JOINT PRODUCTION OF HYDROPOWER AND SALMON – OPTIMAL BIOECONOMIC MEASURE COMBINATION IN A FINNISH CASE RIVER

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SALMON AND HYDROPOWER

- Hydropower is an important source of **renewable energy**
  - **Regulates** the seasonal energy **supply**
  - **Substitutes fossil** fuels

- Once hydropower plants are built, the **passage of migratory fish** to their reproduction areas in the rivers becomes **prevented**, and their habitat seriously **degraded**

- The **multi-functionality** of river systems, including both the **recreational utilization** of fish stocks and **hydroelectricity production**, is called for in the EU Water Framework Directive

⟶ Optimal measures ensuring joint production are needed

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NATIONAL STRATEGIES IN FINLAND

- National salmon strategy: Shift **from compensatory stockings** to **restoration of wild salmon** by protecting the migration routes
  - Obviates the expensive stockings
  - Benefits the genetic variability of salmon

- National fishway strategy: **Fishways** would be the **main measure** to achieve this goal

- However, the **functioning of fishways** is highly **uncertain** and needs careful design

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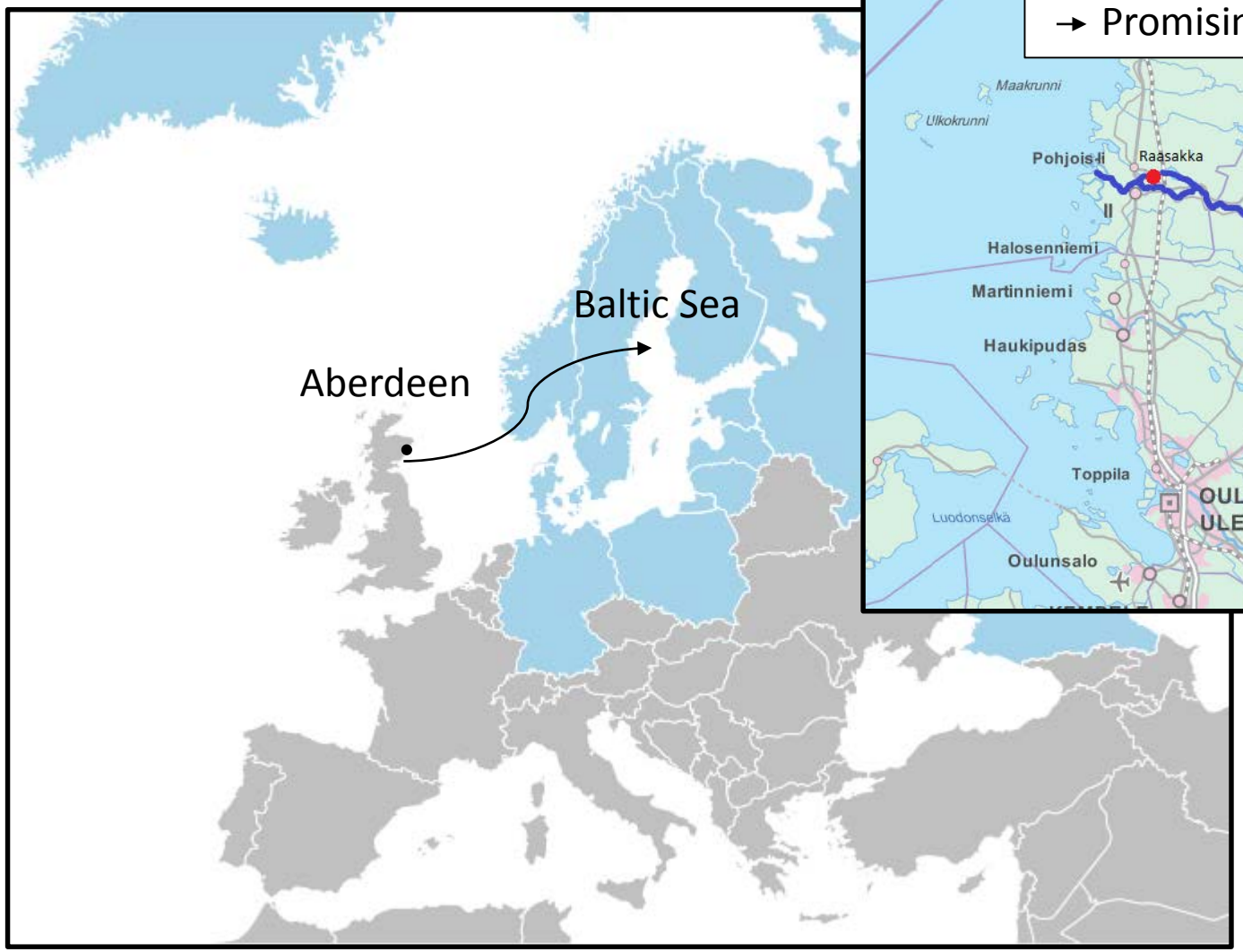
CASE RIVER: IIJOKI

- Five hydropower plants blocking the migration route
- Over 700 hectares of reproduction habitat
- The original salmon stock has been preserved in fish farm

→ Promising conditions for stock restoration



CURRENT STATE

- Iijoki River used to be **one of the most significant rivers in Finland** for migrating fish before the construction of hydropower dams in the 1960s

- Annually 310 000 reared **smolts** are **stocked** to the **river mouth** by hydropower companies
  - **Benefits** only **commercial fisheries** (offshore longline & coastal trapnet fishery)
  - **No access** to the **river** to benefit anglers or to reproduce

- Reared individuals have **lower survival** than the wild counterparts

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OBJECTIVE AND METHOD

- Find the **optimal measure combination** to **maximize society's net present value** arising from the joint production of hydropower and salmon in a case river
- Numerical bioeconomic modelling
- Model includes detailed, **age-structured population dynamics** of salmon and illustration of the **hydropower** production
- The considered time period is **50 years**

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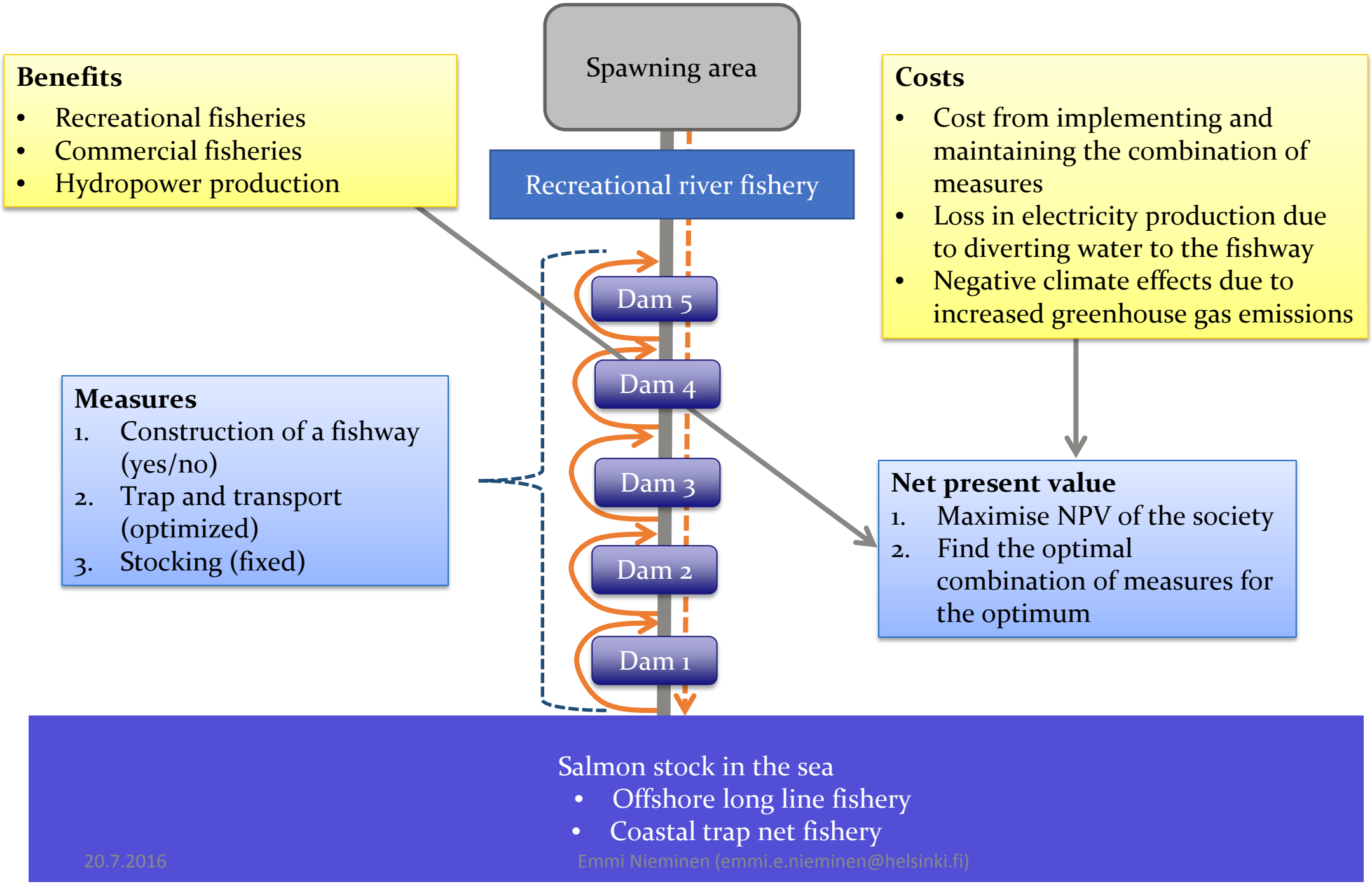

Benefits

- Recreational fisheries
- Commercial fisheries
- Hydropower production

Costs

- Cost from implementing and maintaining the combination of measures
- Loss in electricity production due to diverting water to the fishway
- Negative climate effects due to increased greenhouse gas emissions

Measures

1. Construction of a fishway (yes/no)
2. Trap and transport (optimized)
3. Stocking (fixed)

Net present value

1. Maximise NPV of the society
2. Find the optimal combination of measures for the optimum

SCENARIOS

SQ = status quo = current situation

- 310 000 reared smolts (4-year-old) stocked **into the river mouth**
- **No** transportation of individuals over the dams
- **No** fishways

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SCENARIOS

SQ = status quo = current situation

- 310 000 reared smolts (4-year-old) stocked **into the river mouth**
- **No** transportation of individuals over the dams
- **No** fishways

BS1 = base scenario 1

- First 12 years: 1-year-old salmon stocked **into the river**
- Trap and transport (TaT) **optimized**
- **No** fishways

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SCENARIOS

SQ = status quo = current situation

- 310 000 reared smolts (4-year-old) stocked **into the river mouth**
- **No** transportation of individuals over the dams
- **No** fishways

BS1 = base scenario 1

- First 12 years: 1-year-old salmon stocked **into the river**
- Trap and transport (TaT) **optimized**
- **No** fishways

BS2 = base scenario 2

- First 12 years: 1-year-old salmon stocked **into the river**
- Trap and transport (TaT) **optimized**
- **Fishways** are built at all dams

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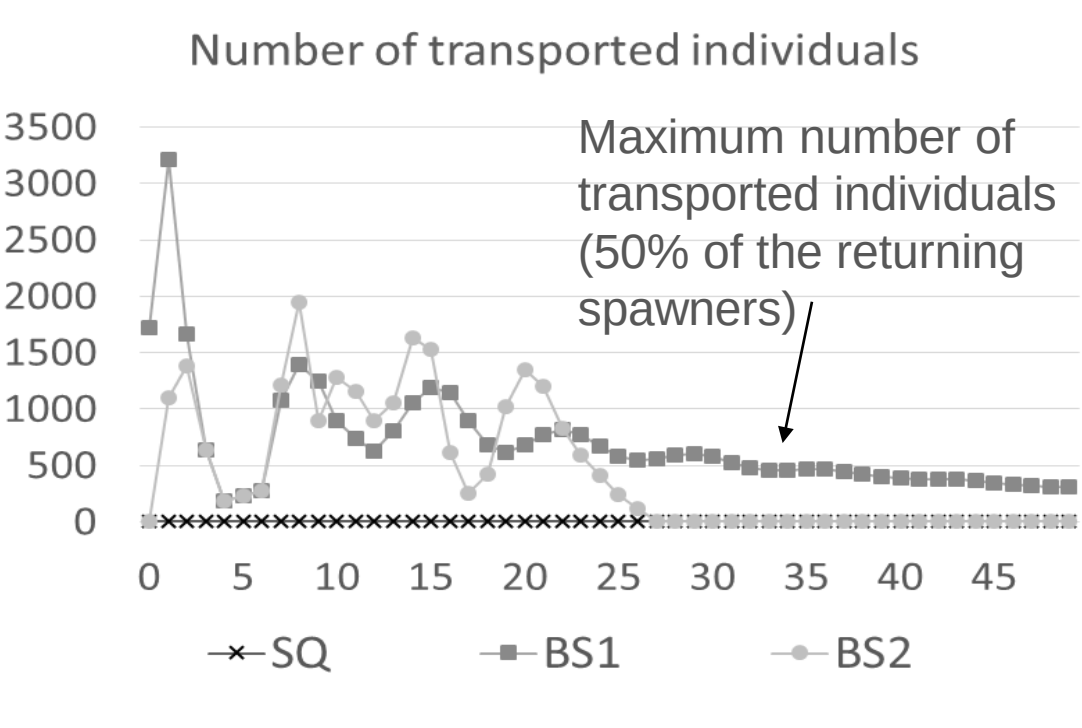
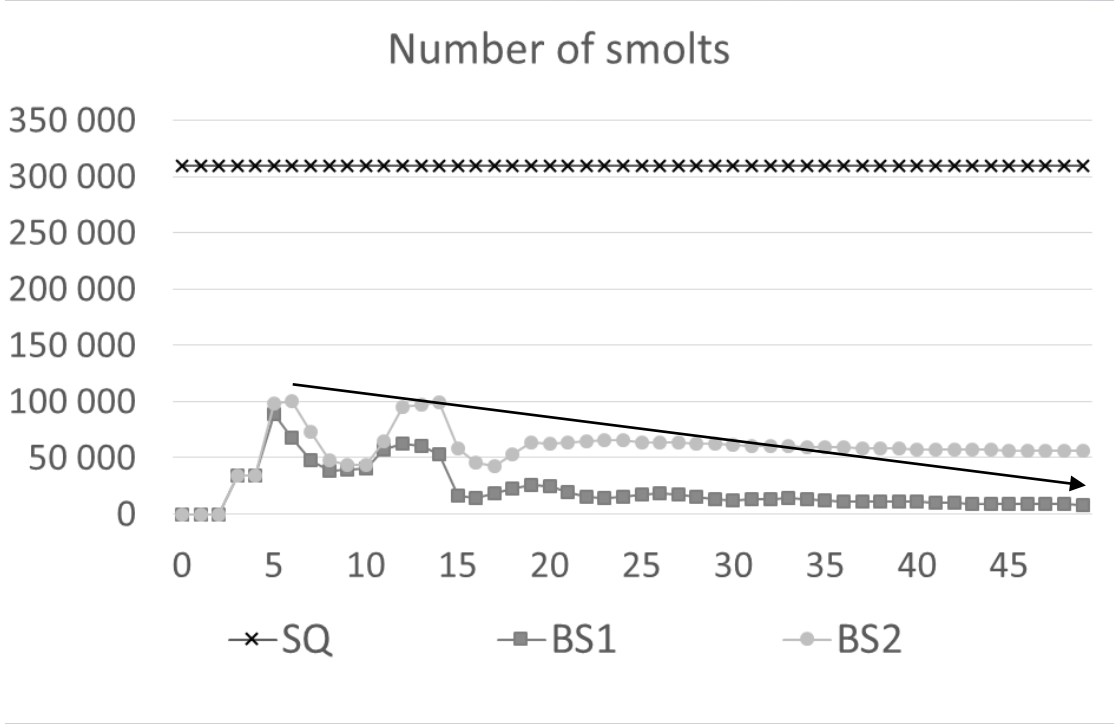
RESULTS (1)

Net present values:

- SQ = Status quo, only stocking = 512 m€
- **BS1 = TaT optimized, no fishways = 528 m€**
- BS2 = TaT optimized, fishways are built = 504 m€

Do **not** construct **fishways**; instead rely on **intense trap and transport** (however, **not** a **sustainable** solution)



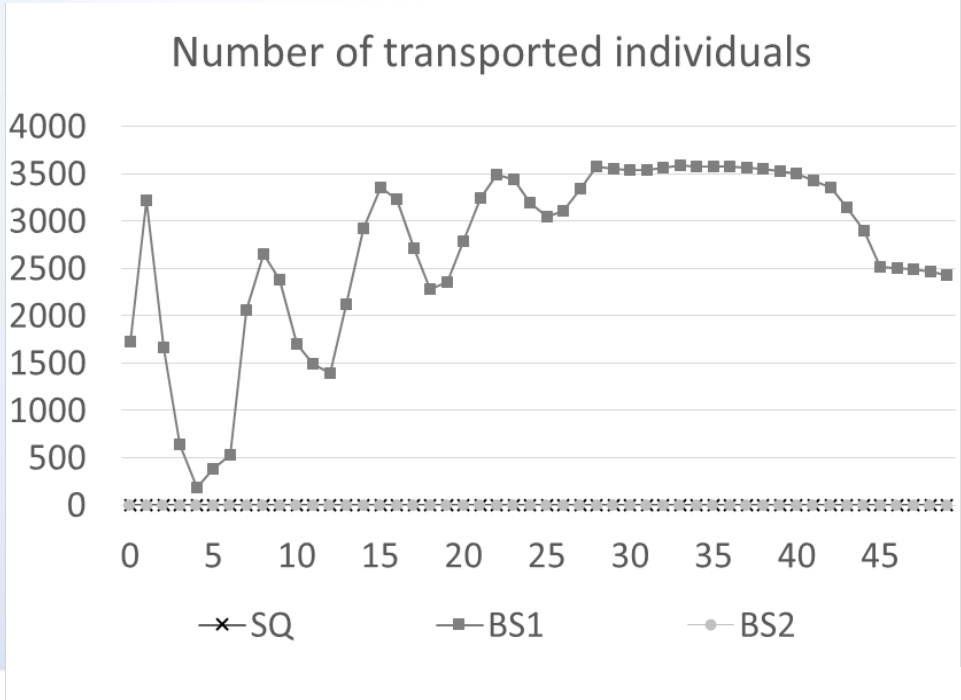


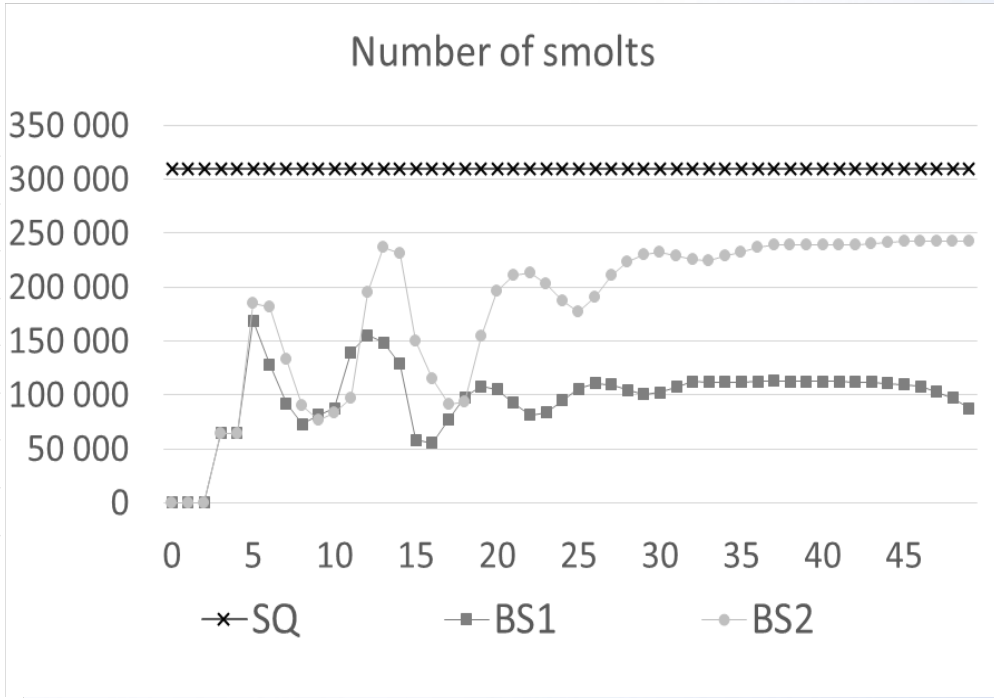
RESULTS (2): WHAT IF THERE WAS ONLY ONE HYDROPOWER PLANT INSTEAD OF FIVE?

Net present values:

- SQ = Status quo, only stocking = 68 m€
- BS1 = TaT optimized, no fishway = 86 m€
- **BS2 = TaT optimized, fishway is built = 89 m€**

Construct a fishway; trap and transport **not** needed





RESULTS (3): WHAT IF POST-SMOLT (PS) OR DOWNSTREAM (DS) MORTALITY RATE DECREASES BY 20%?

Net present values:

- SQ = Status quo, only stocking = 513 m€ (PS) or 512 m€ (DS)
- **BS1 = TaT optimized, no fishways = 529 m€ (PS) or 529 m€ (DS)**
- BS2 = TaT optimized, fishways are built = 509 m€ (PS) or 506 m€ (DS)

NPV of BS2 becomes closer to BS1 and SQ. However, **fishways** still **not** beneficial.

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CONCLUSIONS

- The society's NPV becomes maximized when salmon are **trapped and transported** at a **maximum scale** (50% of the returning spawners) to the river in addition to supportive stockings in the early phase of the restoration
  - However, not a sustainable solution → stock constantly decreases

- If we assumed a river with **smaller hydropower production capacity** (only one hydropower plant), it would be **beneficial to construct a fishway**

- Even if the **post-smolt or downstream mortality** of salmon **decreased** by 20% and the stock would therefore increase, the construction of **fishways** would **not** be **beneficial** with five hydropower plants

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THANK YOU

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