POSSIBLE STEPS TOWARDS REDUCING IMPACTS OF SHIPPING NOISE

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ABSTRACT

Concerns about increases in offshore ambient noise due to commercial shipping have resulted in a work program by the International Maritime Organization to develop technical guidelines to reduce shipping noise. Targets to reduce the contribution from shipping noise to ambient noise have also been endorsed by the IWC Scientific Committee. At frequencies below 300Hz, the underwater noise signature from large vessels will be dominated by propeller cavitation and the noisiest vessels are likely to be those that suffer excessive cavitation. Based on the distribution of source levels across merchant fleets, the noisiest 10% of vessels may contribute between around 48% and 88% of the total sea area ensonified by shipping noise to a given level, depending on assumptions about propagation conditions. Thus noise reduction targets could most easily be achieved by targeting measures at a relatively small percentage of the noisiest vessels. These measures may also result in efficiency savings which could pay back initial costs within 1 or 2 years. Reductions in overall ambient noise achieved through quieting the noisiest vessels may also assist whales in avoiding collisions with quieter vessels and contribute to a reduction in ship strike mortality. Many data gaps remain in the understanding of factors that contribute to the variation in noise output from different vessels and there is a clear need for systematic studies of vessel noise. The equipment and deployment of recording devices for studies of whale vocalisations, combined with individual vessel tracking, may provide opportunities to obtain data on noise signatures from ships.

INTRODUCTION

The primary concern regarding potential adverse impacts of incidental shipping noise on marine mammals is not related to acute exposures, but rather to the general increase in ambient noise (IMO, 2008a). Studies have suggested that there has been a 10-12dB increase in offshore marine ambient noise in the 10-50Hz range during the last 40 years, attributed primarily to increased commercial shipping (McDonald *et al*. 2006). At its 2008 meeting, the IWC Scientific Committee endorsed as a target a reduction in the contribution of shipping to ambient noise levels in the 10-300Hz range by 3dB in 10 years and by 10dB in 30 years relative to current levels. This target was proposed at an International Workshop on Shipping Noise and Marine Mammals held in Hamburg in April 2008 (Anon, 2008) and achieving it will require changes within the shipping industry, particularly because shipping tonnage is predicted to increase. Nevertheless, international workshops, including two symposia hosted by NOAA (Southall, 2005; Southall and Scholik-Schlomer, 2008) have suggested that substantial reductions (5-20dB) in noise emissions could be achieved for most types of vessel at relatively little cost without major technical innovation.

In the past few years, there has been increasing international recognition of the potential impact of shipping generated noise on marine life. Recent legislation such as the EU Marine Strategy Framework Directive and international conventions, such as the UN Convention on Migratory Species (CMS) and its daughter agreements, recognise underwater noise, including noise from shipping, as a form of pollution that needs to be addressed (EU, 2008; CMS 2008, ACCOBAMS 2007 and ASCOBANS 2006).

Based on a proposal by the USA, the International Maritime Organization (IMO) added "Noise from commercial shipping and its adverse impact on marine life" as a high priority item to the work program of its Marine Environment Protection Committee (MEPC) in October 2008 and established a correspondence group to work on the development of non- mandatory technical guidelines for ship-quieting technologies as well as potential navigation and operational practices (IMO, 2008b). The target completion date for this work should be either MEPC 61 (October 2010) or MEPC 62 (July 2011) but progress reports will be submitted to each intervening session of the MEPC. The IMO correspondence group report (IMO, 2009) will be discussed at the 59th meeting of the MEPC in July 2009. Issues that have arisen in the course of discussions include the need for a better understanding of noise output from large commercial vessels, the need to target noise reduction measures towards vessels that contribute most to overall noise impacts on cetaceans, and the relationship between vessel noise and ship strikes.

Understanding noise output from large commercial vessels

As a contribution to the work of the IMO, IFAW funded a study to look at possible ways of reducing underwater noise pollution from large commercial vessels (Renilson, 2009). The report identified many data gaps in the understanding of shipping noise. In particular, there is a lack of standard methods for conducting and analysing full scale noise measurements from commercial vessels. The ISO Technical Committee on Ships and Marine Technology is also currently developing measurement methods and formats for reporting data on underwater noise from vessels (Piersall, 2009). There is also a general lack of data on noise output from large commercial vessels across a range of operating conditions, for example when fully laden or in ballast.

Acoustic systems designed to monitor baleen whale vocalisations generally cover the frequency ranges that are of most concern in terms of shipping noise. Long term deployments of acoustic recording devices may also provide opportunities to study the contribution of shipping to background noise (e.g. Andrew *et al*., 2002; McDonald *et al*. 2006) but also to relate noise measurements to transits by individual vessels (e.g. Hatch *et al*., 2008). Many of the technologies developed for studying whale acoustics could also be effectively applied to monitoring noise output from individual vessels, particularly when combined with tracking individual vessels using Automatic Identification Systems (AIS). There is considerable potential to address some of the data gaps identified in understanding the factors related to hydro-acoustic noise from ships by using data collected during studies of marine mammals. Studies using towed hydrophones to monitor marine mammal vocalisations may also provide information on individual vessels and how noise levels change with speed and operating conditions (e.g. Leaper and Scheidat, 1998).

Targeting noise reduction measures across shipping fleets to optimum effect

The combined contribution of individual vessels to overall ambient noise will be complex and depend on propagation conditions along the route of the vessel, particularly with respect to surface ducting and water depth.

Reducing the contribution of shipping to ambient noise levels at an ocean basin level will require addressing the ships that make the greatest contribution. NRC (2003) recommended calculation of the relative contribution made by individual sound sources to overall noise levels to establish a 'noise budget' within an area. Hatch *et al*. (2008) present such calculations for the contribution of shipping noise to the Stellwagen Bank National Marine Sanctuary. They calculated the relative contribution of different vessel types in terms of total acoustic power based on source levels and total time spent within the area.

Although contribution to total acoustic power is a good measure, it does require considerable data. One simple approximate measure of the likely relative contribution of an individual ship is its 'acoustic footprint' – or the area of ocean ensonified to a particular noise level. This area increases exponentially with source level

$$A = 10^{\left(2 \times \frac{(SL-T)}{L}\right)}$$

Where A is the area of the acoustic footprint, T is the noise threshold used to define the footprint and the loss in dB with distance r is expressed as $L\log r$. For cylindrical spreading, L will be 10 and for spherical spreading L will be 20. Empirical measurements have suggested that L=15 is a good approximation in many areas (Hatch *et al*., 2008). A commonly used value for T is 120dB re 1μPa. Hatch *et al*. (2008) present estimates of the distances at which the received level from vessels where source levels had been measured was expected to be below120dB re 1μPa. These distances ranged from 380m for a research vessel up to 26km for an oil tanker.

For widely spaced ships across ocean shipping routes (giving minimal overlap in acoustic footprints), the total acoustic footprint will be the sum of the areas from each individual vessel. The proportion of the total contributed by each individual vessel is an approximate, but nevertheless useful, indicator of the likely proportional contribution of that vessel to overall shipping noise. Wales and Heitmeyer (2002) measured noise from 54 vessels and found source levels across the 30–150Hz frequency band to be approximately normally distributed with a standard deviation of 5.3dB. Figure 1 illustrates the proportion of the total acoustic footprint in relation to the distribution of source levels across all vessels assuming a normal distribution and standard deviation of 5.3dB, for different assumptions about propagation loss. In all cases, vessels that are quieter than average contribute 10% or less to the total acoustic footprint. The noisiest 10% of vessels, i.e. those that are 6.8dB or more above average, will contribute between 48% and 88% of the total acoustic footprint.

In many coastal areas, the localised vessel noise will be more important than the off-shore ambient noise. In these situations there may be a need to reduce noise output for specific vessels that operate in important areas of whale habitat. These vessels may not necessarily be the noisiest in terms of the global merchant fleet.

A key conclusion of Renilson (2009) is that there is scope for reducing noise from the noisiest large commercial vessels which are assumed to have poor wake flow or less than optimal propeller design. These noise reduction measures could be achieved alongside possible increases in efficiency. For vessels that are already operating at optimum efficiency there is unlikely to be scope for reducing noise without some loss in efficiency. However, these vessels are likely to be towards the quiet end of the distribution of noise levels.

Is there an increased risk of ship strikes from quieter vessels?

One concern that has arisen in the context of discussions within IMO on reducing shipping noise is that making ships quieter may increase the risk of collisions with cetaceans. Acoustic cues are likely to be the main factors that alert a whale to an oncoming ship that may pose a risk of collision. As yet there is little information on how whales interpret such cues and how vessel noise relates to collision risk. Whales are likely to be aware of the presence of a large ship within a few kilometres but many whales will have been exposed to heavy levels of shipping noise throughout most of their lives, and so may not respond until the ship gets very close. In addition, the whale response to an acoustic stimulus may not necessarily reduce collision risk (Nowacek *et al*., 2003). It is therefore difficult to predict the effect of ship noise on collision risk but it seems reasonable to assume that risk would increase in conditions of high ambient noise levels and possibly relate to the signal-to-noise ratio of the sound from an approaching vessel. If this is the case then reducing the noise of the noisiest ships will also reduce the overall risk of ship strikes, since for a given speed the quietest vessels would pose the greatest risk. For example, taking a mean source level of 175dB and a standard deviation of 5.3dB for vessel assemblages (Wales and Heitmeyer, 2002) if whales reacted to vessel noise at 125dB this would put whales within 200m of the ship's propeller when they reacted for 24% of vessels, assuming simple spherical spreading. With a 3dB reduction in ambient noise this would reduce to 10% of vessels.

DISCUSSION

Based on the technical measures for potential noise reduction reviewed in Renilson (2009), it does seem possible that the target endorsed by the Scientific Committee of a reduction in the contribution of shipping to ambient noise levels in the 10-300Hz range by 3dB in 10 years could be achievable by tackling a small proportion of the global merchant fleet comprising of the noisiest ships. At frequencies below 300Hz, the underwater noise signature from large vessels will be dominated by propeller cavitation and the noisiest vessels are likely to be those that suffer excessive cavitation. Improving wake flow or propeller design on such vessels should reduce noise and may result in improvements in efficiency. Noise reduction achieved alongside improvements in efficiency may pay back initial costs within 1 or 2 years. (Renilson, 2009).

Despite considerable research into the noise output of certain types of vessel (mainly military and research vessels) there is still a relatively poor understanding noise output from large commercial vessels and a need for more data. In particular, there is a need for a large data set of full scale measurements on ships where the design features likely to influence noise are known. Hydrophone deployments for marine mammal studies combined with AIS data have the potential to contribute to these data sets.

Finally, the underwater noise environment is likely to affect the risk of collisions with cetaceans. If it is assumed that the greatest risk will be from the quiet vessels operating in noisy environments, then reducing ambient noise from shipping through noise reduction measures for the noisiest ships should reduce the overall collision risk. Even in areas of high background noise from sources other than shipping it seems unlikely that reducing the noise levels for the noisiest ships could result in any significant increase in collision risk. Where shipping density is high, it is likely that noise levels will also be elevated. For example, Hatch *et al*. (2008) found that locations subject to high ship traffic experienced double the acoustic power of less trafficked areas. Thus areas of high collision risk are also likely to have elevated noise levels due to shipping.

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Figure 1. Relative contribution to total 'acoustic footprint' by proportion of total merchant fleet ranked by noise levels