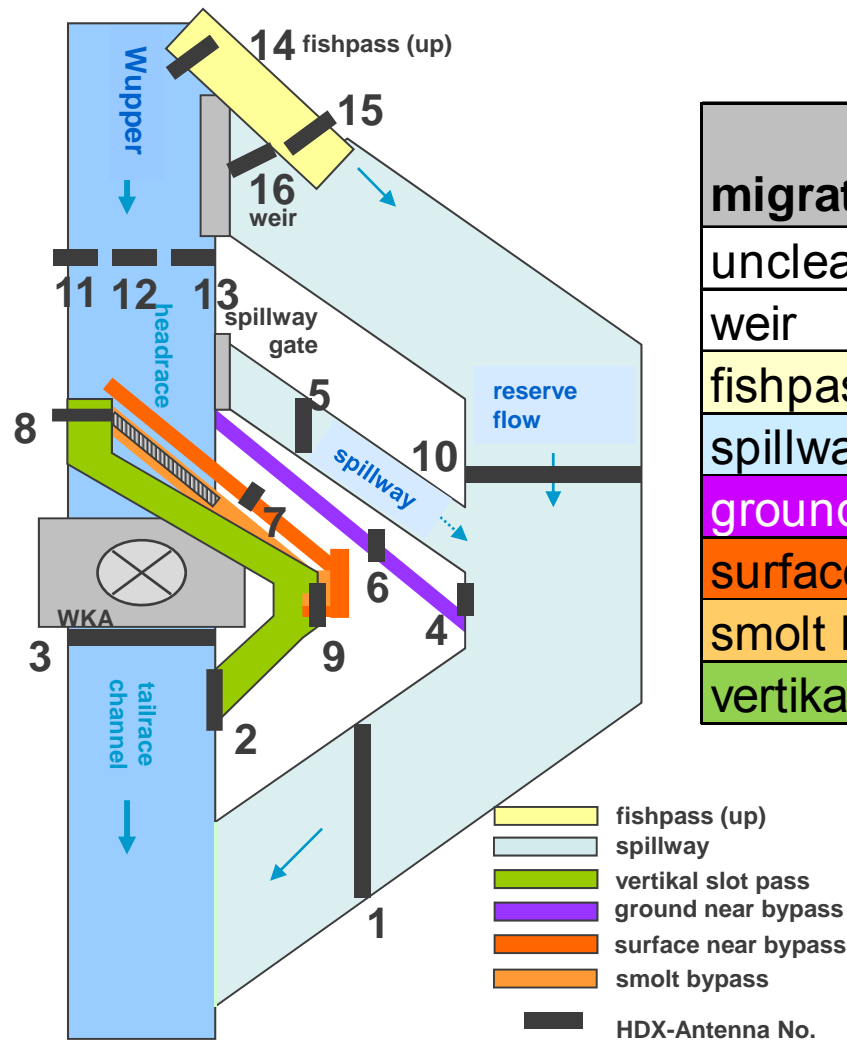


# Redetection rates, smolts 2018



# smolt downstream migration @ Auer Kotten

## 2014



migration route	salmon smolts (n = 525)	
	number	rate
unclear	47	9%
weir	1	0%
fishpass (up)	11	2%
spillway	135	26%
ground near bypass	1	0%
surface near bypass	205	39%
smolt bypass	46	9%
vertikal slot pass	79	15%

Of the salmon smolts registered at Auer Kotten, about 90% have successfully descended into the main river channel below

# smolt downstream migration @ Auer Kotten

## differences between the years

migration route	2014 salmon smolts (n = 525)		2015 salmon smolts (n = 212)		2018 salmon smolts (n = 537)	
	number	rate	number	rate	number	rate
unclear	47	9,0%	4	1,9%	2	0,4%
weir	1	0,0%	0	0,0%	0	0,0%
fishpass (up)	11	2,0%	1	0,5%	9	1,7%
spillway	135	26,0%	7	3,3%	485	90,3%
ground near bypass	1	0,0%	0	0,0%	0	0,0%
surface near bypass	205	39,0%	132	62,3%	28	5,2%
smolt bypass	46	9,0%	37	17,5%	7	1,3%
vertikal slot pass	79	15,0%	31	14,6%	6	1,1%

- Influence of different stocking areas on migration route (2014/2015)
- Influence of a changed operation management since 2016 (spillway)
- Installation of a new antenna 5 (loop) with improved reading performance in May 2016





# smolt downstream migration @ Auer Kotten

migration time over total location  
(entrance gates to underwater):

2015:

14 % within 1 h

49 % within 24 h



2018:

52 % within 1 h

92 % within 24 h



# smolt downstream migration – overall picture

## Redetection rates on HDX-antennas along the river Wupper

Redetection rates, in total:

Smolts	number stocked	redetection rate [%]
March 14	1.000	68,1
April 15	500	65,8
March 18	2.000	32,6

Redetection rates, per stocking area:

redetection rate [%]	Dahlerau (Km 70)	Beyenburg (km 64,5)	Wuppertal (km 43,5)	Kohlfurth (km 36,5)	Müngstener Brücke (km 31,5)	Glüder (km 25)	Auer Kotten (km 22)
2014						68,5	67,7
2015				43,6		88,0	
2018	10,3	24,3	32,6	43,6	48,3	39,7	



# smolt downstream migration @ Auer Kotten

## total migration time of two individuals

Smolt, 16 cm (ID 183596363)		
date	time	action
14.03.2014	11:30	stocking at Glüder
15.03.2014	00:54	redetection at Auer Kotten (Ant. 12)
15.03.2014	01:51	surface near bypass (Ant. 7)
20.03.2014	12:59	inflow gate Auer Kotten (Ant. 12)
20.03.2014	13:07	inflow gate Auer Kotten (Ant. 13)
27.11.2017	22:07	redetection at main channel Auer Kotten (Ant. 1)
28.11.2017	02:51	main channel Auer Kotten (Ant. 1)

Smolt, 16 cm (ID 183590256)		
date	time	action
14.03.2014	11:00	stocking at inflow gate Auer Kotten
15.03.2014	02:06	redetection surface near bypass (Ant. 7)
16.03.2014	several	inflow gate Auer Kotten (Ant. 11-13)
06.04.2014	several	inflow gate Auer Kotten (Ant. 11-13)
03.01.2018	12:07	redetection weir Auer Kotten (Ant. 16)

# Take home messages (all fish)

## method

- The detection security of HDX antennas is:  
“swim-over”: 70 %      “swim-through”: 80 to 90 %
- Fish tolerate transponders well, individuals can be detected for many years.

## biology of migration / changes of location

- fish migration, upstream and downstream, occurs in every season
- Downstream migration
  - occurs mostly at dusk and night
  - > 80% of the fish migrate with the main flow via the water power plant
  - A permanently open migration route with high discharge is preferred
- Upstream migration
  - > 60% of the upstream migrating barbels follow the mainstream to the hydro power plant, while nase prefer the reserve flow, if depth and discharge is sufficient for them
  - Two salmon smolts, transponded and stocked in 2014, were detected as adult returners in 2017 / 2018





# Take home messages (all fish, Auerkotten)

## Efficiency of the 12 mm horizontal rack for the fish protection (Auer Kotten)

- the protective effect is proven for silver eels and salmon smolts

## Efficiency of bypasses for the fish migration (Auer Kotten)

- spillway gate and vertical slot pass are the primary downstream migration routes
- only the surface-near bypass has about 10% effectiveness, all other bypasses make no significant contribution

## Efficiency of operation management (spillway gate, Auer Kotten)

- good for salmon smolts: their migratory time is reduced significantly and the ½-hour changes from 19 to 6 o'clock fit
- brings only little improvement für eels



# Take home messages

## Continuity the watercourse for migrating smolts

- about 1/3 of the downstream migrating smolts reached the river Rhine

## Functionality of fish passes for potamodromous fish species

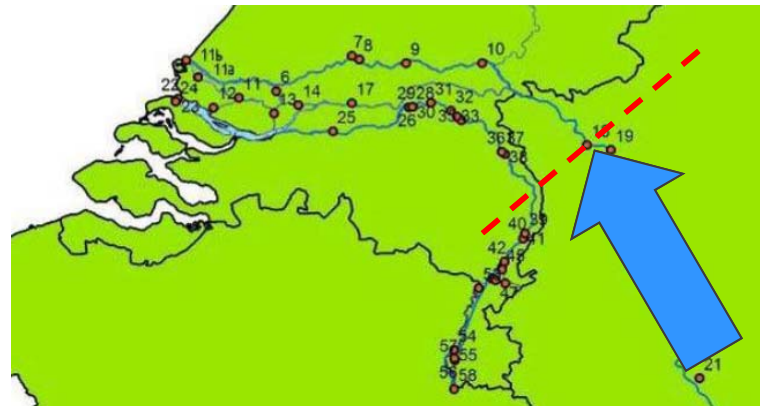
- Good fishways for upstream migration achieve a maximum effectiveness of 70%
- An ecological continuity for 50% of the fish has already been reached after the first hydropower plant location

# Migrating fish program - investigations

## NEDAP studies on salmon (D / NL)

From 2006-2011 and 2013-2016, we tagged every year around 130 smolts (aquaculture) with NEDAP transponders in D-NL cooperation and monitored their run from german Rhine tributaries to the North Sea.

- Including the losses due to technical reasons, average losses of 90% of the fish were detected for the entire salmon run to the North Sea.
- The losses occurred mostly above the station Xanten (stocking in rivers Sieg / Wupper / Dhünn)

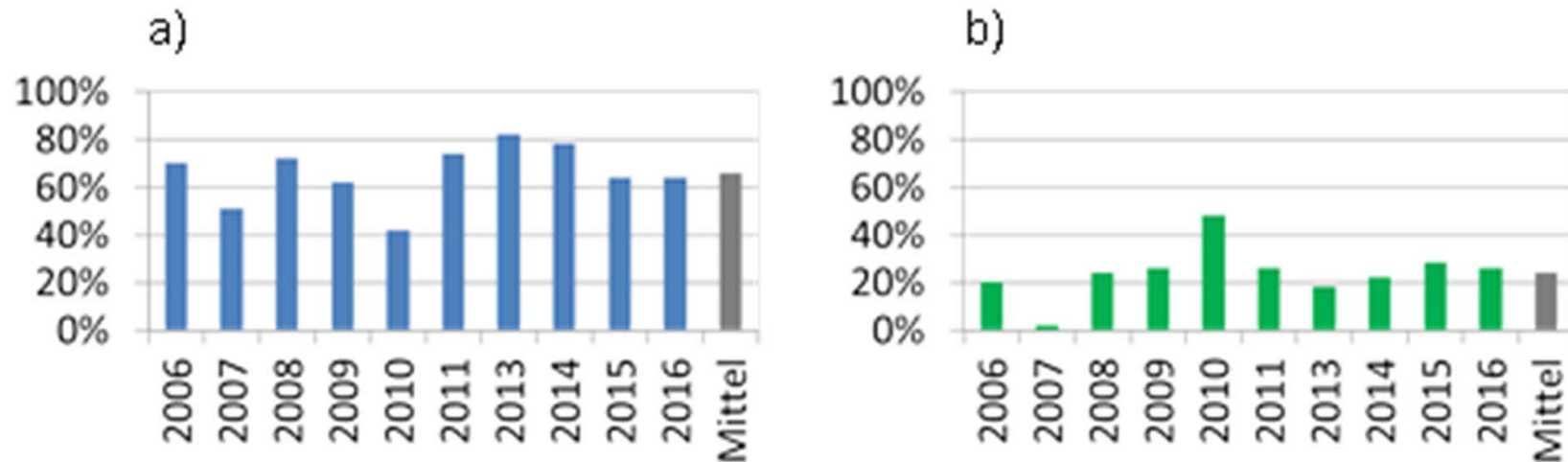




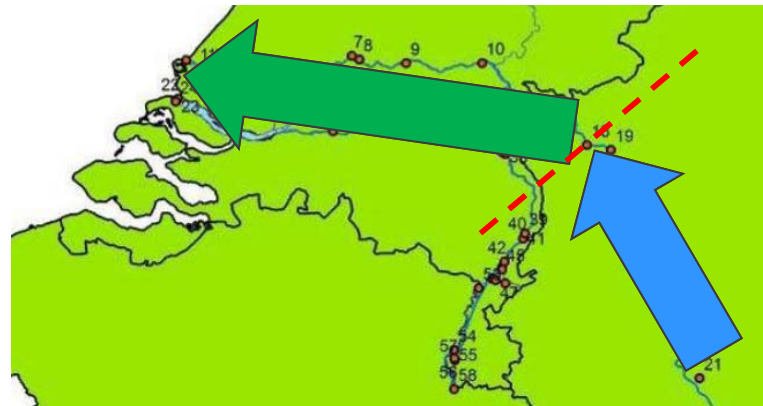
# Migrating fish program - investigations

## NEDAP studies on salmon (D / NL)

Detection losses during the smolt run from NRW program waters  
a) to Xanten\*, b) from Xanten to the North Sea



\* numbers include losses through damage / weakening / stress (transport / marking, etc.)



# Migrating fish program - investigations

## Search of transponders in german cormorant colonies

Motivated by a random finding of transponders of tagged fish in a colony of cormorants at the Maas in 2013 (NL), subsequent orienting searches were carried out, there.

Likewise, special investigations were carried out in the course of monitoring the smolt migration from the North Rhine-Westphalian program waters

- Involved: Dutch and North Rhine-Westphalian state employees (RWS, LANUV, MKULNV), their representatives and other regional representatives (bio station, fisheries association)
- Location: Bislicher Insel, Dondorfer See, Monheimer Baggersee, Sieglarer See, Trerichsweiher, Dhünntalsperre

# Migrating fish program - investigations

## Search of transponders in german cormorant colonies

- A total of 115 NEDAP transponders were found

Jahr	2013	2014	2015	2016
Bislicher Insel	-	4	-	-
Dondorfer See	-	2	1	-
Monheimer Baggersee	-	9	15	1
Sieglarer See	4	10	3	19
Trerichsweiher	-	9	19	37
Dhünntalsperre	-	-	0	-





# Migrating fish program - investigations

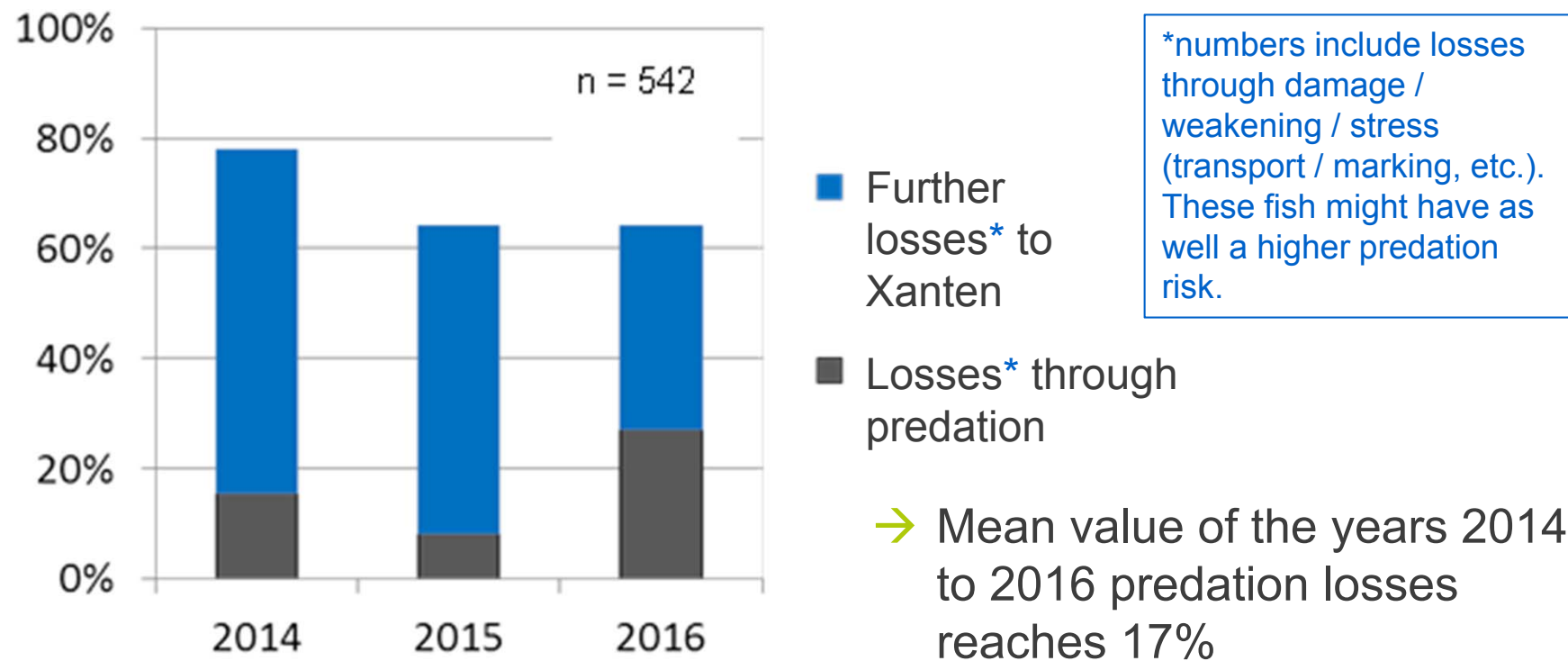
## Search of transponders in german cormorant colonies, transponders:

- 95 of the found transponders could be uniquely assigned to the respective smolt stocking batches of the NRW program waters
- 20 transponders came from projects of previous years and / or other studies (two smolts from 2010, two smolts from 2011 and 2013, two eels from 2011 and 2014, a sea lamprey from 2009), or were not yet assigned
- Remarkable: Detection of five transponders, which were implanted in fish exposed more than 100 km from the site in the Maas system

# Migrating fish program - investigations

## Search of transponders in german cormorant colonies

**Losses of downstream migrating smolts** (*Salmo salar*, from aquaculture) **by predation**, evidenced by found transponders in cormorant colonies as well as further losses to Xanten



# Migrating fish program - investigations

## Search of transponders in german cormorant colonies

### Preliminary conclusion:

- A significant proportion of detection losses in the immigrant investigations of smolts are due to predation!

It is not possible to say clearly:

- whether smolts were first taken by other fish and then by the cormorant, or the predation was made directly by the bird
- the role of the marking / transport stress in relation to the predation events (higher risk)
- to what extent wild smolts would fall prey to a comparable predation, since so far none could be used (size of NEDAP is too big)
- further evaluations and investigations are in progress / planning ...



# Thank you!

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