Song Meter Trials Report

For the Detection of Western Ground Parrots in Cape Arid National Park 2011 - 2012

Jeff Pinder

For the South Coast Threatened Birds Recovery Team

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Department of
Parks and Wildlife

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1.0 Note to readers

Please note for the purposes of reading, the particular bio-acoustic recording unit featured in this report may be referred to as a song meter, a SM2, an automated recording unit or an ARU.

2.0 Summary

The use of Wildlife Acoustics' SM2 song meter™, an automated recording unit (ARU) purpose built for wildlife surveillance, was investigated through a series of field trials to test its effectiveness for detecting Western Ground Parrot (WGP) calls in the wild. Two main field trials were undertaken.

Trial 1 was designed to compare detection rates of WGP calls between the SM2 and human listeners. Significantly the song meters detected almost as many calls as 'experienced listeners' recorded. For 'less experienced' listeners the song meters consistently detected more positive calls.

Trial 2 investigated the detection capabilities of the SM2, particularly its minimum range of detection. The distance over which the song meters were able to detect WGP calls in over half the number of positive detections was a minimum of 140 metres and a maximum of unknown amount due to the difficulty in locating the precise origin of the call. To increase the minimum range from 140 metres, the 3x3 grid arrangement of the song meters at 200 metre spacings would need to be expanded. Such a recommendation should be carried forward into a future trial of this nature.

For determining the presence or absence of WGPs in 'unknown areas', using song meters *alongside* experienced human listeners would be preferable. Only one or 2 calls may occur during a survey session and therefore detection of these is paramount. Furthermore, the song meter allows the status of 'maybe' calls to be verified after the event using 'playback'.

For monitoring purposes ARUs potentially offer a more consistent and standardized approach than using human listeners who will have varying degrees of experience and auditory capability for detecting WGP calls. ARUs can be left out in the field over a long period of time with minimal disturbance to monitor activity both seasonally and annually for a specific location.

From these initial trials the use of ARU technology in WGP research shows great promise. In order to cover large, remote areas ARUs are the most suitable and practical known option currently available to the recovery project.

3.0 Background

Worldwide, many semi-autonomous or autonomous recording units (ARUs) have been used to detect or record natural sounds. The current study investigated use of the Wildlife Acoustics SM2 unit, which is an automated recording unit designed for the "long-term acoustic monitoring of birds, frogs, bats, fish, cetaceans and other wildlife in harsh field conditions" (Wildlife Acoustics, 2007).

The motivation for using ARUs to advance WGP research was driven by certain constraints and weaknesses of current monitoring techniques alongside the development and improvement of ARU technology.

The use of ARU technology has certain strengths and advantages. Firstly the Wildlife Acoustics units are relatively small and portable (just over 1kg in weight). They are resilient; enclosed in a weatherproof housing and able to operate in a range of temperatures (-20C to +85C).

Large amounts of information can be stored electronically allowing ARUs to be left in the field for extended periods of time. For the SM2s in this project, the storage capacity is currently 64Gb (4 x 16Gb SD cards) but with the potential to increase to 128Gb by inserting 4 x 32Gb SD cards.

The length of the recording time can be reduced by programming the SM2s recording schedule. As WGPs only call reliably in the hour before dawn and the hour after dusk the recording schedule need only be programmed for 1 to 1.5 hours per day. With such a short daily running time the SM2s can comfortably operate continuously for months. Also as each daily sound file is restricted to 1 to 1.5 hours the size of data to be stored and analysed is consequently contained within manageable proportions in terms of time, cost and effort.

ARU technology is relatively cheap to run. Aside from the initial outlay of purchasing the units (SM2s currently priced $800 each) the running costs are low (1 or 2 people to set up song meters) compared to the expense of a 10 day monitoring trip with a full complement of human listeners.

ARUs can be used in more isolated areas away from tracks and cover a greater area than can be achieved with human listeners. The units can be transported to their recording location during the day and left out overnight and over many subsequent nights.

This report summarises trials conducted to test the effectiveness of the song meter (model SM2) in detecting Western Ground Parrots through various field and office based trials. If successful, ARU technology could have important applications for improving research techniques to further protect this threatened species. ARUs may become an effective tool to help find new populations of WGPs and to be an important component of standardized monitoring protocols of known populations.

4.0 Song Meter set-up

4.1 Hardware Installation

The Song Meter units were mounted on 2 x 120mm aluminium droppers. Knotted loops of cord were threaded through the song meter housing screw holes (see figure 1 below) and then attached by small 2.5mm cable ties to the droppers. In some situations the top and bottom of the units were then bound to the droppers with duct tape to minimize movement and therefore noise interference.

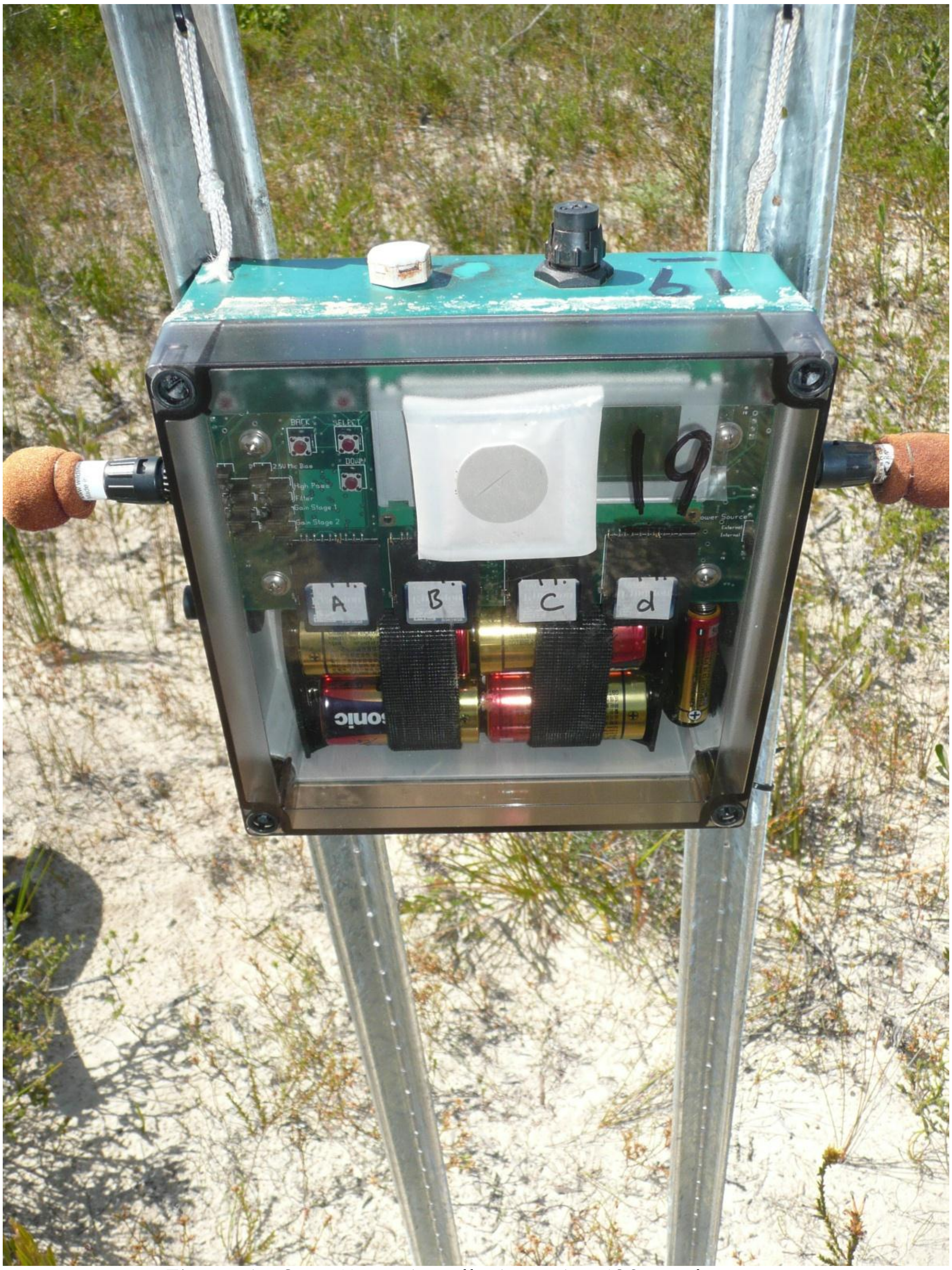


Figure 1: Song Meter installation using 120mm droppers

4.2 Scheduling and software set-up

The song meters were programmed to record to a schedule appropriate for times when WGPs would be most reliably calling i.e. for 45 minutes 1 hour before sunrise and for 45 minutes from sunset. These schedules were set up using Wildlife Acoustics' Song Meter Configuration Utility. The schedule used for the trials can be seen in appendices a, b and c. Once the schedule had been set this information was uploaded onto an SD card which in turn was inserted and uploaded into each unit. Alternatively the schedule can be set by programming each song meter manually using the function buttons of the units. This is more time consuming but does not require the Configuration Utility software and so can be done in the field without a computer. As well as the schedule other settings were also programmed, such as the location, sample rate and

microphone gain. Appendices a, b and c show the actual values that were attributed to these settings for the purposes of this study.
The software used for analysis of the song meter sound files in this research was ‘Syrinx’, which is a free downloadable program that supports WAV files (the sound files generated by song meter units and stored on an SD card). Syrinx presents sound files in graphic form known as spectrograms enabling the observer to scroll through multiple sounds quickly and efficiently. Syrinx also features a playback function which is useful for familiarizing and checking a particular sound represented graphically against its corresponding acoustic format. For the purposes of WGP calls ‘Windows Settings’ were set up as shown in Figure 2. ‘Wav’ files were dragged into the Syrinx program which then created a window containing the spectrogram for this file which was then scanned visually for the presence of WGP calls.

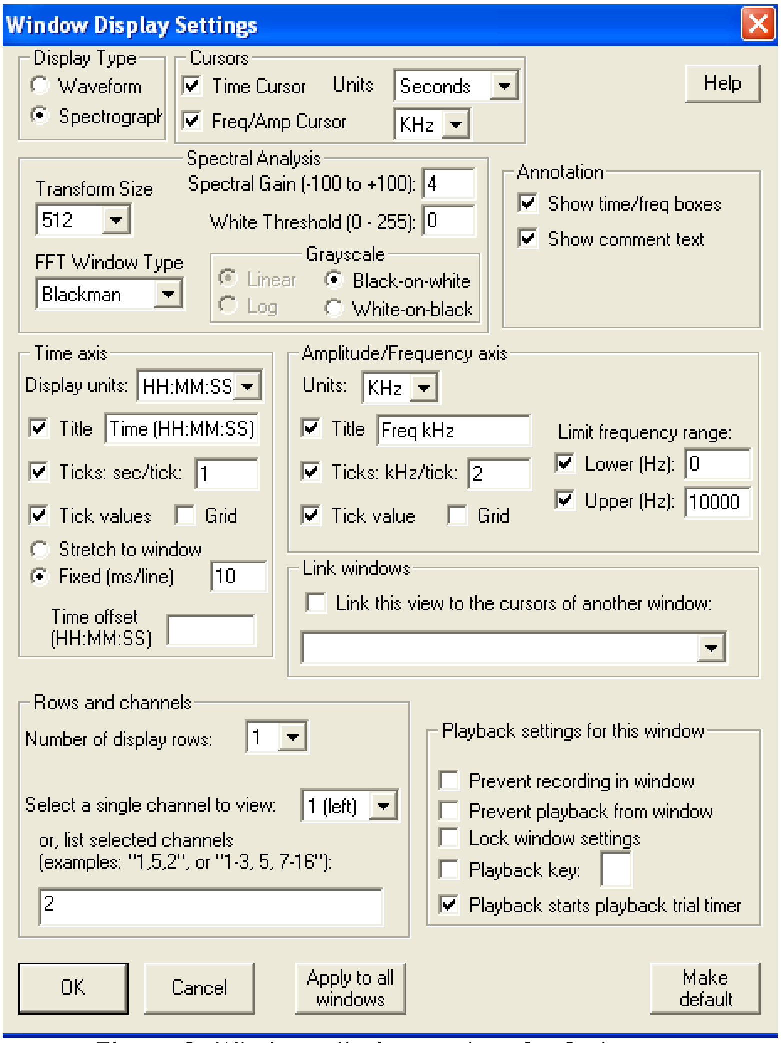


Figure 2: Windows display settings for Syrinx

5.0 The Field Trials

5.1 Trial 1 – Song Meters Versus Human Listeners

5.1.1 Aim of trial 1

To compare the capability of SM2 units with human listeners for detecting Western Ground Parrot calls

5.1.2 Methodology for trial 1

In November 2011 a group of DEC staff and community volunteers were assembled to survey a known population of Western Ground Parrots on the eastern side of Cape Arid National Park. Unfortunately access to this population was not possible due to wet soil conditions and the risk of spreading Phytophthora Dieback.

Therefore the only other known population of WGPs, located in the Park's central southern sand plains, became the focus for this work instead. This choice of site was less preferred as the WGP population here had been impacted by the effects of a wildfire in January 2011. These birds' current whereabouts were unknown.

The group of listeners consisted of people with a range of experiences relating to the monitoring of WGPs and recognition of WGP calls. The profile of this group was representative of many previous Western Ground Parrot monitoring trips so could provide a meaningful comparison.

After a few training sessions spent introducing listeners to, or re-familiarising listeners with the calls of wild birds, each participant was given a song meter to take out to their pre-arranged listening site. Two listening sessions per day were undertaken: one at dawn and one at dusk. The timing and length of these sessions were similar to those of the yearly WGP monitoring for population estimates i.e. for the dawn sessions listening from 1 hour before sunrise for 45 minutes, and for the dusk sessions starting at sunset and listening for 45 minutes. The song meters were programmed to record with the same start and finish time and each unit's inbuilt clock was adjusted to be synchronized to GPS time. Listeners were also asked to synchronize their personal time pieces with GPS time so that if calls detected by both human and song meter shared the same time then they could be identified as a likely match with some degree of confidence.

5.1.3 Results of trial 1

Encouragingly the song meters detected almost as many calls as heard by the 8 listeners. From a total of 33 listening sessions 95 positive calls were detected by the song meters and 133 positive calls were detected by human listeners (see Table 1). It would first appear that detection rates were approximately 35% higher in humans. However of those 133 calls, 34 were identified by the 'inexperienced' human listeners as only 'maybes'.

From experience it is considered likely that many of these 'maybe' calls were not WGPs. Further testing of these potentially false positives was achieved by checking the times of these 'maybe' calls on the spectrograms against the same time for the corresponding song meters. For many of these cases there was no corresponding call from the song meter. Therefore by excluding the human listeners' 'maybe' calls the total number of positive calls recorded that can be stated with any certainty by the human listeners is 99, resulting in an even closer comparison with the song meter detection rate of 95 calls.

Listener ID	Date (2011)	Human: # of WGP calls detected	Song Meter: # of WGP calls detected	Number of human calls / No. of SM calls (with # of matches)
listener 1*	7-Nov	7	4	7/4 with 4 matches
	9-Nov	8	7	8/7 with 1 match
	10-Nov	15	11	15/11 with 10 matches
listener 2	7-Nov	0	0	0/0 with no matches
	9-Nov	13 (6 maybes)	0	13/0 with no matches
listener 3	7-Nov	2 (2 definite)	4	2/4 with 2 matches
	8-Nov	0	0	0/0 with no matches
	9-Nov	16 (1 maybe)	9	16/9 with 6 matches
	10-Nov	0	0	0/0 with no matches
	10-Nov	0	0	0/0 with no matches
	11-Nov	0	2	0/2 with no matches
listener 4	7-Nov	1 (1 maybe)	3	1/3 with no matches
	8-Nov	0	0	0/0 with no matches
	9-Nov	10 (9 maybes)	3	10/3 with no matches
	11-Nov	2 (1 maybe)	2	2/2 with 2 matches
listener 5	7-Nov	3 (3 maybes)	0	3/0 with no matches
	8-Nov	0	0	0/0 with no matches
	9-Nov	2 (2 maybes)	9	2/9 with no matches
	10-Nov	0	0	0/0 with no matches
listener 6	7-Nov	0	0	0/0 with no matches
	8-Nov	3 (3 maybes)	1	0/1? With no matches
	9-Nov	6 (2 maybes)	9	6/9 with no matches
	11-Nov	8 (3 maybes)	0	8/0 with no matches
listener 7*	7-Nov	0	1	0/1 with no matches
	8-Nov	0	0	0/0 with no matches
	9-Nov	7 (1 maybe)	6	7/6 with 5 matches
	10-Nov	1 (1 maybe)	0	1/0 with no matches
	10-Nov	10 (1 maybe)	11	10/11 with 8 matches
	11-Nov	2	2	2/2 with 2 matches
listener 8*	7-Nov	0	0	0/0 with no matches
	8-Nov	0	0	0/0 with no matches
	9-Nov	16	10	?
	10-Nov	1	1	?
totals	33 session	133 (34 'maybes')	95 (1 'maybe')	

1 * denotes an 'experienced listener'
2 The 'definites' and 'maybes' in the 'human' column were allocated by the listeners themselves. In the case of a 'less experienced listener' even a call not listed as a 'maybe' should be viewed with some degree of caution
3 All song meter calls were confirmed 'definites'. Therefore human listeners' calls could also be confirmed by matches with song meter calls. The more matches; then the more human listener calls could be confirmed as 'definite' WGP calls.

Table 1: Trial 1 results - comparison between humans and song meter units to detect WGP calls in Cape Arid National Park November 2011

If detection rates are further examined by comparing with inexperienced listeners only, then song meters' rates of detection are higher still. Compared with the 5 less experienced listeners, the song meters detected more positive WGP calls than 3 of these listeners once the 'maybe' calls are removed from the totals (see table 2). Overall, song meters detected more calls (42) than their corresponding human counterparts did (35).

For experienced listeners (see table 3) detection rates were higher for 2 of the 3 listeners and also in total (64 calls) compared to song meters (53 calls). As expected experienced listeners' detection rates compared favourably with those of song meters. Although experienced listeners' detection rates were slightly higher no account was made of the number of false positives generated from these listeners (even experienced listeners get it wrong sometimes!)

Listener ID	# of sessions	Human: # of WGP calls detected	Human: Definite calls	Song meter: # of WGP calls detected
Listener 2	2	13 (6 maybe)	7	0
Listener 3	6	18 (1 maybe)	17	15
Listener 4	4	13 (11 maybe)	2	8
Listener 5	4	5 (5 maybe)	0	9
Listener 6	4	17 (8 maybe)	9	10
Totals	20	66 (31)	35	42

Table 2: Comparison of *inexperienced listeners*' and song meter detection rates

Listener ID	# of sessions	Human: # of WGP calls detected	Human: Definite calls	Song meter: # of WGP calls detected
Listener 1	3	30	30	22
Listener 7	6	20 (3 maybe)	17	20
Listener 8	4	17	17	11
Totals	13	67 (3 maybe)	64	53

Table 3: Comparison of *experienced listeners*' and song meter detection rates

More evidence of the accuracy of detection rates for both experienced human listeners and song meters can be sought by quantifying the number of matches between them where a WGP call recorded by a human is also detected by a song meter. From Table 4 it can be seen that the number of matches for experienced listeners was 50-75%. For inexperienced listeners the figure was 0-44%. For 3 of the 5 inexperienced listeners there were no match ups with song meters.

Inexperienced Listener	# of WGP calls detected by human	# of human calls matching song meter	%	Experienced Listener	# of WGP calls detected by human	# of human calls matching song meter	%
Listener 2	13	0	0	Listener 1	30	15	50
Listener 3	18	8	44	Listener 7	20	15	75
Listener 4	13	2	15	Listener 8	No record		
Listener 5	5	0	0				
Listener 6	14	0	0				

Table 4: Comparison between experienced and inexperienced listeners and how many of their calls were confirmed by matches with corresponding song meter call detections

5.1.4 Discussion for Trial 1

As has already been mentioned, human detection rates are subject to doubt concerning their authenticity as WGP calls. All calls detected by song meters that were entered into the analysis were considered 'definites'. With the benefit of 'playback', potential WGP calls detected by the song meters could be screened time and time again (unlike human listeners who only get to hear the calls 'live' (i.e. once).

However at the analysis stage, in a very few instances, even after thorough checking some song meter calls could still not be verified (not entered into final data above). Most of these unconfirmed calls were possible WGP chick calls. These chick calls are less developed than their adult counterparts.

Consequently on the spectrogram chick calls wavered up and down in frequency and note length was more variable. On the other hand adult calls were much more uniform with consistently level or gently rising frequency and even note length (see WGP spectrogram figure 1, page 14). It is recommended that consideration be taken in future regarding the time of year for using song meters in relation to the accuracy of detection. In late spring WGP chicks are starting to call and these can easily be misidentified both by human listeners and song meter analysts alike.

It must also be emphasized that song meter detection rates did not always follow a similar pattern to experienced listeners records. Why certain calls were missed and extra calls detected by the songs meters is beyond the scope of this trial. Too many variable factors such as wind speed and direction, call decibel level and microphone quality were not measured and therefore not quantified to provide any co-variance data. The gaps in detection between humans and song meters are in some ways as revealing as the overlaps suggesting there is room for both types of 'ears' to optimize WGP call detection.

5.2 Trial 2 – Investigating the detection range of song meters in the field

5.2.1 Aim of trial 2

To undertake a field trial to determine the detection range of SM2 song meter units to detect wild Western Ground Parrot calls

5.2.2 Methodology for trial 2

10 Song Meters were positioned in the field, in Cape Arid National Park, 140 kilometres to the east of Esperance. The site chosen was an area adjacent to Old Poison Creek Road (see map – figure 3). This site had been surveyed for Western Ground Parrots by human listeners the week before as part of a post-fire monitoring exercise. The monitoring confirmed that WGPs were still present in the area and so it was anticipated that the song meters would also be able to detect WGP calls.

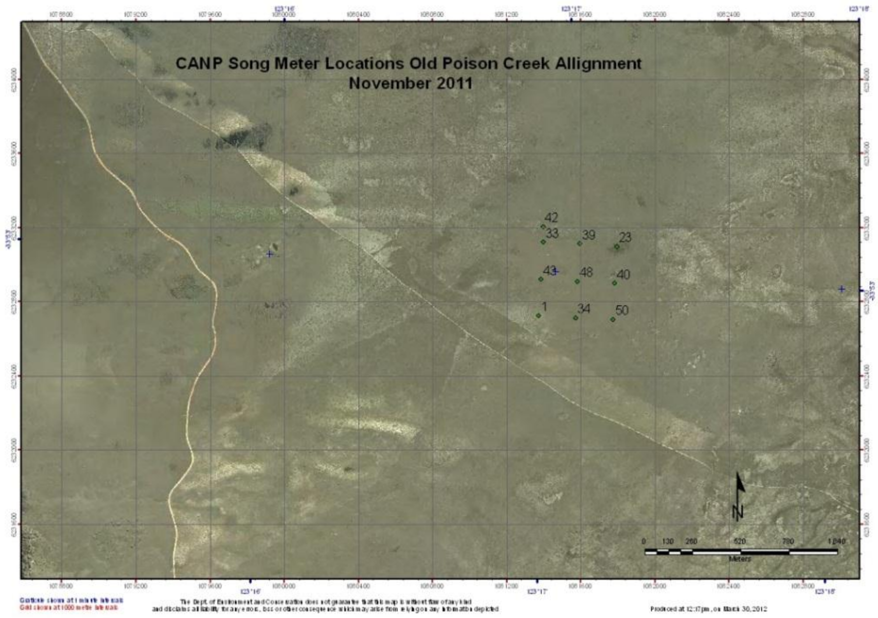


Figure 3: Trial 2 – location of song meter installations

Each song meter was mounted on 2 x 1200mm droppers secured with cable ties and duct tape. The units were placed 200 metres apart in a 3x3 grid plus one extra unit to the north-east of the grid to give a total of 10 units. Two omni-directional microphones (Wildlife Acoustics SMX-11) were attached to each SM2 unit. The units' settings were adjusted (as in appendix 4) and all set to the same outputs. The units were then programmed to record twice per day every day. These 2 daily recording times and durations were the same as in trial 1 i.e. for 45 minutes starting from one hour before sunrise, and for 45 minutes starting from 15 minutes after sunset. The song meters commenced recording on the 10th November 2011 and were switched off on the 8th January 2012, equating to 60 consecutive recording days.

After the song meters had been collected from the field the recordings, stored on 4 x 16 Gigabyte Secure Digital memory cards (SD cards), were analysed using Syrinx software. The software converts the recordings from a sound file into a series of spectrograms. These can be viewed on screen and scrolled through manually to identify WGP calls and reject calls from all other birds, crickets, wind etc.

5.2.3 Results of trial 2

Results were based on the analysis of 10 song meter units over 6 evening sessions (i.e. 10th/11th/17th/18th/24th/25th November 2011).

In the raw data (see appendix 1) calls identified as 'chick' calls were eliminated from the final results below as they could not be verified with confidence. Other dubious WGP calls (more probably from Tawny Crowned Honeyeaters and entered as "tche?" in the results table in appendix 1), could not, even after repetitive playback, be considered for the same reason.

Analysis of the 6 sessions produced a total of 125 WGP calls from the 10 song meters. These 125 calls were not individual calls but 125 records where some calls were detected more than once i.e. by more than one unit. Individual calls numbered 45.

The 125 detections were divided between the song meters as shown in Table 5.

song meter ID number	1	23	33	34	39	40	42	43	48	50
# of WGP calls detected	0	7	22	16	14	5	0	28	28	5

Table 5: The number of WGP calls detected by each SM2 unit

A fully comprehensive dataset was not achieved as 2 out of the 10 units did not appear to work for the duration of the trial period. SM2 units 1 and 42 were deemed faulty. SM2 1 generated sound files but within these files there were no spectrograms of any sound. SM2 42 provided no sound files for the analysis period although inexplicably did start producing sound files with spectrograms from the 22nd December. Hence in table 5 above no WGP calls were attributed to these 2 song meters despite the fact that WGPs may have been calling close by and therefore some level of detection by the units would have been expected.

The number of SM2 units detecting individual WGP calls was as follows:-

DATE	Individual WGP calls	Number of SM2 units detecting each WGP call					
		1unit only	2 units	3 units	4 units	5 units	6 units
10-Nov-11	12	✓	✓✓	✓✓✓✓	✓✓✓✓	✓	
11-Nov-11	5		✓✓	✓✓		✓	
17-Nov-11	12	✓✓✓✓	✓✓	✓✓✓	✓✓	✓	
18-Nov-11	9	✓✓	✓✓	✓✓✓			✓✓
24-Nov-11	5	✓✓✓	✓		✓		
25-Nov-11	2		✓✓				
Totals	45	10	11	12	7	3	2

Table 6: The number of SM2 units detecting each individual WGP call.

From Table 6 it can be seen that of the 45 individual WGP calls:

10 WGP calls were only heard by one SM2
11 WGP calls were heard by 2 units
12 WGP calls were heard by 3 units
7 WGP calls were heard by 4 units
3 WGP calls were heard by 5 units
2 WGP calls were heard by 6 units

Therefore 35 out of 45 calls (78%) were heard by multiple units. This high figure provides some useful information about the song meter's detection range.

5.2.4 Discussion for trial 2

This trial was designed to look at the range of detection of the SM2 unit. It should be first noted that for a WGP call to be heard by 2 adjacent song meters (200 metres apart) the origin of the call would have to be a minimum of 100 metres distance from at least one of the units. Therefore for 45 WGP calls, at least one of the 2 song meters (at 200 metre spacings) was able to detect the same WGP call heard by both from a minimum of 100 metres away as follows: 35 times out of 45 or 78% of the time (for 2 or more units).This provides a significant level of confidence for a song meter detection rate of a minimum of 100 metres.

As more song meters detected the same individual call the minimum distance or range of detection increased. Three adjoining song meters surrounding and detecting the same WGP call would put the minimum distance of the origin of the call further away than 100 metres, at approximately 140 metres (geometric calculation derives the actual figure at 141.4 metres).

However a larger minimum detection figure could not be ascertained due to the limitations of the 3x3 grid arrangement. For example the diagonal distance from one corner of the grid to the other measured approximately 560 metres. Therefore if a given call was detected on all 9 SM2s, then the greatest minimum distance for detection must have been at least 280 metres (distance from any one corner to the centre of the grid). But if the call originated from anywhere other than the centre, including from outside the grid, then the maximum distance would have been greater than 280 metres, but by an unknown amount. A larger grid incorporating more song meters would have allowed for greater minimum detection outcomes.

Number of SM2s detecting WGP calls	Frequency of detection	Minimum detection (metres)
For 2	11 times out of 45 or 24%	100
For 3	12 times out of 45 or 27%	140
For 4	7 times out of 45 or 16%	140
For 5	3 times out of 45 or 7%	225
For 6	2 times out of 45 or 4%	225
For 7	0 times out of 45	282
For 8	0 times out of 45	282
For 9	0 times out of 45	282

Table 7: The frequency of detection by SM2s at various distances

Knowing which song meters detected the same call and their whereabouts on the grid allows an estimate of the minimum detection distance. For example from the raw data (appendix 1) it can be seen that song meter units 33 and 34 both detected the same 5 WGP calls. From the map (Figure 3) it can be seen that these units were at least 447 metres apart and therefore their range of detection for these calls was a minimum of 225 metres (assuming the origin of the WGP call was equi-distance from both units). However this is a minimum distance and in all probability not the actual distance of the detection. Hence a limitation imposed on the trial is the difficulty in knowing the precise location of the origin of the WGP call and therefore the difficulty in calculating the actual distance (including the furthest distance) that any given song meter was able to detect the call.

Therefore the distances in Table 7 are based on the greatest minimum possible detection distance and as can be seen this figure increases as the number of units detecting a specific call increases. Without knowing the origin of the WGP call only a minimum distance can be derived at. For example 3 song meters detecting the same WGP call could place the origin of the call anywhere between 140 metres and an unknown amount. Therefore at least 1 of the 3 song meters was picking up the call from a minimum of 140 metres away. So the ability to measure the actual detection distance of any of the song meters cannot be deduced without this known call origin but the data does provide a confidence level in the reliability of minimum distances a song meter is capable of hearing. For example there were 24 situations out of 45 where multiple song meter detections occurred which means for 53% of all detections at least 1 song meter on every occasion had to pick up the call from a minimum distance of 140 metres. Therefore the frequency with which a song meter can detect a call at this range is significant and means that for this study it is more appropriate to talk about the range of detection in terms of minimum rather than maximum distances.

For future trials of this nature it is suggested that in order to test the minimum distance song meters are capable of detecting WGP calls from, the distance between song meters is widened to 400 metres (minimum distance then becomes 200 metres). Alternatively sticking with the 200 metre spacings a bigger grid incorporating more song meters could be utilised and hence achieve the same ranges as above. This would also provide a bigger sample size and therefore more confidence in any of the range outcomes.

A cautionary note regarding the units' detection capabilities was the variability in local conditions at each site and the difficulty in measuring the effect of these variations on any sound emitted by a WGP or other (e.g. Burbidge *et al*. 2007). Such variations included the effects of wind speed and wind direction, slope and aspect, decibel level of each WGP call, microphone reliability and local noise interference on detection rates. One possible improvement if this trial was to be repeated would be to ensure song meters are all aligned in one direction to minimise the variation generated by wind direction.

Another variable factor potentially compromising detection range was the variation in sound detection between units. In theory all units should have been equally capable of detecting any given sound. However in the field this was very unlikely to be the case particularly as units and microphones were of different ages and conditions. Under laboratory conditions ARUs could be tested to assess variations between units and variations between microphones providing some measurable guide to performance and hence only selecting units of a similar capability. One simple way to improve consistency would be to ensure all microphones and windshields are new at the time of repeating any similar trial.

In summary the trial was limited in scope but did indicate that the SM2s were capable of a detection range much greater than 100 metres. That this was not achieved with consistency and therefore significant confidence maybe the result of adverse listening conditions such as wind strength and direction, soft and close contact WGP calls and faulty or variable microphones. But as we know, these factors all serve to undermine the capabilities of human listeners as well!

6.0 Analysis of Syrinx spectrograms to detect WGPs

6.1 Findings from Syrinx spectrogram analysis

As analysing song meter recordings for the detection of WGPs was new territory for research the exercise provided valuable lessons. For example due to the size of the data set for trial 2 it was possible to learn and refine identification strategies for faster and more effective detection of WGP calls. The size of the data set for trial 2 was as follows. Ten units operating for 60 days for 90 minutes each day represented a total of 54,000 minutes (or 900 hours) of recordings. With this in mind the sample to be analysed was reduced to make it more manageable and time and cost effective. The data set was reduced in the following ways:-

a) By rejecting morning recordings
(Discerning WGP calls amongst plethora of honeyeater calls becomes very difficult)
b) By selecting only 2 days in each week (the same two week days)
c) By concentrating on the first 35 minutes of each recording including the critical 20 minute call-flight period and largely ignoring the ‘redundant’ final 10 minutes

Syrinx was the bio-acoustic software chosen to perform the data analysis. Identifying WGP calls was quite easy once the general pattern of the WGP spectrogram was learnt including some additional guidelines and anomalies. And this ease of identification made analysis of the data relatively quick (a 30 minute sound file could be analysed in 1-2 minutes by an experienced analyst). A WGP spectrogram is made up of a very simple, neat, uniform collection of notes unlike most of the other recorded sounds represented on the sound file. These notes may rise continuously and gently such as in Figure 1 below or remain level and be contiguous as in Figures 2 and 3. However in both scenarios the note length and distance between the notes is very uniform.

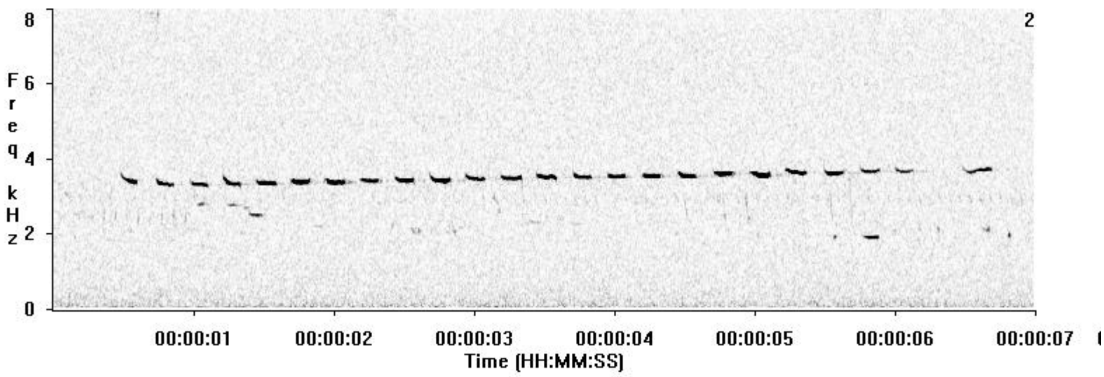


Figure 1: WGP rising call

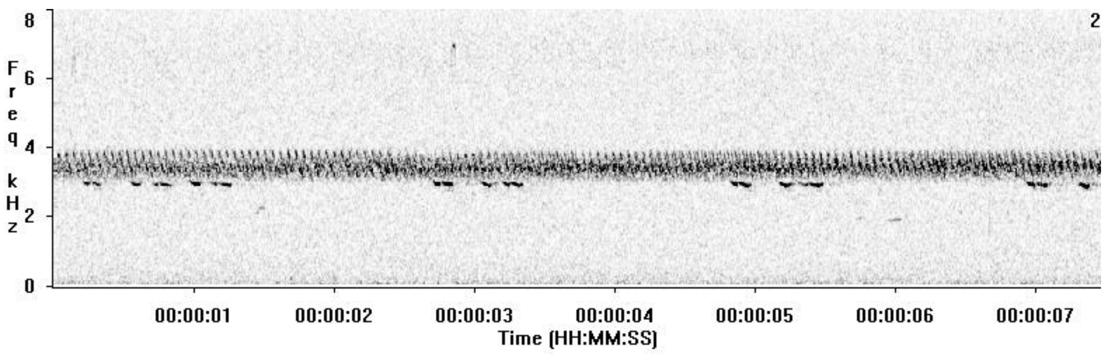


Figure 2: WGP level call with distinct pauses. Often associated with flight

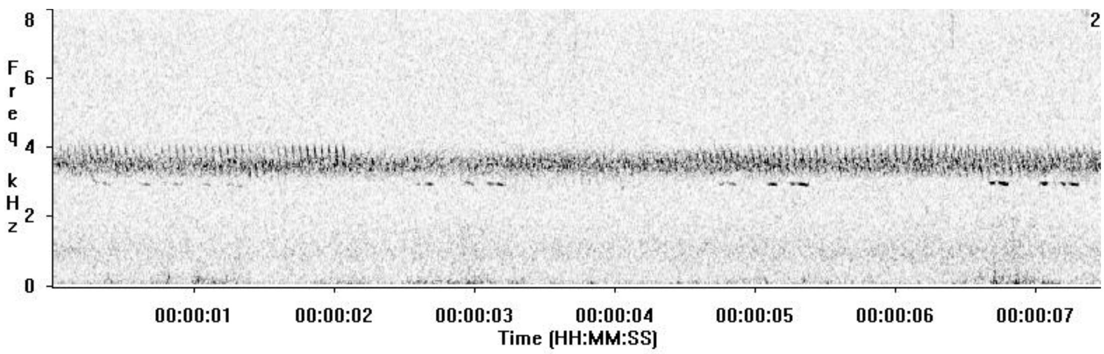


Figure 3: Another WGP level call with pauses

One cautionary note concerns loud and/or close calls. Figure 4 below appears to show a duet between 2 birds. This could then be wrongly identified as 2 calls. The top spectrogram is in fact produced by reverberation from a single bird's very loud call; also known as harmonic frequency where the 'second call' is double that of the first. A reliable guide to identifying this false positive is to observe the frequency range at which the spectrogram occupies. In this example the calls starts at 7kHz and rises to 8kHz. WGP calls are found within a range of 2-5kHz only.

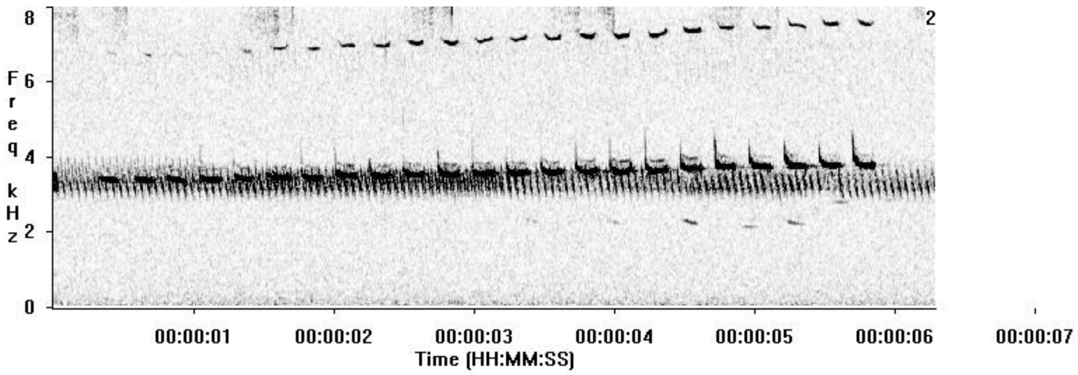


Figure 4: Echo effect from a loud WGP call

One of the most likely ways a WGP spectrogram may go undetected is because it shows up only very faintly on the screen. In Figure 5 before the start of the distinct rising call there is a very faint level call (a 'toot') at 2kHz. Such calls can often only be picked up as a suggestion of a line rather than as individual notes. It may help to adjust the contrast setting of the window in order to darken these faint calls. Figures 11 and 12 are further examples. Figure 6 shows a level and rising call exchange similar to Figure 5 except this time the level call is very much in evidence.

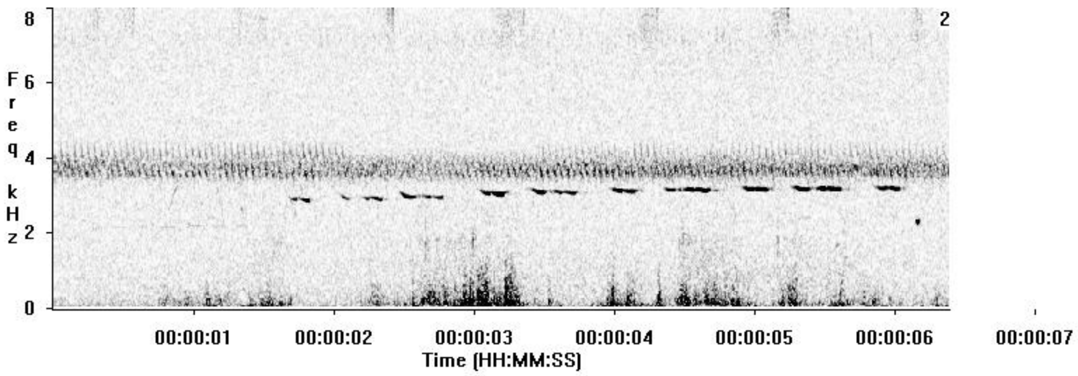


Figure 5: Faint level call at 1 second proceeding a very definite rising call

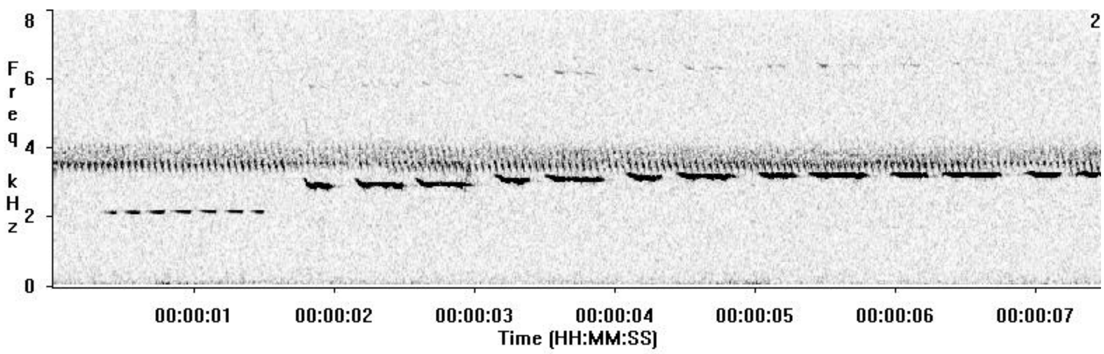


Figure 6: Rising call with clear level call (toot) lead in. Note also presence of 'reverb'

As with many 'rules' there are associated anomalies which don't conform. The rule of evenness and uniformity does not always apply to WGP spectrograms. Figure 7 shows an atypical WGP spectrogram. This call doesn't appear to fit the type. Irregular spacing between the notes and wavering in pitch would point to a Tawny-crowned Honeyeater (TCHE). However confirmation through playback showed that this is a WGP call, emphasizing the potential pitfalls but thankfully also the value of the Syrinx software in enabling audio as well as visual detection. The playback suggested that this WGP was a fledgling with under-developed vocal skills, lacking the clear, crisp notes of an adult bird and, instead, possessing a rather 'nasally' chick call. This spectrogram also highlights the difficulty of WGP detection at this time of year (November) when WGP fledglings are practising their calls.

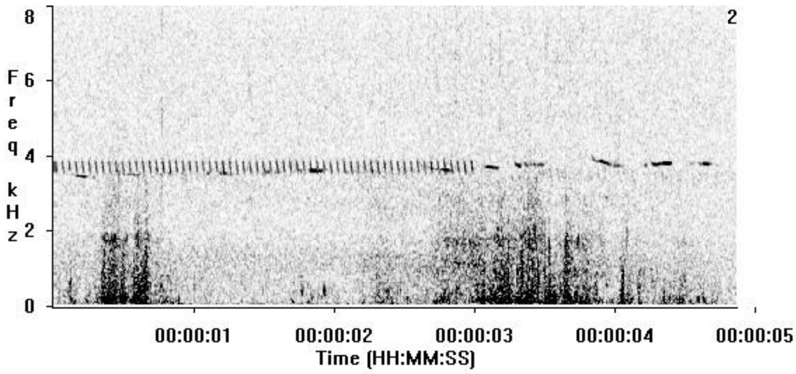


Figure 7: A very irregular WGP call needing playback to verify

Another limiting factor in the detection of WGP spectrograms is the persistent calling of crickets. These calls show up as a continuous, dark band. Some WGP calls, at approximately 3kHz, sit just beneath those of crickets (Figure 8) but some, at 3.5kHz, fall within the frequency range of cricket calls (Figures 9 & 10). Again adjustment of the contrast setting may help to draw out the WGP call but the mere presence of this dark band markedly extends the analysis time and severely compromises the ease of detection. Cricket activity is greater in the warmer months, which may be a consideration for timing of song meter installations.

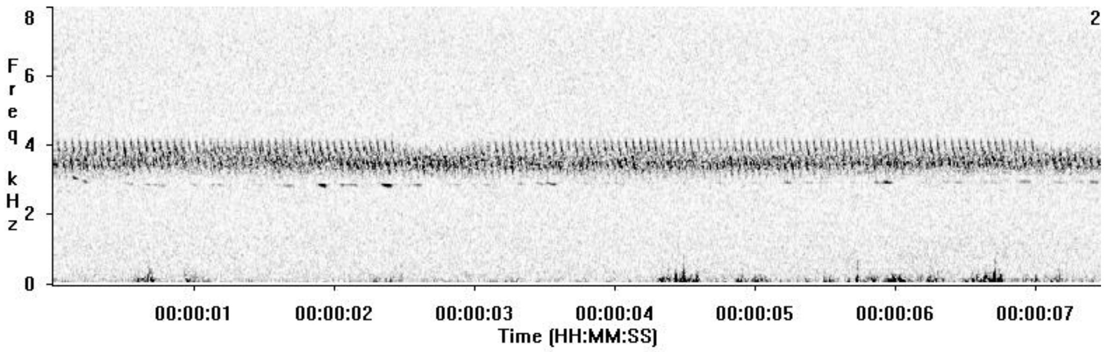


Figure 8: Potential nuisance crickets

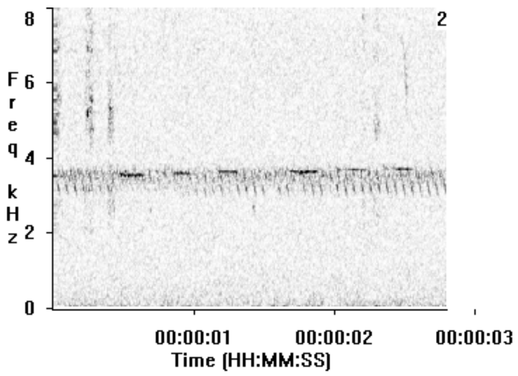


Figure 9: WGP call within cricket call range but loud enough to stand out

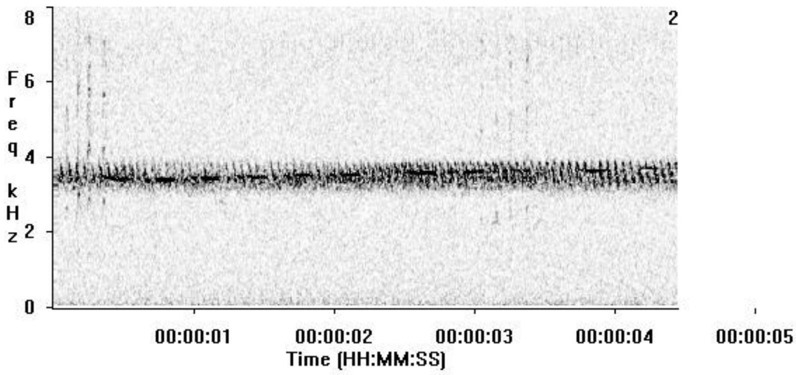


Figure 10: WGP call almost hidden within band of cricket calls

As previously mentioned some WGP calls appear very faint on the spectrogram and require a keen eye to detect. A suggested long line of similar sized dashes evenly spaced such as in Figure 11 often betray WGPs existence despite the faintness. Always use playback to confirm. Figure 12 combines some of the other anomalies and restrictions alongside the faintness, namely lack of uniformity of notes and interference from other calls.

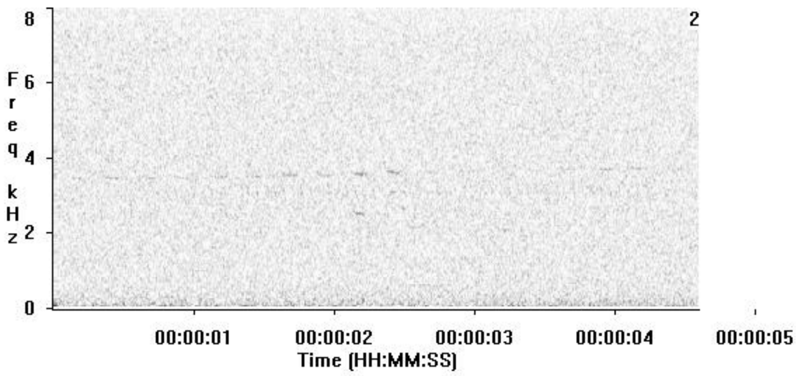


Figure 11: The suggestion of the line on this WGP spectrogram rather than clear, continuous notes is what gives the bird away here

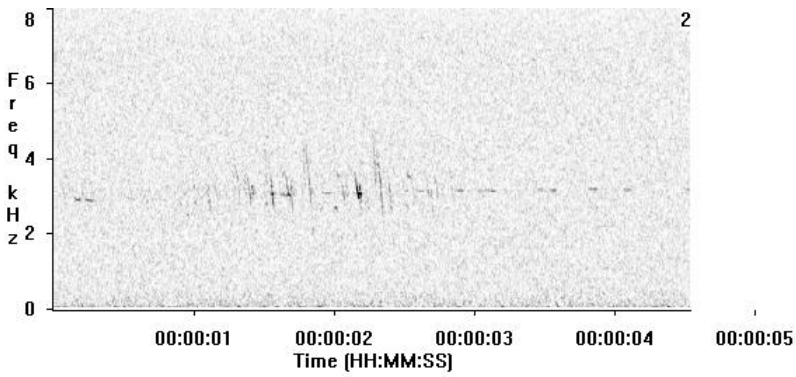


Figure 12: Faintness and interference from other sounds partially obscure this WGP call

The spectrogram in Figure 13 below suggests a possible WGP four note level call, albeit with some potential anomalies such as uneven note lengths. The call is in fact from a Tawny-crowned Honeyeater. The subtle but reliable clue is the dropped note at the beginning, in this instance very faint.

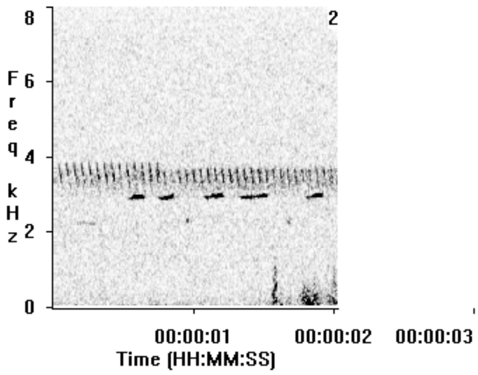


Figure 13: A Tawny-crowned Honeyeater spectrogram with faint dropped note at beginning

The following (Figures 14 – 19) are some more examples of TCHE calls masquerading as WGP calls. Although visually some of the examples appear to be close to text book WGP spectrograms it can be seen that the first note is always dropped in each set and the spatial arrangements and note lengths are slightly less regular.

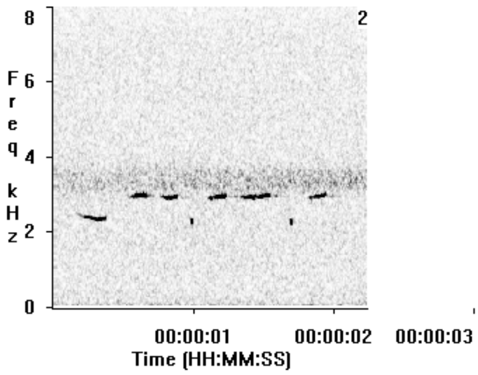


Figure 14: A Tawny-crowned Honeyeater spectrogram with well-defined dropped note at beginning

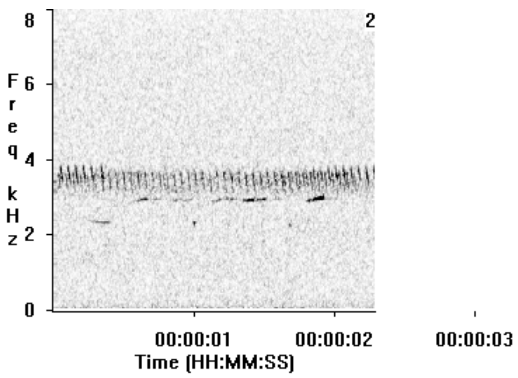


Figure 15: Tawny-crowned Honeyeater

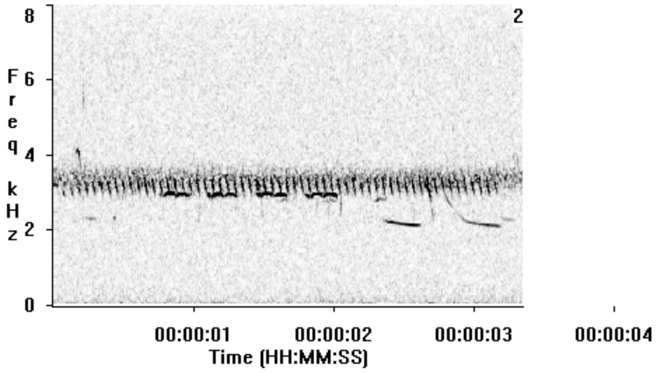


Figure 16: Tawny-crowned Honeyeater

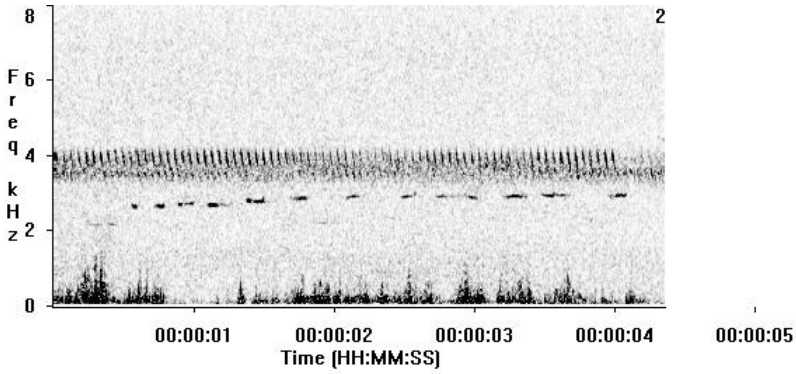


Figure 17: Tawny-crowned Honeyeater

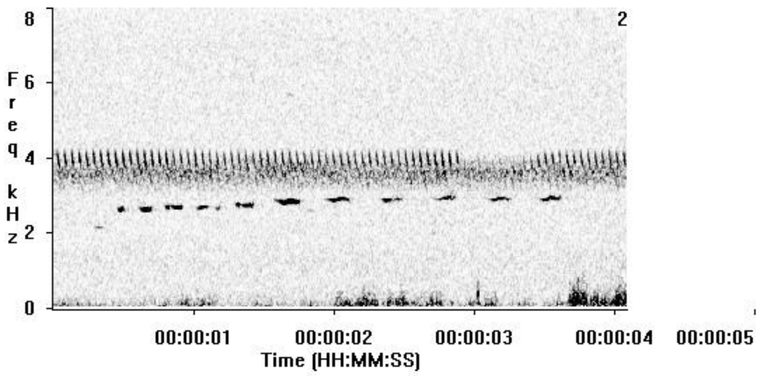


Figure 18: Tawny-crowned Honeyeater

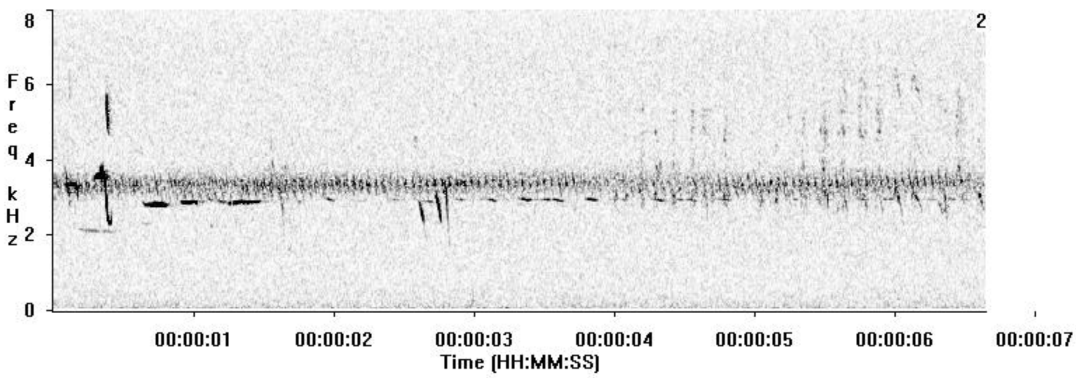


Figure 19: Tawny-crowned Honeyeater

Although the 'dropped note' rules seems to hold up, all of these calls are worth checking using playback.

Of course it is not unreasonable to expect to hear WGPs and TCHEs to be calling one after the other as in the example below (Figure 20). The WGP could even be calling in response, particularly as this TCHE call is a credible attempt at a WGP level call. Also the WGP call would be easy to miss in this example as the eye is drawn to the bolder, more pronounced set of notes.

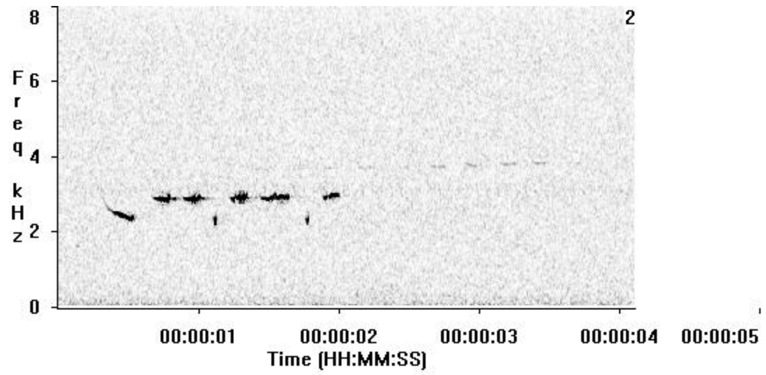


Figure 20: WGP responding(?) to a TCHE call

6.2 Problems encountered during analysis

1. Analysing 'busy' morning sessions. Detecting WGPs in the morning recordings was much more difficult than for the evenings because of the prolific calling rates of other birds, particularly the honeyeater species. These 'busy' spectrograms were represented by contiguous, thick, dark bands of lines occupying the frequency range that WGPs would otherwise be found in. Not only were these lines distracting to the eye when screening for calls but they also had the potential to completely obscure WGP spectrograms.

2. Sound interference, particularly from wind, rain and crickets, produced spectrograms in the form of thick, dark bands which could fully or partially obscure WGP spectrograms

3. Clock times. Although clock times for each SM2 unit were synchronized at the time of set-up using GPS time, all units gained or lost time over the 2 month trial period. A further trial was undertaken (see Appendix 2) to measure the time gained and lost between units over a given time frame to illustrate this point. Different clock times for each unit made comparisons of WGP call times between SM2s difficult. Could a particular call detected on one SM2 1/3/5 seconds earlier than detected on a neighbouring unit be the same call? And with what confidence? Spectrograms of both calls could be recalled to compare the spatial patterning of the notes to confirm a match.

4. Chick and immature WGP calls. Due to the variability of pitch and length of note from these calls, it was difficult to discern some potential WGP calls from the calls of TCHEs and some crickets, even after playback. Numbers of WGP calls could therefore be possibly under- or over-estimated. More and better positively identified chick and immature WGP reference calls would assist with eliminating many false positives.

5. Operator fatigue. Due to the amount of sound files quickly and easily generated, manual screening of spectrograms involved a lot of constant, repetitive mouse operation over many hours over successive days. Initially this resulted in fatigue particularly eye strain, wrist and hand repetitive strain injuries and posture related issues.

6. Time. Despite improvements in technique and screening strategies honed from practice and getting 'one's eye in', manual analysis of the data set for trials 1 & 2 still took 2 weeks.

6.3 Recommendations for analysis

1. To streamline the time it takes to manually analyse sound files and reduce operator fatigue, recording time and/or analysis could be reduced to evenings only as on most occasions these sessions prove to be more productive than mornings. Also the recording time could be reduced from 45 minutes to 30 minutes to capture critical calling time only i.e. between 20 minutes and 40 minutes after sunset. A 5 minute buffer either side would allow for slight variations in clock time and gps calculations of sunset time and bird flight and calling behaviour (see Figure 2 in Burbidge et al. 2007).

2. To improve protection of microphones when out in the field. In order to preserve the life of the microphones, reduce replacement costs (a pair of SM2 microphones costs approximately $180) and maintain detection capabilities over a longer period, some form of shelter should be trialled. Retail wildlife research equipment specialists Faunatech sell a song meter microphone protector which is essentially a simple roof design protecting the microphones from the worst impacts of rain and UV. Significant interference generated from the sound of raindrops falling onto the aluminium surface would need further investigation.

3. SM2 unit clocks should be checked and adjusted to local GPS time before each time units are installed to ensure that the clocks are accurate and synchronized with all other units' clocks. Synchronization is particularly important when comparing recordings between neighbouring units in an attempt to match calls. If repeating this exercise in the future and, if practical to do so, Song Meters should be re-synchronised weekly to minimise time discrepancies.

4. It is strongly recommended to avoid song meter installation in late spring when chicks are mobile and practicing their calls. This is particularly important with trial work when confidence levels for WGP detection of both SM2 and human listener need to be optimised.

5 & 6. To trial automated recognition software to speed up analysis, increase the size of the analysed dataset and provide a standard and consistent form of analysis.

6.4 Problems encountered in the field

1. Damaged microphones or SM2 units. The housing of some of the microphones had loose fittings and exposed wiring therefore potentially affecting recording capabilities. Microphone socks were visibly degraded through exposure to weather and UV. Some of the units experienced condensation inside the housing, presumably due to faulty seals.

2. Physical damage to units in transport and storage and exposure to dust, humidity and temperature.

3. No suitable naturally-occurring, tall, rigid structure for mounting SM2 units in WGP heathland habitat which comprises largely knee-high vegetation. Therefore a suitable mount had to be carried into the site. The use of droppers (see Figure 1) was preferred as they are relatively light and stack neatly. However the use of cable ties and cloth tape was somewhat fiddly and time consuming. If not done carefully, loosely attached units could knock against the droppers producing undesirable, repetitive and obscuring sound.

4. Screw down lids were time consuming to remove and the threads of the screws were prone to damage thus affecting the integrity of the water-tight seal. However this type of fixture did provide a measure of security against tampering with the settings.

5. Battery carousel. Despite the SM2 having been modified to make the battery carousel more user-friendly, inserting batteries still proved to be fiddly and quite difficult. Of more concern was the fact that in transit some of the batteries were liable to slip off their terminal and therefore become non-operational.

6.5 Recommendations for field installations

1. To test existing microphones. Despite the microphones being weatherproof, they will degrade over time to a point where their detection capabilities are significantly reduced and so their future use cannot be relied upon. Even satisfactorily working microphones may have a degree of variability between them which would affect how standardised they were for monitoring purposes. It is recommended that some form of acoustic testing be established and performed using a measurable tone generator to ascertain the capability of each microphone for WGP detection purposes.

2. Strongly recommended to transport SM2s in robust cases (e.g. Pelican cases). At nearly half the cost of the SM2 some storage cases are expensive but were considered essential for field work where vibration and adverse environmental conditions (e.g. moisture and dust) are potentially very damaging to bio-acoustic hardware. The cases purchased for this project were chosen so that they could house 2 units each and therefore reduce the unit cost burden.

3. To devise a more user-friendly, quick-to-erect stand therefore lessening the chance of poor installation. More recently such a stand has been trialled using a metal plate attached to a single, aluminium dropper. So far this has worked quite well (lightweight, quicker installation) despite being less rigid than the double dropper structure used for this report. A purpose designed and built product on the market could improve the set-up further.

4. After installation in the field it is strongly recommended to remove the lid of the SM2 and check that batteries are seated correctly and secure in the carousel. Also to check that the unit wakes up to display the next expected recording time.

5. To be able to more accurately assess the battery life. The Song Meter Configuration Utility does predict the battery life for a particular recording schedule but only on the assumption that the batteries are new or fully charged. Since the trials in this report, this problem has been overcome by replacing disposable alkaline batteries for rechargeable batteries, and ensuring that such batteries are fully charged before each and every installation.

6. To be able to generate location coordinates i.e. for the SM2 to be able to create a waypoint for its field location in the same way that a hand-held GPS functions.

7. To be able to extract wind speed and direction data from the song meter using an in-built data logger. This would help with the selection of which sound files to analyse when undertaking manual analysis, as less windy days could be selected. Also possible relationships between WGP calling rates, Song Meter detection rates and weather parameters could be interrogated.

References:

Agranat, I. (2007). 'Automatic detection of Cerulean Warblers using autonomous recording units and Song Scope bioacoustics software'. (Wildlife Acoustics Inc: Concord, Massachusetts.) Available at: http://www.fs.fed.us/t-d/programs/im/acoustic_wildlife/Cerulean%20Warbler_%20Report_Final.pdf.

Burbidge, A. H., Rolfe, J., McNee, S., Newbey, B., and Williams, M. (2007). Monitoring population change in the cryptic and threatened Western Ground Parrot in relation to fire. *Emu* 107, 79–88.

7.0 Appendices

Appendix 1: Trial 2 table of results showing complete data set of times of positive WGP calls recorded on Song Meter units at CANP between 10 November 2011 & 7 January 2012

Notes

- 10 x song meters deployed (unit # *39aa incorrect clock setting therefore extra column denotes adjusted time to synchronise with other units
- Blank, white cells indicate no WGPs were detected
- Coloured cells containing times denote a matchup of times between 2 or more song meters (to within a few seconds)
- Song meter '1aa' was faulty for the entire time (no sound recorded - damaged microphones?) and therefore no records were attained
- Song meter '23aa' was missing first file therefore no records for 10/11/11
- Song meter '42aa' was missing first folder therefore no records between 10/11/11 & 16/12/11

101111

SM ID 1aa	23aa	33aa	34aa	39aa	*39aa - 27 mins	40aa	42aa	43aa	48aa	50aa
faulty	missing file	6:27	6:32	33:27:00	6:27:00	no wgps	missing file	6:28	6:28	
		7:17	7:22	34:16:00	7:16:00				7:17	
				36:05:00	9:05:00			9:06	9:06	
		10:05		37:04:00	10:04:00			10:07		
		12:08		39:09:00	12:09:00					
		13:00		40:01:00	13:01:00			13:02		
				42:18:00	15:18:00					
		16:17						16:19	16:19	
		17:04	17:11					17:06	17:06	
		17:32	17:38					17:33	17:33	
			17:43							17:43
		24:03:0	24:09:00					24:04:00	24:04:00	

111111

1aa	23aa	33aa	34aa	39aa	39aa - 27	40aa	42aa	43aa	48aa	50aa
faulty	7:28		no wgps	34:26:00	7:26	no wgps	missing file	7:28	7:27	7:23
		9:02		36:03:00	9:03					
		18:10						18:12	18:12	
		18:47						18:48	18:49	
		20:58						21:00		

171111

1aa	23aa	33aa	34aa (+10s?))	39aa	39aa - 28	40aa (+15s?)	42aa	43aa	48aa	50aa
faulty	no wgps						missing file	1:31		no wgps
									2:58	
		5:06						5:07	5:09	
		5:38						5:39		
		6:19		34:23:00	6:23	6:36		6:21	6:21	
						6:41			6:39	
		6:44		34:45:00	6:45			6:45	6:47	
		8:22						8:22	8:26	
								8:41		
								9:22	9:11	
			11:02					10:51	10:56	
			12:36	40:26:00	12:26			12:26	12:28	

181111

1aa	23aa	33aa	34aa (+10s?))	39aa	39aa - 28	40aa (+15s?)	42aa	43aa	48aa	50aa (-16s?))
	8:30					8:42			8:29	
	10:38	10:33		38:36:00	10:36	10:50		10:35	10:36	
		11:52								
faulty	13:58	13:54		41:54:00	13:54	14:10	missing file	13:55	13:56	
	14:57								14:55	
			16:51							
			17:36						17:31	17:14
			18:24							18:08
			18:45						18:35	18:22

241111

1aa	23aa	33aa	34aa (+10s?))	39aa	39aa - 28	40aa (+15s?)	42aa	43aa	48aa	50aa (-16s?))
			6:39 chick?						6:26 chick?	6:08 tche?
									10:23	
			12:36 chick							12:12 chick?
			16:18							
faulty				no wgps	no wgps		missing file			16:48 chick?
	17:05	17:00				17:22 (tche?)		17:01	17:04	
								17:13	17:14	
			17:33							

251111

1aa	23aa	33aa	34aa (+10s?))	39aa	39aa - 28	40aa (+15s?)	42aa	43aa	48aa	50aa (-16s?))
	8:04					8:22 (chick)				7:56 chick
faulty		no wgps	15:36	no wgps	no wgps		missing file	15:18	no wgps	
			19:43					19:26		

011112

1aa	23aa	33aa	34aa (+10s?))	39aa	39aa - 28	40aa (+15s?)	42aa	43aa	48aa	50aa (-16s?))
			11:07							
									12:52	
			13:14					13:03		
faulty		no wgps	16:59	no wgps	no wgps	no wgps	missing file			no wgps
	17:46									
	17:58									

021112

1aa	23aa	33aa	34aa (+10s?))	39aa	39aa - 28	40aa (+15s?)	42aa	43aa	48aa	50aa (-16s?))
		5:39								
		6:54								
faulty	no wgps	7:20	no wgps	no wgps	no wgps	no wgps	missing file	no wgps	no wgps	no wgps
		7:43								
		9:29								

081211

1aa	23aa	33aa	34aa (+10s?))	39aa	39aa - 28	40aa (+15s?)	42aa	43aa	48aa	50aa (-16s?))
								3:28	3:30	
				32:01:00	4:01					
						5:00				
faulty	no wgps	no wgps	no sound?	38:02:00	10:02		missing file			no wgps
				38:30:00	10:30					
								11:58		
								14:21	14:26	

091211

1aa	23aa	33aa	34aa (+10s?))	39aa	39aa - 28	40aa (+15s?)	42aa	43aa	48aa	50aa (-16s?))
		3:04	3:13					3:01	3:07	
								9:02	9:07	
		9:34								
faulty	no wgps			37:54:00	9:54	no wgps	missing file			no wgps
									10:48	
				41:46:00	13:46					
									14:25	

151211

1aa	23aa	33aa	34aa (+10s?))	39aa	39aa - 26	40aa (+15s?)	42aa	43aa	48aa	50aa (-16s?))
	1:18	no wgps	no sound except wind			no wgps	Missing file	no wgps	1:16 wavery	no wgps
				31:15:00	5:15					

161211

1aa	23aa	33aa	34aa (+10s?))	39aa	39aa - 26	40aa (+15s?)	42aa	43aa	48aa	50aa (-16s?))
	4:25	4:13								
			no wgps	no wgps		no wgps - hardly any sound	Missing file	5:14 thce?	no wgps	no wgps
								5:59		

221211

1aa	23aa	33aa	34aa (+10s?))	39aa	39aa - 23	40aa (+15s?)	42aa	43aa	48aa	50aa (-16s?))
			4:26?			4:35 chick?			3:54 chick?	
			4:45?							
			10:14?							11:56 wgp?
			10:30?							14:12 wgp?
faulty		no wgps	12:56?	no wgps	no wgps		no wgps	14:50 chick?		14:41 wgp?
			15:21?							15:32 wgp?
	16:14 tche?		16:42?							
			25:57:00					25:18 wgp?	25:26:00	

231211

1aa	23aa	33aa	34aa (+10s?))	39aa	39aa - 23	40aa (+15s?)	42aa	43aa	48aa	50aa (-16s?))
	13:26 wgp? l/toot?		13:48	33:13:00	10:13			13:08	13:16	12:37
faulty		no wgps		34:35 toot?	11:35	no wgps	no wgps		15:13 wgp?	
				38:44:00	15:44					

291211

1aa	23aa	33aa	34aa (+10s?))	39aa	39aa - 20	40aa (+15s?)	42aa	43aa	48aa	50aa (-16s?))
faulty	no wgps	no wgps	no wgps	no wgps	no wgps	no wgps	no wgps	no wgps	no wgps	no wgps

301211

1aa	23aa	33aa	34aa (+10s?))	39aa	39aa - 19	40aa (+15s?)	42aa	43aa	48aa	50aa (-16s?))
faulty	no wgps	no wgps	no wgps	31:05:00	no wgps	no wgps	no wgps	no wgps	no wgps	no wgps

060112

1aa	23aa	33aa	34aa (+10s?))	39aa	39aa - 15	40aa (+15s?)	42aa	43aa	48aa	50aa (-16s?))
faulty	no wgps	no wgps	20:50	no wgps	no wgps	no wgps	no wgps	10:19 wgp?	no wgps	19:21
			22:02							

070112

1aa	23aa	33aa	34aa (+10s?))	39aa	39aa - 14	40aa (+15s?)	42aa	43aa	48aa	50aa (-16s?))
faulty	no wgps	no wgps	19:15	21:29	7:29	no wgps	no wgps	no wgps	7:37	no wgps

Appendix 2 Table showing SM2 song meter in-built clocks accuracy over time

Over 42 days from 28 February to 11 April 2012 most units gained time. The slowest unit lost 30 seconds, the fastest gained 65 seconds. These time changes do not significantly affect WGP recording times only shaving a small amount of time off the 'buffer' time purposefully built around the critical call-flight period. The 'buffer' is normally 5-10 minutes of recording time before and after the critical period so 1 minute lost or gained over nearly 2 months does not compromise the dataset. Where the time changes do cause problems is for comparison studies between calls detected between units or between a unit and a human listener. It becomes that much harder to match up calls where units and humans are not synchronised to with a second or two of each other.

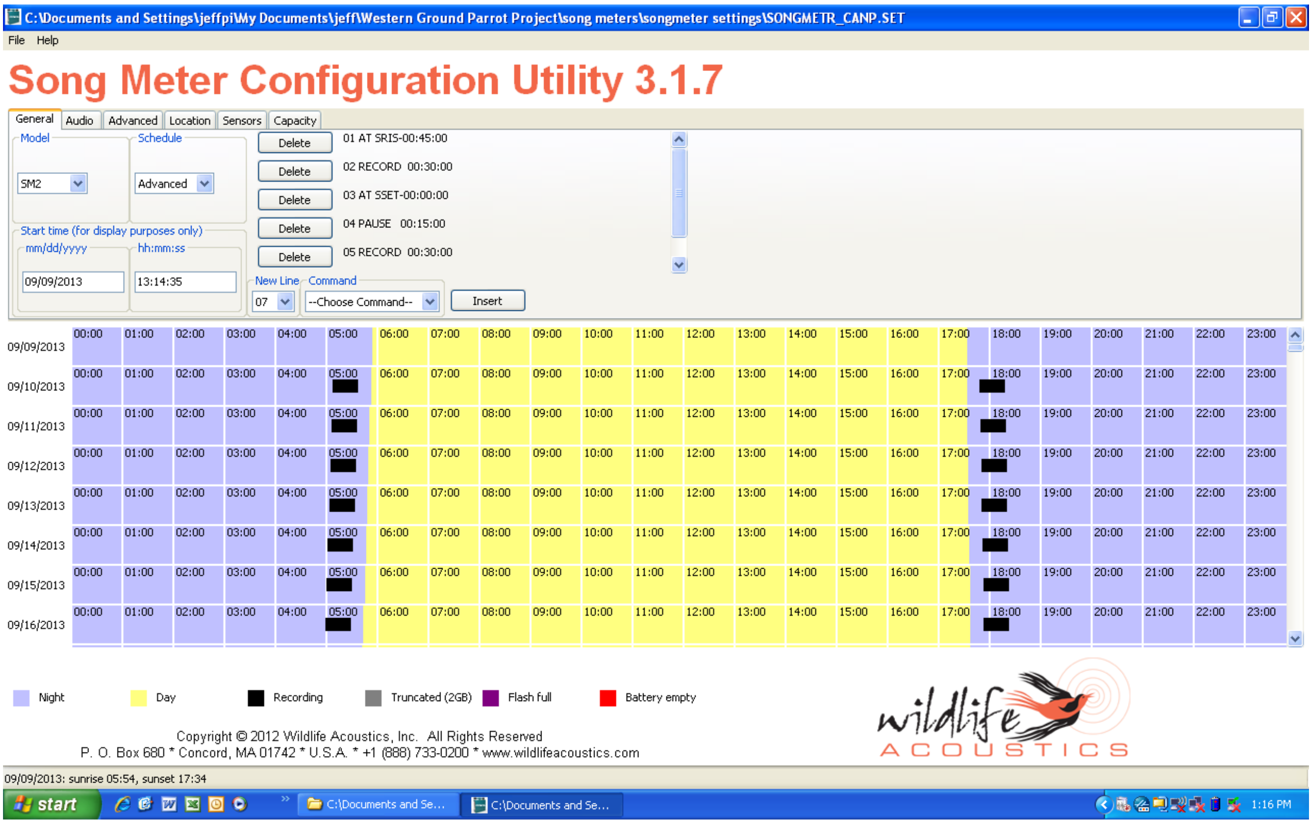
Song Meter	28-Feb-12	7-Mar-12	gain since last	30-Mar-12	gain since last	11-Apr-12	gain since last	11-Apr-12
1	synched*	5 slow	-5	20 fast	25	not checked	not checked	
16	synched*	on time	on time	11 fast	11	14 fast	3	Re-synched
18	synched*	11 slow	-11	63 fast	73	65 fast	2	
19	synched*	on time	on time	15 fast	15	19 fast	4	Re-synched
21	synched*	9 slow	-9	5 fast	14	10 fast	5	Re-synched
23	synched*	10 slow	-10	on time	10	4 fast	4	Re-synched
25	synched*	8 slow	-8	8 fast	16	14 fast	6	Re-synched
27	synched*	1 fast	1	15 fast	14	19 fast	4	Re-synched
29	synched*	6 slow	-6	9 slow	-3	13 slow	-4	Re-synched
32	synched*	6 fast	6	33 fast	27	45 fast	12	Re-synched
33	synched*	5 fast	5	10 fast	5	not checked	not checked	
34	synched*	6 slow	-6	20 fast	26	29 fast	9	Re-synched
35	synched*	4 slow	-4	3 slow	1	4 slow	-1	
39	synched*	1 slow	-1	4 fast	5	5 fast	1	Re-synched
40	synched*	12 fast	12	41 fast	29	not checked	not checked	
42	synched*	1 fast	1	6 slow	-7	12 slow	-6	Re-synched
43	synched*	4 fast	4	11 fast	7	not checked	not checked	
47	synched*	10 slow	-10	2 slow	8	on time	2	Re-synched
48	synched*	11 slow	-11	1 slow	10	1 fast	2	
50	synched*	16 slow	-16	24 slow	-8	30 slow	-6	Re-synched

* Synchronised with official Perth time

Appendix 3

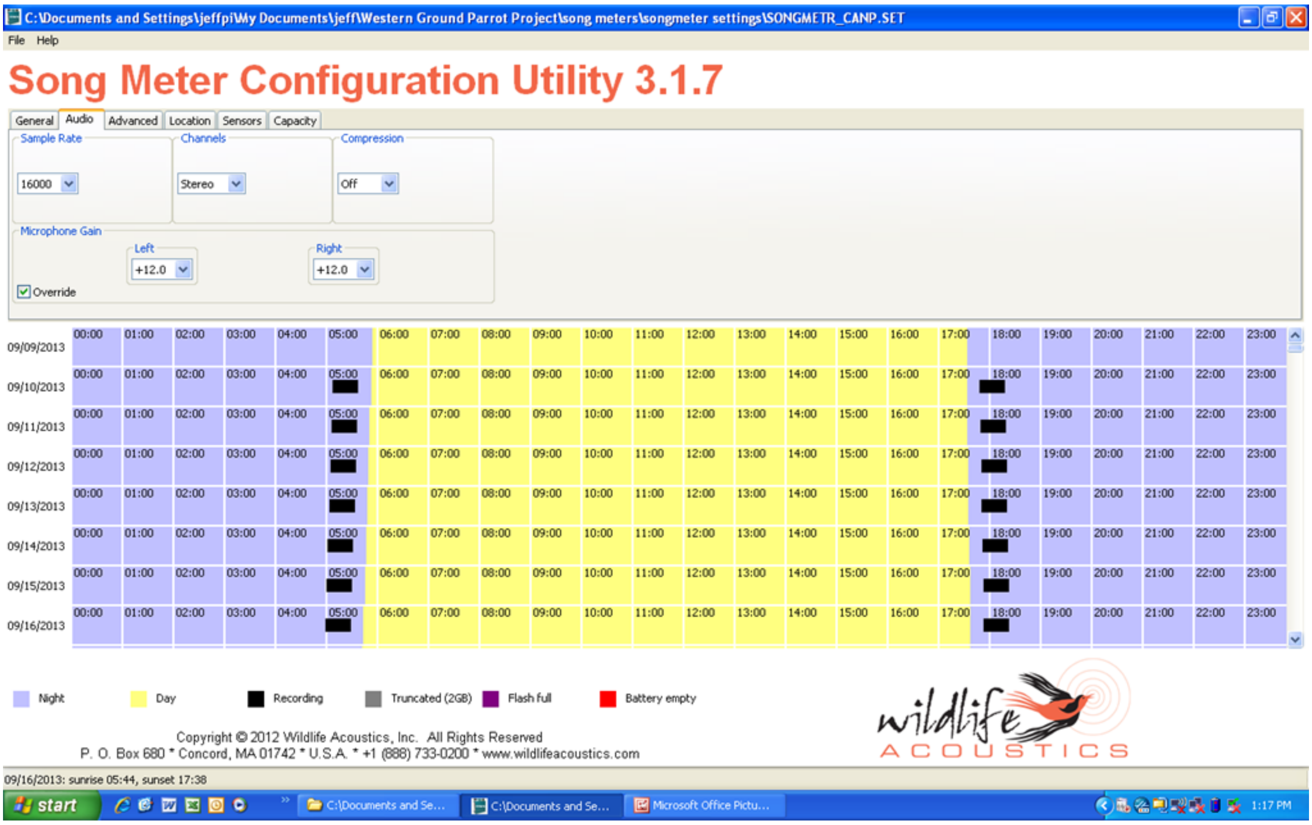
Song Meter Configuration Utility software where advanced recording schedules can be programmed.

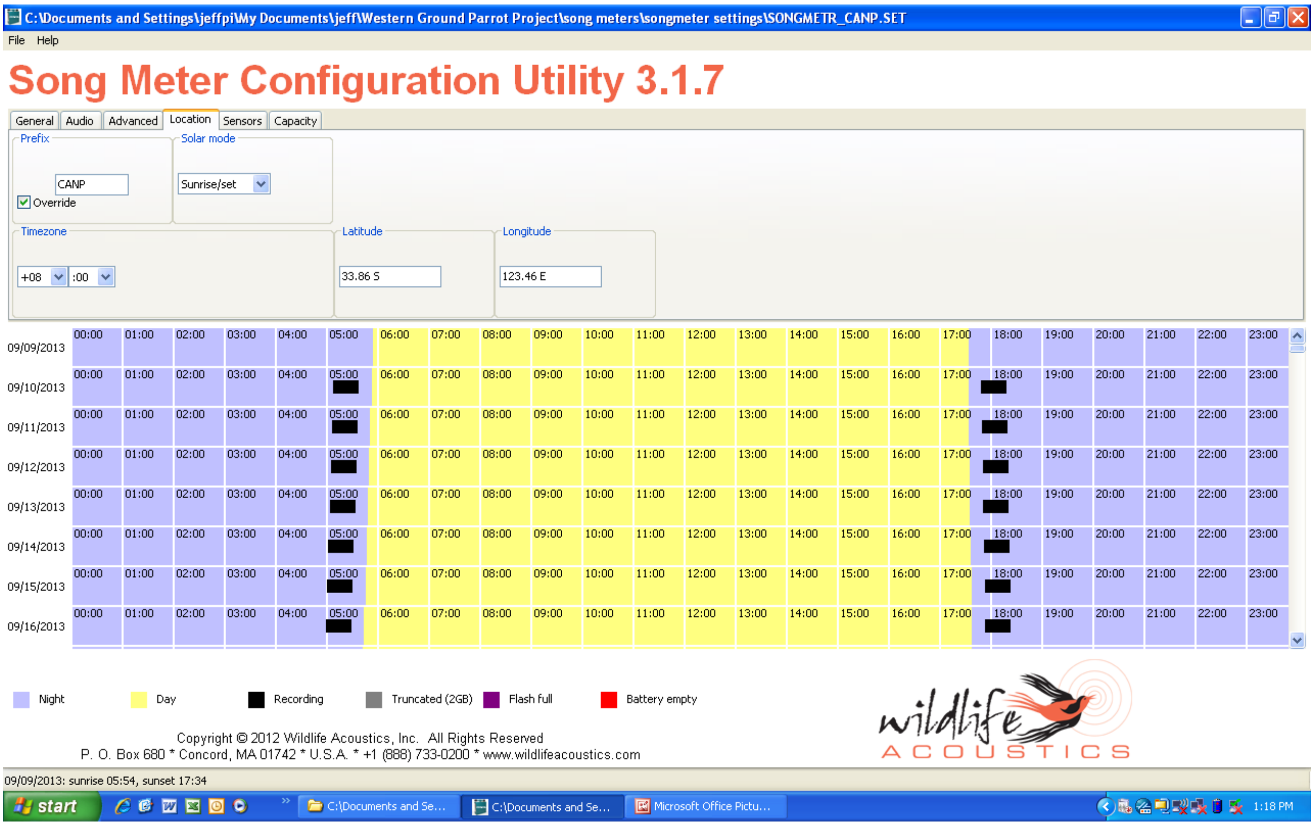
The top table shows the schedule that has been created for the Western Ground Parrot. It can be seen that the selected song meter will begin recording at sunrise minus 45 minutes (i.e. 45 minutes before sunrise) and record for 30 minutes. At sunset the recording will be paused for 15 minutes before starting and then record for 30 minutes. The bottom table illustrates this recording schedule graphically. The black bars indicate the time and duration of recording for a 24 hour period.



Appendix 4

Audio settings set for WGP recording. Note in the top table that the microphone gains are both set to maximum gain of 12dB to optimise detection of distant calls.





Also remember to set file to WAV not WAC.

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