Behavioural responses of fish on underwater noise
- experimental approaches

Heikki Peltonen, Timo Tikka, Riikka Puntila, Jukka Pajala (Finnish Environment Institute)
Juha Lilja (Natural Resources Institute Finland)
Underwater sound

- All sounds in sea including natural and anthropogenic sounds constitute the **underwater soundscape**
- Natural sounds are induced by waves, rain, ice, thunder, earthquakes, animals etc.
- Noise is unwanted sound
- During the last 6 decades, noise levels in ocean increased by >3 dB per decade (= doubling of the sound power per area)
- In particular, noise from marine traffic has become a part of the underwater soundscape in large sea-areas
- Sounds are important for marine animals for finding prey, avoidance of predators, communication, orientation in space etc.
Impacts of noise

Loud and/or continuous anthropogenic underwater noise may damage individuals → impact populations → ecosystem-scale changes → losses in the ecosystem services etc.

(ES - many and varied benefits that humans freely gain from the sea - provisioning, regulating, supporting and cultural services)
Shipping - noise emissions and propagation

Modelled noise emissions (in energy)
125 Hz 1/3 octave band, March 2014
(Jalkanen et al., Karasalo et al., SHEBA)
Experiments on impacts of noise on fish in SHEBA

Why and how noise affects marine organisms are poorly understood, with only some aspects and an extremely small proportion of the marine organisms having been investigated.

In the *Baltic Sea*, lack of information on the biological impacts of noise e.g. to support impact assessment and management.

In fish experiments in SHEBA the goals were

- find the behavioral responses of fish to underwater shipping noise
- explore the sensitivity of hearing of the local fish species
- develop methods for noise sensitivity assessment
Methods

Experiments via exposure of fish in a net cage to underwater sounds via loudspeakers + observing fish with a multibeam imaging sonar

Location: Tvärminne Zoological Station, SW Finland
Imaging sonar

- Didson “acoustic camera”, 1.8 MHz
- Beam dimensions 30 ° (horizontal) * 15° (vertical), consisting of 48 slices
- Gives video-resembling images even in turbid water and in dim light
Didson imaging sonar, operating at 1.8 MHz, window length 12 m
Cone-shaped cage — in accordance to the beam shape of the sonar — detection of fish in the whole volume of the cage (dimensions L*W*D = 12*3*2.5 m)
The site
Fish species

In the experiments herring, freshwater bream, whitefish, perch, roach
Noise exposure

- recordings of underwater shipping noise + tones of 125, 500, 1000 and 8000 Hz

Typical ambient sound and signal SPL levels (1/3 octave bands) during experiments
Analyses

- in Didson videos, it is **difficult to track individual fish** in a dense fish school
- but preliminary observations supported that fish may form **denser schools when exposed to sounds**
- we programmed an **automated pattern recognition system** for tracking the fish school relying on **convex hull**
- convex hull is like a shape arising in 2d space when a rubber band is stretched around the items in a group
- convex hull → area and centroid of the school → changes in size and swimming speed school
Processing of the Didson video data
Observed behavioral responses of perch
– changes in school size

Fish school area (m²), species perch
Fish school area (m^2), species roach
Success

• We had success with imaging sonar + school tracking with video image analysis
• An alternative to behavioral experiments: measuring auditory evoked potential (AEP) from the ear or brainstem, but AEP does not include signal processing by the brains.
• In our experiments less handling of fish compared to AEP.
• Possibility for long-time exposure experiments → threshold shifts, habituation.
• We learned a lot about the potential of the experimental approach

Challenges

• Controlling of sound pressure levels (ambient + signal)
• Working with low frequencies - availability of loudspeakers
• Sound propagation in shallow water at the experimental site
• Particle motion was not included
• Working outdoors – all factors (e.g. weather) cannot be controlled
Ongoing modeling

Modeling of the impacts of sound – considering the school area and movements simultaneously.
To conclude...

To understand how healthy marine ecosystems can coexist with industrial and other anthropogenic activities we need to know sensitivity of species to understand which sounds are harmful and which are not. And we also need to know more about the soundscape in the sea.

This is the case in seas in general, and in the Baltic Sea in particular as it is a fragile ecosystem due to low number of species, shallowness, low water volume, lack of tides, high population density around, industrialized, multiple stressed, heavy shipping etc.

Experimenting is likely to be useful in learning about the sensitivity of species also in future.
Thank you for attention!

Acknowledgements
BONUS SHEBA project has received funding from BONUS (Art 185), funded jointly by the EU, Innovation Fund Denmark, Estonian Research Council, Academy of Finland, Forschungszentrum Jülich Beteiligungsgesellschaft mbH (Germany), National Centre for Research and Development (Poland) and Swedish Environmental Protection Agency