Humpback whale

Using hydroacoustic stations to monitor large whales

A case study in the South West Indian Ocean

BY FLORE SAMARAN

The hydroacoustic network is a key component of the International Monitoring System (IMS). The network contains 11 stations to monitor compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT) in the world's oceans. IMS hydroacoustic stations around the world collect a wide range of signals from numerous sources, including large whale vocalizations, that could be used for scientific applications. By providing critical information on these endangered species, IMS hydroacoustic data could be of great significance.

MOST LARGE WHALE POPULATIONS REMAIN AT LOW LEVELS

Overexploitation during the 20th century from commercial whaling reduced large whale populations to a fraction of their original number. Despite gaining complete international legal protection several decades ago, most large whale populations remain at low levels and their recovery is uncertain. Today, basic knowledge regarding the distribution, abundance, specific habitat preferences or migration patterns of many large whale populations is very limited. Monitoring these mammals to evaluate their post-whaling recovery remains difficult due to their wide-ranging distribution, low density, extensive migration, difficult visual identification, and inaccessibility. However, the long-term deployment of passive acoustic recorders has proved to be a very efficient and non-intrusive way to assess and monitor large whale populations over ocean basins and for long periods.

ADVANTAGES OF PASSIVE ACOUSTIC MONITORING

Most of the year large whales emit low frequency calls (10-100 Hz) with high intensity, which propagate over ranges of many hundreds of kilometres. Using passive acoustic monitoring to assess whale populations has several benefits in comparison with conventional survey methods (i.e. visual sightings). The animals can be studied continuously without any negative impact. This method is also less dependent on weather conditions than visual methods and does not rely on animals surfacing in order to be detected. It can be applied globally, including remote areas where visual sightings are usually either too sparse to be relevant, difficult, or costly. Other advantages of passive acoustic monitoring are that it helps to identify areas of concentration, assesses seasonal occurrence and distribution patterns, and can facilitate the long-term monitoring of whale abundance through variations in call rates over the years.

POSSIBLE SCIENTIFIC APPLICATIONS OF IMS HYDROACOUSTIC DATA

IMS hydroacoustic stations record whale sounds around the world, including remote locations such as sub-tropical or sub-Antarctic areas. These stations have been making such recordings continuously for several years. They therefore represent a unique data set for obtaining critical information on large whales. Studying IMS hydroacoustic data for biological purposes helps to expand our knowledge on the occurrence

and movements of large whales on an ocean-wide scale. Moreover, multi-year acoustic monitoring using IMS data should facilitate the assessment of large whale population sizes and trends. This new and valuable information could be helpful for determining the conservation status and the management of these important species. In addition, such studies could improve the CTBTO's processing efficiency by characterizing hydroacoustic events and periods of important large whale vocal activity.

MONITORING THE AREA AROUND THE CROZET ISLANDS

To test and carry out this kind of research, data recorded by the IMS hydroacoustic station located near the Crozet Islands in the southern Indian Ocean - HAO4 (FIG. 1 – see overleaf) from May 2003 to April 2004 were made available to the CNRS-Centre d'Etudes Biologiques de Chizé (Villiers en Bois, France). The data were provided by the Commissariat à l'Energie Atomique (CEA) centre DAM-île de France (Bruyère-Le-Châtel, France) within the framework of the South Indian Ocean biological noise identification and characterization project[1].

[1] The IMS data have been made available through the CEA under contract. The information released in this article conforms to the conditions set forth in the contract.

HYDROACOUSTIC MONITORING

Hydroacoustic technology is used to measure changes in the water pressure caused by sound waves. Data obtained from hydroacoustic monitoring provide information on the location of a nuclear explosion underwater, near the ocean surface or near its coasts.

WATCH ONLINE:
ctbto.org/hydroacoustic

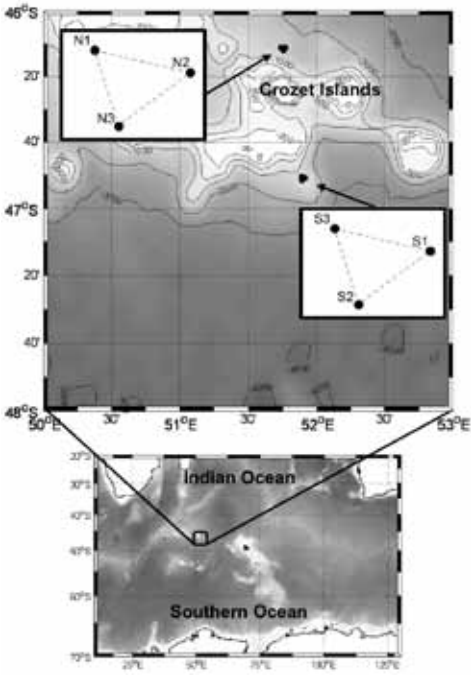

FIGURE 1: *Location of the two arrays of the IMS hydroacoustic station HAO4 moored in the South West Indian Ocean near Crozet Islands.*

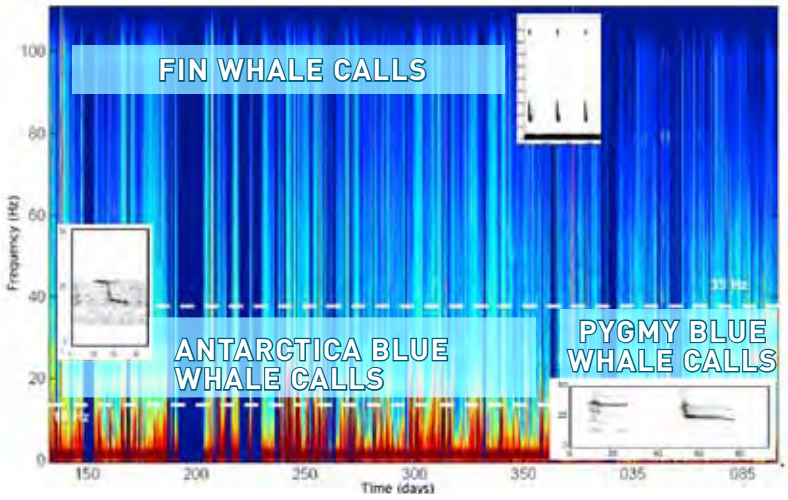

FIGURE 2: *Spectrogram of one year of acoustic data recorded at HAO4 which contained different specific sounds produced by large whales and detected with a seasonal occurrence.*

The main objective of the research was to identify biological noise. Monitoring the area around the Crozet Islands is particularly interesting for baleen whale biology and ecology. This is because it encompasses two main but poorly monitored whale sanctuaries created by the International Whaling Commission for the preservation of habitats of whale species, which were decimated extensively as a result of whaling.

Simple spectrogram observations from these long-term acoustic recordings have revealed that the low frequency (< 100 Hz) sea noise spectrum was dominated by a band of sound at 15-35 Hz, corresponding to large whale vocalizations (FIG. 2). Five species, sub-species and sub-populations of calling whales were also identified based on their similarity to large whale calls, which had been previously recorded in the Southern Hemisphere (i.e. the fin whale, the Antarctic blue whale and the pygmy blue whale 'Madagascan' type, 'Australian' type, and 'Sri Lanka' type).

WHALE VOCAL ACTIVITY FOUND TO BE HIGHLY SEASONAL

Each call type exhibited a variation in occurrence and intensity over the recorded period. Algorithms for automatic whale call detection, extraction and discrimination have been developed and used on the available data in order to assess the seasonal occurrence of each large whale species, sub-species and sub-population. Vocal activity was found to be highly seasonal and varied according to the species (FIG. 3). Results have revealed the seasonal occurrence and migration patterns of whales, providing information about ecology and habitats in this former commercial whaling area. Fin and Antarctic blue whale calls were recorded all year-round indicating their continuous presence in the region, which contradicts the migration pattern attributed to these species. Three geographically distinct types of pygmy blue whale calls were recorded only during summer and autumn. The 'Madagascan' type call was the most frequently recorded while 'Sri Lankan' and 'Australian' type calls recorded in this area suggest basin scale longitudinal and latitudinal movements. During spring and summer, blue whale calls were often associated with the high frequency 'D' call, which has been attributed to feeding activity. The co-occurrence of fin whale and blue whale sub-species during the summer has highlighted the importance of this productive sub-Antarctic area as a large whale hotspot, providing new insights into blue whale seasonal distribution and segregation.

ANTARCTIC BLUE WHALE

Photo: Kate Stafford

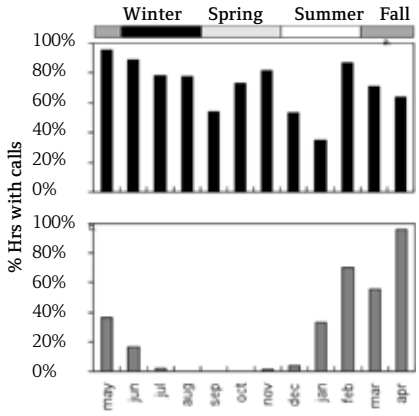

FIGURE 3: *Spectrogram of one year of acoustic data recorded at HA04 which contained different specific sounds produced by large whales and detected with a seasonal occurrence.*

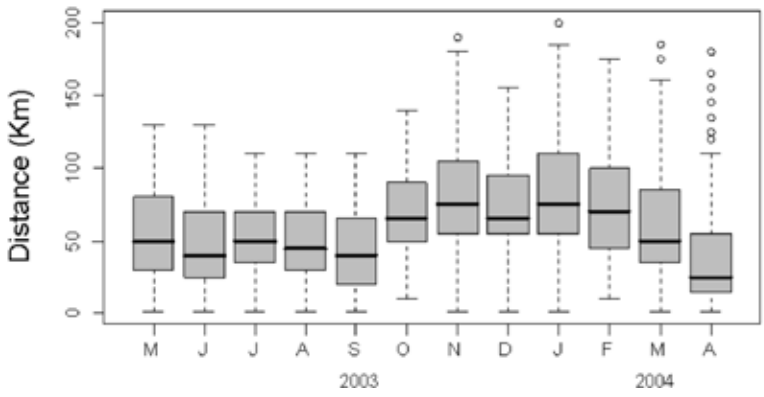

FIGURE 4: *Distribution of the ranges where Antarctic blue whale were detected on the northern array of HA04 using the range-dependant acoustic model.*

FIRST REPORTED SOURCE LEVEL ESTIMATIONS FOR BLUE WHALES IN THE INDIAN OCEAN

In addition, the triangular configuration of the calibrated hydrophones of HA04 (FIG.1) has permitted localization methods to be applied in order to track calling whales and to estimate the movement and detection range between the recording system and the animals. Such data are critical to study the habitat of calling whales without human disturbance. The differences in arrival times of the signals at the three hydrophones were used to calculate the location of whales. The sound levels of received calls may also be used to estimate the level of sound emitted by the vocalizing whales. These were the first reported source level estimations for blue whales in the Indian Ocean.

A mathematical model – a range-dependent acoustic model (RAM) – was used to predict how sound levels changed with distance between vocalizing whales and IMS receivers. This approach allowed the size of the monitored area to be estimated. The maximum detection area of the whale calls was estimated within a radius of 200km. Over the course of the year, acoustic detection ranges varied according to the whale species; e.g. pygmy blue whales seemed to be present closer to the station than Antarctic blue whales. The distribution of the estimated distances confirmed the presence of whales close to the Crozet Islands, showing the importance of this sub-Antarctic area for these endangered species especially during the austral summer feeding season (FIG. 4).

To conclude, this case study highlights the value of some of the possible scientific applications of IMS hydroacoustic data, which have provided a unique data set for obtaining crucial information on large whales. The study also demonstrates how the CTBTO and the scientific community can both benefit from close cooperation. Further monitoring of these endangered mammals on a larger scale could provide valuable information about their seasonal occurrence, distribution and relative abundance.

FLORE SAMARAN *after helping to moor automated hydrophones in the southern Indian Ocean in January 2010. The hydrophones record seismic activity and biological sounds.*

BIOGRAPHICAL NOTE

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