Life4Fish
Closing conference

Wednesday, Sept. 6, 2023
Brussels

Part 1 – Innovative and inspiring solutions for the protection of migratory fish

09.15	Welcome	Pierre Theunissen, Senior Project Manager, Luminus
09.30	Introduction - Background International Commission for the Meuse and Masterplan for migratory fish	Johan Coeck, President of the Working Group Fish of the International Meuse Commission
09.45	Recent discoveries about the eel's life cycle and the causes of its decline	Eric Feunteun, Professor of Marine Ecology at the French National Museum of Natural History, in Dinard (Bretagne)
10.15	LIFEEL - Urgent measures in the Eastern Mediterranean for the long-term conservation of the European Eel	Cesare Puzzi, Founding partner and managing director of the environmental design and applied research company GRAIA
11.00	Field Investigation of American Eel Response to a Light Guidance Array	Maarten Bruijs, Principal Consultant and Owner of Pecten Aquatic, the Netherlands.
11.30	Hydropower and fish migration in the Meuse: background, policy, research and recent developments	Jochem Hop, Dutch water authority Rijkswaterstaat, member of the International Meuse Commission Tim Vriese, fish migration specialist at ATKB in Waardenburg (NL)
12.00	Results of recent studies about fish and hydropower plants in the NL Maas	Erwin Winter, Researcher (PhD) at Wageningen Marine Research & Aquaculture and Fisheries Group, Wageningen University & Research
12.30	Lunch & networking	

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Part 2 – Life4Fish : global results

13.45	Introduction	Grégoire Dallemagne, CEO Luminus
13.50	Life4Fish summary presentation - tested solutions - behavioural results - measured efficiency compared to initial goals of fish survival	Pierre Theunissen, Senior Project Manager - Luminus Damien Sonny, Fish Biologist PhD, Profish Olivier Machiels, Ingénieur de projets Arcadis
14.50	Q&A	
15.00	Round table and outlook o Downstream migration modelling and management optimisation o Liège-Albert canal knot : status and perspectives o Fish monitoring is the basis to develop solutions o New development of ecosustainable turbines	Eric de Oliveira, Chercheur et Ingénieur EDF R&D Sébastien Erpicum, Chargé de cours adjoint ULiège Damien Sonny, Fish Biologist PhD, Profish Pierre Theunissen, Senior Project Manager, Luminus
16.30	Closure	Pierre Theunissen, Senior Project Manager – Luminus Johan Coeck, President of the Working Group Fish of the International Meuse Commission
	Cocktail	

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Pierre Theunissen

Senior Project Manager,

Luminus

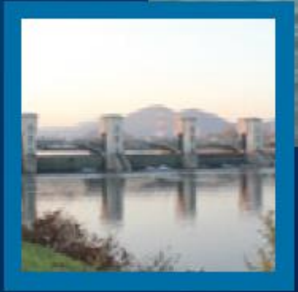
Johan Coeck

President of the Working Group Fish of the International Meuse Commission

Master Plan for Migratory Fish International Meuse Commission

Liife4Fish Closing Conference, Brussels, 6 September 2023




Johan Coeck
Chairman IMC Working Group on Fish
INBO – Research Institute for Nature & Forest, Brussel, Belgium

INTERNATIONAL MEUSE COMMISSION

International platform (countries/regions):

- Provide advise on international catchment level
- Coördination between countries / regions
- Follow-up / evaluation of measures

Adopted Master Plan for Migatory Fish (2011)

- Focus on Atlantic salmon / Sea trout & Eel

Setting the scene

Since 1970:

Global decline of 76 % in migratory freshwater fish populations including 93% collapse in Europe!
(WWF Living Plannet Index)

Before 1840:

20.000 to >100.000 salmon captured in Meuse-Rhine delta (NL)
Abundant salmon population in River Meuse up to Monthermé (F)
10 migratory species in River Meuse (Belgium)

River Meuse

Heavily impacted river morphology in main river

- Dams & weirs
- Haringvliet sluice gates
- Shipping & hydropower
- 100+ of weirs in tributaries
- But, also still large amount of natural free flowing river habitat in the tributaries (Belgian and French Ardennes)

Master Plan for Migratory Fish in the Meuse

Master Plan contains a program of measures:

- Restore the river continuity for upstream migration
- Improve the river continuity for downstream migration
- Develop suitable spawning grounds and other habitats for migratory species
- Reintroduction of migratory species
- Regulation of fisheries
- International coordination of measures in different countries/regions

IMC Working Group on Fish: follow-up & evaluation of this program of measures

Master Plan for Migratory Fish in the Meuse

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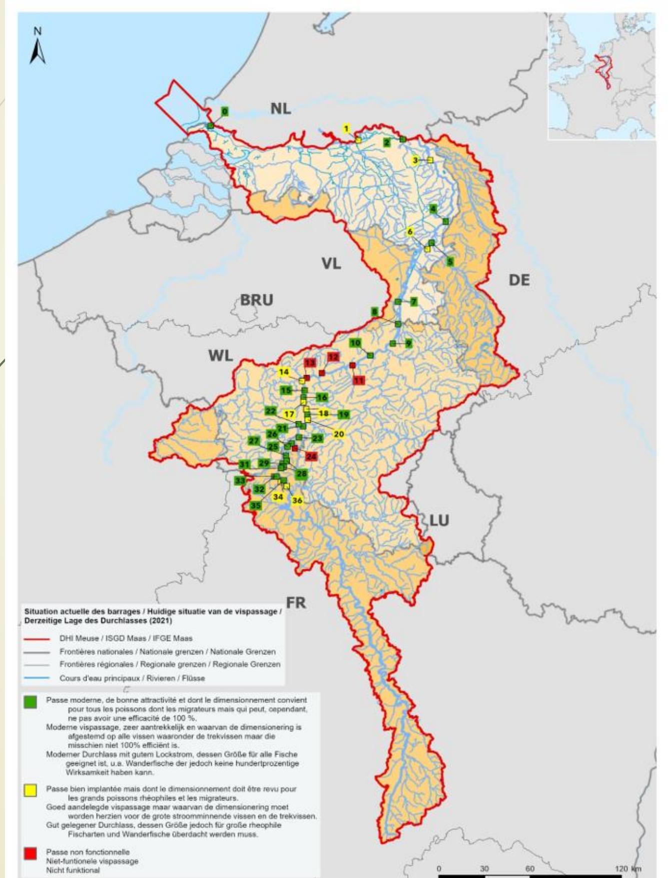
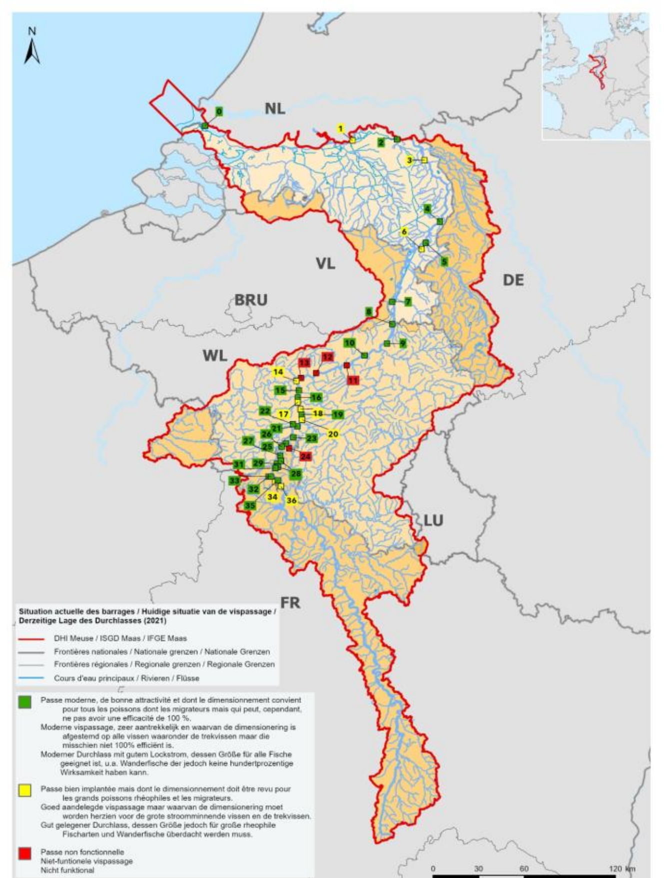
IMC Working Group Fish: follow-up & evaluation of this programm of measures

Restoration of river continuity



37 obstacles (main river)

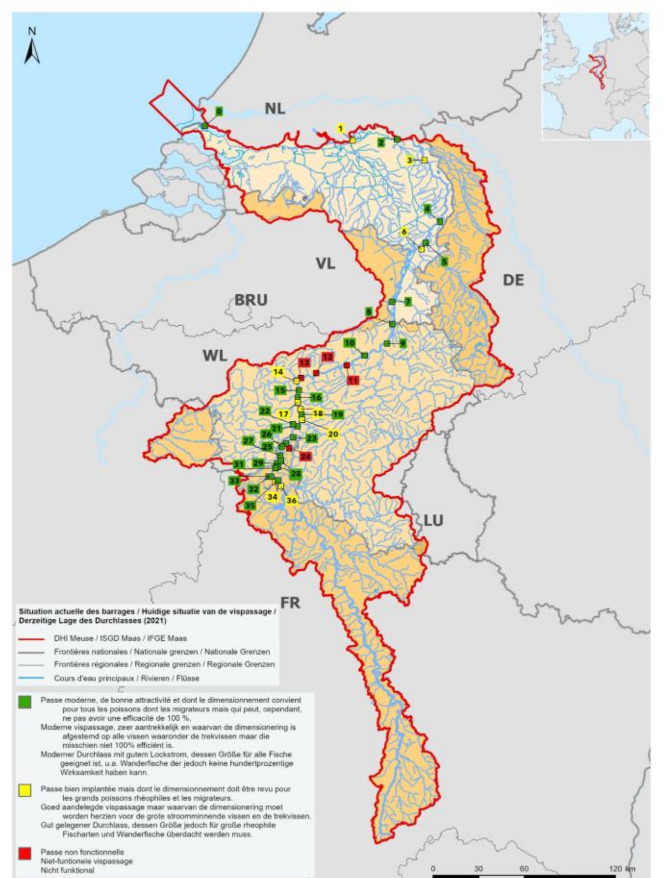
Restoration of river continuity



37 obstacles (main river)

Project Kier "partial opening of sluice gates at sea during rising tide"

Restoration of river continuity



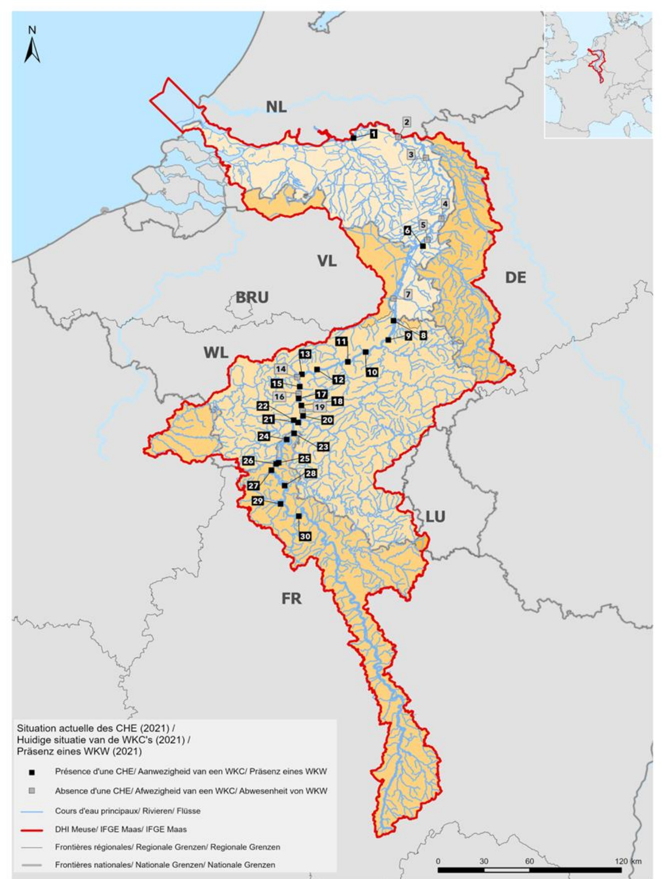
37 obstacles (main river)

Project Kier "partial opening of sluice gates at sea during rising tide"

Fish passes (technical passes)

- modern state of the art fish passes
- old fish passes
- no fish pass

Restoration of river continuity



22 HEP stations (main river)

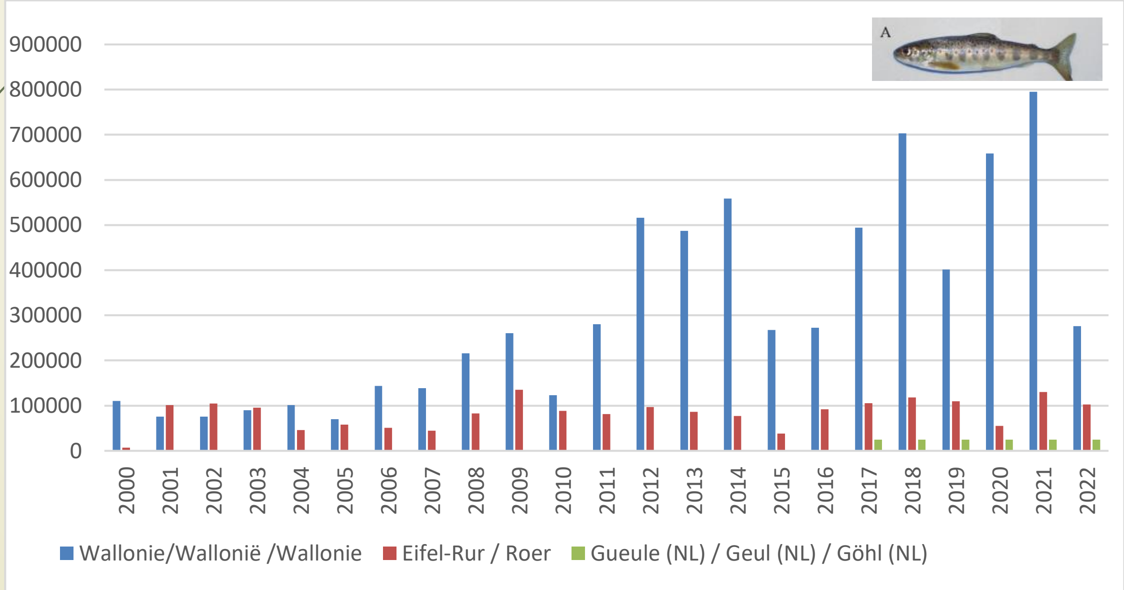
- installed power = 106 MW
- protection of downstream migrating fish:

  - screening / guidance
  - more fish-friendly turbine types
  - more water over weirs
  - temporary shutdown of turbines

Follow-up & evaluation

Reintroduction of Atlantic salmon

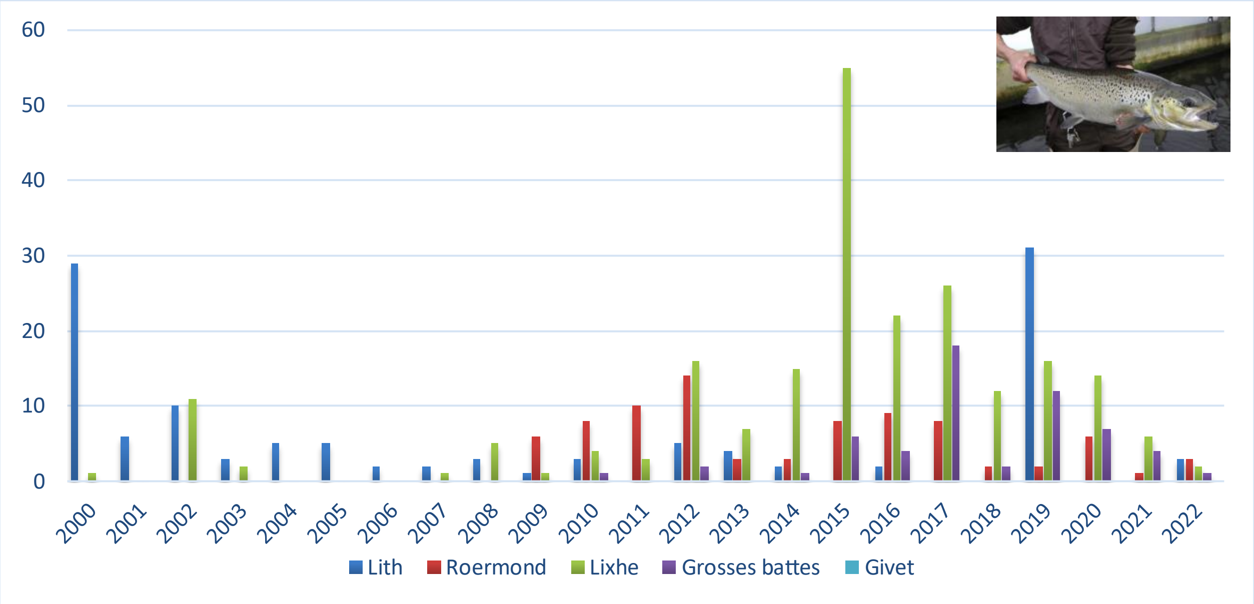
- since 2010: increase of the number of released juvenile salmon



Follow-up & evaluation

Reintroduction of Atlantic salmon

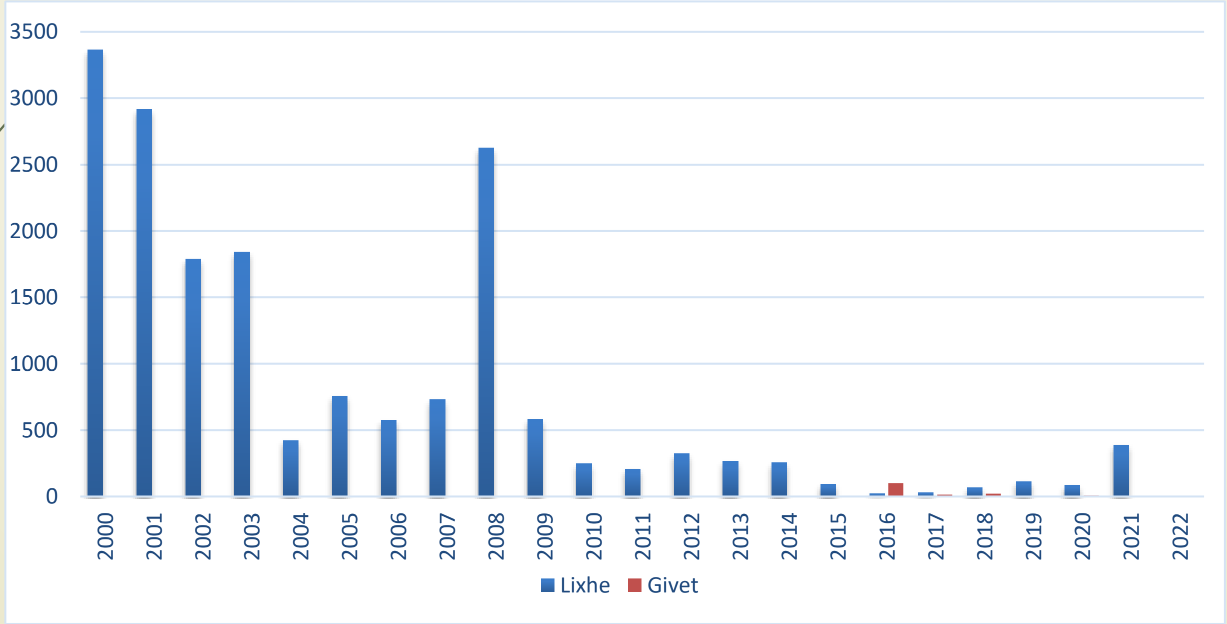
- since 2016: decrease in the number of returning adult salmon



Follow-up & evaluation

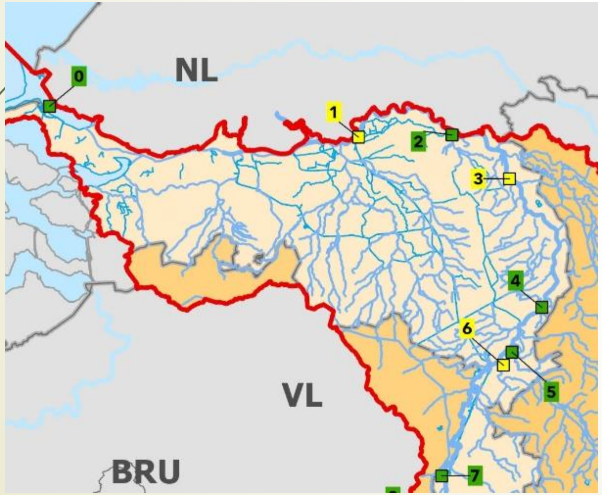
Eel population in the Meuse

- Serious decline in upstream migrating juvenile eel



Follow-up & evaluation

Connectivity of River Meuse in NL unsufficient
(Vriese et al. 2021)

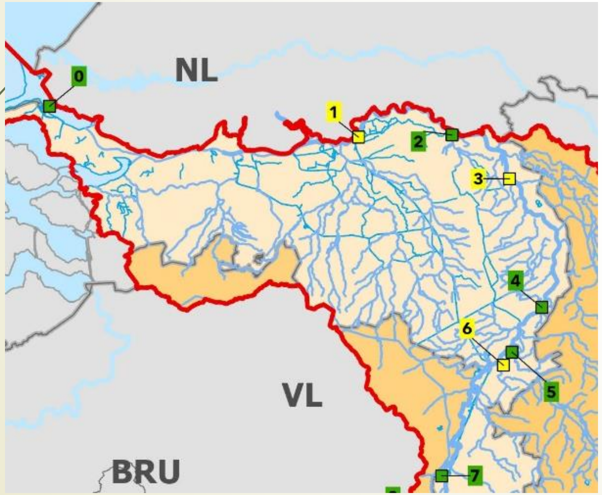


	Fish pass efficiency	Downstream migration	
	upstream / adult salmon	smolt	eel
1. Lith	70 %	83 %	76 %
2. Grave	62 %	99 %	100 %
3. Sambeek	50 %	99 %	99 %
4. Belfeld	88 %	97 %	98 %
5. Roermond	90 %	92 %	99 %
6. Linne	83 %	83 %	77 %
7. Borgharen	100 %	92 %	98 %
Total efficiency	14 %	55 %	55 %

Follow-up & evaluation

Connectivity of R. Meuse in Nl unsufficient

(Vriesse et al 2021)



	Fish pass efficiency upstream / adult salmon	Downstream migration smolt	eel
1. Lith	70 %	83 %	76 %
2. Grave	62 %	99 %	100 %
3. Sambeek	50 %	99 %	99 %
4. Belfeld	88 %	97 %	98 %
5. Roermond	90 %	92 %	99 %
6. Linne	83 %	83 %	77 %
7. Borgharen	100 %	92 %	98 %
Total efficiency	**14 %**	**55 %**	**55 %**

Follow-up & evaluation

Goals of the Masterplan for Migratory Fish

- Establishment of an Altlantic salmon population
- Restoration of the eel population

Serious issues to handle…

Thank you!

Atlantic salmon (Lixhe, 14 mei 2021 – male, 980mm – 10000g)

www.meuse-maas.be

Eric Feunteun,

Professor of Marine Ecology at the French National Museum of Natural History

luminus · profish MONITORING FISH ECOLOGY · LIÈGE université · eDF R&D · UNIVERSITÉ DE NAMUR · Life

Cesare Puzzi

Founding partner and managing director of the environmental design and applied research company GRAIA

CLOSING CONFERENCE - SEPTEMBER 6, 2023

LIFEEL PROJECT – LIFE19 NAT/IT/000851

Urgent measures in the Eastern Mediterranean for the long term conservation of endangered European eel (2021-2024)

Cesare Puzzi, GRAIA srl (Italy)

PROJECT STRUCTURE

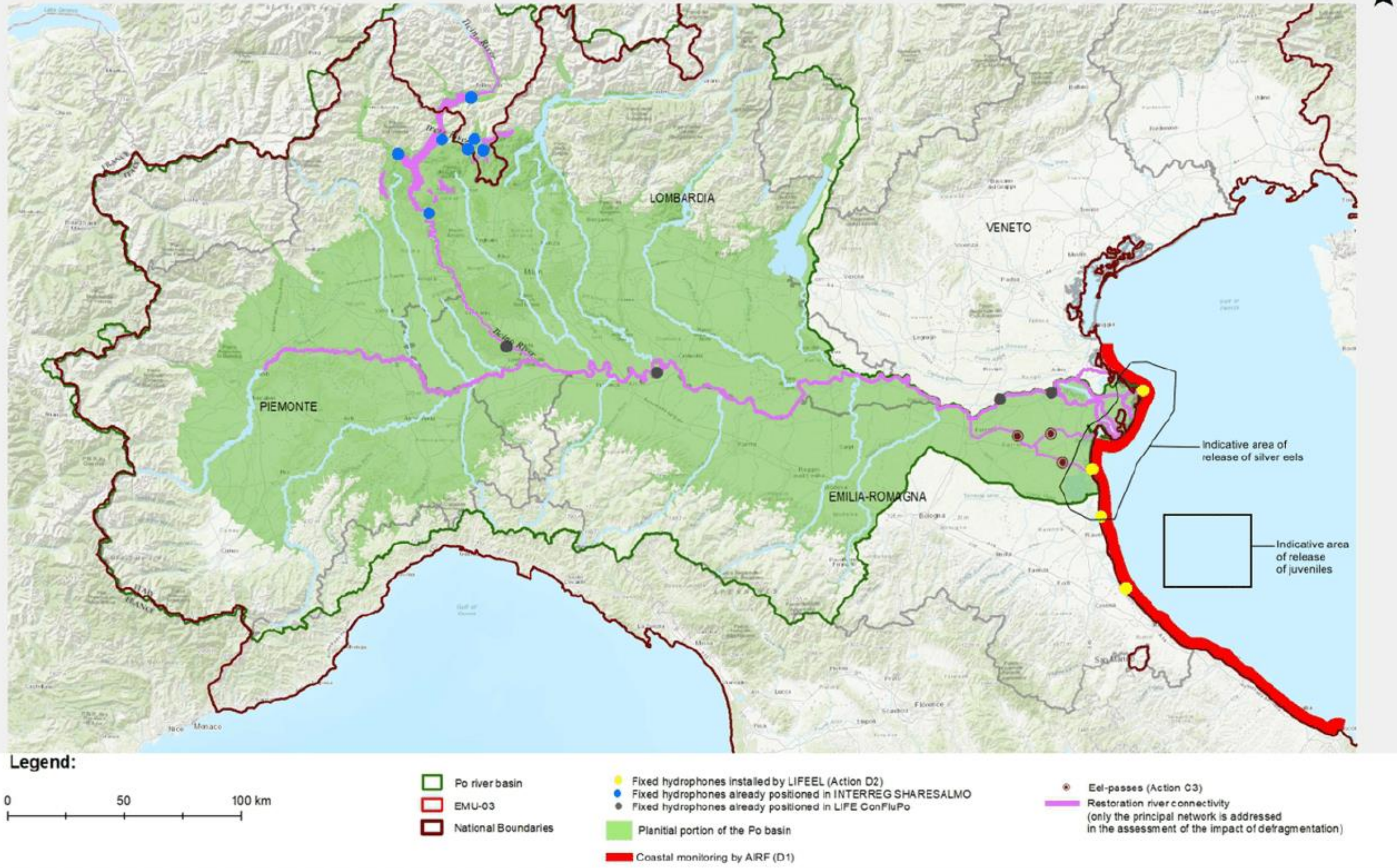
► 9 BENEFICIARIES:

- Regione Lombardia DG Agricoltura - coordinator
- Hellenic Agricultural Organization DIMITRA (Fisheries Research Institute)
- Regione Emilia – Romagna Dir. Agricoltura, Caccia e Pesca
- Università di Bologna - DIMEVET
- Università di Ferrara
- Parco Lombardo della valle del Ticino
- Ente Parco Delta del Po Veneto
- Ente di gestione per i Parchi e Biodiversità Delta del Po
- GRAIA srl – Gestione Ricerca Ambientale Ittica Acque

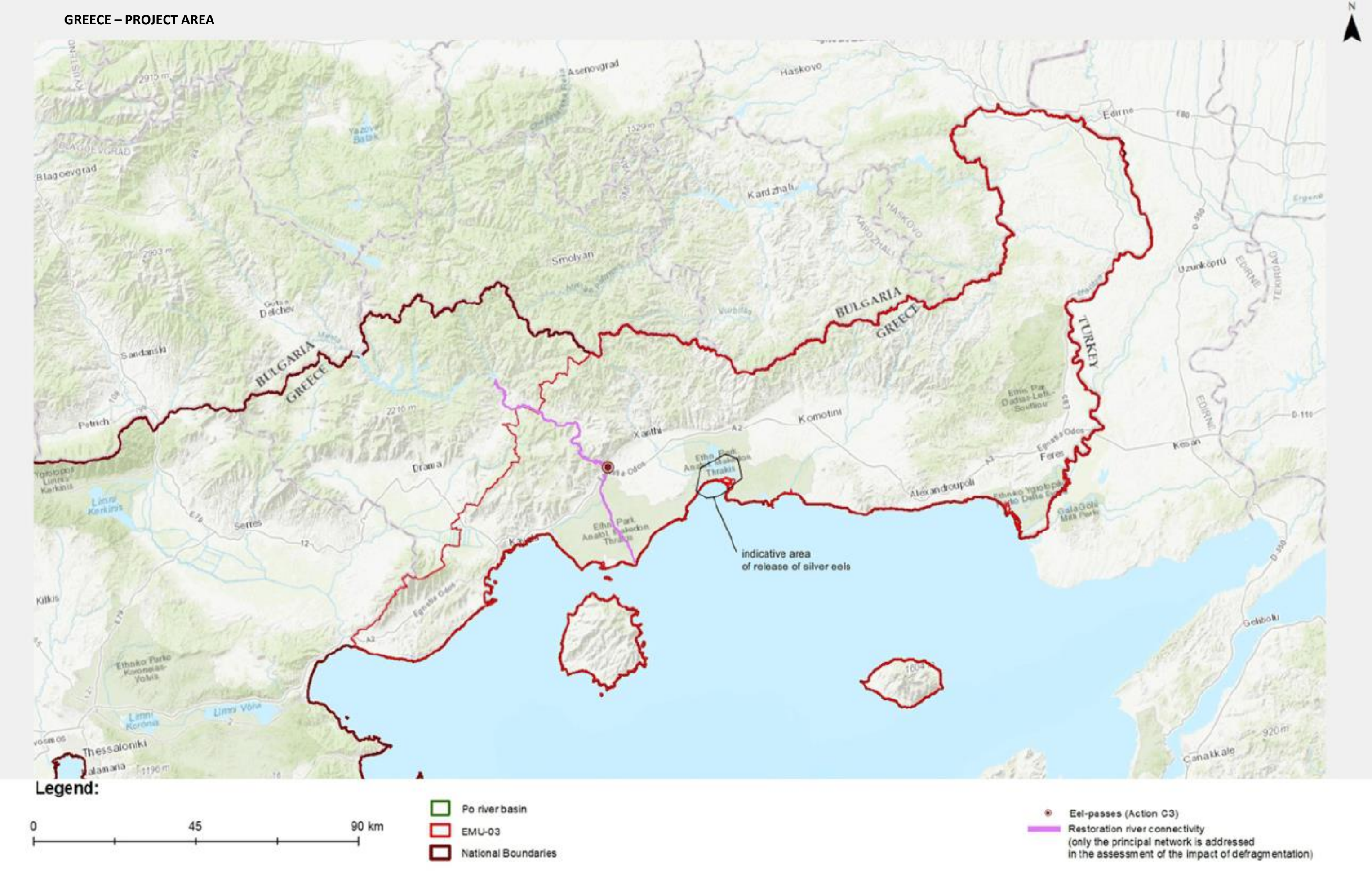
► 4 COFINANCERS:

- Canton Ticino - Ufficio Caccia e Pesca
- Enel Green Power
- Fondazione Cariplo
- Associazione Italiana Pesca Sportiva e Ricreativa

ITALY – PROJECT AREA



GREECE – PROJECT AREA



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MAJOR THREATS - LIFEEL SPECIFIC OBJECTIVES

- T1. Pressure of fishery and aquacolture
  - SO1. Increase the release of best silver eels breeders
  - SO2. Safeguard wild stocks of juveniles from fishery & aquacolture
- T2. Habitat fragmentation and range reduction
  - SO3. Restore the access to areas vocational for the species
- T3. Turbine mortality
  - SO4. Reduce lethal impact of the turbines from hydroelectric plants
- T4. Lack of information and stakeholders' involvement
  - SO5. Involvement of stakeholders and local communities

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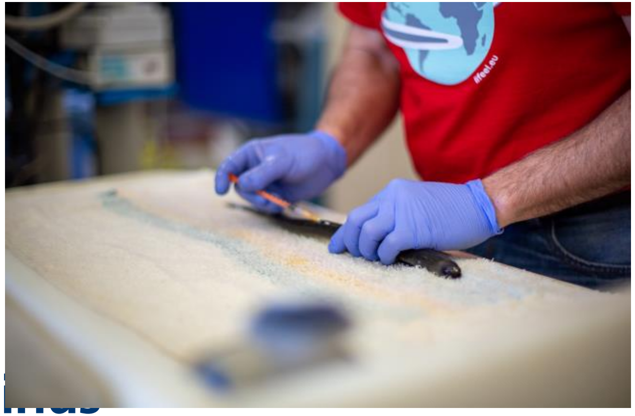
T1. PRESSURE OF FISHERY AND AQUACOLTURE

- SO1. INCREASE THE RELEASE OF BEST SILVER EELS BREEDERS

  - **Action A2** : Protocol for selection of migrant breeders



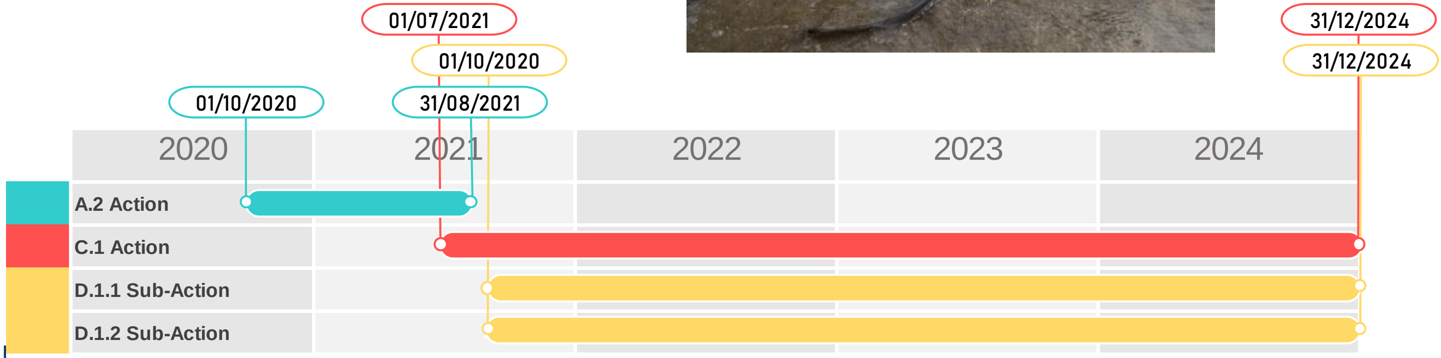
T1. PRESSURE OF FISHERY AND AQUACOLTURE

▶ SO1. INCREASE THE RELEASE OF BEST SILVER EELS BREEDERS

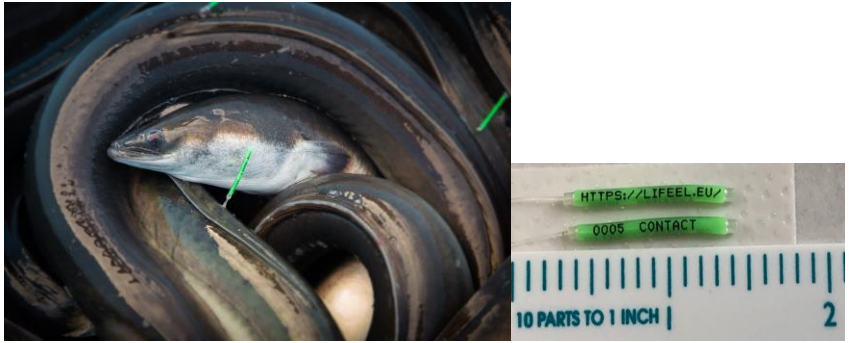
Action C1 : Release to the sea of fully mature breeders

Action D1.1: Monitoring effectiveness of the breeders

Action D1.2: Migration start monitoring



Action D1.2 Monitoring the migration start of the breeders
s/as 01/10/21 – e/ae: 31/12/24



1) ITALY

10,000 silver eels released with Action C1:

A) MONITORING (2021-2023): 2.000 released with **external tag**

possible recapture of tagged specimens by Fishery cooperative

involved

:**B) TRACKING (2021-2024):** 230 with **internal sonic tag** detected by

4 sonic receivers

Sonic emitters

MM-R-SO model, 69 Hz,
(ØxL) (mm) 8,5x 42,
duration of 102 days,
covering an emission
distance of 350-400 m

Action D1.2 Monitoring the migration start of the breeders
s/as 01/10/21 – e/ae: 31/12/24

2) GREECE

1,200 silver eels released with Action C1:

A) MONITORING (2021-2023): 1,000 released with **external tag**

possible recapture of tagged specimens by Fishery cooperative involved

B) TRACKING (2022-2023): 14 with **pop-up system**

With CINEA authorization of 4/02/2022, the purchase of the pop-up systems

it was transferred from DEMETER to UNIFE.

Deliverable: progress report (IT & GR) 31/12/2022
final report (IT & GR) 31/12/2024

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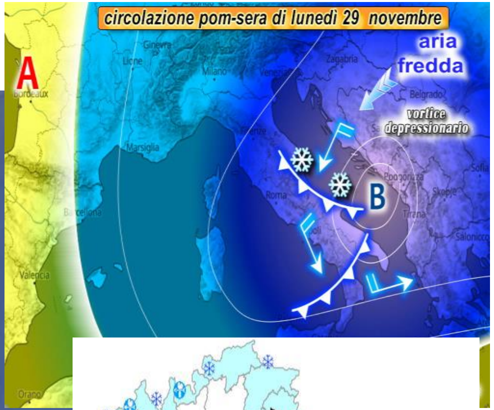
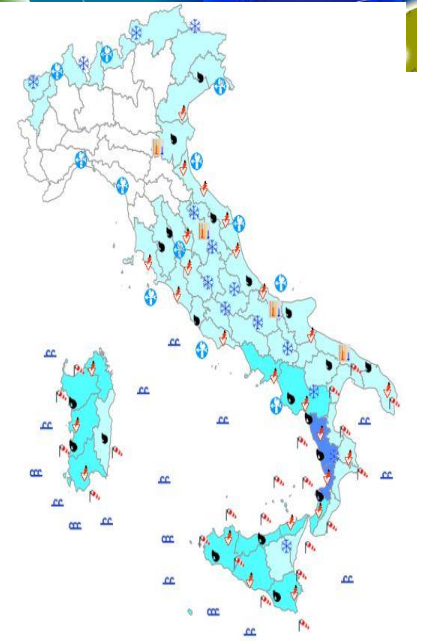
EXTERNAL TAGS results

EXTERNAL TAGS results





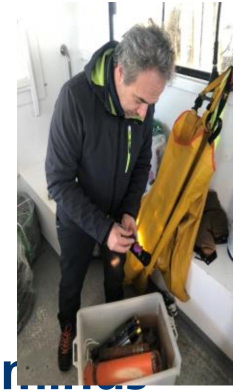
ITALY TRACKING: 10-12-21 first installation of sonar receivers

Between 0.5 and 3 miles, 1.5 m from the bottom, variable depth on the first water step from 5 to 12 m

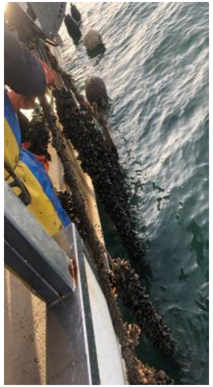




La Fenice CERVIA
Produzione mitili di alta qualita'



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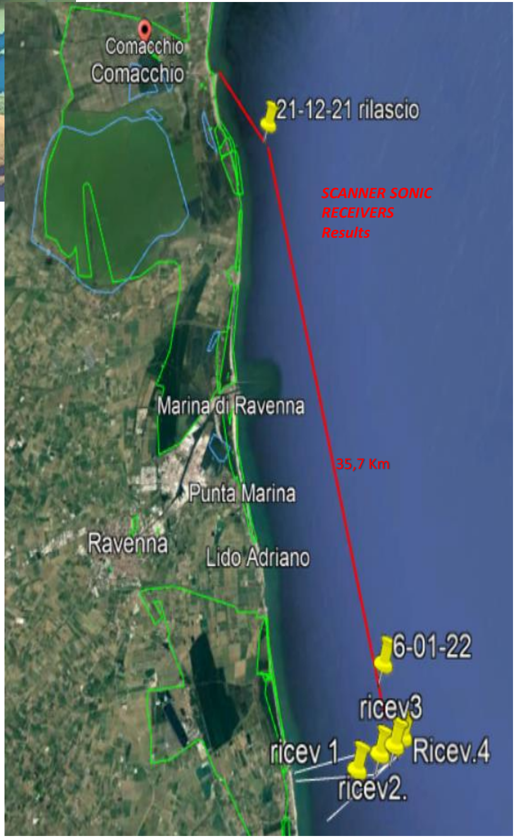
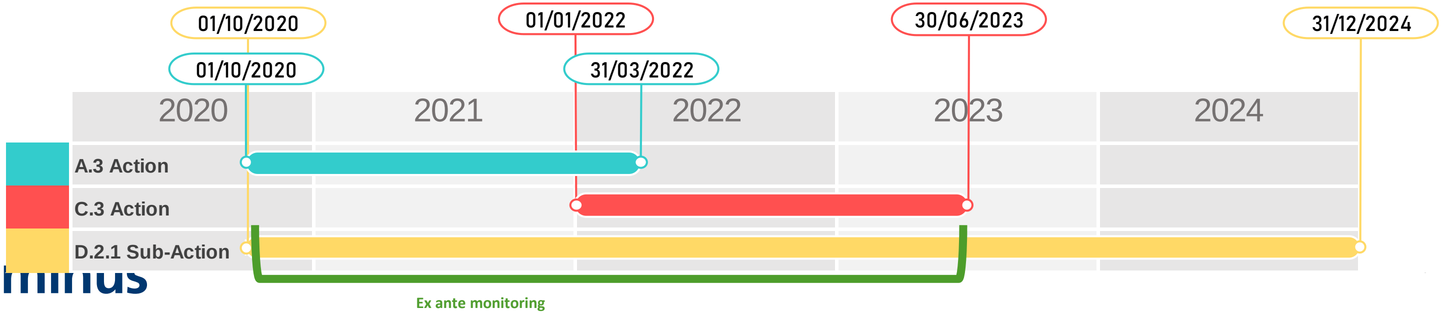
200
400
400
1100
1000


5-6 GENNAIC
EVOLUZIONE
TORNANO PIOGGIA E NEVE SU
NETTO CALO TERMICO
GELO
A
B

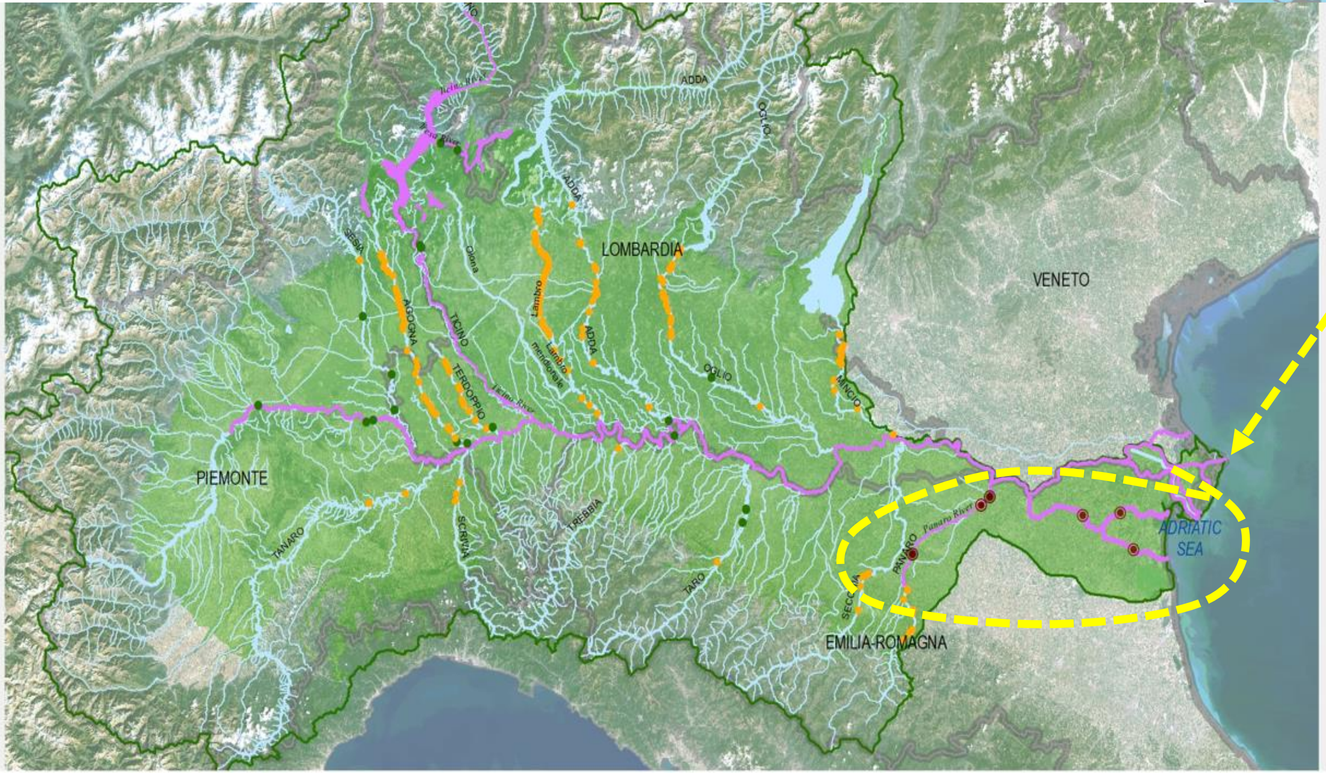

Comacchio
Comacchio
21-12-21 rilascio
SCANNER SONIC
RECEIVERS
Results
Marina di Ravenna
35,7 Km
Punta Marina
Ravenna
Lido Adriano
6-01-22
ricev3
ricev 1
Ricev.4
ricev2.

T2. HABITAT FRAGMENTATION AND RANGE REDUCTION

- SO3. RESTORE THE ACCESS TO AREAS VOCATIONAL FOR THE SPECIES
  - Action A3: Design of 7 eel specific fish passes
  - Action C3: Realization of 7 eel specific fish passes
  - Action D2.1: Monitoring the effectiveness of fish passes built



Restoration of the Po basin connectivity



0 25 50 100 km

Legend:

- Eel-passes (Action C3)
- Restoration of the Po River basin connectivity (only the principal network is addressed in the assessment of the impact of defragmentation)
- Artificial barriers whose valicability has to be assessed
- Artificial barriers already valicable by Eel
- Po river basin

Scale: 1:1.500.000

Action D2.1 Monitoring effectiveness of fish passes built

s/as 01/10/20 – e/ae 31/12/24

Referent UNIFE - DEMETER

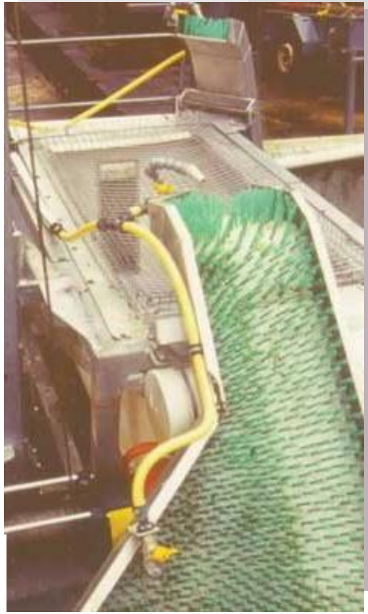
ITALY monitoring in May-July for 4 years (2021-2024):

2021-2024 *(2021 -2022 EX ANTE):* in Po river at Pontelagoscuro with nets, once a month to verify upstream migration

2023-2024: in Po delta 3 selective fish passes with traps, to verify use of passes

2023-2024: in Panaro 3 fish passes with ramps: with nets before and after the passage

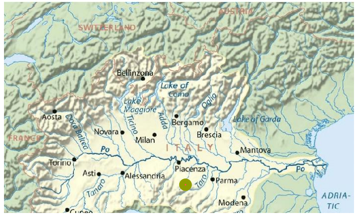
GREECE: in 2023-2024: 1 selective fish pass on Nestos with trap, to verify use of pass



Deliverable: report on eel migration and management suggestion __________ ________expected by: 31/12/2024_____actually foreseen by: 31/12/2024

Action D2.1 Ref. GRAIA

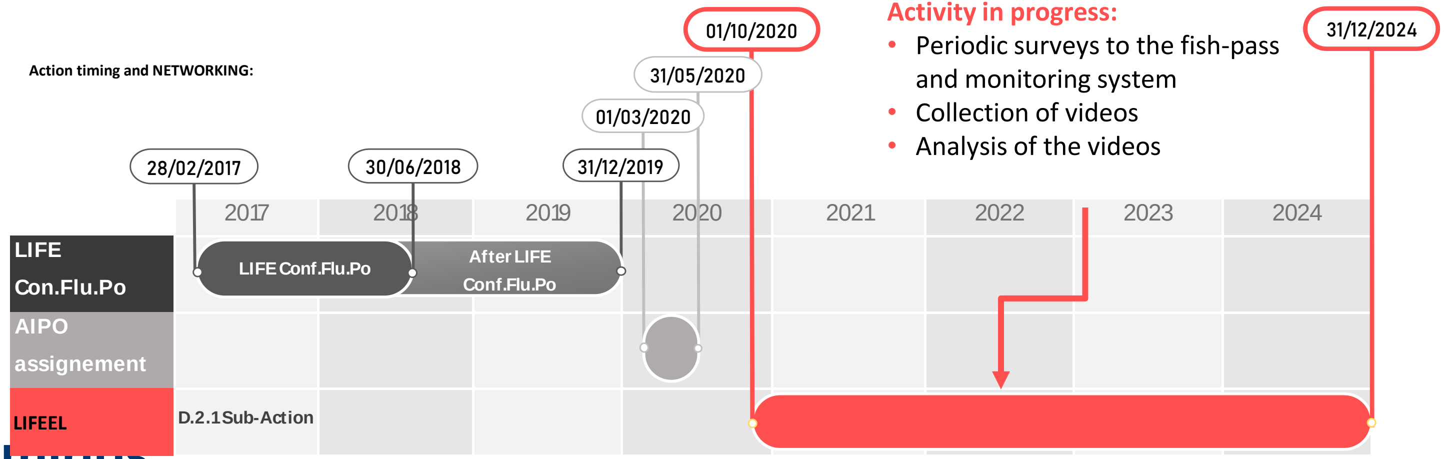
Continuous video monitoring at Isola Serafini fish-pass



Activity in progress:

- Periodic surveys to the fish-pass and monitoring system
- Collection of videos
- Analysis of the videos

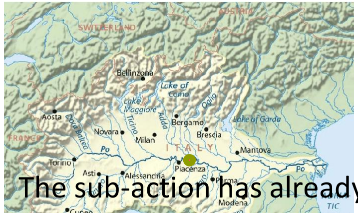
Action timing and NETWORKING:



Action D2.1

Ref. GRAIA

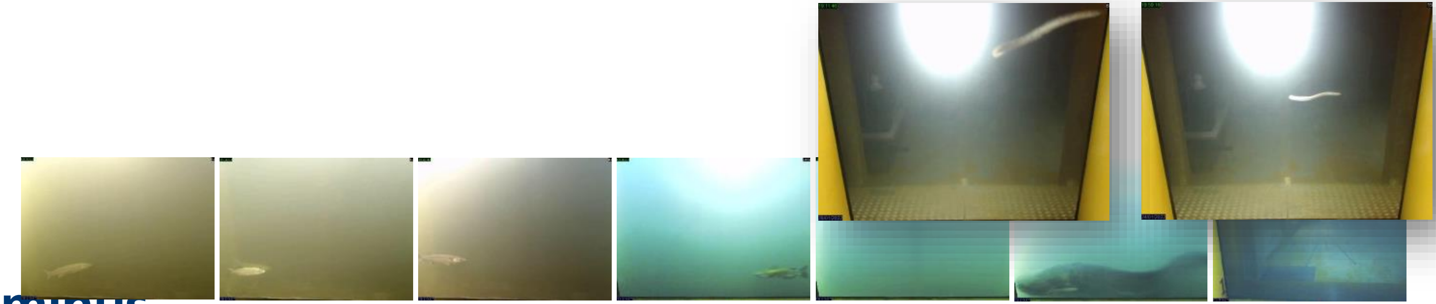
Continuous video monitoring at Isola Serafini fish-pass




The sub-action has already started at the beginning of the project.

Activity in progress:

- Periodic surveys to the fish-pass and monitoring system (6 surveys completed)
- Collection of videos (Up to June 2023 – **1,300 total days monitoring**)



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Action A.3 Design of 7 eel specific fish passes s/as 01/10/20 – e/ae 31/03/2022

requested end date: 30/09/2022

ITALY: GRAIA responsible for design, UNIFE assistance to designers, RER

technical support, permissions and procedures

n.6 FISH PASSAGES:

n. 3 fish ramps on Panaro river (Bondeno, Casumaro, Nonantola)

n. 3 eel passes in Po Delta (Tieni, Valle Lepri,Valpagliaro)

GREECE: GRAIA responsible of design, DEMETER support, permissions and procedures

n. 1 eel pass on Nestos river, at Toxotes dam

Deliverable: executive design for fish passes by 31/03/2022
Milestone: executive design for fish passes approved by 31/03/2022

ACTION A.3

Referent: GRAIA, RER, UNIFE, DEMETER

ITALY: GRAIA responsible of design, UNIFE assistance to designers, RER permissions and procedures

n.6 FISH PASSAGES:
- n. 3 fish ramps on Panaro river (Bondeno, Casumaro, Nonantola)
- n. 3 eel passes in Po Delta (Tieni, Valle Lepri, Valpagliaro)

Contact
- AIPO, RER
- First web meeting with the parties involved

Visit on site
- New improved solutions shared for the Po Delta sluices

Study
- Gathering of all the information needed, related to: structural data of sluices and weirs, hydrological data, environmental data, permissions.

Design
- First submission of the draft of the definitive design
- Official submission of the Definitive Design to RER

Approval
- Services Conference
- Approval of the fish/eel passes

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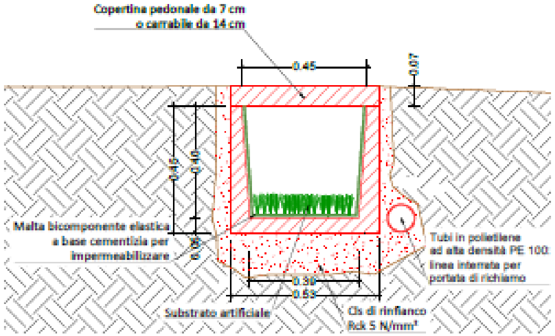
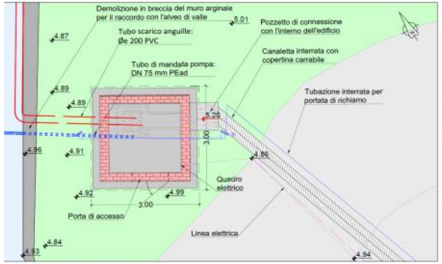
LIFEEL

ACTION A.3 ITALY

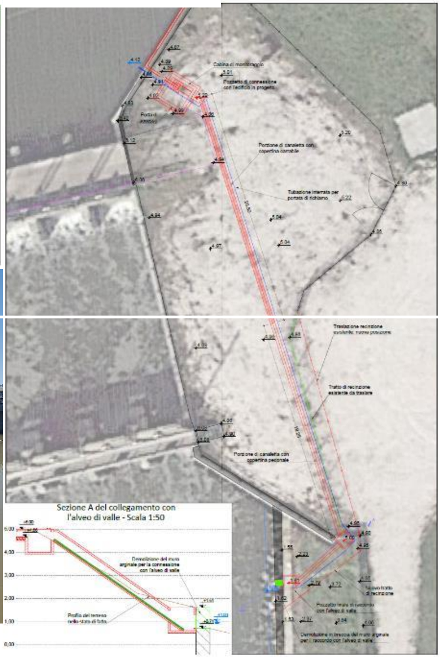
Valpagliaro. Definitive design of a specific pass for elvers.



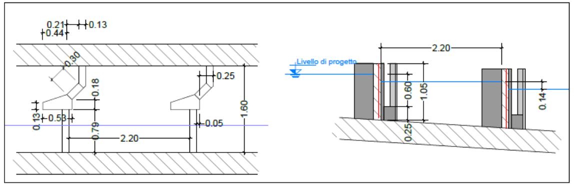
Monitoring chamber

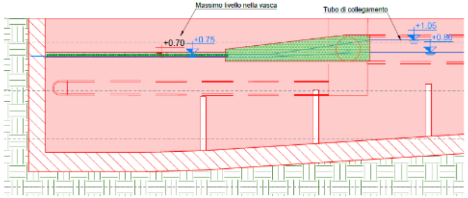


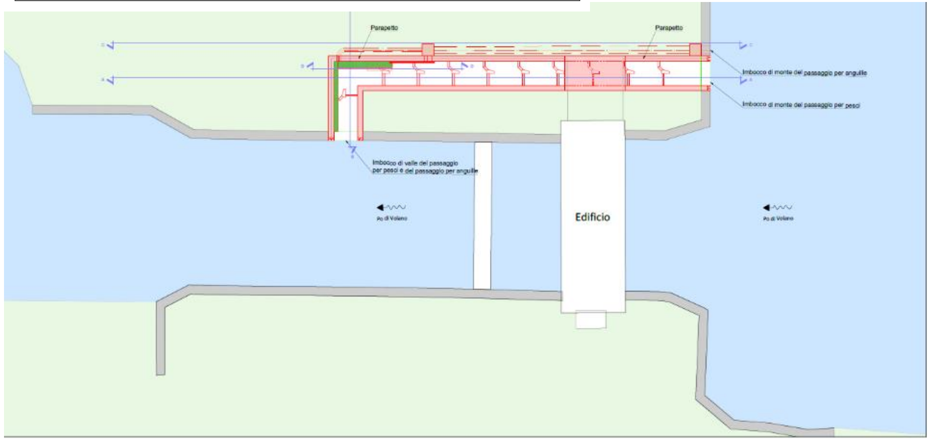
Plan view



Planimetria e sezione tipologica di un setto ed un bacino tipo - scala 1:40







ACTION A.3 ITALY

Tieni. Definitive design of a **NON-SPECIFIC *Vertical Slot* fish-pass**, functional to the whole fish fauna, not only to eel.

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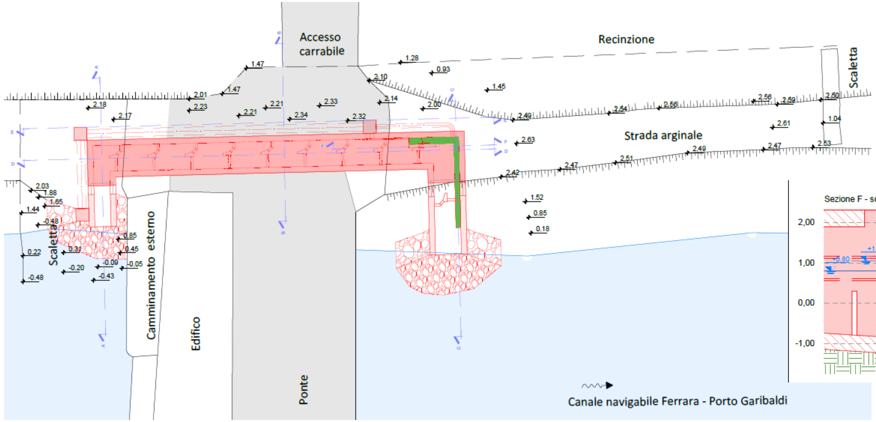
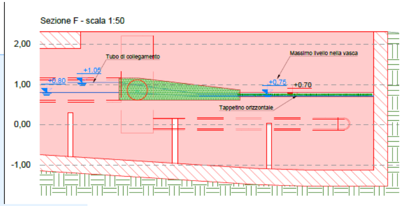
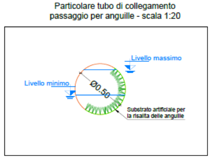
ACTION A.3 ITALY

Valle Lepri. Definitive design of a **NON-SPECIFIC *Vertical Slot* fish-pass**, functional to the whole fish fauna, not only to eel.



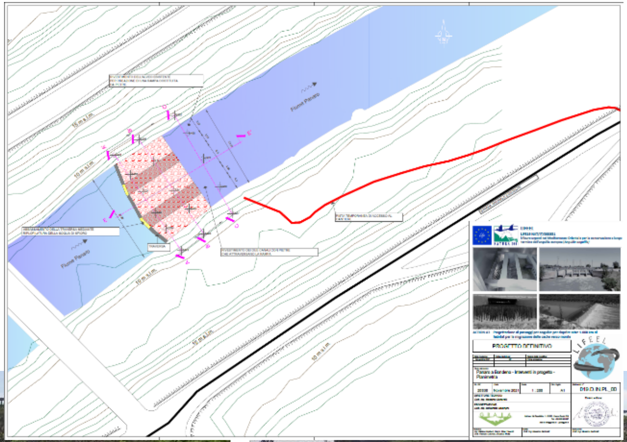




ACTION A.3 ITALY

BONDENO. Definitive design of a

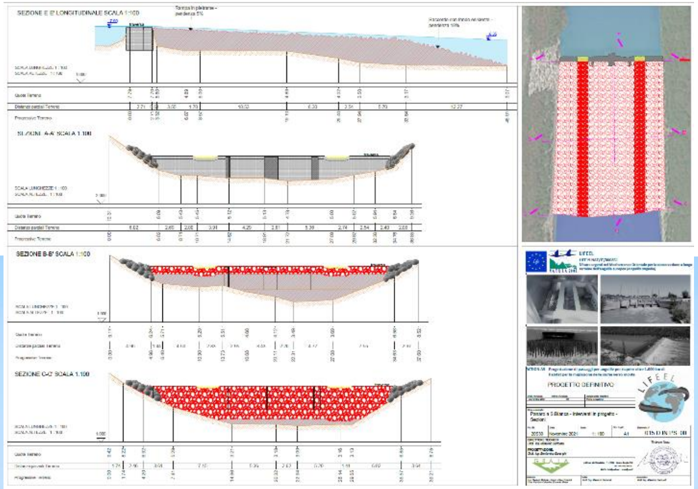
FISH RAMP

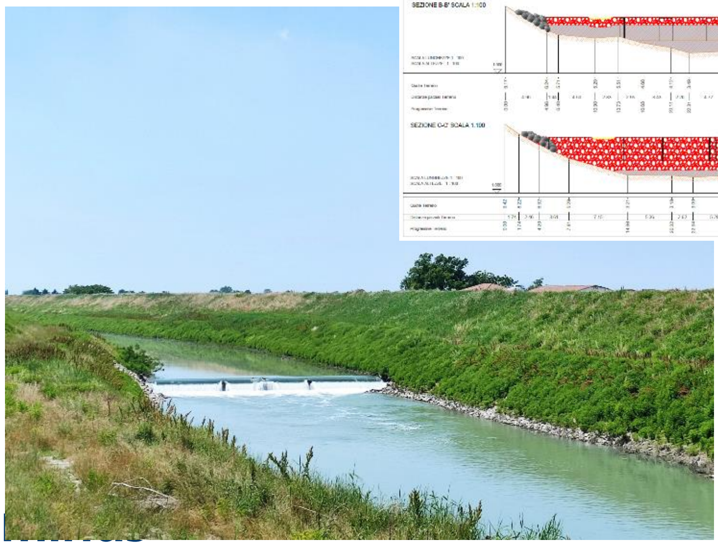


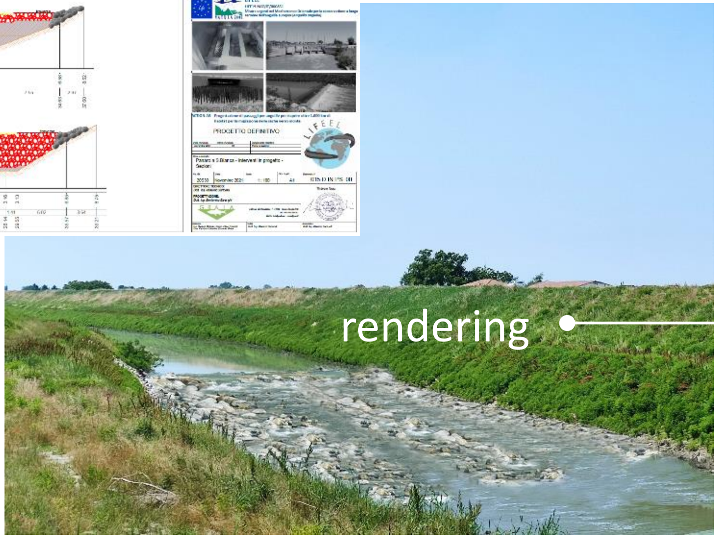
ACTION A.3 ITALY

CASUMARO. Definitive design of

FISH RAMP



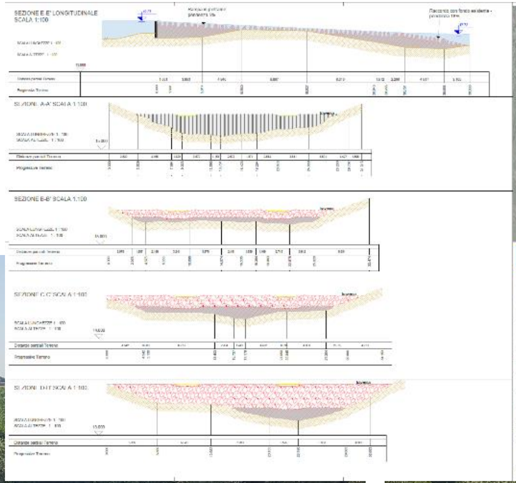


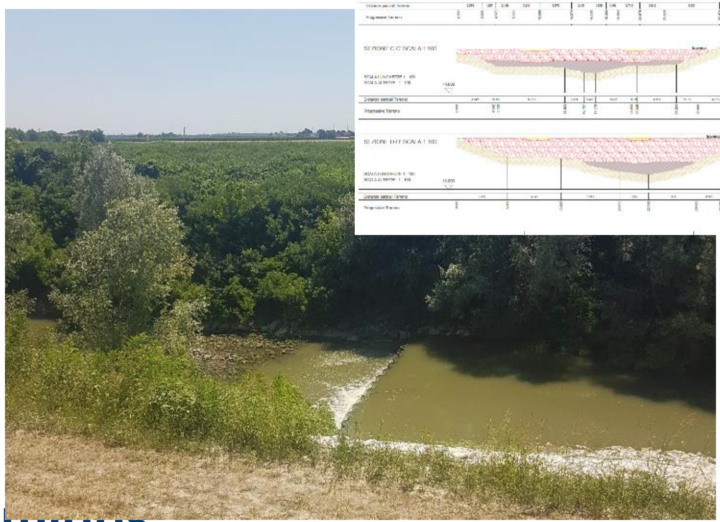


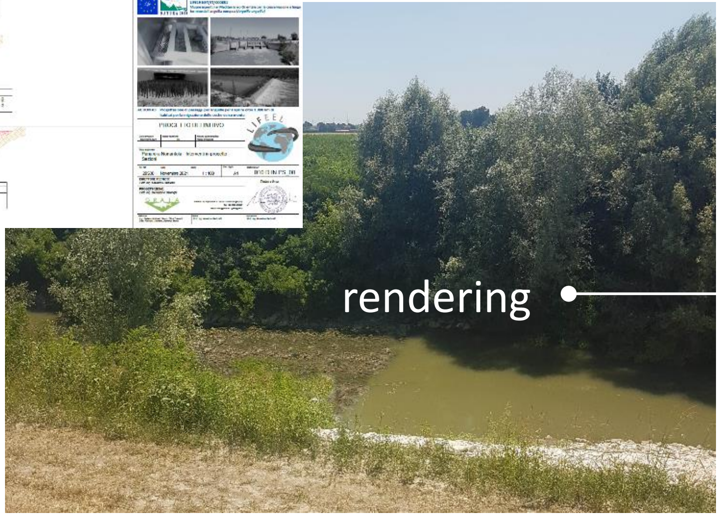
ACTION A.3 ITALY

NONANTOLA. Definitive design of a

FISH RAMP





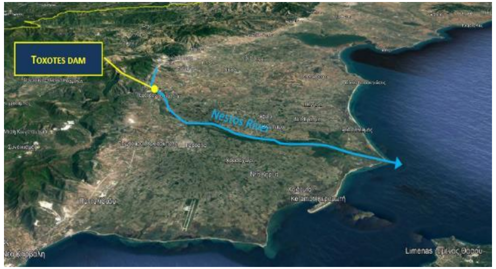


rendering

ACTION A.3 GREECE

NESTOS RIVER

Definitive design of an eel pass



Contact
- FRI; Deputy Regional Head of Fisheries Policy East Macedonia and Thracia; Dep. of Fisheries, Dep. of Agricultural Economy & Veterinary Med. unit of Xanthi; National Park of River Nestos Delta, Vistonida-Ismarida and Thassos
- First web meeting with the parties involved

Visit on site
- Survey on site with the Greek Coordination Committee

Study
- Gathering of all the information needed, related to: structural data of sluices and weirs, hydrological data, environmental data, permissions.

Design
- First submission of the draft od the definitive design
- Official submission of the Definitive Design
- Official delivery of the Executive Design

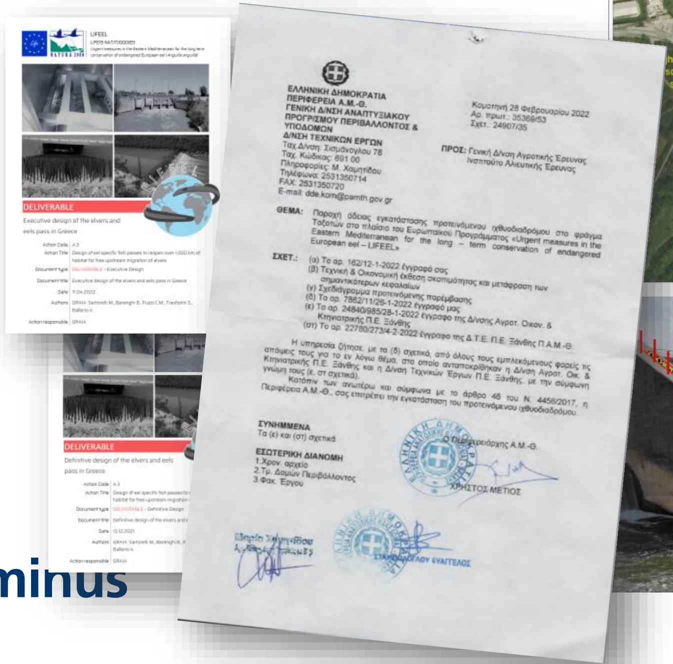
Approval
- Approval of the fish/eel passes

ACTION A.3 GREECE

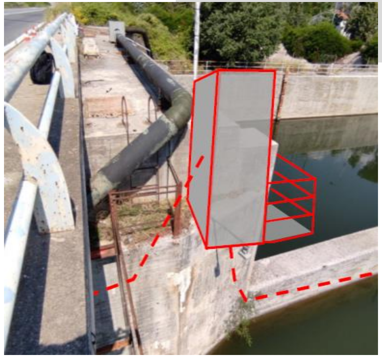
NESTOS RIVER

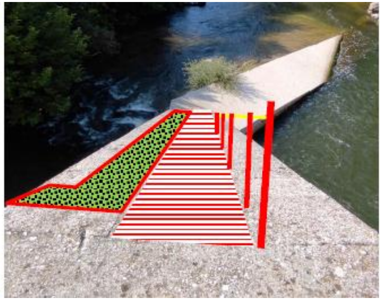
Definitive design submitted to DEMETER for approval procedure on the 13th of December 2021
Executive design delivered on the 11th of April 2022

The solution designed:
a specific eel-pass installed at the dam



GENERAL PLAN - Scale 1 : 5.000





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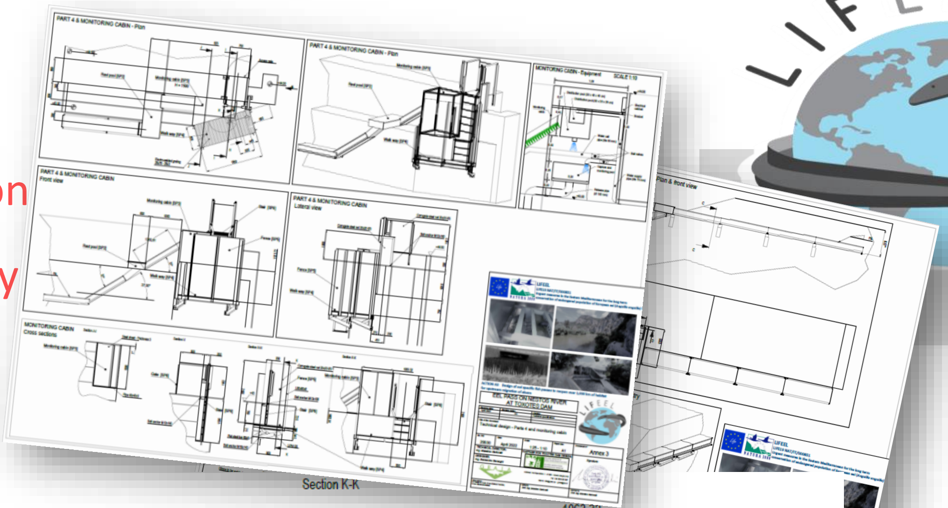
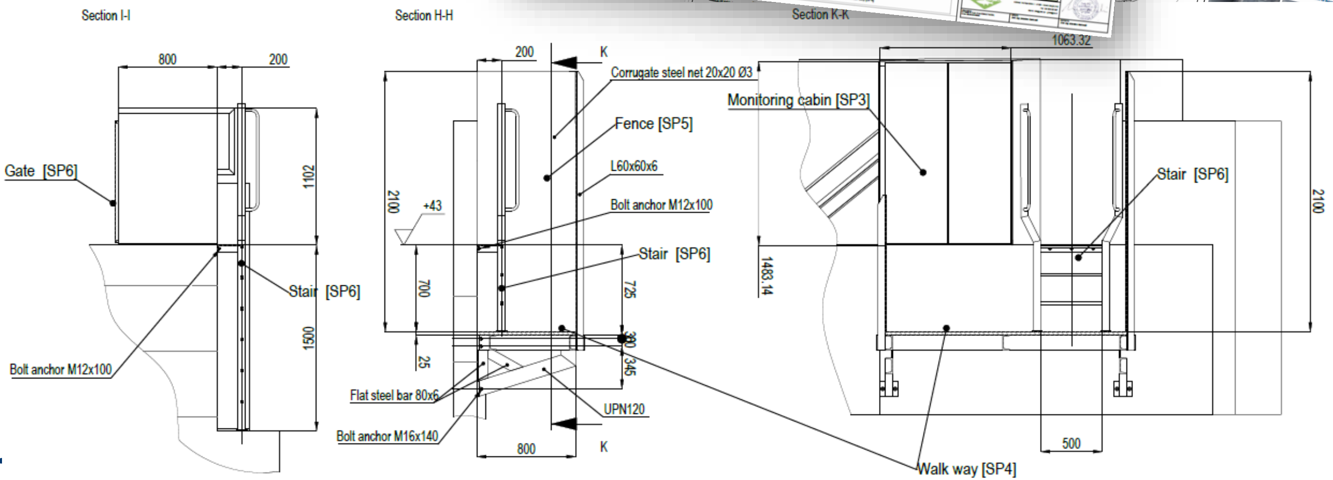
ACTION A.3 GREECE

Executive design of the eel pass - construction details of metal carpentry





Deliverable: certificate right esecution 30/06/2023
Milestone: infrastructure realization 30/06/2023

T3. TURBINE MORTALITY

- SO4. REDUCE LETHAL IMPACT OF TURBINES FROM HYDROELECTRIC PLANTS

Action A4. 1: Site-specific guidelines

Action A4.2: Design of demostrative deterrent system for eels

Action C4: Realization of demostrative deterrent system for eels

Action D2.2: Monitoring effectiveness of demostrative deterrent system

Fish migration is “**a two-way street**”. This is particularly true for the eel, whose life cycle depends on the opportunity to move upstream and than downstream the rivers, in order to reach the Ocean and the Sargasso Sea for reproduction.

Downstream passage technologies are at a much more nebulous state of development than upstream passage technologies and require **further evaluation** and improvement before rigorous **design guidelines** can be established.

For this reason, the action is divided in two sub-actions:

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SUB-ACTION A.4.1 : s/as 01/10/20 – e 31/12/21
Analysis Po basin permeability downstream migration

requested end date: 31/12/2022

Objective: to draft a clear frame of the threat in the Po river catchment basin, mapping and characterizing every hydro structure in order to evaluate its damage level for eel and the possible compliance strategies

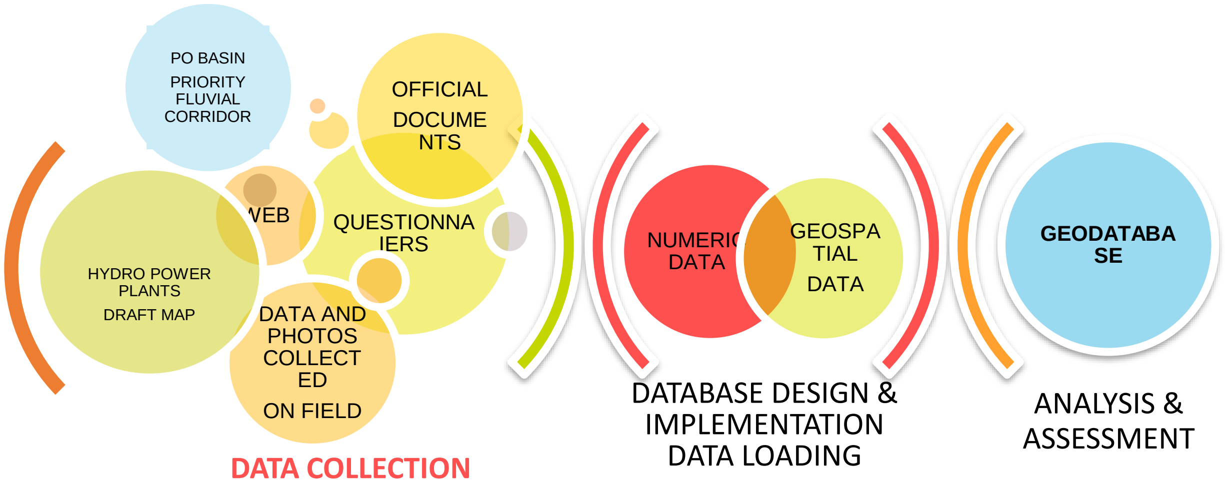
Drafting of the first *Guidelines for the compliance of hydro structures with downstream migration of silver eels* in the Po basin

DELIVERABLES:

- **Geodatabase** of hydroelectric and other hydro facilities of the «Priority fluvial corridor for the conservation of eel». Delivery date: expected 31/12/2021, requested 31/12/2022
- **Guidelines** for the compliance of hydro structures with downstream migration of silver eels. Delivery date: expected 31/12/2021, requested 31/12/2022

Geodatabase of hydroelectric and other hydro facilities of the «Priority fluvial corridor for the conservation of eel»

DATABASE DEVELOPING PROCESS



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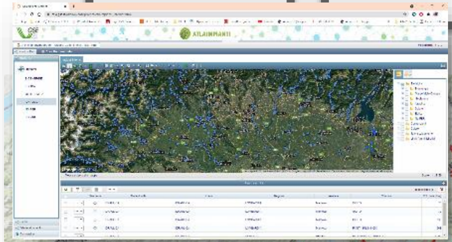
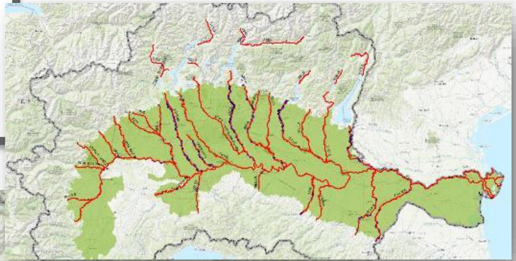
DATABASE DEVELOPING PROCESS - DATA COLLECTION

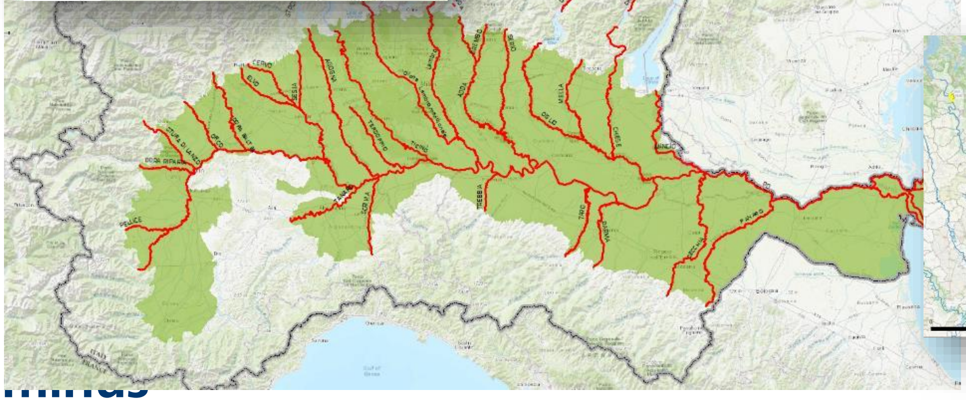
Po basin PRIORITY FLUVIAL CORRIDOR

Po basin HYDRO POWER PLANTS

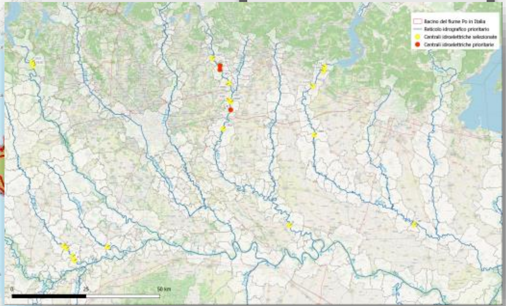
and other hydro facilities (irrigation)





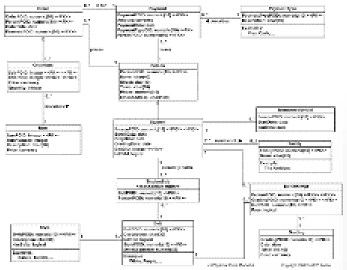


21 Priority Power Plants

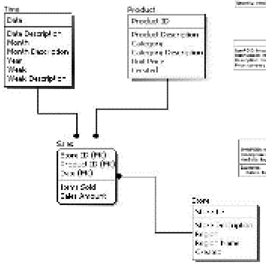


GEODATABASE

Physical design



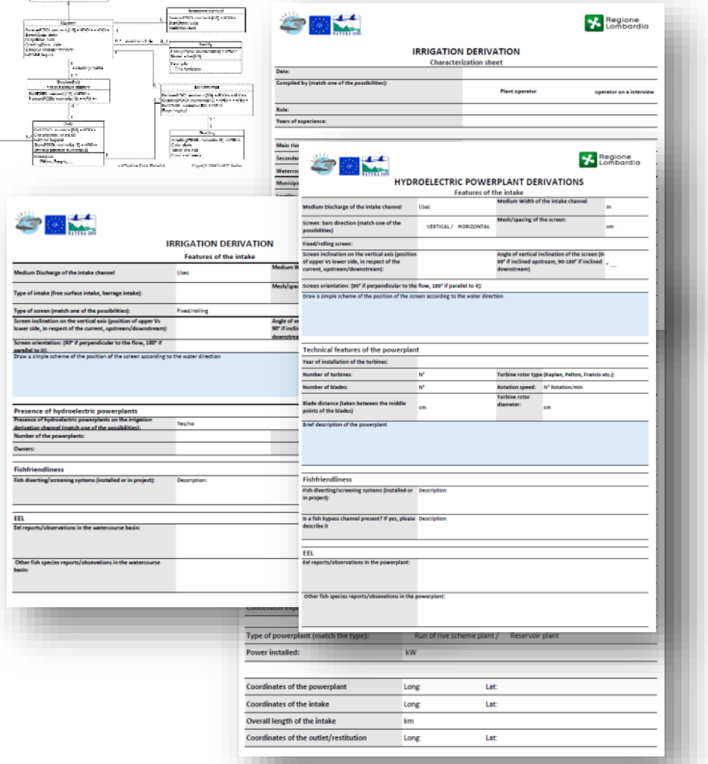
Logical design

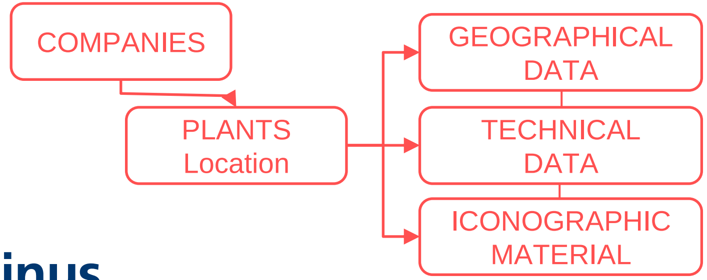


Conceptual design

build a conceptual model based upon the previously identified requirements

entity-relationship model





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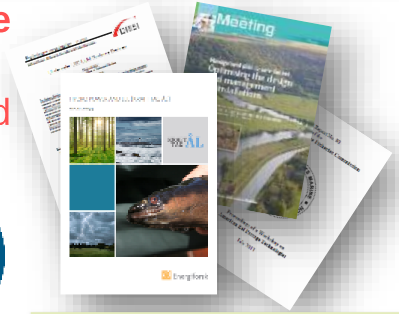
Guidelines for the compliance of hydro structures with downstream migration of silver eels

IN PROGRESS

Literature review

completed



Search and evaluation of the available **literature** in the subject. It documents the state of the art with respect to different types of deterrent systems.

Literature review

GEODATABASE

(data related to the area of interest)

SWOT analysis

or similar approach

Guidelines for the Po basin

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Guidelines for the compliance of hydro structures with downstream migration of silver eels

Review of the specific literature produced in the last 20 years (more than 80 publications).

Deterrent systems analysis:

- Physical guidance barriers (inclined bar racks; angled bar racks and louvers);

- Behavioural barriers (bubble curtains, electrical barriers, acoustic fish deterrents; artificial lighting - *eels are negatively phototactic*).

The best solution seems to be a combination of the two deterrent system types

Sub-action A4.2 takes advantage of the first results of sub-action A4.1

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ACTION A.5

Plans of the priority interventions to restore river connectivity for eel conservation and Guidelines for the compliance of hydro structures with downstream migration of silver eels

Responsible: GRAIA, DEMETER

Subaction A5.1 Plan of priority interventions for the restoration of river connectivity for the conservation of eel

s/as 1/10/2020 – e/ae 31/12/2024

Parallel activities in Italy (Po basin) and Greece (EMU3).

Work performed for successive steps:

Data collection
- Collection of eel presence and distribution data through the review of previous work and studies

Geodatabase
- Storage of the data in a GIS geodatabase

Status of EEL
- definition of potential and current distribution

Eel Priority River Corridor
- Definition of the priority river corridor for the two-way migration of the eel

Current threats to migration UPSTREAM and DOWNSTREAM in the priority corridor

Scale of priorities for intervention

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IN ITALY

SCALE of PRIORITY

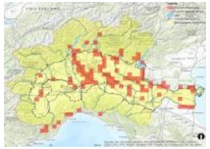
Establishment of a scale of priorities for intervention on structures on the basis of:

- the extent of the damage to migration (none, poor, moderate...)
- Critical aspects of the site, in terms of extension of the fluvial corridor that would be reopened intervening in that point
- territorial and technical constraints
- the estimated cost of constructing the fish passage (for ascent) or the deterrent (for free descent)

For each artificial obstacle a descriptive data sheet will be drawn up including the **possible solution** identified to ensure the migration of eels.

Fluvial corridor → Eel past and current distribution → Eel potential distribution → Barriers to eel migration → Priority of intervention

First draft to be implemented



First draft to be implemented

IN PROGRESS

First draft to be implemented

IN PROGRESS

For the first 5 barriers indicated as priority, the preliminary project of the proposed intervention will be carried out.

DELIVERABLE: The draft of the Plan will be drawn up within the first three years of the project, in order to be shared with stakeholders and then drawn up in its final version by October 2024 and approved by the Consulta Po by the end of December 2024

IN GREECE

SCALE of PRIORITY

Establishment of a scale of priorities for intervention on structures on the basis of:

- the extent of the damage to migration (none, poor, moderate...)
- criticality of the site, in terms of extension of the fluvial corridor that would be reopened intervening in that point
- territorial and technical constraints
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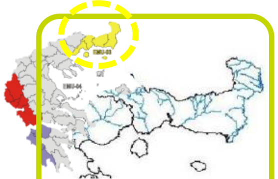
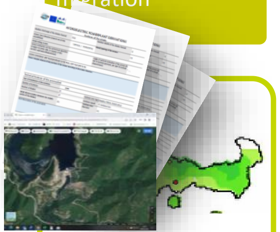
Fluvial corridor → Eel past and current distribution → Eel potential distribution → Barriers to eel migration → Priority of intervention



First draft to be implemented

Data collection in progress

IN PROGRESS



Data collection in progress

IN PROGRESS

For the first 5 barriers indicated as priority, the preliminary project of the proposed intervention will be carried out.

DELIVERABLE: The draft of the Plan will be drawn up in the first 3 years of the project in order to be shared with stakeholders and then drawn up in its final version by October 2024 and included in the Anguilla Plan of EMU3 by December 2024

Action A4.2 Design of deterrent/guidance device

s/as 01/10/2020 – e 31/03/2022

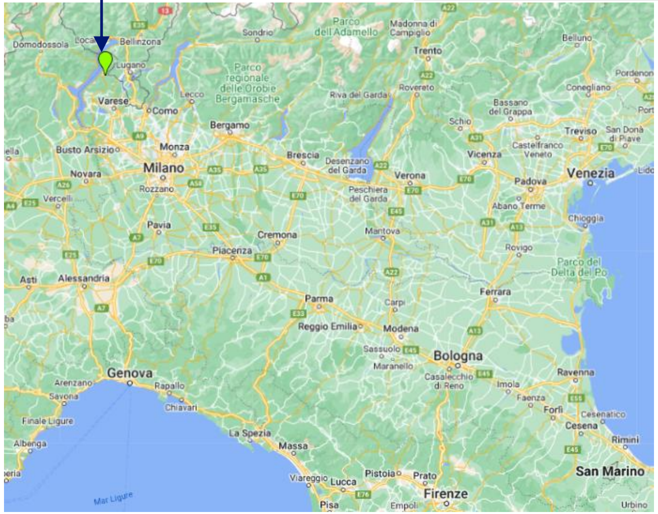

LIFEEL
LIFE19 NAT/IT/000851
Urgent measures in the Eastern Mediterranean for the long term conservation of endangered European eel (*Anguilla anguilla*)

DELIVERABLE

Design of the deterrent/guidance device for silver eels at Creva Dam

Action Code	A.4
Action Title	Analysis of the Po basin permeability to downstream migration of silver eels and assessment of the best deterrent or guidance systems to prevent their entry into hydro structures
Document type	DELIVERABLE – Design
Document title	Design of the deterrent/guidance device for silver eels at Creva Dam
Date	15.12.2021
Authors	GRAIA: Sartorelli M., Barenghi B., Puzzi C.M., Ballerio A.
Action responsible	GRAIA

Creva Dam



The deterrent/guidance device at Creva Dam

The solution adopted: a demonstrative deterrent system at Creva dam composed by a metal grid with stroboscopic lights preventing the entry of downstream migrating eels into turbines due to their photophobic behaviour.

LIFE EEL

Analysis

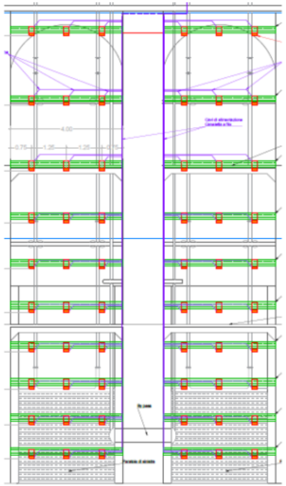
- Analysis of the environmental context and eel physical and physiological characteristics

Screening

- Screening of the different possible solutions, in the light of the environmental and structural conditions and of the eels requirements

Solution

- Positioning and dimensioning of the solution adopted



Positioning scheme of the lights

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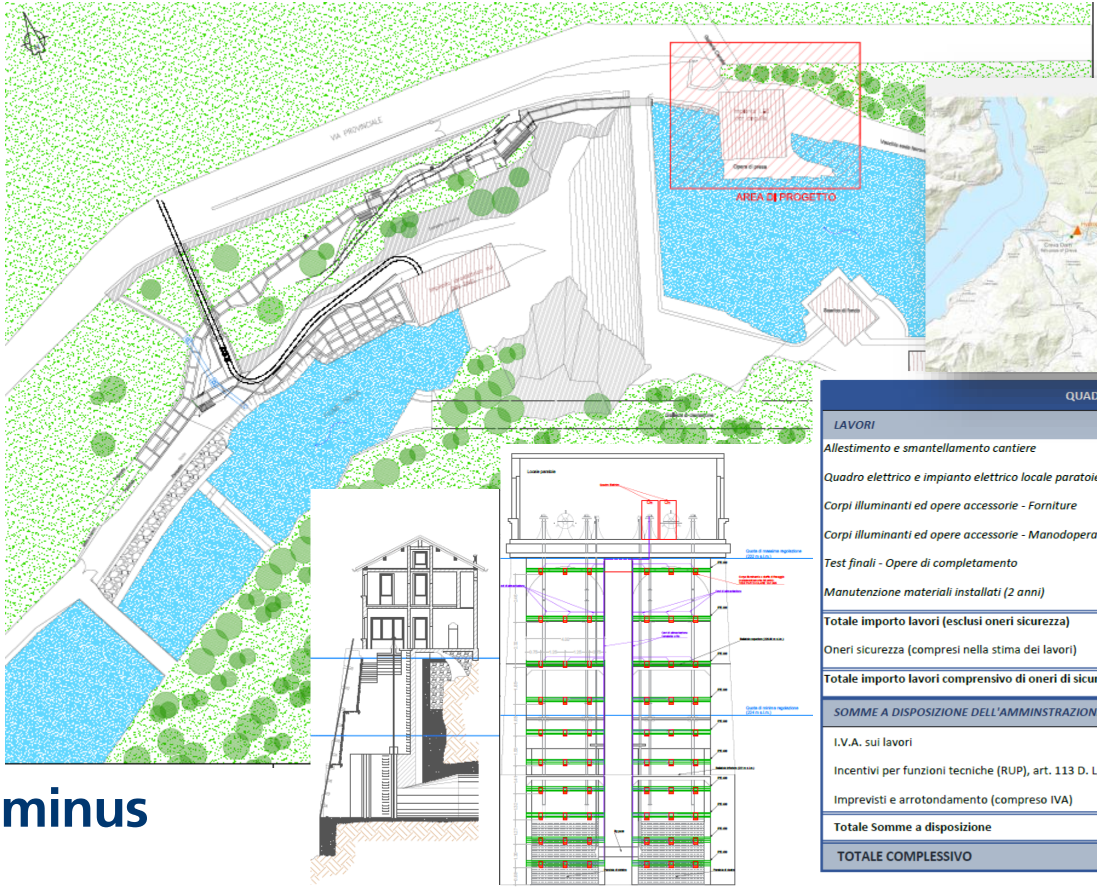
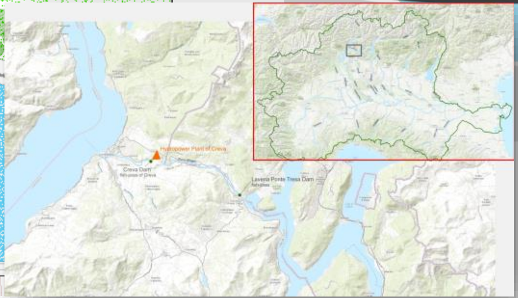
The deterrent/guidance device at Creva Dam





QUADRO ECONOMICO			
LAVORI			
Allestimento e smantellamento cantiere		€	2 500,00
Quadro elettrico e impianto elettrico locale paratoie		€	18 793,87
Corpi illuminanti ed opere accessorie - Forniture		€	52 754,25
Corpi illuminanti ed opere accessorie - Manodopera		€	62 684,52
Test finali - Opere di completamento		€	2 732,99
Manutenzione materiali installati (2 anni)		€	11 087,45
Totale importo lavori (esclusi oneri sicurezza)		€	**150 553,08**
Oneri sicurezza (compresi nella stima dei lavori)		€	1 086,26
Totale importo lavori comprensivo di oneri di sicurezza		€	**151 639,34**
SOMME A DISPOSIZIONE DELL'AMMINSTRAZIONE			
I.V.A. sui lavori	*22%*	€	33 360,65
Incentivi per funzioni tecniche (RUP), art. 113 D. Lgs 50/2016	*1,5%*	€	2 274,59
Imprevisti e arrotondamento (compreso IVA)		€	2 725,42
Totale Somme a disposizione		€	**38 360,66**
TOTALE COMPLESSIVO		€	**190 000,00**

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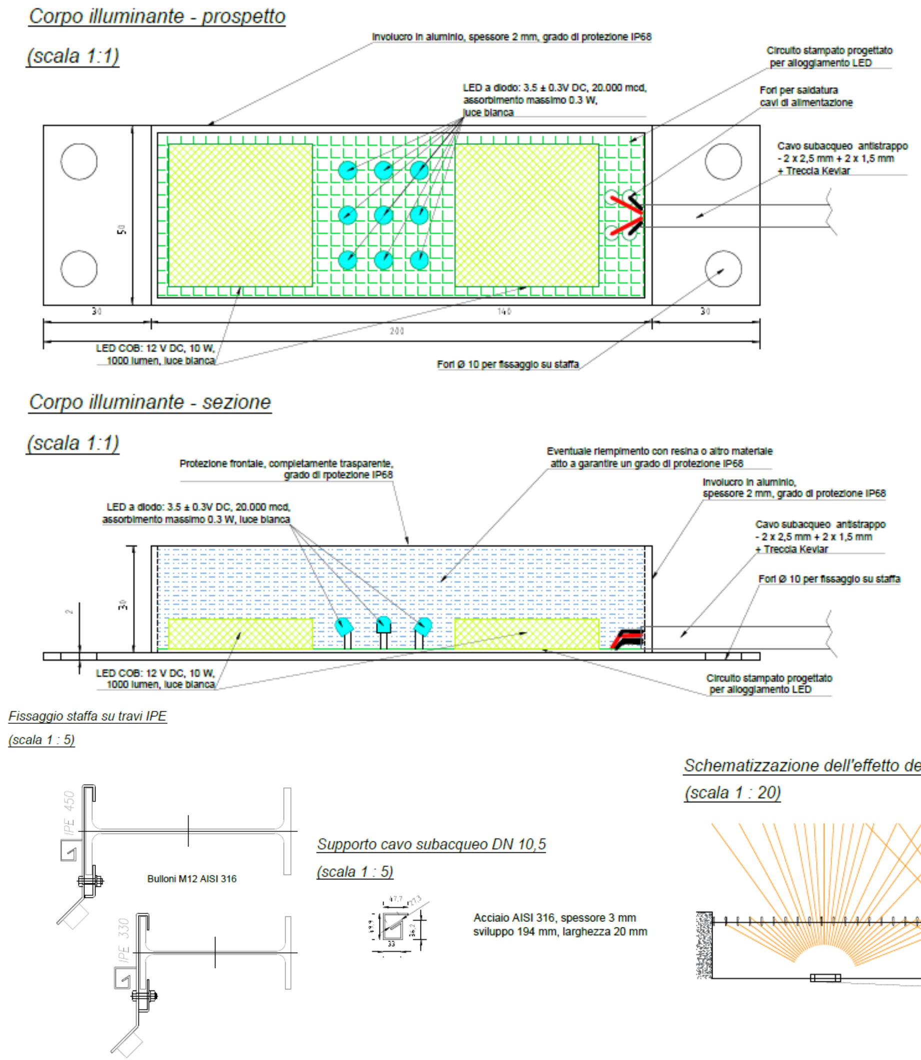
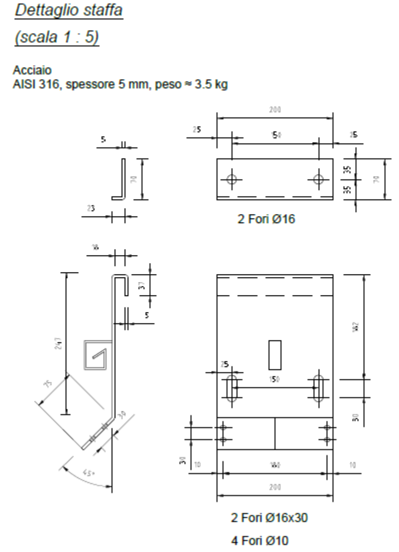
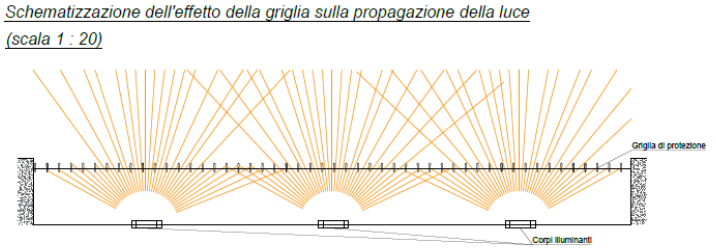
The deterrent/guidance device at Creva Dam







Thank you very much!

Maarten Bruijs

Principal Consultant and Owner of Pecten Aquatic, the Netherlands

Jochem Hop

Dutch water authority Rijkswaterstaat, member of the International Meuse Commission

Tim Vriese

Fish migration specialist at ATKB in Waardenburg (NL)

luminus profish MONITORING FISH ECOLOGY LIÈGE université EDF R&D UNIVERSITÉ DE NAMUR Life

Rijkswaterstaat
Ministerie van Infrastructuur en Waterstaat

Hydropower and fish migration in the Netherlands

Background, policy, research and recent developments

Jochem Hop (RWS) & Tim Vriese (ATKB)

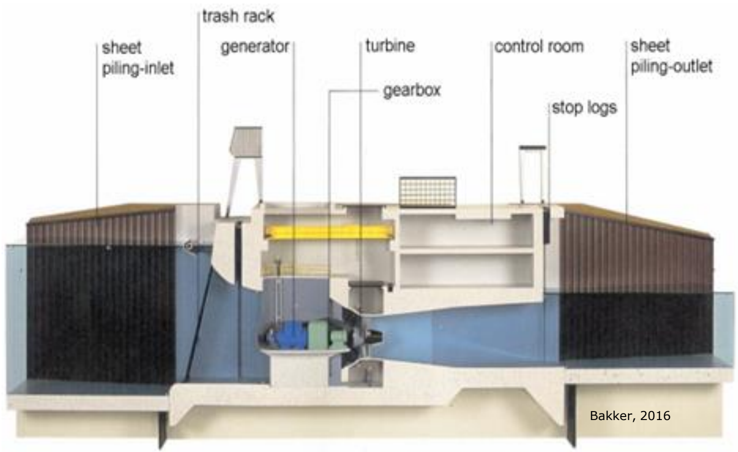
Life4Fish Closing conference - September 6th, 2023

1988-2023

35 years hydropower stations and fish migration in the Meuse

1988-1990 Maurik, Linne, Lith

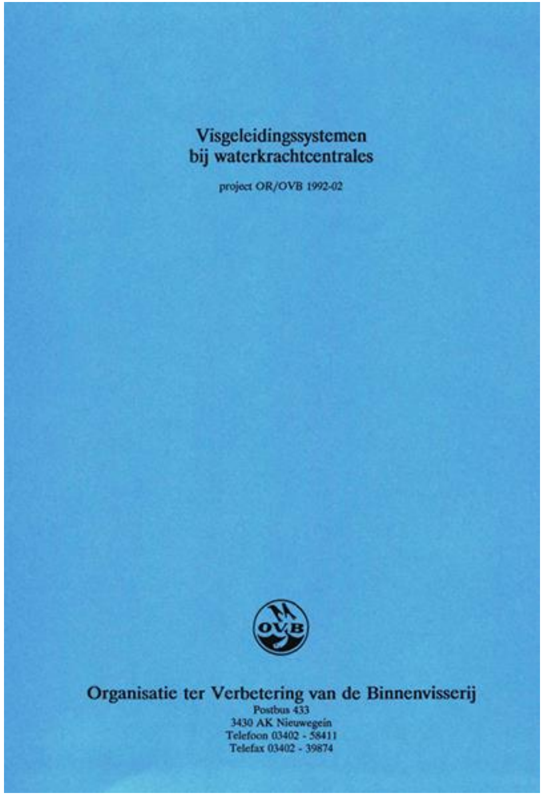
- Large hydropower stations (10-14 MW);
- 4 Horizontal Kaplan bulb turbines;
- 400-450 m^3/s, max. head: 3,0-4,6 m.



Bakker, 2016

Early ’90s awareness

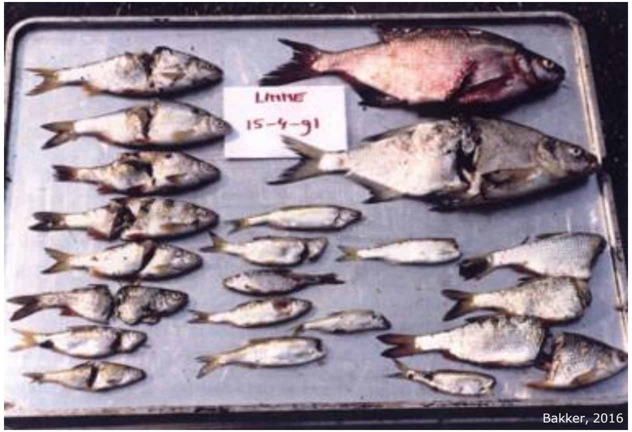
- Awareness importance downstream migration;
- New (larger) fishpasses.



Early ‘90s research Linne

- Downstream passage;
- Mortality;
  - Silver eel: 13-24%
  - Smolts: 6-8%
  - Other species: <5%
  - Fish>30 cm: <10%


Bakker, 2016



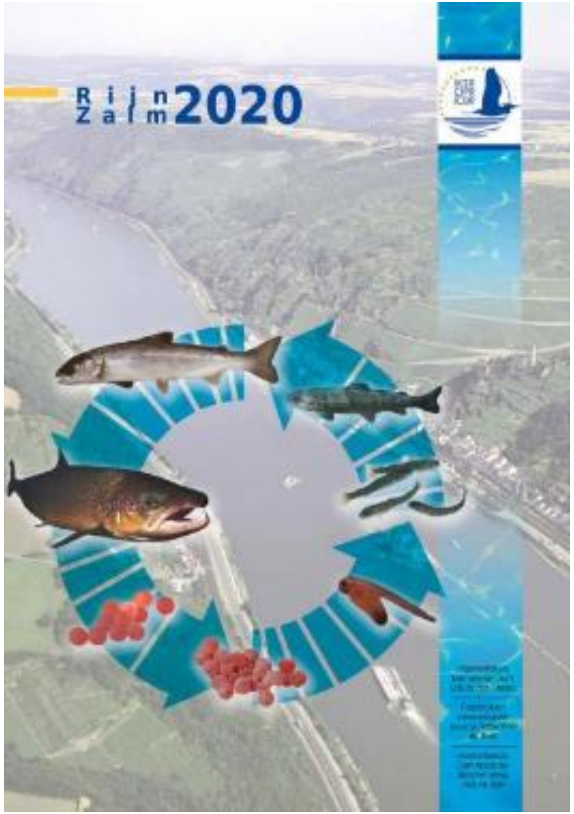
Bakker, 2016

Late '90s

- Stimulation of renewable energy by governance;
- International projects on restoring fish migration;

→ Several plans for new hydropower stations Meuse;
→ Risk of high cumulative mortality of migratory species;

Different ministries → conflicting interests → discussion
(Economics, Agriculture & Fisheries, Infrastructure and Watermangement)



2001 First standard for fish mortality

- Max. 10% fish mortality for individual protected fish species in the Dutch part of the Meuse.

Considering;

- The target will always be 0% fish mortality;
- Other fish species (not protected) will also profit from measures;
- The cumulative standard should be translated to each hydropower station;

→ Hydropower stations Linne & Lith: fish mortality > 10%

1645-41

Waterkrachtcentrales en Vismigratie in de Maas

Januari 2001

1. Voorstel ten behoeve van interdepartementale meningsvorming

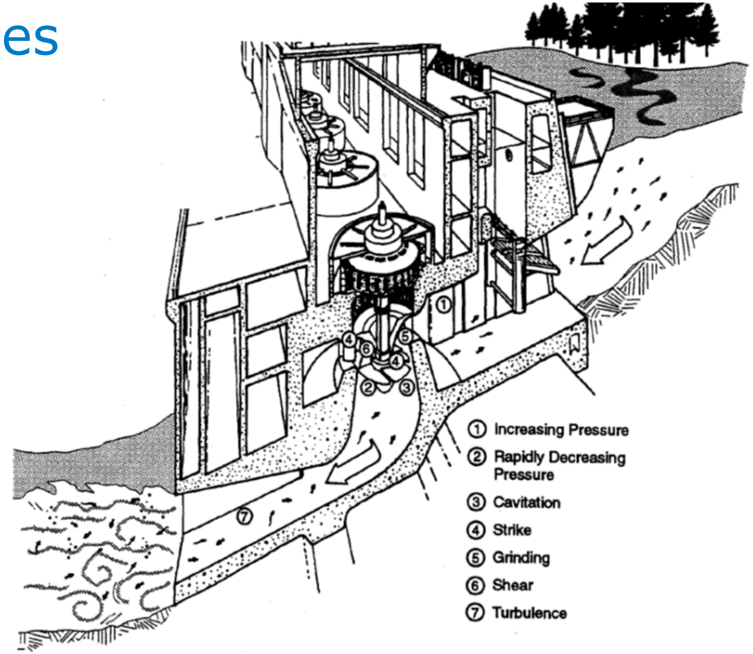
2. Achtergrondnotitie met bijlagen

Werkgroep, bestaande uit
- H. Bakker (RWS directie Limburg)
- R. Kwanten (RWS directie Limburg)
- W. Muyres (Organisatie ter Verbetering van de Binnenvisserij (OVB)
- G. van der Sar (LNV directie Zuid)
- M. van Steenhoven (EZ directie Energie)
- C. Verheijen (LNV directie GRR)

Januari 2000 1

2002 Resolution House of Representatives

- Reduction of fish mortality at hydropower stations;
  - Collision (strike);
  - Getting wedged (grinding);
  - Barotrauma, shear & turbulence, cavitation…

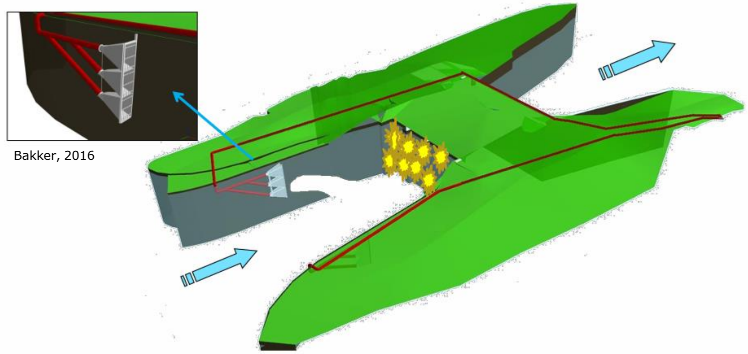


→ Research to implement measures at existing hydropower stations.

2004 Study of fish guidance systems

- Three systems which were supposed applicable, reliable and cost effective;
  - Screens with smal bar spacing;
  - Light & Sound screens;
  - Migromat®

→ New system existing of two siphons and light screen (fish behavior)



Bakker, 2016

2009-2012 Experiments with new system HPS Linne

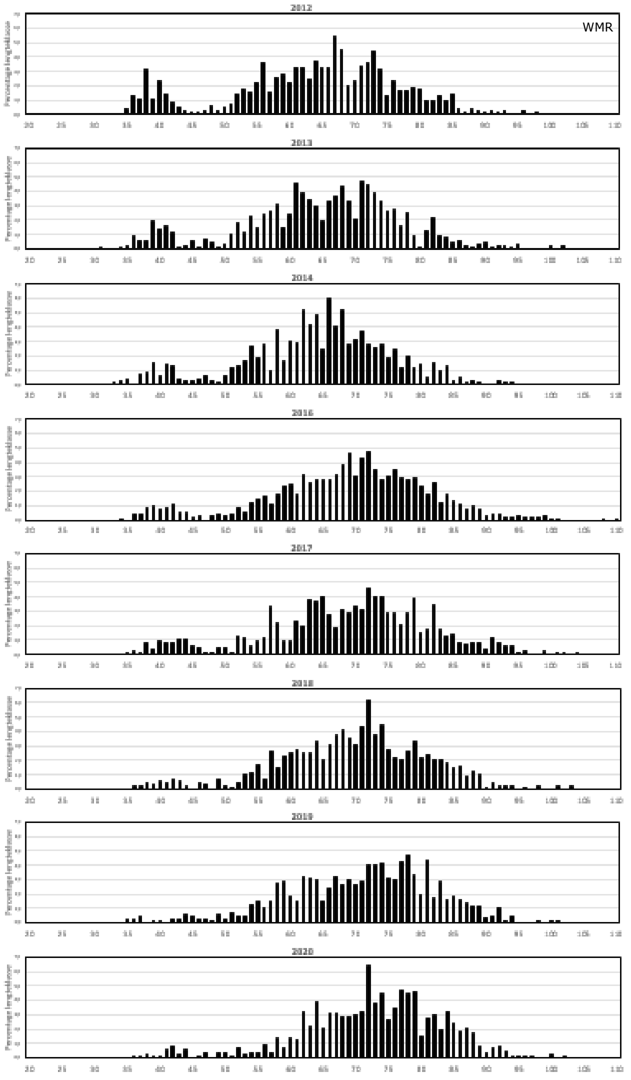
- Not effective at the investigated hydropower station;
  - Eels didn’t turn around;
  - Lights had limited range (turbid water);
  - High flow rates at intake;
  - Small discharge through bypass.

Bakker, 2016

2009-2012 Eel mortality HPS Linne

- 2010 → 36% (Kessel & Jeuken, 2010);
- 2012 → 33% (Kemper & De Bruijn, 2012).

Increased mortality compared to early ’90s, due to larger size of (female) silver eels.



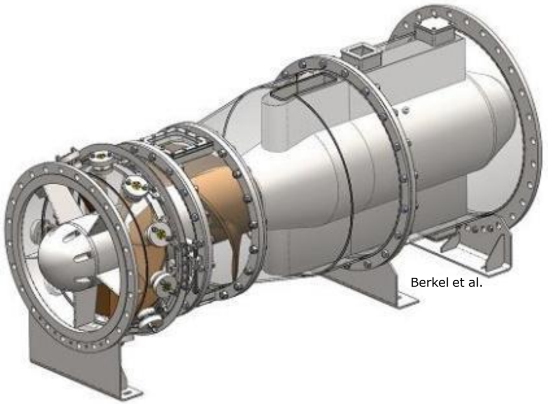
2013 Expert workshop Roermond (NL)

- (Inter)national experts (Germany, Austria, United Kingdom, USA, Netherlands);

→ Behavioral systems (light & sound);
  - Insecure operation at this location (depth, turbid, debris);
  - Large dimensions;

→ Mechanical systems;
  - Applicable and reliable;
  - High expense;

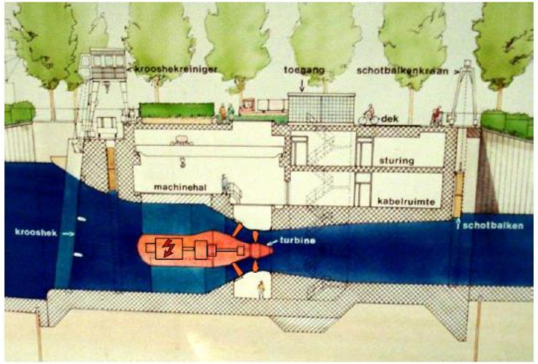
→ "Fish friendly" turbines.



Berkel et al.

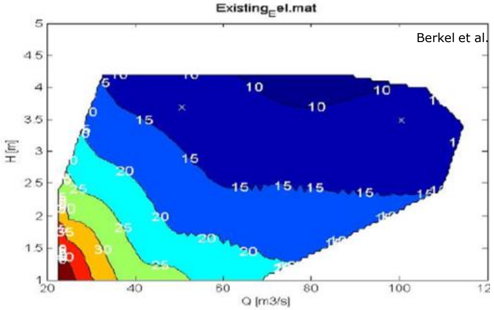
Experts: "… only fish friendly turbines can solve the problems on the Meuse…"

Fish Friendly Turbine Options
for
Hydro Power Plant Linne

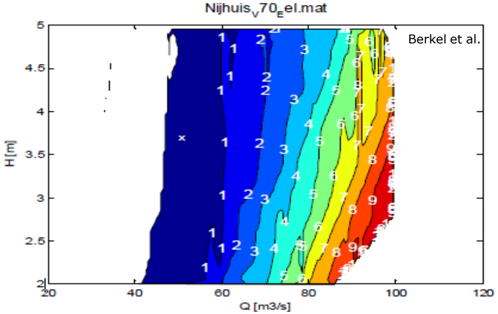


Dr. ir. J. van Berkel
Dr. ir. B.P.M. van Esch
Ir. F.T. Vriese

Research commissioned by:
RWS-GPO, Essent Power and Province Limburg



Probability of mortality for 65 cm Eel, existing turbine.



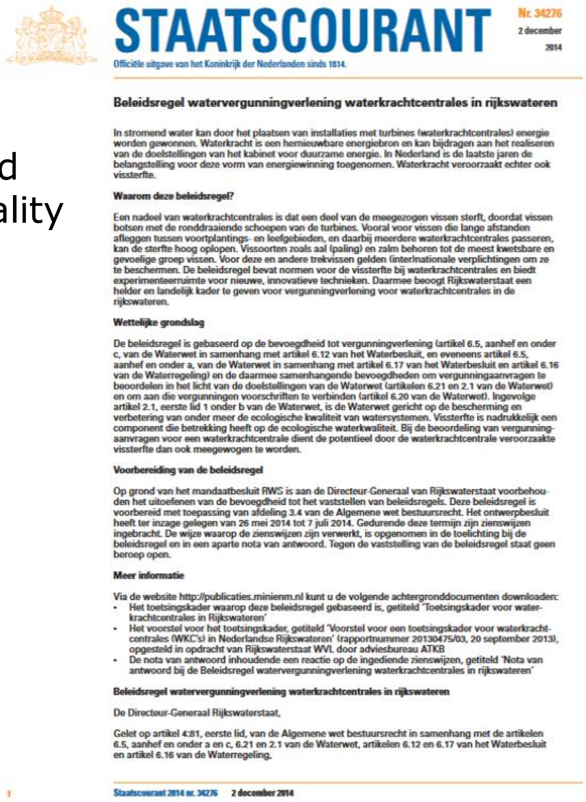
Nijhuis turbine

2014 Hydropower and licensing

- Licensing process of hydropower initiative used to be evaluated against goals of the Dutch Water Act (effects on ecological quality and fish stock);
- New official guideline hydropower licensing;
  - Applies to salmonid smolts, silver eel and other prioritary species;
  - Max. cumulative mortality of 10%;
  - New hydropower stations should be "BAT";
  - Nationwide coverage.

→ A new guideline hydropower licensing was published in 2021
(previous was declared void in 2020 – it was not established under the Law of Environmental Conservation)

→ Rijkswaterstaat acts on the ecological necessity of taking measures to protect silver eel and smolts.



STAATSCOURANT

Nr. 34276
2 december
2014

Officiële uitgave van het Koninkrijk der Nederlanden sinds 1814.

Beleidsregel watervergunningverlening waterkrachtcentrales in rijkswateren

In stromend water kan door het plaatsen van installaties met turbines (waterkrachtcentrales) energie worden gewonnen. Waterkracht is een hernieuwbare energiebron en kan bijdragen aan het realiseren van de doelstellingen van het kabinet voor duurzame energie. In Nederland is de laatste jaren de belangstelling voor deze vorm van energiewinning toegenomen. Waterkracht veroorzaakt echter ook vissterfte.

Waarom deze beleidsregel?

Een nadeel van waterkrachtcentrales is dat een deel van de meegezogen vissen sterft, doordat vissen botsen met de ronddraaiende schoepen van de turbines. Vooral voor vissen die lange afstanden afleggen tussen voortplantings- en leefgebieden, en daarbij meerdere waterkrachtcentrales passeren, kan de sterfte hoog oplopen. Vissoorten zoals aal (paling) en zalm behoren tot de meest kwetsbare en gevoelige groep vissen. Voor deze en andere trekvissen gelden (inter)nationale verplichtingen om ze te beschermen. De beleidsregel bevat normen voor de vissterfte bij waterkrachtcentrales en biedt experimenteerruimte voor nieuwe, innovatieve technieken. Daarmee beoogt Rijkswaterstaat een helder en landelijk kader te geven voor vergunningverlening voor waterkrachtcentrales in de rijkswateren.

Wettelijke grondslag

De beleidsregel is gebaseerd op de bevoegdheid tot vergunningverlening (artikel 6.5, aanhef en onder c, van de Waterwet in samenhang met artikel 6.12 van het Waterbesluit, en eveneens artikel 6.5, aanhef en onder a, van de Waterwet in samenhang met artikel 6.17 van het Waterbesluit en artikel 6.16 van de Waterregeling) en de daarmee samenhangende bevoegdheden om vergunningaanvragen te beoordelen in het licht van de doelstellingen van de Waterwet (artikelen 6.21 en 2.1 van de Waterwet) en om aan die vergunningen voorschriften te verbinden (artikel 6.20 van de Waterwet). Ingevolge artikel 2.1, eerste lid 1 onder b van de Waterwet, is de Waterwet gericht op de bescherming en verbetering van onder meer de ecologische kwaliteit van watersystemen. Vissterfte is nadrukkelijk een component die betrekking heeft op de ecologische waterkwaliteit. Bij de beoordeling van vergunning-aanvragen voor een waterkrachtcentrale dient de potentieel door de waterkrachtcentrale veroorzaakte vissterfte dan ook meegewogen te worden.

Voorbereiding van de beleidsregel

Op grond van het mandaatbesluit RWS is aan de Directeur-Generaal van Rijkswaterstaat voorbehouden het uitoefenen van de bevoegdheid tot het vaststellen van beleidsregels. Deze beleidsregel is voorbereid met toepassing van afdeling 3.4 van de Algemene wet bestuursrecht. Het ontwerpbesluit heeft ter inzage gelegen van 26 mei 2014 tot 7 juli 2014. Gedurende deze termijn zijn zienswijzen ingebracht. De wijze waarop de zienswijzen zijn verwerkt, is opgenomen in de toelichting bij de beleidsregel en in een aparte nota van antwoord. Tegen de vaststelling van de beleidsregel staat geen beroep open.

Meer informatie

Via de website http://publicaties.minienm.nl kunt u de volgende achtergronddocumenten downloaden:
- Het toetsingskader waarop deze beleidsregel gebaseerd is, getiteld 'Toetsingskader voor water-krachtcentrales in Rijkswateren'
- Het voorstel voor het toetsingskader, getiteld 'Voorstel voor een toetsingskader voor waterkracht-centrales (WKC's) in Nederlandse Rijkswateren' (rapportnummer 20130475/03, 20 september 2013), opgesteld in opdracht van Rijkswaterstaat WVL door adviesbureau ATKB
- De nota van antwoord inhoudende een reactie op de ingediende zienswijzen, getiteld 'Nota van antwoord bij de Beleidsregel watervergunningverlening waterkrachtcentrales in rijkswateren'

Beleidsregel watervergunningverlening waterkrachtcentrales in rijkswateren

De Directeur-Generaal Rijkswaterstaat,

Gelet op artikel 4:81, eerste lid, van de Algemene wet bestuursrecht in samenhang met de artikelen 6.5, aanhef en onder a en c, 6.21 en 2.1 van de Waterwet, artikelen 6.12 en 6.17 van het Waterbesluit en artikel 6.16 van de Waterregeling.

1

Staatscourant 2014 nr. 34276 2 december 2014

2014 Hydropower and licensing

- 10% mortality
  - Does not jeopardise the population of salmonids or eel;
  - It falls within the normal fluctuation of the population size;
- However the existing hydropower stations at Linne and Lith already exceeded the 10% mortality;
- Exception for the 10% mortality → license for experiments to reduce fish mortality.
- Vattenfall (Lith) and RWE (Linne) were asked tot take further measures (mortality <5% per HPS);

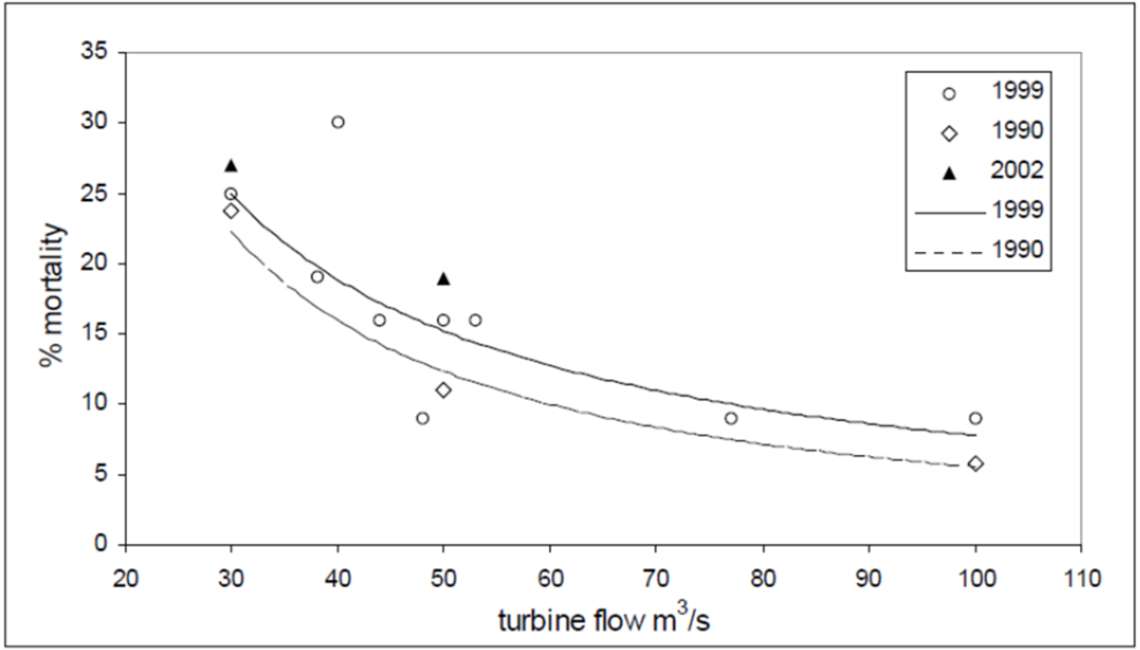
provisional measures – research – evaluation

Vattenfal and RWE commissioned the research, wich was conducted by VisAdvies

2017-2022 Experiments hydropower stations Lith and Linne

Fish Friendly Turbine Management form 2011 onwards;

- 2nd turbine is started when 1st turbine is at maximum of capacity.

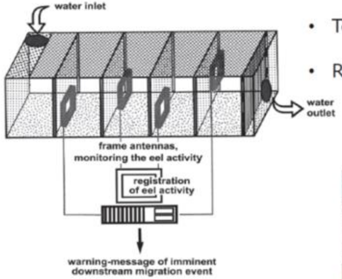


2017-2022 Experiments hydropower stations Lith and Linne

Early warning systems

- Migromat® for silver eel;
- Temperature based Early Warning System for smolts.

Early warning system silver eel: MIGROMAT



- Tested at HPS's Meuse in 2002
- Reduction of silver eel mortality max 69%

Bakker, 2016

Early warning system smolts:

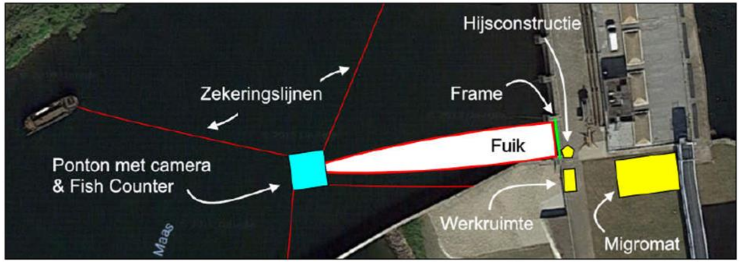
- Start migration when water temperature exceeds 10°C for three days;
- 80% of the smolts pass in 21 days;
- Shut down HPS for 21 days.

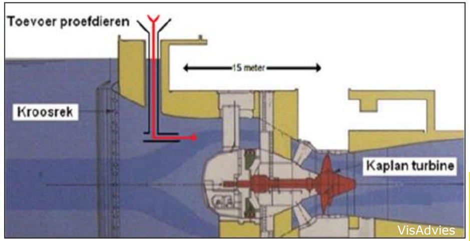
2017-2022 Experiments hydropower stations Lith and Linne

Research;

- Monitoring silver eel migration;
- Monitoring smolt migration;
- Establishing silver eel mortality;
- Establishing smolt mortality;
- Establishing mortality other prioritairy species;

(Mortality during natural migration and (partly) forced exposure).

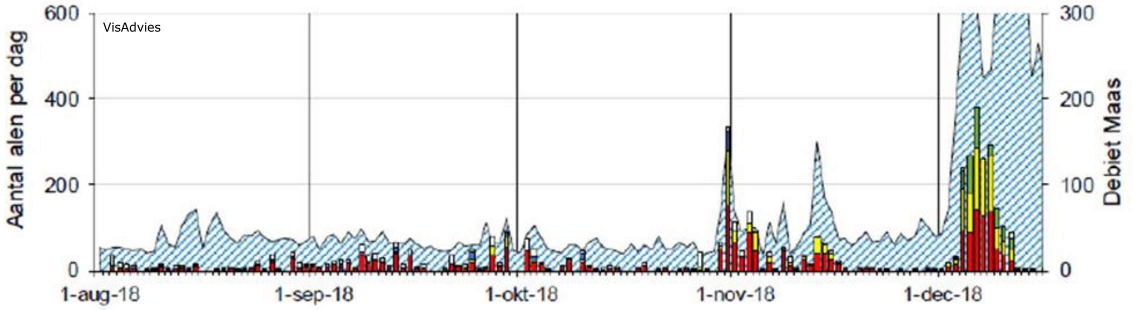


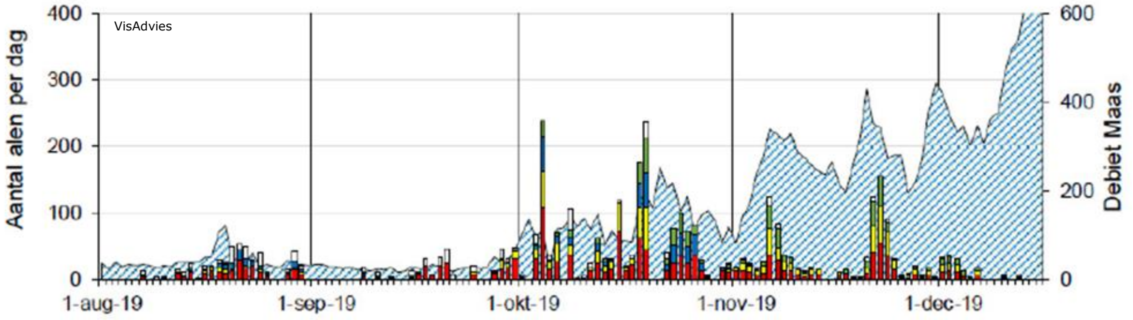


2017-2022 Experiments hydropower stations Lith and Linne

Some results silver eel

- Migration of silver eel through HPS Lith in relation to Meuse discharge (2018-2019).



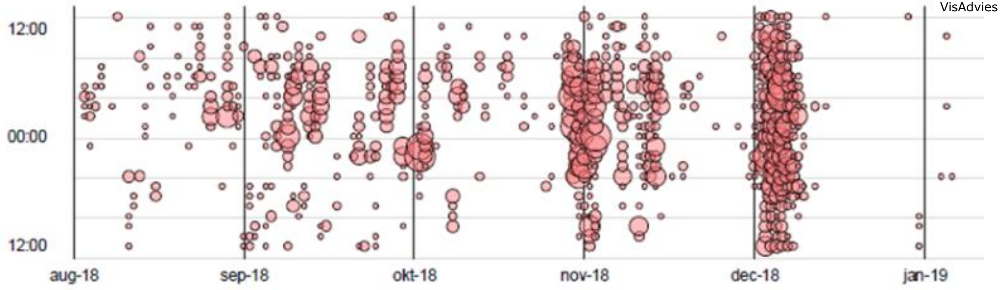


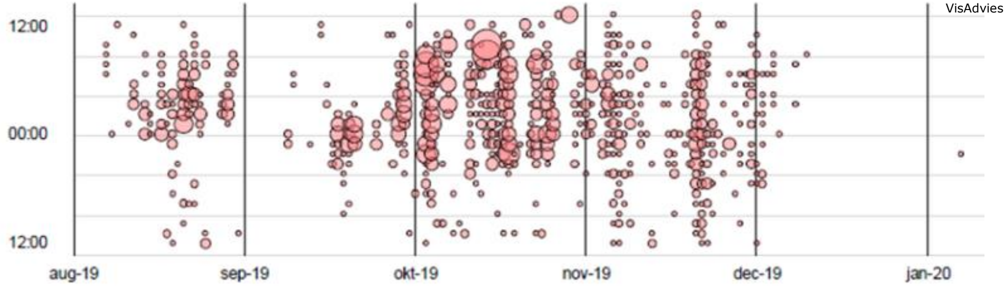
(red bar: number of silver eel migrating through turbine 1; other bars: calculated number of silver eel passing through the other turbines 2, 3 and 4).

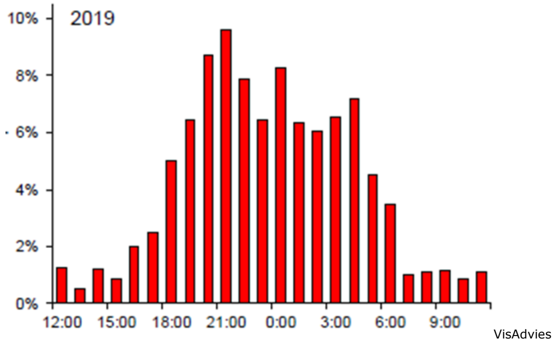
2017-2022 Experiments hydropower stations Lith and Linne

Some results silver eel

- Migration of silver eel through HPS Lith in relation to Meuse discharge (2018-2019)





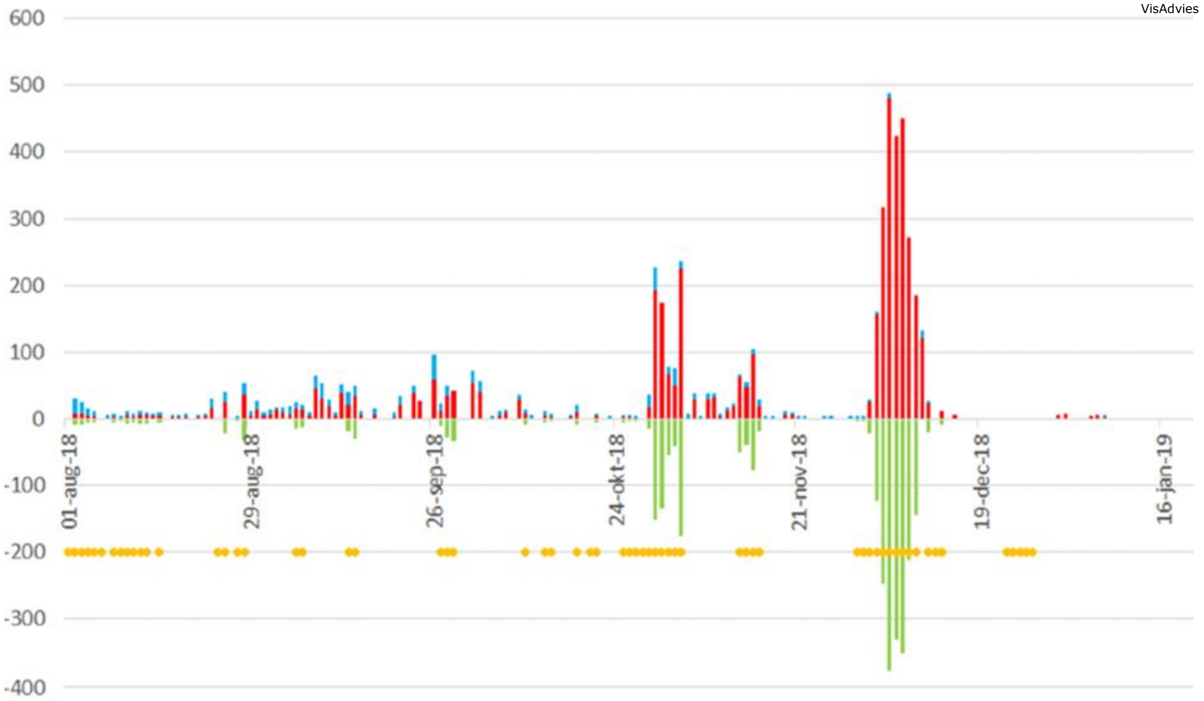


Migration is mainly nocturnal

2017-2022 Experiments hydropower stations Lith and Linne

Some results silver eel

- MIGROMAT® **2018**
- <u>Mortality could decrease with **76%**</u>

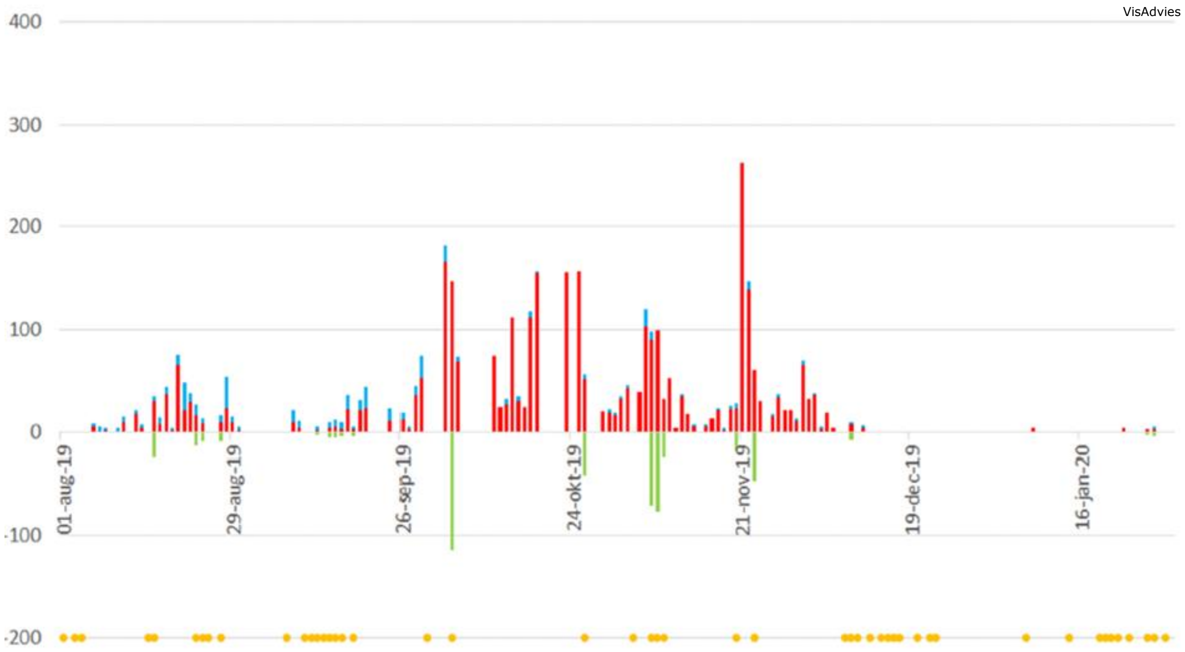


Yellow dots: alarms MIGROMAT®;
red bars: eels through turbines;
blue bars: eels over the weir;
green bars: eels theoretically saved by the MIGROMAT®

2017-2022 Experiments hydropower stations Lith and Linne

Some results silver eel

- MIGROMAT® **2019**
- <u>Mortality could decrease with **15%**</u>



Yellow dots: alarms MIGROMAT®;
red bars: eels through turbines;
blue bars: eels over the weir;
green bars: eels theoretically saved by the MIGROMAT®

2017-2022 Experiments hydropower stations Lith and Linne

Some results silver eel

- Trap & Transport Lith
    - 2018 = 828 silver eel
    - 2019 = 1.882 silver eel

2017-2022 Experiments hydropower stations Lith and Linne

Lith 2018 – 2019

- Silver eel mortality;
  - 2018 = 23%
  - 2019 = 24%
- Silver eel mortality with MIGROMAT®;
  - 2018 = 9%
  - 2019 = 20%
- Silver eel mortality with MIGROMAT® and Trap&Transport;
  - 2018 = 7,9%
  - 2019 = 13,0%

→ Not reliable and effectiveness to low to reach the desired level of 5% silver eel mortality…

2022 Permit for hydropower station Lith

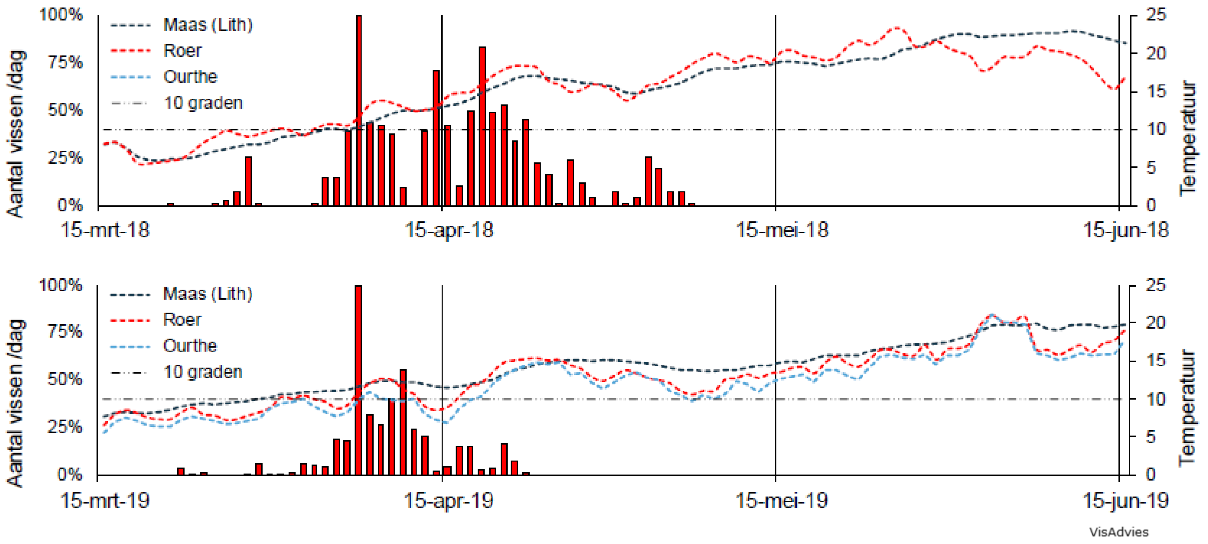
The following requirements in the permit for **silver eel**;

- Shut down from 16:00h - 08:00h in the period from the 1st of August untill 31st of December;
- Turbine management should be executed during silver eel migration season: minimum discharge to engage a turbine is 50 m^3/s;
- In combination with fish friendly turbine management: the next turbine is started when the first turbine is at maximum capacity.

2017-2022 Experiments hydropower stations Lith and Linne

Some results smolts

- 2018: 647 smolts detected (turbine 1) → total estimation 2.294 smolts;
- 2019: 1.183 smolts detected (turbine 1) → total estimation 4.396 smolts;
- Smolt passing HPS is mainly nocturnal: 90% passes between 18:00 – 06:00



2017-2022 Experiments hydropower stations Lith and Linne

Lith

- Smolt mortality = exactly **5%** → BAT → further measures are necessary!
- Vattenfal: Early Warning System for smolts;
  - Shut down during 21 days at a discharge of <50m3/s;
  - Between 18:00 – 06:00;
  - Smolt mortality = **3,4%**
- Rijkswaterstaat: EWS not reliable:
  - No prediction of migration peaks (due to constant period of 21 days);
  - No other parameters (like Teichert *et al*., 2020);
  - Temperature is measured in the Meuse at Lith and not in the tributaries of the Meuse;
  - In 2019 smolt migration from the Ourthe started much later than predicted by EWS;
  - EWS not future-proof…

2022 Permit for hydropower station Lith

The following requirements in the permit for **smolts**;

- Shut down from 21:00h - 04:00h in the period from the 1st of April untill 31st of May;
- In the same period turbine management should be executed: minimum discharge to engage turbine is 50 m^3/s;

→ With these measures it is certain that smolt mortality is below 5% → 2,5%

→ Requirements for hydropower station Linne are more or less the same, however migration period is predicted using Teichert model (optimized for Meuse Linne ≈ 70-80%).

2023 and further…

- Permits for hydropower station Lith and Linne are challenged by Vattenfall and RWE;
- Later this year both permits will be judged by the highest court in the Netherlands (the Administrative Jurisdiction Division of the Council of State)…

Erwin Winter

Researcher (PhD) at
Wageningen Marine Research
Aquaculture and Fisheries
Group,
Wageningen University &
Research

SILVER EEL MIGRATION IN THE DUTCH REGULATED MEUSE

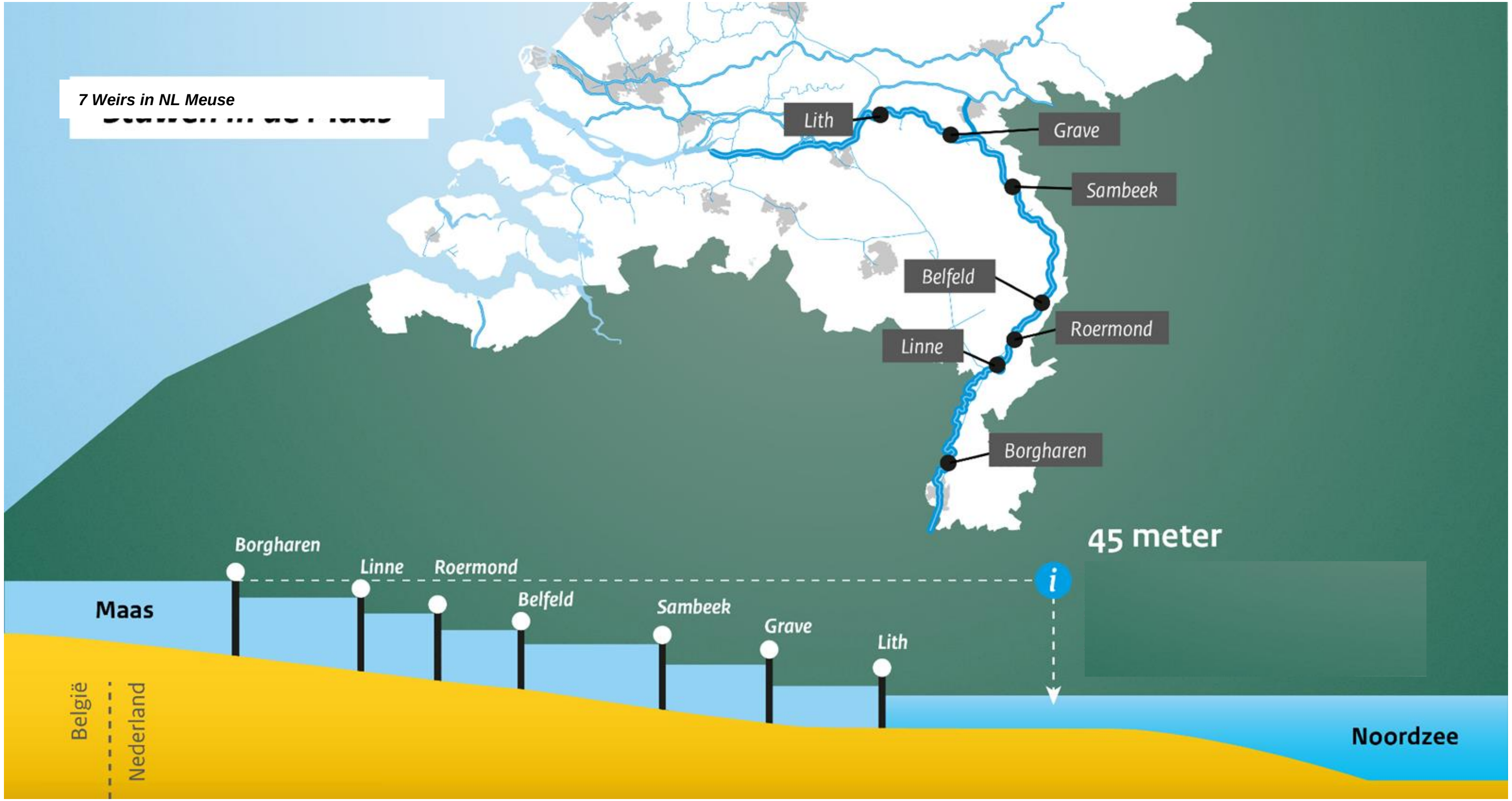
06.09.2023

luminus

ERWIN WINTER

Fish migration researcher (PhD)
Wageningen Marine Research
Wageningen University & Research

Dutch section river meuse highly regulated



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Weir-complex linne

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Weir-complex lith (most downstream)

Potential barriers for migratory fish

Downstream Migration of Silver Eel

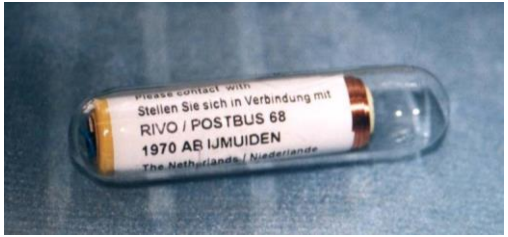
luminus

Telemetry studies

NEDAP-TRAIL:

Inductive coupling
Fixed detection stations
covering river (route)width

2002-2019 NEDAP: 150 eels per study year
(2023 acoustic)



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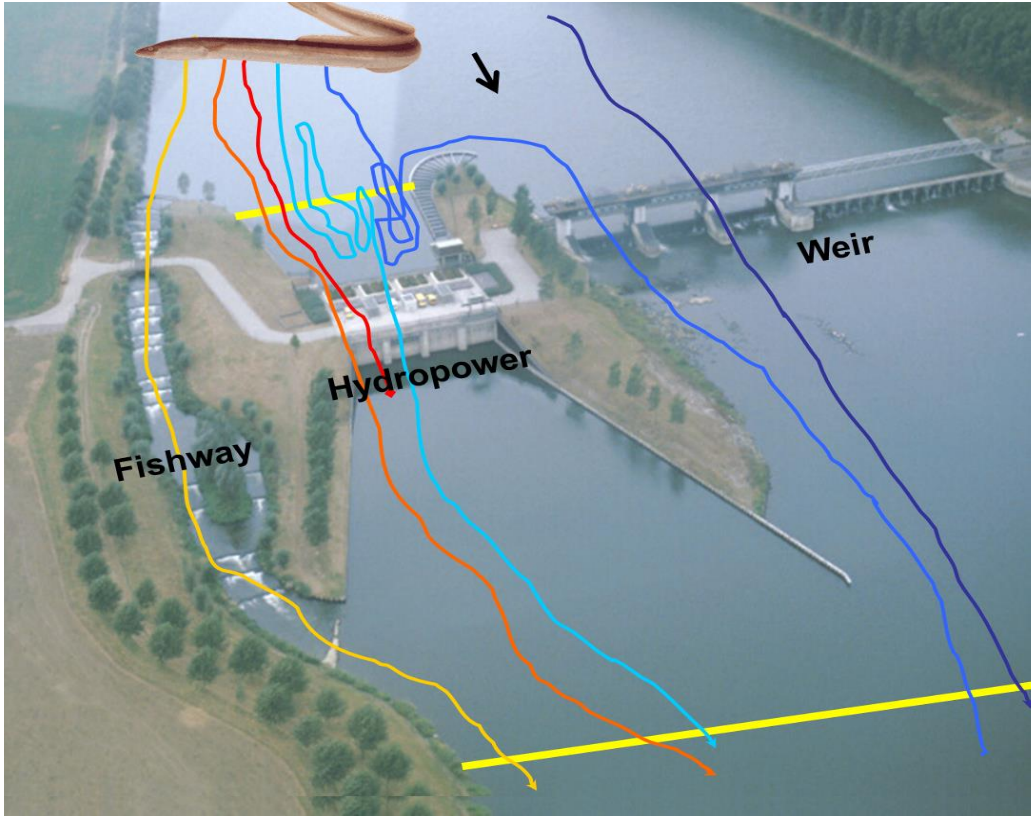
Route selection of eel at weir-sites



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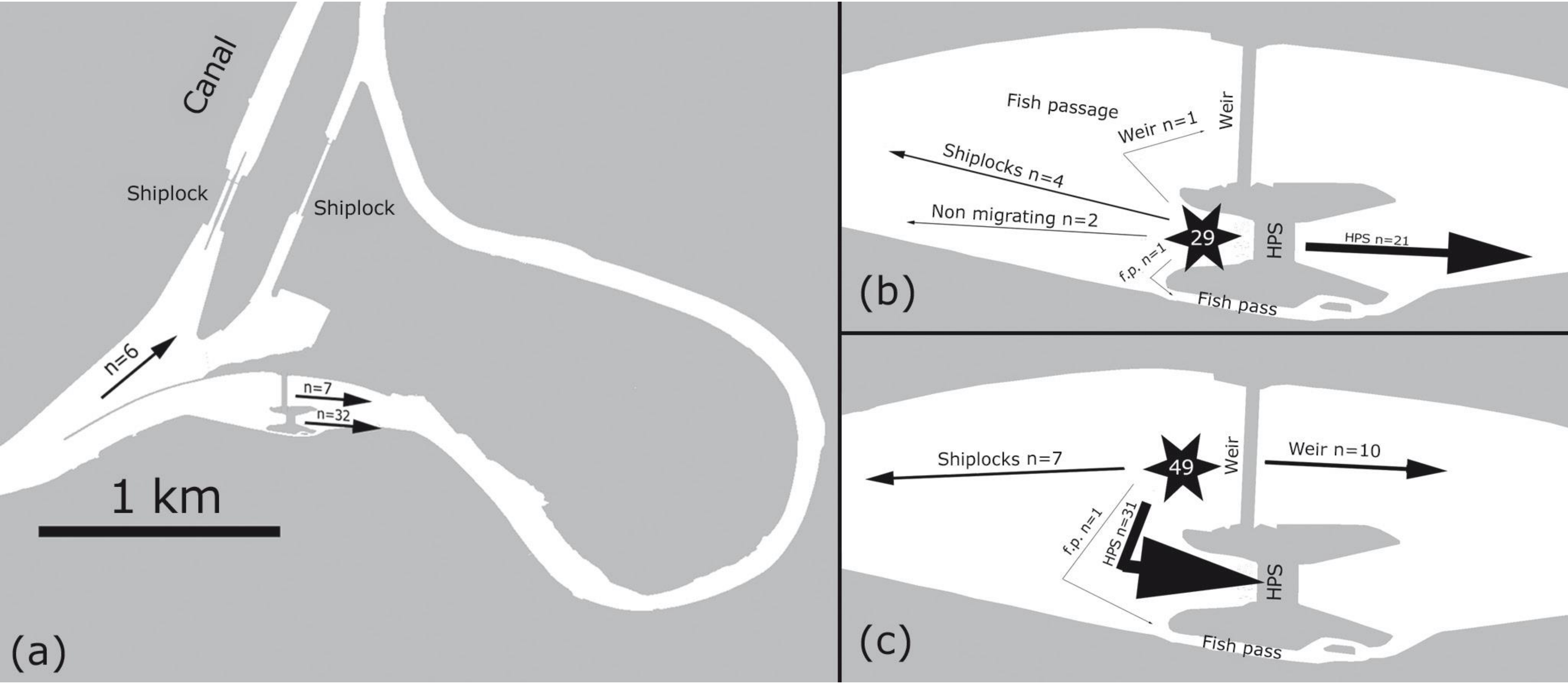
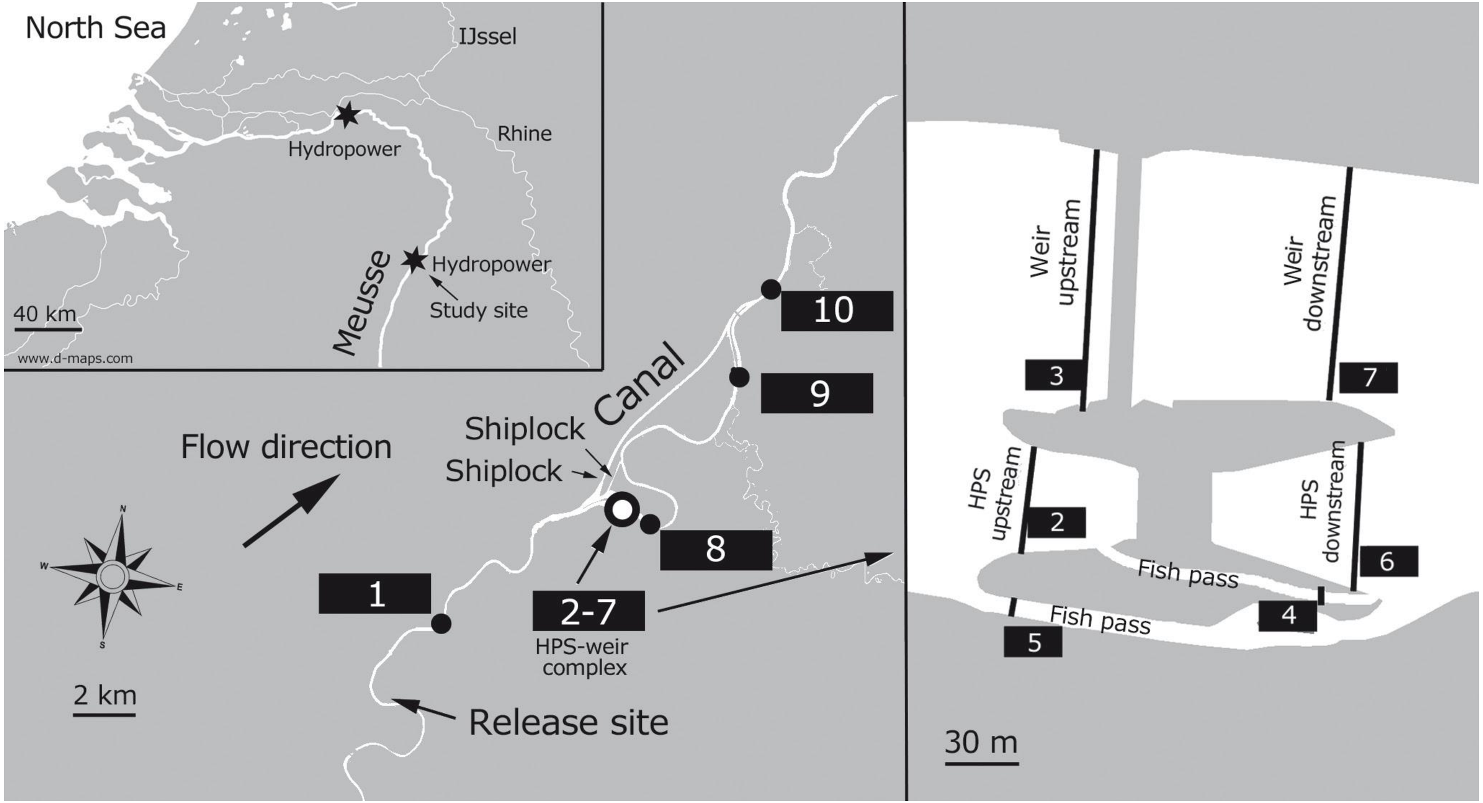
Hydropower location linne



Hydropower location linne



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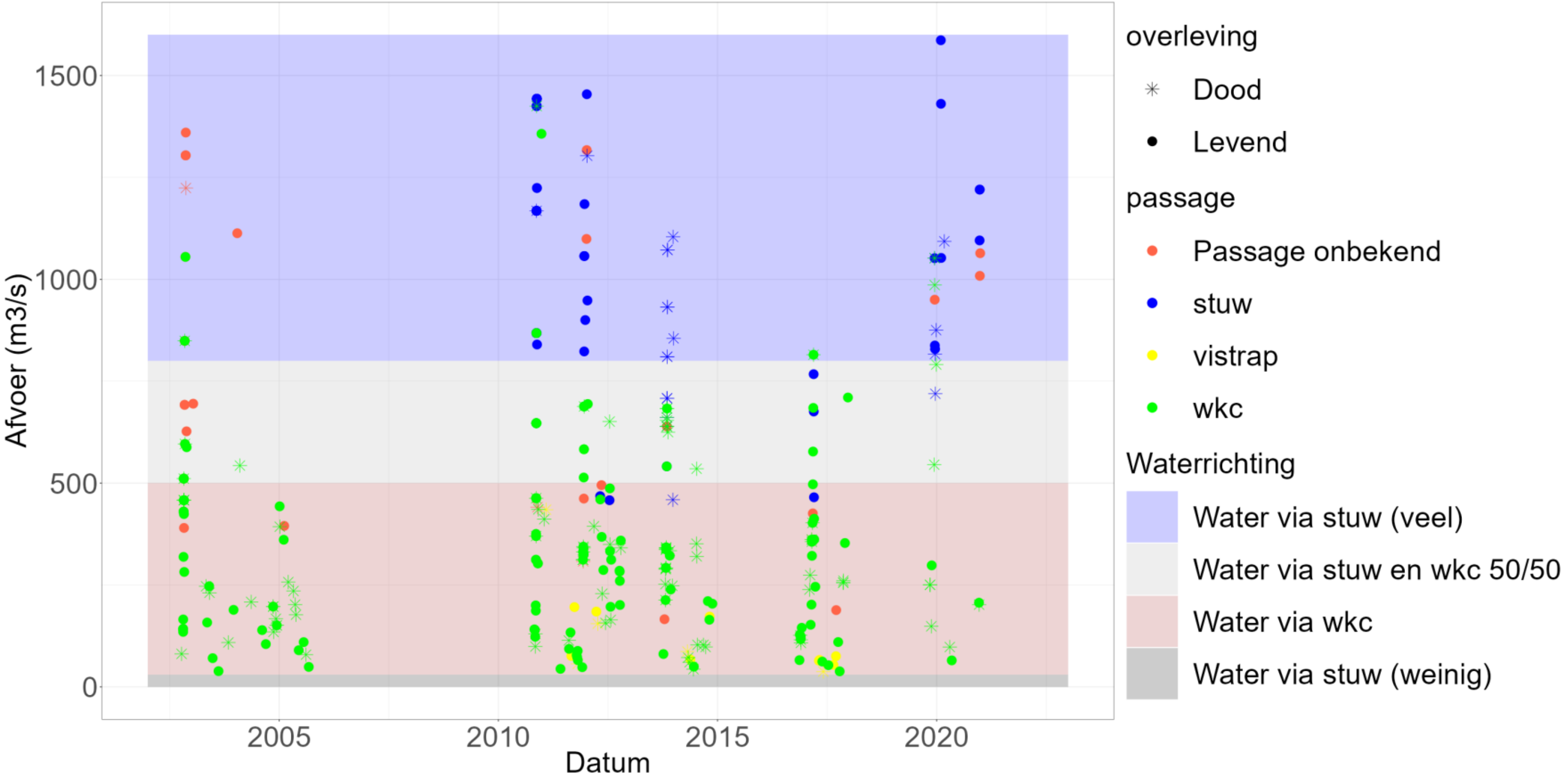
Route selection i.r.t. discharge at lith



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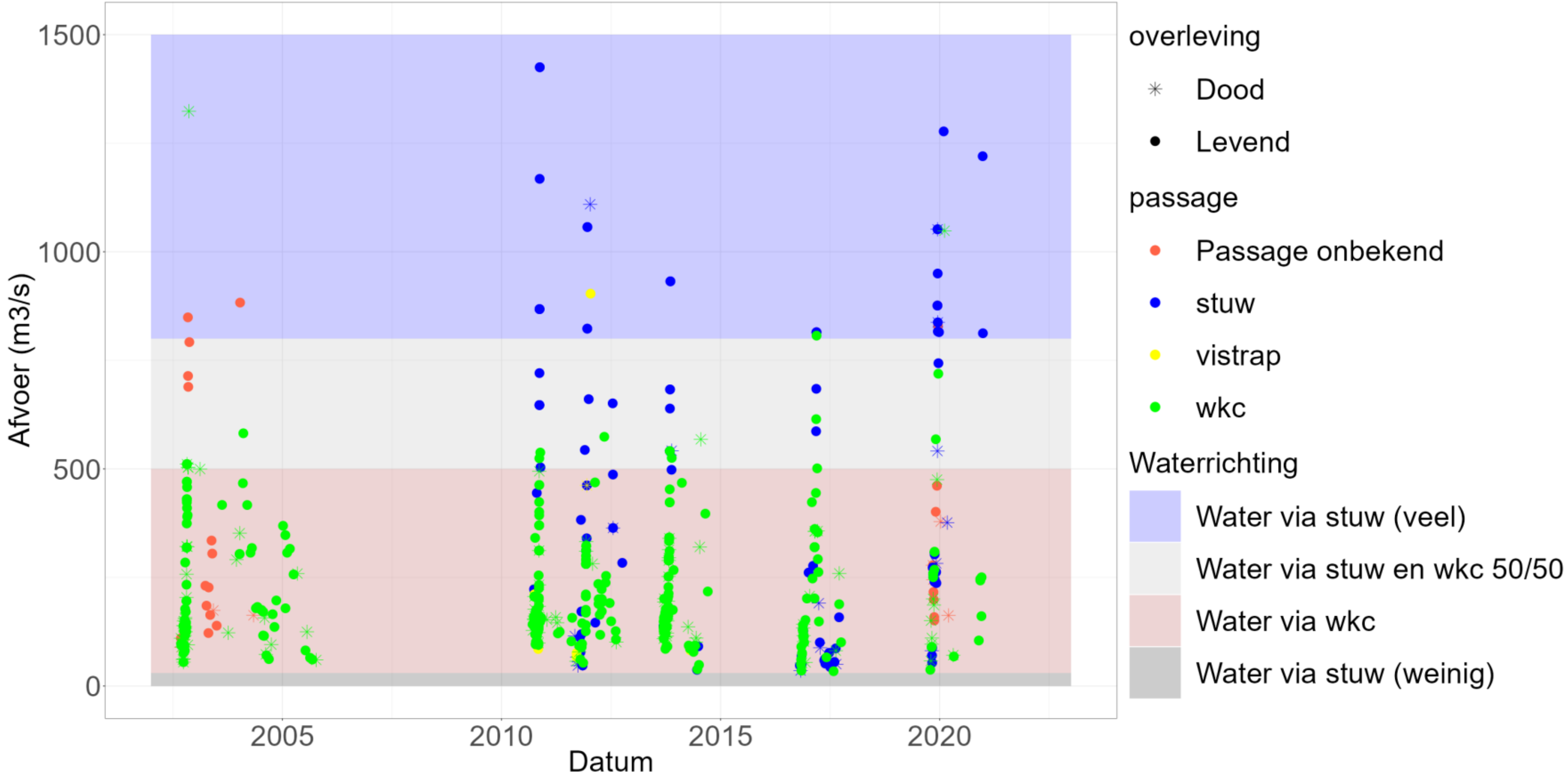
Route selection i.r.t. discharge linne



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Strong variation in individual behaviour

Mortality – fate of eels migrating to sea

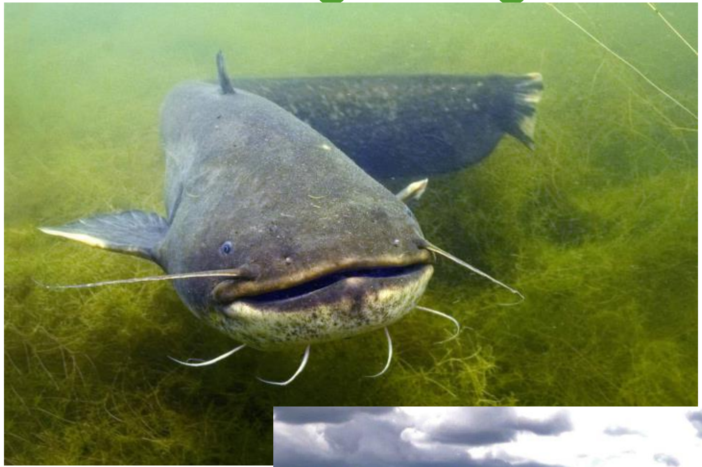
Successful to sea: ~10-40%

Hydropower mortality: ~5-25%

Fisheries mortality: ~10-25%

Unaccounted 'losses': ~20-40%

→ predation? e.g. catfish?
→ illegal fishing/poaching?
→ shipping mortality?
→ 'pausing' migration (at start/during)



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Upcoming studies

Acoustic telemetry

WAGENINGEN UNIVERSITY & RESEARCH

Sportvisserij Nederland

Rijkswaterstaat

Thanks for your attention

luminus

Grégoire Dallemagne

CEO Luminus

luminus

profish
MONITORING FISH ECOLOGY

LIÈGE université

eDF R&D

UNIVERSITÉ DE NAMUR

Life

Life4Fish summary

- Tested solutions
- Behavioural results
- Measured efficiency compared to initial goals of fish survival

Pierre Theunissen, Senior Project Manager, Luminus
Damien Sonny, Fish Biologist PhD, Profish
Olivier Machiels, Project Engineer Arcadis

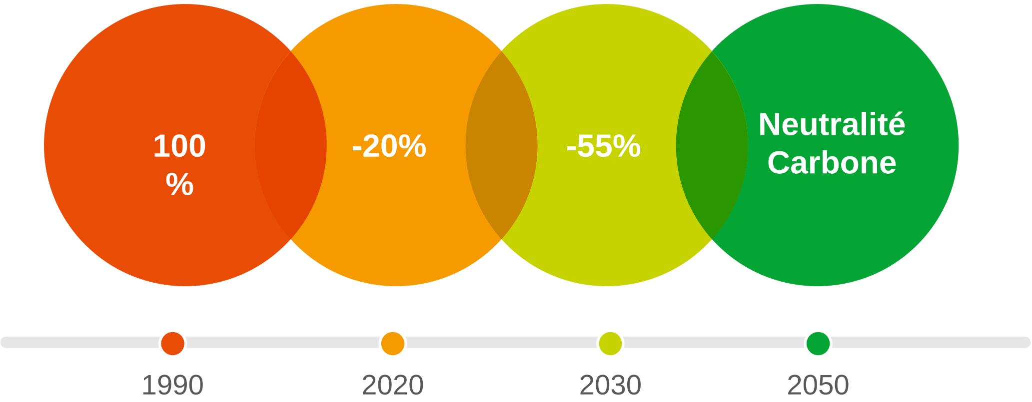
luminus profish MONITORING FISH ECOLOGY LIÈGE université EDF R&D UNIVERSITÉ DE NAMUR Life

PIERRE THEUNISSEN

Senior Project Manager Luminus

Summary of the project & Main actions of Luminus

TOWARDS CARBONE NEUTRALITY IN 2050



European Objectives

LIFE4FISH

WHY LIFE 4 FISH ?

Let's build a CO_2-neutral energy future that reconciles planet preservation, well-being and development through electricity and innovative solutions and services.

We produce electricity
To be a leader in renewable energy and flexibility solutions

We provide Energy
Provide green and affordable energy and bring comfort to our customers

We offer solutions
Secure and reduce consumption through our network of professionals

Thanks to our committed and positive teams

Accelerating innovation to improve our business and invent our future

ALL TOGETHER
TOGETHER EACH ACHIEVES MORE

CUSTOMER FIRST
OUR CUSTOMERS ARE OUR BEST AMBASSADORS

ENTREPRENEURSHIP
WE BEHAVE AS OWNERS

luminus · EDF R&D · profish MONITORING FISH ECOLOGY · LIÈGE université · UNIVERSITÉ DE NAMUR · Life

Why Life 4 Fish ?

LUMINUS IS THE NUMBER 1 IN HYDROPOWER IN BELGIUM WITH AN INSTALLED CAPACITY OF 67 MW

Lifetime extensions (> 60 years)
Green certificates are no longer granted and environmental legislation is becoming more stringent

Installation of fish-friendly turbines in 2019
New green certificates granted for 15 years

EU LIFE programme
Study and solutions to reduce fish mortality

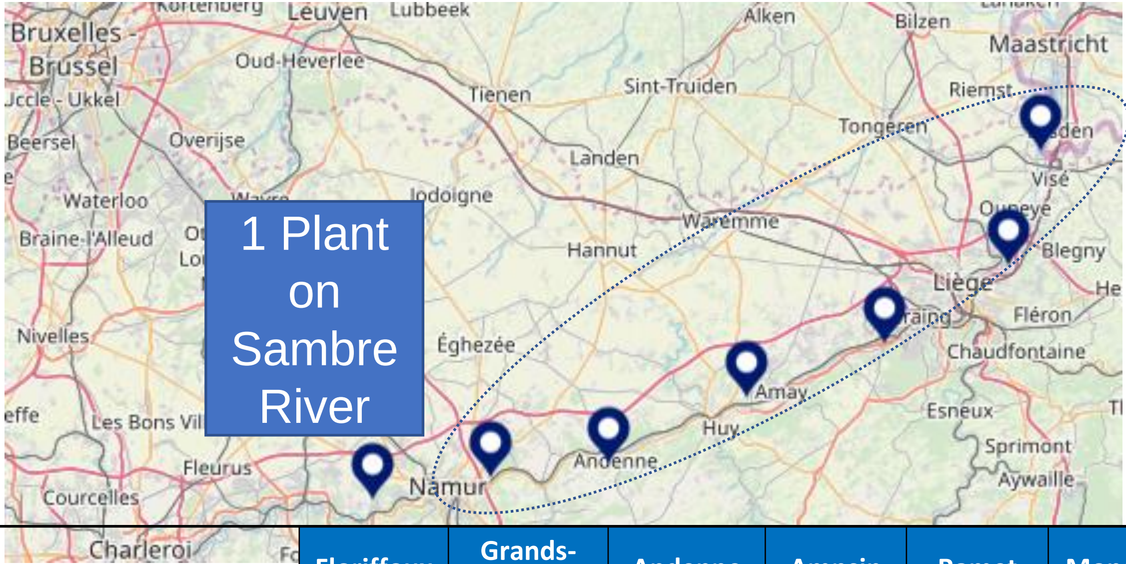
LUMINUS LAUNCHED A **PARTNERSHIP** WITH **SPW MI** IN 2017 AND A LARGE **BIODIVERSITY PROGRAM** IN 2018

Wallonie service public SPW

- **Close collaboration** with **SPW MI** for optimizing flow and level control of the 2 main rivers Meuse and Sambre was signed on **17 November 2017** by the Minister **Carlo Di Antonio** in charge of waterways **and Luminus CEO ➔** « **Convention de collaboration pour une gestion optimisée des débits de la Meuse et de la Sambre en Région wallonne** ».
  - This agreement targets to optimize **navigation, tourism, biodiversity preservation, prevention of flooding,** and **renewable energy production**.
  - The common goal is to **automatize Meuse** and **Sambre rivers** regulation based on flow setpoints provided by hydrology service of SPW MI.
- **The willingness of Luminus is to sustain renewable energy production considering biodiversity preservation and public interest in the waterways:**
  - **New environmental constraints in the permits** (renewal every 20 years) **on fish mortality** could lead to reduce by **-40%** the renewable production or **-100 GWh/year** for Luminus fleet. This would have an impact on **Walloon/Belgian/European** renewable energy targets.
  - To satisfy this goal Luminus with **Universities of Liège and Namur, EDF R&D** and **Profish** launched in **2018** a **large biodiversity program** called **Life4Fish**. The main subject is to innovate, study and implement solutions to **preserve migrating fishes as Eels and Salmons** in the Meuse valley**.**
  - This project is funded by Europe via **LIFE funds.**

luminus | EDF R&D | profish MONITORING FISH ECOLOGY | LIÈGE université | UNIVERSITÉ DE NAMUR | Life

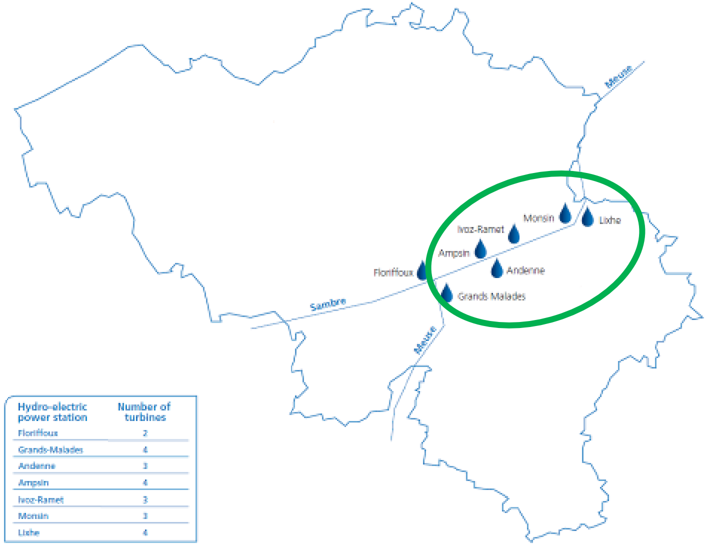
1ST POSITION IN HYDRO WITH 23 TURBINES ON 7 HYDRO PLANTS



6 Plants on Meuse River

	Floriffoux	Grands-Malades	Andenne	Ampsin	Ramet	Monsin	Lixhe	Total
MSI	1993	1988	1980	1965	1954	1954	1980	
Capacité (MW)	0,9	5	7	10	10	18	16	**67**
# Turbines	2	4	3	4	3	3	4	**23**
Prod annuelle (GWh/an)	1,4	19,4	31,2	36,1	34,1	52,4	52,9	**227**
Hauteur de chute (m)	2,8	3,8	5,35	4,65	4,6	5,7	7,5	
Débit d'équipement (m3/s)	24	170	210	270	285	450	340	

Context of the project



Hydro-electric power station	Number of turbines
Floriffoux	2
Grands-Malades	4
Andenne	3
Ampsin	4
Ivoz-Ramet	3
Monsin	3
Lixhe	4

83 km long-stretch between Namur and Lixhe
Concrete –channelised river
6 HPP Dams (annual levelized production 245 GWh).

For 15 years, fish protection impositions in new permits dedicated site by site.

Salmon : >90% of the population is concerned by 2 sites Monsin and Lixhe.

Eels : population distribution in the river catchment in not sufficiently documented. Number of juveniles in drastic decline.

Objectives of the project

Project objectives:

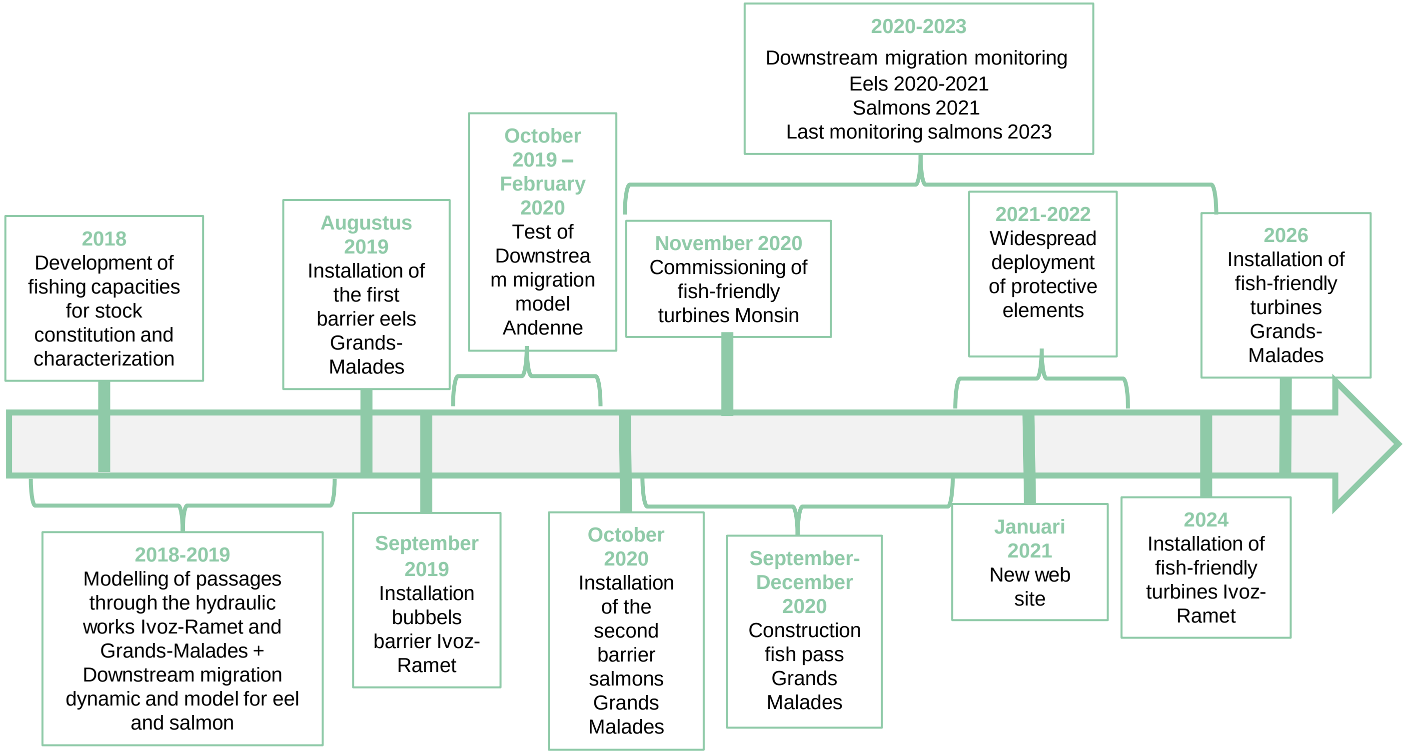
- Increase the survival rate of silver eels > 80% and salmon smolts > 90%.
- Optimize the renewable energy produced and the balance between loss of green energy (< 5% as a target) and biodiversity.
- Integrate ecological processes or devices into the regular operational management of HPP, fish become an industrial variable influencing production decisions.
- Demonstrate the performance and transferability of the deployed solutions.
- Establish and demonstrate the value of a River Meuse stakeholder committee.
- Establish a benchmark

The solutions consist of 4 specific technologies :

- Turbine shutoff/reduction strategies driven by fish migration prediction models
- Repulsive barriers
- Fish passage facilities (bypass, adapted spillage associated with prediction models)
- Upgrade sites with new type of turbine with less impact on fish (eco-sustainable design)

The multi-site, multi-solution approach is proving to be a relevant choice

TIME LINE



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PRINCIPAL ACTIONS OF THE PROJECT

FIELD ACTIONS OF LUMINUS

- Phase I. Diagnostic phase on the field 2017-2018
- Phase II. Establishment of the reference state 2018-2019
- Phase III. Development of solutions 2018-2019
- Phase IV. Test of solutions at pilot scale 2019-2021
- Phase V. Deployment of best solutions developed at full scale 2021-2022
- Phase VI. Verification of the efficiency at the global scale 2022-2023

LIFE4FISH

Establish A Reference state (Continuity tests)

Several measurement done, before & during the project.

Two methodologies used for continuity test (net and Hi-Z-Tag)

- Net (Grands-Malades, Andenne, Monsin): fast measurement, flow < 100m³/s, level of precision +/- 10%, only for single exhaust path, affordable.

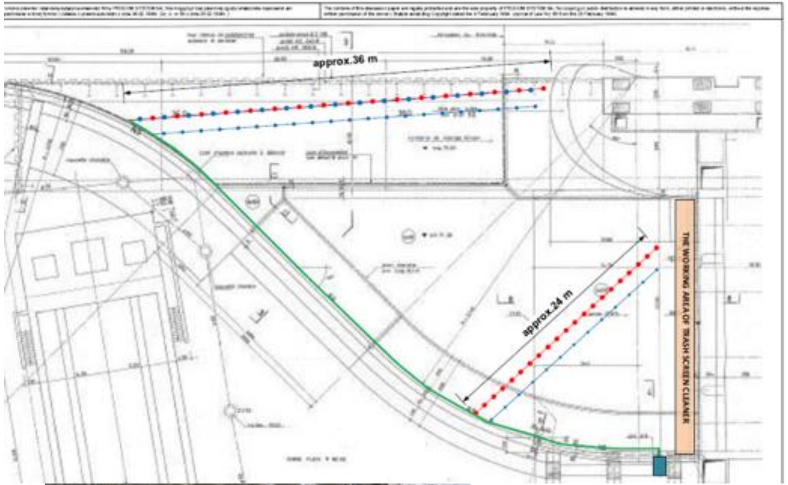
- Hi-Z-tag (Monsin): long period of preparation, no limit of flow, high level of precision < 5%, expensive procedure.

LIFE4FISH

ELECTRICAL BARRIER

1) Barrier selection and positioning to meet project and site production requirements:
    - Highest efficiency rate, "guiding" individuals in the right direction via a variable electric field.
    - No impact on production
    - Resistance to waste (see photo of the boat)
    - Functioning according to different hydrological conditions
2) Implementation of the Smolt and Eels electric barrier with fixation at the bottom of the riffle.
3) Validation of the operation by telemetric observation of the distribution of fish passage between the turbine and the weirs under different hydrological conditions.

Solution validated for Eels for Ampsin and Grands-Malades



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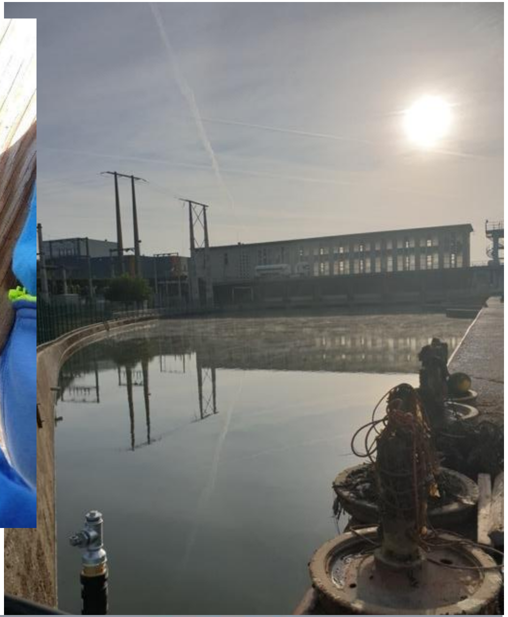
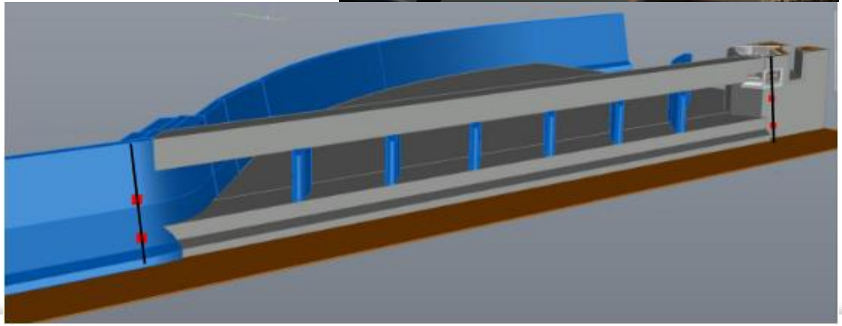
BUBBLE BARRIER

1) Barrier selection and positioning to meet project and site production requirements:
    - Highest efficiency rate, "guide" individuals in the right direction via light screen, noise and bubbles.
    - No impact on production.
    - Resistance to waste (see photo of pipe)
    - Operates under different hydrological conditions
2) Implementation of the bubble barrier with fixation via train bogies.
3) Validation of the operation by telemetric observation of the distribution of fish passage between the turbine and the weirs under different hydrological conditions.

Solution not validated





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EXHAUST PATH GRANDS-MALADES

1) Desing and positioning according to Uliège studies:
    - Good efficiency, but waste management difficult.
    - Low impact on production (flow 3,4 vs 160 m³/s).
    - Cleaning every day required during winter period
2) High Capex required for implementation of the exhaust past. Difficult to implement exhaust path on existing site.
3) Validation of the operation by telemetric observation of the distribution of fish passage between the turbine and exhaust path under different hydrological conditions.

Solution Validated for Grands-Malades

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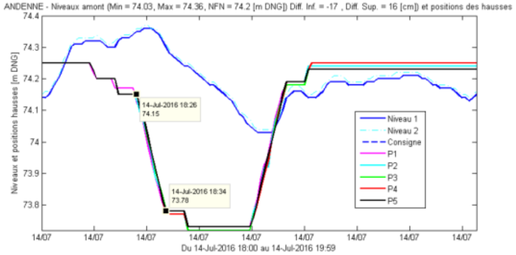
Installation of an advanced remote-controlled hydropower management

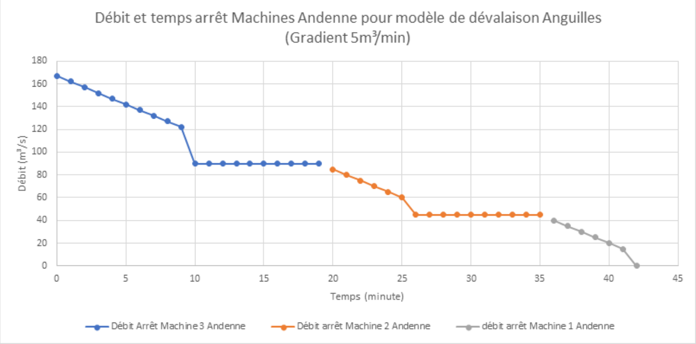
- Predictive flow send by SPW is integrated in the model.
- The model give to the operator the order to stop the units for migration
- The dam is set in a “Downstream Migration” mode in order to give an exhaust channel for the Eels.
- Based on the response of the dam to water level increase. The flow of the power station is transferred to the dam by stopping each turbine one by one.
- A global pilot system will be set to pilot each dam at the same time.

1. Vitesse des hausses du barrage d’Andenne



⇨ Vitesse hausse d’Andenne = (74.15 - 73.78)/(18h34 – 18h26)

⇨ Vitesse hausse d’Andenne = 3 [cm/minute].



LIFE4FISH

Monitoring efficiency of fish protection measures and global performances of the project

06.09.2023

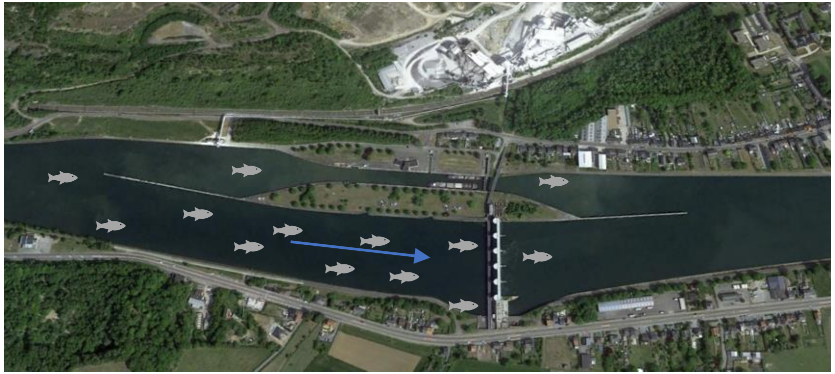
Profish
Damien Sonny
Marc Lerquet, Dylan Colson, Jeremy Beguin, Romain Roy, Delphine Goffau

Arcadis : Olivier Machiels

LIFE4FISH MONITORING OF EEL AND SALMON PASSAGE AT HPP

→Establishment of fish passage proportion :

- Sluice
- Dam
- Turbine
- Other (bypass, …)



Require a telemetry network able to detect active tags in a noisy and hostile environment

LIFE4FISH MONITORING OF EEL AND SALMON PASSAGE AT HPP

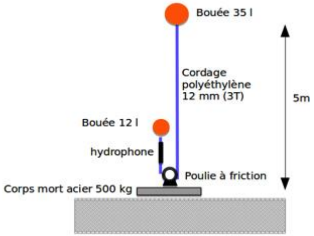
JSATS Acoustic telemetry selected after preliminary tests

LOTEK
WHS4250

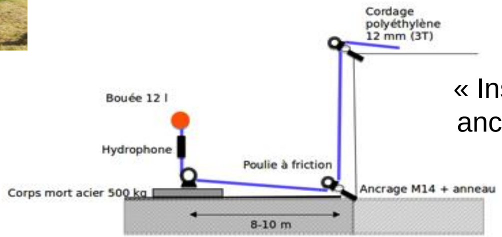
ATS
SR3001

ATS
SR3017

Steel train wheel
(500 kg)



« Offshore »
anchorage



« Inshore »
anchorage

8 to 20 hydrophones per site → Up to 72 hydrophones on 6 sites

MONITORING OF EEL AND SALMON PASSAGE AT HPP

Example of the equipment of CHR with 6 hydrophones :

LOTEK WHS4250 on the dam (short range)
LOTEK SR in the HPP forebay (long range)

+ 1 hydrophone in the sluice
+2 hydrophones downstream

LIFE4FISH MONITORING OF EEL AND SALMON PASSAGE AT HPP

→2017 : Definition of the reference situation – 150 eels and 150 salmon tracked in telemetry

→2019 : efficiency of pilot solutions for eels – 140 eels tracked in telemetry

→2021 : efficiency of pilot solutions for smolts – 237 smolts tracked in telemetry

→2022 : efficiency of global solutions for eels – 148 eels tracked in telemetry

→2023 : efficiency of global solutions for smolts – 201 smolts tracked in telemetry

Eel catching

Fish biometry

Fish tagging

Release after tagging

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REFERENCE SITUATION 2017 (PRIOR LIFE4FISH)

Eel and salmon passage proportion at each site (telemetry)

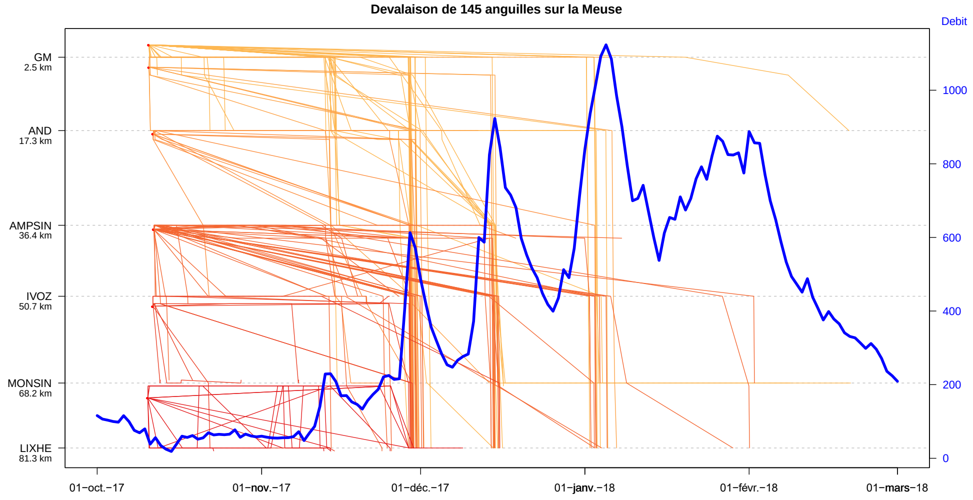
+

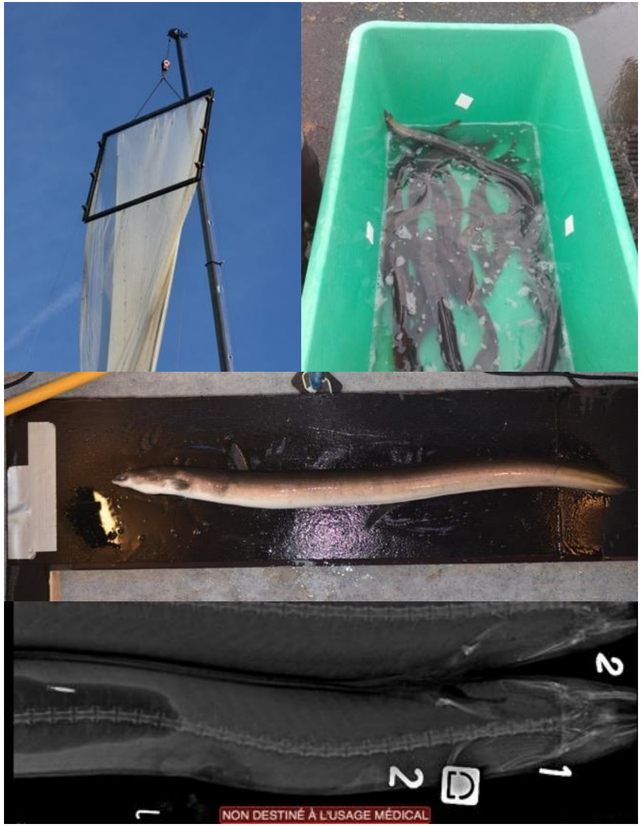
Measured survival after turbine passage

(injection N = 1000 salmonids & N = 300 eels)

=

Measured impact of each site





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DEVELOPMENT OF PILOT SOLUTIONS

Selected solutions at the beginning of the project

Silver eels :
- Electrical barrier
- Bubble barrier
- Migration prediction model

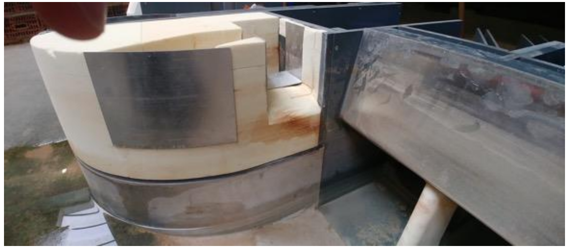
Public tender by Luminus

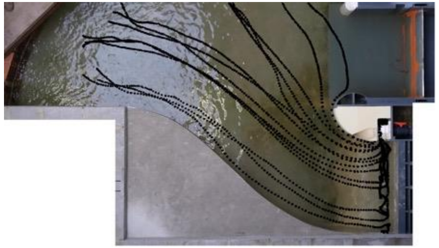
EDF R&D & MNHN

Salmon smolts :
- Electrical barrier
- Design of downstream bypass
- Optimized spillage on a single gate of the dam
- Migration prediction model

HECE – ULIEGE for hydraulic design and test in lab

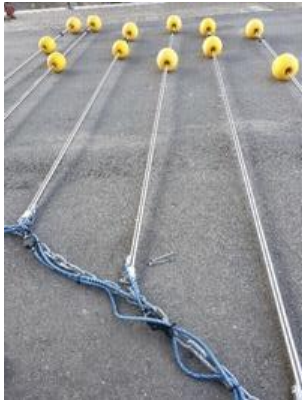
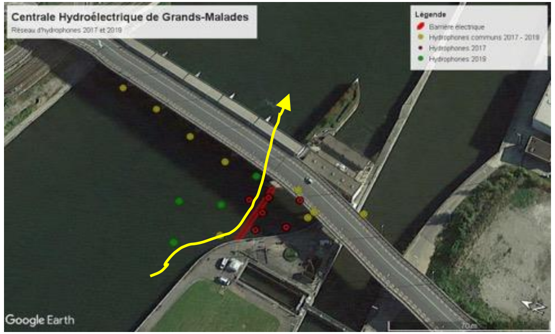
EDF R&D – MNHN - ULIEGE

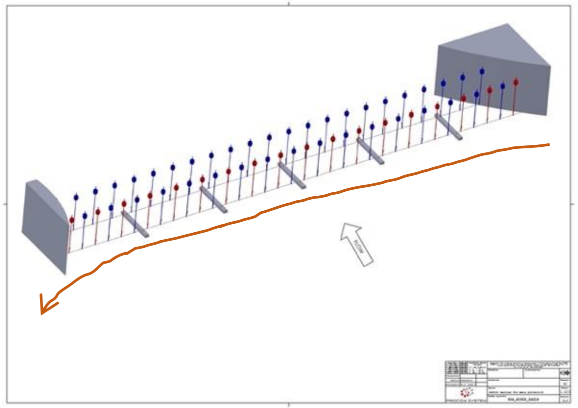




TESTED SOLUTION - EELS

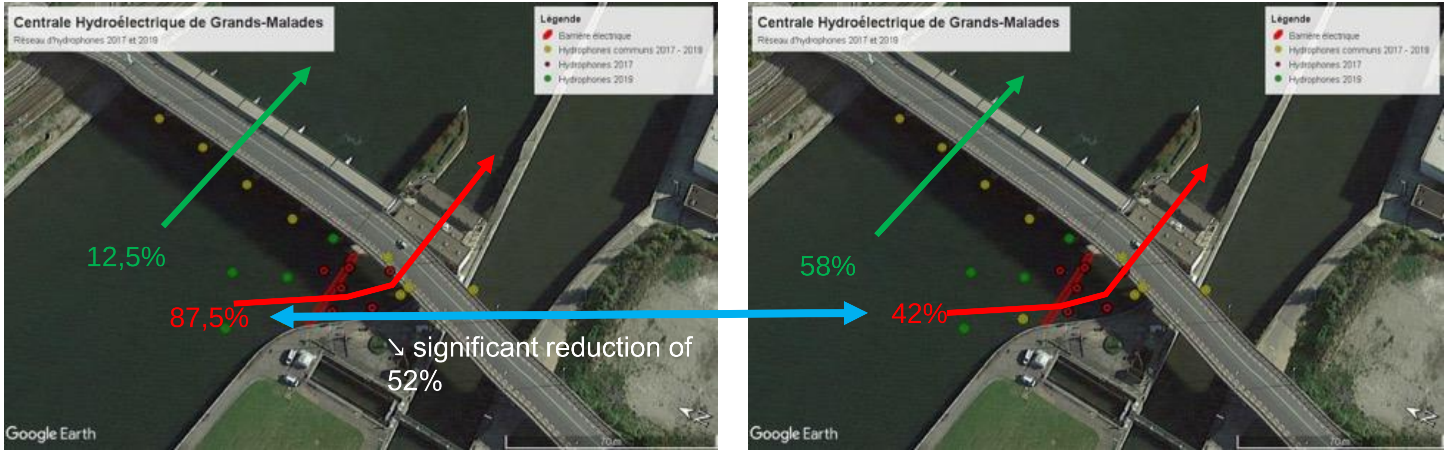
The Neptun electrical barrier (Procom System) – *Public Tender Luminus*



Site : CHG
Installation : Summer 2019
Electrodes : vertical stainless steel pipes, bottom anchored, vertically positioned by buoys
Principle : close the entrance of the forebay with the electrical field and keep eels migrating towards the dam

LIFE4FISH TESTED SOLUTION - EELS



Sonny et al. In prep

→ A significant efficiency of 50% when eels are migrating in river conditions < 300 m³/s = $Q_{turbine} > Q_{dam}$

→ 64% of eels migrated in these conditions in 2017 and 51% in 2019

→ Above these conditions, eels are mostly passing by the dam

→ Dam escapement has been improved by the electrical barrier

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LIFE4FISH TESTED SOLUTION - EELS

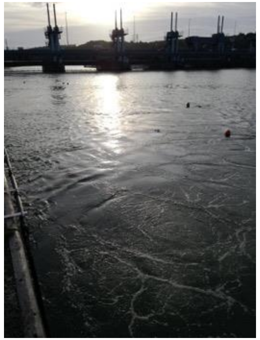
Bubble barrier – APUMA - Public Tender Luminus

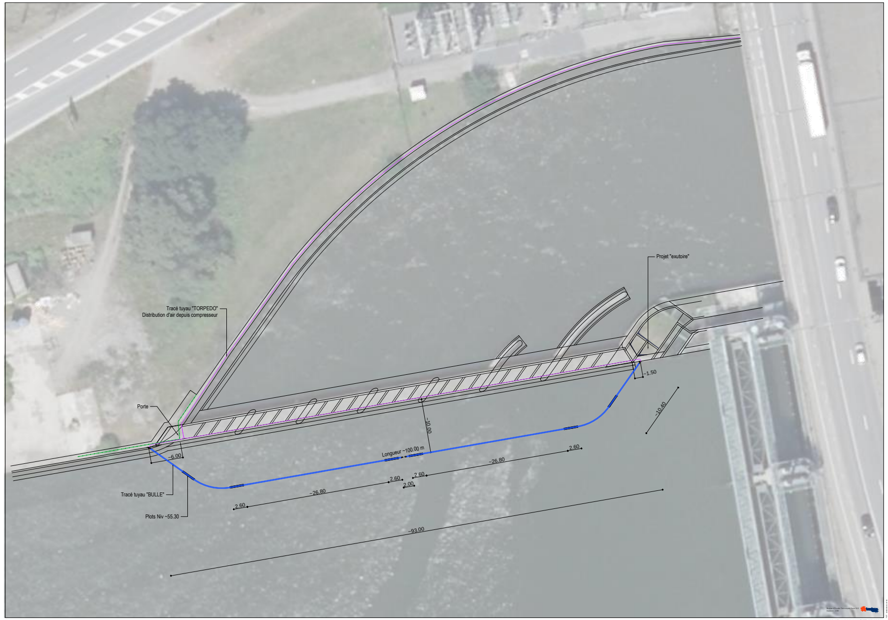
Consists in a massive air compressor

Sending compressed air into a long pipe

On the bottom of the river, 10 m away the water intake

Perforated pipe creating a bubble curtain





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TESTED SOLUTION - EELS

Operating between 20th Sept to 30th Nov 2019
Destroyed by flood, annual occurrence

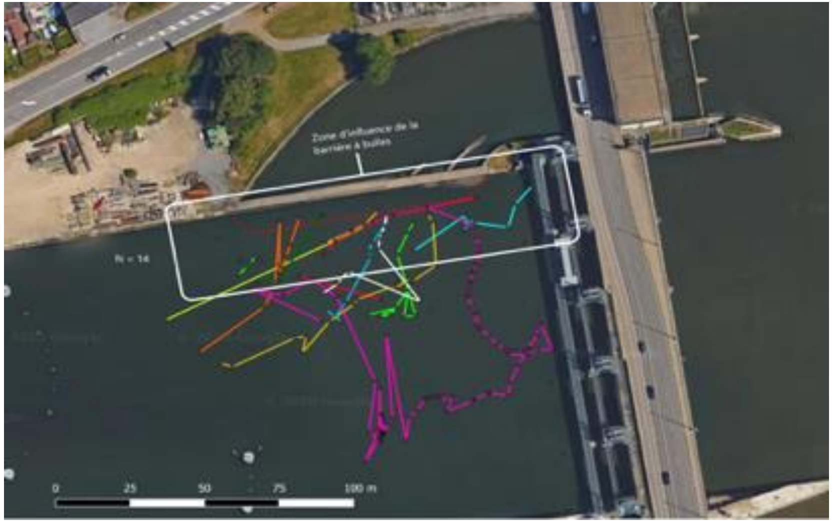
15 eels arrived in the vicinity of the barrier

2D telemetry tracking

All crossed the site through the turbines

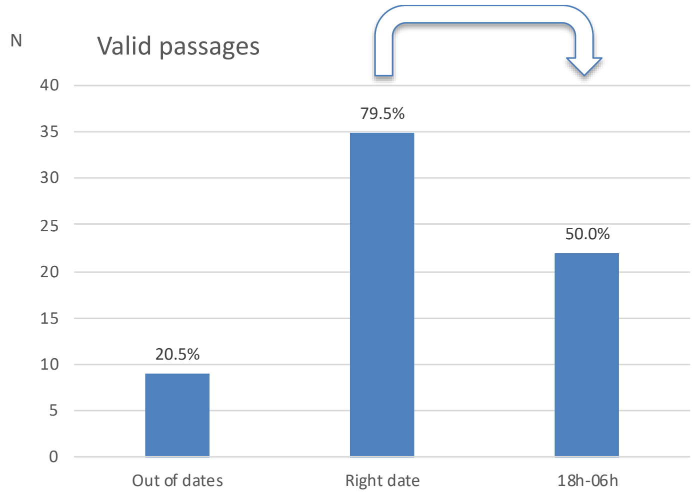
No avoidance observed

The dam was closed during this period

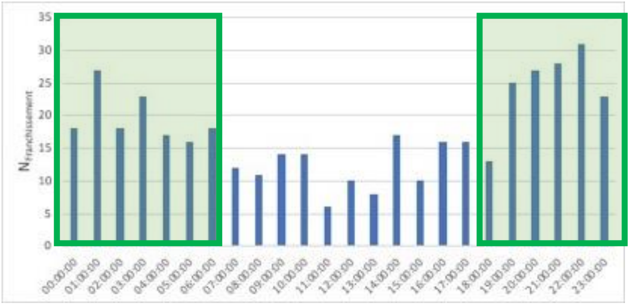


TESTED SOLUTION - EELS

Eel migration prediction model (EDF R&D – MNHN)



Time repartition of all eel passages at all sites in 2019



Removing eels detected < 7days after tagging and release :

- 79.5% of success of predication for the date
- 50.0% of success of prediction in the shutdown timeframe 18h-06h

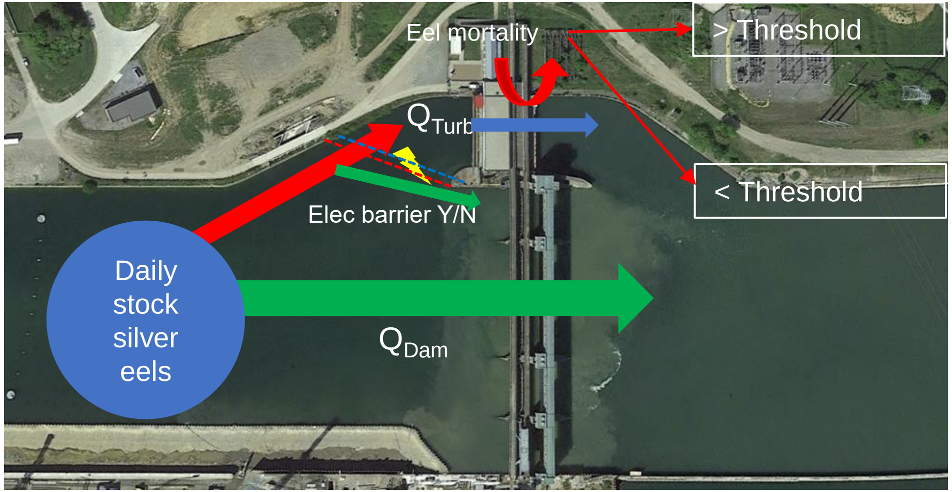
Operational shutdown was not optimum due to some technical troubles :
Temporary failure of the discharge probe, coordination with the dam operator, …

TURBINE SHUTDOWN OPERATION

Fish survival 6 sites

≈ 90% all sites

System working at an hourly step from 1st August



Loss of production

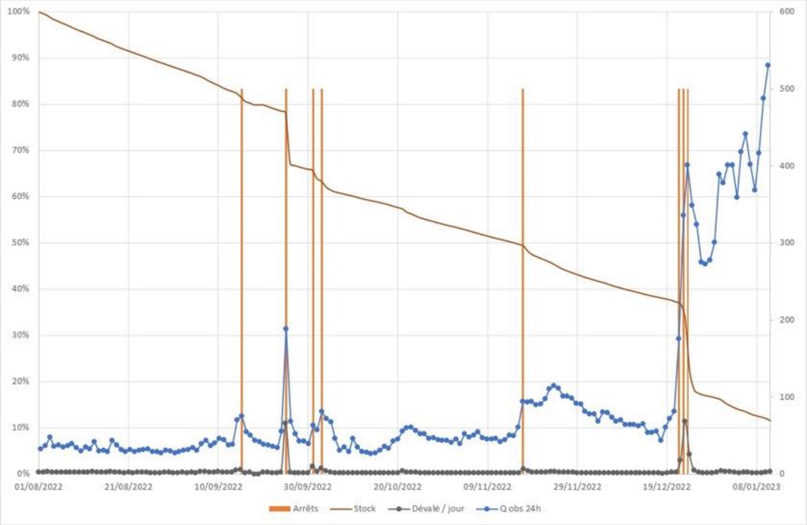
Max 5% all sites

Turbine shutdown as long as impact stay > threshold

Normal production

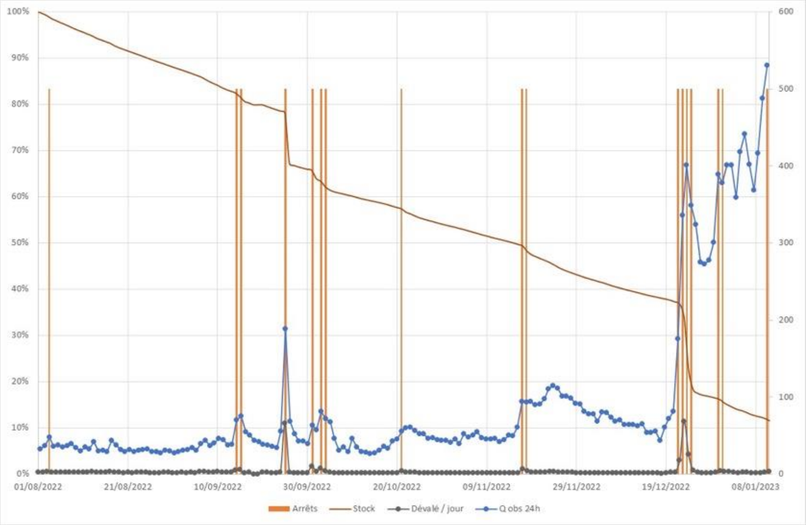
TURBINE SHUTDOWN OPERATION

CHG – CHN – CHM (less impacting)



168h turbine shutdown required by the model

CHR (more impacting)



396h turbine shutdown required by the model

LIFE4FISH

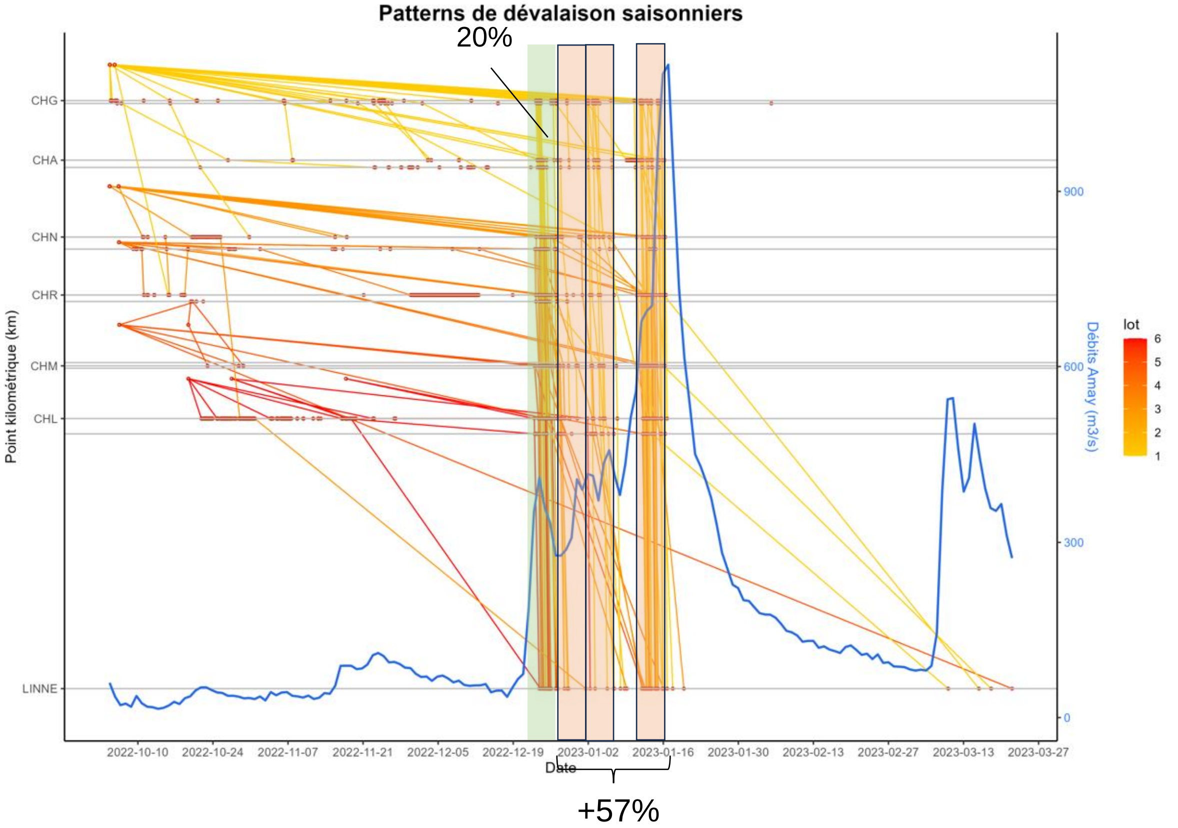
Turbine shutdown operational from 2nd December → Few eels migrating before…

The study started after first alarms of summer (due to eel availability).

All sites driven the same way, not site by site as designed.

Turbine shutdown covered 20% of passage.

57% of passage on the next peaks in Dec-January, not covered by alarms due to low stock of eels remaining in the model.



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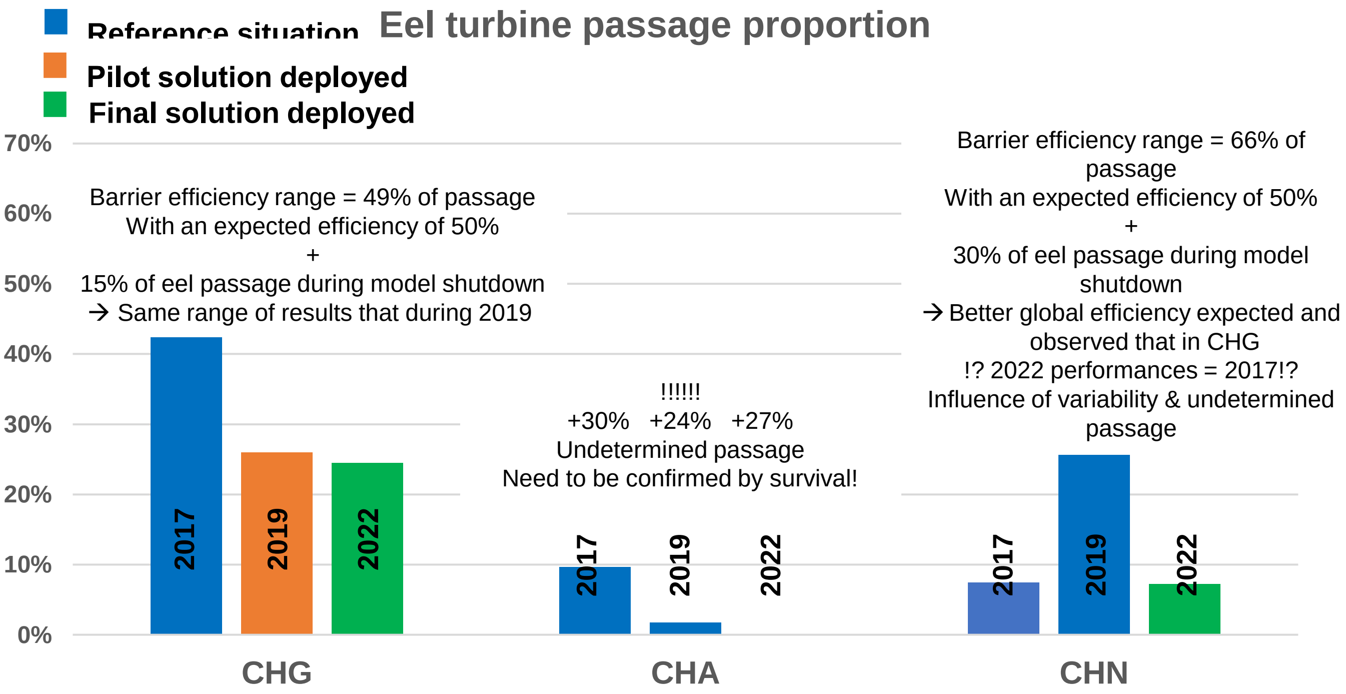
FULL SCALE DEPLOYMENT – RESULTS EELS

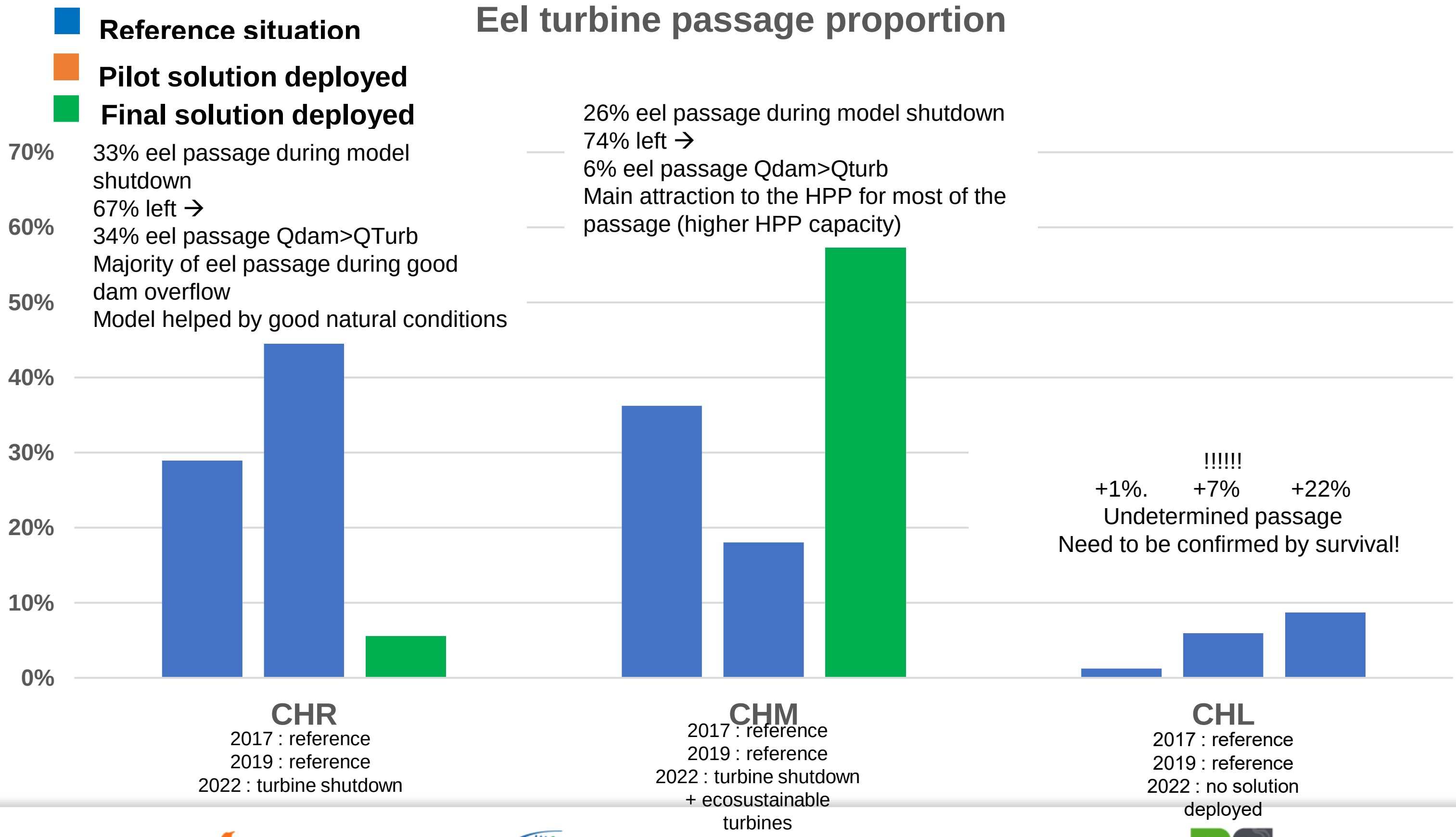


2017 : reference
2019 : Electrical barrier
2022 : Electrical barrier + turbine shutdown

2017 : reference
2019 : reference
2022 : no solution deployed

2017 : reference
2019 : reference
2022 : Electrical barrier + turbine shutdown

FULL SCALE DEPLOYMENT - EELS



FULL SCALE DEPLOYMENT - EELS

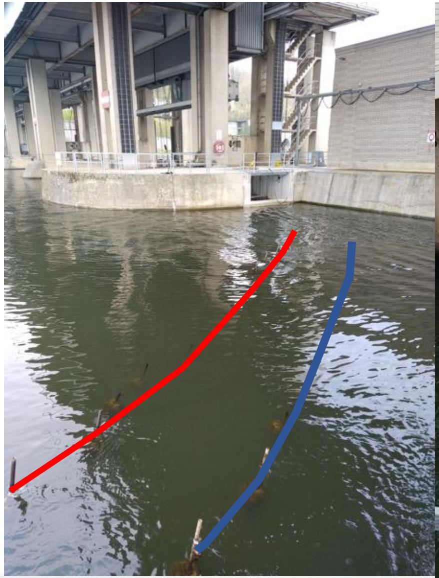
Conclusions

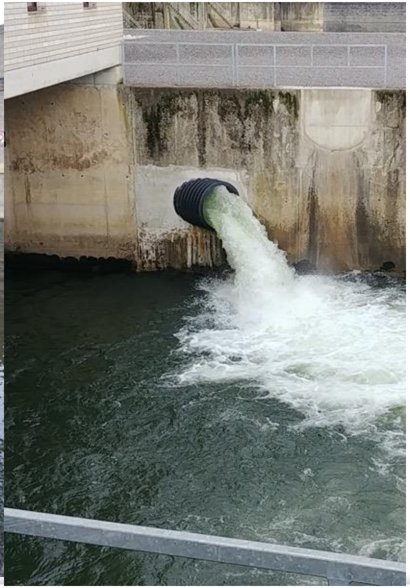
- The electrical barrier seems to reach the expected efficiency on both sites
- Combination of barrier and shutdown effect seems confirmed in CHN
- The turbine shutdown model has been challenged and probably needs some fine tuning :
    - Each site should be reacting differently based on its own impact (capacity-escapement-mortality)
    - Is the eel stock of the model declining accordingly the real eel stock? Adjustment with 2021&2023 dataset from the present study...

1 year for reference + 1 year for pilot test + 1 year of final solution is still exposed to variability. Lot has been done, but the dataset remains exposed to variability. Validation requires probably more confidence from the field.

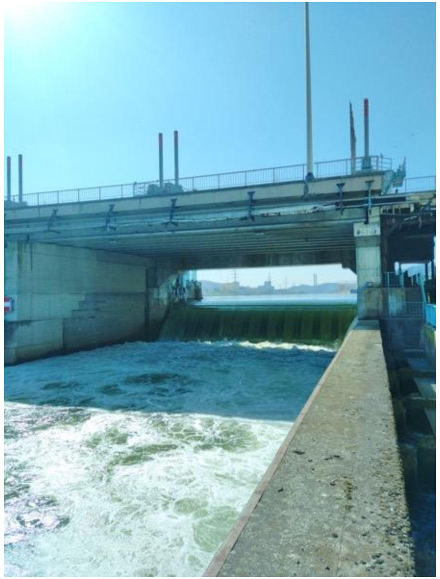
LIFE4FISH PILOT TESTS FOR SMOLTS – 2021 SURVEY

CHG : Electrical guidance + bypass





CHR : 50-90 cm on gate close to HPP
CHM : 90 cm on gate opposite to HPP



LIFE4FISH • Results of pilot tests - CHG

- Bypass by itself succeeds to transit up to 55% of smolts 😀

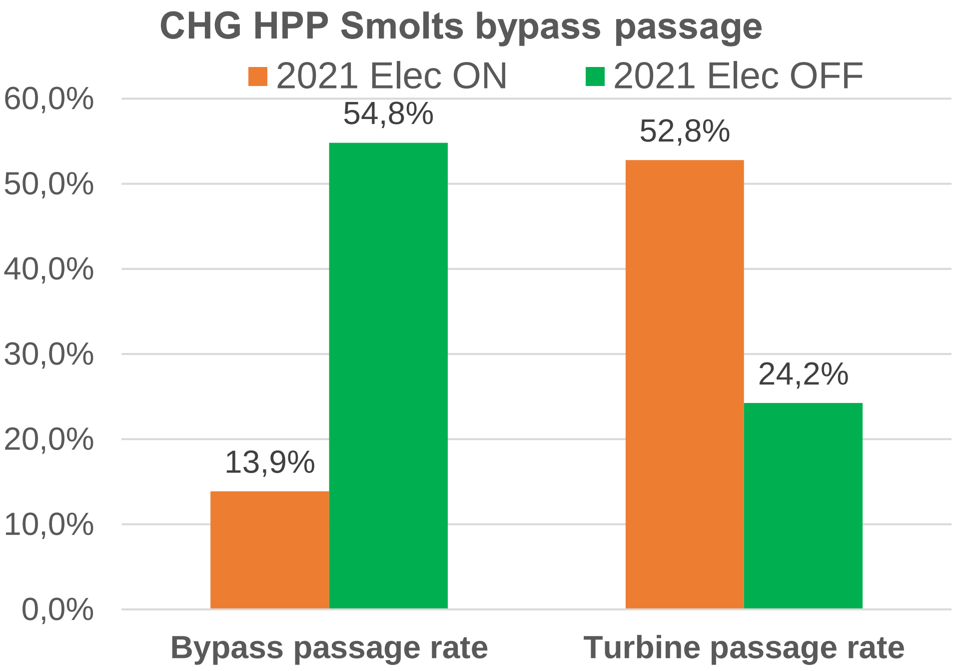
- Transit by the bypass is physiologically safe ! (Analysis UNAMUR)

- The electrical barrier reduces dramatically the bypass efficiency! ☹

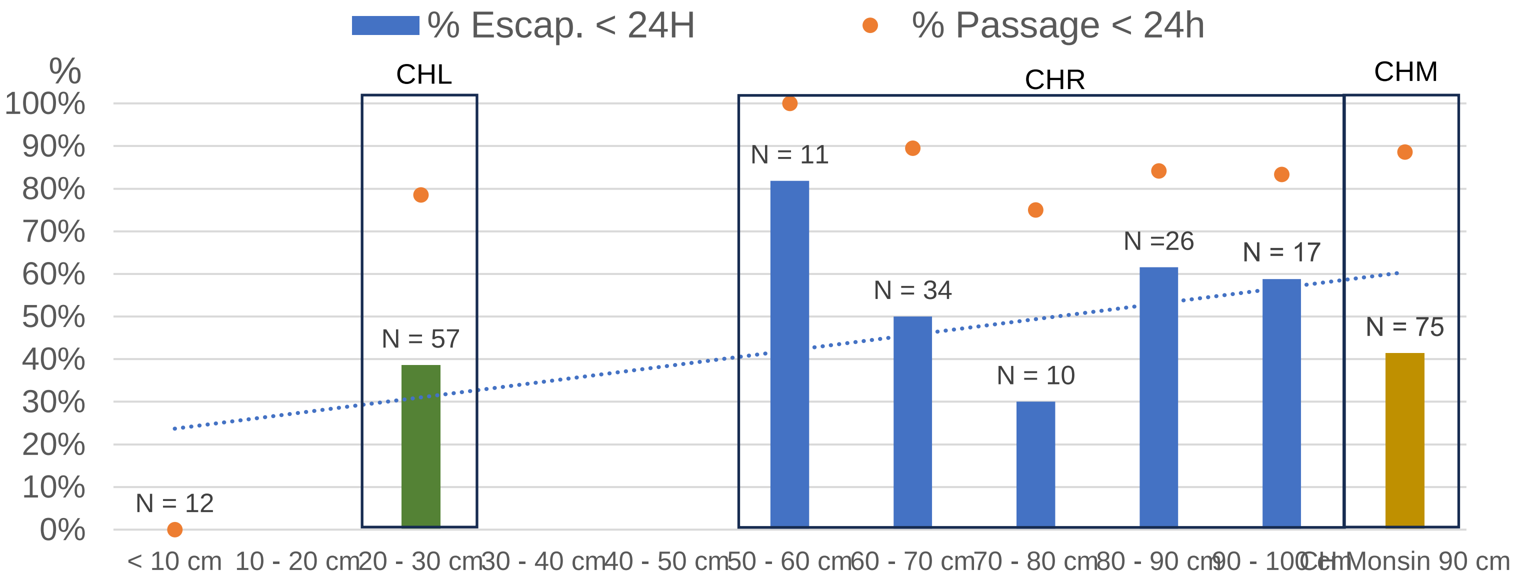
Negative effect of the barrier?

Smolts passage delay :
1.76h with the barrier ON
11.08 h with the barrier OFF

The barrier precipitates the smolt passage → Electrical narcosis?



Results of pilot tests – Gate opening



CHL : close to 40% efficiency with 20-30 cm of gate opening (close to the HPP)

CHR : Mean efficiency of 56% with 50-100 cm (variability probably due to sample size effects)

CHM : >40% of efficiency with 90 cm opening opposite to the HPP

Deployment of final solutions on all sites for smolts

Measures are focused on the most impacting sites in regards with the migrating population

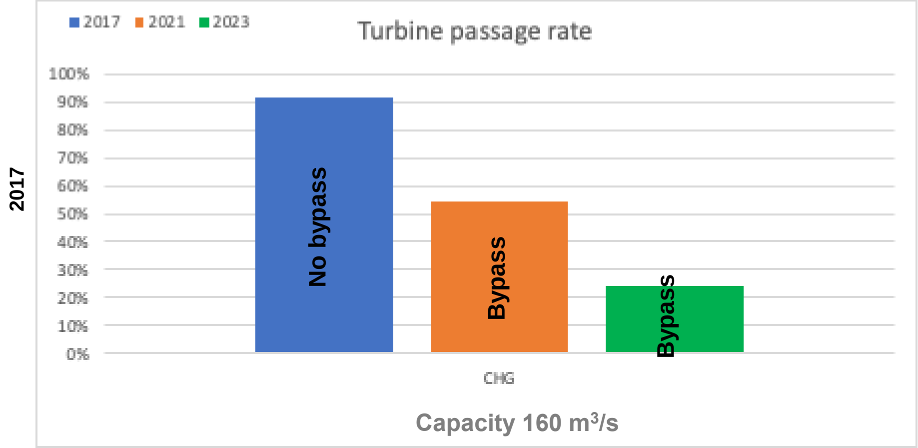
CHG : Bypass (since existing from the pilot test)
CHA : -
CHN : -
CHR : -
CHM* : Gate opening 50 cm during smolt migration
CHL* : Gate opening 50 cm during smolt migration

Smolt migration Ourthe prediction model (Teichert et al. 2020)

Start : 5% of migrating stock
Stop : 95% of migrating stock

LIFE4FISH • Results from the 2023 telemetry survey

CHG : bypass (~ 3 m^3/s)



Q_{Meuse} conditions differed among years of study

2017 mean Q = 62 m^3/s

2021 mean Q = 146 m^3/s → Bypass efficiency of ~50% (only monitored for a fraction of the tracked smolt)

2023 mean Q = 163 m^3/s → Bypass efficiency of ~38%

→ Bypass and dam overflow decreased the proportion of turbine passage in 2023 !

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Results from the 2023 telemetry survey

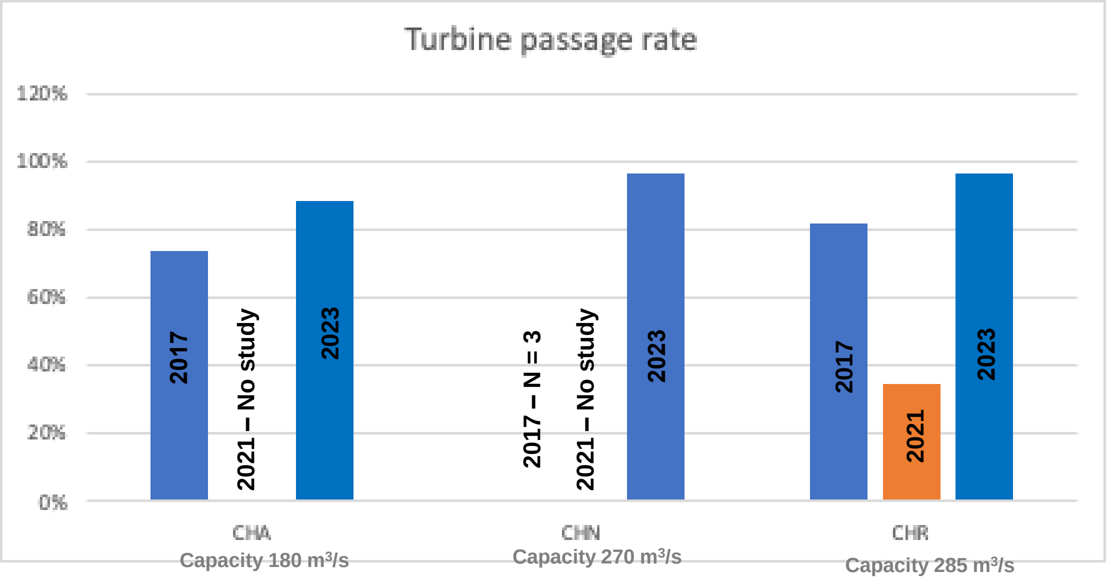
CHA – CHN - CHR

2017 mean Q = 62 m^3/s
2021 mean Q = 146 m^3/s
2023 mean Q = 190 m^3/s

Mostly turbine passage → Underline the efficiency of the measures taken in CHR in 2021!

No solution

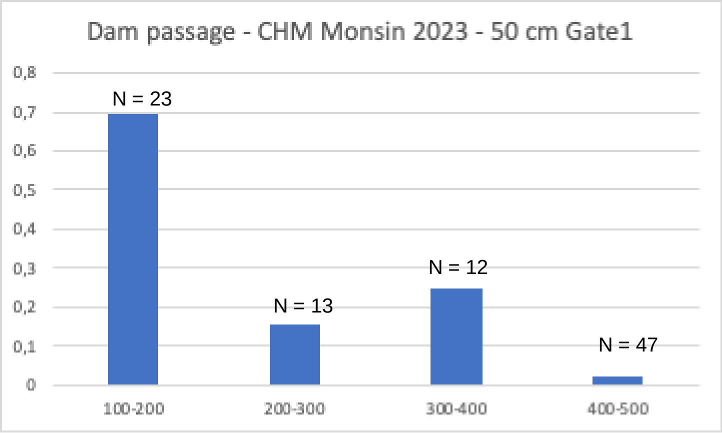
Pilot solution (50 & 90 cm gate spillage)

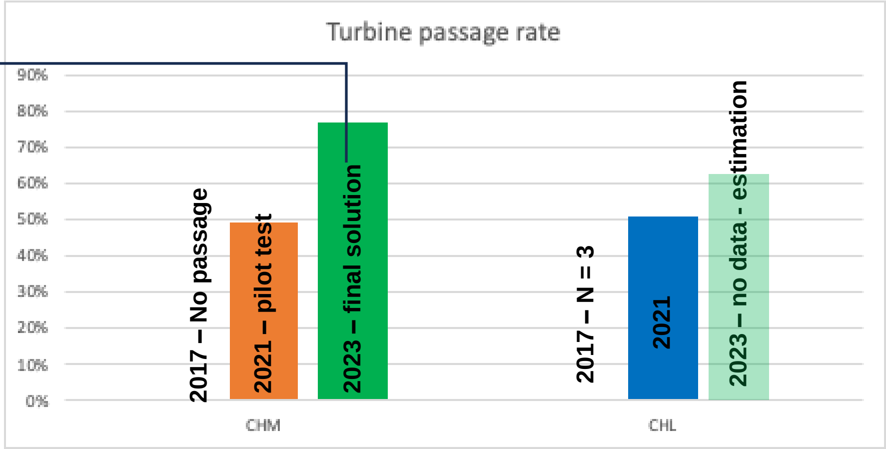


Results from the 2023 telemetry survey

CHM-CHL : 50 cm gate opening (HPP side of the dam)

2017 mean Q = 62 m^3/s
2021 mean Q = 146 m^3/s
2023 mean Q = 339 m^3/s





Capacity 450 m^3/s

Capacity 280 m^3/s

→ Confirmation of the good efficiency of 50cm of gate opening at low discharge (≈ 18 m^3/s).
→ Increase of the spillage for higher discharge?
→ Possibly necessary for Lixhe
→ Can be confirmed by new modelizations

GLOBAL CONCLUSIONS SMOLTS

2023 migration has been conducted in favourable conditions for smolts (high flow)

Bypass passage at CHG confirmed its efficiency.

Dam gate opening close to the HPP was successful in CHM when Qmeuse < 200 m^3/s.

The same range of efficiency is expected in CHL but could not be verified on the field.

All measures not only decreased turbine passage, but also increased effective passage of smolts !

The global situation for smolts is now probably improved in terms of success of migration in CHM and CHL.

Success of migration can still be impacted by other factors in low flow conditions like lack of flow velocity in the River and abstraction by the Albert Canal.

LIFE4FISH Data treatment => Meuse model

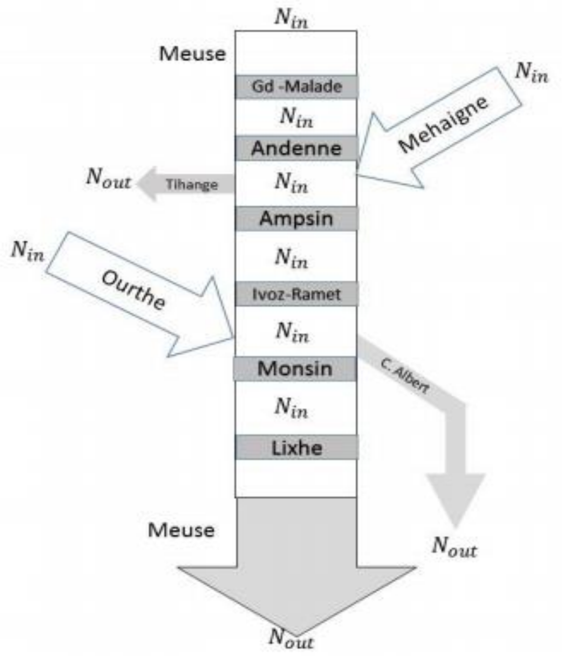
- Nin : Management Plan for Eel / reintroduction plan for salmon => Eel repartition along Meuse (according to fisheries results – Unamur D2) => Silvering and sanitary status along Meuse and tributaries (according to sanitary analysis – Unamur D1)

Tabel 17. Répartition par bassins hydrographiques des effectifs numériques et de la biomasse de l'anguille dans les cours d'eau non canalisés du bassin de la Meuse en Wallonie pour la situation 1990-2007. Superficie colonisée: 1.566 ha (sauf Meuse, Sambre et Canal Albert).

Bassin	Superficie (ha)	Nombre	Biomasse (kg)
Ourthe-Amblève-Vesdre	-	10.637	4.124
Lesse-Lhomme	-	4.113	1.490
Semois	-	4.017	2.484
Méhaigne	-	2.264	753
Hermeton	-	1.167	188
Geule	-	748	217
Viroin	-	649	384
Berwinne	-	632	203
Ruisseau des Awirs	-	472	102
Houille	-	457	199
Affluents Sambre	-	358	188
Molignée	-	229	190
Bocq	-	214	70
Samson	-	121	32
Chiers	-	101	21
TOTAL		25.579	10.653

Tabel 18. Essai d'estimation de l'ordre de grandeur du stock d'anguille européenne dans la partie belge du bassin de la Meuse.

Milieu	Superficie (ha)	Nombre	Biomasse (t)
Meuse	1.600	113.700	22,0
Canal Albert	100	7.100	1,4
Sambre	300	1.200	0,2
Affluents en Wallonie	1.566	25.600	10,7
Grensmaas	-	-	-
Affluents Grensmaas	-	-	-
Total sauf Grensmaas	3.566	147.600	34,3



Reach	N_{in} *Eel*	N_{in} *Salmon*
Upstream GM	56%	20%
GM-And	2%	0%
And-Amp	6%	0%
Amp-IR	2%	0%
IR-M	17%	80%
M-L	5%	0%
Downstream L	7%	0%
Albert Canal	5%	0%

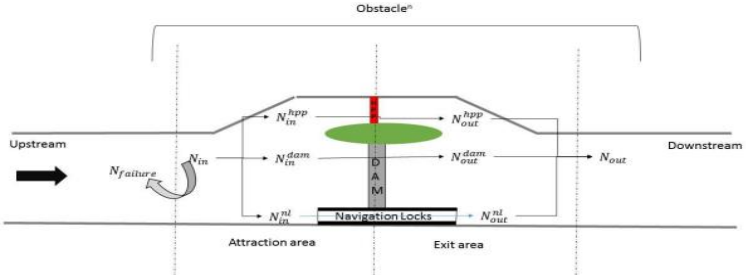
$$n_i = 113700 \times D_{ri} \times L_i$$

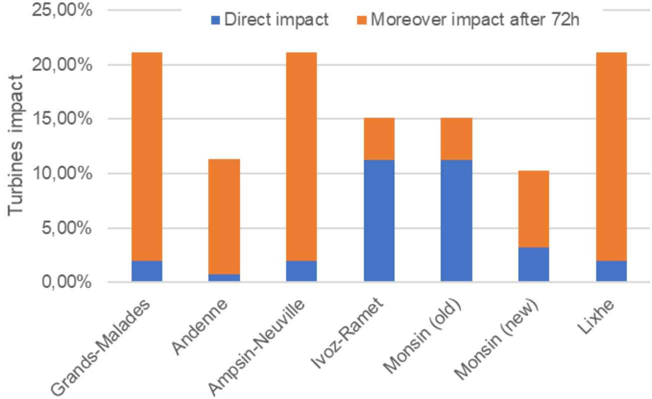
$$N_{in\,i} = n_i \times \tau_{a\,i} \times \tau_{s\,i}$$

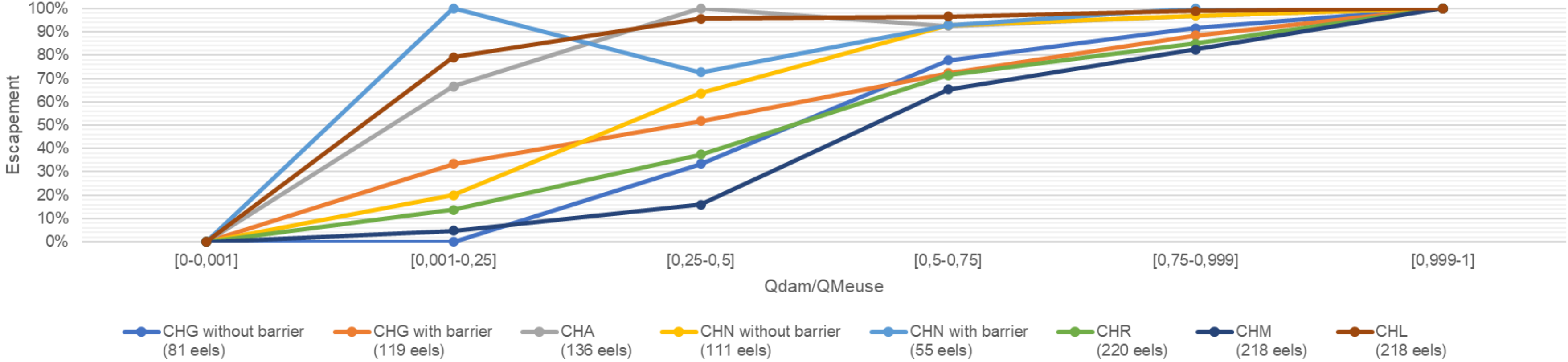
LIFE4FISH Data treatment => Meuse model

- Site escapement and impact based on field data (Profish – D2)

Eels



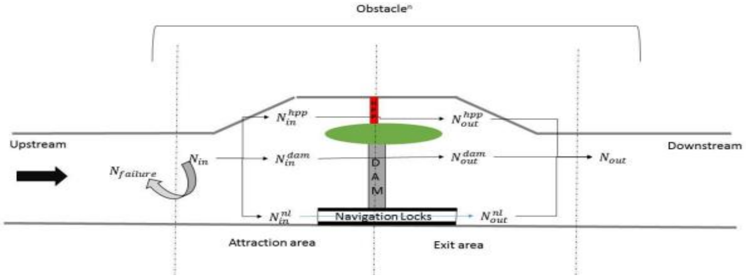


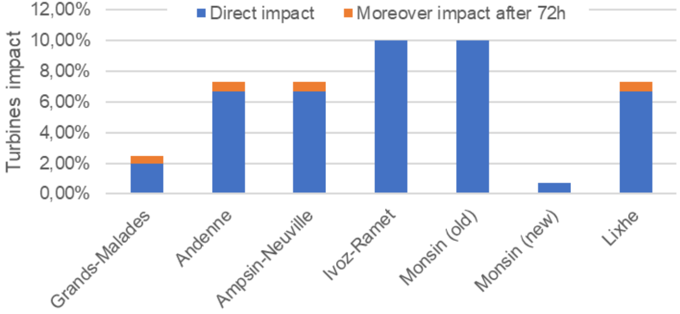


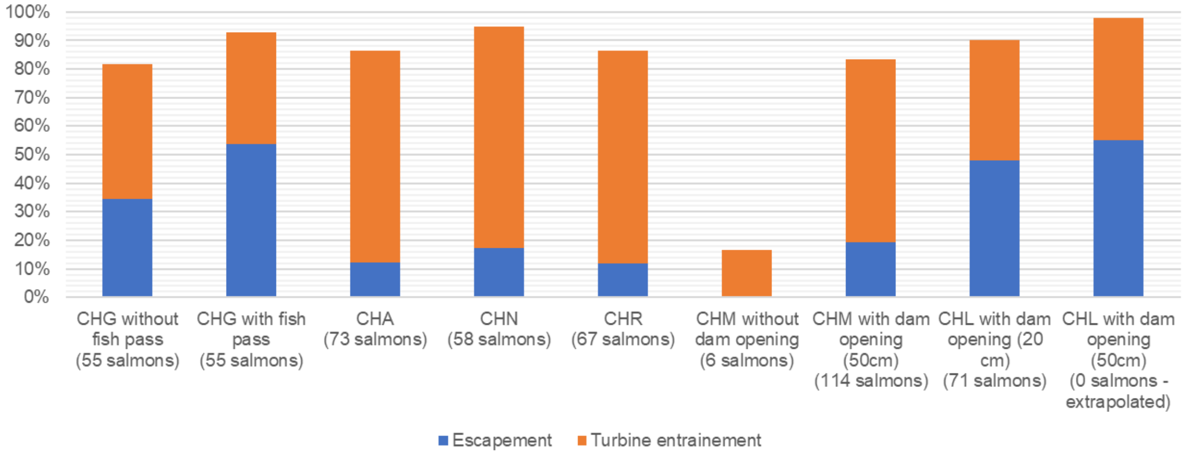
Data treatment => Meuse model

- Site escapement and impact based on field data (Profish – D2)

Salmons

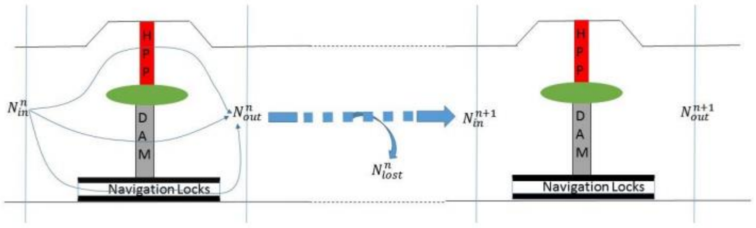


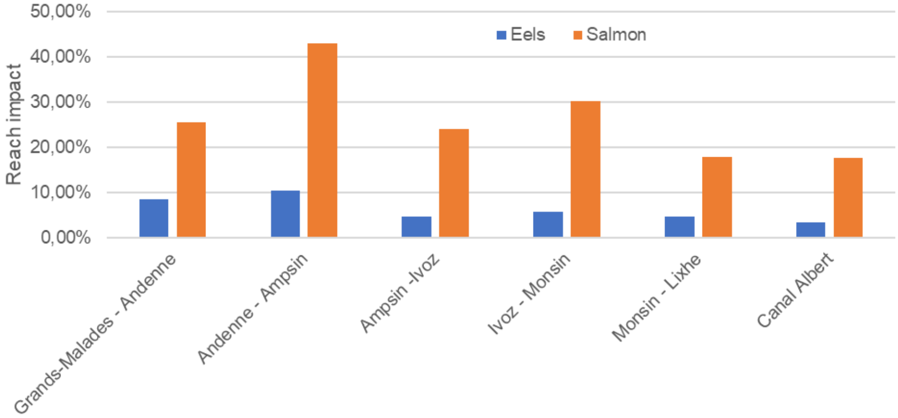


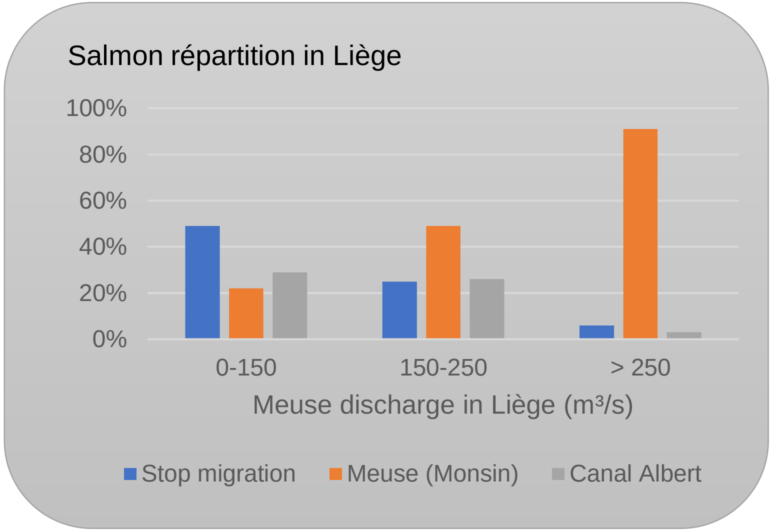


Data treatment => Meuse model

- Reach impact based on field data (Profish – D2)

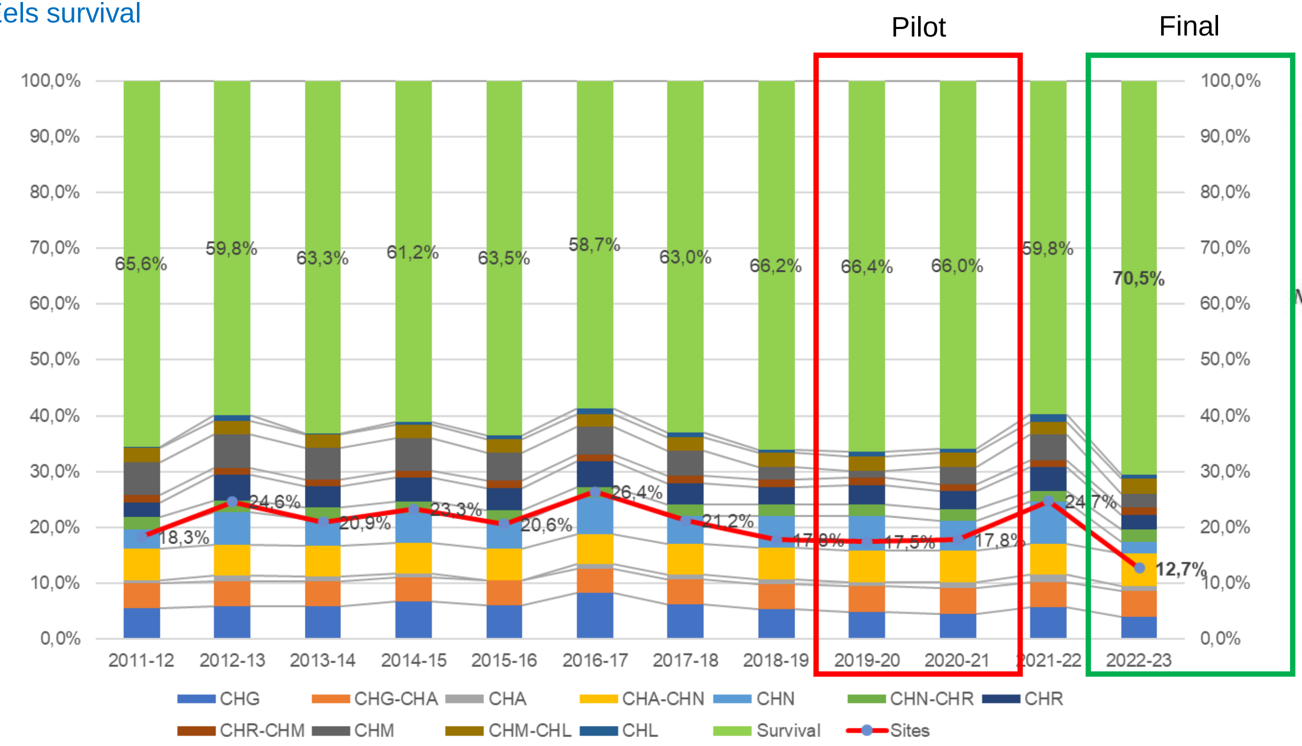


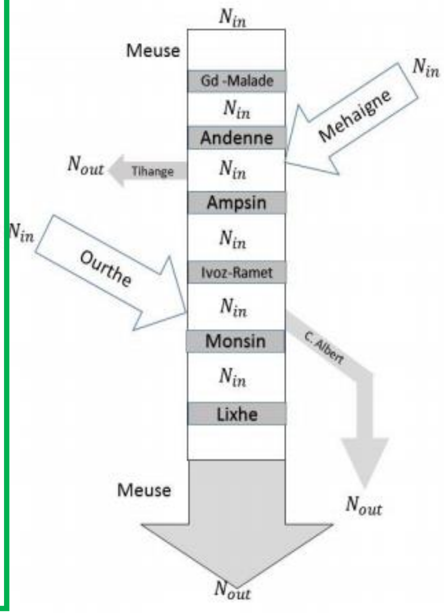




Data treatment => Meuse model

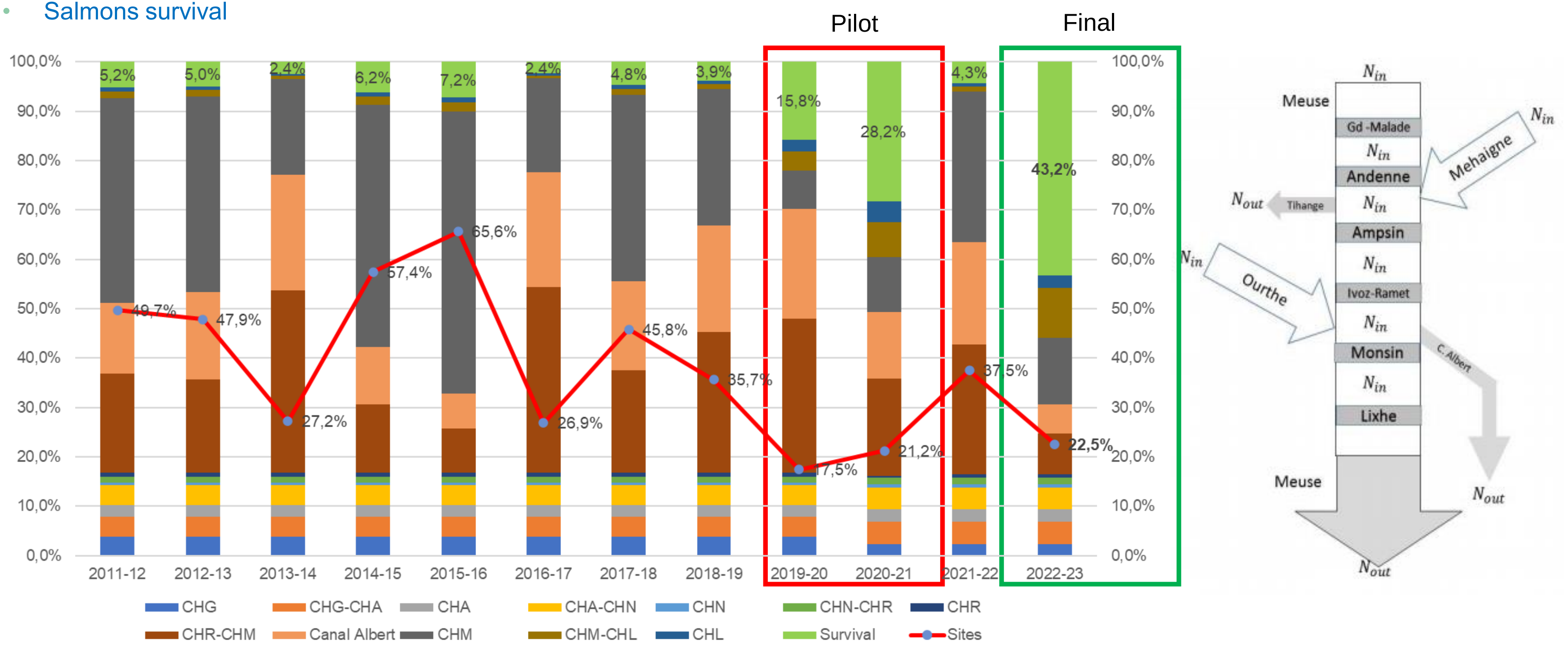
- Eels survival





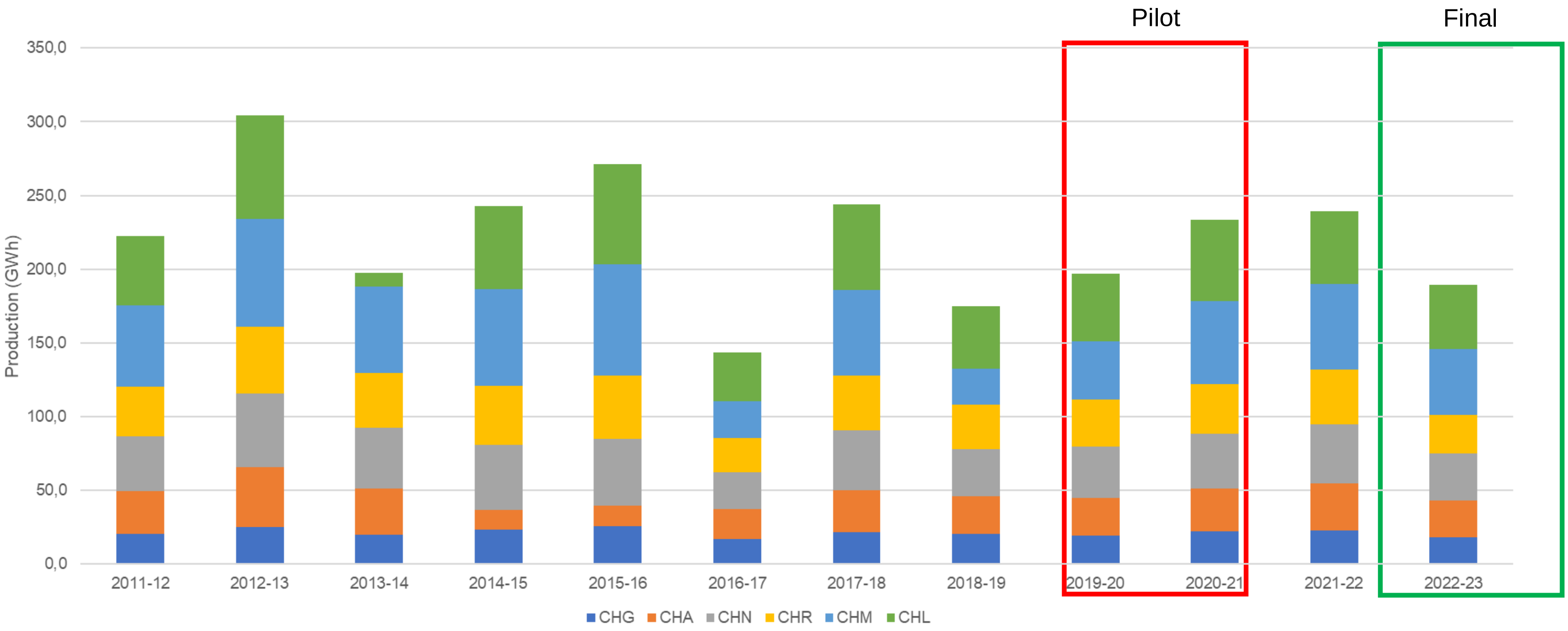
Data treatment => Meuse model

- Salmons survival



Data treatment => Meuse model

- Green Energy production



LIFE4FISH Project indicators

- Eels site's impacts :
  - Goal : 20%
  - Initial : 20%
  - Pilot : 16,5%
  - **Final : 12,7%**
- Salmons site's impacts :
  - Goal : 10%
  - Initial : 40,9%
  - Pilot : 16,7%
  - **Final : 22,5%**
- Saved green energy :
  - Goal : 237,5 GWh
  - Initial : 243,8 GWh
  - Pilot : 233,4 GWh
  - **Final : 189,3 GWh**
- Turbines shutdowns :
  - Goal : 900 h
  - Initial : 0 h
  - Pilot : 1141 h
  - **Final : 446 h (906h planned)**
- Predictive automated plant management :
  - Goal : 6 sites equipped
  - Initial : 0 sites
  - Pilot : 1 site
  - **Final : 5 sites**

Round table

- Downstream migration modelling and management optimization
- Liège-Albert canal knot : status and perspectives
- Fish monitoring is the basis to develop solutions
- New development of eco sustainable turbines

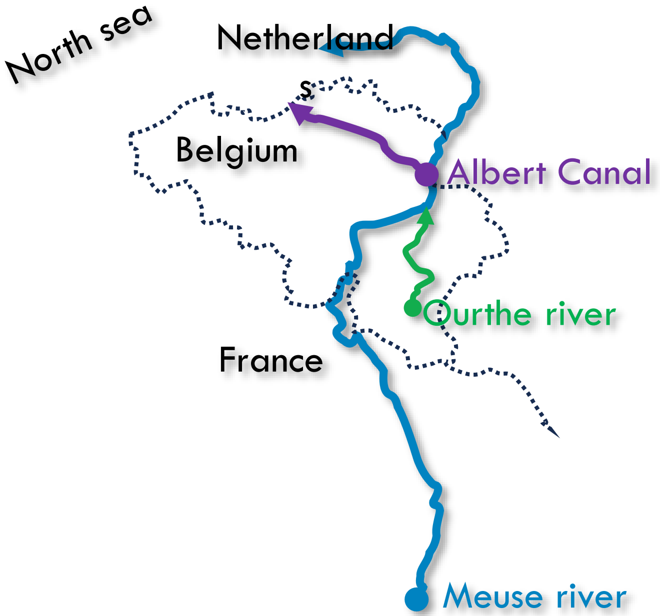
Eric de Oliveira, Researcher and Engineer, EDF R&D
Sébastien Erpicum, Assistant Lecturer, ULiège
Damien Sonny, Fish Biologist PhD, Profish
Pierre Theunissen, Senior Project Manager, Luminus

SEBASTIEN ERPICUM

Associate Professor – ULiege

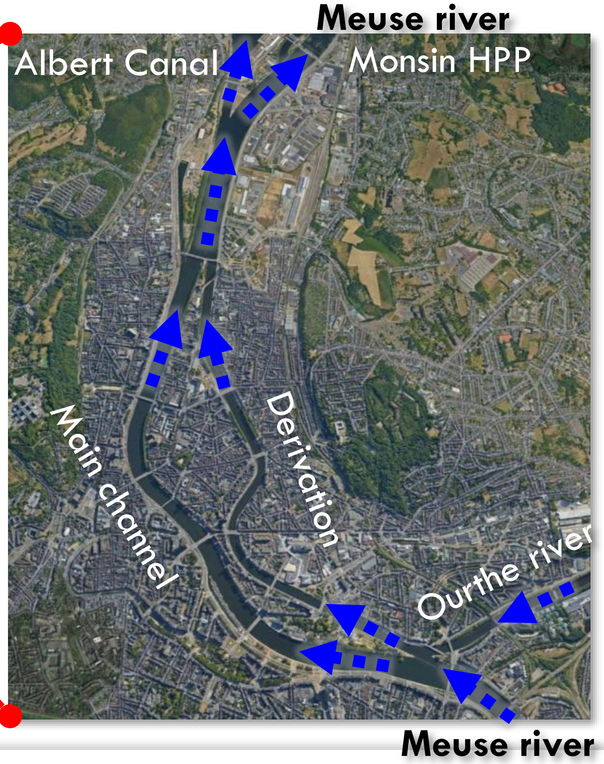
Liège-Albert canal knot : status and perspectives

MEUSE-ALBERT CANAL JUNCTION: STATUS AND PERSPECTIVES



LIFE4FISH

MEUSE-ALBERT CANAL JUNCTION: STATUS AND PERSPECTIVES



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DATA

Smolts behavior:

- ULiege – LDPH – 2014 to 2016 – N=56
- Life4Fish project – 2021 survey – N=91

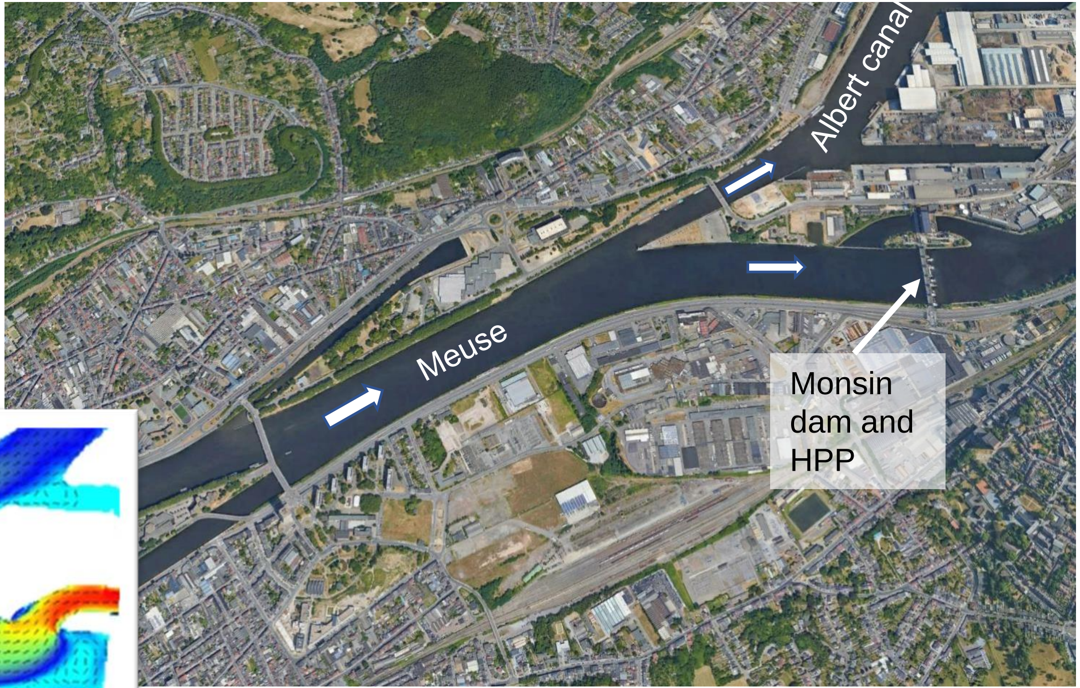
Hydraulics:

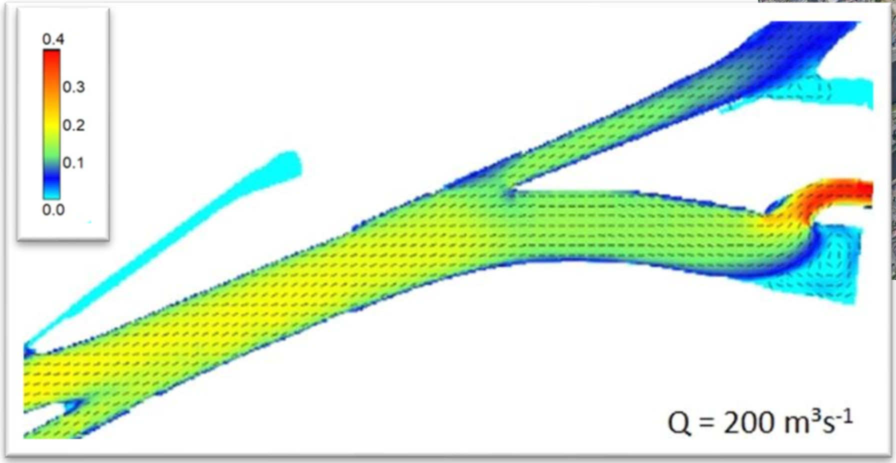
- SPW jauging stations + dam operation
- 2D numerical modeling (Wolf2D software)

LIFE4FISH

RESULTS

2014 – 2016 data
(Renardy et al., 2021)





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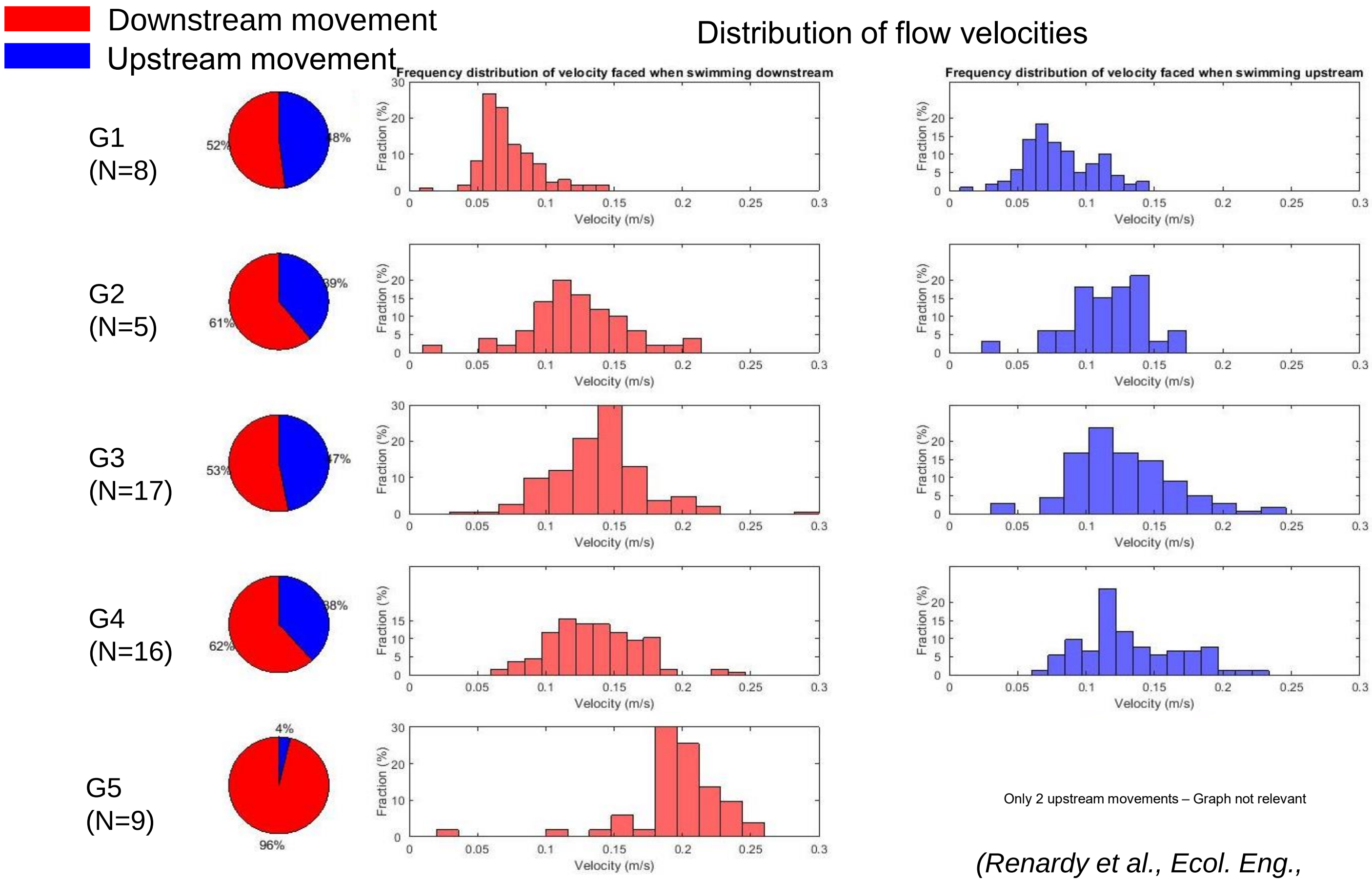
RESULTS

Hesitation



(Renardy et al., Ecol. Eng., 2021)

LIFE4FISH

RESULTS

Hesitation

Downstream movement
Upstream movement

Distribution of flow velocities

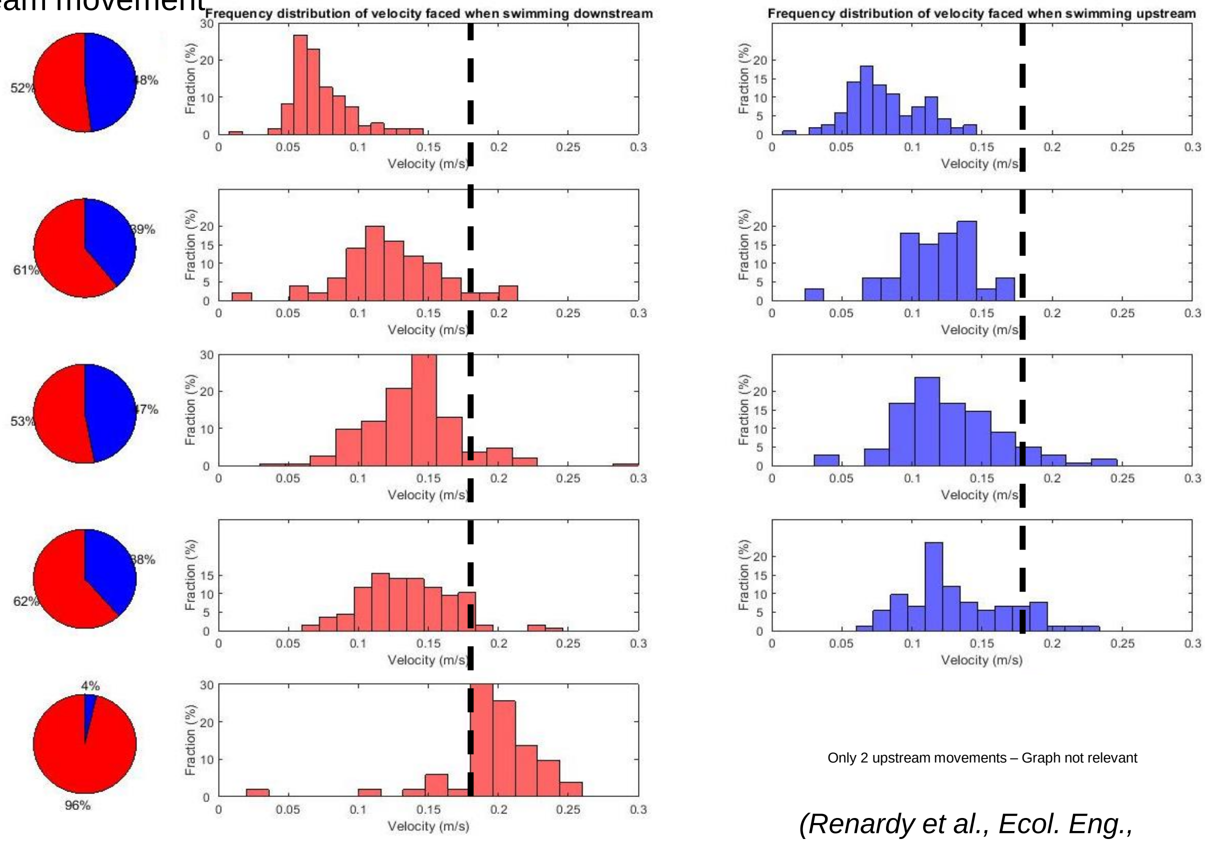
G1 (N=8)

G2 (N=5)

G3 (N=17)

G4 (N=16)

G5 (N=9)



Only 2 upstream movements – Graph not relevant

Flow velocity threshold

≈ 0.17 m/s

(Renardy et al., Ecol. Eng., 2021)

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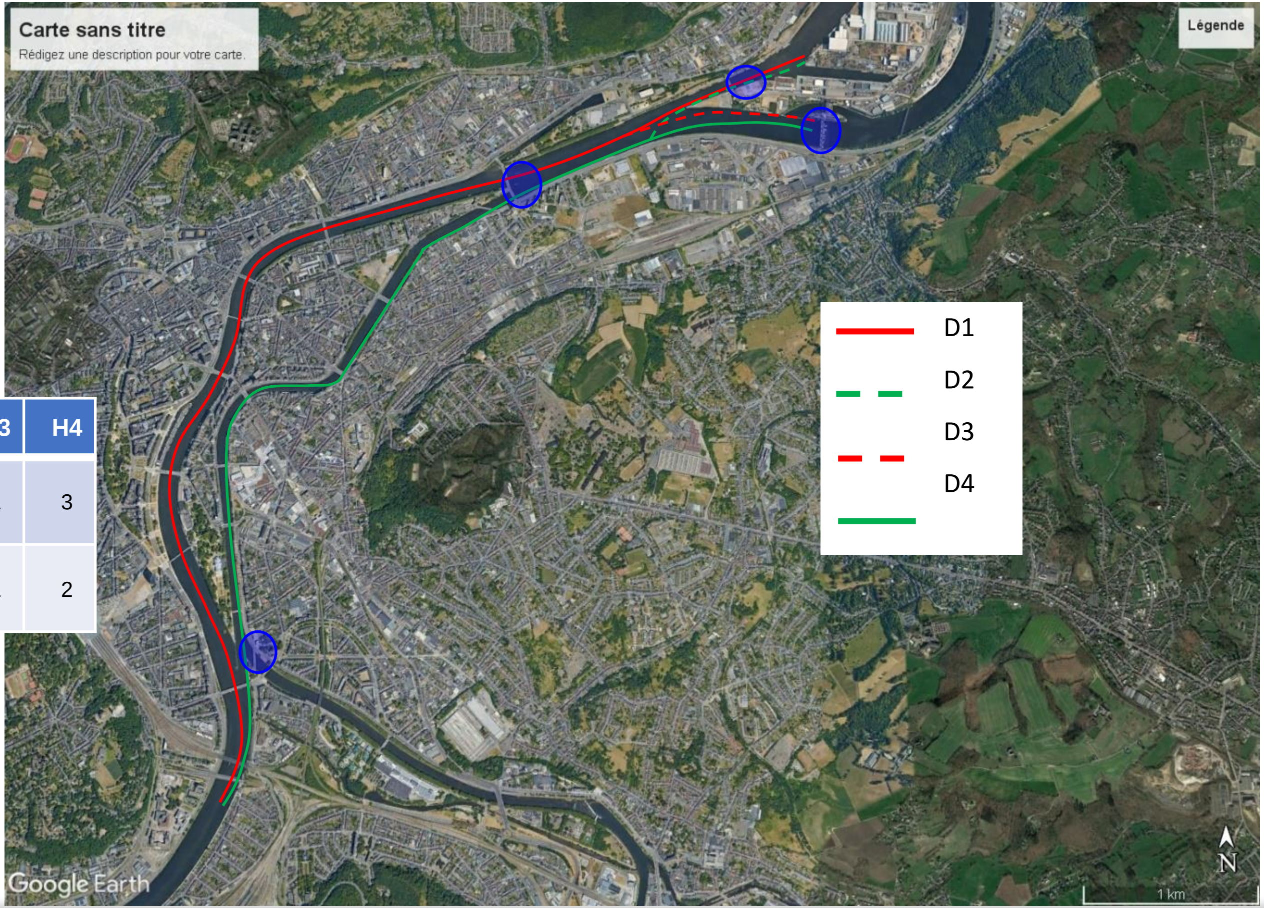
RESULTS

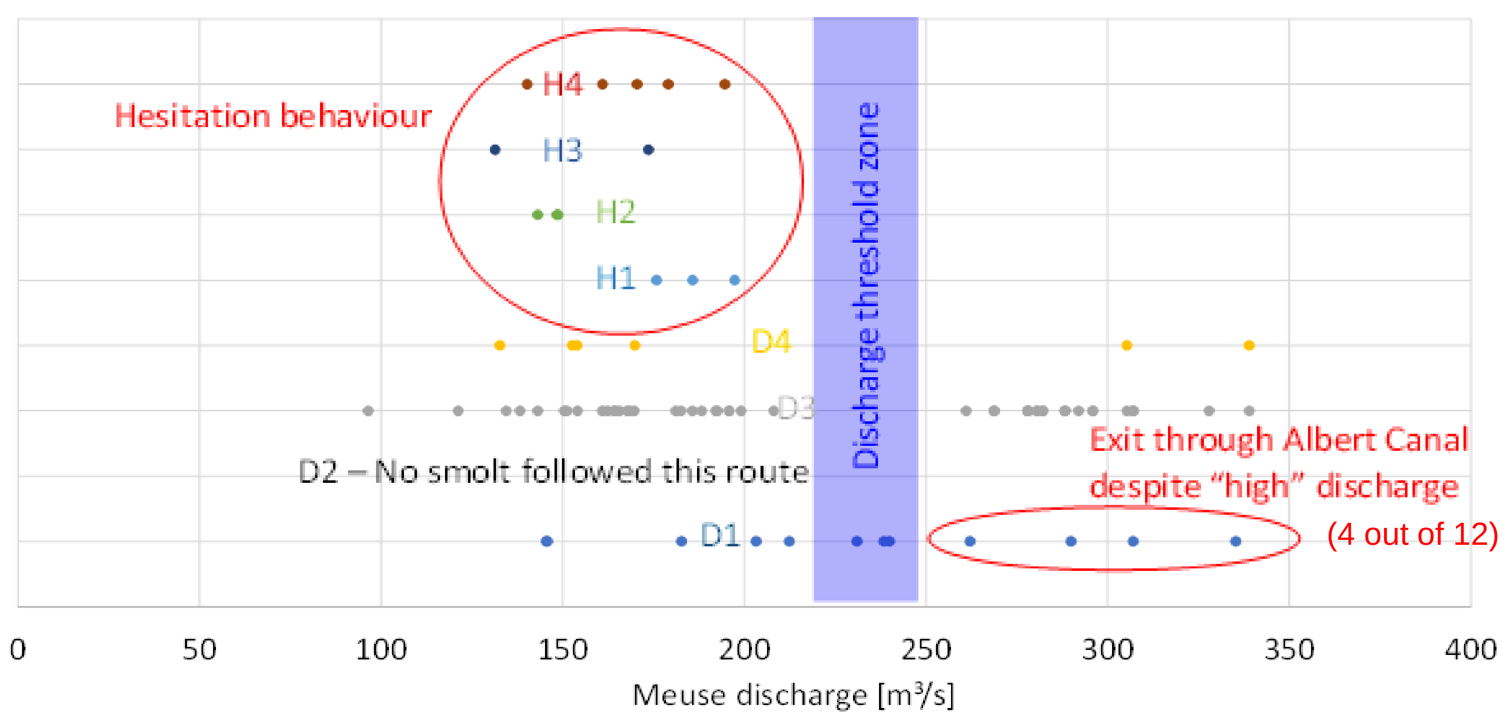
2021 data

Exit	D1	D2	D3	D4	H1	H2	H3	H4
Albert Canal	12	0			0	2	1	3
Monsin dam			49	6	3	1	1	2



RESULTS

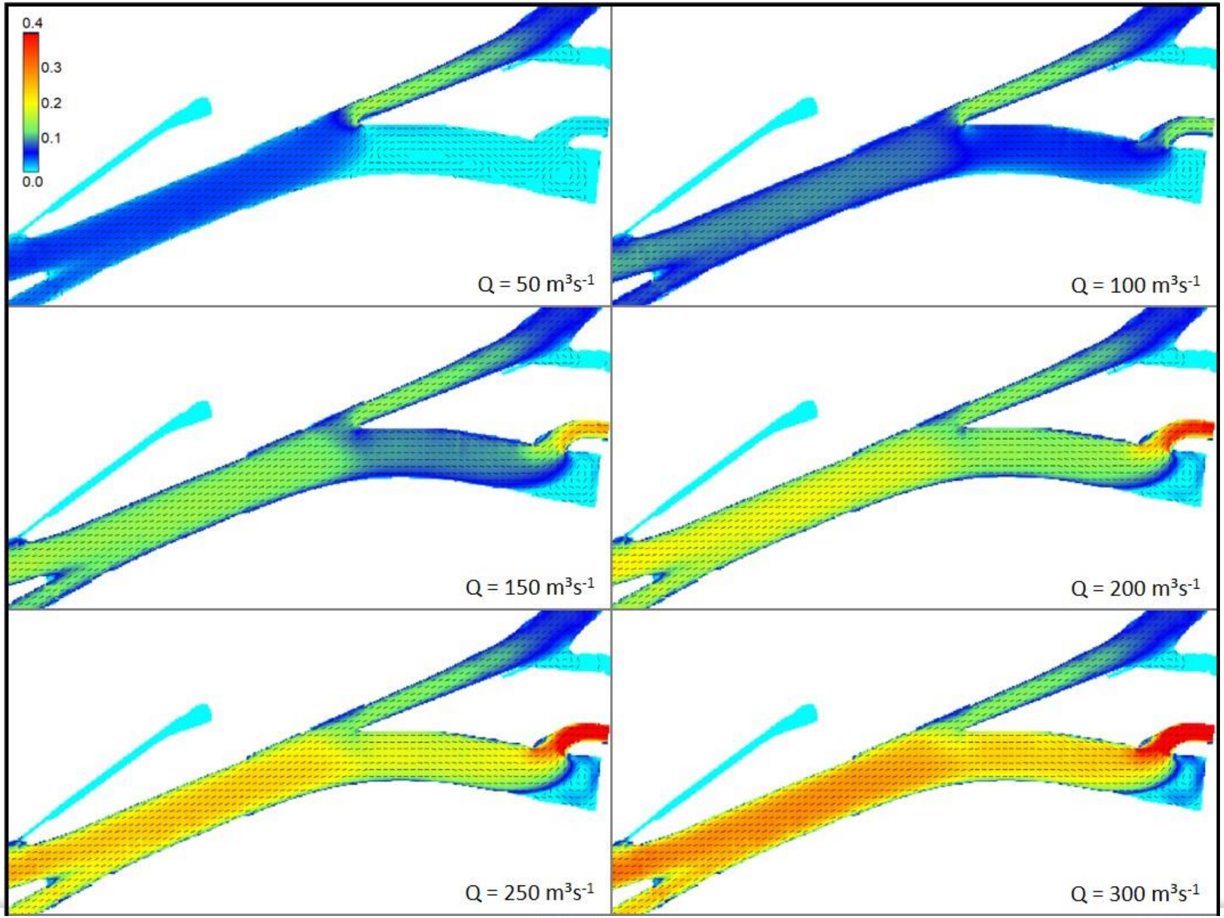
2021 data



LIFE4FISH

RESULTS

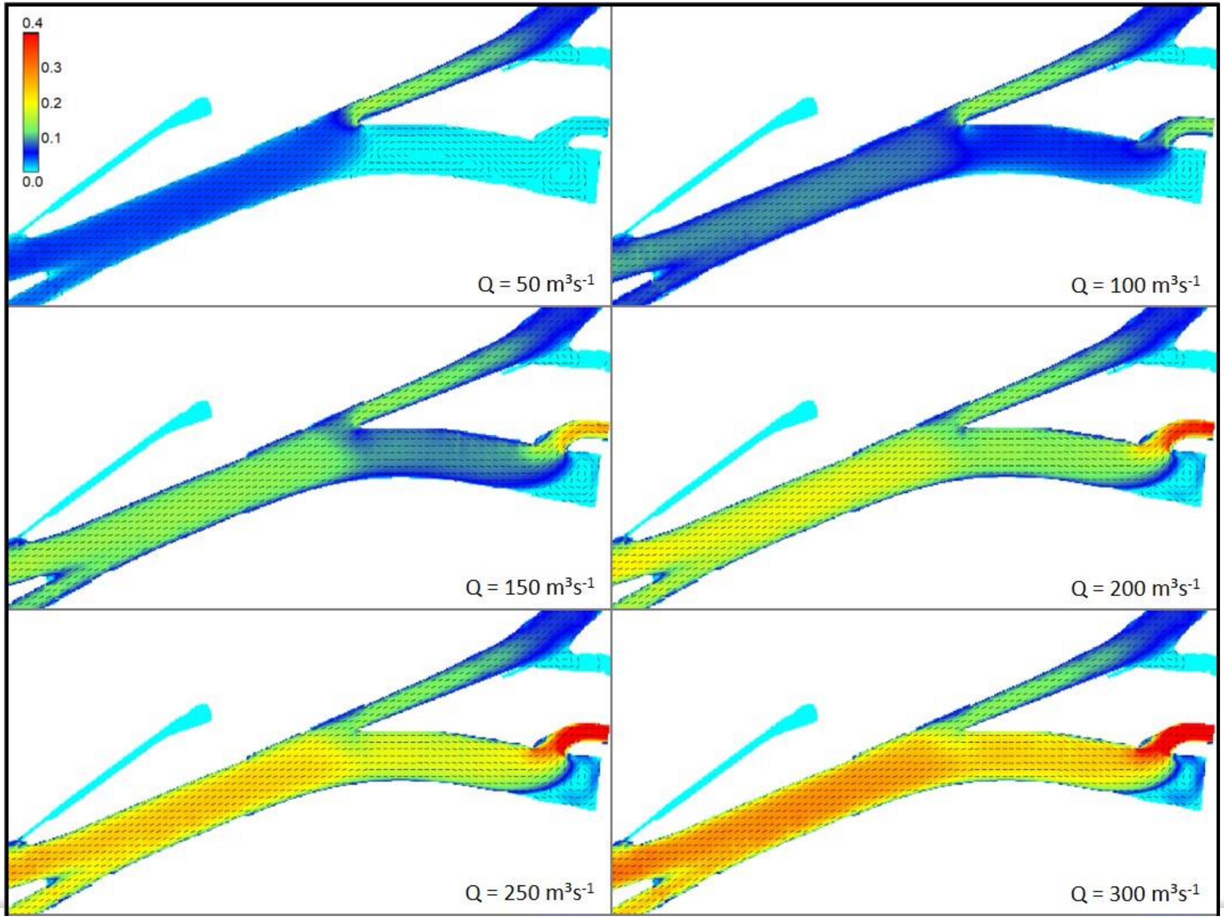
2021 data



RESULTS

2021 data

Flow velocity is a key parameter driving smolts movement



OUTPUTS

Flow velocity is a key parameter driving smolts movement

Flow velocity lower than ≈ 0.2 m/s creates hesitation in smolts movement (confirmed by Ben Jebria et al., 2021 on Allier river - France)

OUTPUTS

Flow velocity is a key parameter driving smolts movement

Flow velocity lower than ≈ 0.2 m/s creates hesitation in smolts movement (confirmed by Ben Jebria et al., 2021 on Allier river - France)

- Albert Canal flow velocity is almost constant (cst discharge) but lower than 0.2m/s

- Flow velocity to Monsin dam varies a lot depending on Meuse discharge.

- For discharge lower than 200 m^3/s, flow velocity to Monsin dam is lower than flow velocity to Albert Canal

LIFE4FISH

OUTPUTS

Problem:

Navigation on Meuse River → constant water depth whatever discharge
→ velocity decreases with decreasing discharge (not the case in natural conditions)

Only solution to increase flow velocity while maintaining navigation is to increase discharge…

… but increasing Meuse discharge by 125 m^3/s during 2 months requires 648 millions m^3 of stored water (global full capacity of the 4 larges dams on Ourthe River is 10 times smaller)

PERSPECTIVES

Solution to make Ourthe

River “smolts friendly”

LIFE4FISH

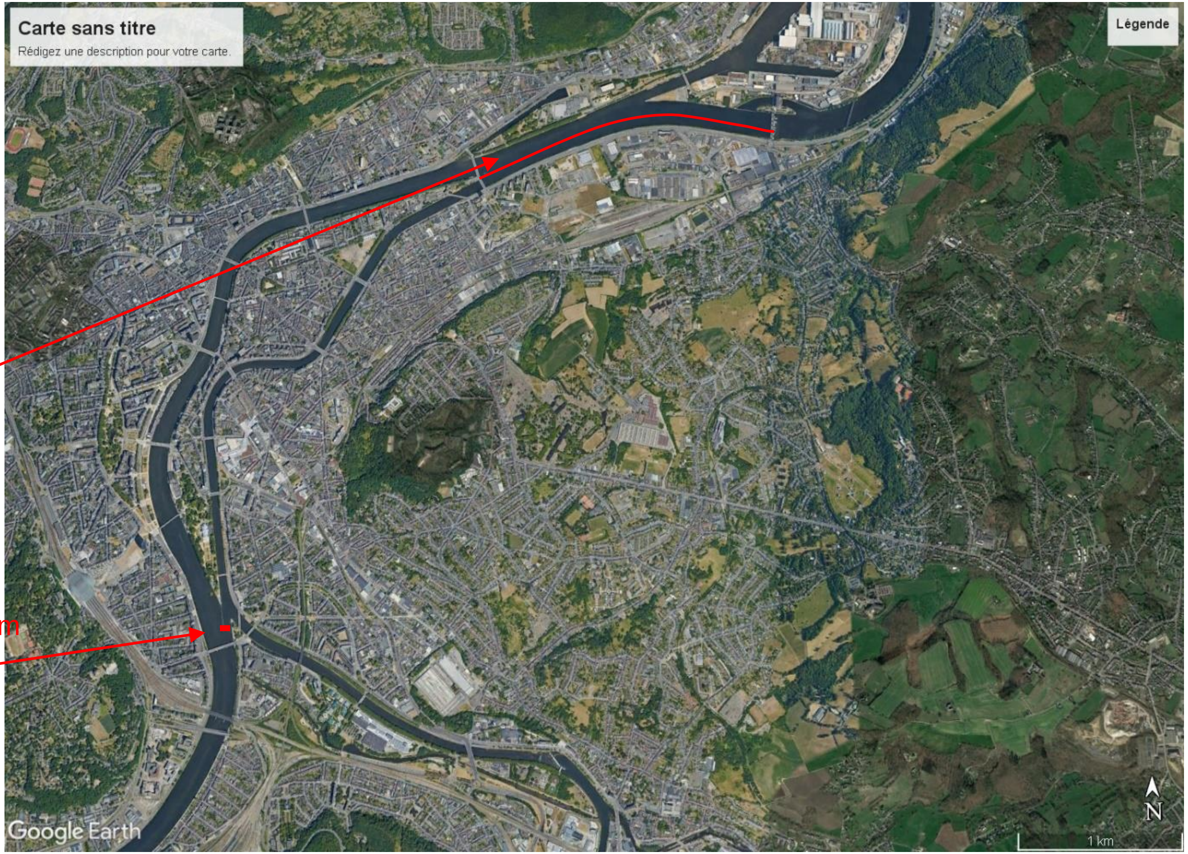
PERSPECTIVES

Solution to make Ourthe River “smolts friendly”

Extending Derivation to Monsin dam

→ Lowering of water depth from Ourthe mouth to Monsin dam

New active dam at Fragnée



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DAMIEN SONNY

Fish Biologist PhD, Profish

MONITORING FISH MIGRATION SUCESS IN LARGE CANALISED RIVERS : NEXT PERSPECTIVES

LIFE4FISH UPSTREAM & DOWNSTREAM OF L4F?

The LIFE4FISH project has focused on 6 HPP of the Meuse – 83 km of river

It aims to meet permits requirements at the scale of the Luminus exploitation zone more than at the site scale.

But still, this is not a basin scale approach…

- Are we sure that the fish protected by L4F actions are safely migrating towards the sea?

- Are we sure that the fish migrating from upstream do have chance to reach the sea?

Profish decided to explore these questions through our own research program :

WALLONEEL

Supported by Wallonie | SPW Service public de Wallonie

WALLONEEL PROJECT

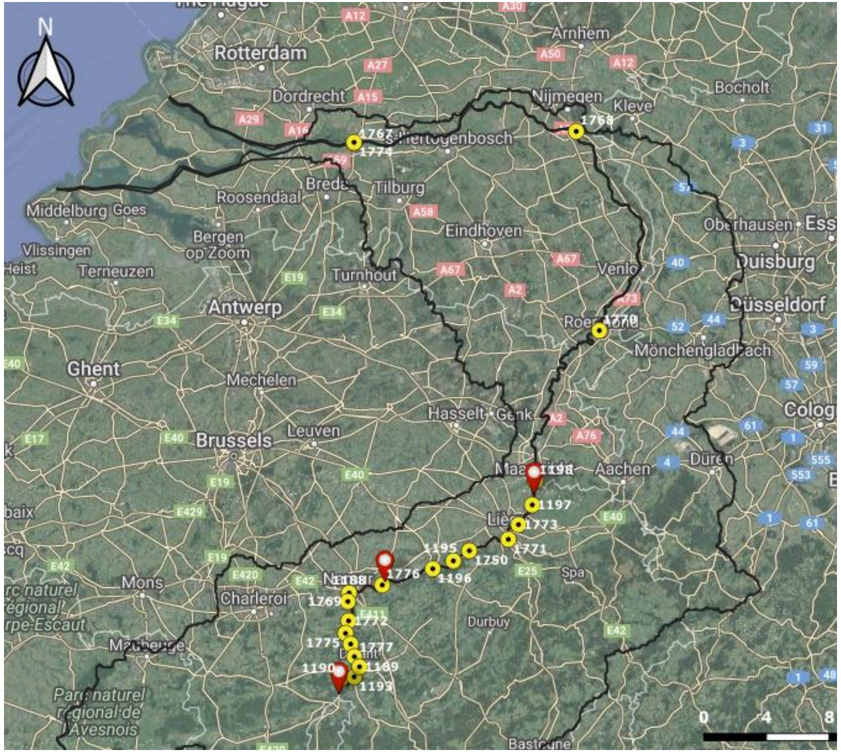
Tracking silver eel migration from the French border to the Meuse estuary by acoustic telemetry.

20 detection stations along 367 km fragmented by 20 dams

3 years of tracking, started in September 2021

N = 150 eels as target

3 catch & tagging stations :
Hastière (French border)
Andenne (mid-course of the Belgian Meuse)
Lixhe (Deutch border)



LIFE4FISH WALLONEEL PROJECT

After 2 migration periods (2021-2022) :

N = 262 eels caught in the fyke nets

N = 83 eels tagged (FIV-FV)

N = 46 eels in migration

2021-2022 migrations

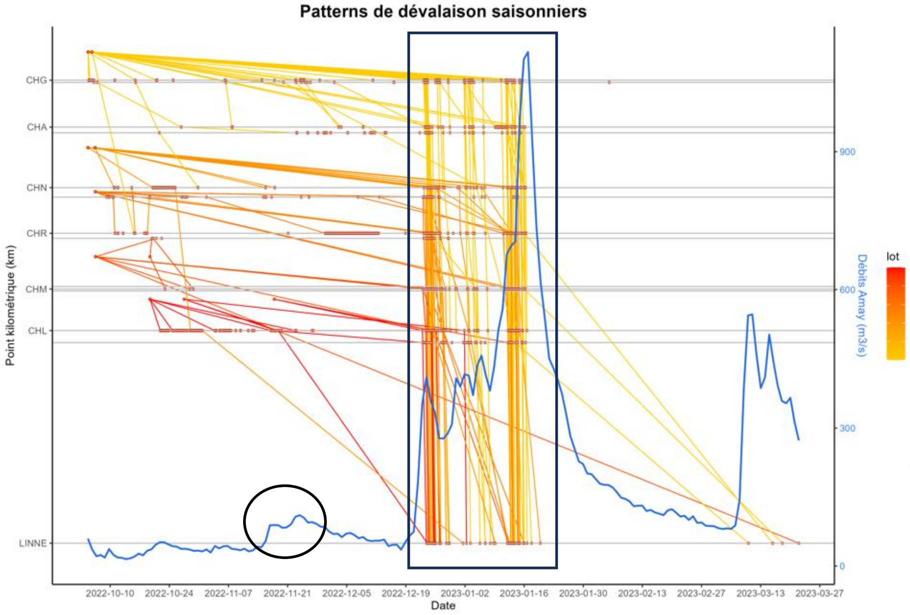
Categories	Hastière	Andenne	Lixhe
N eel tagged	24	26	33
N non migrating	13 (54%)	11 (42%)	12 (36%)
N migrating	11 (46%)	15 (58%)	21 (64%)
Success of migration to the estuary	2 (18%)	6 (40%)	13 (62%)

Success of migration increases for stations closer to the sea…Quite normal…

Number of obstacle seems more impacting that distance to travel

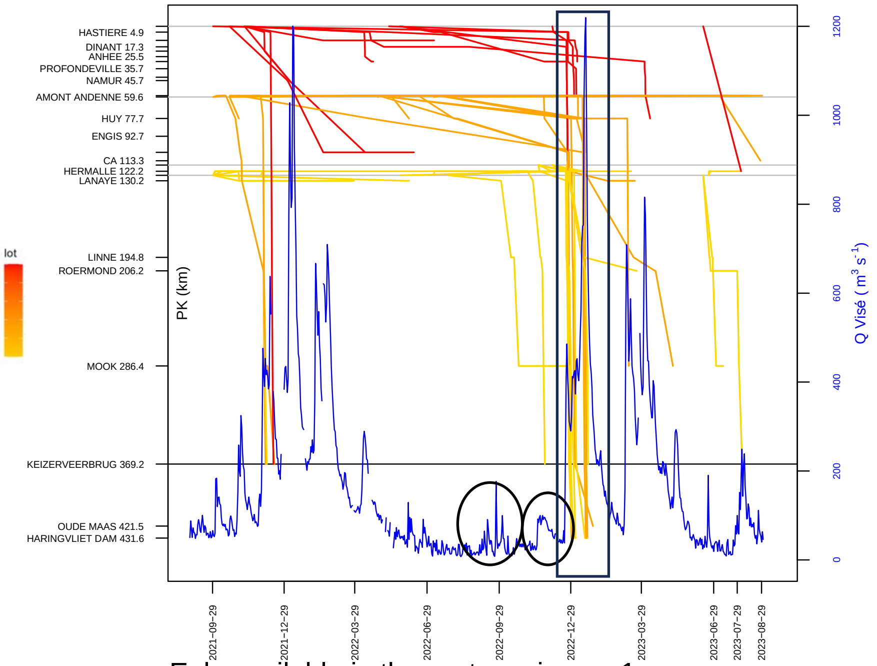
LIFE4FISH WALLONEEL PROJECT

LIFE4FISH project



Eels released in early octobre

WALLONEEL Project



Eels available in the system since > 1 year

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LIFE4FISH WALLONEEL PROJECT

Main peaks of eel migration are following the same trends in both studies (at least in 2022!)

Sensitivity of the eel migration model seems too high for peaks of September, and too low for large peaks of winter.

→ The eel migration model seems to dilute the eel population faster than in real.

Good news : Readjustment of the model is feasible !

Possible to optimize the turbine shutdown operation without loosing more energy but in increasing precision…

→ Less eels through the turbines and more eels through the dam…

WALLONEEL PROJECT

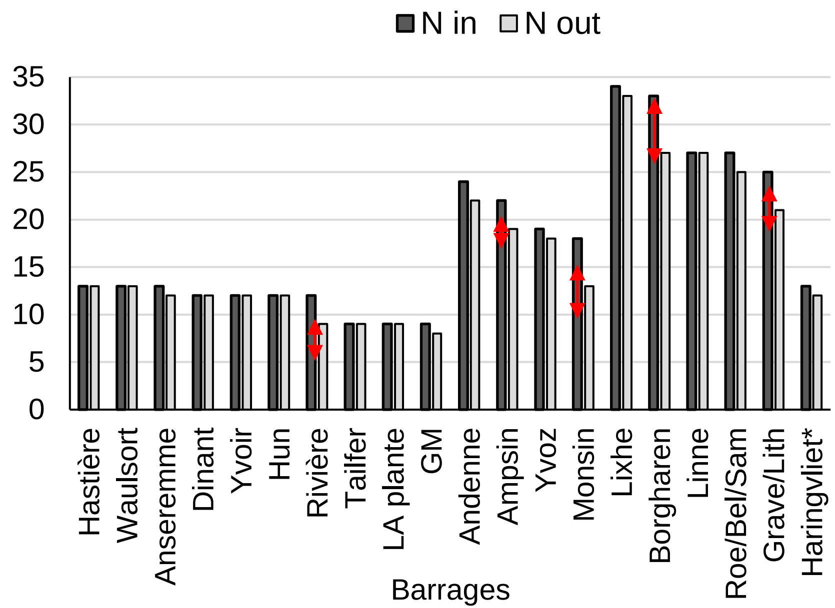
Loss of eels in the network → revealing more impacting stretches?

Eel loss can be caused by many factors :

- Turbine passage impact
- Dam passage impact
- Stop of migration
- Predation

……

No information about dam-turbine passage in this project
Stations are in between dams.



WALLONEEL PROJECT

Confirmation of eels reaching the sea!

Since December 2022, a network covers the Haringvliet (WUR University, Meijer & Winter)…

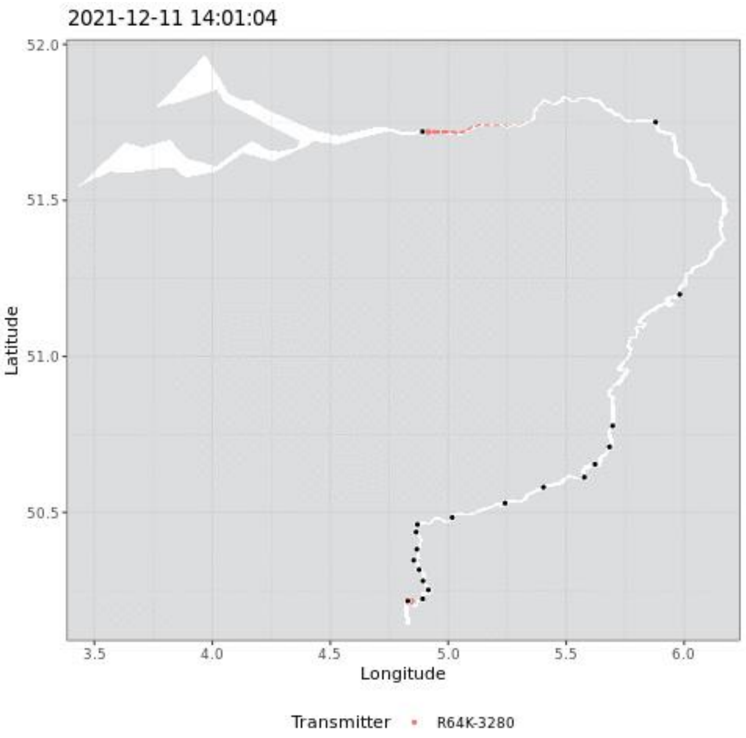
Since this period, 92% of eels detected (12/13) in our last station have been detected in the Haringvliet !

From now, sea escapement can be quantified !

- ∽ 60% for Lixhe
- ∽ 40% for Andenne
- ∽ 20% for Hastière…

Another 2 years of migration to monitor… the trend will maybe change with efforts taken at HPP in BE and NL.

Adding a French network?

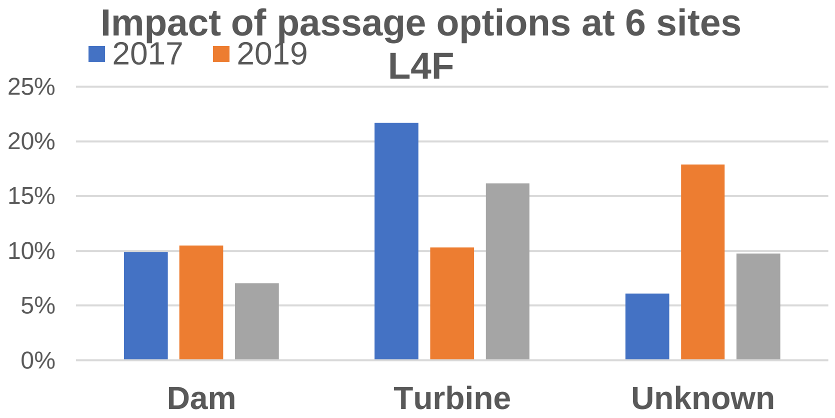


POTENTIAL IMPACT OF DAMS ON SILVER EELS

A pretty precise source of impact estimation of migration routes over 3 successive telemetry surveys at LIFE4FISH

N = 719 dam passage
N = 209 turbine passage
N = 204 unknown passage

Impact =
Missing eel at the next station



Dams ∽ 2 times less impacting than turbines
But concerned by 70-80% of eel passage
Taking into account the entire migrating population across a HPP-Dam complex, dam potentially has a greater impact than HPP…

POTENTIAL IMPACT OF DAMS ON SILVER EELS

Same situation observed on another study we are conducting in the Seine River

Poses = last dam before the sea
10% of the French national silver eel stock passing

Estuarine station (+100 km)

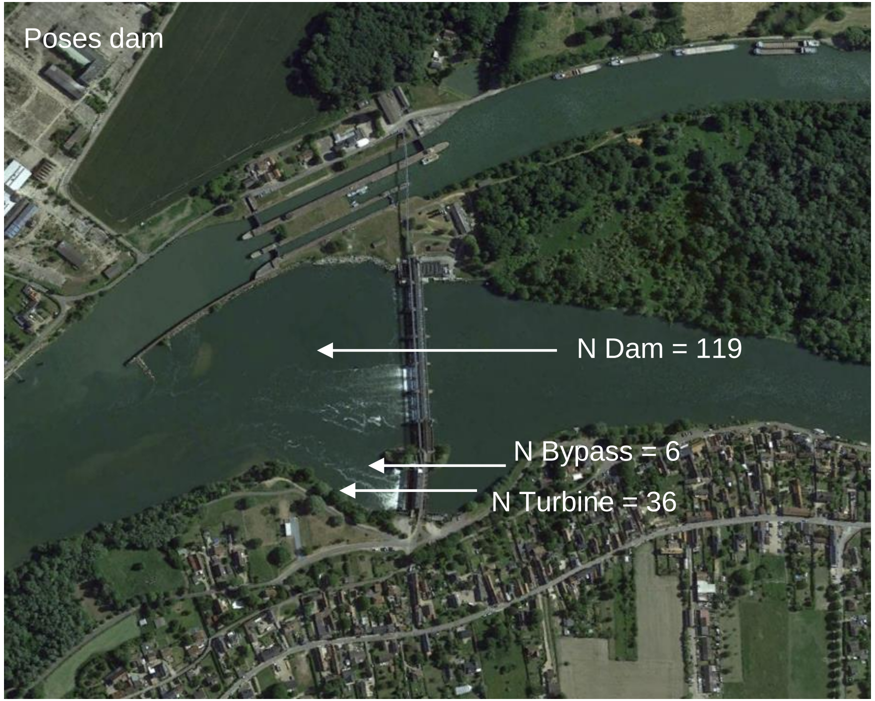
Dam passage : 10/119 missing → 8.4% impact

Turbine passage : 7/36 missing → 19.4% impact

At the migrating population (N = 161) scale :

Dam impact = 10/161 = 6.2%
Turbine impact = 7/161 = 4.3%

Dam and Turbines of Poses have a similar impact !



POTENTIAL IMPACT OF DAMS ON SILVER EELS

Source of impact?
Mechanical contact (gate, dissipation concrete structures, …)
Pressure
Shear forces – turbulences
Dissolved gas supersaturation

Must be evaluated

POTENTIAL IMPACT OF DAMS ON SILVER EELS

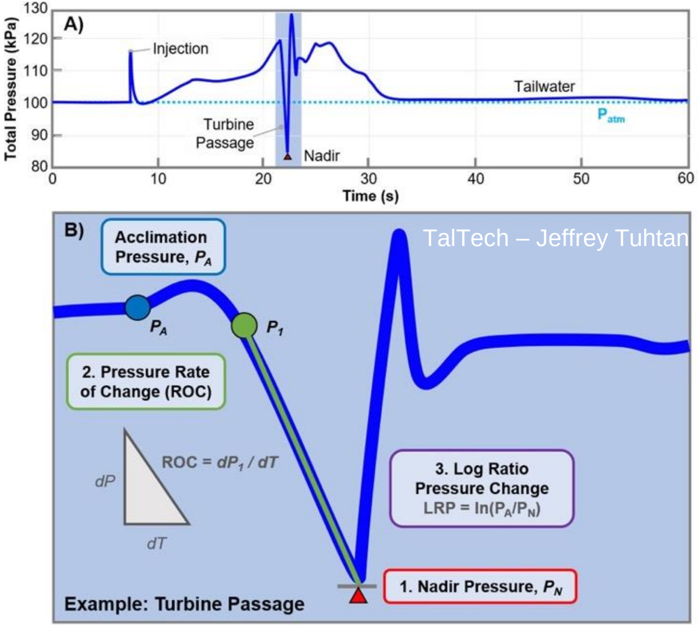
Which method?

Technical feasibility – Safety of operators…

→ New technologies

Sensor fish (Tallin University) + balloon tags

- Pressure
- x, y, z acceleration
- mechanical contact
- …



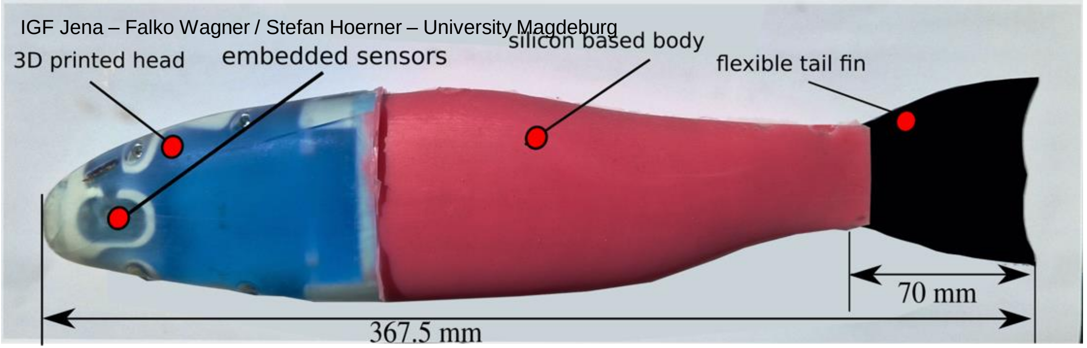
Turbine passage pressure diagram

POTENTIAL IMPACT OF DAMS ON SILVER EELS

POTENTIAL IMPACT OF DAMS ON SILVER EELS

Sensor fish miniaturisation

"Backpack" sensor fish…



Robotfish with learned behavioural rules
+ sensors inside

Replace living fish in experiments…

POTENTIAL IMPACT OF DAMS ON SILVER EELS

HPP impact can't be reduced down below the intrinsic impact of navigation structures…

In many countries, HPP operators also manage the dams…

→ 2 touchy issues to manage for fish for a single user !

In Belgium, dams are under the responsibility of Public Authorities…
→ More easy to put the responsibility of the dam when you don't manage it !

Who is responsible for these public structures at the end?

These are a legacy from the past…

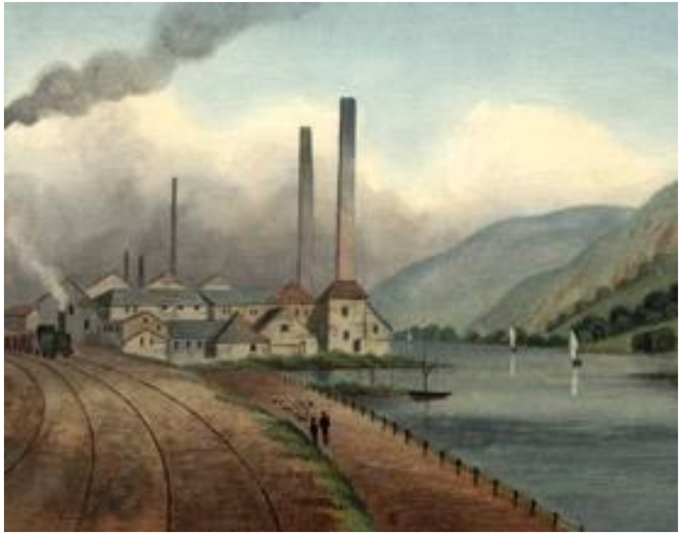
ECOLOGICAL CONTEXT OF THE RIVER MEUSE

The River Meuse reflects the context of other large European navigable rivers :

Middle-Age, the Meuse was a commercial axis of first importance like the Rhine or the Loire Rivers.

The River Meuse offered to Belgium the possibility to export product from our coal and steel industry, helping Belgium to become one of the most powerful countries of the World (a bit helped by resources on the Congo…).

From middle of 19th century, we decided to transform the river into an economic tool…No matter what was inside…



ECOLOGICAL CONTEXT OF THE RIVER MEUSE

From a dynamic self-sufficient river

To

A controlled succession of ponds with concrete banks

Loss of biodiversity

Loss of eco-systemic services

Loss of self-regenerating capacity

Loss of all we are trying to restore nowadays

PERSPECTIVES FOR FISH MIGRATION IN LARGE RIVERS

Dams, concrete banks, Albert canal…→ navigation tools.

→ Public industrial facilities !

No environmental studies have been made when we built the dams and the Albert Canal.

Are these structures controlled by permits and environmental studies?

The status of these structures should be clarified.

PERSPECTIVES FOR FISH MIGRATION IN LARGE RIVERS

Public authorities started lot of things to help fish migration !

Fish passes, Salmon 2000 project, ……

Lot of studies involving public authorities are under progress in many countries !

Public authorities are often the main motor for studies and progress !

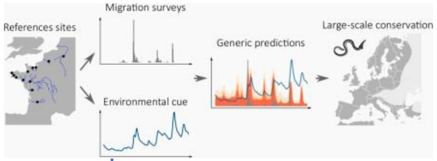
Integrating the downstream migration as a single issue at the basin scale, melting all users (private & public) :

→ Coordinated strategy at the basin scale
→ Coordinated scientific studies
→ Shared budget for actions deserving the same purposes
→ Coordinated field task force for monitoring
→ Coordinated field task force for control (Environmental police)

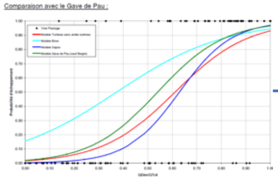
LIFE4FISH DIAGNOSTIC AND SOLUTIONS

An available tool developed by EDF to simulate impacts and solutions of HPP
→ Enlarge to other variables like navigation, potabilization, …?

Dynamic migration prediction/forecast (river flow)

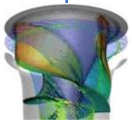


3- Repartition of the passageways

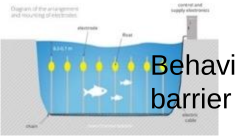


2- survival rate (regulation)

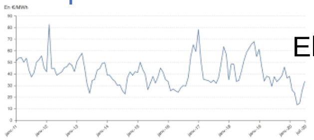
Catch/transport



Survival rate



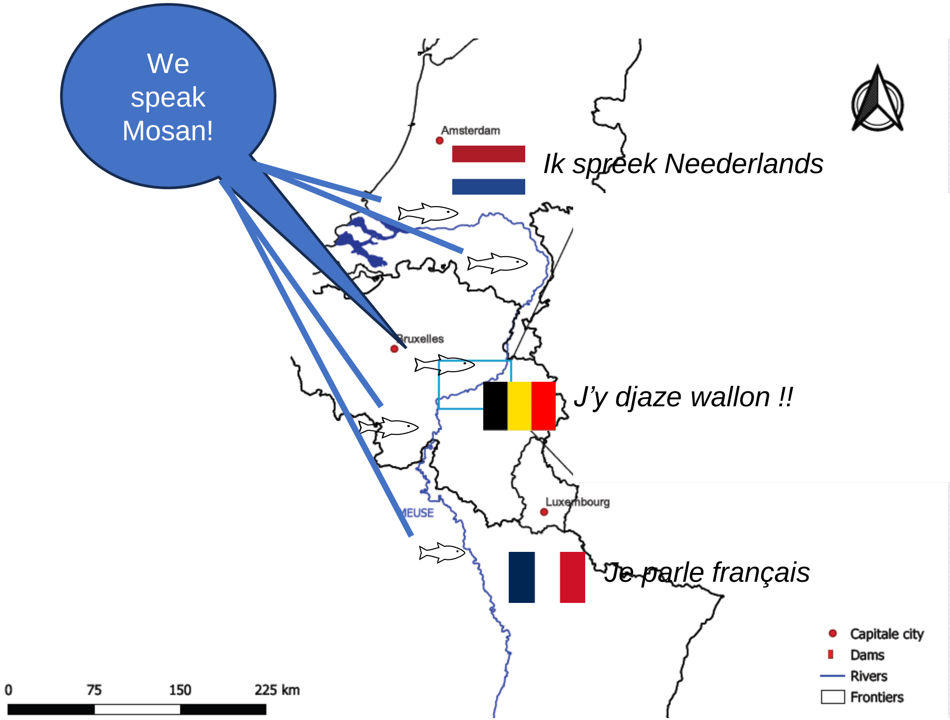
Behavioral barrier



Electricity market

LIFE4FISH PERSPECTIVES FOR FISH MIGRATION IN LARGE RIVERS

Towards the same language



PIERRE THEUNISSEN

Senior Project Manager Luminus

Eco-sustainable turbine

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New design eco-sustainable for Hydraulic turbine, a solution for downstream migration.

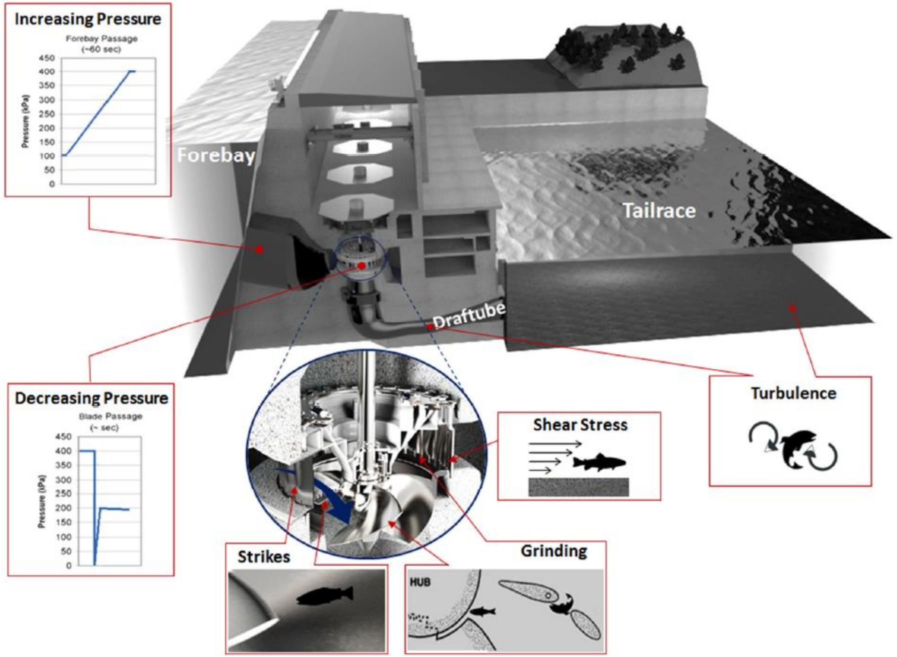
The new turbines of Monsin were not a part of the Life 4 Fish grant.

- The Design of the turbines of Luminus is 50-60 years old.
- Ichtyocompatibility had never been a characteristic taken into account in the design of turbines.
- Permit are renewed with new impositions regarding fish fauna. Retrofit is the best moment to upgrade the turbine.
- Even if CAPEX was very high, there was an incentive to improve the characteristics of the turbine regarding environmental regulation.

Monsin the first Eco-Sustainable turbine for Luminus

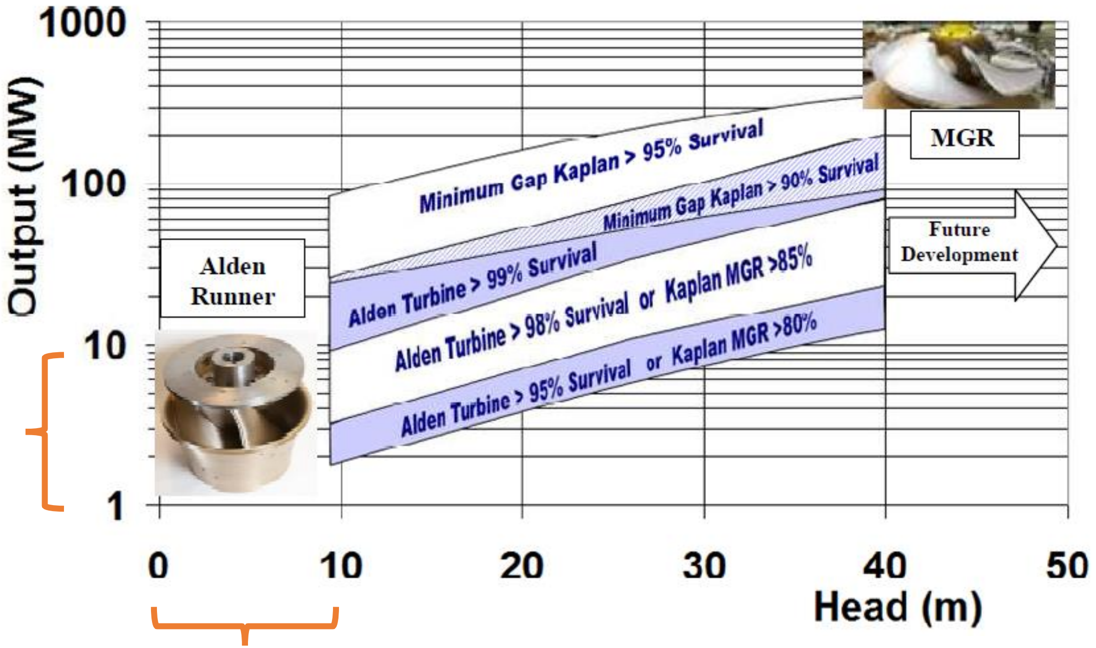
ECO-SUSTAINABLE TURBINE DESIGN

- No contractual commitment from manufacturers on the impact rate of turbines.
- Need for a new approach via the publication of a reference note on eco-sustainable protocol in order to define the best design parameters to reduce the impact of turbines
- Mechanical stresses
  - Shock on fixed or moving parts
  - Scratching
  - Wedging / pinching
- Hydraulic stress
  - Pressure
  - Shearing
  - Turbulence (indirect death)



EXPECTED SURVIVAL RATES

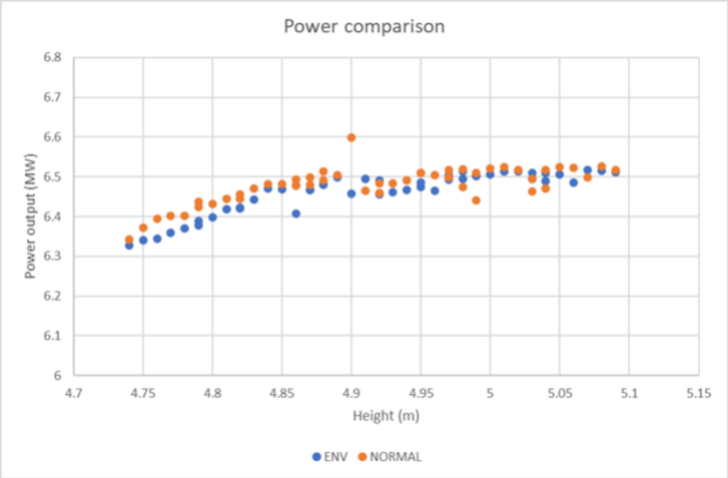
- Conventional Kaplan turbines have impact rates:
  - 80% < Salmon < 98%
  - 50% < Eels < 85
- Measurements made on our turbines:
  - 92% < Salmon < 93% (predictive formulas 7.8% impact)
  - 80% < Eels < 88% (predictive formulas at 48% impact)
- The machines of Luminus have low impact due to a low speeds (<150rpm) and height is below 10m head.



RANGE OF OPERATION OF THE TURBINES OF LUMINUS

LIFE4FISH Results of the eco-sustainable turbine of Monsin

- Specific design for machine with height lower than 10m (3 blades, low rotating speed, dedicated design for blades & vanes).
- Measurement done with patented technology of Normandeau : “We did not observe a single incidence of severance or decapitation of eels during passage through the new turbine. That is impressive and very rare for propeller turbines”
- Healthy **salmons unaffected** by the HPP turbine : Impact 48h below 2%
- Healthy **Eels relatively less affected** by HPP turbine : Impact 72h 7%



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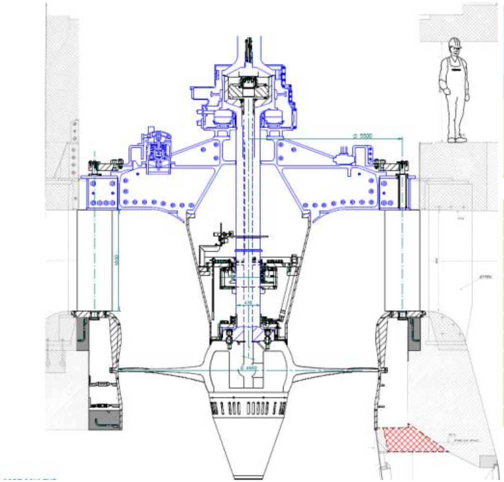
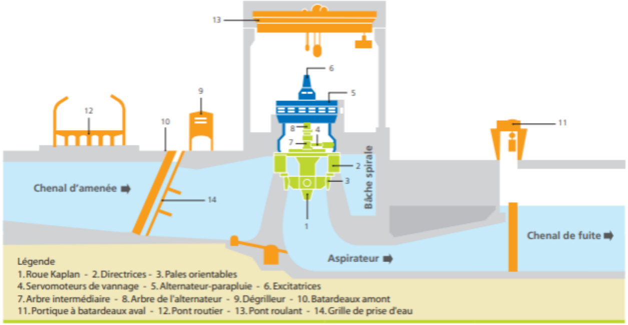
LIFE4FISH

POTENTIAL NEW PROJECT FOR LUMINUS : IVOZ-RAMET

Retrofit of Ivoz-Ramet

- “Copy-paste” of Monsin’s Turbine.
- Manufacturers do not guarantee the eco performances.
- Project of 7M€/machine
- Estimated production 34GWh/y with fish constraints.
- Extension of Lifetime for 35 years.
- Green certificate could be obtained for 25 years.
- The project is currently not profitable.





	Ivoz-Ramet	Monsin
Type de turbines	Kaplan à axe vertical	Kaplan à axe vertical
Nombre de turbines	3	3
Diamètre de roue	4,65 m	5,60 m
Vitesse de rotation	75t/m	65,2 t/m
Côté amont de retenue	64,6 m	60 m
Côté aval à l'étiage	60 m	54,3 m
Chute maximum	4,6 m	5,7 m
Débit d'équipement	285 m³/s	350 m³/s
Puissance nominale par turbine	3,3 MW	6 MW
Puissance totale par centrale	9,9 MW	18 MW
Rendement d'un groupe	85 %	87 %
Production annuelle moyenne	37.000.000 kWh	62.000.000 kWh

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Key performance parameters for an Eco-sustainable design example of Ivoz-Ramet

Example for Ivoz-Ramet, actual engineering

Base on a hydrodynamical & mechanical model several parameters are checked

- Flow (m^3/s)
- Minimum pressure of fluid stream (P in kPa) : @ runner hub, @ mid-blade, @ runner chamber
- Relative velocity at leading edge of blades (m/s & rad) : @ runner hub, @ mid-blade, @ runner chamber
- Maximum average weighted acceleration m/s^2 : @ runner hub, @ mid-blade, @ runner chamber
- Turbine synchronous speed (N) in rpm
- Number of blades (Nap): 3
- Thickness of blades leading edge (Ep) in mm: : @ runner hub, @ mid-blade, @ runner chamber

Mandatory Mechanical Properties

- Gaps between blade and runner hub or discharge ring shall not be more than 2mm.
- No cantilever on wicket gates.
- Wicket gates and stay vanes shall be aligned
- The minimum possible roughness level shall be achieved along wicket gates, runner blades and draft tube line.

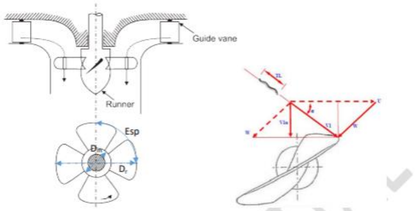

Figure 1. geometric symbols representation

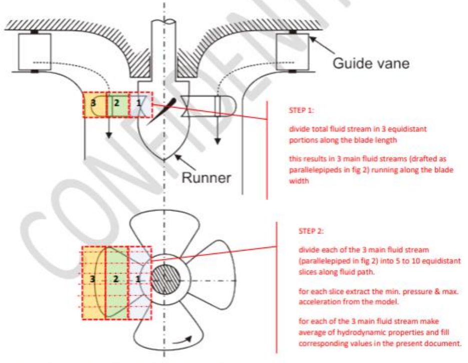

Figure 2. hydrodynamic properties construction in requested fluid streams

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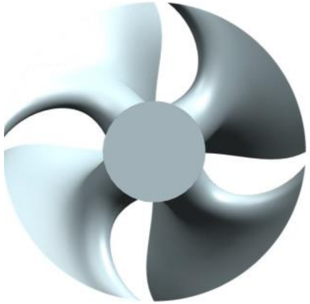
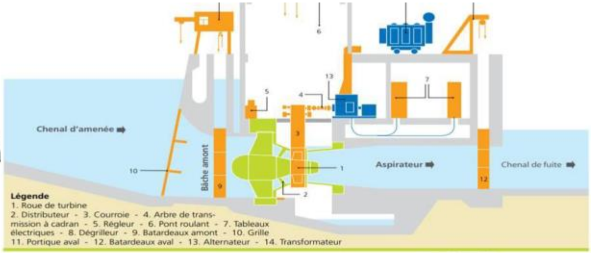
POTENTIAL NEW PROJECT FOR LUMINUS : GRANDS-MALADES

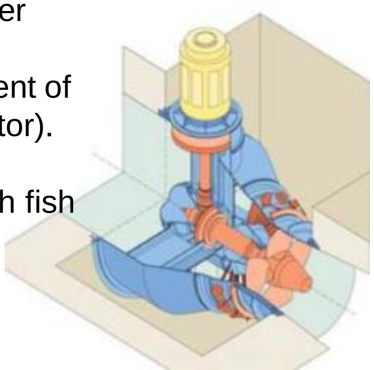
Retrofit of Grands-Malades

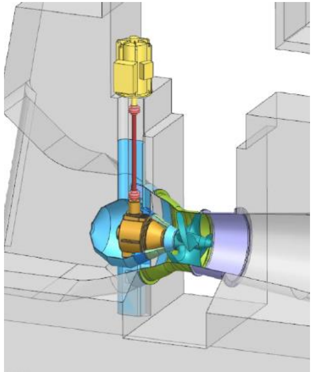
- “Copy-paste” of Monsin’s Turbine not possible as it is H-Kaplan.
- 1 Manufacturer could guarantee the performances regarding ichtiocompatibility. The manufacturer would only supply the wheel.
- Project is for a complete replacement of the turbo-group (Turbine + Generator).
- 4,5M€/machine.
- Estimated production 12GWh/y with fish constraints.
- Business case has not yet been established.





	Grand Malades
Type de turbines	Straflo à axe horizontal
Nombre de turbines	4 (1 à pales de roue orientables)
Diamètre de roue	2,60 m
Vitesse de rotation	132 t/m
Côté amont de retenue	78,4 m
Côté aval à l’étiage	74,6 m
Chute maximum	3,8 m
Débit d’équipement	170 m³/s
Puissance nominale par turbine	1,25 MW
Puissance totale de la centrale	5 MW
Rendement d’un groupe	88%
Production annuelle moyenne	13.000.000 kWh





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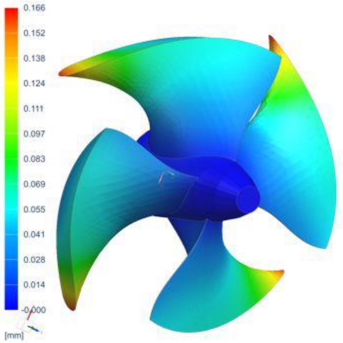
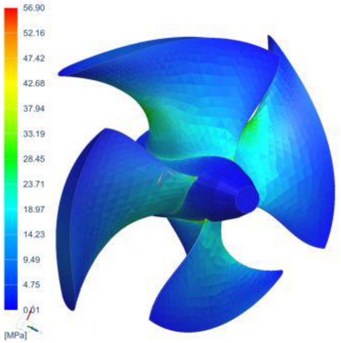
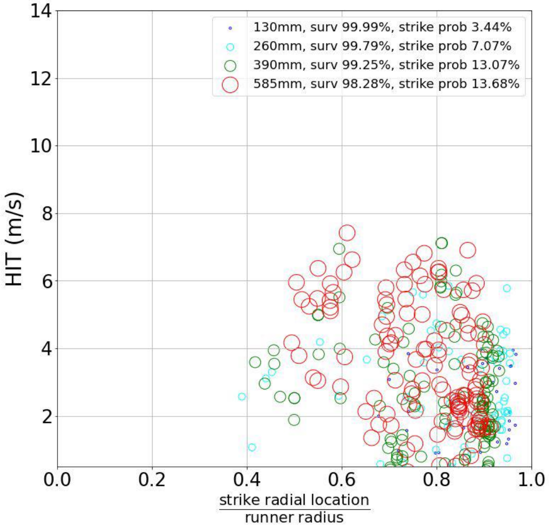
POTENTIAL NEW PROJECT FOR LUMINUS : GRANDS-MALADES

Turbine manufacturers are becoming more aware of ichtiocompatibility requirement mainly driven by new permit rules regarding fish fauna.
Manufacturers start to offer and guarantee the performance.

>99% survival expected for eels
>99% survival expected for salmonids <40 cm
>98% survival expected for salmonids 50-60 cm







DISCUSSION

- Can Eco-sustainable turbine be the best chanel for downstream migration ?

- What solution can be offered for the non-passing individual ?

- Actual vision, regarding fish protection, is limited to the responsability of the energy producers, don’t we have also to focus on reach, dam, lock to lower the impact on fish fauna ? Is a global vision required ?

Conclusions

- Pierre Theunissen, Senior Project Manager, Luminus

Together we make the difference

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