Application of Acoustic Techniques in the Management of a Threatened Migratory Bird (Orange-bellied Parrot)

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ABSTRACT

The Orange-bellied Parrot *Neophema chysogaster* (OBP) is a threatened, obligate migrant. The species breeds in south west Tasmania (Oct-Feb) and migrates along the Tasmanian west coast and western Bass Strait to South Australia and Victoria where it spends the winter months foraging in a range of coastal habitats. A method to estimate the total population and habitat usage during migration and at wintering sites is difficult for this mobile species which often frequents rugged and remote areas. The possibility of using long-term audio recording at various strategic locations throughout the OBP's range is being investigated as a survey technique. At this stage it is believed that long-term recording followed by laboratory-based signal analysis offers significant advantage over, and is a precursor to, a call-triggered data logger approach. If successful, the method has the potential to greatly extend the data collection effort compared to direct observer methods. The acoustic method can operate at night (OBPs are known to fly at night) and can be used where continuous observation is beyond personnel resource availability. Preliminary field trials indicate that the flight call of the OBP, at between 6 and 8.5 kHz, can be successfully recorded and subsequently identified by a skilled ornithologist. The next stages of the investigation are an assessment of the 'uniqueness' of the OBP call compared to closely related species; development of recording devices and power supplies suitable for operation in remote locations; and a review of field trials to determine the potential for development of call-triggered data loggers.

INTRODUCTION

This project was conceived during a site visit to a proposed wind-farm site on the west coast of Tasmania. The site was in relative rugged terrain, many kilometres from power. During the site visit, the two authors discussed various problems associated with identifying the migratory flight-path of OBPs in the vicinity of the proposed wind-farm to inform the decision making process in regard to potential collision risk. As there are less than 200 wild OBPs moving through this site over a 2-4 month period, it is relatively unlikely that conventional observer techniques would detect many individuals and consequently there would be relatively little statistical significance attributable to such observations.

The development of a remote sensing technique as proposed here would significantly increase the power of the observational data as well as substantially reduce the costs of labour intensive survey. Although this technique was initially conceived to apply to wind-farm collision risk assessment it was soon realised that such devices have a much broader application in assessing OBP movements across the range and for remote sensing of key feeding habitats. This would significantly improve the knowledge of the ecology and behaviour of the species, which is difficult to study over such a large range. This in turn will provide useful information to focus conservation management activities.

THE PROJECT

The ultimate 'real world' problem is to provide a technique for estimating numbers and flight behaviour of OBPs. The current proposal is to record the calls of OBPs as they pass across a perpendicular to the migration trajectory. From a practical perspective, it is desirable to choose a location where the birds are distributed over a relatively narrow path, which is most likely to occur along the west coast of Tasmania.

The northward migration is spread over several months with adults departing the breeding area February-March and juveniles following March-April. As migratory flocks move northward they can settle on particular feeding resources for several days or even weeks depending on food availability. Some of these 'stopover' sites (ie saltmarshes in the far northwest and on King Island) are occupied in most years. During these stopovers, individuals and small flocks will move back and forth within a localised area, foraging for food. These repeat flights will significantly confuse any survey effort that is designed to estimate passage of numbers. On the southward migration, it is believed that the birds tend to move in a fairly direct manner towards the breeding area and are likely to provide a better survey opportunity than the northern migration.

If individuals and flocks can be relied on to fly gently through a fairly narrow pathway, the most basic acoustic survey technique would be achieved by locating several microphones with recorders distributed across the flight pathway (perpendicular to the direction of travel). The separation of the microphones would be chosen so that there would be a high probability of recording most birds. This may be a practical impossibility if the flight pathway is wide or if the signal to noise ratio of the birdcalls above the otherwise ambient sound is relatively small. Under relatively quiet conditions the OBP call can be clearly detected over several hundred metres by an experienced observer.

The ideal area to locate the survey equipment is where the flight pathway is as narrow as possible, due to either the drawing together of flight paths near the breeding area or as a result of topographic features that confine or restrict the migration path width.

THE OBP CALL

The OBP has several quite distinctive calls. The flight call exhibited during localised movements and migration is described as a single ‘zeet’ usually emitted at the apex of an undulating flight pattern. This call is repeated about once a second, between about 5.5 and 8 kHz characterized by an inverted ‘V’ frequency versus time spectrogram, as shown in **Figure 1**. The amplitude profile has a ‘classic fish skeleton’ shape as shown in **Figure 2**. Most chirps follow these general patterns although there can be significant variations in spectral and temporal characteristics. The OBP flight call is quite obvious to a trained observer. At times of restricted visibility, during rain, mist or in the evening, the birds can often be identified by their call well before visible confirmation.

Figure 1. Spectrogram of a field recording of five OBP flight calls. The vertical scale is linear frequency for 0 to 10 kHz and the horizontal axis is 6 seconds duration. Low frequency noise was from a light aircraft and there is a harmonic of an insect sound at about 6 kHz.

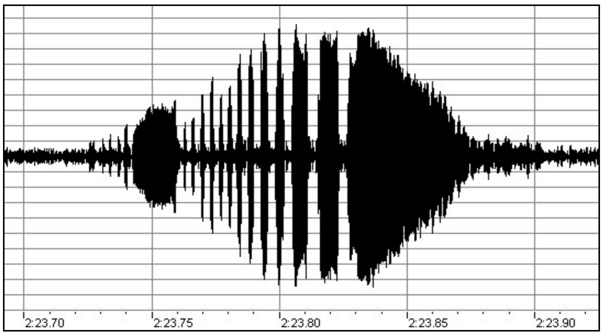

Figure 2. Oscilloscope style display of a typical OBP call. Vertical axis is linear signal (volts) and the call duration is about 0.15 seconds.

It is believed that there is sufficient information in the OBP call to provide a definite species identification. There will be practical limitations to the certainty of identification imposed by low signal strength for distant birds and the influence of potentially confounding sounds.

FIELD TRIALS

During the 2002/03 summer, before the commencement of the current project, several DAT tape recordings of OBP calls were made at Melaleuca, south west Tasmania. These recordings were made close to feeding tables and, although they provide an excellent record of feeding and contact calls, they did not provided clear information on the flight call.

During the 2003/04 summer, a recording trial was undertaken with the main aim of collecting some good quality recordings of flight calls. These recordings were made midway between two feeding tables located about 2 kilometres apart. The recordings were made using a four-channel USB audio interface and a laptop computer. The microphones were electret capsules with battery-powered preamplifiers driving 25 metre cables to the USB interface. The preamplifiers and associated batteries were housed in weatherproof containers, located with the microphones. Battery consumption was relatively low with a conventional 9-volt alkaline battery lasting about two weeks. The recording software was an off-the-shelf personal computer audio recording and editing package, which supported four-channel input and output devices.

Initially, the microphones were configured as upwards facing pressure zone microphones by locating the electret capsules above circular plastic plates. In practice, the pressure zone design would have suffered under heavy rain, which is relatively common on the west coast of Tasmania. A thin plastic sheet cover was placed over the pressure zone plate to prevent rain from flooding the electret capsule, however, it was considered that this cover would undesirably increase the interference from wind. After the first deployment, one of the zone pressure plates broke during transit and the microphones were converted to a vertical facing electret located above the preamplifier.

The main recording limitation was the power consumption of the laptop computer and the secondary limitation was the limited free space on the computer’s hard drive - about 4 gigabytes. The laptop could operate for a little over one hour on its internal battery and so recording sessions were purposely limited to one hour to be certain that there was sufficient charge in the computer’s battery to ensure that the recording process could be concluded in an orderly manner. This is a fairly critical issue when recording ‘WAV’ formatted files because the header of the file contains the number of stored data points, which is not known until the end of active recording. If power is lost before the file’s header information is correctly saved, it can be difficult to recover the data.

Four channel recording at 16 bit, 44,100 kHz sampling produces about 1 gigabyte of uncompressed data per hour and so four sessions of one hour each could be recorded before it became necessary to transfer the data off the laptop. The complete system - laptop, interface and microphones - was configured at Hobart and flown to Melaleuca by light aircraft. A small solar power system was available at Melaleuca to charge the laptop’s battery between sessions and the complete system was returned to Hobart after four recording sessions to transfer the data from the laptop and to check preamplifier batteries and general system operation.

The four microphones were located in a tetrahedral array, at the vertexes of a triangular pyramid. The three ground-level microphones were located about 20 metres out from the central vertical axis of the array and the fourth microphone at the apex of the pyramid was located about 4.5 metres above the ground. The tetrahedral arrangement of microphones was chosen to evaluate the possibility of using differential time-of-flight of the audio signals to the four microphones to estimate the location of the source of the flight call.

RESULTS FROM THE FIELD TRIAL

Some good recording sessions were achieved during the field trial although the number of OBP calls was relatively low. The quality of some of these calls was excellent. Wind noise has not been a significant problem at this stage as low wind speed conditions were targeted and prevailed for most of the active recording time. The microphones used for the trial were fairly responsive to wind noise and it would be highly desirable to minimise the response to this noise otherwise it is likely that significant observation time would be lost to wind noise induced overloading of the microphones and/or preamplifiers.

The laptop-based recording system performed well, as far as obtaining good quality recordings, although it was a bit problematic for the untrained operator. This type of system would not be suitable for long-term field deployment due to the relatively high power consumption of the laptop computer and the limitations of the software. The 'WAV' file format is limited to about 2 gigabytes, which means that the data has to be stored in multiple sequential files. This in itself is very sensible as it provides some security against the corruption of an otherwise very large data file, and it would be much easier to manage the subsequent data handling processes. The production of sequential data files at the time of recording can be achieved by alternative software and the options are currently under review. Ultimately, the system must operate in a highly robust manner, without operator intervention, for about two weeks . A relatively uncomplicated system with low computing overheads is therefore desirable.

There were relatively few other sources of sound that had the potential to interfere directly with the flight calls, principally due to frequency segregation. As mentioned earlier, it is likely that moderate to high speed winds could lead to overload of the preamplifier stages which would ruin the recorded signal. Apart from wind noise, the other significant sounds at the Melaleuca site were from tourism related light planes, insects, frogs and other birds. Some digital signal processing routines have been developed to manage the recorded data, including finite impulse response (FIR) filters for cleaning up the recorded signal and spectrogram (time versus frequency) analysis routines.

HARDWARE CONSIDERATIONS

There have been several advances in computer technologies over the past few years that are having a significant impact on the application of audio and visual techniques to data acquisition projects. The first of these advances is the incredible drop in the cost of memory and hard disk storage, with an associated increase in the availability of large capacity memory and storage devices. Putting aside the problems of power consumption, the current project could be based around a relatively cheap portable computer fitted with a 120-gigabyte hard drive. The processing power of the computer is not important if the intention is to simply record audio constantly for 2 weeks. A more robust recording device could be constructed using a fairly basic microprocessor to sit between an audio analog-to-digital converter and a 120-gigabyte hard disk. Although this may result in a better field deployable recorder, it is likely that such a device would require a significant development effort. The second advancement that is highly relevant to this project is the development of consumer MP3 devices for storing and playing audio tracks. There are now quite a few of these devices on the market and some of them provide for the recording of audio signals at various qualities up to CD quality and beyond. These devices are small (hand-held), have very low power demands and the high-end devices currently contain up to 60 gigabyte hard drives. The cost of these devices is very reasonable compared to the computer-based option. These devices were not designed to be re-programmed but some of them can support high-level operation systems and can be used for tasks that they never were intended.

Somewhere between the PC and the modified MP3 type device is the option of using a low-power 'embedded' single board computer as the basis for the field recorder. The nice thing about these devices is that they do not require any special programming or development and align closely with conventional computers. The embedded board is a little bit more 'open' than the MP3 type device and has additional interface ability, including USB ports, additional disk drive interfaces and RS232 ports. An additional advantage of the embedded board is that it would be possible to extend the basic recorder system to include signal processing and detection decoding without the need to change the platform.

The use of low quality recording or the use of compression algorithms is not considered appropriate for this project. Although the OBP call is quite detectable due to its narrow spectral distribution, it is a relatively small component of the overall acoustic signal and is likely to be corrupted by recorders with limited frequency response or limited dynamic range and by the use of compression algorithms.

FUTURE OPTIONS

Various associated applications of acoustic techniques within the OBP management program have been considered and may prove to be useful resource-efficient tools. Other survey deployments of long-term recording equipment could be used to identify the spatial distribution of birds throughout the migration range. In addition, these devices have the capacity to be used to measure presence/absence, relative abundance and localised movements at key feeding sites throughout the species' range.

The use of recorded OBP calls to attract individuals to specific areas is currently being trialed using calls derived from the tetrahedral microphone field trial.

There will be an evaluation of the accuracy of software detection and identification of OBP calls that will be applicable to both laboratory and real-time signal analysis. Two major advantages of recording high-quality audio in the field and then post-processing the recordings in the laboratory are that the post-processing algorithm can be modified to improve the accuracy of OBP detection or can be modified for a different purpose. Other purposes that would not require any modifications to the field equipment include localisation from the differential time-of-flight analysis from an array of co-located recorders or the detection of other vocally active species.

Hybrid systems, incorporating both on-line detection and some limited recording would be a reasonable compromise. On-line detection would open up the possibility of communicating the presence of OBPs via the satellite mobile telephone network, which may have advantages for other OBP ecological questions.

SIMILARITIES IN THE ASSESSMENT OF INDUSTRIAL NOISE

There are many situations where it is desirable to assess the possible impact of noise from industrial activities on residential communities. This assessment is normally based on subjective evaluation and objective measurements, made at a variety of locations, that provide an indication of the general noise environment both with and without the industrial noise present. The assessment is then based on the likely impact of the industrial sound compared to the otherwise ambient sound-scape. Generally, the characteristics of the industrial sound emissions are measured at locations where they are clearly identifiable above the other sound in the area and these results are then extrapolated to more distant areas containing residences. The extrapolation process, normally referred to as environmental noise modelling, is an efficient procedure that can be used to provide a basis for assessment over a relatively large area from a relatively small set of measurements.

Noise modelling is a straightforward process over relatively flat land but becomes much more complicated over complex terrain and over bodies of water. From a practical perspective, the difficulties arise from not being able to access suitable measuring positions. Added to this, the terrain and water significantly influence the propagation of sound and the extrapolation of measurement results in the near-field to provide predictions in the far-field becomes somewhat more complicated and tend to be highly dependent on meteorological conditions. This dependency on the prevailing meteorology is often a profound problem when attempting to evaluate the impact by direct measurement at a moderately distant site because it becomes necessary to take measurements under a variety of meteorological conditions. This is very resource intensive if the investigator has to be present at several measurement sites for extended periods of time.

Traditionally, tape recorders have only had limited application in the regulation and management of environmental noise from industries (and other sources of noise) due to the relatively short sound sample that could be conveniently recorded and due to certification and/or calibration issues with medium quality recorders. Digital audio tape and hard disk recorders do not have any significant calibration issues and are thus being applied to environmental noise measurements. The hard disk recorder has the added advantage that it becomes possible to record sound over many days or weeks, without the investigator present, with a calibrated recording system that can provide various sound pressure level dB(A) statistics (L_{eq}, L_{90}, etc), a high quality recording that can be assessed by ear and a recording suitable for one-third octave and narrow-band spectral analysis. Statistical analysis and spectral analysis, that have traditionally been carried out with dedicated equipment, can now be carried out on digital recordings using digital signal processing routines. Unlike single-mode transport noise, such as traffic noise or aircraft noise, industrial noise does not have a consistent set of characteristics and each situation has to be assessed on an individual basis. Hence the need to acquire significantly detailed data.

The long-term hard disk recorder and subsequent analysis by digital algorithms that has significant potential in the field of environmental industrial noise management is essentially the same inherent technology considered here for the OBP applications.

CONCLUSIONS

On the basis of field-trial measurements, we believe that the use of acoustic techniques for surveying the OBP during migration is both technically and practically achievable. At this stage there are still some details of the field equipment yet to be finalised but sufficient test data has been acquired from field trials to progress to a final design.

It is considered that the development of long-term recording equipment that is suitable for deployment in remote and rugged locations has many advantages, beyond the direct potential benefits to the management effort for the Orange-bellied Parrot. In particular, the application of similar technology, both the hardware and signal processing software, will be very valuable in the assessment of environmental noise from industry.