Session E2: Downstream Migration of 2+ Salmon Smolts (Salmo Salar) in the River Meuse in the Netherlands

Rijkswaterstaat
Ministry of Infrastructure and the Environment

Downstream migration of 2+ Salmon smolts (*Salmo salar*) in the river Meuse in the Netherlands.

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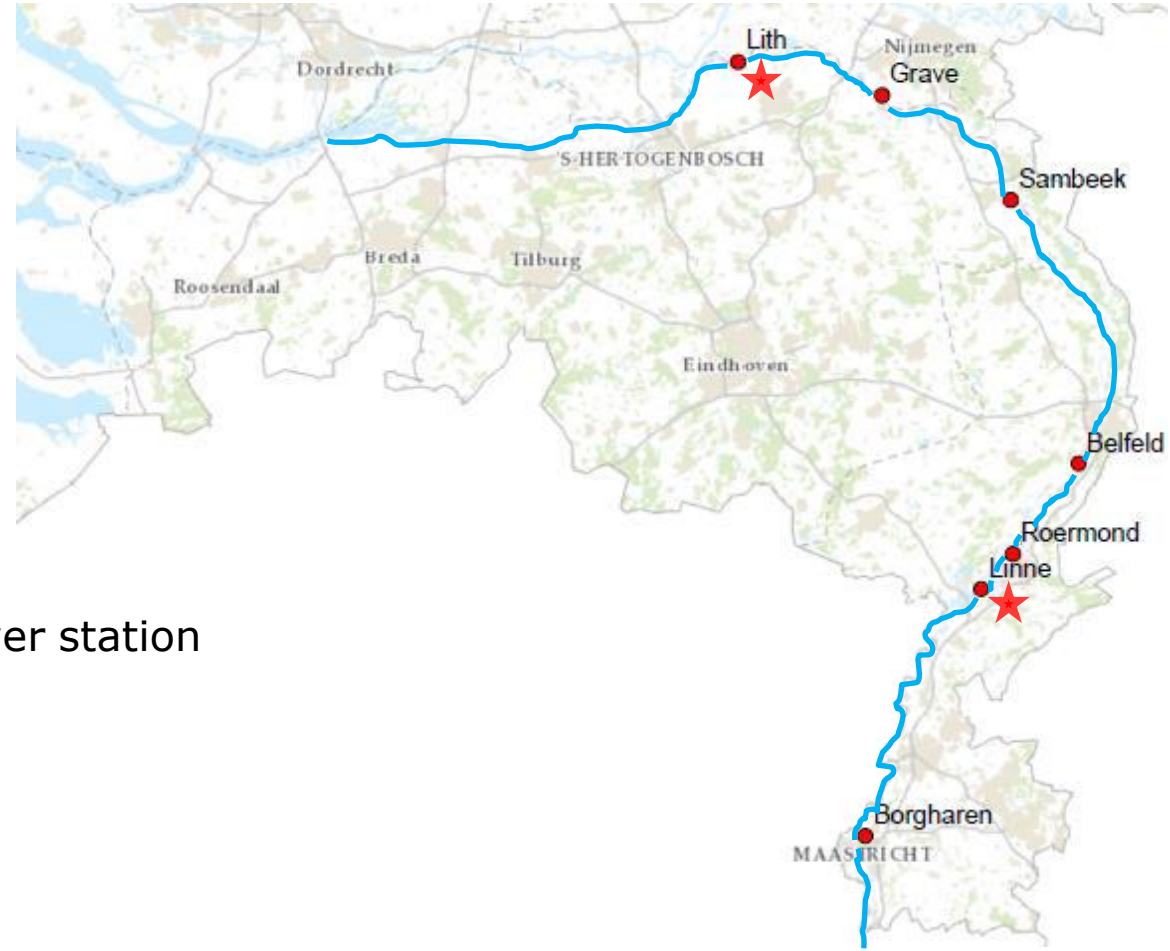
Aim of the study

- To gain insight in the migration of Salmon smolts in the river Meuse, to determine choice of route and migration speed of individual fishes in relation to river discharge and other factors;
- To obtain a reliable estimation of the average mortality of Salmon smolts during downstream migration in the Dutch part of the river Meuse
- To quantify direct and indirect mortality of smolts passing hydropower stations and weirs.

This knowledge helps to formulate suitable measures to facilitate fish migration at barriers like hydropower stations and weirs, to protect fish in general and to support decision making in the process of licencing hydropower stations.

Weirs and hydropower stations in the river Meuse

North Sea



★ = hydropower station

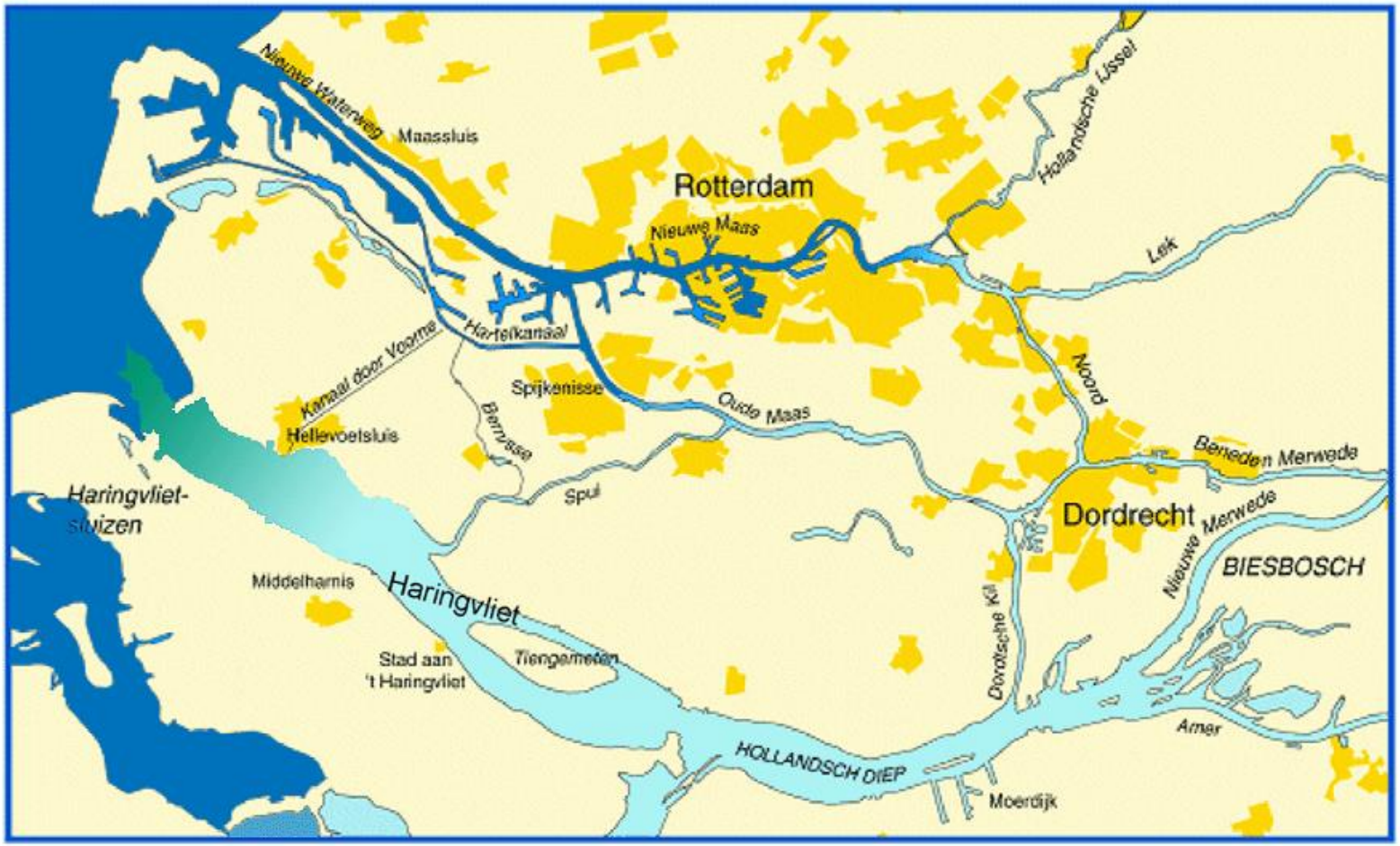
● = weir

Hydropower station Linne, weir and fishway

Weir at Linne

Fishway Linne

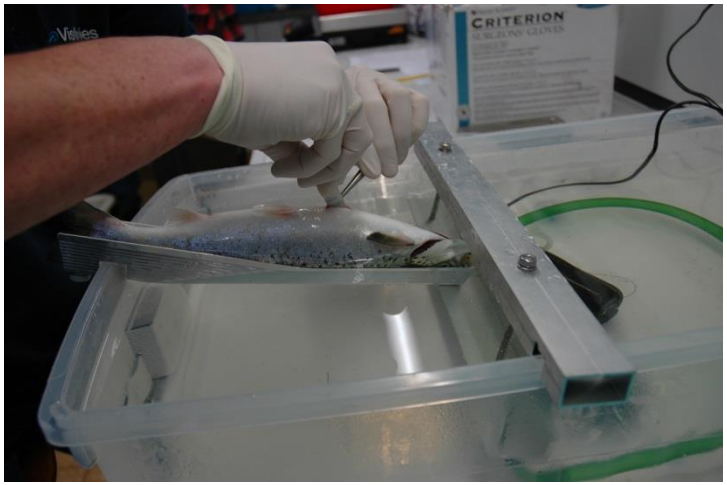
Delta area of river Rhine and Meuse

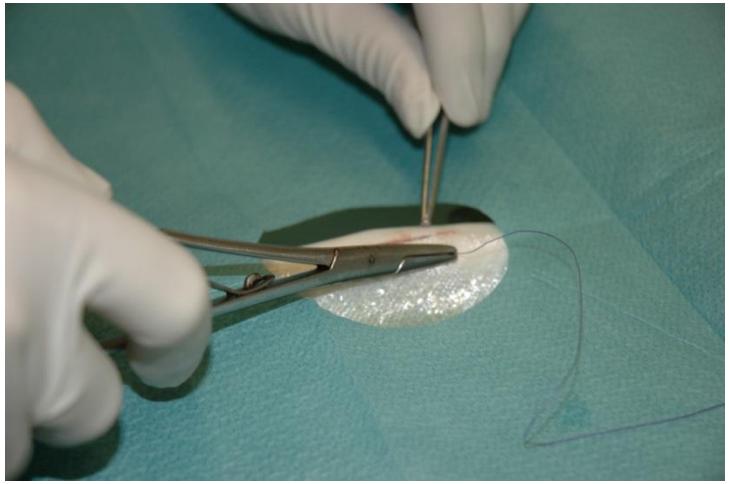


Haringvliet dam near the North Sea

Sluices of Haringvliet dam

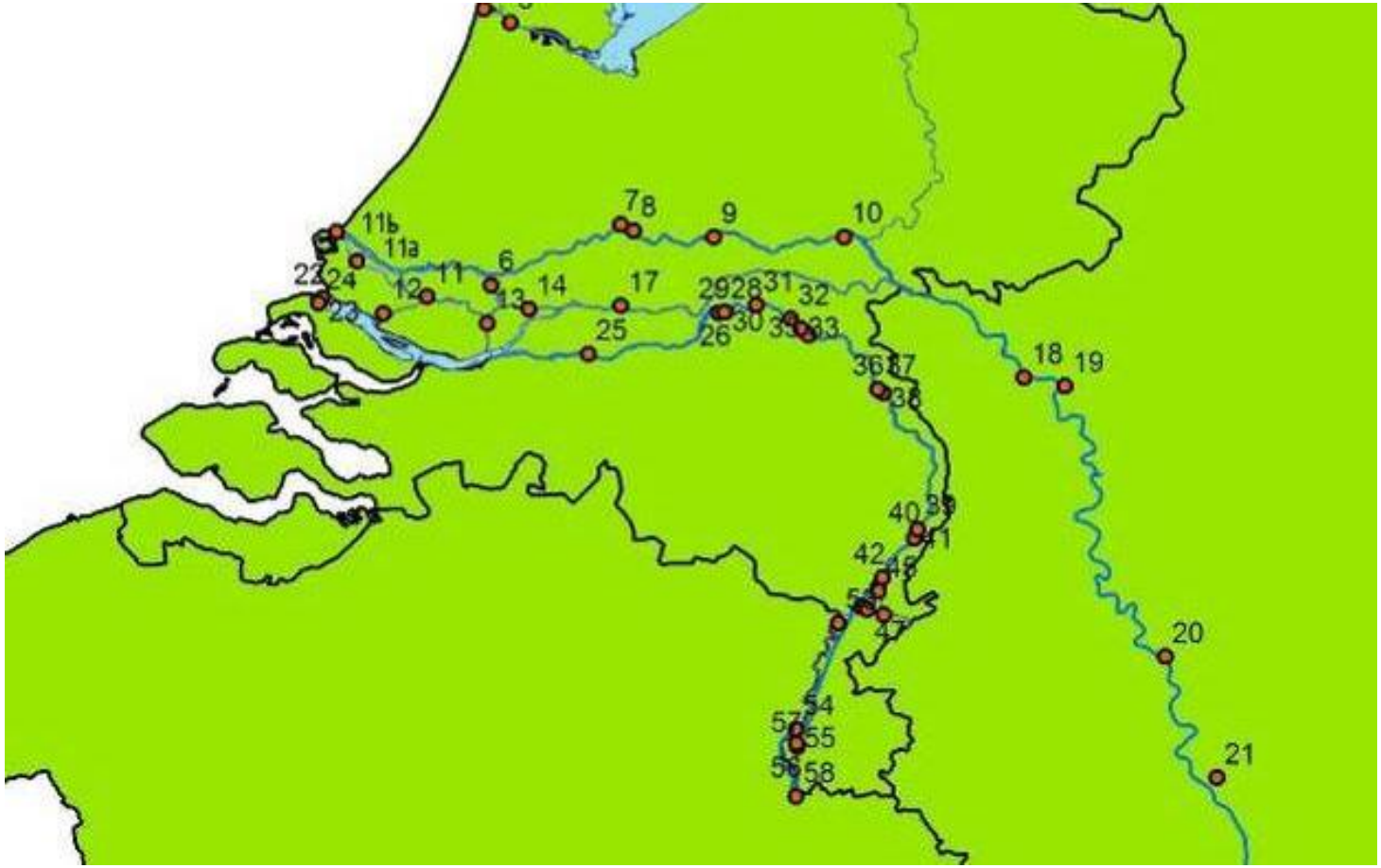
Implantation of a transponder



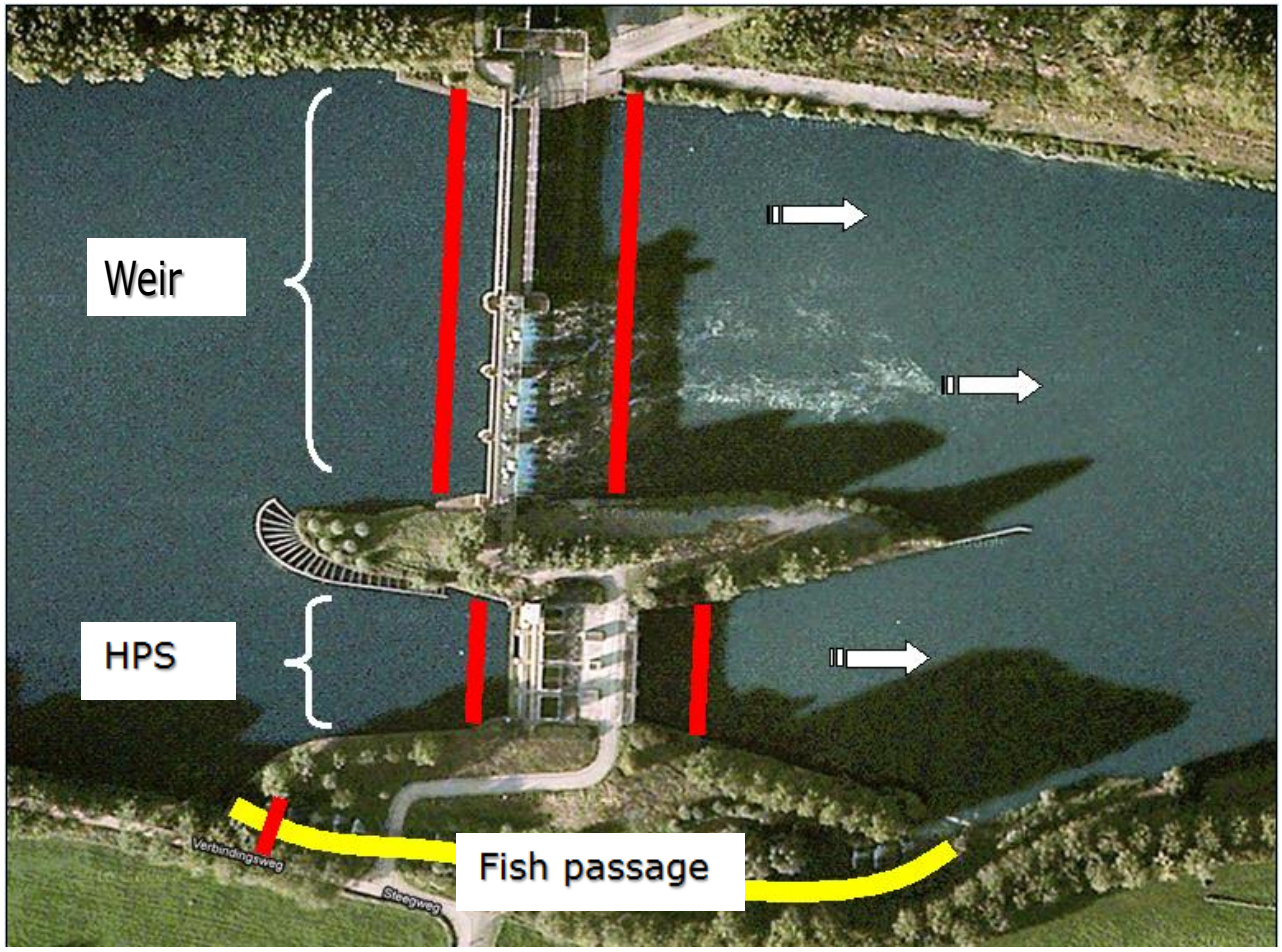


Transponders

Detection stations in river Rhine and Meuse



Detection stations at Linne

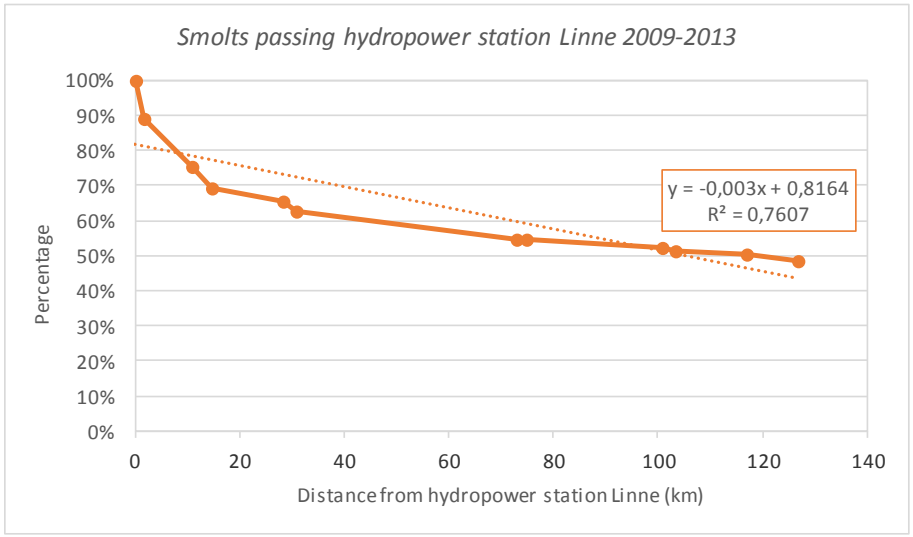


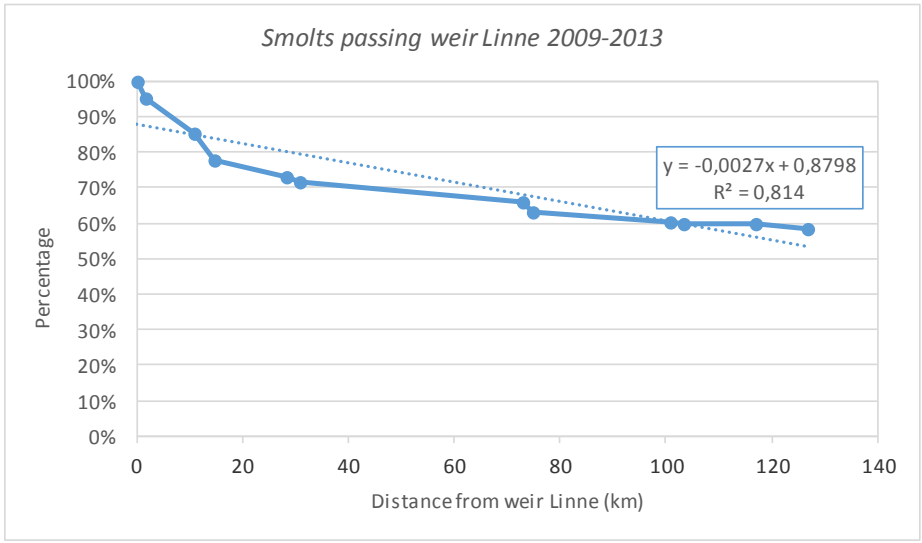
Results migration of smolts 2009-2013

- In total 897 smolts were released at two different locations in the river Meuse (near Belgian border and 56 km downstream)
- At location Linne, 192 smolts passed through the hydropower station and 144 smolts passed over the weir in downstream direction.
- In the downstream river stretch from Linne to Lith (126 km), 52% of the smolts that passed through the hydropower station Linne were lost, compared to 42% of the smolts that passed over the weir

Migration of smolts 2009-2013

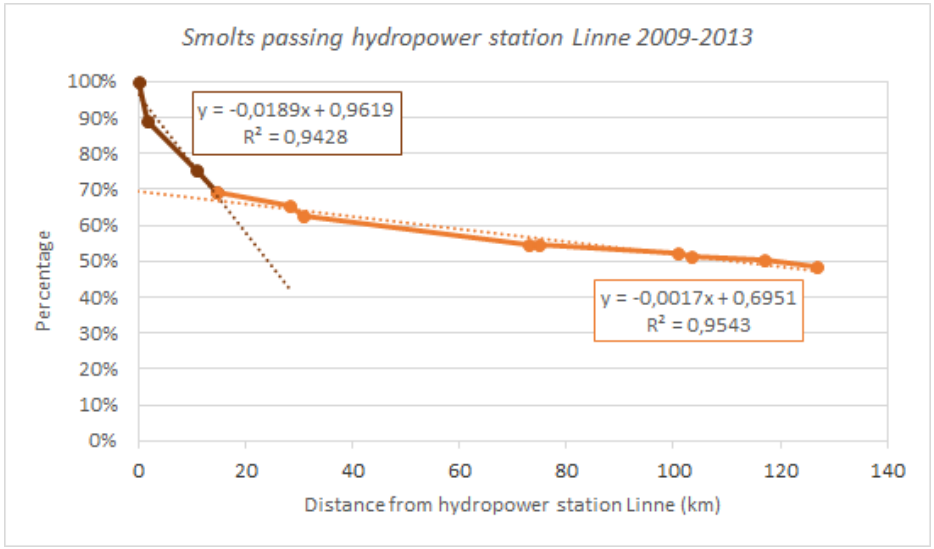
Linear regression shows no significant difference in mortality rate of smolts passing through the hydropower station and smolts passing over the weir.

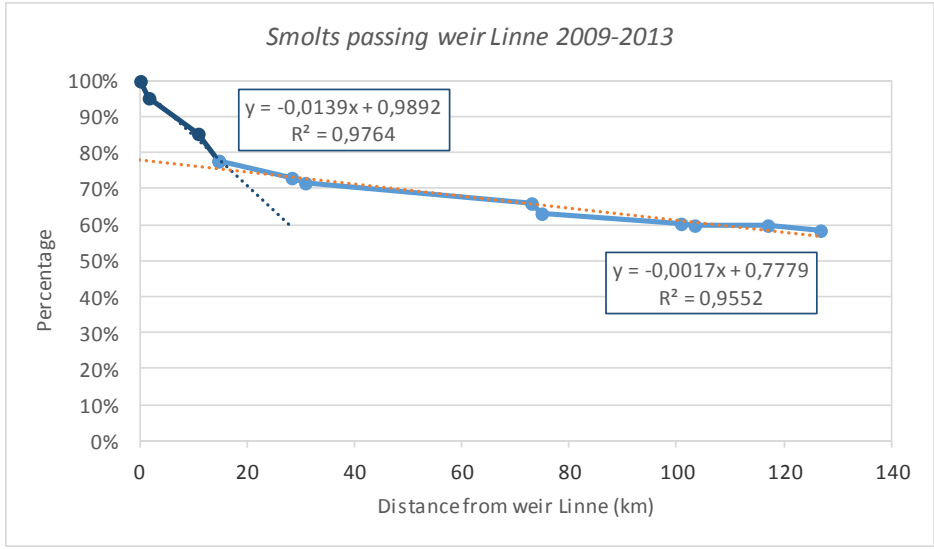




Migration of smolts 2009-2013

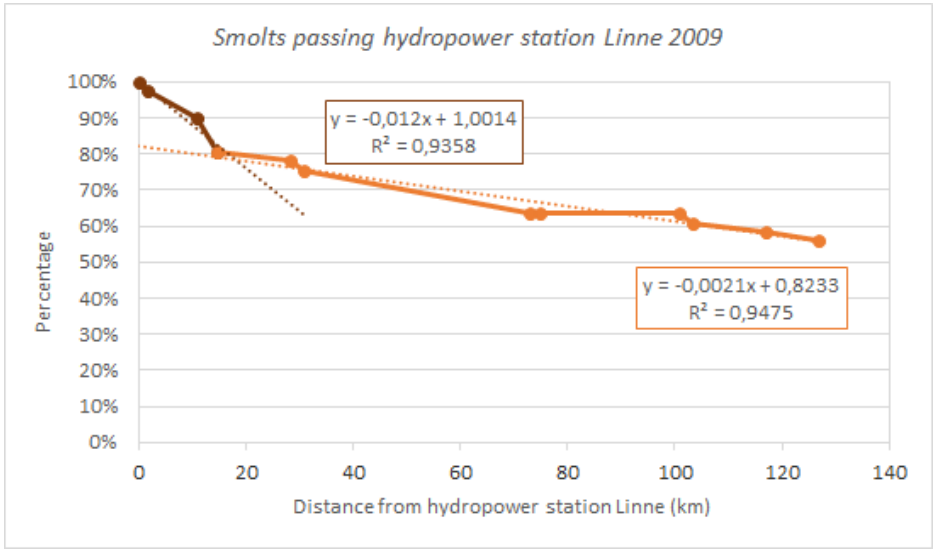
Segmented linear regression shows significant difference in mortality rates over the first stretch after passing hydropower station and weir, compared to the latter part of the route to sea.

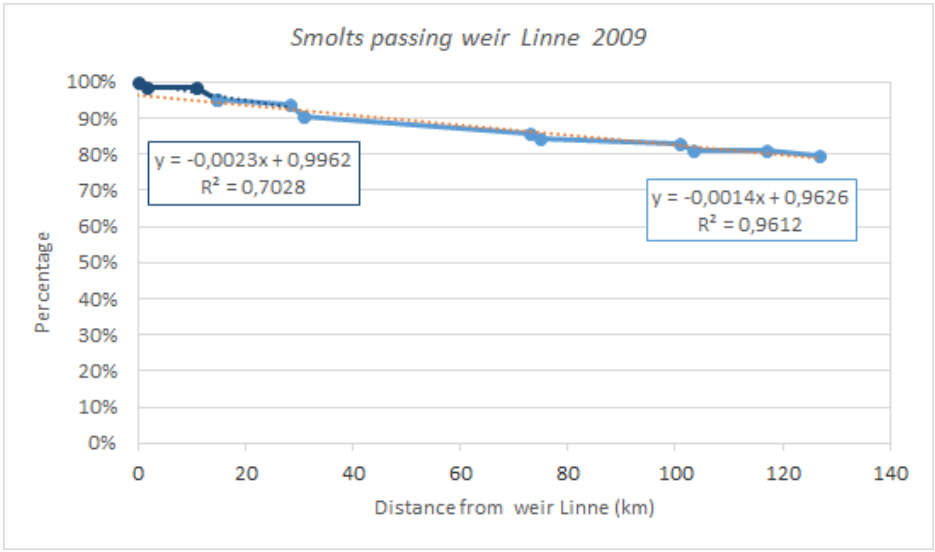




Migration of smolts 2009

Segmented linear regression in 2009 shows a higher mortality rate of 'hydropower smolts' compared to 'weir smolts', but only over the first river stretch (15 km)





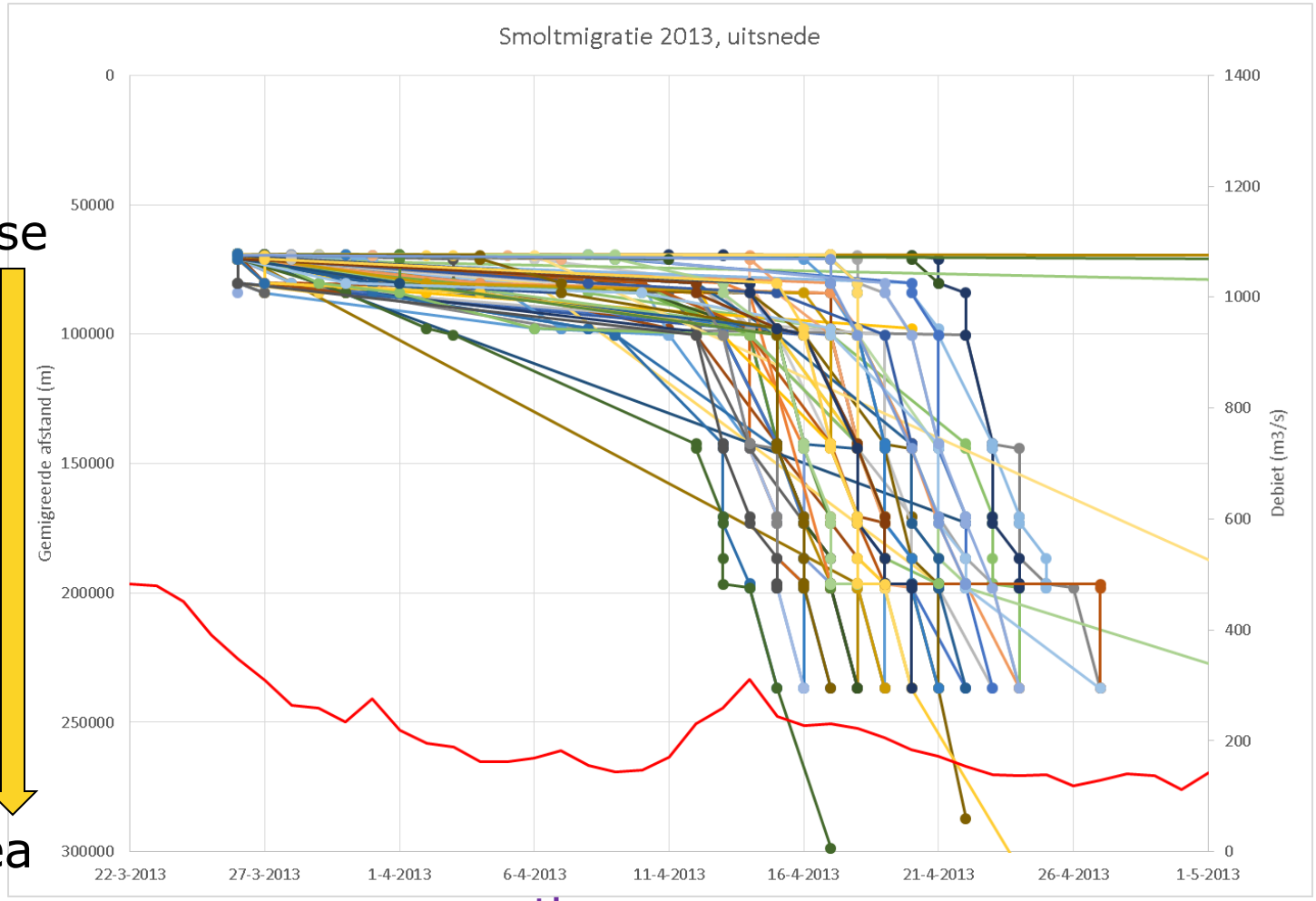
Mortality per kilometer of smolts that passed through hydropower station Linne

Route				Mortality smolts per kilometer (hydropower station)					
Nr	*Start*	*End*	*distance (km)*	***2009-2013***	*2009*	*2010*	*2011*	*2012*	*2013*
1	Maas_Linne_boven	Maas_Linne_beneden	0,2	**0,0%**	0,0%	0,0%	0,0%	0,0%	0,0%
2	Maas_Linne_beneden	Maas_Linne_dorp	1,5	**7,1%**	1,6%	2,8%	64,6%	16,2%	11,6%
3	Maas_Linne_dorp	Maas_Roermond_bov	9,3	**1,6%**	0,8%	0,5%	0,0%	4,8%	3,1%
4	Maas_Roermond_bov	Maas_Buggenum	3,7	**2,2%**	2,9%	0,4%	0,0%	5,4%	4,1%
5	Maas_Buggenum	Maas_Belfeld_bov	13,7	**0,4%**	0,2%	0,1%	0,0%	1,8%	0,9%
6	Maas_Belfeld_bov	Maas_Steyl	2,5	**1,9%**	1,2%	1,3%	0,0%	13,2%	2,7%
7	Maas_Steyl	Maas_Afferden	42,1	**0,3%**	0,4%	0,3%	0,0%	1,2%	0,1%
8	Maas_Afferden	Maas_Sambeek_ben_stu	1,8	**0,0%**	0,0%	0,0%	0,0%	0,0%	0,0%
9	Maas_Sambeek_ben_stu	Maas_Grave_bov	26,2	**0,2%**	0,0%	0,4%	0,0%	0,0%	0,0%
10	Maas_Grave_bov	Maas_Balgoij	2,5	**0,4%**	1,5%	0,0%	0,0%	0,0%	0,0%
11	Maas_Balgoij	Maas_Megen	13,6	**0,1%**	0,3%	0,2%	0,0%	0,0%	0,0%
12	Maas_Megen	Maas_Lith_boven	9,8	**0,4%**	0,4%	0,4%	0,0%	10,2%	0,0%
13	Maas_Lith_boven	Maas_Lith_beneden	0,3	**8,0%**	16,1%	0,0%	0,0%	0,0%	14,2%
14	Maas_Lith_beneden	Maas_Lith_dorp	1,3	**12,2%**	13,5%	13,5%	0,0%	0,0%	8,9%
15	Maas_Lith_dorp	Bergsche Maas_Capelse Veer	38,9	**0,3%**	0,0%	0,2%	0,0%	0,0%	0,7%
	Total number of smolts (n)			**192**	41	70	2	12	67
	shaded yellow: weir present								

Mortality per kilometer of smolts that passed over the weir at Linne

Route				Mortality smolts per kilometer (weir)					
Nr	*Start*	*End*	*distance (km)*	***2009-2013***	*2009*	*2010*	*2011*	*2012*	*2013*
1	Maas_Linne_boven	Maas_Linne_beneden	0,2	**0,0%**	0,0%	0,0%	0,0%	0,0%	0,0%
2	Maas_Linne_beneden	Maas_Linne_dorp	1,5	**3,1%**	1,0%	0,0%	0,0%	3,8%	5,7%
3	Maas_Linne_dorp	Maas_Roermond_bov	9,3	**1,1%**	0,0%	0,0%	5,4%	2,7%	1,9%
4	Maas_Roermond_bov	Maas_Buggenum	3,7	**2,4%**	0,8%	0,0%	0,0%	2,2%	5,0%
5	Maas_Buggenum	Maas_Belfeld_bov	13,7	**0,5%**	0,1%	0,0%	0,0%	2,0%	0,6%
6	Maas_Belfeld_bov	Maas_Steyl	2,5	**0,8%**	1,3%	0,0%	0,0%	0,0%	0,0%
7	Maas_Steyl	Maas_Afferden	42,1	**0,2%**	0,1%	0,0%	0,0%	1,2%	0,1%
8	Maas_Afferden	Maas_Sambeek_ben_stu	1,8	**2,3%**	1,0%	0,0%	55,2%	13,8%	1,8%
9	Maas_Sambeek_ben_stu	Maas_Grave_bov	26,2	**0,2%**	0,1%	1,0%	0,0%	1,3%	0,1%
10	Maas_Grave_bov	Maas_Balgoij	2,5	**0,5%**	0,8%	0,0%	0,0%	0,0%	0,0%
11	Maas_Balgoij	Maas_Megen	13,6	**0,0%**	0,0%	0,0%	0,0%	0,0%	0,0%
12	Maas_Megen	Maas_Lith_boven	9,8	**0,2%**	0,2%	0,0%	0,0%	5,1%	0,0%
13	Maas_Lith_boven	Maas_Lith_beneden	0,3	**17,6%**	21,8%	0,0%	0,0%	0,0%	12,8%
14	Maas_Lith_beneden	Maas_Lith_dorp	1,3	**8,3%**	10,8%	0,0%	0,0%	0,0%	5,3%
15	Maas_Lith_dorp	Bergsche Maas_Capelse Veer	38,9	**0,3%**	0,1%	0,0%	0,0%	2,6%	0,6%
	Totaal aantal vissen (n)			**144**	64	4	2	17	57
	shaded yellow: weir present								

Smolt migration in 2013



release

Distance (km)

sea

time

River discharge (m3/s)

Conclusions

- In all relevant years, mortality of smolts is higher when passing through the hydropower station compared to passing over the weir:

  2009: 48% hydropower smolts, 25% weir smolts (+23%)
  2010: 37% hydropower smolts, 31% weir smolts (+8%)
  2013: 65% hydropower, 54% weir smolts (+11%)

- The mortality rate of smolts is increased in the first 15 km downstream the hydropower station and weir. More downstream mortality rate is lower.

- An increase of river discharge seems to stimulate the migration.

Thanks for your attention!