Agenda Item 5	Review of New Information on Threats to Small Cetaceans (reporting cycle 2016 only) Disturbance Underwater Noise
Document Inf.5.1.1.a	**Comments on ASCOBANS monitoring and reporting process with regards to underwater noise affecting cetaceans**
Action Requested	• Take note
Submitted by	Peter Tyack

NOTE:
DELEGATES ARE KINDLY REMINDED
TO BRING THEIR OWN COPIES OF DOCUMENTS TO THE MEETING

Secretariat's Note

The Rules of Procedure adopted at the 19th Meeting of the ASCOBANS Advisory Committee remain in force until and unless an amendment is called for and adopted.

Comments on ASCOBANS monitoring and reporting process with regards to underwater noise affecting cetaceans.

Peter Tyack

The ASCOBANS reporting process for underwater noise affecting cetaceans distinguishes between acute incidents vs cumulative effects. I agree with this fundamental distinction, but I think that both reporting processes could be improved to better meet conservation and management goals.

Reporting for acute incidents linked to intense impulse sounds

The sound sources that are relevant for reporting incidents are those that can cause acute injury or death to marine mammals. All of the noise sources demonstrated to cause acute injury or death to marine mammal are impulsive. These include explosions (Ketten 1995) and mid-frequency (1-10 kHz) naval sonar (D'Amico et al. 2009). There is also some evidence that seismic surveys can cause strandings, but this is weaker than for explosions and naval sonar.[1] These are the sources for which it is important to focus on individual incidents where the source may injure or kill a marine mammal.

The ICES registry of impulsive noise events could assist in the analysis of whether incidents such as stranding are associated with anthropogenic impulse noise. However, these analyses require comparisons between sites known to have high or low levels of impulse noise. Currently the ICES registry lacks entries from some ASCOBANS countries, and none of the national entries appear to form complete lists of any sonar, echosounder, airgun, and explosion exposures occurring in their waters. If reporting is to play a constructive role in environmental risk analysis, it would be much better to have complete reporting from well-defined areas, even if these areas are a subset of national waters, than to have incomplete reporting from unspecified areas. If users of the current registry cannot have confidence that it is complete and accurate, then it will have limited utility. Analyses of associations between strandings and exposure to sound sources that just rely on user reports about when and where they transmit have been hampered if they do not have measurements of what sounds were in the water. A critical ground truth for the registry of intense impulsive sounds would involve making recordings in ocean regions predicted to have high and low levels of these sounds. A limited number of recorders may suffice for this task because intense sounds can travel long distances in areas with good sound propagation. For example, Nieukirk et al (2004) recorded 4 species of whales near the mid-Atlantic ridge along with airgun pulses from seismic surveys that could be recorded on one recorder from as far as Canada, Brazil, and West Africa. Propagation will be less efficient in the shallow ASCOBANS seas, but propagaton modeling can inform strategies for selecting the number and locations of recorders required to sample defined areas.

[1] There is some evidence associating strandings of beaked whales with airguns used for seismic surveys and a 12 kHz multi-beam echosounder operated during a seismic survey was also implicated by Southall et al. (2013) as the most likely cause of stranding and death of at least 75 delphinids.

A few underwater recorders strategically placed using sound propagation models and the geographical data from the registry should be able to provide ground truthing data on all of the intense impulse sources that would be critical for analyses of coincidence between acute incidents and operation of these sources. Establishing empirical monitoring of sound in strategic ocean areas would be practical and cost effective. Given the frequency range of these sound sources and frequency dependent attenuation of sound in the sea, acoustic sampling rates used in commercial audio (~44 kHz) should be fine for this purpose. A variety of underwater recorders are available commercially, and international standards for ocean noise data are being established for underwater acoustics by ISO DIS 18405 (ISO 2012) and for regulation of intense impulse sounds such as pile driving (de Jong et al. 2011). Thriving academic communities of marine bioacousticians and ocean acousticians are very capable of analyzing these kinds of ground truthing in many of the ASCOBANS signatory countries.

Reporting for cumulative effects of underwater sound on marine mammals.
Changing focus from acute incidents to cumulative effects requires changing the time scale from hours to years. Regulations on cumulative effects often organize the information by each human activity. The ASCOBANS reporting scheme for impulsive noise follows this pattern. But to understand the cumulative effects of human activities on marine mammals requires a focus not on human activities, but rather on the relevant marine mammal population or ecosystem on which it depends. The key issue is what are the natural and anthropogenic stressors that the population and its prey, predators, and competitors are exposed to (NRC 2016).

An approach to assessing this kind of environmental risk was initially developed to assess risk to human health from toxic chemicals (NRC 1983), and this approach now has been applied to assess risks of many hazards to humans and to wildlife. The basic approach calls for mapping the distribution of the hazard and comparing this to the distribution of humans or animals to assess the probability of exposure. Assessing the distribution of chemicals often requires mapping the locations of each human activity that discharges each chemical. It seems complex and burdensome to require every human activity producing noise in the ocean to report on where and when it produces noise. Luckily the more relevant information is what sounds occur in the ocean where the animals are. This can be measured directly more easily and more precisely than can be estimated from lists of where each human source is reported to operate.

This risk assessment approach requires measurement of noise in different areas. One important strategy for efficient sampling is to identify animal hot spots and areas predicted to have high or low noise. Stationary activities, such as ports, oil fields or wind farms, that will be broadcasting for long time periods in one place also will be noise hot spots that require monitoring. The major source of anthropogenic noise comes from commercial shipping, and some of the most intense shipping traffic goes through areas such as the English Channel to ports such as Rotterdam. Correlating noise from ships in these areas with data on each individual ship from the Automated Identification System may enable better prediction of the acoustic fields generated by different scenarios for ship traffic.

ASCOBANS reporting for cumulative effects may be able to assess the areas with highest probability of exposure by comparing the distribution of anthropogenic noise to the distribution of marine mammals. Estimating potential impacts could be refined by comparing the frequency distribution of noise (which requires broad band recordings) to the hearing capacities of different species, ideally including both marine mammals and their prey. If noise sources can be displaced far enough away from critical marine mammal habitats through spatial planning of marine activities, then this may suffice to maintain good environmental status. However, marine mammals are so mobile and sound carries so far in the ocean that there will be many cases where marine spatial planning cannot prevent exposures that might cause harm. In this case research is essential to establish dose:response relationships for effects of noise on marine mammals that can be used to estimate the consequences of different levels of exposure.

For an example in the ASCOBANS area, a series of studies have established the spatial and temporal scales over which harbour porpoise will avoid noise such as sounds of construction of windfarms. Nabe-Nielsen et al. (2014) have used such data to assess the cumulative impact of noise and bycatch on harbor porpoise populations in Danish waters. If the exposure of a development is assessed as potential posing an unacceptable risk, then strategies can be developed to manage the risk. The Nabe-Nielsen study found that harbor porpoise populations were sensitive to mortality from bycatch and from depletion of their prey, but that noise from ships and proposed new windfarms was unlikely to have an effect. This kind of study of cumulative effects helps both define management priorities to protect populations and also to identify critical data gaps. Note how important it is that assessment of cumulative effects not be limited to noise, but include all the major stressors that may affect marine mammal populations.

Models such as the one developed by Nabe-Nielsen et al. (2014) can predict the long-term effects of exposure to noise based upon shorter term dose:response studies. Monitoring programs can be designed to test these predictions, a critical feedback loop for management. One response of wildlife to noise that is particularly well suited to this kind of monitoring involves avoidance of noisy areas, which can reduce the habitat available to wildlife, and if carried too far may reduce the quality of the ocean environment for marine mammals. The same methods used to record ocean noise can also be used to detect the calls of marine mammals, which can in turn identify responses to noise (e.g. Tyack et al. 2011) or changes in abundance in different regions (e.g. Marques et al. 2013). Careful selection of locations to record that include similar densities of wildlife in areas predicted to receive higher or lower levels of noise are very promising for providing data on the cumulative effects of chronic exposure (Tyack et al. 2014). It would help this kind of study for ASCOBANS to include reporting about planned noise-producing developments with enough lead time to study animal densities before, during, and after exposure to noise. Ideally the ASCOBANS reporting should be integrated into a quantitative risk assessment process that can iteratively improve information available for critical environmental decision making.

Questions

Acute Incidents and Impulse Noise

- How sure is each nation that your ICES registry of impulsive noise events is complete and accurate?
- What evidence can you provide to ground truth the completeness and accuracy of reporting?
- If you are not certain that the data are complete, what purpose do you see for the registry?
- Would you support a strategic program to record ocean noise for ground truthing?
- Is enough information available to identify areas expected to have high or low levels of anthropogenic noise? High or low abundance of marine mammals?
- Are there specific subareas in the waters under your jurisdiction for which you can provide complete and accurate records of impulse noise?
- Could acoustic monitoring target areas of high abundance of marine mammals and expected increases or decreases in noise to monitor for effects of changes in exposure?

Cumulative Effects

- Do you have a geographical database for marine mammal abundance and density that can be compared with maps of noise and other stressors?
- Do you maintain reporting of stressors other than noise, such as chemical pollution or bycatch?
- How confident are you whether marine mammal populations in your waters are growing, stable or declining?
- Can you use marine spatial planning to prevent exposure of marine mammals to noise?
- If not, are data available to you to estimate the effects of different levels of exposure to relevant noises to relevant marine mammal species?
- How do you assess the cumulative impact of exposure of cetaceans to noise in your waters? Of cumulative impacts of noise along with other stressors?
- Do you have a monitoring scheme that can test your estimates of impact?

Literature Cited

D'Amico AD, Gisiner R, Ketten DR, Hammock JA, Johnson C, Tyack P, Mead J. 2009. Beaked whale strandings and naval exercises. *Aquatic Mammals* 35:452-472

De Jong, C.A.F., Ainslie, M.A. and Blacquière, G., 2011. Standard for measurement and monitoring of underwater noise, Part II: procedures for measuring underwater noise in connection with offshore wind farm licensing. Report no. TNO-DV, p.C251.

ISO (2012). ISO/TC 43/SC 3 Underwater acoustics (International Organization for Standardization, Geneva), http://www.iso.org/iso/standards_ development/technical_committees/other_bodies/iso_technical_committee.htm?commid=653046, last accessed 11 August 2014.

Ketten, D.R., 1995. Estimates of blast injury and acoustic trauma zones for marine mammals from underwater explosions. Sensory systems of aquatic mammals, pp.391-407.

Marques TA, Thomas L, Martin S, Mellinger D, Ward J, Tyack P, Moretti D. 2013. Estimating animal population density using passive acoustics. Biological Reviews. doi: 10.1111/brv.12001

Nabe-Nielsen, J., Sibly, R.M., Tougaard, J., Teilmann, J. and Sveegaard, S., 2014. Effects of noise and by-catch on a Danish harbour porpoise population. *Ecological Modelling*, *272*, pp.242-251.

National Research Council (1983) Risk assessment in the federal government: managing the process. National Academy Press, Washington DC.

National Research Council (2016) Approaches to Understanding the Cumulative Effects of Stressors on Marine Mammals. National Academy Press, Washington DC.

Nieukirk, S.L., Stafford, K.M., Mellinger, D.K., Dziak, R.P. and Fox, C.G., 2004. Low-frequency whale and seismic airgun sounds recorded in the mid-Atlantic Ocean. The Journal of the Acoustical Society of America, 115(4), pp.1832-1843.

Southall, B.L., Rowles, T., Gulland, F., Baird, R. W., and Jepson, P.D. 2013. Final Report of the Independent Scientific Review Panel Investigating potential contributing factors to a 2008 mass stranding of melon-headed whales (*Peponocephala electra*) in Antsohihy, Madagascar.

Tyack PL, Zimmer WMX, Moretti D, Southall BL, Claridge DE, Durban JW, Clark CW, D'Amico A, DiMarzio N, Jarvis S, McCarthy E, Morrissey R, Ward J, Boyd I. 2011. Beaked whales respond to simulated and actual navy sonar. PLOS One 6(3):e17009

Tyack PL, Frisk G, Boyd I, Urban E, Seeyave S. (2014) International Quiet Ocean Experiment Science Plan. http://www.scor-int.org/IQOE/IQOE_Science_Plan-Final.pdf