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AMBIENT SEA NOISE IN AUSTRALIAN WATERS

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Abstract

The wide range of oceanic conditions around Australia result in wide variation in the characteristics and the levels of ambient sea noise, showing significant differences to observations of noise in the northern hemisphere. Contributions from independently varying sources result in variations in noise level of more than 30 dB with variations of up to 20 dB occurring commonly. Spectral shapes vary widely depending on the dominant sources at the time. Because of low levels of traffic noise in many areas, sea surface generated noise is often dominant at low frequencies (below about 200 Hz) in contrast to most northern hemisphere observations. Biological noise is usually dominant in tropical waters, except for conditions of high winds or heavy rain. Biological choruses that result when countless fish or invertebrates are calling are widespread in tropical and temperate waters, some showing regular diurnal variation. These choruses are often rise more than 20 dB above the background noise. Intense transient signals from whales also make significant contributions to the ambient noise.

Introduction

The low absorption attenuation of sound in water allows sources at long distances (up to thousands of kilometres) to contribute to the ambient background noise in the ocean. This results in high and variable noise levels. The first studies of ambient noise (Knudsen, Alford and Emling, 1948) identified the main sources of noise in shallow water as (a) water motion near the sea surface (breaking waves), (b) marine life and (c) shipping. Wenz (1962) refined the interpretation of the ambient noise, based on a large series of measurements. He defined "traffic noise" as the background noise from distant shipping, in which no single ship was detectable. Noise from the sea surface was found to correlate better with wind speed than with surface wave properties and so became known as "wind dependent noise".

Studies in Australian waters have shown that there are significant differences in the noise compared to the colder Northern Hemisphere waters where most measurements have been made, though the broad categorisation of Wenz remains applicable. Some differences are due to the different environment of tropical waters, particularly in respect to noise from marine animals. Other differences are due to lower shipping densities which result in lower traffic noise but also reveal other components of noise usually masked by traffic noise in the northern hemisphere measurements.

This paper reviews ambient noise in Australian waters, based on many different studies around the continent. Figure 1 summarises the main components of ambient noise and may be used for noise prediction.

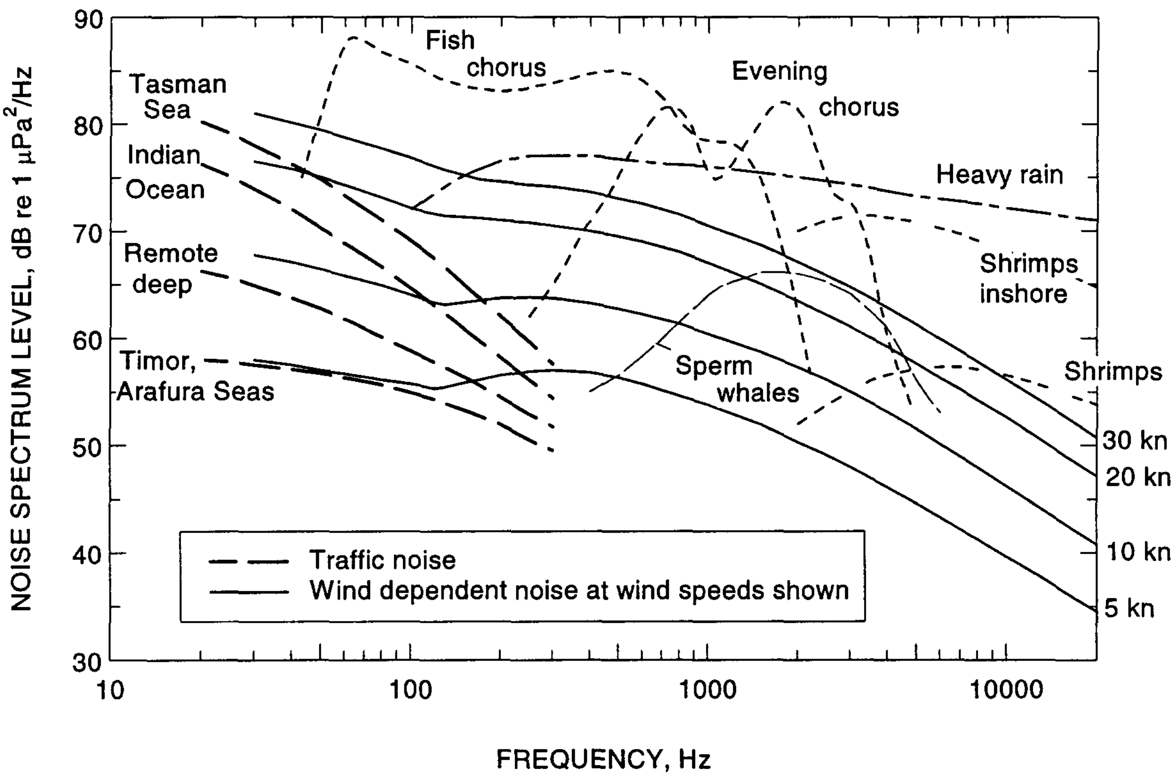

Figure 1. Representative components of ambient noise in Australian waters. Traffic and wind dependent noise spectra are averaged values, and significant variation about these averages may be observed. The spectra for the biological chorus are typical of values at the maximum of diurnal variation. Shrimp noise is shown as the typical spatial range of values from open water to very shallow water close to shore or in bays.

Traffic noise

Traffic noise around Australia varies widely as a result of the wide variation in the concentration and distribution of shipping, and in the propagation conditions (Cato, 1976). Traffic noise levels, averaged for each oceanic region, vary by more than 20 dB between regions. There is also significant temporal variation (around ± 5 dB) about the regional averaged levels shown in Fig. 1. The highest levels are on and near the continental shelf of the Tasman Sea off the east coast, where the propagation is good along the shelf and in deep water, and there is considerable shipping. Traffic noise levels there are almost as high as those presented by Wenz (1962) for the North Atlantic Ocean.

In the Indian Ocean off the west coast, propagation conditions are similar but shipping densities are lower, leading to lower traffic noise levels. The curve marked "remote deep" in Fig. 1 refers to deep waters where shipping densities are lower still, such as the Southern Ocean. In some of the shallow tropical seas north of Australia such as the Arafura and Timor Seas, shipping densities are low, long range propagation in the shallow water is poor, and traffic noise is usually masked by other components of noise (e.g. wind dependent and biological noise). It is at least 20 dB less than in the Tasman Sea. Very low levels of traffic noise are also observed in partially enclosed waters such as gulfs. Actual traffic noise levels vary with location in any region between the representative values shown in the figure, for example they will decrease moving south from the Indian Ocean to the Southern Ocean.

Wind Dependent Noise

The generally low traffic noise in many of the oceanic areas near Australian provides a good environment to measure wind dependent noise, especially at low frequencies. Figure 1 shows averaged spectra in open oceanic waters for different wind speeds. At frequencies above about 200 Hz the wind dependent noise spectra of Fig. 1 are similar to the spectra of Wenz (1962) which showed a broad peak at around 500 Hz. Below 200 Hz in Fig. 1, there is evidence of a second component, providing high levels of noise at low frequencies. This component was not included in the prediction methods of Wenz, and consequently does not usually appear in other sea noise prediction methods. The reason is that it is difficult to measure in the high shipping areas where most of these measurements were made, because of the masking by traffic noise. Wenz's data do, however, show evidence of this component in a small number of measurements, a point that Wenz noted.

The generally lower traffic noise around Australia compared with the waters of measurement in the Northern Hemisphere has allowed more accurate measurements of low frequency wind dependent noise (Cato, 1976; Burgess and Kewley, 1983; Cato and Tavener, 1997). In low traffic noise areas, variation in wind speed over the range often experienced at sea would cause a variation in noise level of around 20 dB. Wind dependent noise levels at wind speeds of 20 to 30 knots are comparable to the traffic noise levels in the Northern Hemisphere data. In most of the world's oceans, shipping densities would be less than in the regions of measurement in the Northern Hemisphere (e.g. the North Atlantic Ocean), so that wind dependent noise would be a significant component at low frequencies. The absence of the low frequency wind dependent component in the Northern Hemisphere prediction methods gives the impression that there is a notch in naturally occurring noise at low frequencies, leading to speculation that whales exploited this notch to communicate prior to the advent of modern shipping. It is evident from Fig. 1, however, that this notch never existed.

The low frequency component of wind dependent noise is significantly lower in enclosed waters, such as Spencer Gulf, than in open oceanic waters for similar wind speeds (Cato and Tavener, 1997).

Biological Noise

A major component of the ambient noise in Australian waters is from biological sources, especially in shallow tropical waters where it is the dominant component for much of the time (Cato, 1978, 1992). The best known biological noise source is the snapping shrimp which abounds in shallow waters in latitudes less than about 40 °. They were first described by Knudsen et al (1948) and are the dominant source of noise in shallow Australian waters from frequencies of a few kilohertz to at least 300 kHz, except during heavy rain which would dominate for some of this frequency range.

Biological choruses that result when countless animals are calling at the same time increases noise spectrum levels typically by 20 dB, and up to 30 dB on occasions. Such choruses are due to fish and invertebrates and cover varying parts of the spectrum from about 40 Hz to 5 kHz. While snapping shrimp choruses show little diurnal or seasonal variation, most other choruses have very pronounced diurnal variation, usually rising and falling over a period of a few hours.

The evening chorus, which occurs for a few hours following sunset, is the most widespread. It has been observed almost everywhere we have measured in shallow water. Similar choruses are sometimes observed near sunrise and occasionally at other times of day. Diurnally varying choruses usually cover some part of the spectrum between 500 Hz and 5 kHz, and result from the stridulatory clicking sounds from fish or invertebrates, often related to feeding.

Fish choruses, often related to spawning, are also common but are less predictable. They may occur for longer periods of the day and often have pronounced seasonal occurrence (McCauley, 1992), which may differ significantly between species. Many fish use their gas filled swim bladder to generate sound, and such sounds are the dominant source of these choruses which are usually evident over a frequency range from about 50 Hz to a few kilohertz.

Whales produce intense sounds that are significant either as individual transients or sometimes as choruses. These are becoming an important part of the ambient noise as numbers increase. The most significant sources are the humpback whale which migrates through temperate and tropical waters to breed, producing the complex songs, and sperm whales which produce choruses of clicking sounds.

Figure 1 shows representative spectra of biological choruses typical of the usual maximum values. Significantly higher levels may be evident in certain locations at some times.

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