

Underwater Acoustics: Webinar Series for the International Regulatory Community

Webinar: Sound Exposure Criteria (for Fishes) and Their Development

Tuesday, November 27, 2018

12:00 pm U.S. (Eastern, Standard Time); 5 pm UK (London), 12:00 midnight China (Nov. 28, Beijing)

Sound Exposure Criteria (for Fishes) and Their Development

(Dr. Arthur N. Popper, Environmental BioAcoustics LLC & University of Maryland)

Email: apopper@umd.edu

Please note: This outline provides background information on topics that may be discussed in the webinar. However, because of time constraints, some items may not be included in the presentation but may be addressed in the question period.

Please refer to the earlier webinar by Dr. Radford on basics of fish bioacoustics (hearing and sound production) since that material will not be repeated here. An outline of Dr. Radford's presentation can be found on the DOSITS website, and a recording of his webinar will be posted shortly (<https://dosits.org/decision-makers/webinar-series/webinars-2018/>).

Webinar Outline:

- Why do fishes and humans hear?
 - Communication
 - Learn about the world around them – the soundscape
 - Anything that interferes with detection of the soundscape (or acoustic scene) can impact fitness and survival
- Reminder that fishes all fishes (including elasmobranchs) and invertebrates detect the particle motion component of sound, whereas only a limited number of fishes use sound pressure.
- When reviewing literature and seeing studies using fishes in tanks, take caution that the sound field is likely to have been very different than in the wild.
 - Hearing studies in tanks give poor data
 - Behavioral studies in tanks must be taken with great caution since animals do not behave in confined spaces as they would in the wild
- Some anthropogenic sources: Intermittent vs. continuous
- Potential effects of anthropogenic sound on fishes
 - Mortality
 - Physiological
 - Temporary threshold shift (TT)
 - Masking
 - Behavior
- Issues in understanding potential effects of anthropogenic sound on fishes
 - Few data
 - Hard to do studies, especially in the field
 - Far more species of fish than there are all other vertebrates combined, so how does one decide on species to study?

- Current US criteria developed in 2008 – out of date and not based on best available science. They are for onset of physical injury
- Behavioral criteria has one number for all species, and no scientific basis for that number
- UK criteria have significant weaknesses as well
- Recent studies that inform revised criteria has been on pile driving – we will discuss these studies (e.g., Halvorsen et al. 2012; Casper et al. 2017)
 - Based on lab studies of pile driving in specially designed tank
 - Overall findings who that current criteria for onset of physical injury from impulsive sound substantially lower than sound levels that actually affect fishes
- Current needs for decision makers
 - Criteria and guidelines based on best available science
 - Understanding what we do and do not know
- Updating criteria – Popper et al. (2014)
 - Based on best available science
 - Recent review of newer literature suggests no changes in these interim criteria
 - Based on groupings of sources and of fishes so we do not have to have criteria for every species or every source
- Still have substantial gaps in knowledge that must be filled if we are to improve criteria
 - Most important data needs is on behavior since many more fishes exposed to low level anthropogenic sound than to the highest level sounds near sources

Recommended Reading

- Casper, B. M., Halvorsen, M. B., Carlson, T. J. & Popper, A. N. (2017). Onset of barotrauma injuries related to number of pile driving strike exposures in hybrid striped bass. *The Journal of the Acoustical Society of America* 141, 4380-4387.
- Halvorsen, M. B., Casper, B. M., Woodley, C. M., Carlson, T. J. & Popper, A. N. (2012). Threshold for onset of injury in Chinook salmon from exposure to impulsive pile driving sounds. *PLOS ONE* 7, e38968.
- Hawkins, A. D., Pembroke, A. & Popper, A. (2015). Information gaps in understanding the effects of noise on fishes and invertebrates. *Reviews in Fish Biology and Fisheries* 25, 39-64.
- Hawkins, A. D. & Popper, A. N. (2016). Developing sound exposure criteria for fishes. In *The Effects of Noise on Aquatic Life II* (Popper, A. N. & Hawkins, A. D., eds.), pp. 431-439. New York: Springer.
- Hawkins, A. D. & Popper, A. N. (2018). Effects of man-made sound on fishes. In *Effects of Anthropogenic Noise on Animals* (Slabbekoorn, H., Dooling, R. J., Popper, A. N. & Fay, R. R., eds.), pp. 145-177. New York: Springer Nature.
- Popper, A. N., Hawkins, A. D., Fay, R. R., Mann, D. A., Bartol, S., Carlson, T. J., Coombs, S., Ellison, W. T., Gentry, R. L., Halvorsen, M. B., Lokkeborg, S., Rogers, P. H., Southall, B., Zeddis, D. & Tavolga, W. A. (2014). *ASA S3/SC1. 4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI*. New York: Springer.
- Popper, A. N. & Hawkins, A. D. (2018). The importance of particle motion to fishes and invertebrates. *The Journal of the Acoustical Society of America* 143, 470-486.

Additional information on the DOSITS website:

Science of Sound > Advanced Topic > Sound Pressure Levels and Sound Exposure Levels

(<http://www.dosits.org/science/advancedtopics/soundpresslevelsandsoundexplevels/>)

Animals and Sound > Potential Effects > How do you determine if a sound affects a marine animal?

(<http://www.dosits.org/animals/effectsofsound/howdoyoudetermineifasoundaffectsamarineanimal/>)

Animals and Sound > Potential Effects, Marine Fishes

(<http://www.dosits.org/animals/effectsofsound/effectsofsoundonfish/>)

Animals and Sound > Potential Effects, Marine Fishes > Behavioral Changes

(<http://www.dosits.org/animals/effectsofsound/effectsofsoundonfish/behavioralchanges/>)

Animals and Sound > Potential Effects, Marine Fishes > Masking

(<http://www.dosits.org/animals/effectsofsound/effectsofsoundonfish/fishmasking/>)

Animals and Sound > Potential Effects, Marine Fishes > Hearing Loss

(<http://www.dosits.org/animals/effectsofsound/effectsofsoundonfish/hearingloss/>)

Animals and Sound > Potential Effects, Marine Fishes > Physiological Stress

(<http://www.dosits.org/animals/effectsofsound/effectsofsoundonfish/physiologicalstress/>)

Animals and Sound > Potential Effects > How can we moderate or eliminate the effects of human activities?

(<http://www.dosits.org/animals/effectsofsound/howcanwemoderateoreliminatetheeffectsofhumanactivities/>)