# Mitigation measures in Swedish hydropower from a operator perspective – strategy, examples and conclusions

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# Strategy

- **Combining hydraulics and biology**

✓ Ecohydraulics - scientific field concerned with interactions between fluids and biota.

✓ Behavior of aquatic organisms is affected by hydraulic conditions.

✓ Important to combine knowledge how aquatic organisms interact with hydraulic conditions to find suitable mitigation measures to minimise negative effects from hydropower.

# Strategy

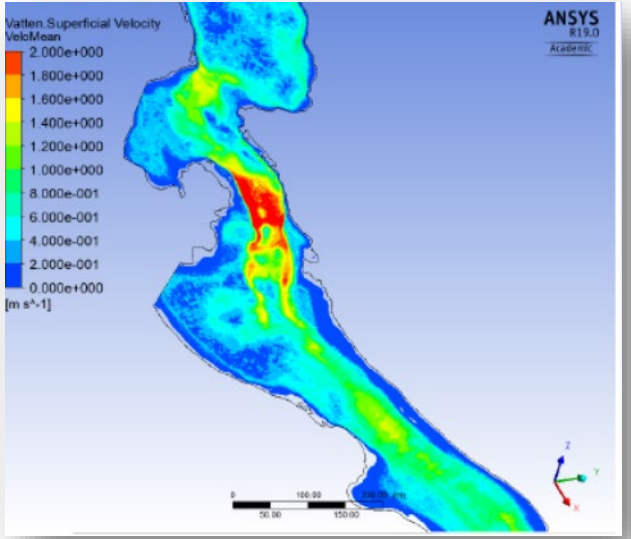
- **Step-by-step knowledge-building**

✓ Working method involves step-by-step knowledge-building process before measures are carried out.

✓ Knowledge building should always be carried out with scientific methodology.

✓ Environmental measures should give good effect on biodiversity but have low impact on hydropower production and balancing capacity.

✓ Important to find smart solutions.



# Strategy

- **Step-by-step knowledge-building**

1. Decide site-specific targets.

2. Use for example hydraulic modelling, model trials, laboratory studies, field studies to find site-specific measures.

3. Analyse  ecological benefits for target species from measures.

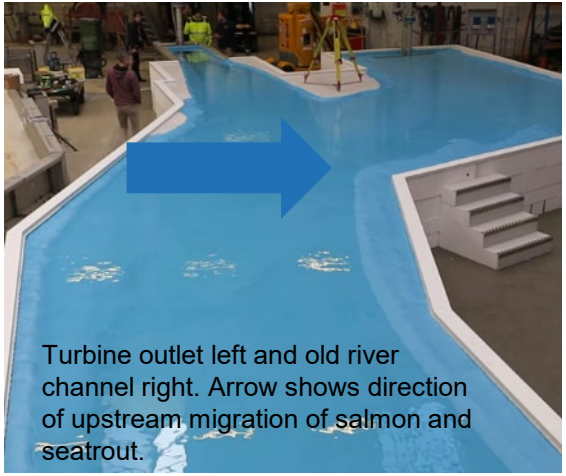
4. Assess consequences for hydropower from measures.

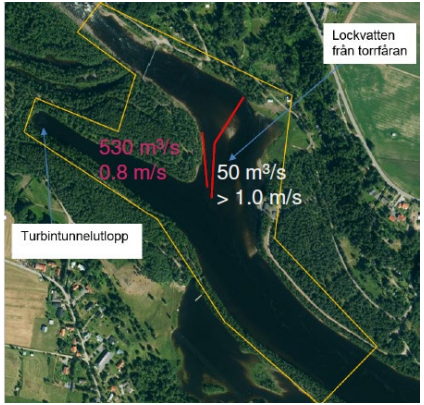
5. Assess balance between ecological  benefits and negative consequences for hydropower of measures.

6. Implement  measures when  impact on biodiversity is sufficiently large and negative consequences for hydropower acceptable.

# Example - Optimisation of attraction flow (Vattenfall/SLU)

- Confluence area downstream Stornorrfors HP, river Umeälven.
- Modelling of attraction flow for fish to old river channel to increase upstream migration of salmon and seatrout by narrowing mouth of old river channel with a wall.
- Water velocity trigger for attraction.



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# Example - Design of intake grids (Vattenfall/KaU)

- Laboratory study in test flume (Laxeleratorn Älvkarleby) .
- Design of intake grids to divert eel and salmon to bypass and avoid turbine passage.
- Smallest possible effect on operation of hydropower station of intake grid design.
- https://youtu.be/Hz_fSXSSj44

# Example – Ecological flows using hydraulic modelling (Uniper/DHI/Kau)

- MQ ca 25 $m^3/s$
- MLQ ca 6 $m^3/s$

- Finsjö övre HP, Emån natural difficult passage.
- The old river stretch is too steep to be an optimal habitat for salmonids. If the purpose is to optimise habitats, recommended flow is 1,5-3,0 $m^3/s$.
- As the habitat potential is limited, focus should be connectivity, suggested flow 3-5 $m^3/s$.
- A minimum flow should be combined with physical measures.
- **Site specific investigations and targets necessary when designing ecological flows.**

# Example – Prioritisation of faunapassages and new reproduction areas (Tekniska verken/ SWECO)

- Priority and ranking of 42 hydropower stations and 70 dams 2014-2017 using following criteria:

*1*) Presence of streamwater-dependent species, migration needs and threat status, 2) Presence of streamwater habitats (reproduction etc.) upstream of obstacles in relation to downstream, 3) Costs, 4) Production losses.

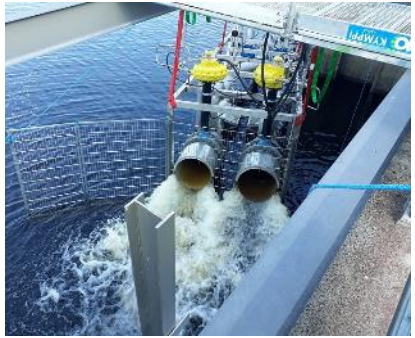
- Example faunapassage Nykvarn Stångån

✓ Ensure the accessibility of fish and other aquatic organisms at the migration barrier and to create improved reproduction areas for asp (*Aspius aspius).*

✓ Lift and strengthen the site's archaeological and cultural-historical values, recreational values and the natural values.

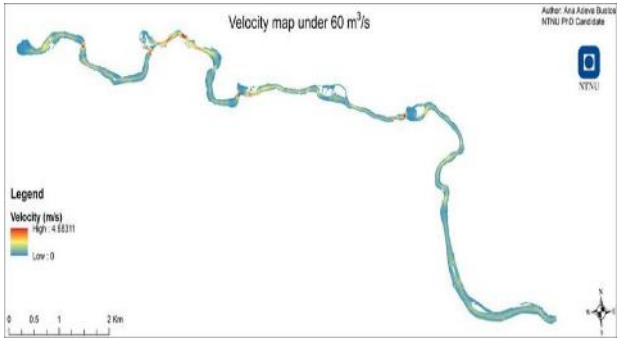
# Example - New technical innovations (Fortum)

- A Whoshh fish transporting system will be installed at Forshaga HP in Klarälven.
- Main objective is to strengthen T&T and broodstock operations as well as testing a new technical solution for passing fish through barriers.
- A floating fish pump device named Fishheart from Finland will be installed at Spjutmo HP in river Österdalälven.
- The Fishheart was tested at Isohara HP in Kemijoki with promising results.



# Example – Mapping of habitat for reproduction (Statkraft)

- Its important to have knowledge about both morphology and flow to find optimal reproduction habitats for salmon in the river Ljungan.
- Traditional mapping of reproduction habitats was compared with green laser.
- Results showed that it was challenges with coloured water when using green laser.
- Additional measurement of water velocity was carried out using  ADCP.
- Using green laser together with additional measurements can in some areas replace traditional inventories of reproduction habitats.



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# Example – Measures with no effects on hydropower (Vattenfall/Statkraft/UmU)

Prevent iceerosion to reestablish riparian vegetation

Restore and secure connectivity to tributaries

Create habitats adapted to regulated conditions

Site-specific restoration measures

# Conclusions

- Important to combine knowledge about hydraulics and biology when measures are considered.
- Use step-by-step knowledge-building process to find acceptable measures.
- Site specific investigations and targets are necessary to have when designing measures.
- Use for example hydraulic modelling, model trials, laboratory studies or field studies to find site-specific measures.
- Restore and create habitats adapted to regulated conditions.
- New innovations and measures are needed to find smart solutions.