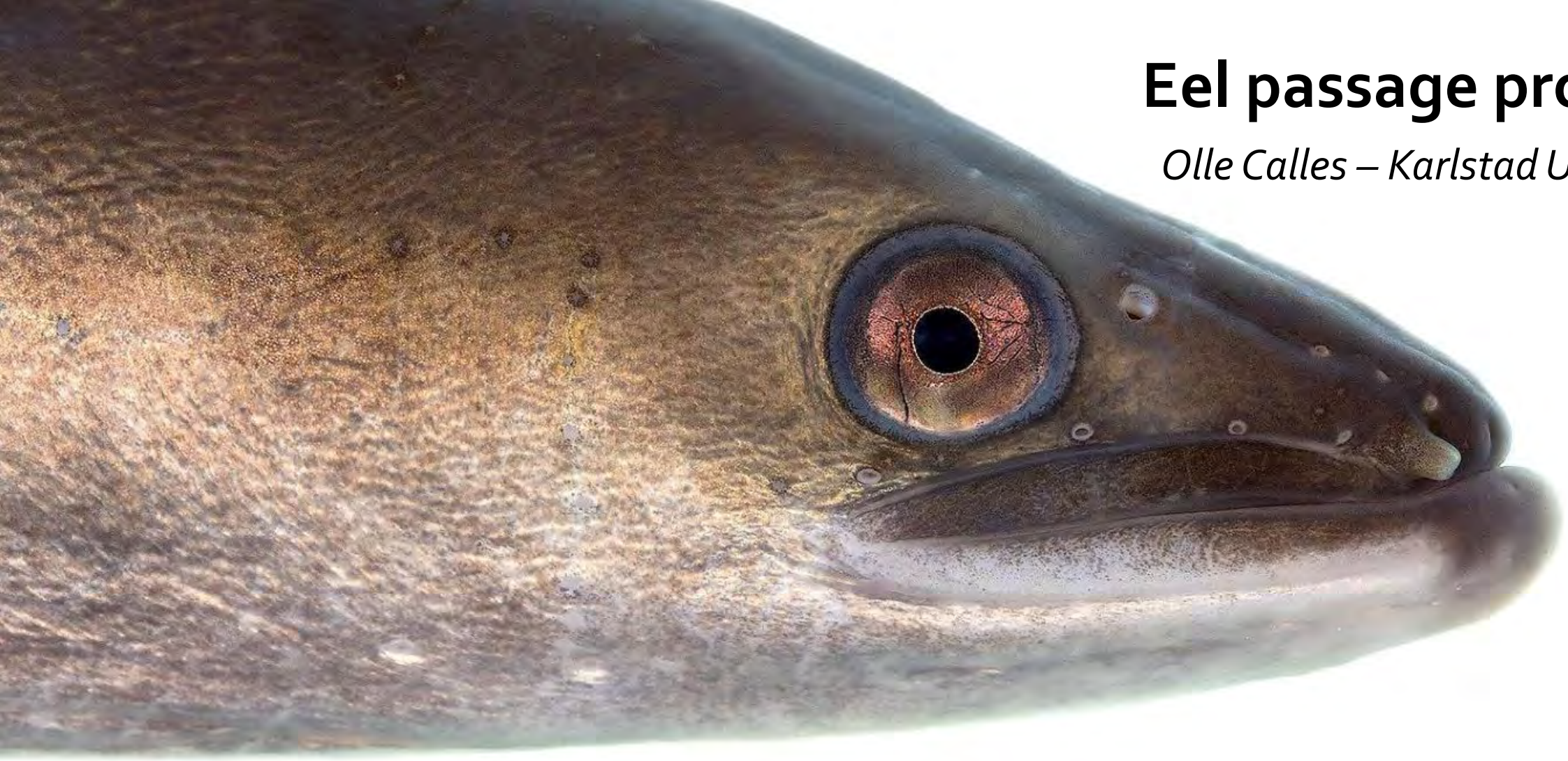


Eel passage projects

Olle Calles – Karlstad University

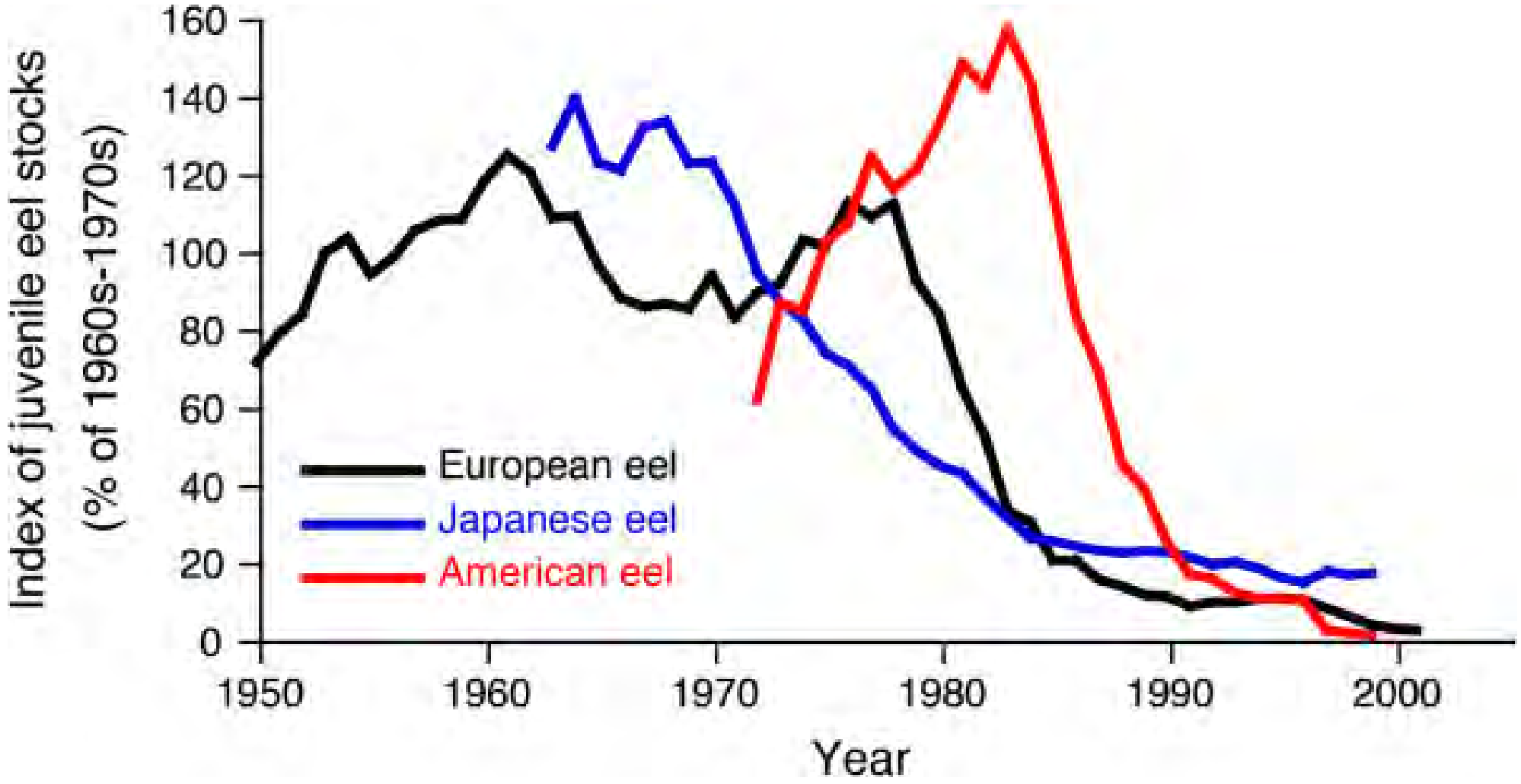
FISHSEC THE FISHERIES SECRETARIAT

GOOD FISH FOUNDATION

RivEM

KARLSTADS UNIVERSITET

Photo: Jörgen Wiklund



Dekker et al. 2003

Courtesy of Willem Dekker

European eel conservation strategy (Council Regulation (EC) No 1100/2007)

National eel management plans:

- *To allow with high probability that the escapement of silver eel to the sea is at least 40% of the best estimate of escapement biomass that would have existed if no anthropogenic influences had impacted the stock.*

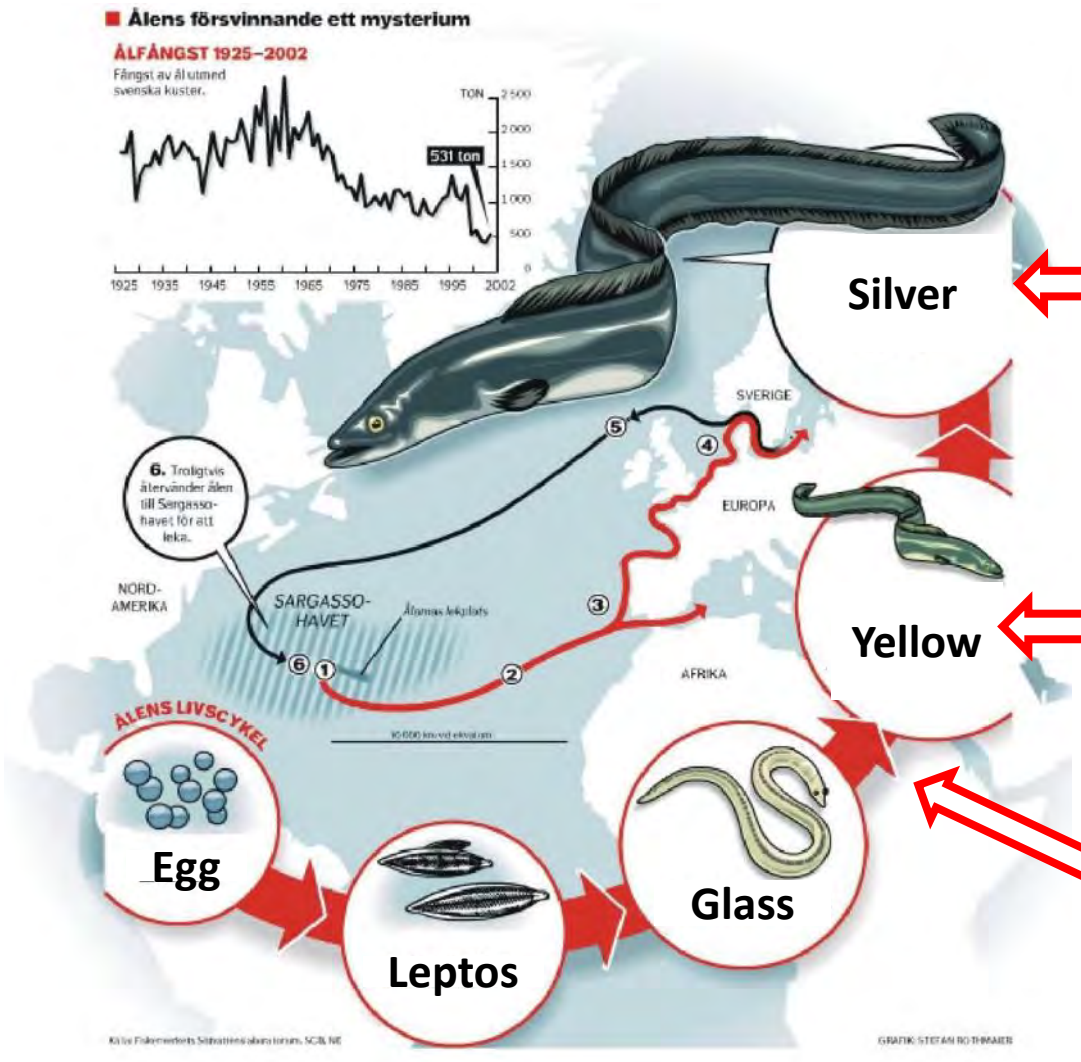
Actions of the Swedish eel management plan (2008):

1) reduction of the fishery
2) increased control measures
3) reduced turbine mortality
4) increase juvenile eel recruitment

Knowledge gaps!

- Downstream passage solutions
- Upstream passage solutions

Swedish eel projects



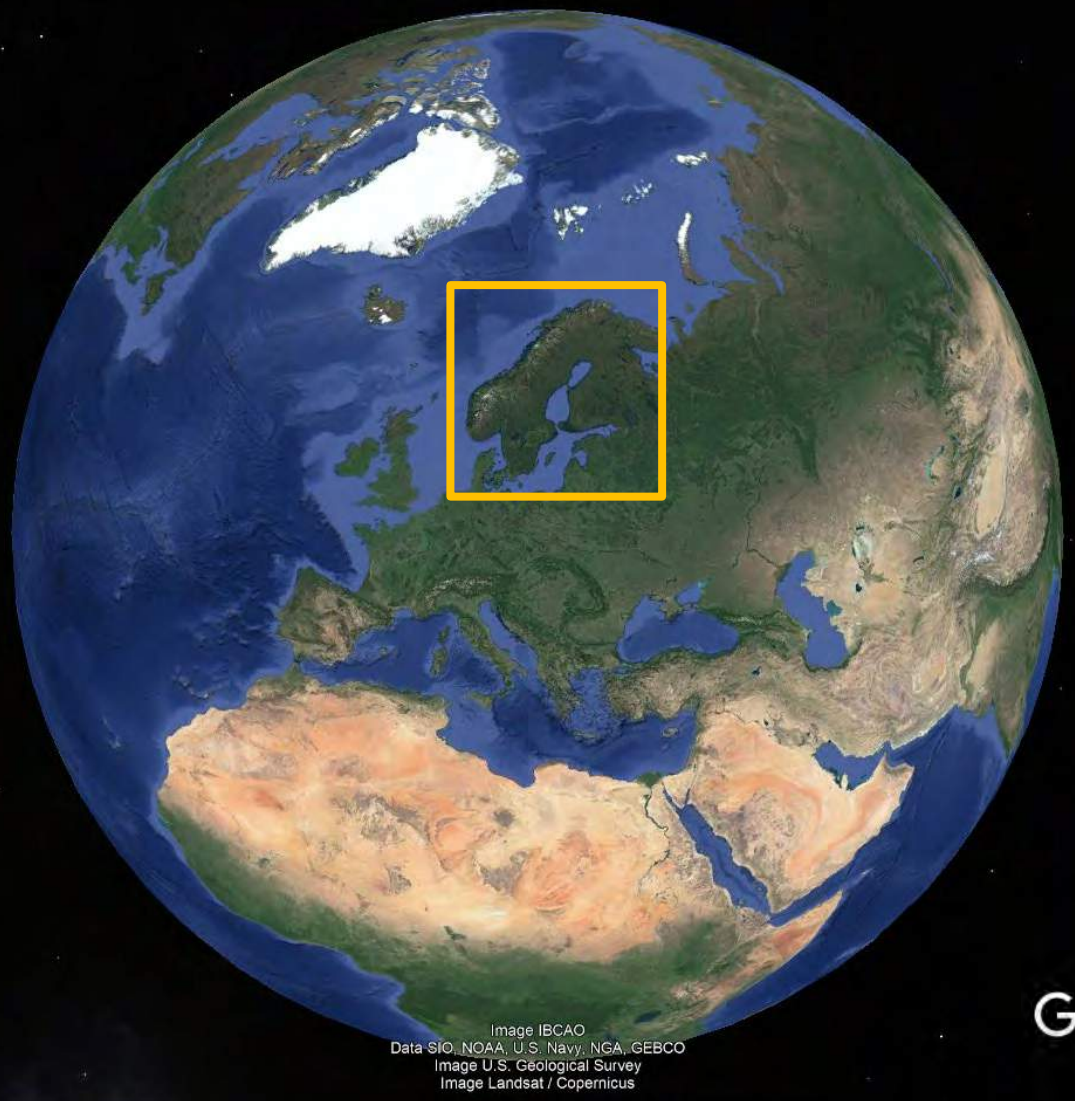
European eel life-cycle

Silver eel downstream passage solutions

Yellow eel foraging, growth & habitat use

Elver upstream passage & habitat use

Sweden → Karlstad → Study area



PROJECT 1

Win-win solutions for hydropower and nature

- Resolving recruitment bottlenecks for the critically endangered European eel

formas

Swedish Agency for Marine and Water Management

Statkraft

uniper

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SLU

KRAFT ÅL TAG

Havs och Vatten myndigheten

VATTENFALL

fortum

HOLMEN

Tekniska verken

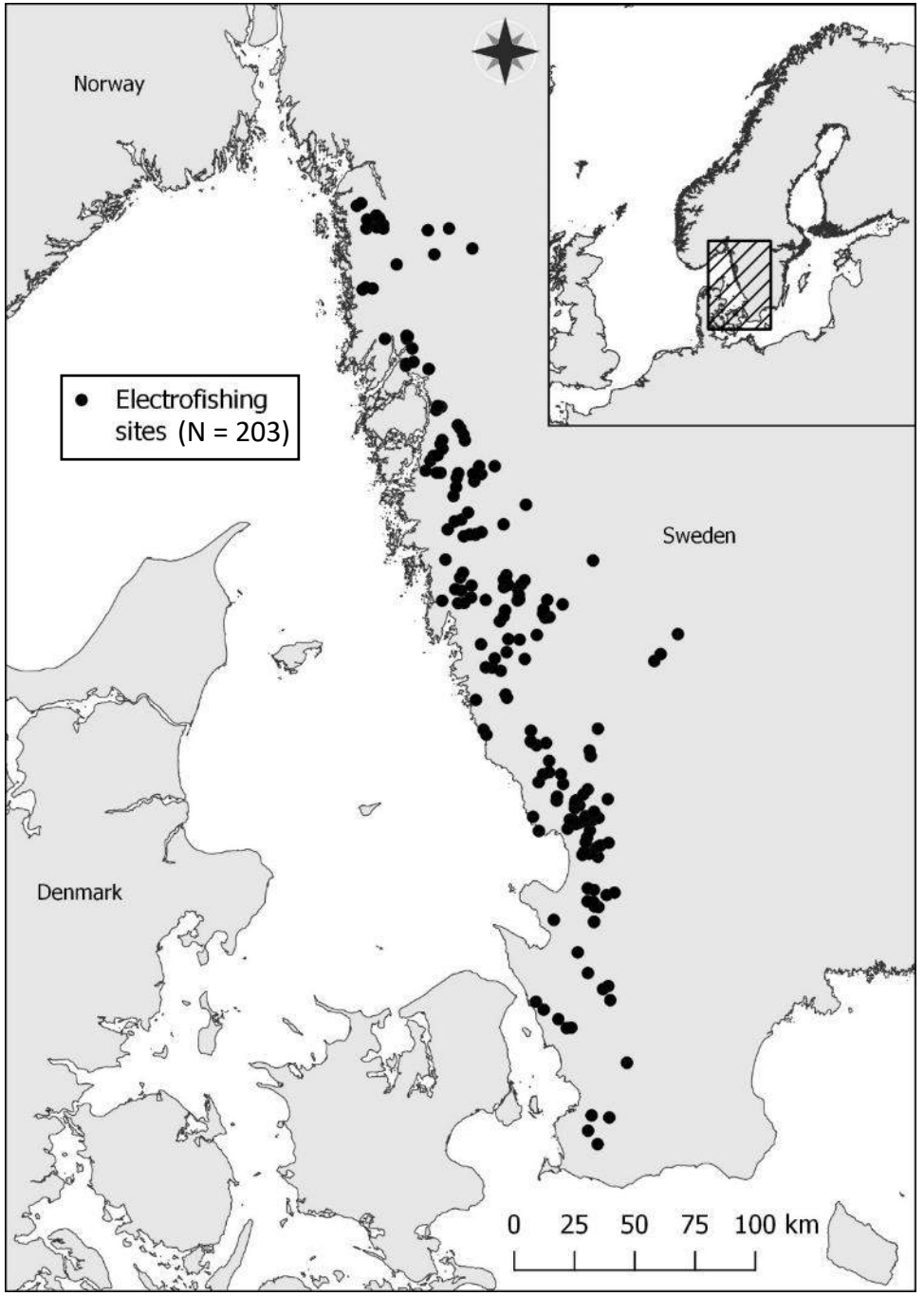
uniper

Statkraft

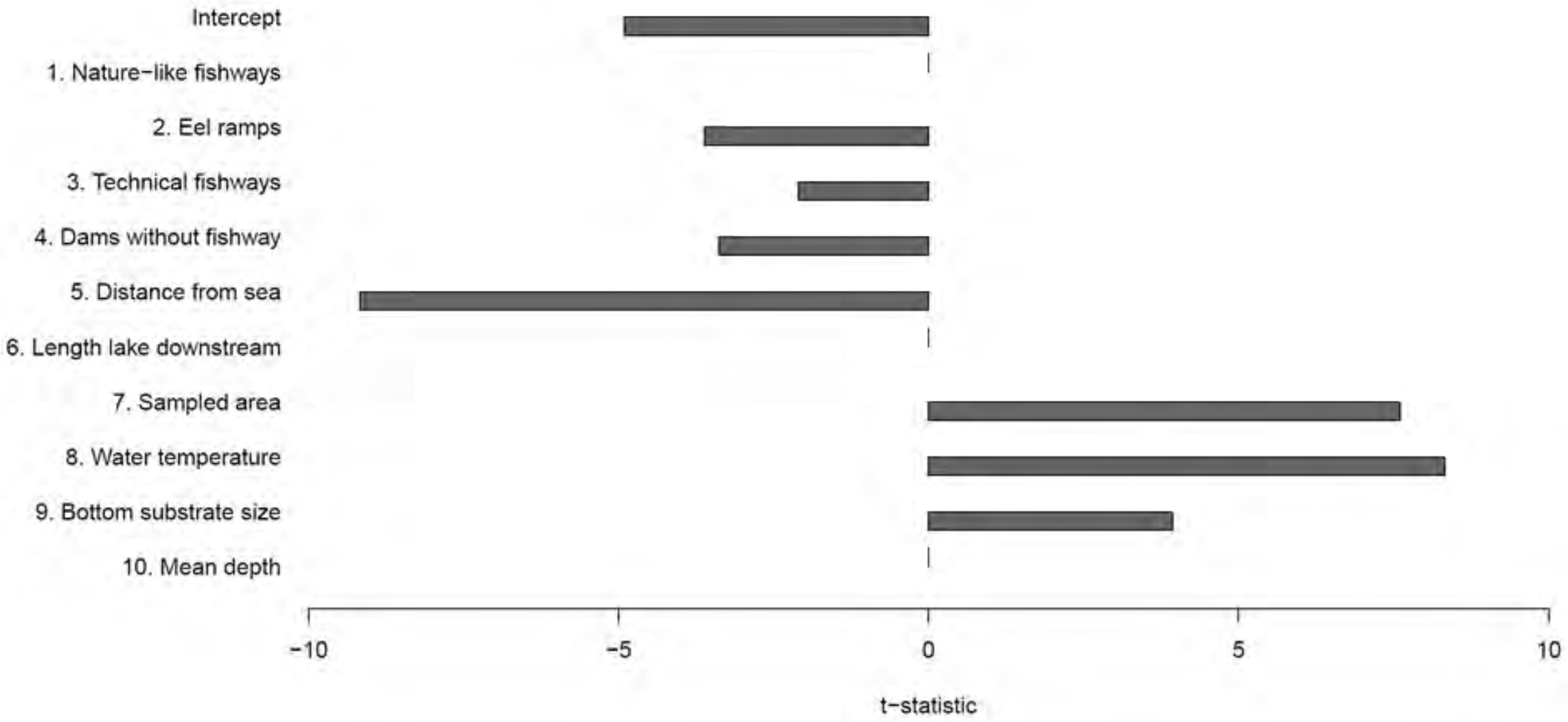
ENERGI

1. Coastal river connectivity

Do the existing upstream fish passage solutions work for juvenile eels?



Tamario et al. 2019 *Aquat. Conserv. Mar. Freshw. Ecosyst.*



Standardized coefficient estimates (t statistics; coefficient estimates divided by the standard deviation of the estimate) received from the initial (light grey) and final (dark grey) generalized linear mixed models. The bars describe the direction and the weight of the effect from each variable on the probability of encountering an eel of ≤300 mm.

Tamario et al. 2019 *Aquat. Conserv. Mar. Freshw. Ecosyst.*

The probability of encountering an eel of ≤ 300 mm upstream an obstacle.

1. Nature−like fishways
2. Eel ramps
3. Technical fishways
4. Dams without fishway

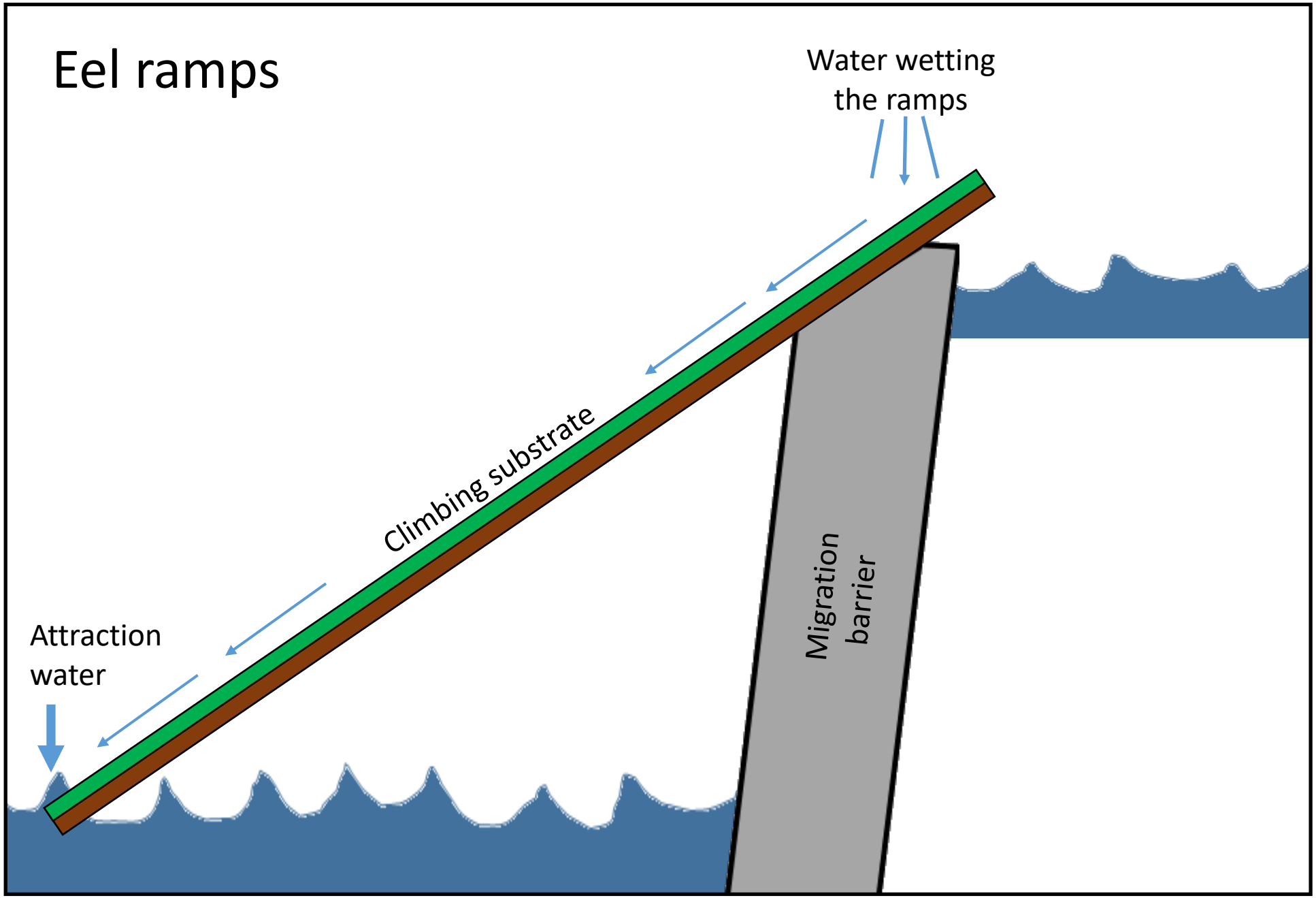
Nature-like

Eel ramp

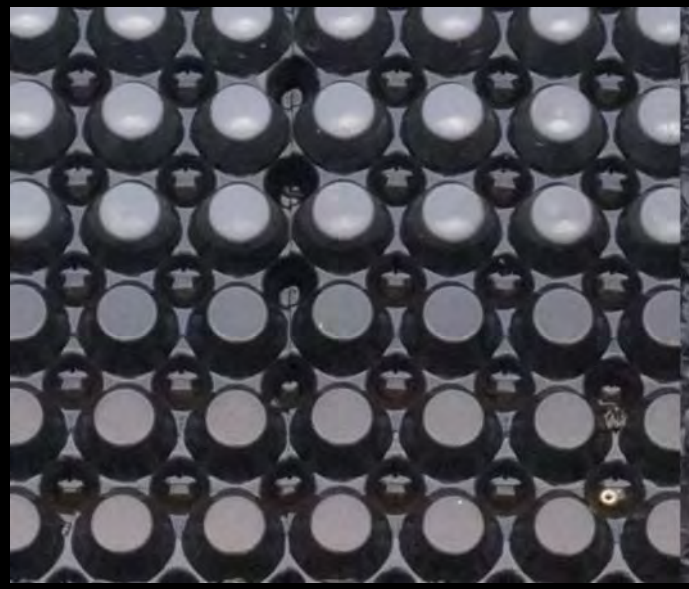
Technical

Tamario et al. 2019 *Aquat. Conserv. Mar. Freshw. Ecosyst.*

2. Eel ramps

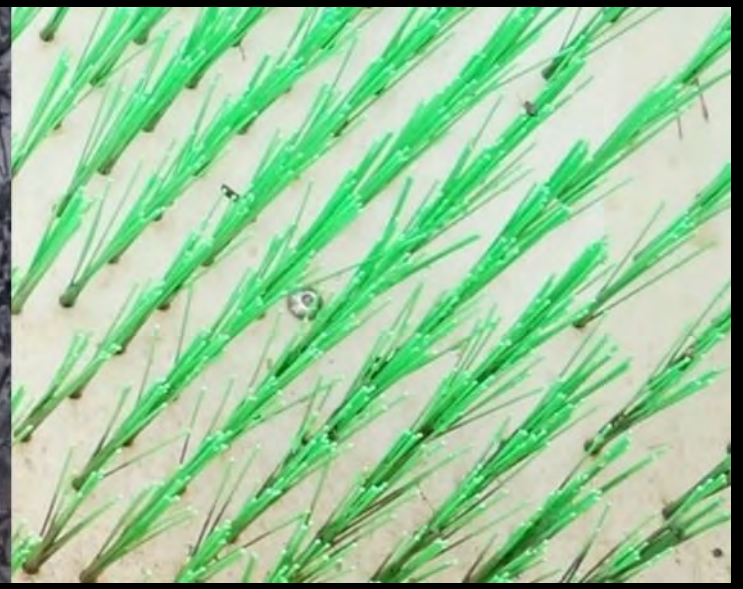

Eel ramps
Water wetting the ramps
Climbing substrate
Migration barrier
Attraction water

Climbing substrate types



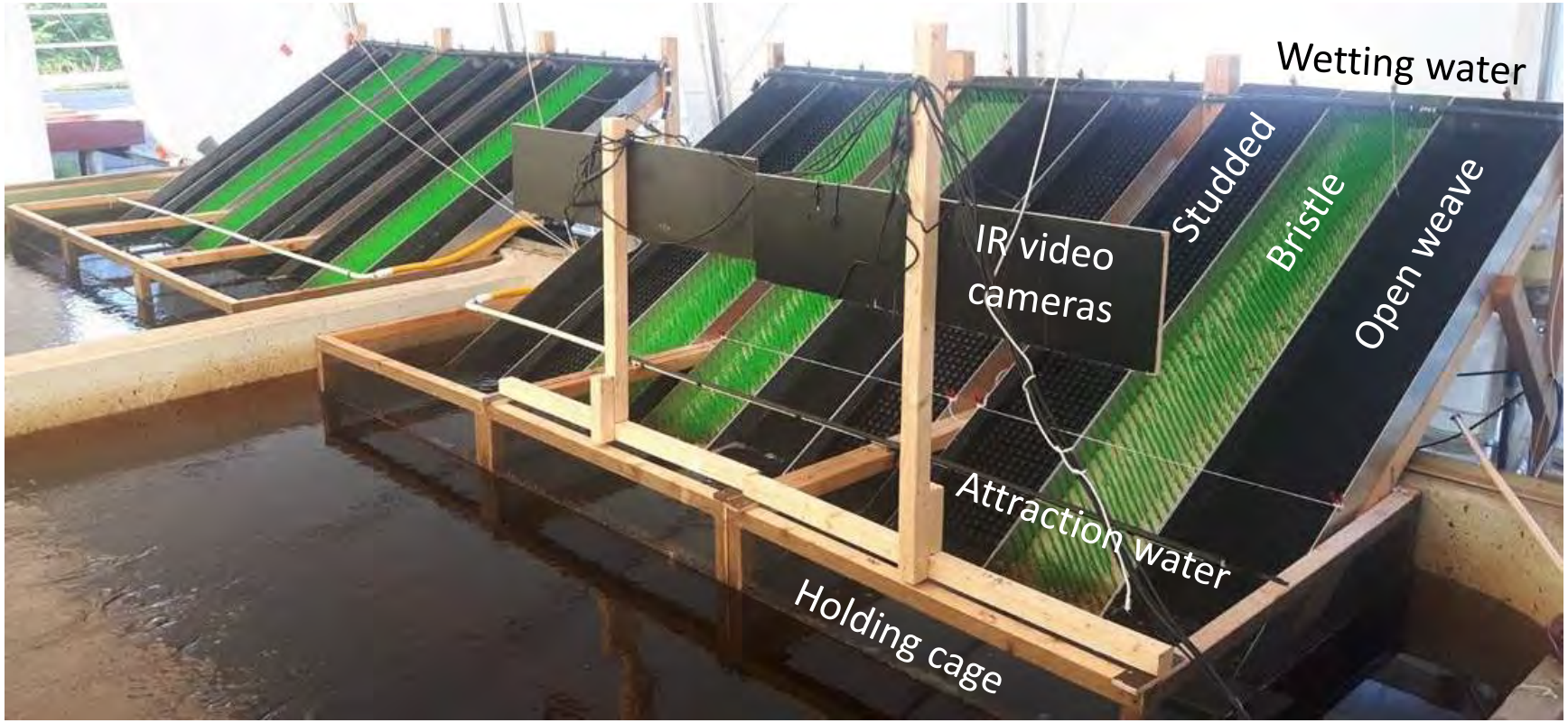
Studded

Open weave



Bristle

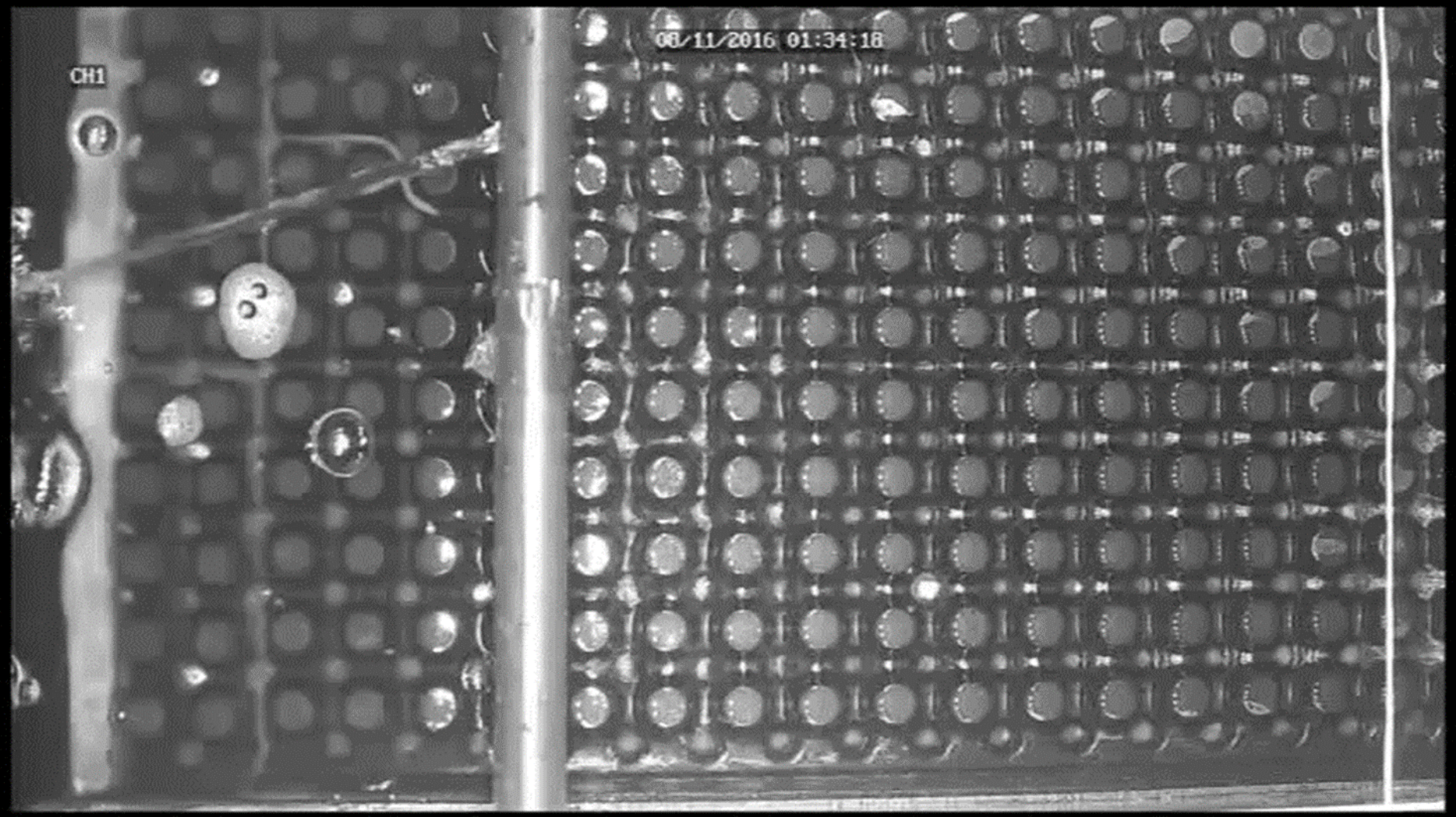
Watz et al. 2019 *Anim. Cons.*



- Substrate selection experiment
- 6 cages with triple ramps
- Over-night trials
- IR-cameras

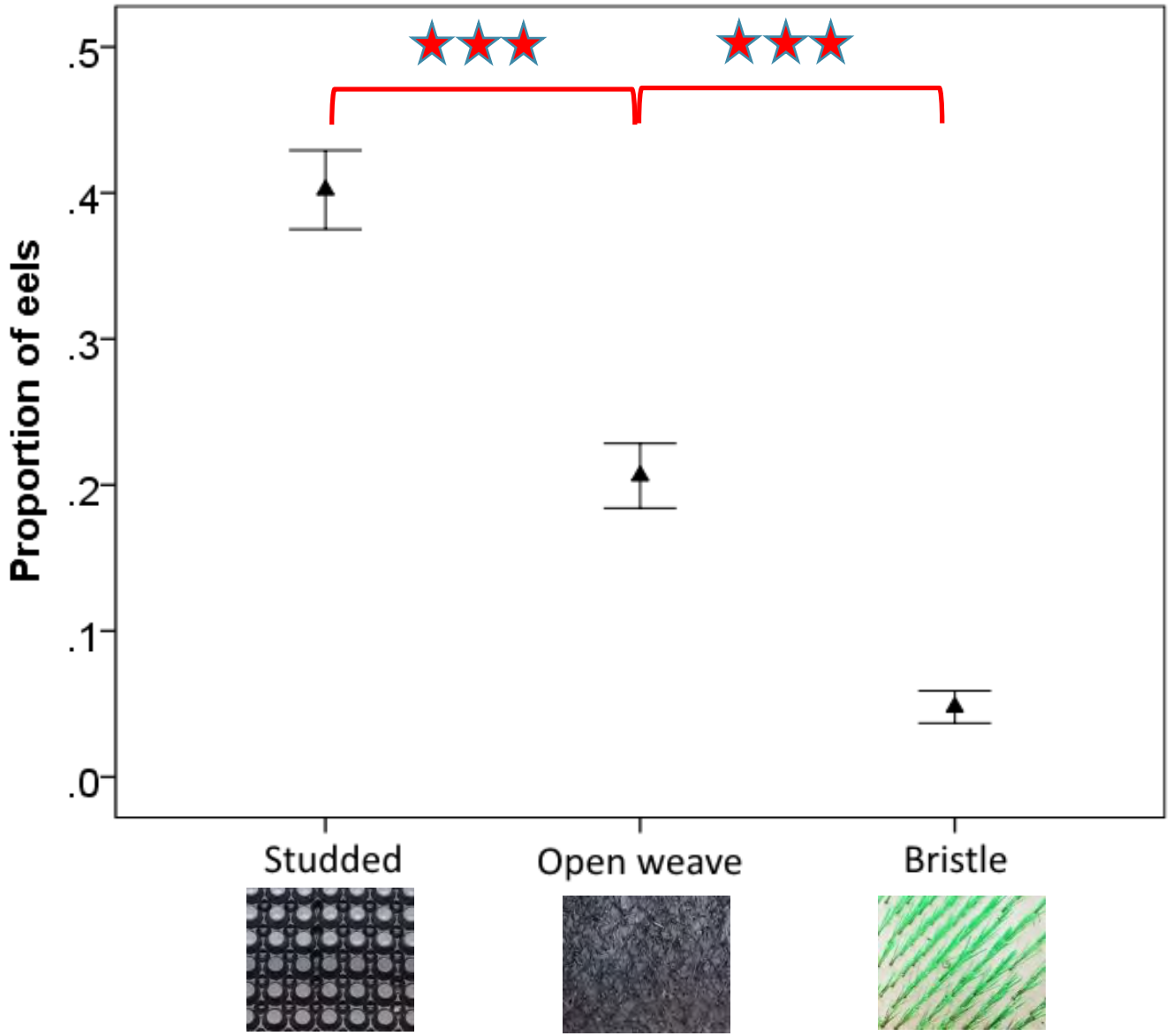
Watz et al. 2019 *Anim. Cons.*

Studded substrate



Watz et al. 2019 *Anim. Cons.*

Which substrate did the eels use?



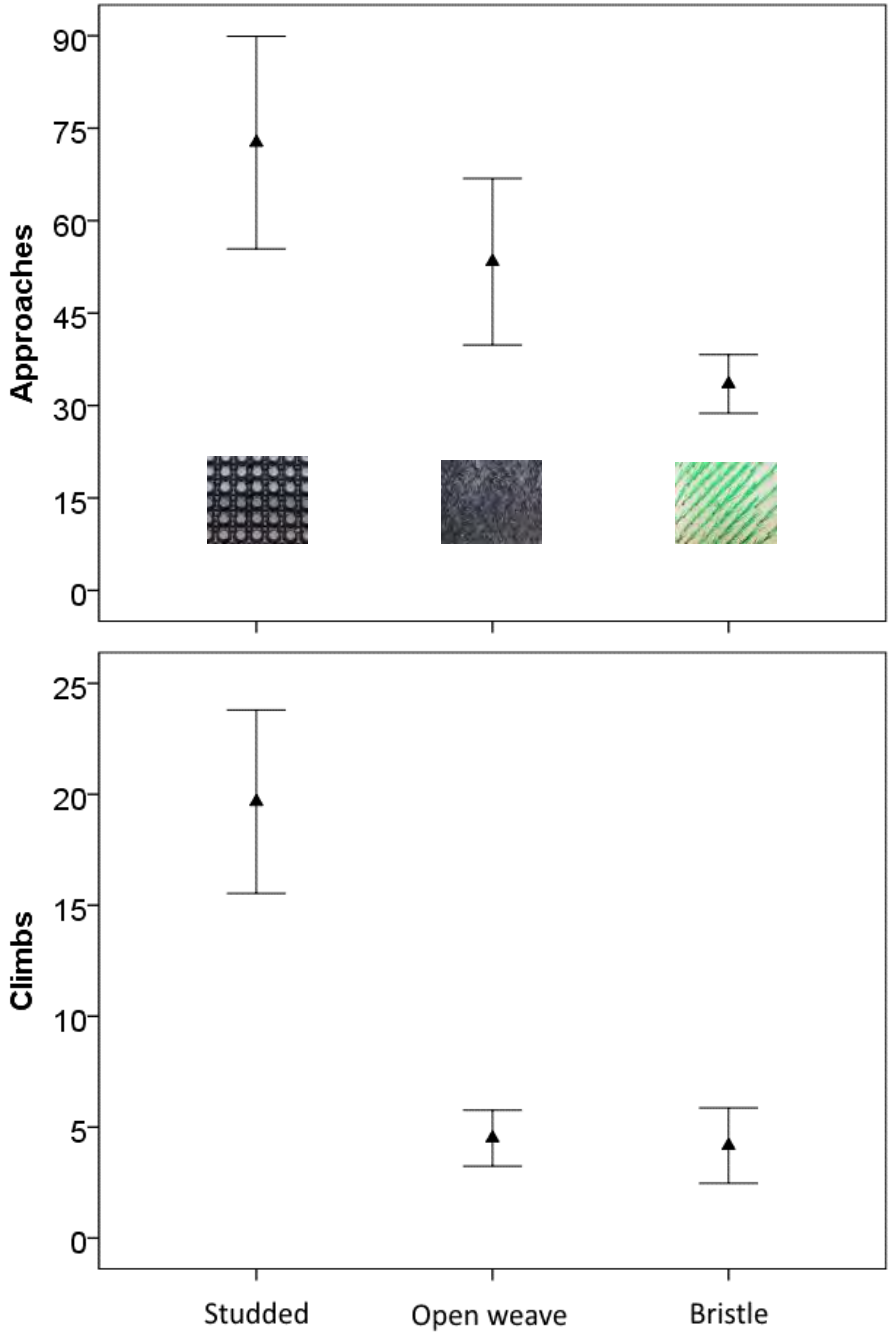
★★★

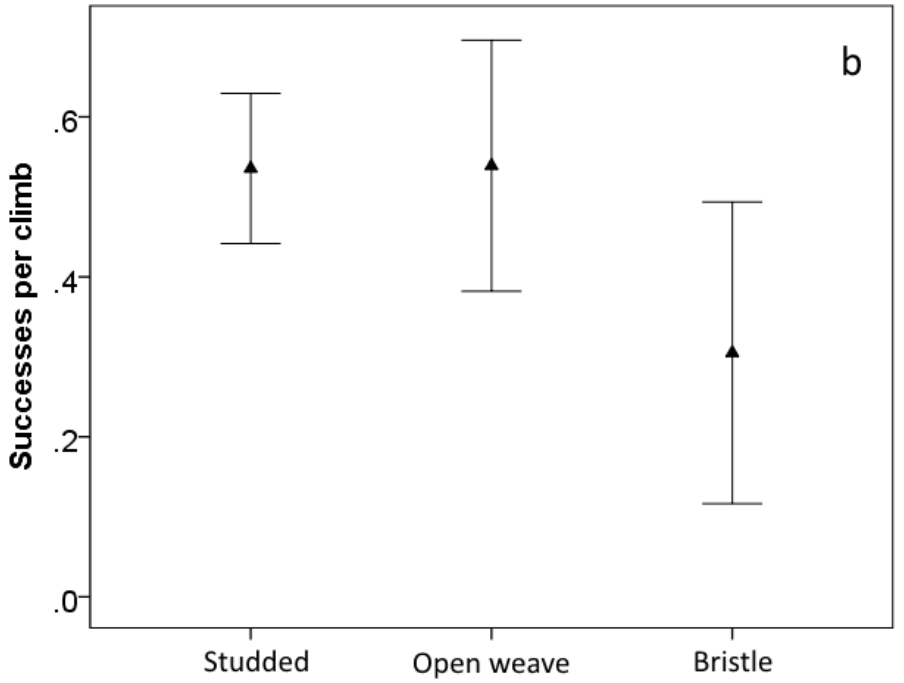
ANOVA

$(F_{2, 134} = 81.0, P < 0.001)$

Watz et al. 2019 *Anim. Cons.*

Why was the studded substrate the most successful one?

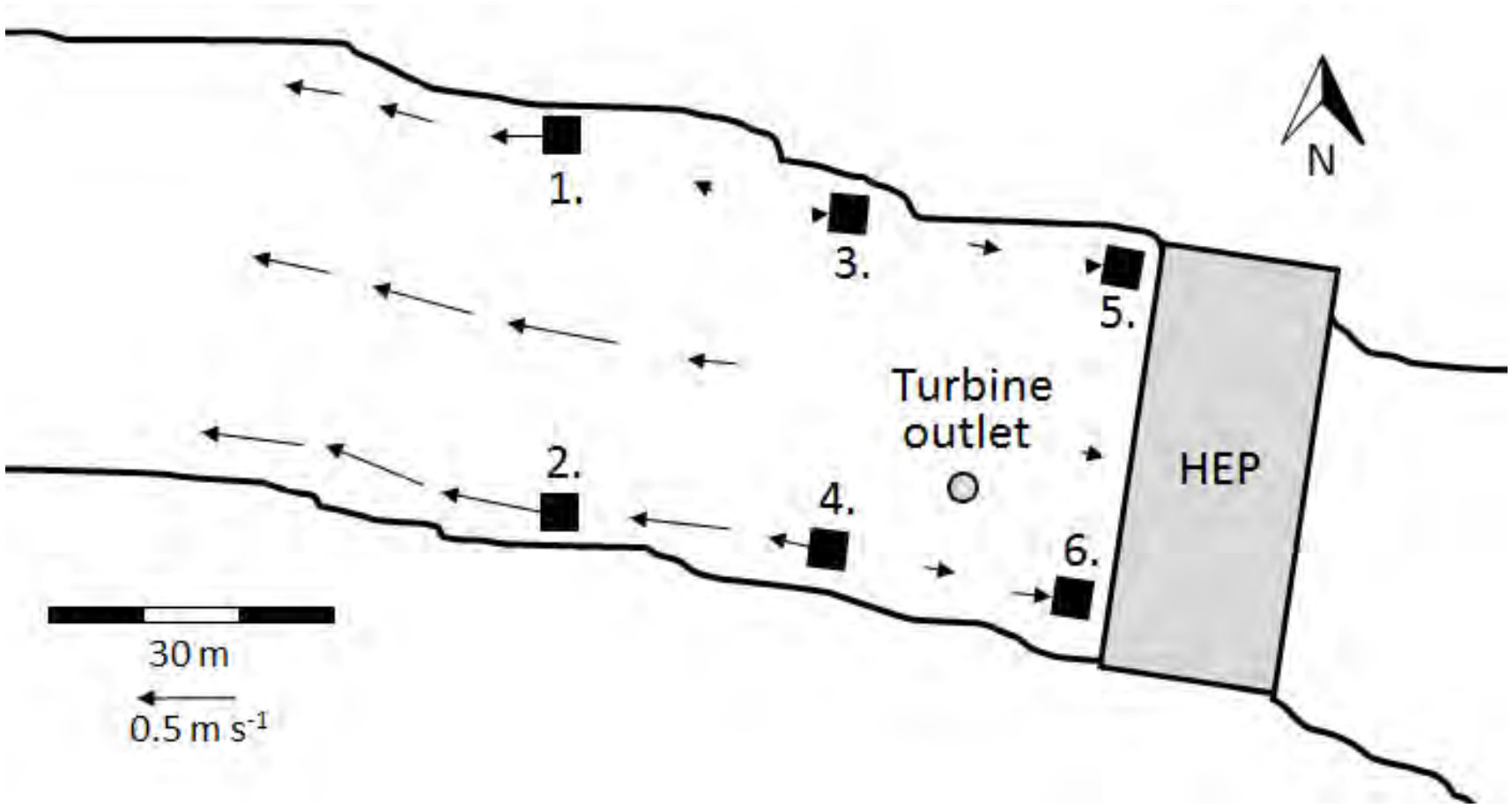




Watz et al. 2019 *Anim. Cons.*


Field validation!

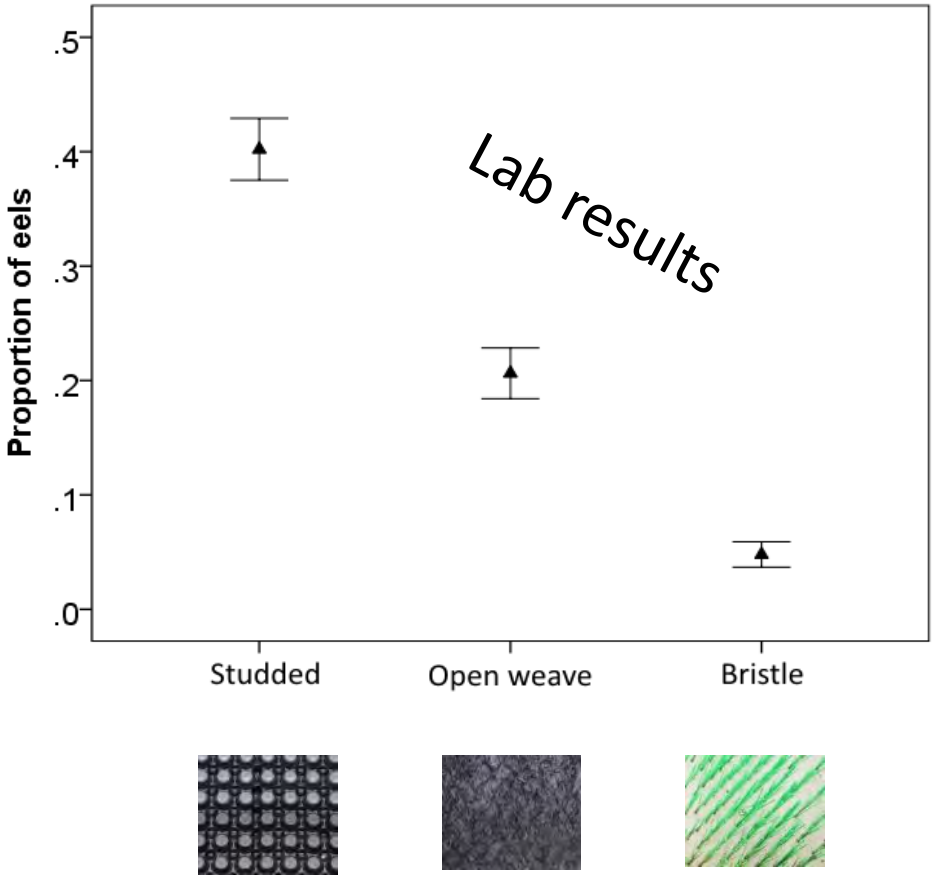
Field validation

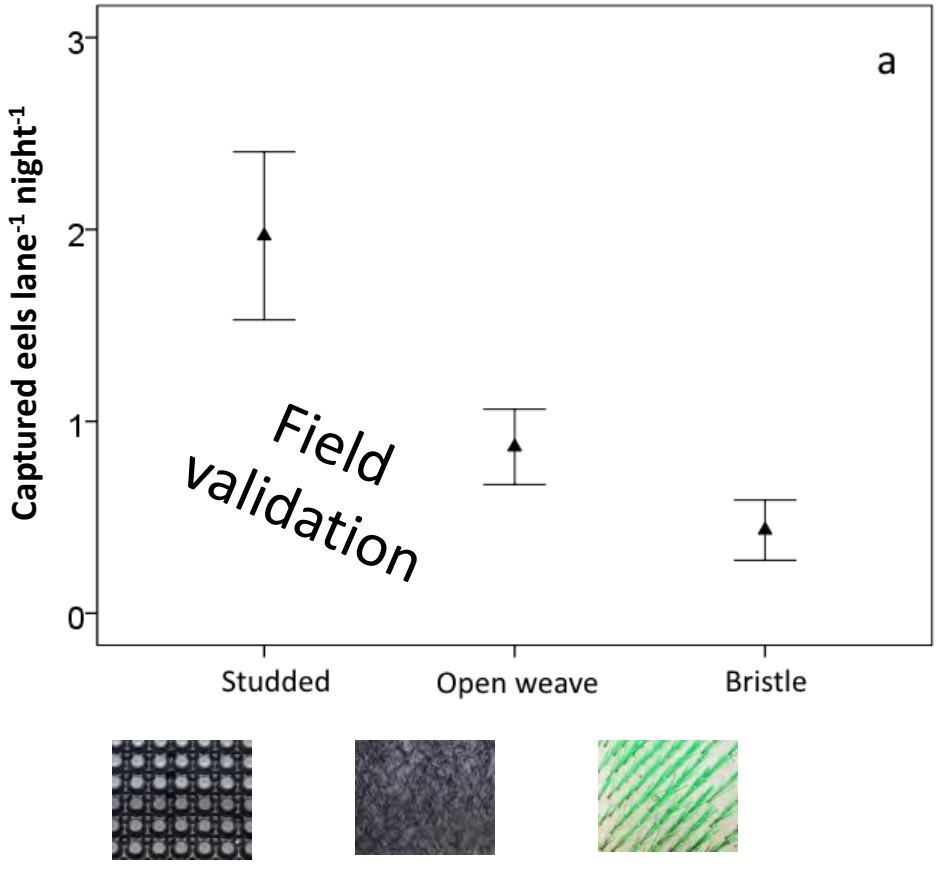


- 6 positions
- 5 nights
- 21:45 – 00:15

Watz et al. 2019 *Anim. Cons.*

Field validation



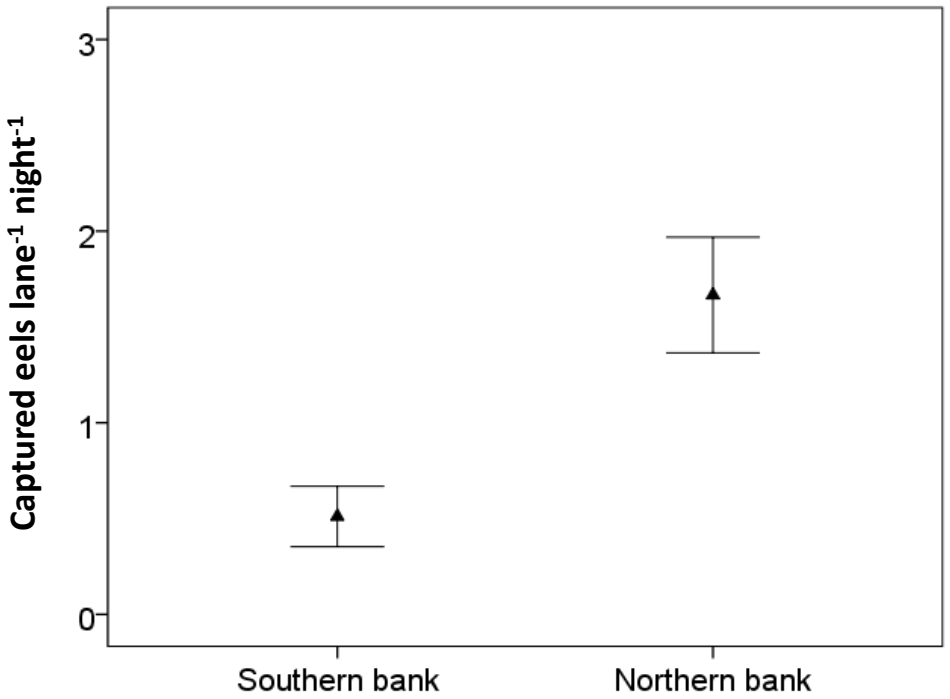


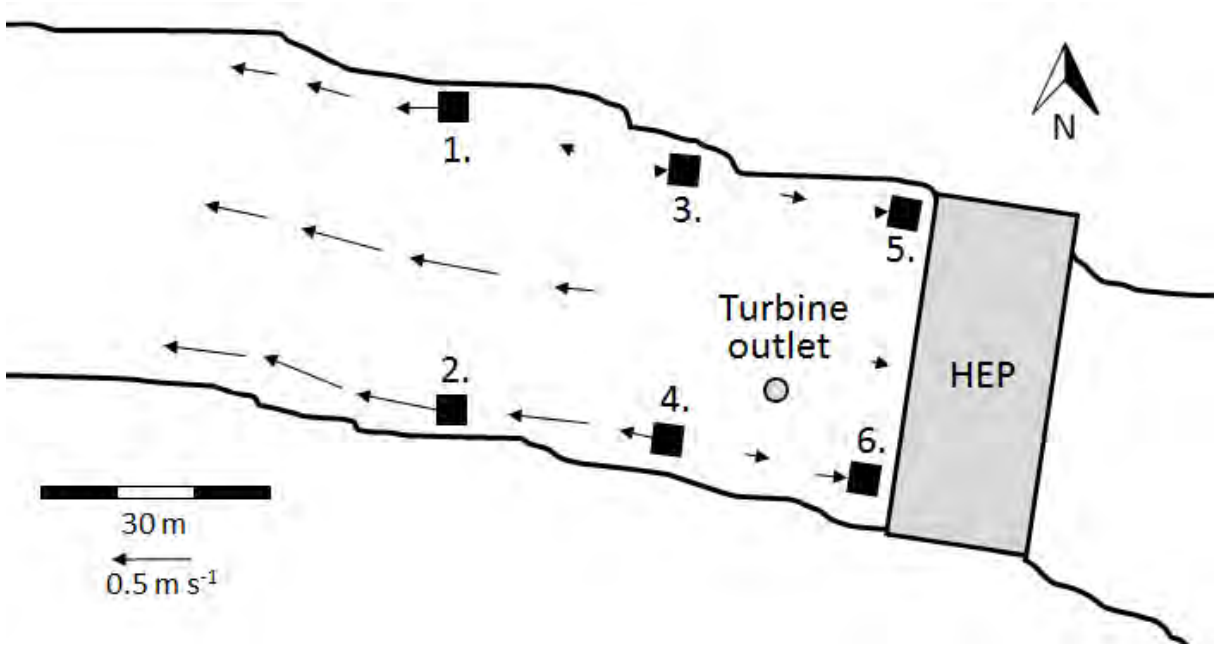
GLM: Substratum

($F_{2, 82} = 15$, $p < 0{,}001$)

Watz et al. 2019 *Anim. Cons.*

Field validation





GLM: North vs. South

($F_{1, 82} = 23.5$, $p < 0{,}001$)

Watz et al. 2019 *Anim. Cons.*

PROJECT 2

The performance of a two-way passage facility for diadromous fish species

The Herting Project 2007-2015

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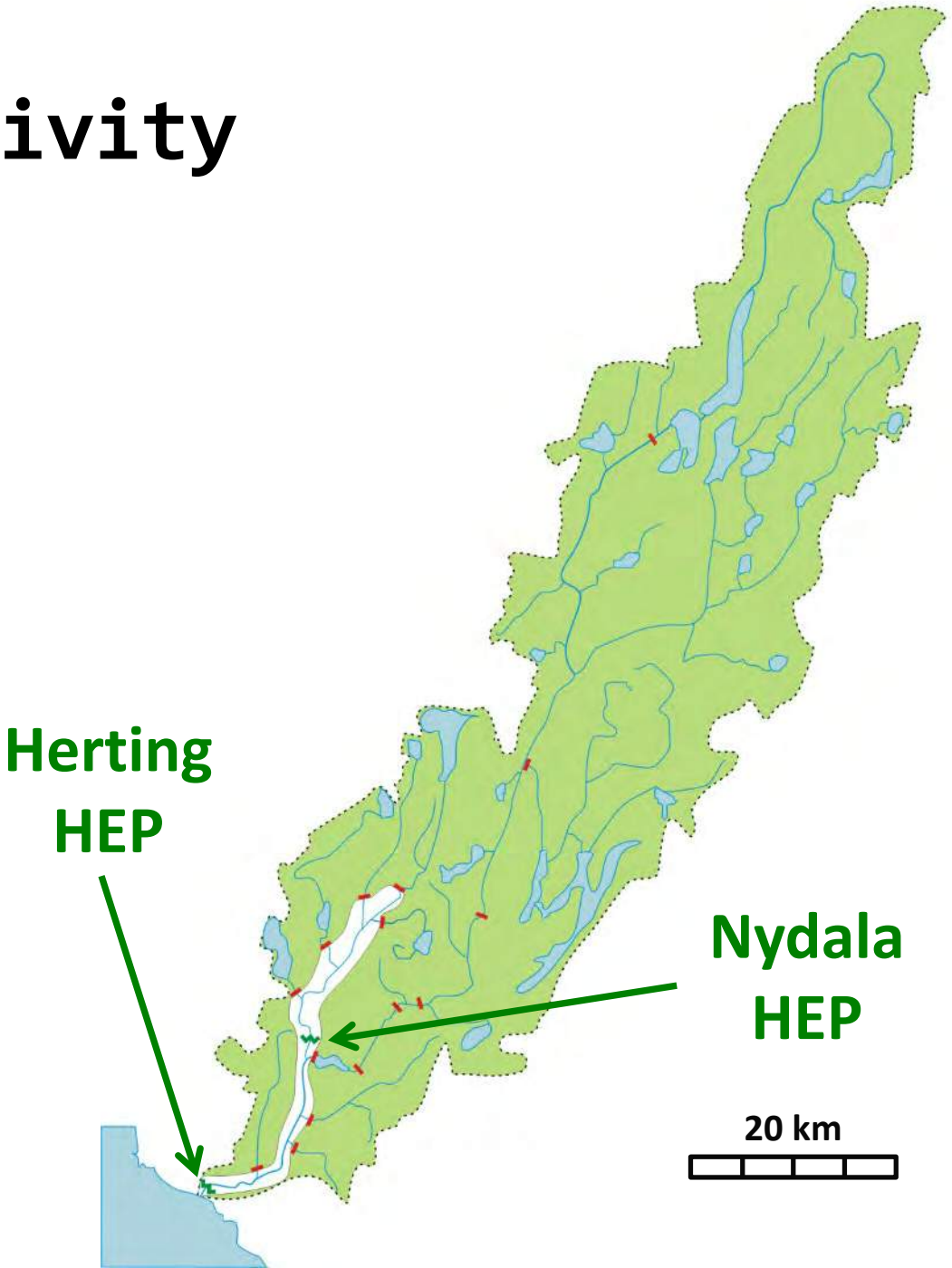
Swedish Agency for Marine and Water Management

River Ätran Connectivity



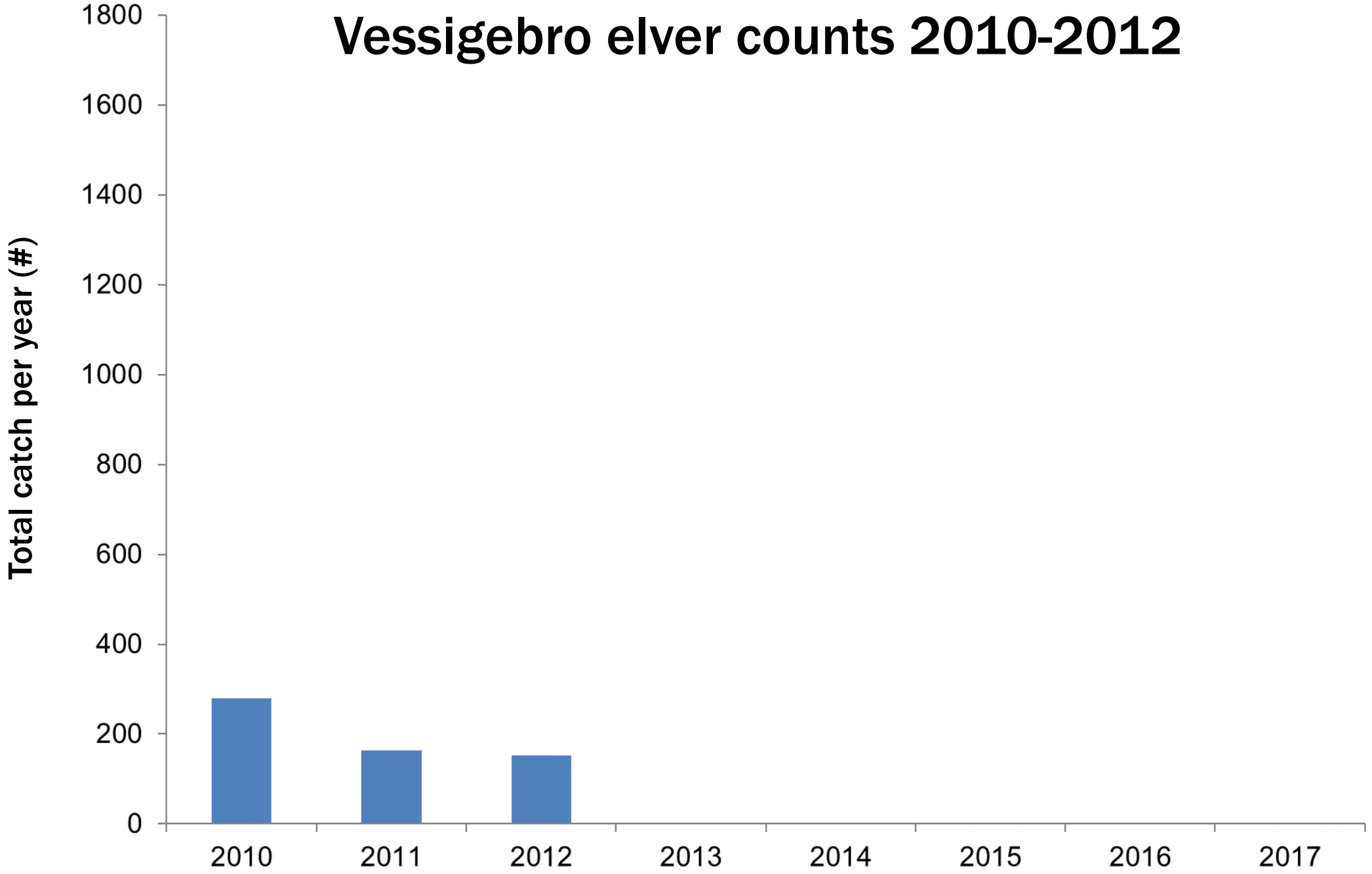
Herting
Before 2013

Herting
Before 2013

H2

H1

Vessigebro elver counts 2010-2012



Herting 2013

Herting
After 2013

Herting
After 2013

Electricity production down by 35%

Downstream passage solution

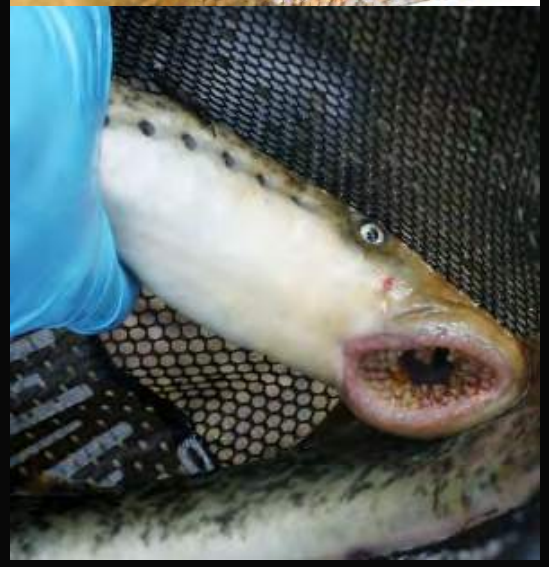
- Conventional rack → Low-sloping rack

Old conventional bar rack

1. Vertical steel bars - 90 mm
2. α = 60°
3. Surface bypass (2.0 cms)

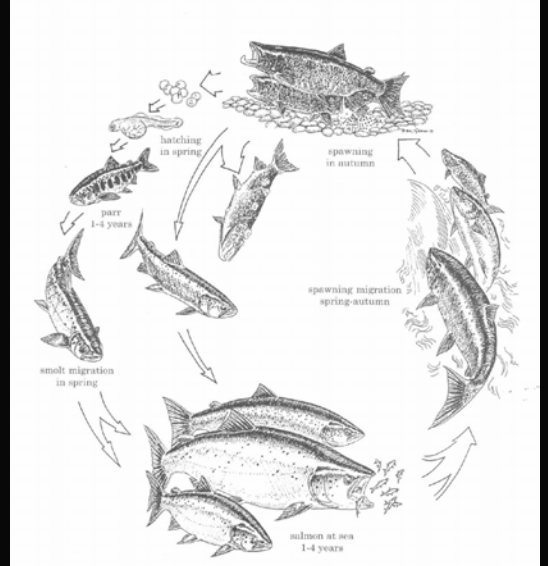
New angled bar rack

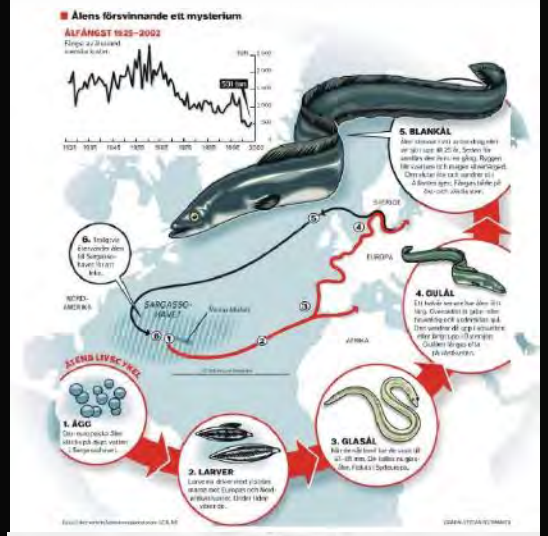
1. Horizontal composite bars - 15 mm
2. β = 30°
3. Full-depth bypass (0.3-3.0 cms)

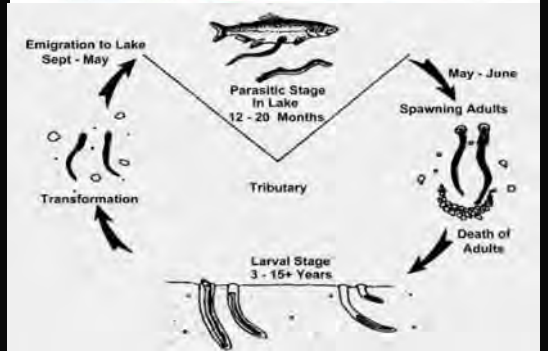


The project goals

- Strengthen diadromous fish populations:
  - Atlantic salmon
  - European eel
  - Sea lamprey







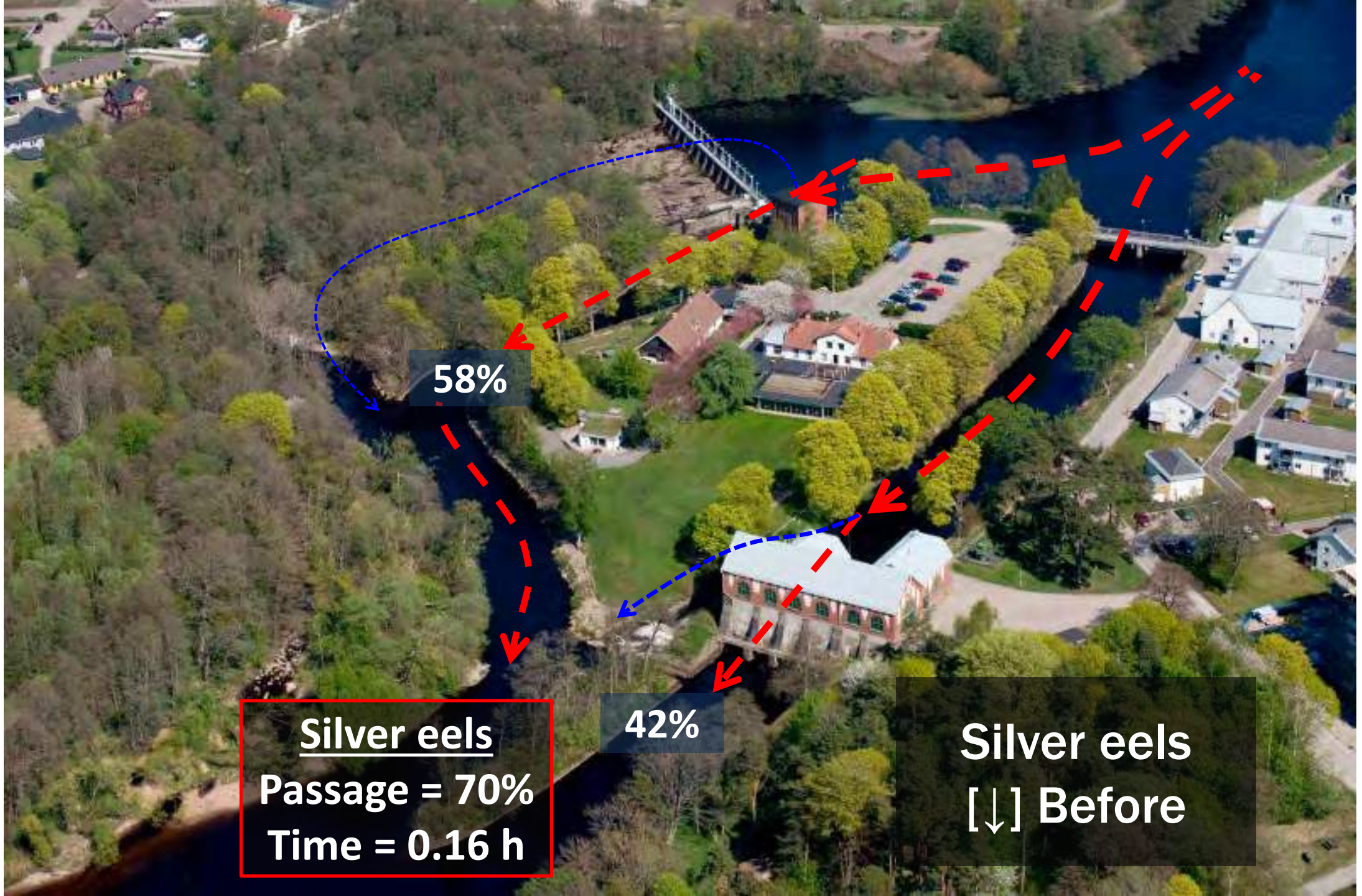
The project goals

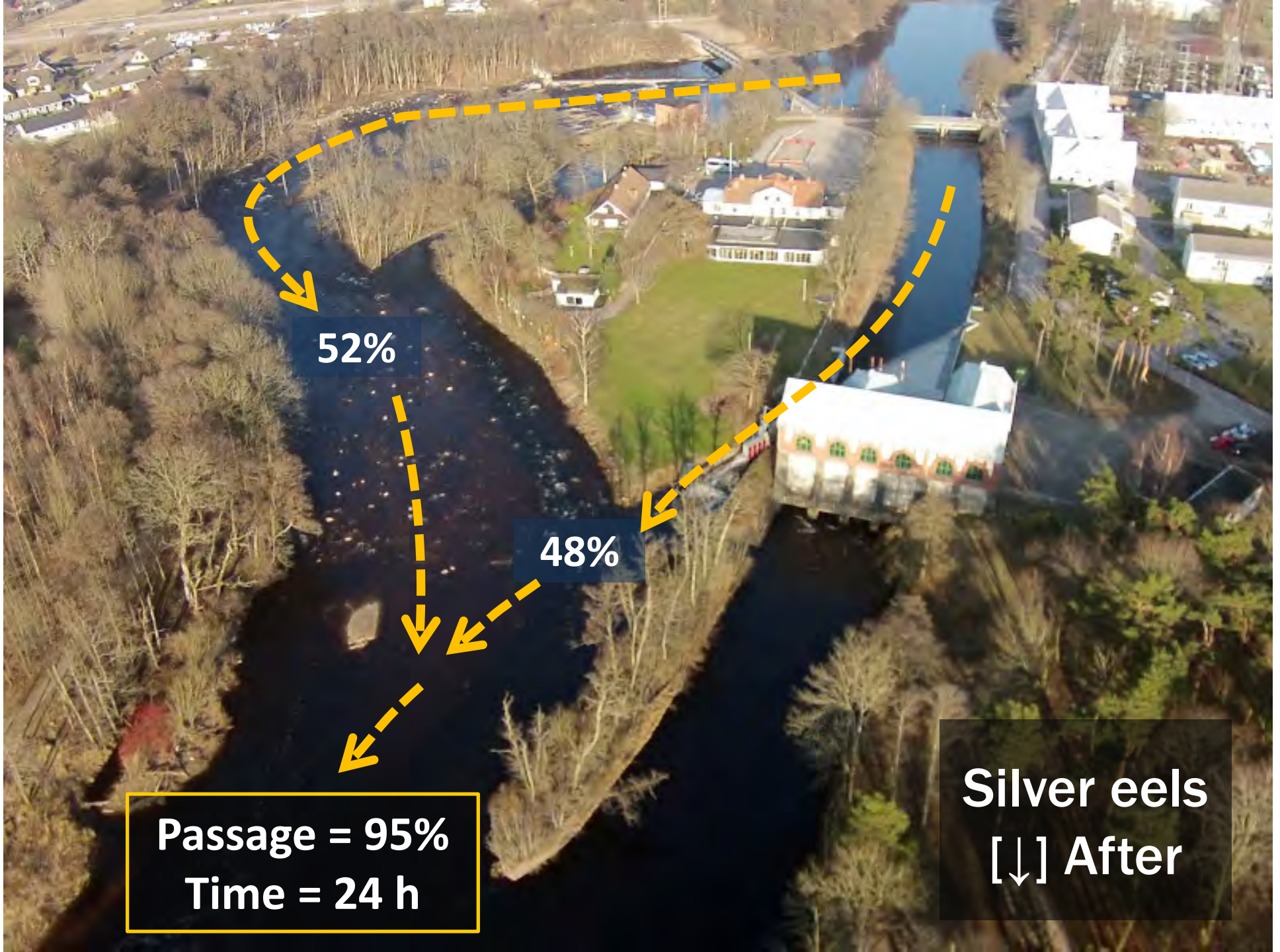
- Strengthen diadromous fish populations:
  - Atlantic salmon
  - European eel
  - Sea lamprey

  …with contrasting life-cycles and behavior
- Evaluation of Fish Passage Solutions, before and after modifications, by quantifying:
  - Passage efficiency (rate)
  - Fish Guidance Efficiency (FGE)
  - Passage time (delay)

Methods

Silver eel results





Herting survival (IPE)

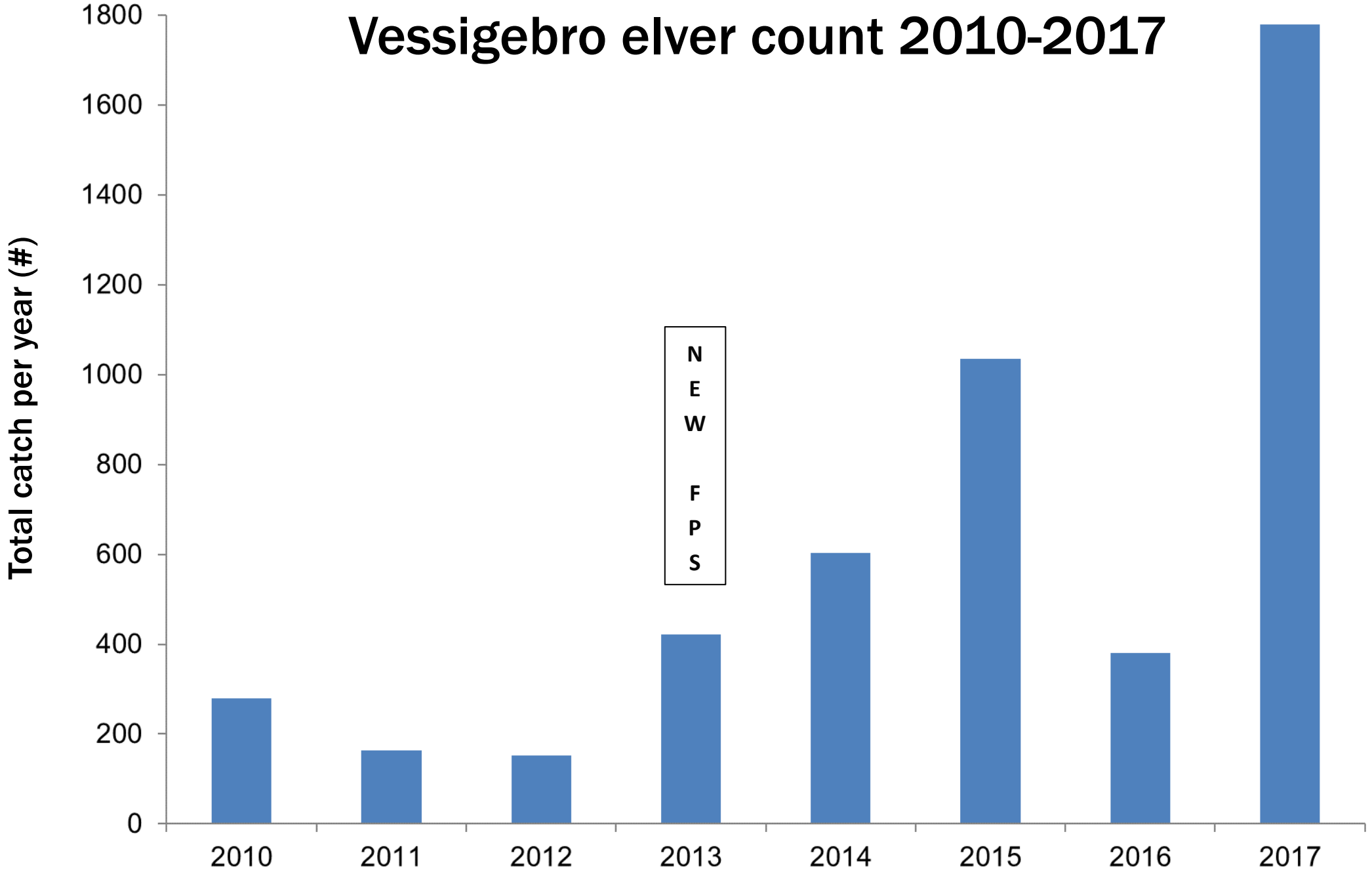
- ✓ Salmon kelts
  - S Before: 33-80%
  - S **After: 96%**
- ✓ Salmon smolts
  - T Before: 90%
  - S **After: 91%**
- ✓ European silver eels
  - T Before: 70%
  - S **After: 95-100%**

Info Herting

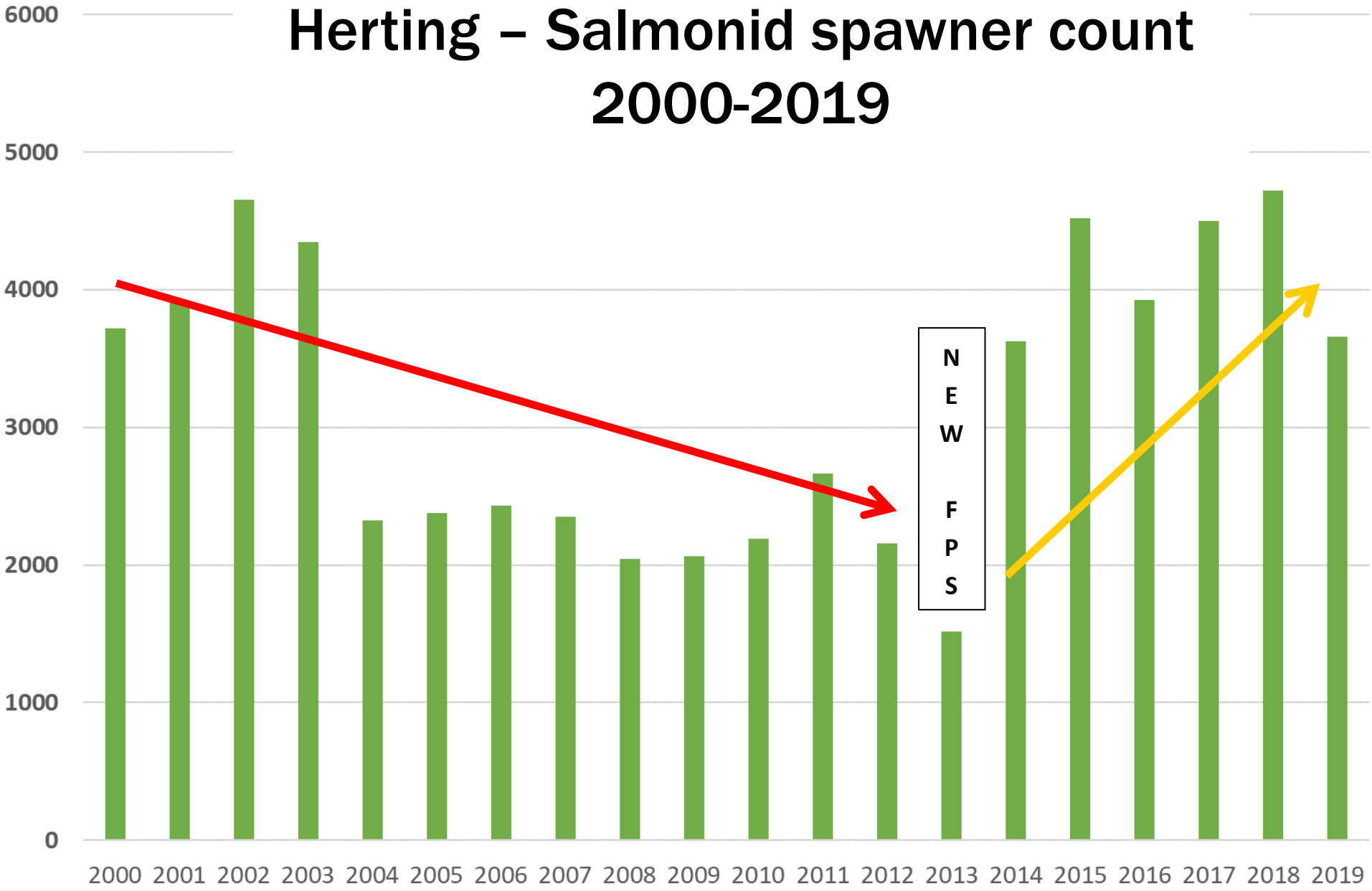
- ✓ Falkenberg Energi
- ✓ 40 m^3/s
- ✓ **15 mm**
- ✓ **β_H = 30˚**
- ✓ 1 entrance (FD)
- ✓ 0.3-2 m^3/s (1-5%)
- ✓ Passage facility

Nyqvist *et al*. 2017. *Ecol. Engin.*
Nyqvist *et al.* 2018. *Mar. FW Res*.
Calles *et al.* 2012. *Ecol. Engin.*
Calles *et al.* 2013. *FW Biology*.

Vessigebro elver count 2010-2017



Herting – Salmonid spawner count 2000-2019



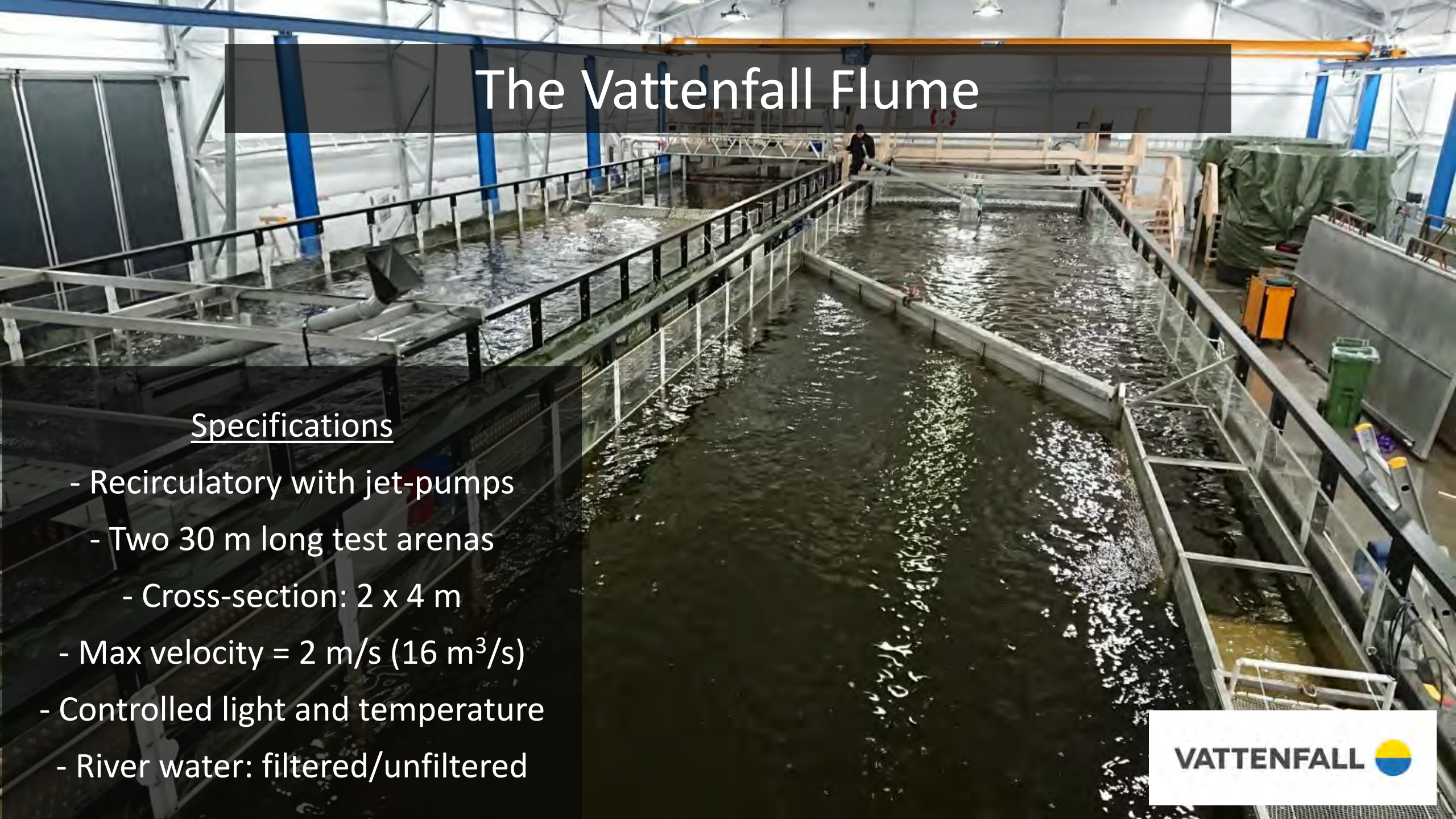
Unwanted guests

PROJECT 3

Racks & the importance of bar spacing & phenotypic diversity for fish passage

Photo: Jörgen Wiklund

The Vattenfall Flume



Specifications

- Recirculatory with jet-pumps
- Two 30 m long test arenas
- Cross-section: 2 x 4 m
- Max velocity = 2 m/s (16 m^3/s)
- Controlled light and temperature
- River water: filtered/unfiltered

VATTENFALL

Eel projects take home message

1. Elver upstream passage & habitat use
    1. Nature-like fishways most efficient FPS
    2. Eel ramps hold potential: optimize design and placement
2. Silver eel downstream passage solutions
    1. Inclined & angled racks offer efficient & timely passage + maintained electricity generation
    2. Individual variation poorly understood: mechanisms & population effects

15 PhD students on fish and hydropower

River flow regulation, fish behaviour & status

- WP1 – Fish stress & behaviour
- WP2 – Fish hydrodynamics
- WP3 – Tools & technologies
- WP4 – Fish management solutions

2020-2023

This project has received funding from the European Union Horizon 2020 Research and Innovation Programme under the Marie Sklodowska-Curie Actions, Grant Agreement No. 860800

Thanks for your attention!

Fiskevårdsteknik AB

Havs och Vatten myndigheten

uni per

SLU

formas

KK-stiftelsen

Naturskyddsföreningen

Norconsult

R2 Resource Consultants, Inc.

Energiforsk

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Statkraft

KRAFT TAG ÅL

Havs och Vatten myndigheten
VATTENFALL
fortum
HOLMEN
Tekniska verken
uni per
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ENERGI

Juvenile eel bottleneck papers

- Tamario, C., Calles, O., Watz, J., Nilsson. P.A. and Degerman, E. (2019). Coastal river connectivity and the distribution of ascending juvenile European eel (Anguilla anguilla L.) – implications for conservation strategies regarding fish passage solutions. *Aquatic Conservation: Marine and Freshwater Ecosystems*. **29:** 612-622.
- Watz, J., Nilsson. P.A., Degerman, E., Tamario, C. and Calles, O. (2019). Climbing the ladder: an evaluation of three different anguillid eel climbing substrata and placement of upstream passage solutions at migration barriers. *Animal conservation*. **22**:452-462.
- Degerman, E., Tamario, C., Watz, J., Nilsson. P.A., and Calles, O. (2019). Occurrence and habitat use of European eel (Anguilla anguilla) in running waters: lessons for improved monitoring, habitat restoration and stocking. *Aquatic Ecology. **53**: 639–650.*
- Nilsson. P.A., Pettersson, I.J., Tamario, C., Degerman, E., Elghagen, J., Watz, J. and Calles, O. (In review). Substrate-size preference in European eel *Anguilla anguilla* elvers is not altered by piscivore chemical cues. *Journal of Fish Biology.*

River Ätran fish passage papers

- Nyqvist D, Elghagen J, Heiss M, Calles O. (2018). An angled rack with a bypass and a nature-like fishway pass Atlantic salmon smolts downstream at a hydropower dam. *Marine and Freshwater Research*. **69**: 1894–1904.
- Nyqvist, D., Nilsson, P.A., Alenäs, I., Elghagen, J., Hebrand, M., Karlsson, S. Kläppe, S. & Calles, O. (2017). Upstream and downstream passage of migrating adult Atlantic salmon: Remedial measures improve passage performance at a hydropower dam. *Ecological Engineering*. **102**: 331-343.
- Calles, O., Karlsson, S., Vezza, P., Comoglio, C. and Tielman, J. (*2013*) Success of a low-sloping rack for improving downstream passage of silver eels at a hydroelectric plant. *Freshwater Biology*. 58, 2168-2179.
- Calles O, Karlsson S, Hebrand M, Comoglio C. 2012. Evaluating technical improvements for downstream migrating diadromous fish at a hydroelectric plant. *Ecological Engineering*. 48: Sid. 30-37.
- Calles, O., Olsson, I.C., Comoglio, C., Kemp, P., Blunden, L., Schmitz, M. & Greenberg, L.A. (2010) Size-dependent mortality of migratory silver eels at a hydropower plant, and implications for escapement to the sea. *Freshwater Biology*, 55, 2167-2180.

Bar rack experiment papers

- Carlsson, N. (2019). Låglutande galler och betydelsen av spaltvidd för passageeffektivitet och beteende av nedströmsvandrande Europeisk ål (*Anguilla anguilla*) Masteruppsats, Karlstads universitet.
- Szabo-Meszarosa, M., Navaratnama, C.U., Aberle, J., Silva, A.T., Forseth, T., Calles, O., Fjeldstad, H-P. and Alfredsen, K. (2018). Experimental hydraulics on fish-friendly trash-racks: an ecological approach. *Ecological Engineering*. **113**: 11-20.
- Russon, I.J., Kemp, P.S. & Calles, O. (2010) Response of downstream migrating adult European eels (*Anguilla anguilla*) to bar racks under experimental conditions. *Ecology of Freshwater Fish*, 19, 197-205.