APPLICATION OF REMOTE SENSING FOR MONITORING FISH SPAWNING SITES OF A LARGE HYDROPOWER PLANT RESERVOIR IN A LOWLAND REGION

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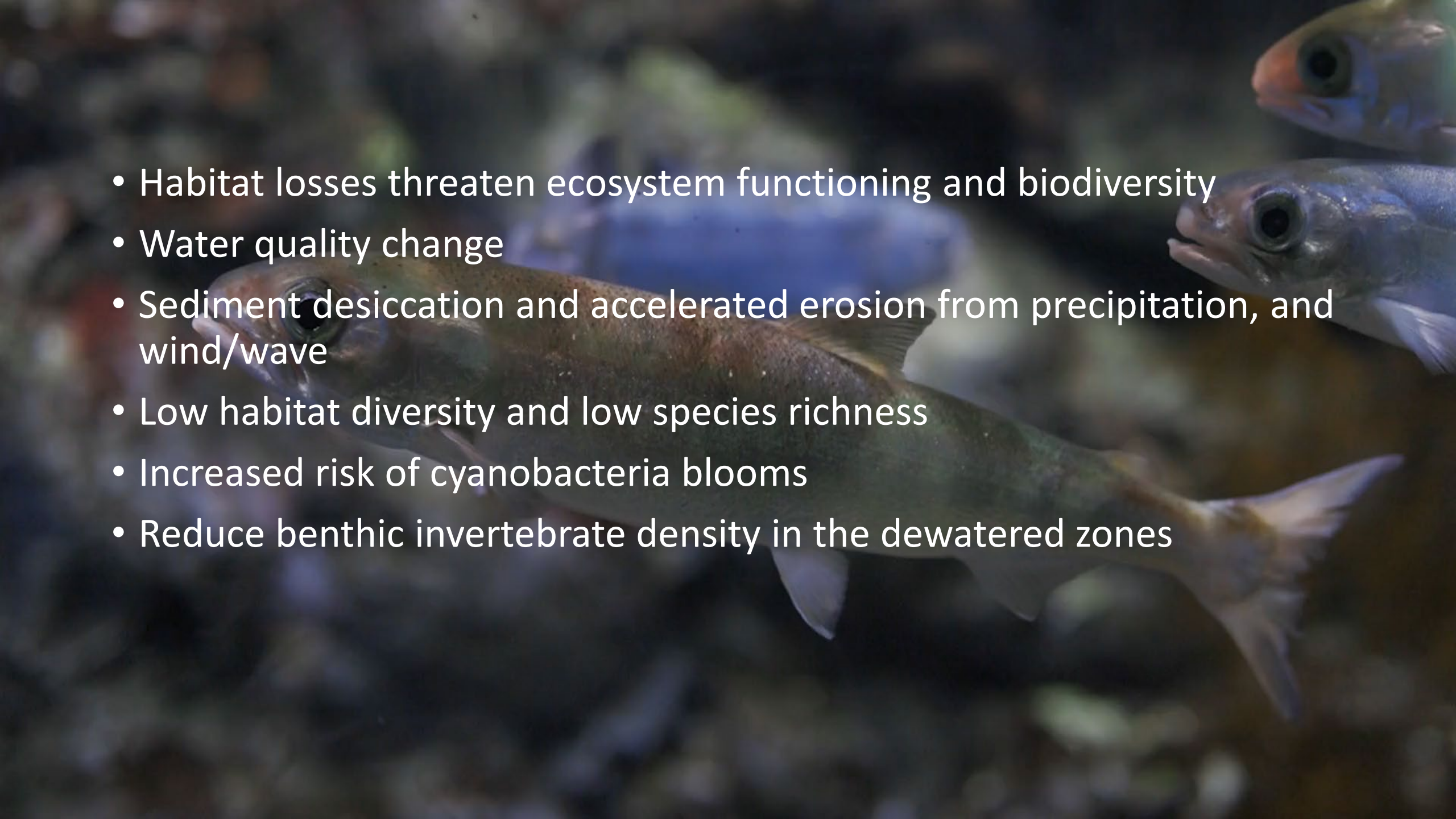
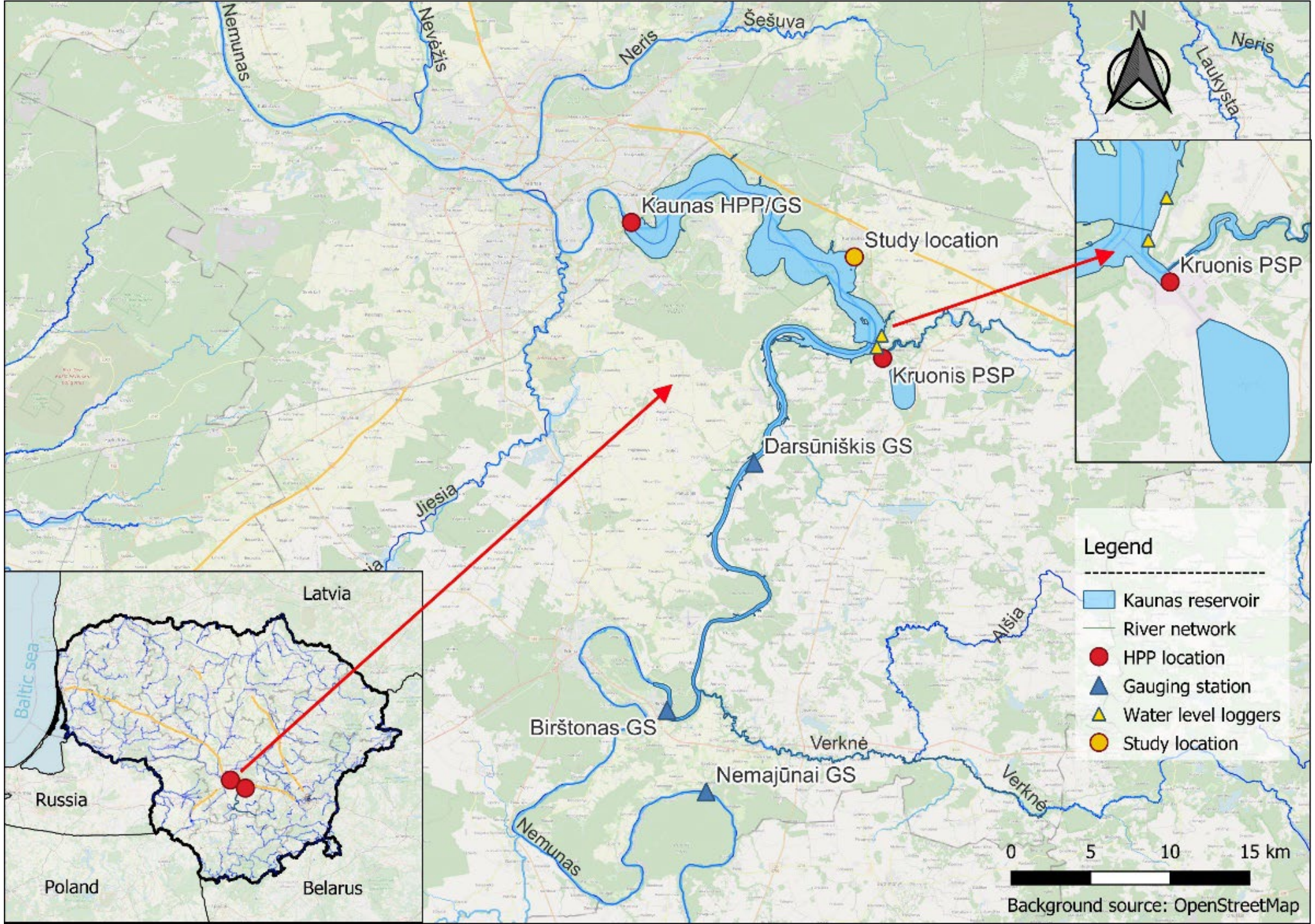
Optimal operation of a large hydropower plant

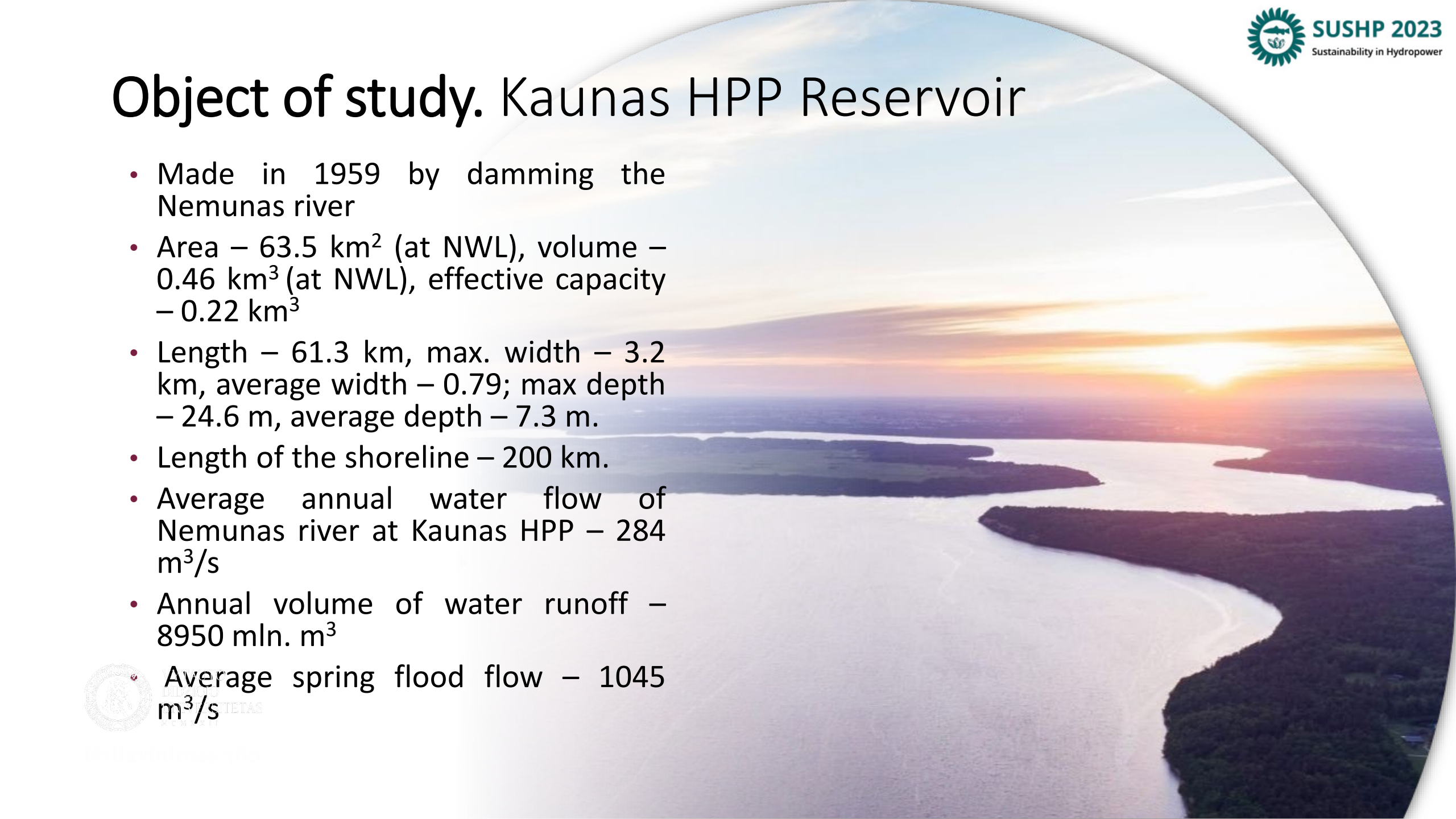


- Habitat losses threaten ecosystem functioning and biodiversity
- Water quality change
- Sediment desiccation and accelerated erosion from precipitation, and wind/wave
- Low habitat diversity and low species richness
- Increased risk of cyanobacteria blooms
- Reduce benthic invertebrate density in the dewatered zones


Nemunas
Nevėžis
Neris
Šešuva
Neris
Laukysta
N
Kaunas HPP/GS
Study location
Kruonis PSP
Kruonis PSP
Darsūniškis GS
Jiesia
Alšia
Birštonas GS
Verknė
Nemajūnai GS
Verknė
Nemunas
Latvia
Baltic sea
Russia
Poland
Belarus
Legend
Kaunas reservoir
River network
HPP location
Gauging station
Water level loggers
Study location
0
5
10
15 km
Background source: OpenStreetMap

Object of study. Kaunas HPP Reservoir

- Made in 1959 by damming the Nemunas river
- Area – 63.5 km^2 (at NWL), volume – 0.46 km^3 (at NWL), effective capacity – 0.22 km^3
- Length – 61.3 km, max. width – 3.2 km, average width – 0.79; max depth – 24.6 m, average depth – 7.3 m.
- Length of the shoreline – 200 km.
- Average annual water flow of Nemunas river at Kaunas HPP – 284 m^3/s
- Annual volume of water runoff – 8950 mln. m^3
- Average spring flood flow – 1045 m^3/s

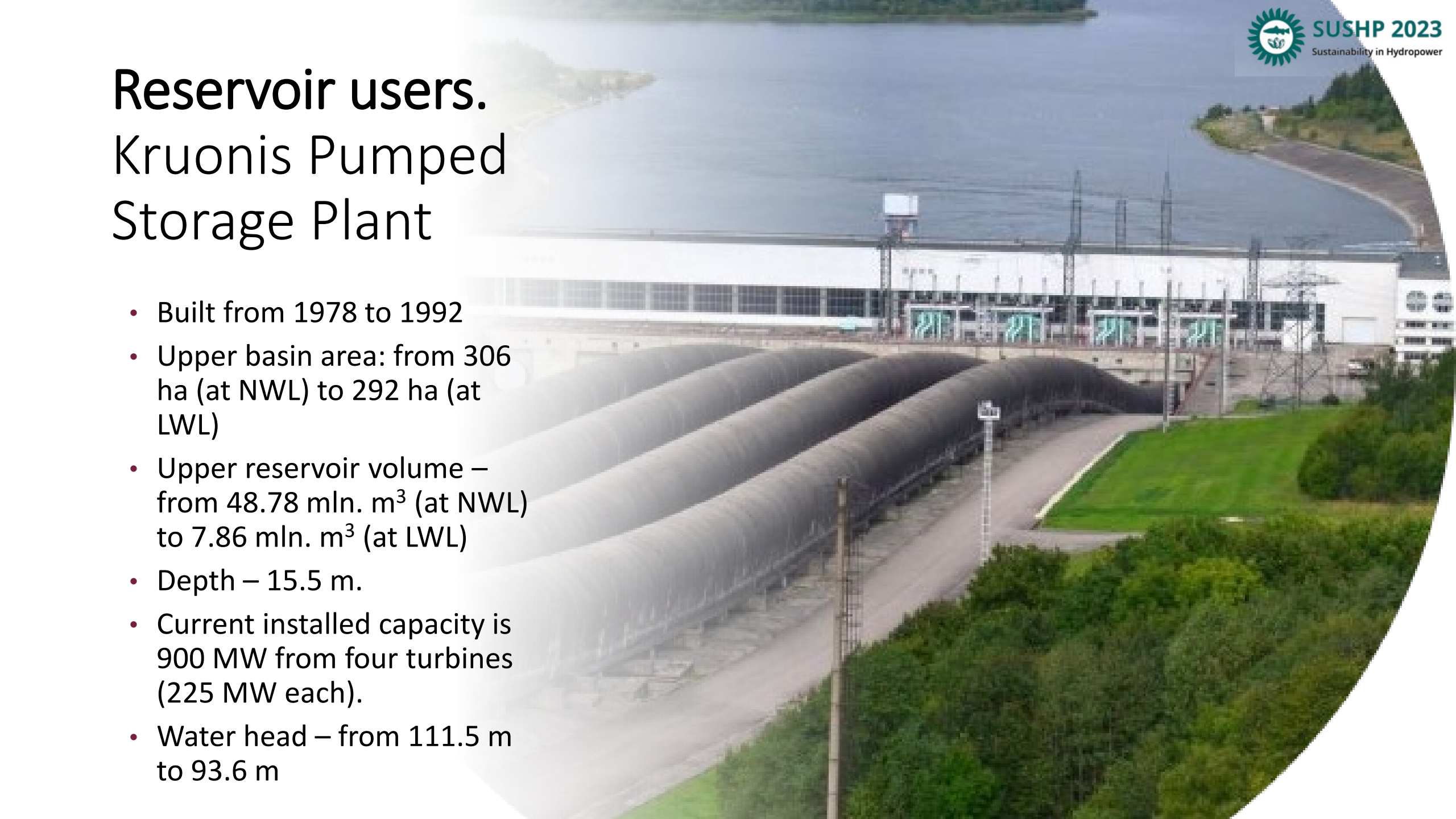


Reservoir users.
Kaunas hydropower plant

- Built in 1960
- Installed capacity of turbines is 101 MW
- Four Kaplan PL 20-661-VB-500 turbines 25.2 MW each
- Max. head of each turbine – 24.6 m, max. water flow – 158 m^3/s at full capacity (632 m^3/s in total)
- Average annual power output – 351 GWh at 20.1 m water head

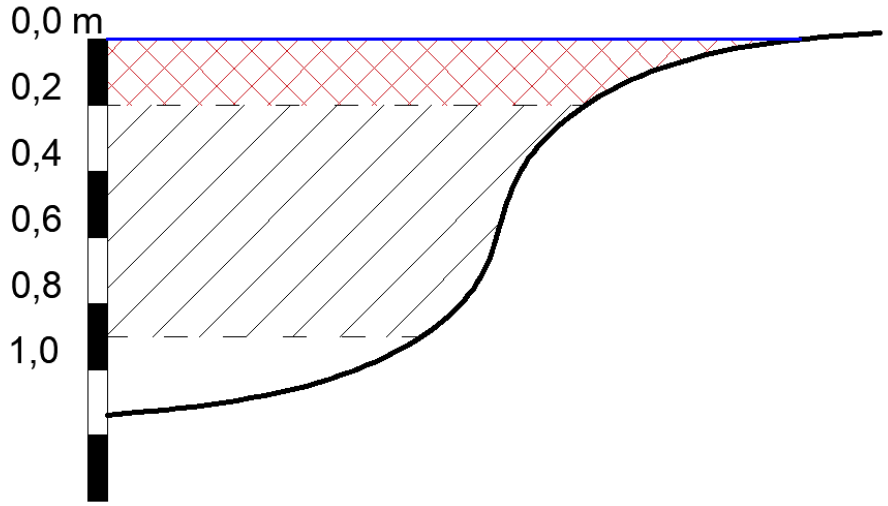
Reservoir users. Kruonis Pumped Storage Plant

- Built from 1978 to 1992
- Upper basin area: from 306 ha (at NWL) to 292 ha (at LWL)
- Upper reservoir volume – from 48.78 mln. m^3 (at NWL) to 7.86 mln. m^3 (at LWL)
- Depth – 15.5 m.
- Current installed capacity is 900 MW from four turbines (225 MW each).
- Water head – from 111.5 m to 93.6 m



Exploitation rules of Kaunas HPP reservoir

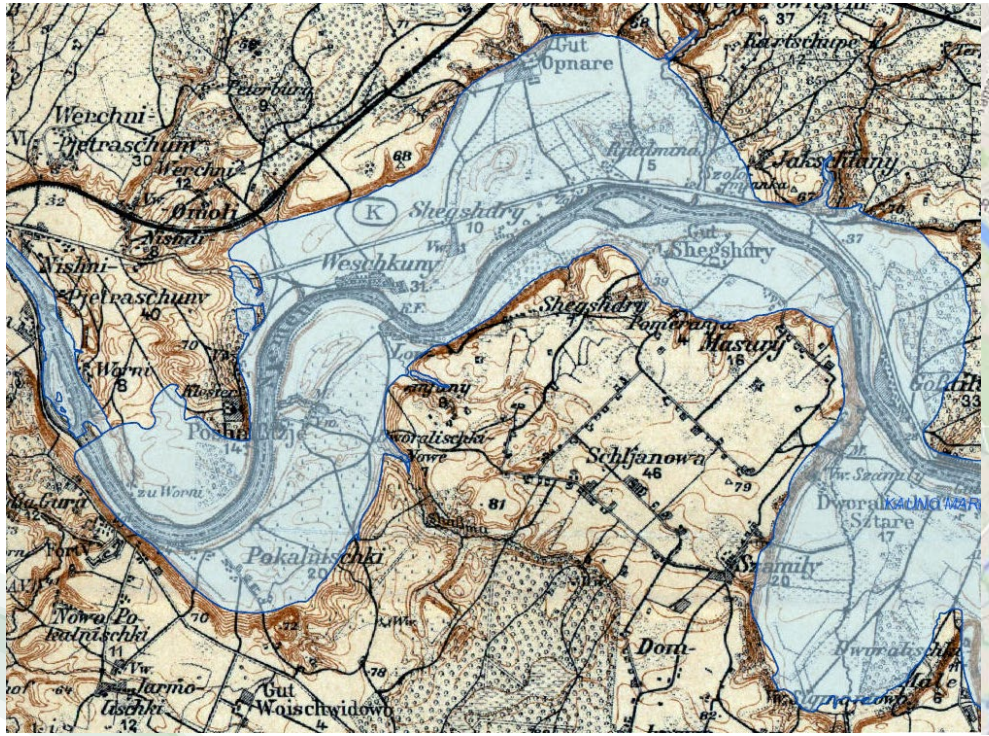
- Kaunas HPP Reservoir exploitation rules were established in 2016 by the Lithuanian Institute of Energy
- Kaunas HPP Reservoir exploitation rules state:
  - normal operation levels of the reservoir are between 43.5 – 44.4 m a.s.l
- During fish spawning period operation of Kaunas HPP is restricted:
  - Kaunas HPP Reservoir must be between 43.7 and 44.0 m a.s.l.
  - Maximum difference of 10 cm between the highest and the lowest daily water level is allowed. Daily water level change of 20 cm is allowed if the owner of Kaunas HPP and the reservoir fulfills research on the state of the environment

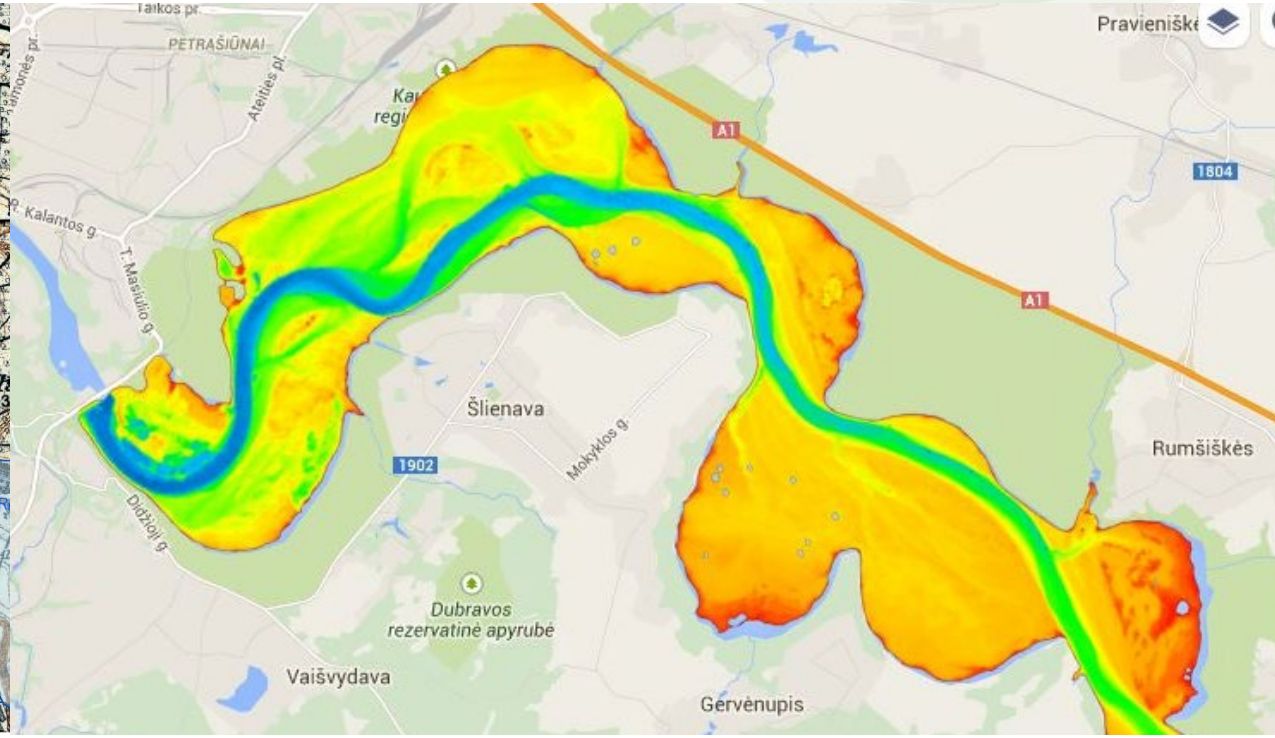


Lack of knowledge

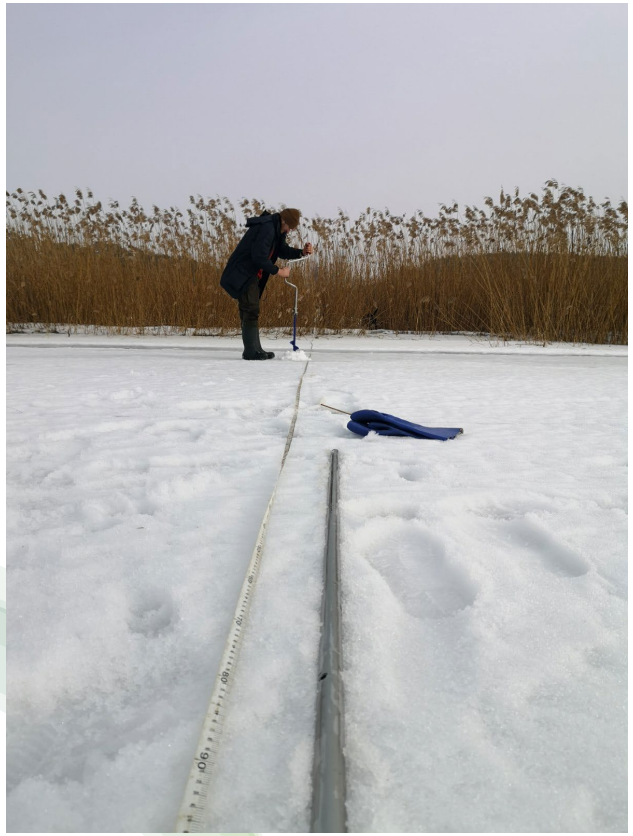
- Identification of the fish spawning sites
- How does the fish spawning site area change when the water level changes

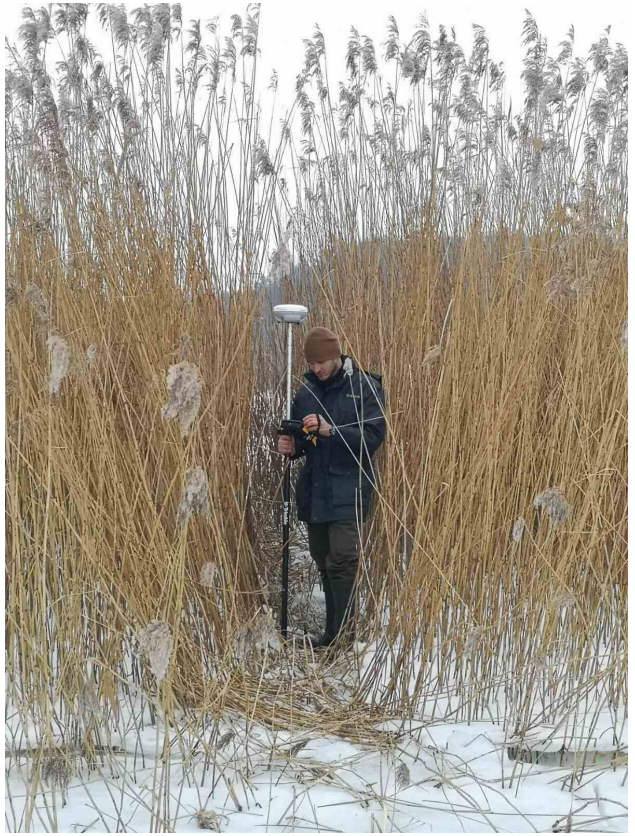
Bathymetry sources of the Kaunas HPP reservoir

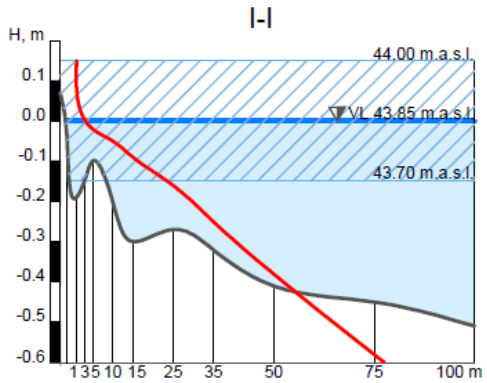


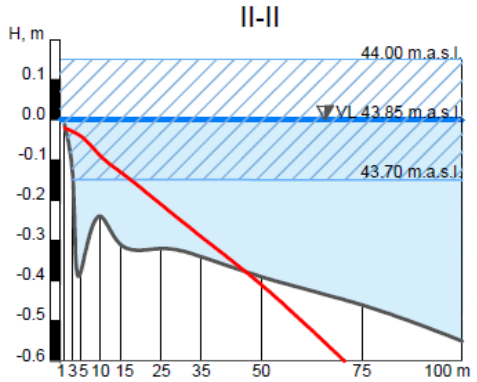


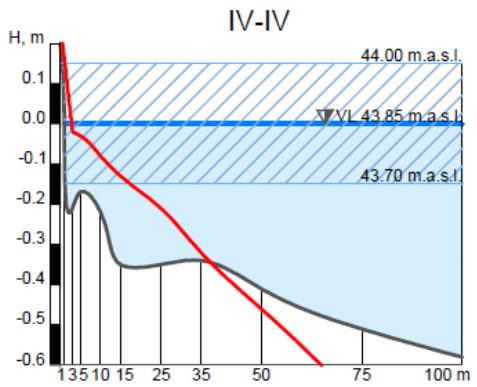
Field research






I-I
H, m
44.00 m.a.s.l.
VL 43.85 m.a.s.l.
43.70 m.a.s.l.
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
1 3 5 10 15 25 35 50 75 100 m


II-II
H, m
44.00 m.a.s.l.
VL 43.85 m.a.s.l.
43.70 m.a.s.l.
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
1 3 5 10 15 25 35 50 75 100 m


IV-IV
H, m
44.00 m.a.s.l.
VL 43.85 m.a.s.l.
43.70 m.a.s.l.
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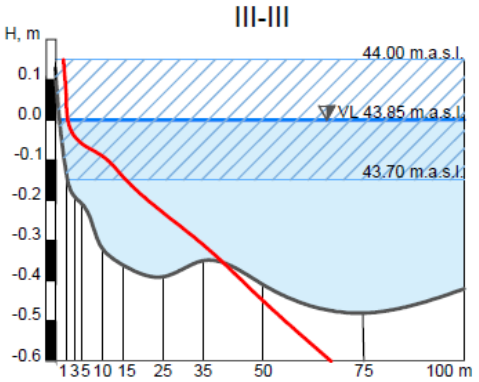
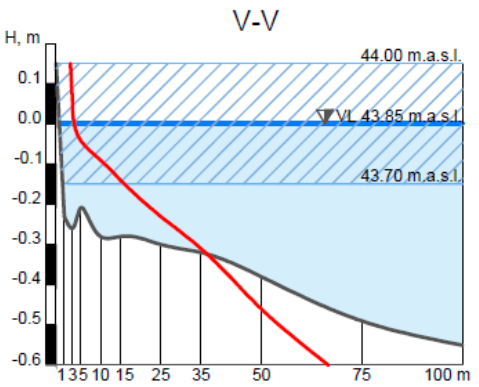
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
1 3 5 10 15 25 35 50 75 100 m


III-III
H, m
44.00 m.a.s.l.
VL 43.85 m.a.s.l.
43.70 m.a.s.l.
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
1 3 5 10 15 25 35 50 75 100 m


V-V
H, m
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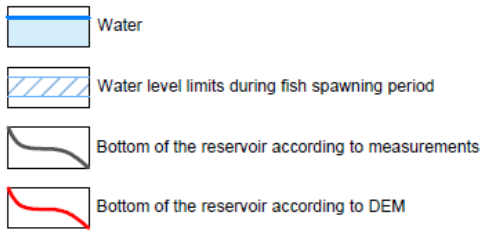
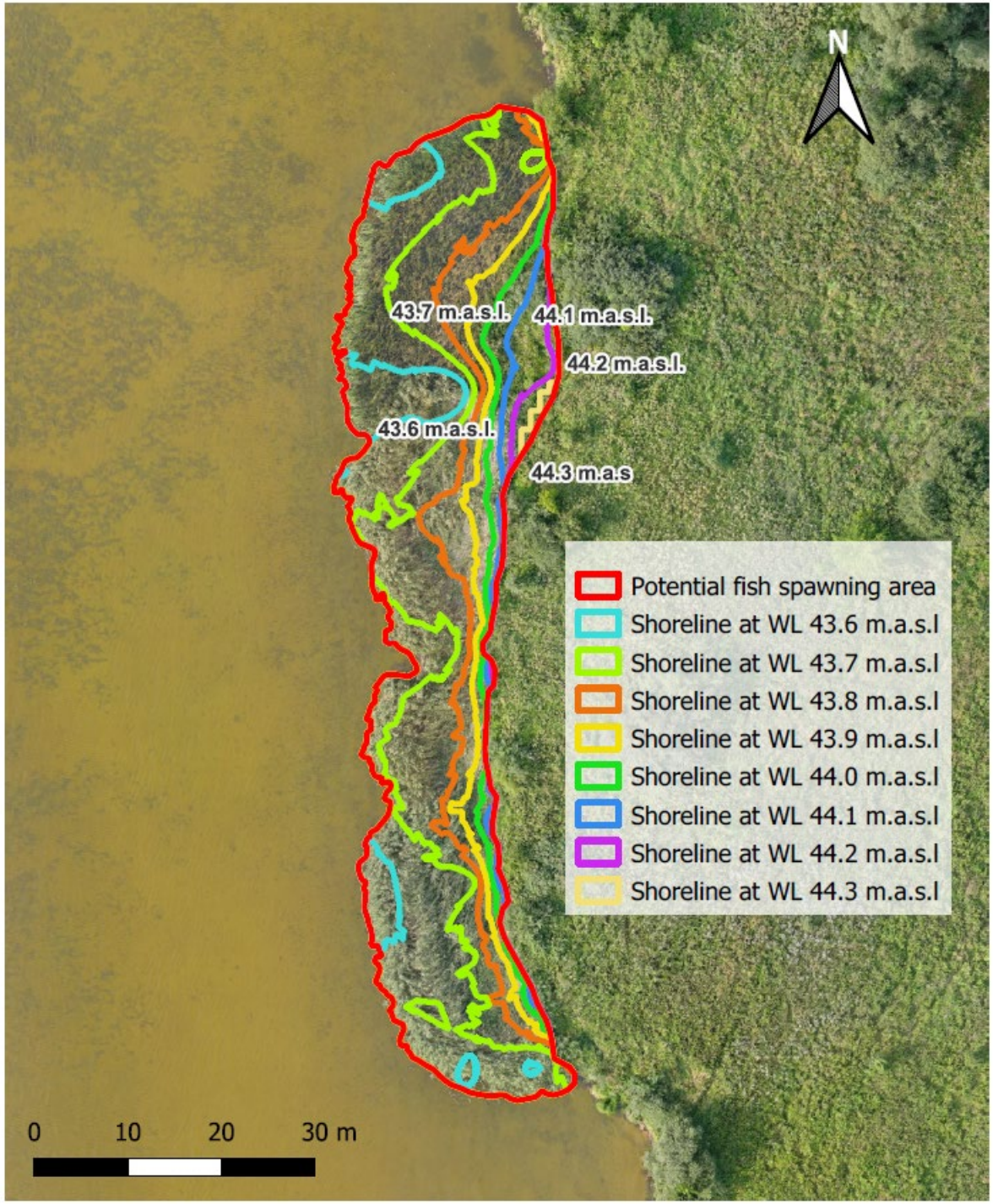
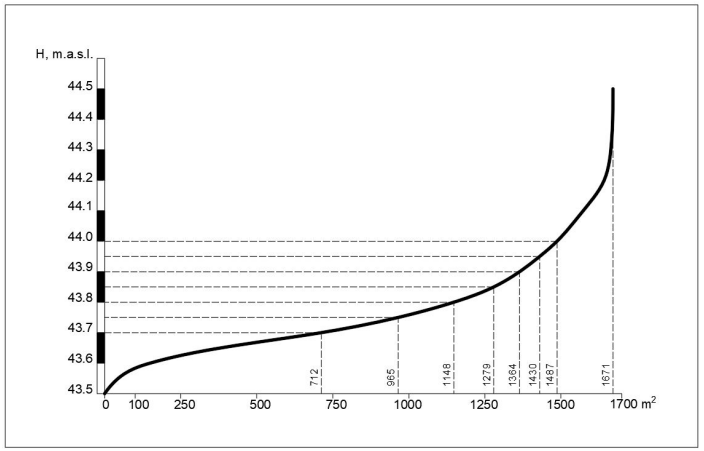
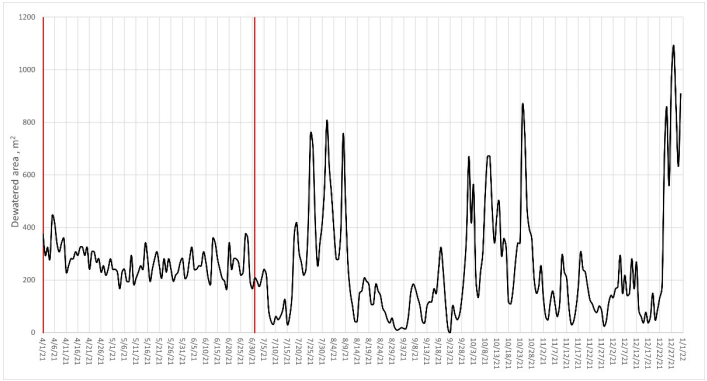
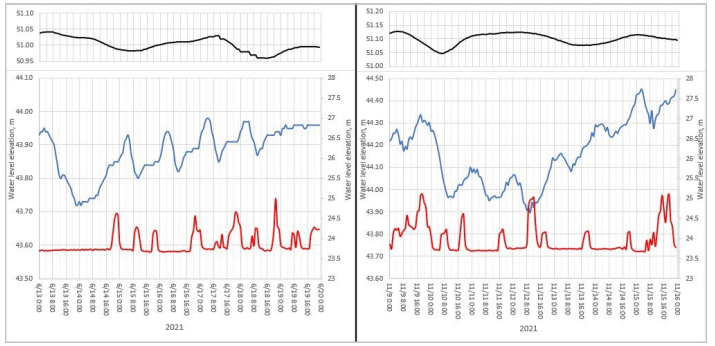
VL 43.85 m.a.s.l.
43.70 m.a.s.l.
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
1 3 5 10 15 25 35 50 75 100 m


Water
Water level limits during fish spawning period
Bottom of the reservoir according to measurements
Bottom of the reservoir according to DEM


N
43.7 m.a.s.l.
44.1 m.a.s.l.
44.2 m.a.s.l.
43.6 m.a.s.l.
44.3 m.a.s
Potential fish spawning area
Shoreline at WL 43.6 m.a.s.l
Shoreline at WL 43.7 m.a.s.l
Shoreline at WL 43.8 m.a.s.l
Shoreline at WL 43.9 m.a.s.l
Shoreline at WL 44.0 m.a.s.l
Shoreline at WL 44.1 m.a.s.l
Shoreline at WL 44.2 m.a.s.l
Shoreline at WL 44.3 m.a.s.l
0
10
20
30 m

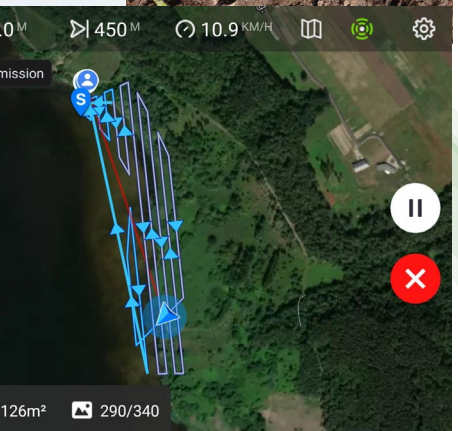


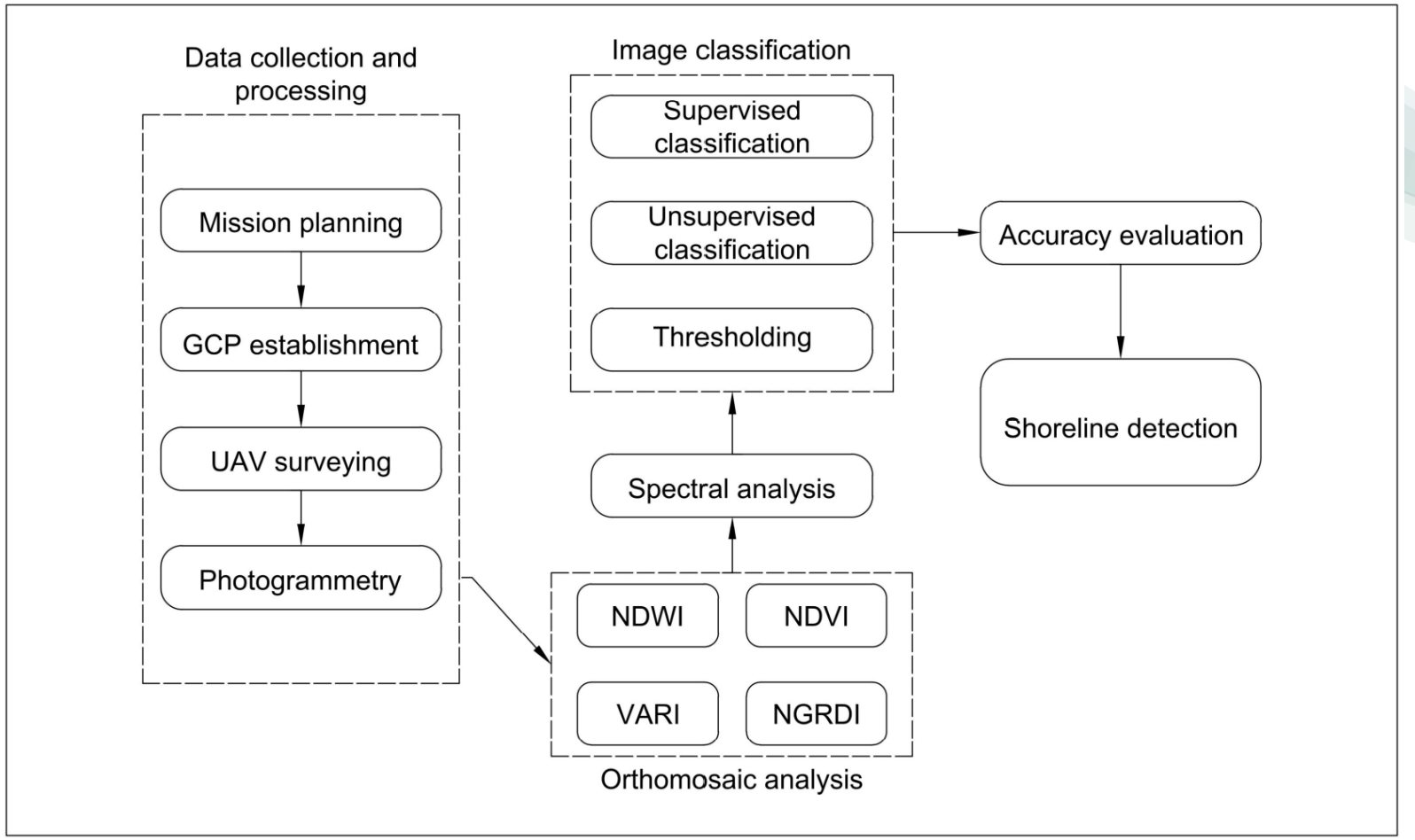




- **Jurevičius L., Punys P., Kasiulis, E., Šilinis L.** *Surveying Dewatered Areas in the Fish Spawning Sites during Short-Term Drawdown Operations: Case Study of a Large Hydropower Plant Reservoir in the Lowland Area, Lithuania.* **Energies 2022**, 15, 8574

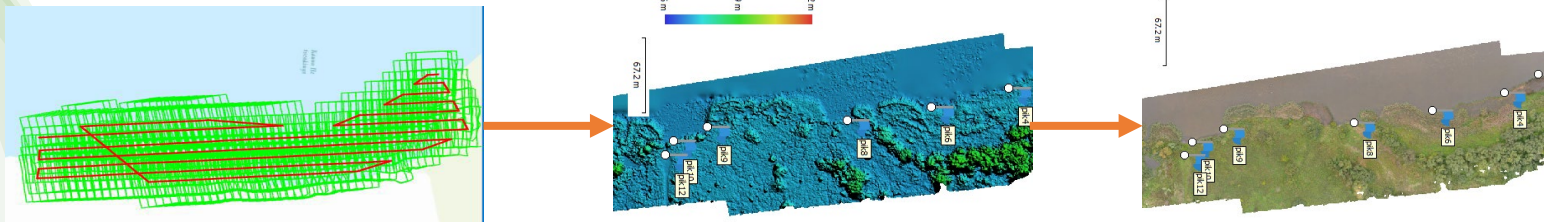
Surveying drawdown areas using UAVs





Autel EVO II Pro

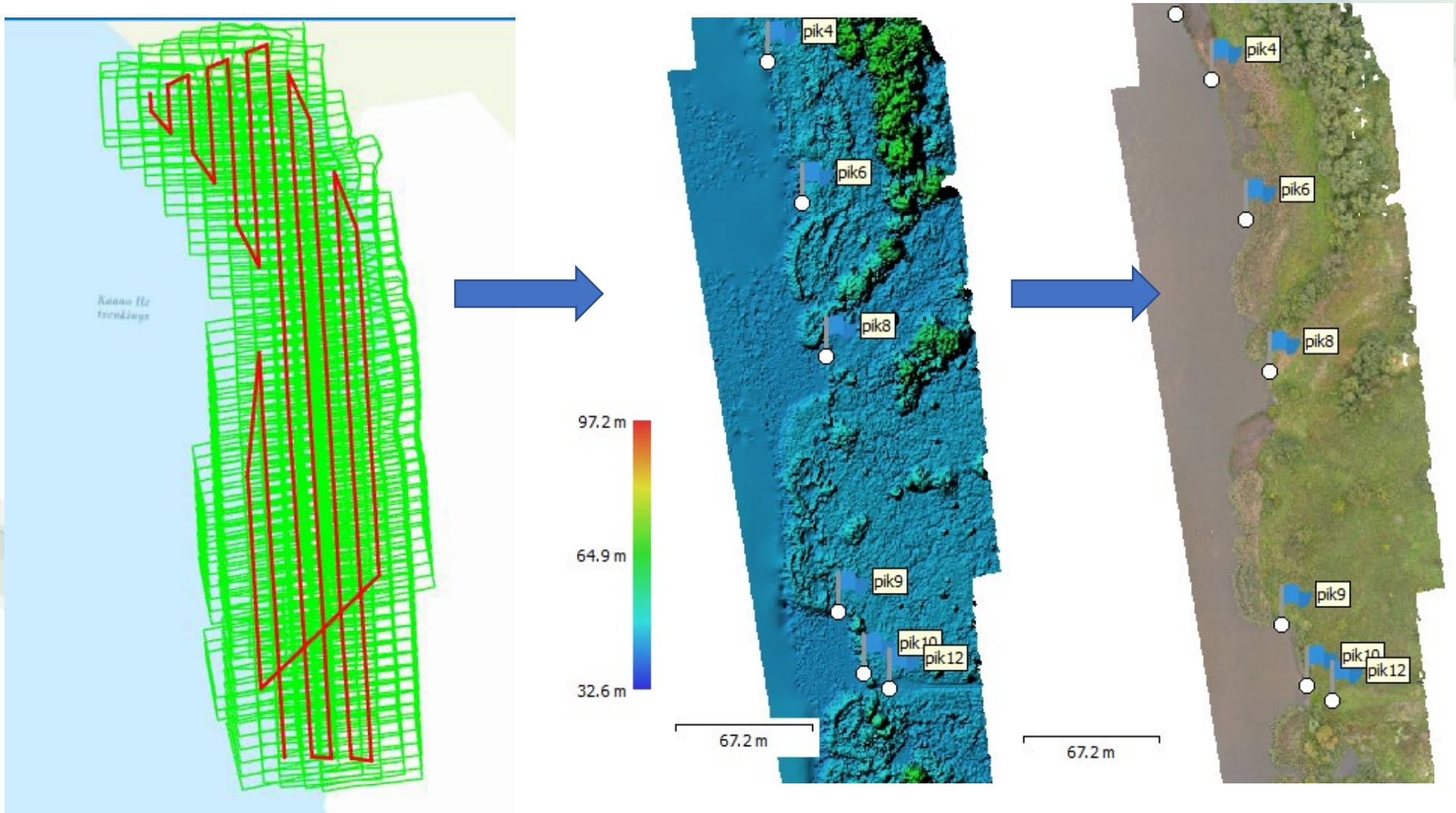
DJI MATRICE 200 V2

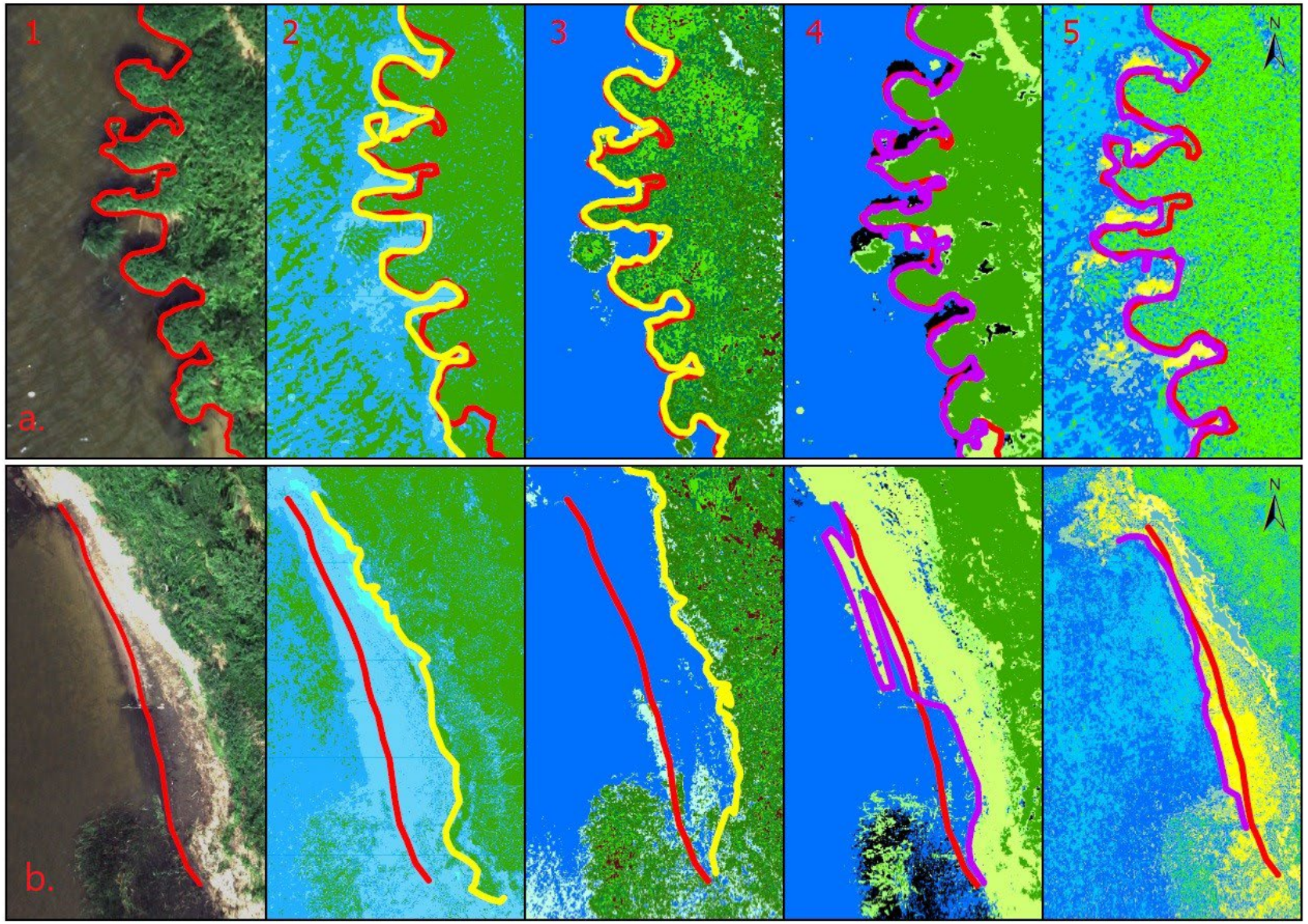


Accuracy is crucial

- Establishing ground control points and water level gauges

Data analysis

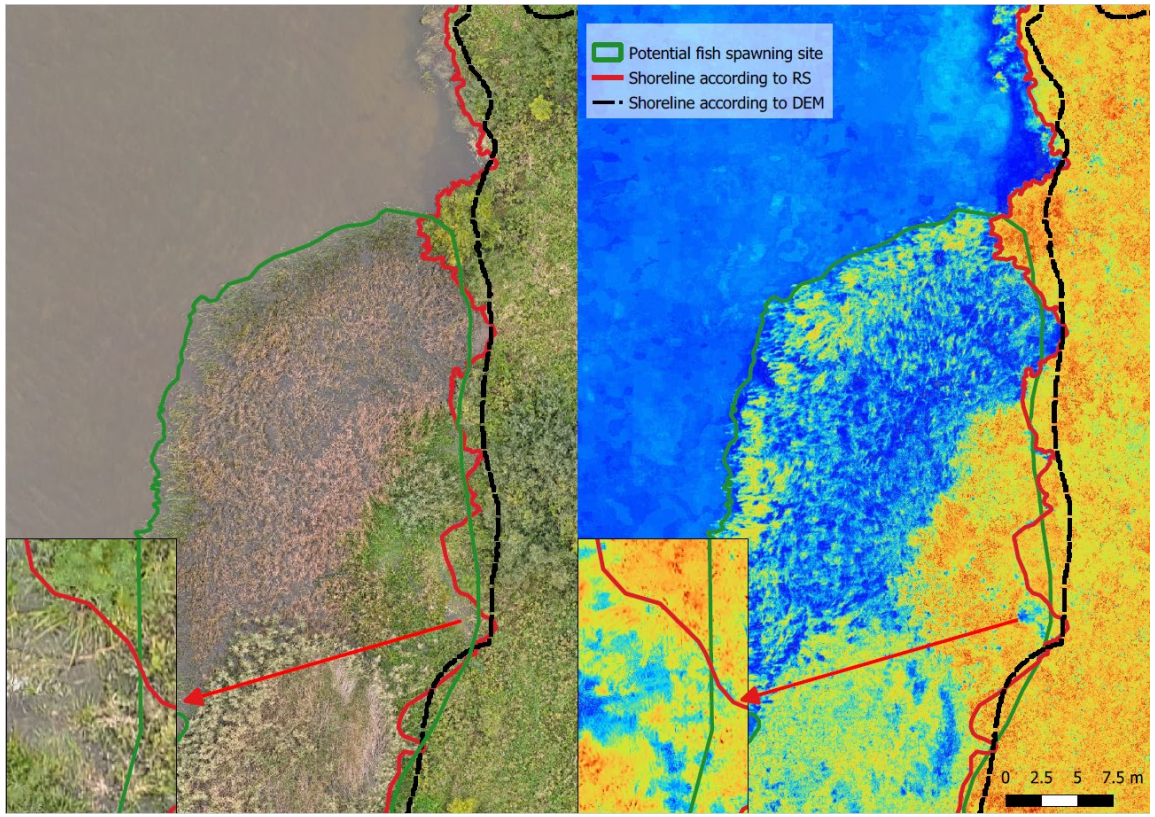


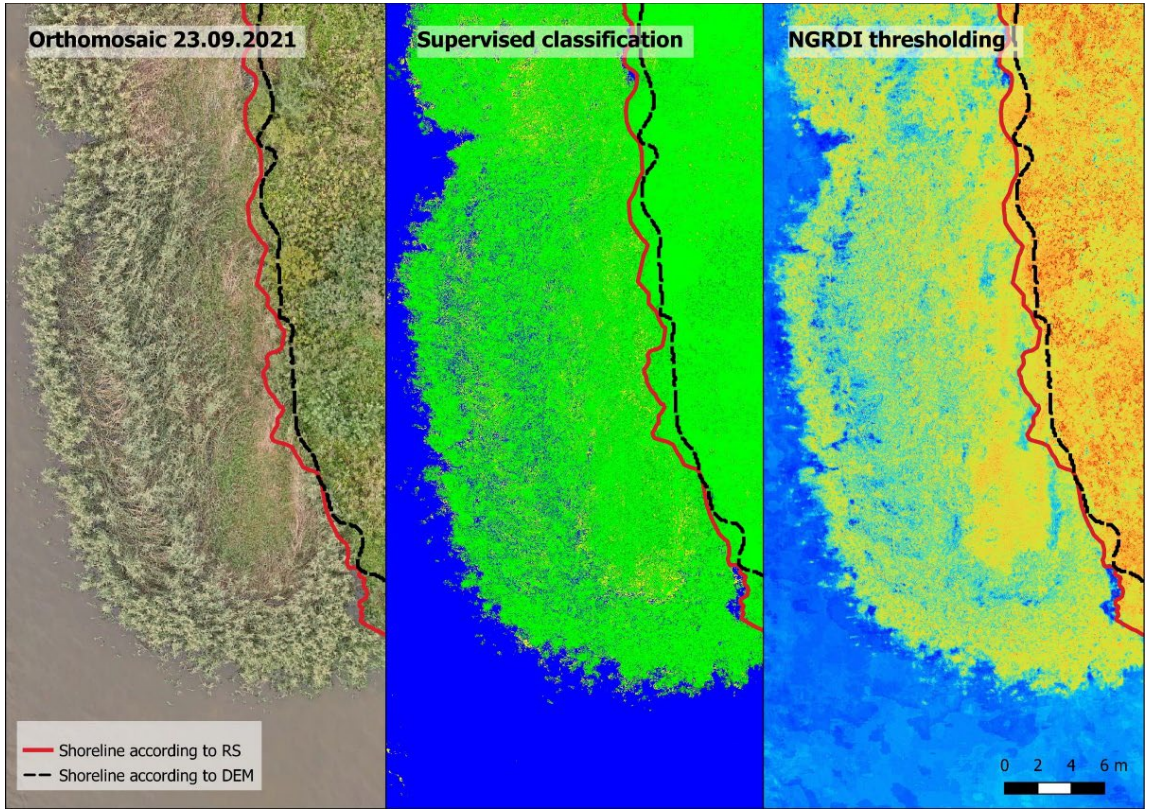


Orthomosaic | NGRDI Classification | NDWI Classification | Ortho Classification | NGRDI thresholding

Area with medium density aquatic macrophytes

Area with high density aquatic macrophytes

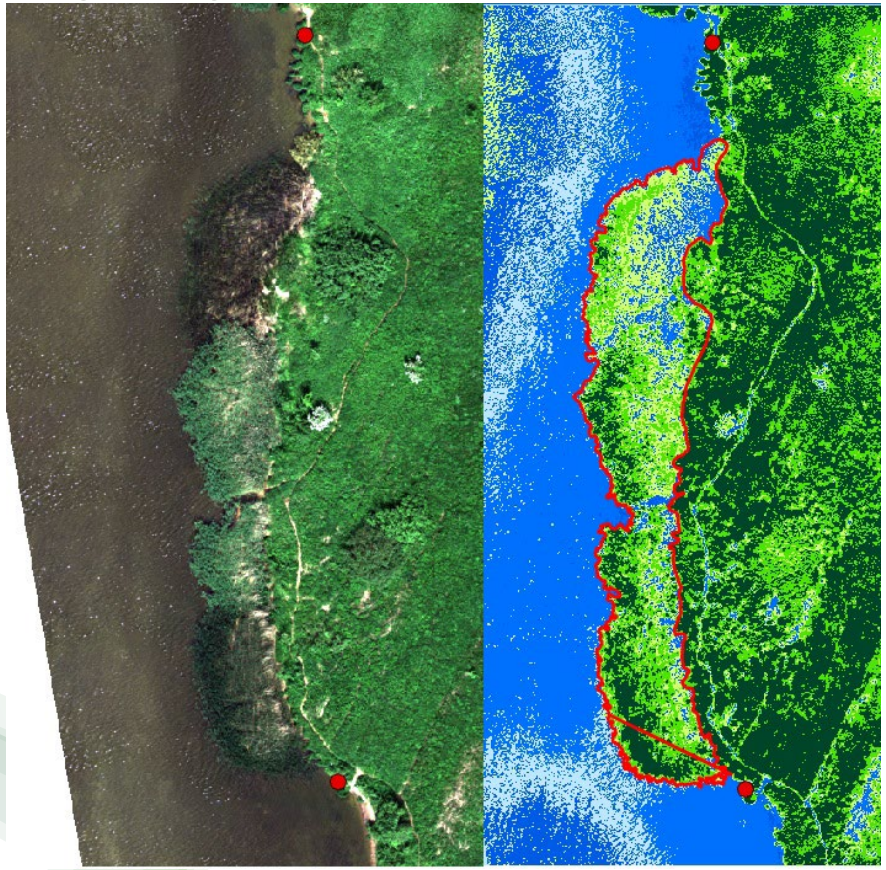


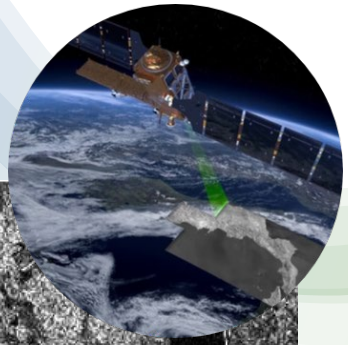


Observing shoreline from orthomosaic image

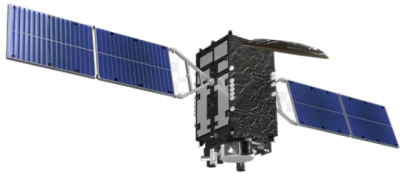
Jurevičius L., Punys P., Šadzevičius R., Kasiulis, E. Monitoring Dewatering Fish Spawning Sites in the Reservoir of a Large Hydropower Plant in a Lowland Country Using Unmanned Aerial Vehicles. **Sensors 2023**, (1):303

Identification of the fish spawning sites on a larger scale

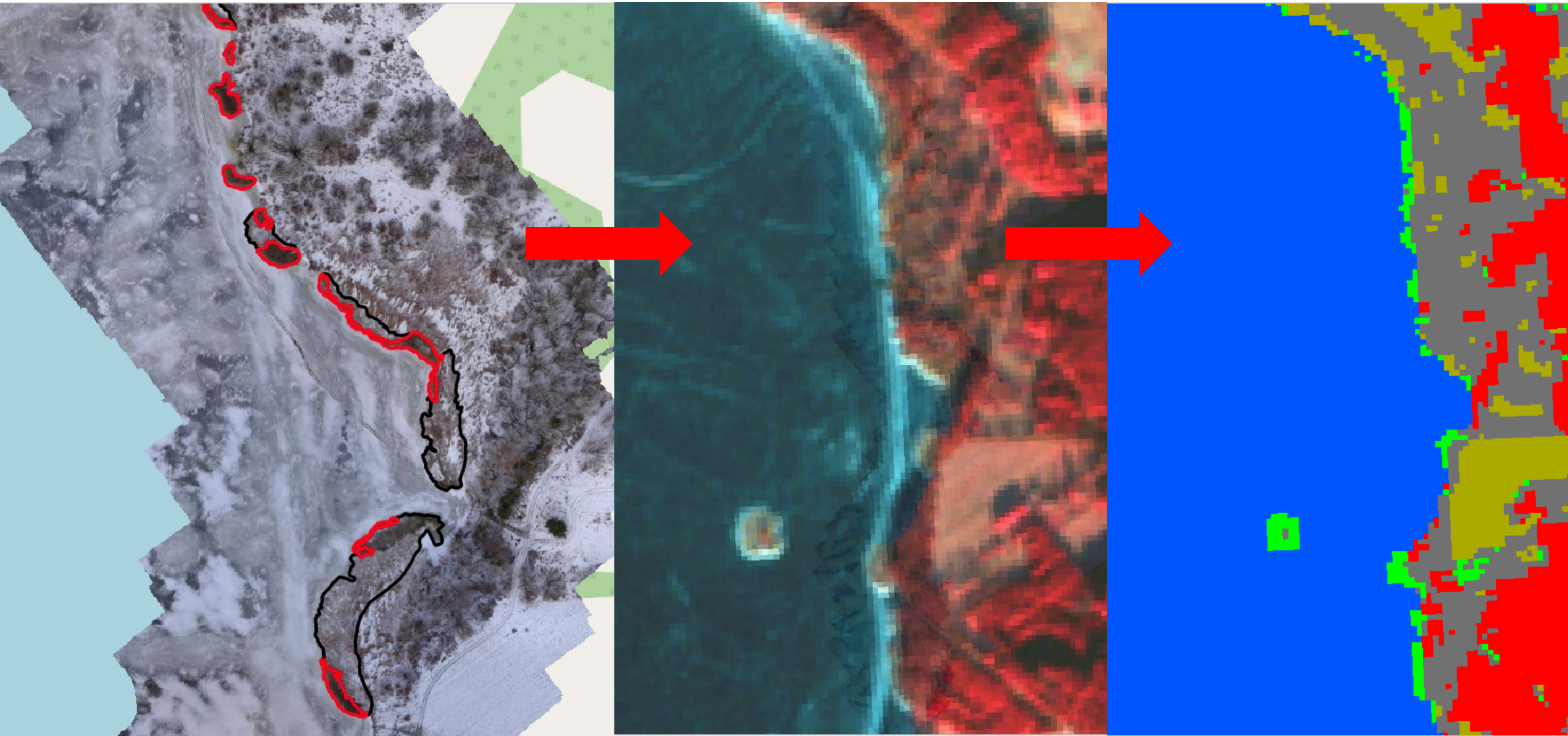




Analysis of the spectral reflections of high resolution multispectral orthomosaic images is the key part in order to to identify and classify fish spawning grounds



SUSHP 2023
Sustainability in Hydropower



Final thoughts

- With the modern research techniques, it is possible to analyze and monitor large and remote areas with difficult accessibility.
- This research provides insights how the water level fluctuations affect the fish spawning sites in the reservoir and alternative methodology for the nearshore surveillance.
- This knowledge would allow for a better decision making for efficient reservoir storage management based on quantitative assessments.

Thank you for attention

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