The role of re-stocking eels as a recovery measure

Dr. Janek Simon, Erik Fladung and Dr. Uwe Brämick
Institute of Inland Fisheries e.V., Potsdam-Sacrow, Germany
Re-stocking is essential

River regulation detains glass eels from their upstream migration

About 55,000 migration obstacles (dams, weirs) exist in Germany (Anonymous 2008)
Objective
Increase silver eel escapement and sustain eel fishery

<table>
<thead>
<tr>
<th>Funding</th>
<th>Re-stocking volume</th>
<th>Re-stocking value</th>
<th>(2006 – 2013)</th>
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<tbody>
<tr>
<td>50% EFF, 25% federal funds, 25% fishermen/angler</td>
<td>&gt;7 MIII. €</td>
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<tr>
<td>35 MIII. glass- &amp; farm sourced eel</td>
<td>&gt;7 MIII. €</td>
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Pilot project on eel stock enhancement in the Federal State of Brandenburg
Elbe River system:
- 56,300 ha water surface area
- Mean discharge: 103 m³/s
- Current velocity: 0.1 m/s
- > 250 weirs

Havel River system:
- 56,300 ha water surface area

Study area:
- North Sea
- Elbe
- Berlin
- Hamburg
Recruitment – Natural Recruitment

- Stainless steel trap (4 mm #)
- Operated from May to October over 5 years
- Number and total body length of trapped eel
• official re-stocking statistics
• samples at re-stocking events since 2006
96 – 98% of the respective total annual recruitment are re-stocked eels.
Age and growth

Method after Simon (2015)

Sagittal otoliths

Growth back calculation

von Bertalanffy function (Francis 1990)

\[ L_t = L_0 e^{k(t - t_0)} \]

Male: \[ L_t = 473(1 - e^{-0.143(t + 0.931)}) \]
Female: \[ L_t = 1,110(1 - e^{-0.064(t + 1.149)}) \]
Coded wire tags (CWT)

Marking glass eels

Farmed eels

Alizarin red S

Oxytetracyclin hydrochloride

Study to comparing growth and survival of glass and farm sourced eel (Simon et al. 2013, Simon & Dörner 2014):

• 7 isolated lakes
  • lakes were consecutively re-stocked with marked cohorts
  • monitoring with fyke nets and electro fishing for 7 years
Comparison based on mean eel growth and a mean water temperature of 11.7°C

Comparison of estimates of cumulated mortality of re-stocked eels and calculated cumulated mortality percentage from Bevacqua et al. (2011) for the Havel River system.

Natural mortality vs. Age (Years)

Cummulated mortality (%)

- Low density
- Medium density
- High density
- Glass eels
- Farm sourced eels

Cumulated mortality from Bevacqua et al. (2011) for the Havel River system comparison of estimates of cumulated mortality of re-stocked eels and calculated.
Mortality by cormorant

Based on:
- bird counts
- daily feed consumption
- average time spent in the study area
- proportion of eels in the cormorant forage (Brämick & Fladung 2006)
Mortality by commercial fisheries

- 89 mixed species commercial fishing companies
- Species-specific catch statistics
Mortality by recreational fishery

- Logbook survey for eel catches (Fladung et al., 2012)
- Return rate of the logbooks: 48%
- ≈ 90,000 recreational fishery license holders

Fangbucht 2010

Wissenschaftliche Angestudie

Initiativ für Biomonitoring Potsdam-Sacow
Mortality by hydropower stations

- Mean mortality of a hydropower station 30% (ICES 2003)
- Pumping station 0.5% (Rauck 1980)
The German Eel Model (GEM)

Version 3 of the German Eel Model (GEM)

- Escapement
- Natural
- Recruitment
- Glass eel recruitment
- Length frequencies
- Length-weight-relation
- VBGF
- Growth
- Recruitment
- Cormorant study back-calculation
- Study lakes
- Silver eel
- Silver eel sex ratio
- Catch statistics
- Commercial
- Recreational
- Stocking
- Scenario tool
- Standing Stock
- Silver Eel production
- Silver eel
- Bevegau 2011 Cormorant study
- Catch survey
- Commercial
- Recreational

(Oberst & Fladung 2012)
Modeling results

Stock losses

- Silver eel escapement: 77%
- Cormorants: 13%
- Other anthropogenic mortalities: 8%
- Fishery mortality: 0.2%
- Natural mortality: 2%

4 Mill.
Marking with Visible Implant Elastomer (VIE) tags (VIE)

- Monitoring station close to the outlet
- Special fyke net with wings spanning about half of the total river width

Real silver eel escapement

Capture-mark-recapture study

- Monitoring station close to the outlet
- Special fyke net with wings spanning about half of the total river width
- Monitoring station close to the outlet
Without stocking, there will be no chance to meet the target of the eel regulation due to low natural immigration numbers, even if all anthropogenic mortality factors could be stopped completely.

![Graph showing biomass of silver eel per year from 2006 to 2016. The graph includes data points for EU target, current biomass, and best mon. biomass.]
Modeled effects of management measures in the Havel River system

Scenario tool of the German Eel Model

Eel re-stocking

% 6 +

Fishery

% 7 +

Cormorant

% 18 +

Hydropower stations

50 %

(re-stocking constant)

50 %

(re-stocking 10 %)

Measure

Result by silver eel escapement

% +

Action

X

+ 72 %

+ 7 %

+ 18 %

+ 6 %

+ 5 %
Consumption, Illegal export

Re-stocking in Europe

No glass eel

Natural mortality in stocked inland water bodies

Anthropogenic mortality in stocked inland water bodies

No Silver eels

Natural mortality in origin water

Anthropogenic mortality in origin water

Silver eels

Anthropogenic mortality capture, transport, stocking

Net benefit of eel stocking

(from WGEEL 2016)
Why stocking?

Biology:
- Panmictic species (one largestock) (Als et al. 2011)
- Re-stocked eels show no differences in upgrowth (e.g. Pawson 2013, Westerberg 2013, Westerberg et al. 2014)
- Faster growth & earlier puberty in coastal waters (e.g. Simon et al. 2014)
- Sex development & survival is density depended (e.g. ICES 2007, Feunteun et al. 2009, Westerberg et al. 2014, Westerberg 2013, Pawson 2013)
- Panmictic species (one large stock) (Als et al. 2011)

Reasons for stocking inland water bodies:
- Compensate for habitat losses & sustain the common distribution area
- Increase of silver eel escapement & reach the target of the eel regulation (e.g. Brämick et al. 2016)
- Maybe decrease mortality in the origin waters
- Produce higher ratios of females and older & larger females (e.g. Moriarty 2009)
- Extension of generation time (survival strategy)
Financial support was provided by the FAF/EFF-Programme of the EU, the Federal State of Brandenburg (grant number AZ 16-1222-09/22) and the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) through the Federal Office for Agriculture and Food (BLE), grant number 2807465036.

For more details of our study please read here...