Observatory reports

Australia Telescope Compact Array

Staff

The overall observatory staff number was relatively stable during 2000 with approximately 32 full-time equivalent members. There were a number of staff changes, both departures and arrivals.

Departures

Tina Earle left after three years as Administrative Assistant.

Longest standing staff member Alan Spencer (Senior Technical Officer) retired after working for CSIRO at the Observatory since 1978 when the Solar Heliograph was in operation. Alan was a great source of knowledge of many aspects of the Observatory and its instrumentation, including the most recent developments. He continued to be very productive right up to his retirement on 31 March 2000.

Mark Bland resigned after more than eight years in the Electronics Group. Mark worked as Senior Technical Officer with the Array's cryogenic systems and also managed the Observatory's engineering drawings.

Graham Baines resigned after seven years at Narrabri. Graham worked first as receiver engineer in the Electronics Group, then took on senior roles, initially as Electronics Group leader then as System and Coordination Engineer. Graham has moved to take up a position at the Deep Space Communication Complex at Tidbinbilla.

Frederic Badia left after three years in the Computer Group where he worked on a number of software developments, including the "Online Imaging" system and a Web-based Compact Array scheduling program.

At the end of the year Electronics Group leader Ben Reddall departed for 12 months exchange leave to work for the University of Chicago at the South Pole on the Degree Angular Scale Interferometer (DASI).

Arrivals

Clive Murphy, a mechanical engineer, formerly working at the Cargill seed oil mill in Narrabri, joined the staff in September and is leading the Site Services and Engineering Group.

Cliff Harvey joined as a technical assistant in the cryogenics area in September.

Rudi Behrendt joined as a technician, also in September.

Anne Reynolds was appointed as administrative assistant in September, and in November began acting for Kylee Forbes who is taking maternity leave. The administrative assistant position was held on a casual basis through the year by Dianne Harris, and during Kylee's absence by Margaret McFee.

David Brodrick joined the Computer Group as a software engineer in December.

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Visitors

From June the observatory was host to visiting scientist Prof. A. Deshpande from the Raman Research Institute, Bangalore, India. Desh lived on site for his six-month visit and was accompanied by his family until September. During his visit Desh worked with ATNF staff on the prototype Pulsar Backend, and also on understanding the interferometer response when one antenna is shadowed by another.

Students

The 1999–2000 summer vacation scholars at the Observatory were Linh Vu and Rachel Deacon. Linh worked with Ravi Subrahmanyan on a mathematical project concerning digital filters. Rachel worked with Dave McConnell producing and analysing a deep 20-cm image of the globular cluster 47 Tucanae.

In December two new vacation students joined the Observatory for the summer: Elizabeth Claridge (University of Tasmania) and Tim Connors (University of Sydney). Liz worked with Steven Tingay, and Tim with Dave McConnell searching for extended radio emission from the globular cluster 47 Tucanae.

During 2000 the Observatory hosted three high school work experience students. All three were from the same school and Tim Kennedy organized a single joint project for them. The project involved purchasing an inexpensive kit to build a simple radio telescope to work at 20 MHz, with the aim of detecting Jupiter's strong decametric radiation. Unfortunately the Jovian ephemeris was not very suitable for the week chosen for the experiment. However the kit was successfully built and a surprisingly accurate measurement of the strength of the Galactic 20 MHz radiation was made.

The Observatory also hosted two older, university undergraduate work experience students who worked with Steven Tingay and Naomi McClure-Griffiths (visiting PhD student observer).

Array performance and time use

The performance and time use of the Compact Array in 2000 is summarized in Table 1. The total number of hours is greater than one year (371 days) because the October 2000 observing term extended into January 2001. Of the 6,705 hours of observations, 12.1% were conducted remotely over the computer networks from a variety of locations within Australia. The downtime figures give the hours lost due to equipment or operational failure during scheduled observations, with the percentage expressing the fraction of scheduled observing time lost. The time used for maintenance and installation work was larger than usual because of several periods of MNRF related installation work, particularly periods in June and July for optic-fibre installation and two weeks in

***Table 1** Compact Array time use, 2000*

	Hours	%
Observing	6705	76.3
Maintenance/installation	1424	16.2
Reconfiguration	375	4.3
Unallocated	278	3.2
Total	**8782**	**100.0**
Downtime	328.9	4.9

November and December for receiver and local oscillator installation. In spite of that, more than 70% of Array time was used for astronomy. Note the unusually high downtime figure, which was close to the target of 5%. This was dominated by two serious failures in the January observing term. An azimuth gear box on antenna 1 failed and required removal and extensive repairs, and a serious electrical failure occurred in antenna 6 which disabled that antenna for several days.

Table 2 summarizes the sources of lost time on the Compact Array during 2000, clearly showing the two large failures in the January term against antenna drives and power. Note that the downtime tabulated for the full Array is usually computed as one third of the time lost on a single antenna.

User feedback

Each observer is requested to assess the quality of support at the Observatory by giving a rating in the range 1–5 where 1 = poor and 5 = excellent. The results of these questionnaires are published in ATNF newsletters, presented to AT Users' Committee meetings and used by Observatory staff to direct development of observing support facilities. Figure 26 summarizes the questionnaire results from 36 responses received during 2000.

Table 2 Time lost on the Compact Array, 2000

	hr			2000	
	00Jan	00May	00Oct	hr	%
Antenna drives	106.5	2.8	3.3	112.5	34.2
ACC	11.1	14.0	15.4	40.5	12.3
Power	26.0	3.1	5.0	34.1	10.4
Cryogenics	14.9	15.6	0.0	30.3	9.2
Correlator	14.6	11.1	4.6	30.3	9.2
Other electronics	1.4	5.9	7.9	15.2	4.6
General computing	8.8	0.3	2.0	11.1	3.4
Receiver	0.0	5.9	.3	10.2	3.1
Operator	0.8	8.8	0.2	9.7	2.9
Other	8.3	0.4	0.8	9.6	2.9
Comms problems	3.7	5.8	0.0	9.5	2.9
Weather	0.0	1.6	5.3	6.9	2.1
Encoders	1.6	2.4	0.8	4.8	1.4
Operations	1.5	1.3	0.7	3.4	1.0
Phase transfer system	0.0	0.2	0.2	0.3	0.1
Air conditioning	0.0	0.3	0.0	0.3	0.1
Totals	**199.2**	**79.4**	**50.3**	**328.9**	**100.0**

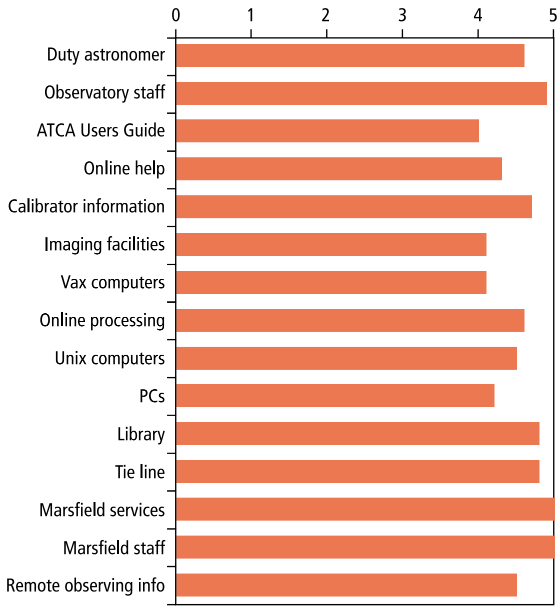


Figure 26 *Narrabri user feedback*

Compact Array calibration sources

During 2000 the program of reviewing all Compact Array calibration sources was continued and by the end of the year each of the 240 sources in the full calibrator list was reobserved at least once in each of the four centimetre-wave bands. A number were also observed at 12 mm and 3 mm. The results of the observations were published on http://www.narrabri.atnf.csiro.au/calibrators/ with information given for time variability, polarization and plots of visibility amplitude against baseline length.

The "Y2K bug"

On 1 January 2000 the Compact Array operated flawlessly through all three relevant "midnights" at 0:00h AEST, Civil

Time, and Universal Time. Over the previous 18 months the operating software for the Array had been examined and tested for the notorious "Y2K bug". The only problems encountered were minor: one with third-party software used in off-line backup of Unix and pc servers; and a curious formatting problem in a rarely used option for labelling export data CD-ROMS.

TECHNICAL DEVELOPMENTS

In 2000 the development work on the Compact Array was again dominated by the MNRF program, a major component of which is funding the upgrade of the Array to operate at high frequencies. The Array upgrade is expected to be complete by the end of 2002 with scheduled mm-wave observing commencing in mid-2003.

North spur and extra stations

Multi-pair cabling to new station posts was completed during the year. In November the north spur was used to reorder the antennas. This was necessary to get a short baseline for the new mm-wave receivers in antenna numbers 3 and 4, while keeping to the advertised 1.5B array configuration. This was an opportunity to do further checks on the modified long-travel drives in these antennas.

12/3-mm receivers

Two prototype receiver packages were installed in November 1999 and operated over the 20.6–22.8 GHz band. During the first part of 2000 they were the subject of a number of performance tests, both of the receivers themselves and of the antenna optics and calibration techniques. Later in the year each was refitted with new single-polarization 22-GHz low noise amplifiers (LNAs) which operated over the 17.5–25 GHz range, and a single channel at 3 mm (84.0–91.1 GHz). The receiver packages were installed in November 2000 and "first light" on a 3-mm interferometer was measured on 30 November (page 16). Since then the performance, optics and calibration testing has continued at both wavelength bands.

Local oscillator distribution

During 2000 optical fibres for local oscillator distribution were laid to almost all of the station posts. Each fibre must be spliced to a connection fibre at the station post and in the screened room; two thirds of the splicing has now been completed. Both the laying and the splicing were major jobs. The fibre laying was done in several sessions using a number of staff from both Narrabri and Marsfield. The splicing at the station posts was done in a specially constructed "splicing van" which provided a controlled environment for the splicing and a degree of comfort for the splicer.

Leigh Panton, an apprentice with the ATNF Narrabri electronics group, splicing fibres at a patch panel in the screened room

Antenna Control Computers

Work on the new Antenna Control Computers continued through 2000. The hardware interfaces between new machines and antenna equipment have been designed and are largely complete. Software development for interfacing the new antenna computers to the existing observing and array monitoring software has continued.

Pulsar Backend

During the last few months of the year outstanding progress was made with the Compact Array Pulsar Backend. This device will allow observations of pulsar profiles from the combined signal of all six antennas, giving a collecting area equivalent to a 54-m dish. The Backend provides spectra with up to 1024 channels in each of 1024 points across the pulsar period. It operates at a number of bandwidths up to a maximum of 64 MHz and can be used in any of the wavelength bands offered by the Compact Array. Martin Oestreich, Scott Cunningham and visitor Prof Deshpande from the Raman Research Institute, Bangalore, have made good progress with the project and made some successful observations with a prototype operating on a single polarization channel. Figure 27 shows a profile of the pulsar J0437-4714 at 1410 MHz, observed using the Pulsar Backend.

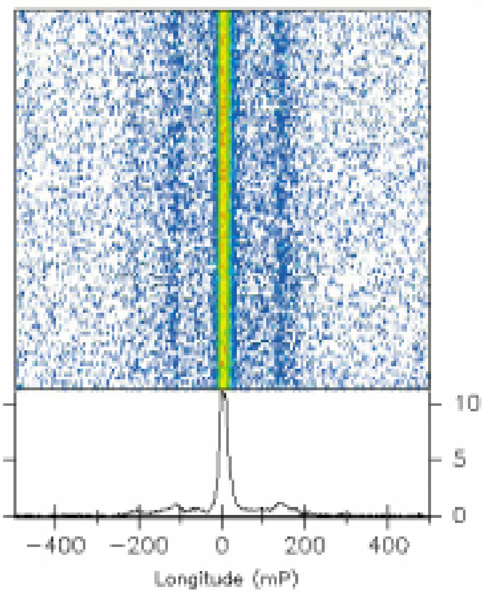


Figure 27 *An averaged profile for the pulsar J0437-4714. The square box shows the strength of the pulsar signal plotted as a function of the pulsar period on the horizontal axis, and time on the vertical axis. The averaged profile is shown below the box.*

Receiver turret positioning

Improving the repeatability of receiver turret positioning has been a goal for more than a year. The small non-repeatability was originally found to limit the precision of circular polarization measurements in 1998. Improvements have been made by providing machined locating notches for each receiver package (replacing the original low precision notches) and careful adjustment of the rollers which bear on the turret ring. These adjustments have been concluded to the point where the expected non-repeatability in axial position is about 0.2 mm. The tangential repeatability is now limited by play in the thruster mechanism itself, which is yet to be measured.

Infrastructure and site works

The site improvement works associated with the north spur construction were completed in 2000. The Observatory roads, which had been damaged during the construction works (because of several periods of very wet weather), were repaired, and most of the roadway around the site centre was resealed. The new access and parking areas around the tourist Visitors Centre has been finished off with a wooden post and rail fence.

Late in 2000, work commenced on rebuilding the stairs in the Control Building. These were in breach of building regulations, being dangerously steep.

Parkes

Performance and time use

The fraction of time scheduled for all observations in 2000 was 82%, down slightly on the figure of 84% for 1999. However, time lost both to equipment faults and to poor weather were also down significantly on the 1999 figures, resulting in an unchanged figure of 79% for the fraction of time successfully used for observations.

The reduced rate of equipment failures reflects in part the increased reliability of two major subsystems overhauled in 1999: the online software, which underwent a major upgrade, and the receiver translator system, which received important corrective repairs.

The multibeam and other receiver systems all performed well throughout the year without any significant problems. Some of the older components of the telescope drive and control subsystems are beginning to show their age and will require attention in the next year or so.

User feedback

The Web-based fault tracking system is continuing to prove an extremely important tool in successful Observatory operations, and a similar system has now been adopted at Narrabri. The Web-based user questionnaire is also working well, with good levels of response from users (both in terms of numbers, and positive evaluations). Figure 28 shows the Parkes user feedback for 2000, on a scale of 1–10 where 1 = poor and 10 = excellent. Responses were received from 32 observers.

The issue of radio frequency interference mitigation continues to be a concern among users, with the incidence of all forms of external interference, both terrestrial and satellite, forever on the increase. Additional shielding measures are also required to protect observations from the rapid increases in CPU clock speed in new Observatory equipment.

Major Activities

Surveys

The HIPASS/ZOA surveys and the Galactic pulsar survey again accounted for approximately 50% of scheduled observing time this year. Observations for the original HIPASS and ZOA surveys were completed around mid-2000, with the northern extensions both well underway and due for completion around mid-2001.

Observations for the Jodrell Bank-ATNF-Bologna pulsar survey are now approximately 88% complete (at January 2001), and are continuing to detect several new pulsars for each day of observing time. The remainder of the survey and the follow-up confirmation and timing observations will continue throughout 2001 and into 2002. The success of the survey has required more time for the follow-up observations than was originally envisaged.

Observatory reports

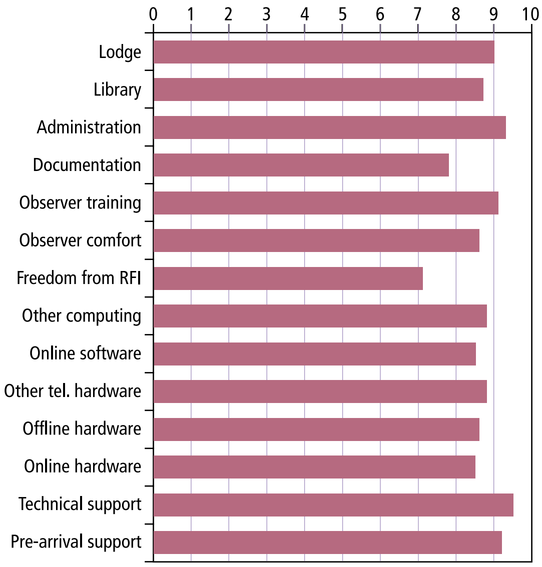


Figure 28 *Parkes user feedback*

Spin-off projects from the major surveys, targeting individual objects or regions of specific interest continue at a steady level, exploiting the excellent performance of the multibeam receiver in this mode.

Pulsar timing

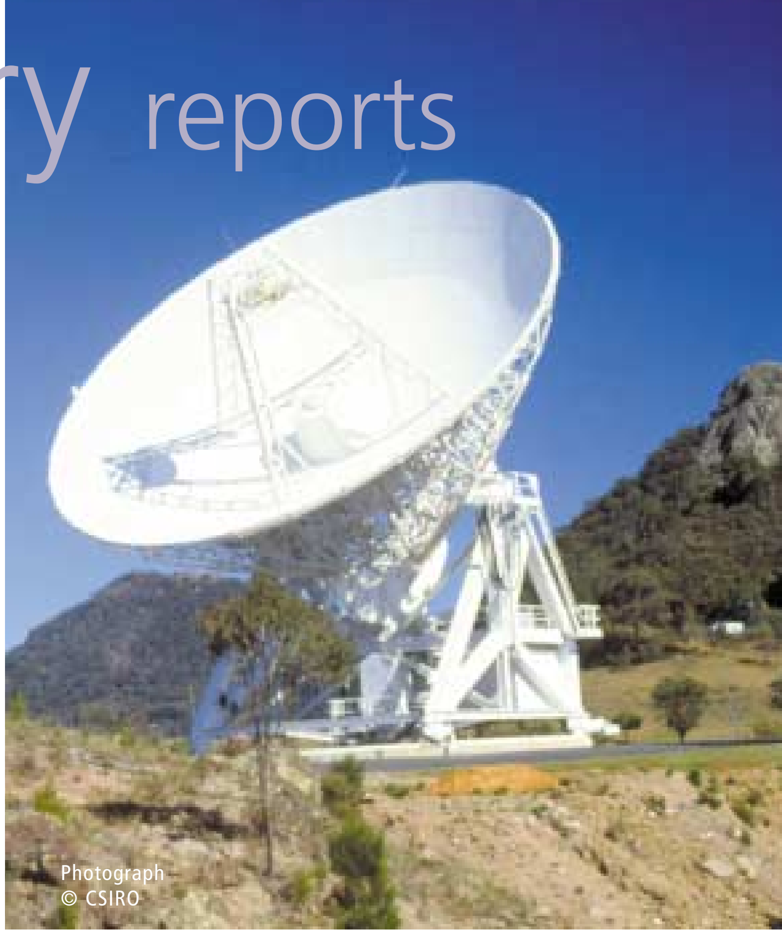
A major new project undertaken at the Observatory in 2000 has begun to yield significant and exciting new results. Timing measurements of the millisecond pulsar J0437-4715 were begun on a semi-daily basis, in a collaborative program between scientists at the University of Swinburne and ATNF. Timing residuals of unprecedented accuracy have been obtained for this binary system (page 26).

Technical developments

With the improvement in the accuracy of pulsar timing measurements made at the Observatory, serious attention has been given to the Observatory GPS systems to ensure the best possible performance in this area. Two additional GPS receivers have been installed on different locations at the Observatory site to overcome the shadowing and multi-path effects of the 64-m telescope itself. A "common-view" GPS receiver is currently being assembled for installation in 2001, which will give access to a second primary time standard, for additional accuracy and intercomparison.

The Telescope Control System (TCS) software commissioned in 1999 performed well in 2000, with only a few minor problems. With a steady flow of improvements and enhancements to this system, a regime of software control implemented at the Observatory ensures quick recovery from software problems by allowing easy reversion to an earlier release at any time.

The Parkes local oscillator conversion system is now fully operational and was used successfully on many occasions in 2000, allowing new modes of operation and reduced setup times.



Mopra

Performance and time use

A Memorandum of Understanding was set up between ATNF and the University of New South Wales (UNSW) in December 1998. Under this agreement, the University operates the Mopra antenna for three months of each year for three years, in return for financial support of the antenna's operations and resurfacing. For half of that time the telescope is used exclusively by the University's staff and students; for the other half, the University operates the telescope as a National Facility. The University run the telescopes in winter, usually the best season for millimetre-wave observing. The UNSW has successfully operated the Mopra telescope during the winters of 1999 and 2000, to the mutual benefit of both the ATNF and the UNSW.

During 2000 the Mopra telescope continued to be used for 3-mm single dish astronomy, for Very Long Baseline Interferometry (VLBI) as part of the Long Baseline Array, and for space VLBI. The University operated the telescope for the period 8 June to 25 September. Table 3 summarizes the telescope usage for the year outside the UNSW period.

Staff

Early in the year, after 31 years with CSIRO, Robina Otrupcek retired. For the last three years Robina was the only member of ATNF staff permanently stationed at the Mopra Observatory. Robina continues to serve the Observatory on a casual basis, particularly for support of VLBI experiments.

Technical developments

Early in the year some effort was put into understanding the telescope optics at 3 mm. This was necessary after the resurfacing out to 22-m diameter with solid panels in 1999 and the new "optics box" installed to illuminate the full aperture. Final verification of the optics and antenna efficiency will not be made until some improved calibration techniques are developed and will possibly require a simpler optical configuration such as that used on the Compact Array antennas.

The computer WARRUM, the Unix file server, was upgraded to a Sun Ultra-10 with a 36-Gbyte disk. It has also been equipped with a 7-Gbyte exabyte magnetic tape drive.

	Days
3.5mm	43
LBA	19
Space VLBI	7
Total astronomy	69

***Table 3** Mopra time use, 2000*

The Australian Long Baseline Array

Staff

A new postdoctoral fellow, Dr Roopesh Ojha, started with the VLBI group in 2000. This position is funded via a collaboration with United States Naval Observatory for work on a large VLBI astrometry program to significantly improve the astrometric grid in the southern hemisphere.

Upgrades

The University of Tasmania is continuing the upgrade of the Hobart and Ceduna telescopes under the MNRF program.

During 2000, the Hobart antenna was upgraded with a new prime-focus cabin and feed translator. The new system allows four feeds to be mounted at prime focus and switched relatively quickly with the translator. This has greatly simplified and speeded up receiver changes in Hobart.

Ceduna is now operating from 2.3–12 GHz, with the 22-GHz system under development and testing. For much of 2000, Ceduna was operated remotely from Hobart, particularly for VSOP observations. However, receiver changes still require manual intervention.

The Long Baseline Array correlator control computer was upgraded and changed to a Unix system and two new 8-GByte hard disks were installed. These changes have significantly improved and streamlined the operation of the LBA correlator facility.

HALCA/VSOP

The radio astronomy satellite HALCA (Highly Advanced Laboratory for Communications and Astrophysics) was launched in February 1977. This satellite is used together with a global network of ground-based radio telescopes, for the VLBI Space Observatory Program (VSOP). In October 1999, serious spacecraft problems interrupted VSOP operations. Observations in a restricted mode began again in March 2000 and continued to the end of the year. The spacecraft has one inoperative reaction wheel and hence lost some operational flexibility. Mopra was again heavily used by the VSOP Active Galactic Nuclei Survey program. NASA tracking will continue only until February 2002. After this it is expected that VSOP observing will be scaled down considerably.

User support

The first Long Baseline Array users meeting was held on 25 October 2000. A report on the operational procedures of the LBA was presented and discussed and feedback sought from users. As a result, the documentation for the LBA is in the process of being extensively rewritten and expanded.

Proposals and scheduling

The demand for time on the LBA in 2000 remained healthy, with an effective oversubscription rate of 1.7, a more typical level than the unusually high rate of 3.0

experienced in 1999. Proposals covered diverse fields of research, with particular emphasis on the unique LBA capabilities in high spectral resolution.

Access to the NASA Deep Space Network (DSN) Tidbinbilla telescopes continued to present problems with the effective scheduling of the LBA array, particularly for sensitive observations requiring the large 70-m antenna. This was also identified as a significant concern at the users meeting. Steps are being taken to liaise more closely with the DSN and improve access.

Operations

Observations on the LBA continued in 2000 at the nominal rate of about one week per term. However, for the October 2000 term the observations were postponed until January 2001 and are not included in this report.

Overall the LBA performed well and a summary is shown in the table below. Most telescopes had a success rate of over 90%. However, the Ceduna antenna was unavailable for a five-day session due to a broken feed and this was the main effect on lowering the overall LBA performance. In addition, VSOP observations at Mopra were severely affected in November following changes in observing software and schedules. For the whole array, after calculating the percentage loss of data due to all known sources, the rate for successful observations with the LBA was 84%. The success rates for LBA observations and for VSOP observations are shown in the following two tables.

Table 4 *Long Baseline Array observations, 2000*

Telescope	Parkes	ATCA	Mopra	Hobart	Ceduna	Tidbinbilla	Hartebeesthoek	LBA
Hours observed	353	358	342	205	202	145	30	374
Success rate %	97	97	92	90	71	92	100	84

Table 5 *VSOP Observations, 2000*

Telescope	ATCA	Mopra	Hobart	Ceduna	Hartebeesthoek
Hours observed	49	133	49	84	75
Success rate %	96	79	96	97.5	96.5