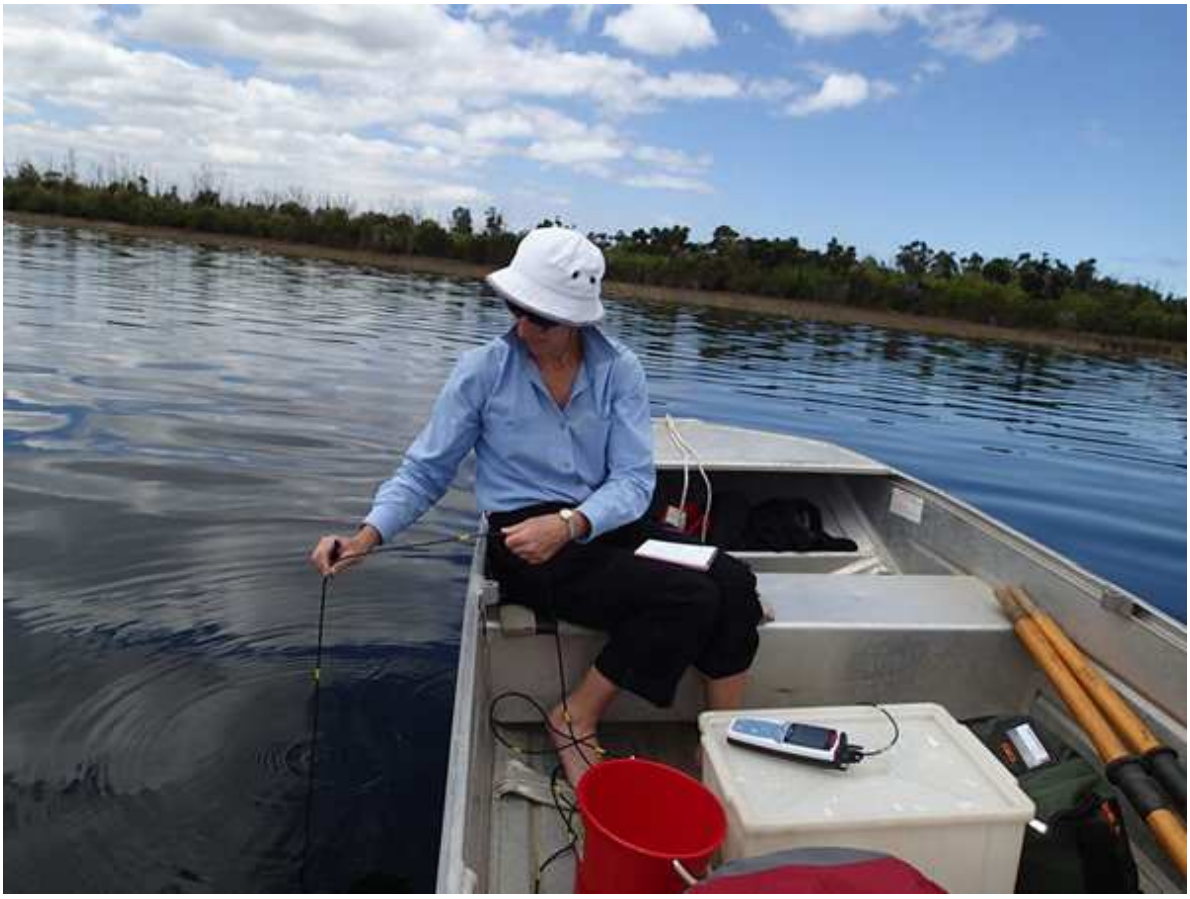
Salinity profiling of Lake Jasper in November 2015



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Cover photograph

Western Australian Department of Parks and Wildlife Senior Technical Officer Yvonne Winchcombe salinity profiling Lake Jasper, in D'Entrecasteaux National Park, near Pemberton. © AG Clarke,

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Contents

INTRODUCTION

Lake Jasper is a large (440ha), open, freshwater lake, 31km west of Pemberton in south-western Australia. It is within the D'Entrecasteaux National Park, vested in the Conservation and Parks Commission of Western Australia and managed by the Western Australian Department of Parks and Wildlife (DPaW Warren Region; Donnelly District). The lake measures 3.5km (NW-SE) by 1.8km (NE-SW) and has a maximum depth in excess of 9m. It is generally considered to be an iconic lake in Western Australia, due to its exceptionally large size, considerable depth, very fresh waters and mostly intact, native fringing vegetation. In recognition of these attributes and associated nature conservation values, Lake Jasper is listed in the *Directory of Important Wetlands in Australia*, as a major component of the 'Gingilup-Jasper Wetland System' (ANCA 1996, Environment Australia 2001). Accounts of the flora, vegetation, water chemistry, macroinvertebrates, fish, frogs and waterbirds of Lake Jasper may be found in Robinson (1992), ARL (1992) and Jaensch (1992a,b; 1993a,b).

Jasper is one of more than 100 wetlands currently included in DPaW's *South West Wetlands Monitoring Program* (SWWMP; Lane *et al.* 2015). Under this program, the water level, surface salinity and pH of Jasper have been routinely measured in September and November each year since 1985.

Jasper's surface salinities (measured at one location near the southern shore of the lake) have increased during the period of SWWMP monitoring. From 1985 to 2002, its September and November surface salinities ranged 0.15–0.25 parts per thousand (ppt), whereas from 2006 to 2015 they ranged 0.25–0.35ppt (Figure 1).

Similar-depth salinity comparisons (e.g. 2009 with 1999 & 2000, 2011 with 2002; 2012 with 1987; 2013 with 1988, and 2014 with 1985, 2001 & 2008; see Figure 1) suggest that Jasper's salt *load* (tonnes) has also increased, however this cannot be conclusively determined on the basis of salinity measurements at only one location.

In order to determine whether salinity measurements at the single SWWMP-monitoring location near the southern shore are indicative of salinities across the entire surface of the lake, and at depth, the authors undertook salinity profiling of Jasper on 4th November 2015[1], seven weeks after the routine September 2015 SWWMP monitoring and one week before the routine November 2015 SWWMP monitoring. This profiling was also aimed at providing a comprehensive salinity baseline suitable for future comparisons.

METHODS

Prior to the day of field work a map was prepared, overlaying a rectified photographic image of Lake Jasper with a grid of coordinates (Eastings and Northings). Intersection points that would provide a reasonably large but achievable number of profiling locations over the entire lake area were then selected. This process resulted in the adoption of 20 profiling locations, at the intersection of six north-south and five east-west grid lines, spaced 500m apart (Figure 2).

The Eastings of the six north-south grid lines were 377700m, 378200m, 378700m, 379200m, 379700m and 380200m. The Northings of the five east-west grid lines were 6190600m, 6191100m, 6191600m, 6192100m and 6192600m (GDA94, 50H). The 20 profiling locations were at the intersections of these lines.

On 4th November 2015, AC and YW drove from the Science Division base at the Busselton DPaW office to Lake Jasper, arriving at 0800hrs.

The water level on the day was found (at c. 0845hrs) to be lower than the measuring range (9.04[2]–10.00 mDPaW[3]) of SWWMP depth gauge 'A', so instead was determined from a nearby WA Department of Water (DoW) gauge that read 39.05m (Australian Height Datum - AHD). This reading converts to 8.96 mDPaW, indicating that, on 4th November 2015, Lake Jasper was 8.96m deep at its deepest point[4].

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[1] The profiling had been planned for 27th October 2015, but was rescheduled due to AC's participation in DPaW's suppression of a wildfire at Cape Arid, east of Esperance.

[2] The lake bed level at DPaW gauge 'A' is 9.04 mDPaW.

[3] Note that mDPaW is equivalent to mDEC and mCALM as used in earlier reports concerning SWWMP and simply reflects changes in department name from Conservation & Land Management (CALM) to Environment & Conservation (DEC) to Parks and Wildlife (DPaW).

[4] To convert from readings (in mDoW) of the DoW 40m gauge to SWWMP gauge readings (in mDPaW), subtract 30.091m (based on March 2015 survey work by AC and YW, who established that 40m on this DoW gauge is equivalent to 9.909m on DPaW gauge 'A').

Note that the Department of Land Administration's Bench Mark at Lake Jasper (BM number 'HP 254', installed on 23May1997 by AC and Jim Payne of DoLA under SWWMP) has an elevation of 40.391 mAHD and 10.304 mDPaW. To convert SWWMP gauge readings (in mDPaW) to mAHD on the basis of this (surveyed) relationship, add 30.087m to the mDPaW value[5].

The conductivity / salinity/ temperature meter — a Thermo Scientific (Thermo Electron Corporation) 'Orion 5 Star pH·Cond·DO Portable' (serial number R 02507) with an 'Orion 013005MD conductivity cell' probe (without serial number) and 10m cable — to be used for profiling Lake Jasper was then calibrated by means of two standard solutions (1.413 mS/cm and 692 ppm[6] at 25°C, and 12.9 mS/cm and 7230 ppm at 25°C). Immediately following calibration, the 12.9 mS/cm standard was tested at 15.2°C and read 10.53 mS/cm. This was considered acceptable, on the basis that this standard has a manufacturer-claimed conductivity of 10.46 mS/cm at 15°C and 10.69 mS/cm at 16°C (which interpolate to 10.51 mS/cm at 15.2°C).

At c. 0850hrs, AC and YW launched a departmental, 3.5m, aluminium punt (flat-bottomed dinghy) with a 4-stroke 6hp outboard motor, from the small beach area on the south side of the lake, near the public picnic area and DPaW and DoW gauges, and motored a very short distance offshore to begin profiling, at 0855hrs.

Between 0855hrs and 1455hrs, AC and YW profiled water depth, conductivity, salinity and temperature at 28 locations, 19 of which were pre-planned locations (JASP-1, JASP-2 and JASP-4 to JASP-20) and nine of which were additional (Beach, 'Jasper 3a', 'Jasper 3b' and 'Jasper A' to 'Jasper F'). 'Beach' and 'Jasper A' to 'Jasper F' were chosen as the day progressed. 'Beach' is the location of the ongoing routine September and November SWWMP monitoring of conductivity, salinity, pH and, in the past, nutrients and ionic composition (Lane *et al.* 2015). 'Jasper 3a' and 'Jasper 3b' were positions that the profiling boat drifted to (the anchor dragged) while attempting to profile at JASP-3 (see below).

The order in which the profiling locations were reached and the profiling was undertaken was follows: Beach, Jasper 3a, Jasper 3b, JASP-1, JASP-2, Jasper A, JASP-4, JASP-5, JASP-9, Jasper B, JASP-8, JASP-7, Jasper C, JASP-6, JASP-10, JASP-11, JASP-12, JASP-13, JASP-14, Jasper D, JASP-18, JASP-17, JASP-16, JASP-15, JASP-19, JASP-20, Jasper E and Jasper F (Figure 3)[7]. This was considered the most efficient route for visiting all locations in one outing.

At each profiling location, a light-weight anchor was lowered over the side of the punt in order to maintain position during profiling.

The punt drifted off-position while the profiling that was commenced at JASP-3 was being conducted. When lifted, there was 'weed' (photos 15 & 16) on the anchor and this (or steep undulations on the lake bed in this position?) was perhaps the cause of the anchor not gripping. The measured depth at the final (i.e. 'Jasper 3a') position (the coordinates of which were not recorded) was 7.0m.

After lifting the anchor, the punt was re-positioned at the pre-planned coordinates of JASP-3 (i.e. at 379700E, 6190600N), the anchor was again lowered, and a second attempt was made at profiling this location. Once again, the anchor dragged and the punt drifted, this time to 379712E, 6190608N, a position (recorded as 'Jasper 3b') approximately 15m ENE of the pre-planned coordinates. The measured depth at 'Jasper 3b' was 9.1m.

Navigation to JASP-3 and each of the other 19 pre-planned profiling locations was achieved by means of a hand-held GPS device ('Garmin GPSmMAP 60Cx'; serial number 1BQ056621; purchased Sept 2009). This device was also used to record the coordinates (WGS84) of profiling locations added on the day.

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[5] Note the close agreement (0.004m difference) between the –30.091m (mDoW to mDPaW) and –30.087m (mAHD to mDPaW) conversion factors.

[6] This meter reports a sample's salinity (TDS) value in mg/L of sodium chloride (NaCl) by comparing the conductivity and temperature of the sample with data obtained from the International Critical Tables. The manufacturer claims the displayed TDS value agrees with ICT values with an accuracy of 0.87% RSD (Residual Standard Deviation). Na^+ and Cl^- consistently dominated the ionic composition of Nov 1998, Nov 2001 and Nov 2002 Lake Jasper water samples (Lane, unpublished SWWMP data). In the context of this report, mg/L (in $g\ l^{-1}$) may be considered equivalent to ppm.

[7] 'Jasper 3a' is not shown in Figure 3, as its coordinates were not recorded. It was, however, within 10-20m of JASP-3 and probably even closer to 'Jasper 3b'.

The 'Orion' conductivity / salinity / temperature probe with 10m cable was lowered by hand over the side of the punt and these three parameters, and distance from the surface, were recorded at 0.5m intervals, from surface to bottom, with the last (deepest) measurement being at a shorter interval if the bottom was not at 0.5m, 1.0m, 1.5m, etc., from the surface. The time at which profiling was undertaken at each location was also recorded, plus any additional observations of significance

Measurements were recorded with the following levels of precision: distance below water surface (nearest 0.1m), salinity (nearest 1ppm), conductivity (nearest 1 µS/cm) and water temperature (nearest 0.1°C).

An attempt was made to find the deepest point in the lake on the day of profiling by additional soundings (between 1430hrs and c. 1515hrs) with a weighted line at a number of locations (WPT 14, WPT 17-21) in the vicinity of the deepest point indicated by the map of Dortch (1996) (Appendix 1).

There was a 'light breeze' at JASP-4 at 1005hrs and at JASP-5 at 1010hrs; a 'southerly breeze and chop on water.at JASP-17 at 1245hrs; a 'strong breeze 12-15 knots' at JASP-16 at 1300hrs, and a '12-15 knot breeze' at JASP-20 at 1400hrs.

RESULTS

Salinities

Surface salinities

Surface salinities across the lake (all profiling locations, n=28) varied by up to 15ppm (4.5%) (range 330–345ppm, mean and median 334ppm) (Table 1 and diagram below). Surface salinities were slightly higher (338–345ppm) near the northern side of the lake than elsewhere (330–338ppm).

			345				
	339	338	339				
335				336			
	331	334	338	330			
	330	334	336	333	332		
							333
		334	335	334	331	330	
					334		
					330		
			335	336	330	331	
					332		

Surface salinity at 'Beach' (the routine SWWMP monitoring site) was 332ppm, just 0.6% different from the mean and median surface salinity value of 334ppm. In total, three of the 28 profiling locations had a value of 332ppm, seven had lower values (330–331ppm), and 18 had higher values (333–345ppm). The second highest value was 339ppm, at two northern locations.

Bottom salinities

Bottom salinities were different from (both higher and lower than) near-bottom salinities at most (17 of 28) locations and were *substantially different* at several, e.g. –90ppm (–27.9%) at JASP-1, –24ppm (–22.9%) at JASP-10, –23ppm (–7.1%) at JASP-15 and +30ppm (+9.3%) at JASP-12, +24ppm (+6.8%) at 'Jasper 3b', +18ppm (+5.6%) at JASP-17 (Table 2).

Bottom salinity readings were also *highly variable* at four profiling locations. Thus at JASP-20 (2.0m deep): 'Meter jumping around, sludgy bottom'; at JASP-10 (2.0m deep): 'Firm bottom, cream sand; conductivity

jumping around all over place'; at JASP-17 (3.2m deep): 'Meter jumping around, bottom covered in weed'; and at JASP-8 (4.6m deep): '[parameters] measured twice'. These locations were widely separate (Figure 3).

Near-bottom salinities

Salinity measurements near the bottom were more stable than at the bottom at all but one location (JASP-8). The instability at the bottom was perhaps due to the effects of possible (and unintentional) stirring of bottom sediments with the salinity probe, or to possible discharge of groundwater, or to both. Consequently, bottom salinities were less representative of water column salinities than near-bottom salinities. Near-bottom salinities are therefore used, in preference to bottom salinities, for the remainder of this Salinities section.

Near-bottom salinities across the lake (i.e. all profiling locations, n=28) ranged 318–494ppm (mean 342ppm, median 332ppm) (table 3 and diagram below). Near-bottom salinities thus ranged more widely (176ppm, 55.3%) than surface salinities, which varied little (15ppm, 4.5%). Near-bottom salinity at 'Beach' (depth 0.5m), was 332ppm, as at the surface.

			344			
	339	333	339			
335				336		
	331	323	322	327		
	325	345	321	412[e]	329	
						333
		325	348	354	356	330
					494	
					351	
			332	320	318	323
					332	

The five highest near-bottom salinities were at profiling locations 'Jasper C' (494ppm), JASP-8 (412ppm), JASP-4 (356ppm), JASP-7 (354ppm) and 'Jasper 3b' (351ppm). These locations were 4.1m, 4.6m, 4.6m, 4.1m and 9.1m deep, respectively. The highest near-bottom salinities were thus in the eastern (central and south) part of the lake, in the lake's deeper waters.

Surface to near-bottom salinity comparisons

Surface salinities were identical to near-bottom salinities at eight locations (all of which were ≤ 2.0m deep); lower than near-bottom salinities at seven locations (all of which were ≥ 3.3m deep), and higher than near-bottom salinities at 13 locations (ranging from 0.7m to 7.0m deep) (Table 3).

The greatest surface to near-bottom salinity *increases* were 'Jasper C' (4.1m deep, +160ppm, +47.9%), JASP-8 (4.6m deep, +79ppm, +23.7%) and JASP-4 (4.6m deep, +25ppm, +7.6%). The greatest surface to near-bottom salinity *decreases* were at locations JASP-6 (5.5m deep, –16ppm, –4.8%), JASP-13 (3.7m deep, –16ppm, –4.7%) and JASP-12 (3.7m deep, –15ppm, –4.5%) (Table 3).

Salinity changes with depth

There was no change in salinity with depth (to near-bottom) at eight locations (B, Beach, A, E, F, 14, 2), all of which were shallow (bottom depths 0.4–2.0m) (Table 1). Salinities declined continuously with increasing depth to near-bottom at 13 locations (D, 18, 10, 5, 9, 15, 19, 17, 12, 13, 1, 6, 3a; bottom depths 0.7–7.0m). Salinities at first declined, then increased near the bottom, at seven locations (16, 7, C, 4, 8, 11, 3b; bottom depths 3.3–9.1m).

Median salinity at each depth across all locations declined continuously (334 to 314ppm) with increasing depth (from surface to near-bottom), except at the deepest location, where the salinity was markedly higher (351ppm) (Table 4). *Mean* salinities showed a similar pattern, except at depths of 3.0m–5.0m, where mean values were higher, due to the influence of high near-bottom salinities at some locations (16, C, 7, 8, 11; refer to Table 1) with near-bottom depths in this depth range.

Salinity changes at 0.5m intervals between the surface and near-bottom were mostly ≤ 3ppm (derived from Table 1). There were relatively large changes (20–170ppm) immediately (≤ 0.5m) above near-bottom at 16, 7, C, 4, 8, 11 and 3b. Other changes were all ≤ 7ppm and were noteworthy (> 5ppm) only at JASP-16 (7ppm from 1.0–1.5m), JASP-13 (6ppm from 0.5–1.0m) and JASP-11 (6ppm from 0.5–1.0m). There was thus no pronounced halocline[8] at Jasper at the time of profiling.

The range of all measured salinities at all depths (surface to near-bottom) throughout the lake was 314ppm ('Jasper 3b' at depth of 8.5m) to 494ppm ('Jasper C' at 4.0m). The second-lowest and second-highest values were 316ppm ('Jasper 3b' at 7.5m and 8.0m) and 412ppm (JASP-8 at 4.5m).

Temperatures

Surface temperatures

Surface temperatures across the lake (all profiling locations, n=28) varied by up to 2.2°C (9.8%) (range 22.5°C–24.7°C, mean and median 23.2°C) (Table 5 and diagram below). The general trend was an increase in temperature from south-east to north-west. Note that this was also the general direction of travel by the profilers (AC & YW)[9], from 0855hrs to 1455hrs. The trend in surface water temperature might therefore be largely or entirely due to insolation and ambient temperature increasing during the day.

			24.7			
	23.9	23.9	23.8			
23.4				23.2		
	23.0	23.4	24.0	22.5		
	23.0	23.3	23.6	23.0	22.7	
						22.9
		23.2	23.4	23.2	22.7	22.6
					23.1	
					22.6	
			23.3	23.4	22.5	22.7
					22.9	

Bottom temperatures

Bottom temperatures were different from (mainly lower than) near-bottom temperatures at most (20 of 28) locations, however most differences (at the 20 locations) were less than 0.3°C, that is, less than 1%. The greatest differences were at JASP-16 (–1.2°C, –5.5%), 'Jasper 3b' (–0.8°C, –4.1%), JASP-C (–0.6°C, –3.0%), JASP-19 (–0.3°C, –1.4%) and JASP-4 (–0.3°C, –1.4%), in western-central and southern parts of the lake (Table 6).

Bottom temperatures were measured twice at JASP-8 (4.6m deep) and JASP-10 (2.0m deep), due to variability in associated salinity readings. There was no variability in these temperature readings. At JASP-17 (3.2m deep) and JASP-20 (2.0m deep) it was noted that 'Meter [was] jumping around', however this might have referred only to bottom conductivity / salinity.

Near-bottom temperatures

Near-bottom temperature at JASP-8 (4.6m deep) was measured twice due to variability in the associated salinity readings. The two readings were different: 20.4°C and 20.6°C.

[8] Halocline = an intermediate layer of water in which salinity changes more rapidly with depth than in layers above and below.

[9] Surface temperatures in the direction of travel, i.e. chronological order, were 22.9, 22.5, 22.6, 22.7, 22.6, 22.9, 22.7, 22.7, 22.5, 23.2, 23.0, 23.2, 23.1, 23.4, 23.3, 23.4, 23.6, 24.0, 23.8, 24.7, 23.9, 23.4, 23.3, 23.2, 23.0, 23.0, 23.9 and 23.4°C.

Near-bottom temperatures across the lake (all profiling locations, n=28) ranged 19.5–24.3°C (mean 22.0°C, median 21.90°C) (Table 7 and diagram above). Near-bottom temperatures thus ranged more widely (4.8°C, 24.6%) than surface temperatures (2.2°C, 9.8%).

Near-bottom temperatures were generally higher towards the margins of the lake, where waters were shallower. The highest near-bottom temperatures were in shallow waters on the north-west side of the lake, where profiling was conducted later in the day.

			24.3			
	23.7	23.1	23.6			
23.3				23.2		
	22.6	21.6	21.5	21.9		
	21.9	21.8	21.4	20.5[e]	22.4	
						22.9
		21.9	21.0	21.2	21.2	22.4
					20.2	
					19.5	
			22.8	20.6	20.8	21.6
					22.9	

Surface to near-bottom temperature comparisons

Surface temperatures were higher than near-bottom temperatures at all but three (i.e. 25 of 28) locations, where they were unchanged (equal). These were the three shallowest locations (0.4–0.6m deep) (Table 7).

The greatest surface to near-bottom temperature decreases were at locations 'Jasper 3b' (9.4m deep, –3.1°C, –13.7%), JASP-C (4.1m deep, –2.9°C, –12.5%) and JASP-6 (5.5m deep, –2.8°C, –12.0%) (Table 7).

Temperature changes with depth

Temperatures declined continuously with increasing depth (surface to near-bottom) at all but one of the 28 profiling locations. There was no change in temperature with depth at 'Jasper A' (bottom depth 0.6m).

Median and *mean* temperatures across all locations declined continuously (from 23.2°C to 19.5°C) with increasing depth (from surface to near-bottom), *including* at the deepest location (where salinity had increased markedly) (Table 8).

Temperature changes at 0.5m intervals between the surface and near-bottom were mostly ≤ 0.3°C (derived from Table 5). There were relatively large changes (–1.0°C and –1.6°C) immediately above near-bottom at 'Jasper C' and JASP-8. Other changes were noteworthy (> 0.6°C) only at JASP-11 (–0.9°C from 0.5m to 1.0m), JASP-13 (–0.8°C from 0.0m to 0.5m and –0.8°C from 0.5m to 1.0m), JASP-16 (–0.7°C from 1.0m to 1.5m) and 'Jasper 3b' (–0.7°C from 8.5m to 9.0m). There was, however, no pronounced thermocline[10] at Jasper at the time of profiling.

The range of all temperatures at all depths (surface to near-bottom) throughout the lake was 24.7°C (at the surface at 'Jasper D') to 19.5°C (near-bottom at 'Jasper 3b', the deepest profiling location). The second-highest and second-lowest values were 24.3°C (0.5m below the surface at 'Jasper D') and 20.2°C (near-bottom at 'Jasper C' and at a depth of 8.5m at 'Jasper 3b').

[10] Thermocline = an intermediate layer of water in which temperature changes more rapidly with depth than in layers above and below.

Depths

Depths at the 28 *profiling* locations on the day of profiling ranged 0.4–9.1m (mean 3.0m, median 2.7m) (last column of Table 1, and diagram below).

			0.7			
	0.7	1.2	1.2			
1.1				0.4		
	2.0	3.2	3.7	2.6		
	2.7	3.3	3.7	4.6	2.5	
						0.6
		2.7	5.1	4.1	4.6	1.7
					4.1	
					9.1	
			2.0	5.5	7.0	4.1
					0.5	

In addition to the depth recordings made during profiling, AC and YW also attempted to find the deepest point in the lake on the day of profiling by additional soundings with a weighted line. These soundings were made at several locations in the vicinity of the deepest point indicated by the map of Dortch (1996) (Appendix 1). These locations, their depths and their coordinates were as follows (listed by Easting, i.e. from west to east). They are also shown in Figure 3 (labelled as 019, 018, JASP 3, 014, 017, 021 & 020).

Location	**Depth (m)**	**Easting**	**Northing**
WPT 19	7.2	0379568	6190660
WPT 18	10.0	0379647	6190633
JASP-3	10.0	0379700	6190600
WPT 14	5.2	0379721	6190746
WPT 17	6.4	0379734	6190697
WPT 21	7.5	0379769	6190555
WPT 20	8.6	0379799	6190617

The greatest depth recorded on 4th November 2015 was 10.0m, at JASP-3 and at WPT 18. This may be compared with the SWWMP depth gauge 'reading' (see Methods section, 4th para) of 8.96 mDPaW on the same day. The difference of 1.04m may be explained, wholly or in part, by the difficulty of determining the deepest point in Lake Jasper, due to the deepest part of the lake being partially filled by a thick peat deposit that varies in penetrability depending upon the type of depth measuring equipment being used (see Appendix 1). Note also that the depths measured on 4th November varied considerably over short distances in the vicinity of JASP-3 and WPT 18. This could also account for differences between maximum depths recorded in different surveys.

Dortch (1996; see Appendix 1) reported a maximum 'non-erroneous' depth of 10.3m, in the vicinity of the soundings listed above. This depth was apparently recorded in February of 1989 or 1990, most probably in the latter year (see Dortch & Godfrey 1990). In November 1989, the SWWMP depth gauge reading was 9.60 mDPaW[11]. If a November to mid-February decline of c. 0.47m is assumed[12], the water level in mid-February 1990 was c. 9.13 mDPaW. This level is c 0.17m *greater than* the water level (8.96m) at the time of our 4th November 2015 soundings. The difference of c. 0.17m would therefore have contributed to the 0.3m difference between Dortch's maximum 'non-erroneous' depth and the maximum depth we recorded.

Clearly there are difficulties in locating the deepest point, and therefore maximum depth, of Lake Jasper, and these may change over time. Comparisons of depth soundings from one survey to another are therefore problematic. It is most important, therefore, that water level and depth measurements are made relative to, i.e. are surveyed to or

[11] It was 9.56 mDPaW in November 1988.

[12] Based on our recording of a 0.59m decline in water level between 4th Nov 2015 (8.96 mDPaW) and 13th Mar 2016 (8.37 mDPaW).

can be converted to, a common datum. This is the case with SWWMP water level recordings (depth gauge readings) and depth soundings, as the SWWMP depth gauge has been surveyed to a nearby Department of Land Administration (DoLA) 'Bench Mark', the elevation of which, in 'meters Australian Height Datum' (mAHD), has also been determined by DoLA survey (see Methods section).

Sediments

The nature of bottom sediments was characterised subjectively by AC and YW on the basis of feel (by probe and anchor) and appearance (sediment or plant material on anchor when raised). Descriptions of the bottom at each point were as follows: Jasper 3a: weed on anchor when lifted; Jasper 3b: sludgy; JASP-1: muddy sand; JASP-2: white sandy, patches of weed just visible; Jasper A: white sandy; JASP-5: wood; JASP-9: firm white sand; JASP-8: sludgy; JASP-7: sludgy; Jasper C: sludgy; JASP-6: sludgy, dead *Baumea* on anchor when lifted; JASP-10: firm, cream sand; JASP-11: sludge; JASP-12: sludge; JASP-13: firm; JASP-14: rocky hard – quartz; JASP-18: hard; JASP-17: covered in 'weed' – *Chara* [?]; JASP-16: sludgy; JASP-15: sludgy, anchor brought up brown diatom ooze; JASP-19: sludgy; JASP-20: sludgy; Jasper E: hard yellow sand; Jasper F: hard. Dortch's (1996) observed that 'a peat deposit extend[ed] over most of the present day lake's floor' and 'the sandy lake floor is mostly covered by peat'. Decomposed *Baumea* (see photos 15 & 16) is one possible source of the peat.

Gas bubbles

At some profiling points, gas bubbles were observed in the water, as follows: Jasper 3b: bubbles rising; JASP-1: no bubbles; JASP-4: large (5cm diam.) bubbles rising to surface regularly; JASP-4: lots of bubbles pulling in anchor, no noticeable smell; JASP-8: small bubbles rising; JASP-7: few small bubbles; JASP-6: no bubbles. The source and identity of the gas were not determined.

Tree stumps

Submerged tree stumps (to 1.5m diameter) were observed from the surface at Jasper D (0.7m deep) and JASP-18 (1.2m deep). Wood was recorded on the bottom at JASP-5 (2.5m deep). Regarding tree stumps, Dortch (1996) wrote 'Radiocarbon dates based on wood samples from tree stumps at various depths on Lake Jasper's floor are interpreted as evidence for the lake expanding to its present size, thus killing the trees, c. 3700–4020 b.p.'[13] Several stumps in water depths of 0.5–2.6m were identified as being of unidentified *Melaleuca* and *Casuarina* species, by means of 'mainly unsuccessful' thin-section analysis of their wood (Dortch 1996).

Waterbirds

Incidental observations were made of c. 20 Black Swans *Cygnus atratus* near JASP-9 at 1025hrs and 30 Black Swans while at Jasper E at 1410hrs. The impression gained was that there were 20-30 swans on the lake for most of the day, and that they were moving about.

CONCLUSIONS

The results of the salinity profiling conducted on 4th November 2015 indicate that single point, surface water sampling at the site of the routine SWWMP monitoring site on the south side of Lake Jasper provide a reasonably precise indication of salinities across the lake and at depth (excluding bottom and near-bottom values in some deep locations), at least at this time of the year. It is therefore probable that the salinity increase observed at the routine SWWMP sampling site since the early 2000s reflects an increase in salinity throughout the lake.

While the observed increase in spring (September and November) salinities at Jasper, from 0.15–0.25ppt in 1985-2002 to 0.25–0.35ppt in 2006-2015, might not have been sufficient to impact significantly upon the lake's biota (Jasper's waters remain 'very fresh', i.e. <1ppt), further increases could potentially do so, resulting in changes to biological and ecological processes and perhaps a significant loss of biodiversity. In their analysis of invertebrate species occurrence in relation to salinity of 230 wetlands in the nearby wheatbelt region of Western Australia, Pinder *et al.* (2005) found total species richness at a wetland showed no response to salinity below 4.1ppt[14] and then declined dramatically as salinity increased. However, when halophilic ('salt-loving') species were excluded

[13] 'b.p.' = before present.

[14] Pinder *et al.* (2005) reported their results in g l^{-1}, rather than ppt. In the context of this report, these units may be considered identical.

from consideration, species richness was found to decline from 2.6ppt. Furthermore, Figure 8 of their paper suggests that species replacement is very likely at salinities *well below* 2.6ppt, and thus the most salt-sensitive species may be lost before richness declines. It may therefore be timely to consider and perhaps investigate the possible cause or causes of Lake Jasper's recent salinity increase and whether preventative actions might be warranted and practicable.

It will also be important to continue the long-term routine monitoring, that is, the biannual single-site SWWMP monitoring, of Jasper's salinity in order to identify future trends. Salinity profiling should also be repeated, at less frequent intervals, to confirm that any trend observed at the single site continues to be representative of waters throughout the lake. More measurements in autumn, when salinities are probably at their annual maximum, are also needed.[15]

Lake Jasper is vested in the Conservation and Parks Commission of Western Australia and the Department of Parks and Wildlife (DPaW) is responsible for its management. It is therefore appropriate that DPaW continue to have a lead role in monitoring and managing its condition. In addition, there are other organisations and individuals, past and present, with an active interest in the lake and its hydrology. It would be potentially beneficial for current key parties to maintain regular contact regarding Lake Jasper and to share their collective knowledge and expertise.

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Photograph credits: The cover photo and photos 8, 10 & 12-14 were taken by Alan Clarke; photos 3-7, 9, 11, 15 & 16 by Yvonne Winchcombe; and photos 17-25 by Jim Lane. Photos 1 & 2 were taken by Alf Lorkiewicz of DPaW Bunbury and entirely funded under SWWMP and Jim Lane is custodian of these.

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[15] Salinities in late autumn are probably somewhat higher in most years than preceding September and November salinities, due to evapo-concentration of salts. This is indicated by a March 2016 salinity measurement of 0.36ppt at the routine SWWMP monitoring site – 12.5% higher than the routine November 2015 SWWMP salinity measurement of 0.32ppt.

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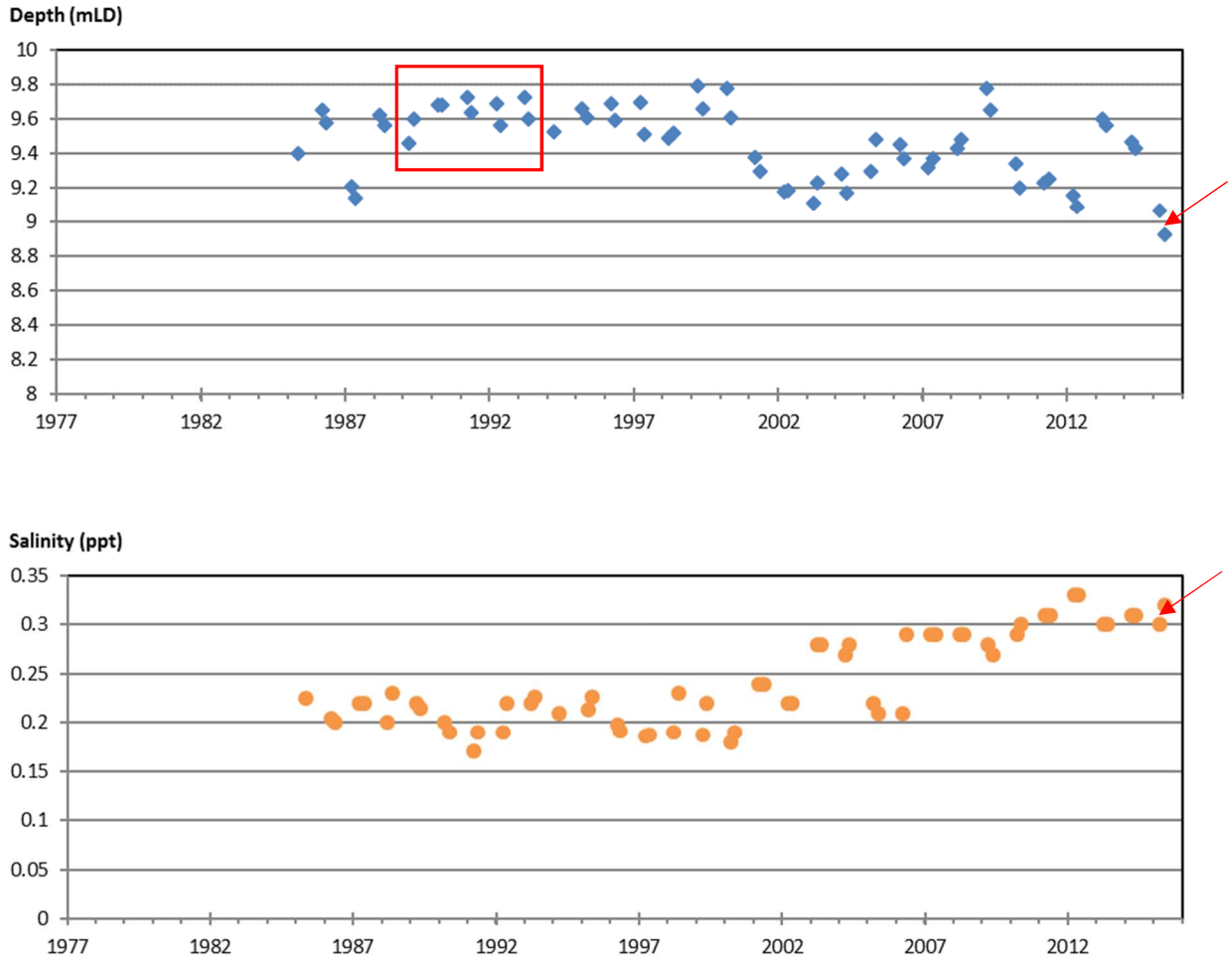
Figure 1. Water levels and salinities routinely recorded at Lake Jasper: 1985–2015.



Notes:

1. Year labels are positioned at 1st July each year.
2. Data are from September and November routine monitoring periods only.
3. Arrows indicate water level and routine surface salinity on day of profiling (4th Nov 2015).
4. Box indicates Sept & Nov water levels during approximate period (1989-93) of depth transects reported by Dortch (1996).
5. The routine 2016 water level and salinity values (not shown in the above graph, which only has data to the end of 2015) were: Sept 2016: 9.28m, 0.31ppt; Nov 2016: 9.34m, 0.30ppt.
6. In autumn 2016 (13th March) the water level was 8.37m and salinity 0.36ppt.

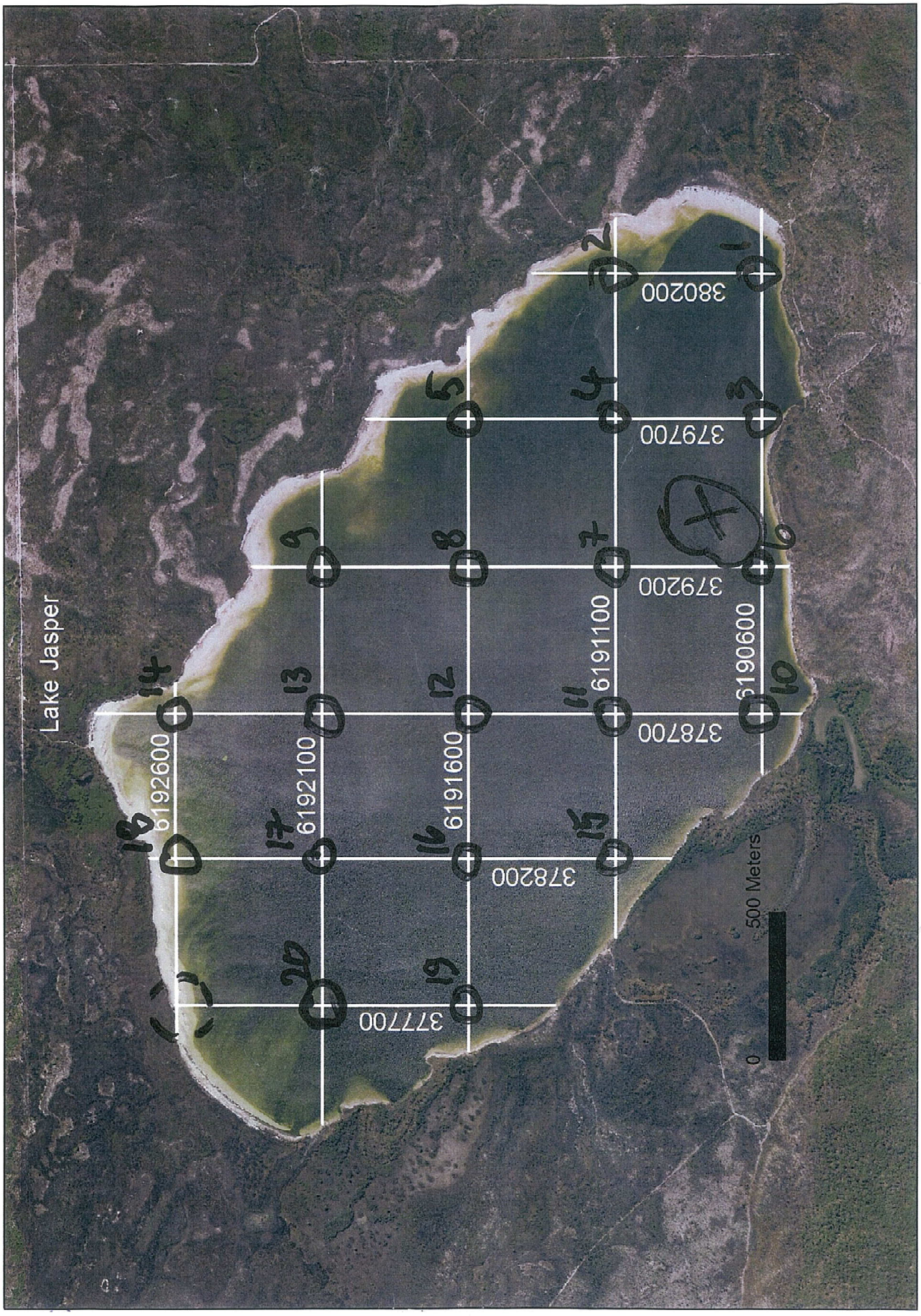


Figure 2. Pre-planned profiling locations JASP-1 to JASP-20 and the grid lines on which they were based.

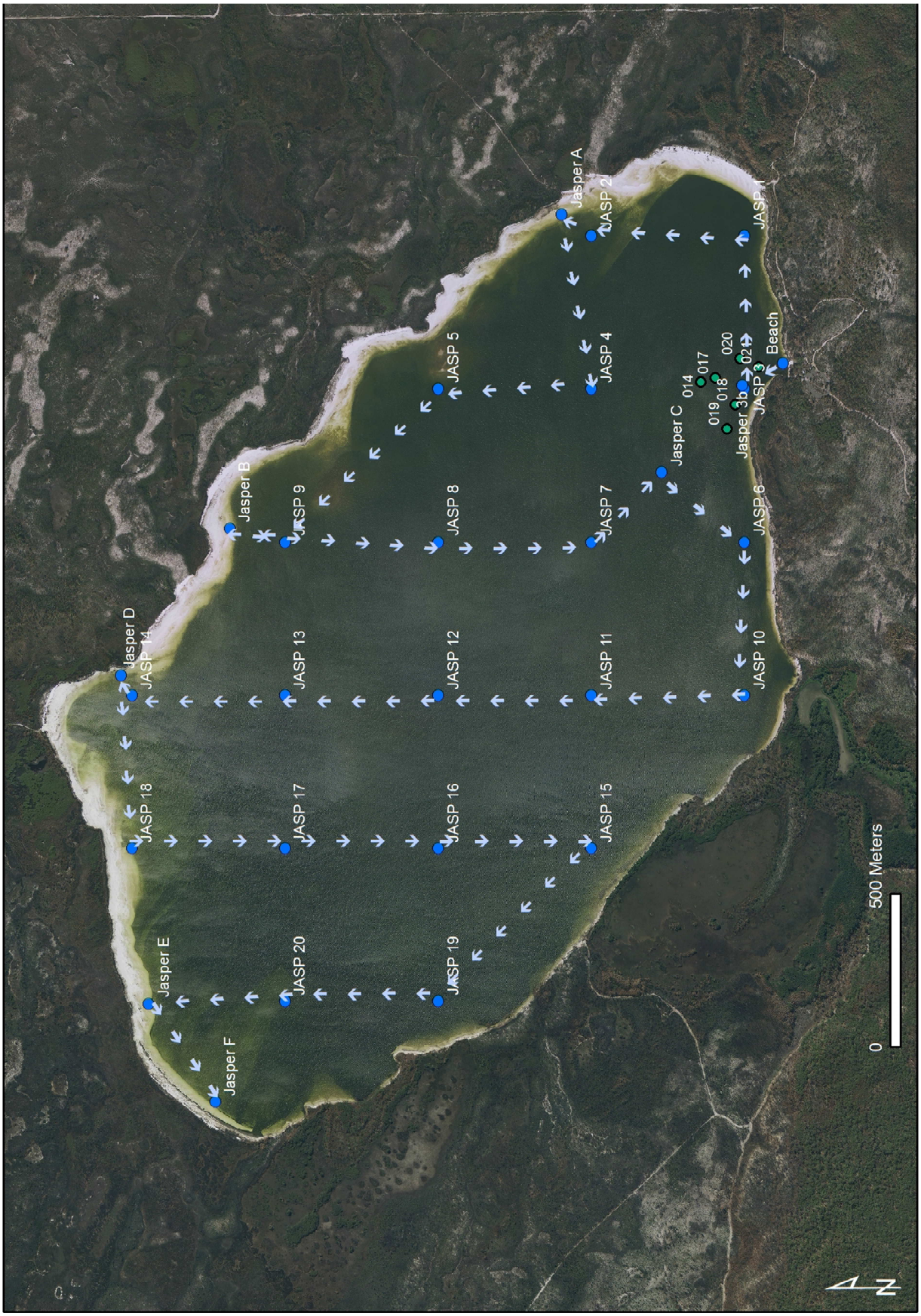


Figure 3. Profiling locations (blue circles) and additional depth measurement locations (green circles) of 4th November 2015 and the boat route that was taken.

Table 1. Salinity (parts per million) profiles of Lake Jasper on 4th November 2015.

LOCATION	SURFACE TO NEAR-BOTTOM SALINITIES (ppm) at 0.5m DEPTH INCREMENTS																		Bottom salinity (ppm)	Bottom depth (m)
	0.0m	0.5m	1.0m	1.5m	2.0m	2.5m	3.0m	3.5m	4.0m	4.5m	5.0m	5.5m	6.0m	6.5m	7.0m	7.5m	8.0m	8.5m	9.0m	
Jasper B	336																			336	0.4
Beach	332																			332	0.5
Jasper A	333	333																		333	0.6
Jasper D	345	344																		345	0.7
Jasper E	339	339																		339	0.7
Jasper F	335	335	335																	320	1.1
JASP-14	339	339	339																	339	1.2
JASP-18	338	338	333																	333	1.2
JASP-2	330	330	330	330																330	1.7
JASP-10	335	334	332	332																256	2.0
JASP-20	331	331	331	331																310	2.0
JASP-5	332	332	330	330	329	328														328	2.5
JASP-9	330	330	329	328	327	327														327	2.6
JASP-15	334	330	328	325	325	325														302	2.7
JASP-19	330	330	330	329	325	325														320	2.7
JASP-17	334	334	330	326	324	323	323													341	3.2
JASP-16	334	333	333	326	325	325	345													362	3.3
JASP-12	336	334	330	328	325	323	322	321												351	3.7
JASP-13	338	334	328	325	324	323	322	322												334	3.7
JASP-1	332	331	330	330	330	330	329	326	323											233	4.1
JASP-7	334	333	329	329	328	326	323	322	354											371	4.1
Jasper C	334	333	330	329	329	328	326	324	494											508	4.1
JASP-4	331	330	330	329	328	327	325	322	320	356										358	4.6
JASP-8	333	331	329	328	326	326	326	324	322	412										412	4.6
JASP-11	335	335	329	324	324	323	323	323	322	320	348									348	5.1
JASP-6	336	335	333	333	333	332	330	327	325	324	321									325	5.5
Jasper 3a	330	330	330	329	329	328	328	327	324	321	320	320	318	318						318	7.0
Jasper 3b	330	330	330	329	328	328	328	327	325	320	320	319	318	318	317	316	316	314	351	375	9.1

See 'Results: Salinity changes with depth' section for comments relating to yellow-highlighted values.

Table 2. Near-Bottom and Bottom Salinities (listed in order of increasing Bottom Depth).

Bottom Depth (m)	Location	Salinity Near Bottom (ppm)	Salinity at Bottom (ppm)	Near-Bottom to Bottom Salinity Difference (ppm)	Near-Bottom to Bottom Salinity Difference (%)	Near-Bottom to Bottom Depth Difference (m)
0.4	B	336	336	*0*	*0*	
0.5	Beach	332	332	*0*	*0*	
0.6	A	333	333	*0*	*0*	0.1
0.7	E	339	339	*0*	*0*	0.2
0.7	D	344	345	1	0.3	0.2
1.1	F	335	320	–15	–4.5	0.1
1.2	18	333	333	*0*	*0*	0.2
1.2	14	339	339	*0*	*0*	0.2
1.7	2	330	330	*0*	*0*	0.2
2.0	20	331	310[a]	–21	–6.3	0.5
2.0	10	332	256[b]	–24	–22.9	0.5
2.5	5	329	328	–1	–0.3	0.5
2.6	9	327	327	*0*	*0*	0.1
2.7	19	325	320	–5	–1.5	0.2
2.7	15	325	302	–23	–7.1	0.2
3.2	17	323	341[c]	18	5.6	0.2
3.3	16	345	362	17	4.9	0.3
3.7	13	322	334	12	3.7	0.2
3.7	12	321	351	30	9.3	0.2
4.1	C	494	508	14	2.8	0.1
4.1	7	354	371	17	4.8	0.1
4.1	1	323	233	–90	–27.9	0.1
4.6	8	412[e]	412[d]	*0*	*0*	0.1
4.6	4	356	358	2	0.6	0.1
5.1	11	348	348	*0*	*0*	0.1
5.5	6	320	325	5	1.6	0.2
7.0	3a	318	318	*0*	*0*	0.5
9.1	3b	351	375	24	6.8	0.1

Bottom salinity readings at JASP-20, JASP-10, JASP-17 and JASP-8, and near-bottom salinity readings JASP-8, were highly variable.

a ‘Meter jumping around, sludgy bottom’.

b ‘Conductivity jumping around all over place’ [256ppm is avg. of 312ppm & 200ppm].

c ‘Meter jumping around, bottom covered in weed’.

d ‘Measured twice’ [412ppm is avg. of 437ppm & 386ppm].

e ‘Measured twice’ [412ppm is avg. of 408ppm & 417ppm].

Table 3. Surface and Near-Bottom Salinities (listed in order of increasing Bottom Depth).

Bottom Depth (m)	Location	Salinity at Surface (ppm)	Salinity Near Bottom (ppm)	Surface to Near-Bottom Salinity Difference (ppm)	Surface to Near-Bottom Salinity Difference (%)	Near-Bottom to Bottom Depth Difference (m)
0.4	B	336	336	*0*	*0*	
0.5	Beach	332	332	*0*	*0*	
0.6	A	333	333	*0*	*0*	0.1
0.7	E	339	339	*0*	*0*	0.2
0.7	D	345	344	–1	–0.3	0.2
1.1	F	335	335	*0*	*0*	0.1
1.2	18	338	333	–5	–1.5	0.2
1.2	14	339	339	*0*	*0*	0.2
1.7	2	330	330	*0*	*0*	0.2
2.0	20	331	331	*0*	*0*	0.5
2.0	10	335	332	–3	–0.9	0.5
2.5	5	332	329	–3	–0.9	0.5
2.6	9	330	327	–3	–0.9	0.1
2.7	19	330	325	–5	–1.5	0.2
2.7	15	334	325	–9	–2.7	0.2
3.2	17	334	323	–11	–3.3	0.2
3.3	16	334	345	11	3.3	0.3
3.7	13	338	322	–16	–4.7	0.2
3.7	12	336	321	–15	–4.5	0.2
4.1	C	334	494	160	47.9	0.1
4.1	7	334	354	20	6.0	0.1
4.1	1	331	323	–8	–2.4	0.1
4.6	8	333	412[e]	79	23.7	0.1
4.6	4	331	356	25	7.6	0.1
5.1	11	335	348	13	3.9	0.1
5.5	6	336	320	–16	–4.8	0.2
7.0	3a	330	318	–12	–3.6	0.5
9.1	3b	330	351	21	6.4	0.1

Near-bottom salinity readings at JASP-8 were variable.

e ‘Measured twice’ [412ppm is avg. of 408ppm & 417ppm].

Table 4. Half-metre-interval Minimum, Mean, Median & Maximum Salinities across all Profiling Locations at each Depth from Surface to Near-Bottom.

Depth (m)	Salinity (ppm)				Number of Profiling Locations (and IDs of individual Locations)
	Min.	Mean	Median	Max.	
0.0	330	334	334	345	28 (3a, 3b, 6, 11, 4, 8, 1, 7, C, 12, 13, 17, 16, 9, 15, 19, 5, 10, 20, 2, 14, 18, F, A, D, E, Beach, B)
0.5	330	333	333	344	26 (3a, 3b, 6, 11, 4, 8, 1, 7, C, 12, 13, 17, 16, 9, 15, 19, 5, 10, 20, 2, 14, 18, F, A, D, E)
1.0	328	331	330	339	23 (3a, 3b, 6, 11, 4, 8, 1, 7, C, 12, 13, 17, 16, 9, 15, 19, 5, 10, 20, 2, 14, 18, F)
1.5	324	328	329	333	20 (3a, 3b, 6, 11, 4, 8, 1, 7, C, 12, 13, 17, 16, 9, 15, 19, 5, 10, 20, 2)
2.0	324	327	326	333	17 (3a, 3b, 6, 11, 4, 8, 1, 7, C, 12, 13, 17, 16, 9, 15, 19, 5)
2.5	323	326	326	332	16 (3a, 3b, 6, 11, 4, 8, 1, 7, C, 12, 13, 17, 16, 9, 15, 19)
3.0	322	327	326	345	13 (3a, 3b, 6, 11, 4, 8, 1, 7, C, 12, 13, 17, 16)
3.5	321	324	324	327	11 (3a, 3b, 6, 11, 4, 8, 1, 7, C, 12, 13)
4.0	320	345	324	494	9 (3a, 3b, 6, 11, 4, 8, 1, 7, C)
4.5	320	342	322	412	6 (3a, 3b, 6, 11, 4, 8) [412ppm is avg. of 437ppm & 386ppm at JASP-8]
5.0	320	327	320	348	4 (3a, 3b, 6, 11)
5.5	319	320	320	320	2 (3a, 3b)
6.0	318	318	318	318	2 (3a, 3b)
6.5	318	318	318	318	2 (3a, 3b)
7.0	317				1 (3b)
7.5	316				1 (3b)
8.0	316				1 (3b)
8.5	314				1 (3b)
9.0	351				1 (3b)

Table 5. Temperature (°C) profiles of Lake Jasper on 4th November 2015.

LOCATION	SURFACE TO NEAR-BOTTOM TEMPERATURES (°C) at 0.5m DEPTH INCREMENTS																		Bottom temp. (°C)	Bottom depth (m)
	0.0m	0.5m	1.0m	1.5m	2.0m	2.5m	3.0m	3.5m	4.0m	4.5m	5.0m	5.5m	6.0m	6.5m	7.0m	7.5m	8.0m	8.5m	9.0m	
Jasper B	23.2																			23.1	0.4
Beach	22.9	22.7																		22.7	0.5
Jasper A	22.9	22.9																		22.9	0.6
Jasper D	24.7	24.3																		24.4	0.7
Jasper E	23.9	23.7																		23.7	0.7
Jasper F	23.4	23.3	23.3																	23.2	1.1
JASP-14	23.8	23.6	23.6																	23.6	1.2
JASP-18	23.9	23.6	23.1																	23.0	1.2
JASP-2	22.6	22.6	22.5	22.4																22.4	1.7
JASP-10	23.3	23.1	22.8	22.8																22.7	2.0
JASP-20	23.0	22.8	22.7	22.6																22.6	2.0
JASP-5	22.7	22.6	22.4	22.4	22.4															22.1	2.5
JASP-9	22.5	22.5	22.2	22.1	21.9	21.9														22.0	2.6
JASP-15	23.2	22.7	22.4	21.9	21.9	21.9														21.7	2.7
JASP-19	23.0	22.7	22.6	22.4	21.9	21.9														21.6	2.7
JASP-17	23.4	23.1	22.6	22.0	21.8	21.6	21.6													21.6	3.2
JASP-16	23.3	23.1	23.0	22.3	21.9	21.9	21.8													20.6	3.3
JASP-12	23.6	23.2	22.7	22.3	21.9	21.7	21.5	21.4												21.3	3.7
JASP-13	24.0	23.2	22.4	22.0	21.9	21.7	21.5	21.5												21.4	3.7
JASP-1	22.7	22.7	22.6	22.5	22.5	22.5	22.4	21.9	21.6											21.5	4.1
JASP-7	23.2	23.0	22.5	22.3	22.2	22.0	21.6	21.5	21.2											21.1	4.1
Jasper C	23.1	23.0	22.6	22.4	22.3	22.2	22.0	21.8	20.2											19.6	4.1
JASP-4	22.7	22.6	22.5	22.4	22.3	22.2	22.0	21.5	21.2	21.2										20.9	4.6
JASP-8	23.0	22.6	22.4	22.2	22.0	21.9	21.9	21.6	21.5	20.5										20.3	4.6
JASP-11	23.4	23.3	22.4	21.8	21.7	21.6	21.5	21.5	21.4	21.2	21.0									21.0	5.1
JASP-6	23.4	23.2	23.0	22.9	22.8	22.8	22.5	22.1	21.8	21.7	21.4									20.8	5.5
Jasper 3a	22.5	22.5	22.4	22.4	22.3	22.2	22.1	22.1	21.7	21.3	21.2	21.1	20.9	20.8						20.8	7.0
Jasper 3b	22.6	22.5	22.5	22.4	22.3	22.2	22.1	22.1	21.8	21.3	21.2	21.1	20.9	20.8	20.7	20.7	20.5	20.2	19.5	18.7	9.1

See 'Results: Temperature changes with depth' section for comments relating to blue-highlighted values.

Table 6. Near-Bottom and Bottom Temperatures (listed in order of increasing Bottom Depth).

Bottom Depth (m)	Location	Start Time (24hr)	Temperature Near Bottom (°C)	Temperature at Bottom (°C)	Near-Bottom to Bottom Temperature Difference (°C)	Near-Bottom to Bottom Temperature Difference (%)	Near-Bottom to Bottom Depth Difference (m)
0.4	B	1030	23.2	23.1	–0.1	–0.4	
0.5	Beach	0855	22.9	22.7	–0.2	–0.9	
0.6	A	1000	22.9	22.9	*0*	*0*	0.1
0.7	E	1410	23.7	23.7	*0*	*0*	0.2
0.7	D	2120	24.3	24.4	0.1	0.4	0.2
1.1	F	1415	23.3	23.2	–0.1	–0.4	0.1
1.2	18	1235	23.1	23.0	–0.1	–0.4	0.2
1.2	14	1215	23.6	23.6	*0*	*0*	0.2
1.7	2	0950	22.4	22.4	*0*	*0*	0.2
2.0	20	1400	22.6	22.6[a]	*0*	*0*	0.5
2.0	10	1130	22.8	22.7[b]	–0.1	–0.4	0.5
2.5	5	1010	22.4	22.1	–0.3	–1.3	0.5
2.6	9	1025	21.9	22.0	0.1	0.5	0.1
2.7	19	1350	21.9	21.6	–0.3	–1.4	0.2
2.7	15	1310	21.9	21.7	–0.2	–0.9	0.2
3.2	17	1245	21.6	21.6[c]	*0*	*0*	0.2
3.3	16	1300	21.8	20.6	–1.2	–5.5	0.3
3.7	13	1205	21.5	21.4	–0.1	–0.5	0.2
3.7	12	1155	21.4	21.3	–0.1	–0.5	0.2
4.1	C	1105	20.2	19.6	–0.6	–3.0	0.1
4.1	7	1055	21.2	21.1	–0.1	–0.5	0.1
4.1	1	0935	21.6	21.5	–0.1	–0.5	0.1
4.6	8	1045	20.5[e]	20.3[d]	–0.2	–1.0	0.1
4.6	4	1005	21.2	20.9	–0.3	–1.4	0.1
5.1	11	1145	21.0	21.0	*0*	*0*	0.1
5.5	6	1115	20.6	20.8	0.2	1.0	0.2
7.0	3a	0905	20.8	20.8	*0*	*0*	0.5
9.1	3b	0915	19.5	18.7	–0.8	–4.1	0.1

PM start times are shaded pale yellow.

Near-bottom temperature readings at JASP-8 were variable.

e ‘Measured twice’ [20.5°C is average of 20.6°C and 20.4°C].

Table 7. Surface and Near-Bottom Temperatures (listed in order of increasing Bottom Depth).

Bottom Depth (m)	Location	Start Time (24hr)	Temperature at Surface (°C)	Temperature Near Bottom (°C)	Surface to Near-Bottom Temperature Difference (°C)	Surface to Near-Bottom Temperature Difference (%)	Near-Bottom to Bottom Depth Difference (m)
0.4	B	1030	23.2	23.2	*0*	*0*	
0.5	Beach	0855	22.9	22.9	*0*	*0*	
0.6	A	1000	22.9	22.9	*0*	*0*	0.1
0.7	E	1410	23.9	23.7	–0.2	–0.8	0.2
0.7	D	2120	24.7	24.3	–0.4	–1.6	0.2
1.1	F	1415	23.4	23.3	–0.1	–0.4	0.1
1.2	18	1235	23.9	23.1	–0.8	–3.3	0.2
1.2	14	1215	23.8	23.6	–0.2	–0.8	0.2
1.7	2	0950	22.6	22.4	–0.2	–0.9	0.2
2.0	20	1400	23.0	22.6	–0.4	–1.7	0.5
2.0	10	1130	23.3	22.8	–0.5	–2.1	0.5
2.5	5	1010	22.7	22.4	–0.3	–1.3	0.5
2.6	9	1025	22.5	21.9	–0.6	–2.7	0.1
2.7	19	1350	23.0	21.9	–1.1	–4.8	0.2
2.7	15	1310	23.2	21.9	–1.3	–5.6	0.2
3.2	17	1245	23.4	21.6	–1.8	–7.7	0.2
3.3	16	1300	23.3	21.8	–1.5	–6.4	0.3
3.7	13	1205	24.0	21.5	–2.5	–10.4	0.2
3.7	12	1155	23.6	21.4	–2.2	–9.3	0.2
4.1	C	1105	23.1	20.2	–2.9	–12.5	0.1
4.1	7	1055	23.2	21.2	–2.1	–8.6	0.1
4.1	1	0935	22.7	21.6	–1.1	–4.8	0.1
4.6	8	1045	23.0	20.5[e]	–2.5	–10.9	0.1
4.6	4	1005	22.7	21.2	–1.5	–6.6	0.1
5.1	11	1145	23.4	21.0	–2.4	–10.3	0.1
5.5	6	1115	23.4	20.6	–2.8	–12.0	0.2
7.0	3a	0905	22.5	20.8	–1.7	–7.6	0.5
9.1	3b	0915	22.6	19.5	–3.1	–13.7	0.1

PM start times are shaded pale yellow. Near-bottom temperature readings at JASP-8 were variable.

e 'Measured twice' [20.5°C is average of 20.6°C and 20.4°C].

Table 8. Half-metre-interval Minimum, Mean, Median & Maximum Temperatures across all Profiling Locations at each Depth from Surface to Near-Bottom.

Depth (m)	Temperature (°C)				Number of Profiling Locations (and IDs of individual Locations)
	Min.	Mean	Median	Max.	
0.0	22.5	23.2	23.2	24.7	28 (3a, 3b, 6, 11, 4, 8, 1, 7, C, 12, 13, 17, 16, 9, 15, 19, 5, 10, 20, 2, 14, 18, F, A, D, E, Beach, B)
0.5	22.5	23.0	23.0	24.3	26 (3a, 3b, 6, 11, 4, 8, 1, 7, C, 12, 13, 17, 16, 9, 15, 19, 5, 10, 20, 2, 14, 18, F, A, D, E)
1.0	22.2	22.7	22.6	23.6	23 (3a, 3b, 6, 11, 4, 8, 1, 7, C, 12, 13, 17, 16, 9, 15, 19, 5, 10, 20, 2, 14, 18, F)
1.5	21.8	22.3	22.4	22.9	20 (3a, 3b, 6, 11, 4, 8, 1, 7, C, 12, 13, 17, 16, 9, 15, 19, 5, 10, 20, 2)
2.0	21.7	22.1	21.9	22.8	17 (3a, 3b, 6, 11, 4, 8, 1, 7, C, 12, 13, 17, 16, 9, 15, 19, 5)
2.5	21.6	22.0	21.9	22.8	16 (3a, 3b, 6, 11, 4, 8, 1, 7, C, 12, 13, 17, 16, 9, 15, 19)
3.0	21.5	21.9	21.8	22.5	13 (3a, 3b, 6, 11, 4, 8, 1, 7, C, 12, 13, 17, 16)
3.5	21.4	21.7	21.6	22.1	11 (3a, 3b, 6, 11, 4, 8, 1, 7, C, 12, 13)
4.0	20.2	21.4	21.4	21.8	9 (3a, 3b, 6, 11, 4, 8, 1, 7, C)
4.5	20.5	21.2	21.2	21.7	6 (3a, 3b, 6, 11, 4, 8) [20.5 is avg. of 20.4°C and 20.6°C at JASP-8]
5.0	21.0	21.2	21.2	21.4	4 (3a, 3b, 6, 11)
5.5	21.1	21.1	21.1	21.1	2 (3a, 3b)
6.0	20.9	20.9	20.9	20.9	2 (3a, 3b)
6.5	20.8	20.8	20.8	20.8	2 (3a, 3b)
7.0	20.7				1 (3b)
7.5	20.7				1 (3b)
8.0	20.5				1 (3b)
8.5	20.2				1 (3b)
9.0	19.5				1 (3b)

PHOTOGRAPHS

Photo 1: Lake Jasper, ESE to WNW. (Photo 20May2008).

Photo 2: Lake Jasper, WNW to ESE. (Photo 20May2008).

Photo 3: Lake Jasper SWWMP gauge 'A' reads to 10.00 mDPaW. (Photo 04Nov2015)

Photo 4: DoW water level reading 39.05 mDoW on 04Nov2015.

Photo 5: Lake Jasper SWWMP gauge 'A' lake bed level reading 9.04 mDPaW on 04Nov2015.

Photo 6: Lake Jasper 40m DoW gauge on 04Nov2015.

Photo 7: A. Clarke navigating to a Lake Jasper profiling location on 04Nov2015.

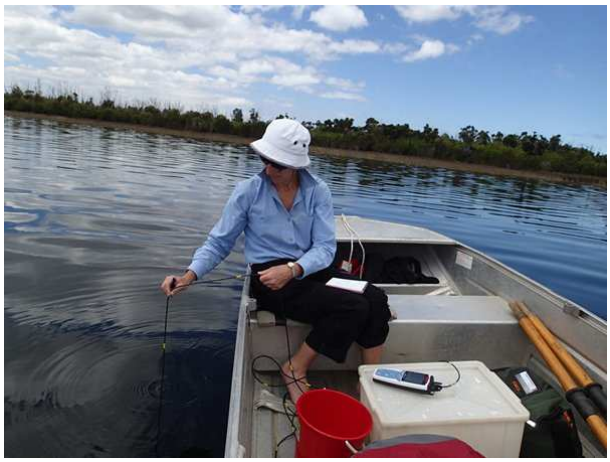
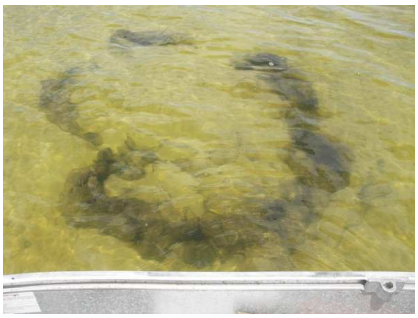


Photo 8: Y. Winchcombe lowering the conductivity / salinity / temperature probe at Lake Jasper on 04Nov2015.



Photos 9 & 10: Tree stumps visible in northern shallows of Lake Jasper on 04Nov2015.

Photo 11: Beach and DoW gauge at Jasper on 16Sep2015.

Photos 12 & 13: Submerged aquatic plants raised with anchor on 04Nov2015.

Photo 14: Single dead fish on SW shore of Lake Jasper on 04Nov2015.

Photos 15 & 16: *Baumea* wrack at Lake Jasper on 19Sep2013

Photo 17: The 13 mCALM 'Munro Datum' at Lake Jasper (Photo 26Jan2016).

Photo 18: DoW instrumentation cabinet at Lake Jasper. (26Jan2016).

Photo 19: DoW telecommunications cabinet, antenna and solar panel at Lake Jasper. (26Jan2016).

Photos 20 & 21: DoW benchmark and 'witness plate' at Lake Jasper. (26Jan2016).

Photo 22: 40m DoW gauge and instrumentation pipe at Lake Jasper. (26Jan2016).

Photo 23: 40m DoW gauge and end of instrumentation pipe at Lake Jasper. (26Jan2016).

Photo 24: 40m DoW gauge and end of instrumentation pipe at Lake Jasper. (26Jan2016).

Photo 25: 40m DoW gauge and measured water level of 38.69 (39.00 – 0.31m) at Lake Jasper on 26Jan2016.

APPENDIX 1: Earlier depth soundings at Lake Jasper.

In his publication 'Dortch, C.E. (1996), *Prehistory down under: archaeological investigations of submerged Aboriginal sites at Lake Jasper, Western Australia.* Antiquity 70: 116-123', Charles Dortch refers to 'depths to 10m' and 'some of the lake's deeper parts (9–10m)'. His map (his Figure 2 below) show 10 depth transects and c. 110 depth recordings along these transects. Near the south-eastern end of the lake an 'area of erroneous depth readings' (see Figure 1 of Dortch & Godfrey 1990 for these) is indicated by a dashed line. Recorded depths surrounding this area range from 1.9m to 10.3m, with the latter value being the greatest depth shown on the map. This appears to also be archaeological Site 9 (an Aboriginal 'open-air camp-site') of Dortch's Figure 2, which is 'situated directly on the shore of the earlier smaller lake'. The second greatest depth shown is 8.2m, approx. 300m to the WNW.

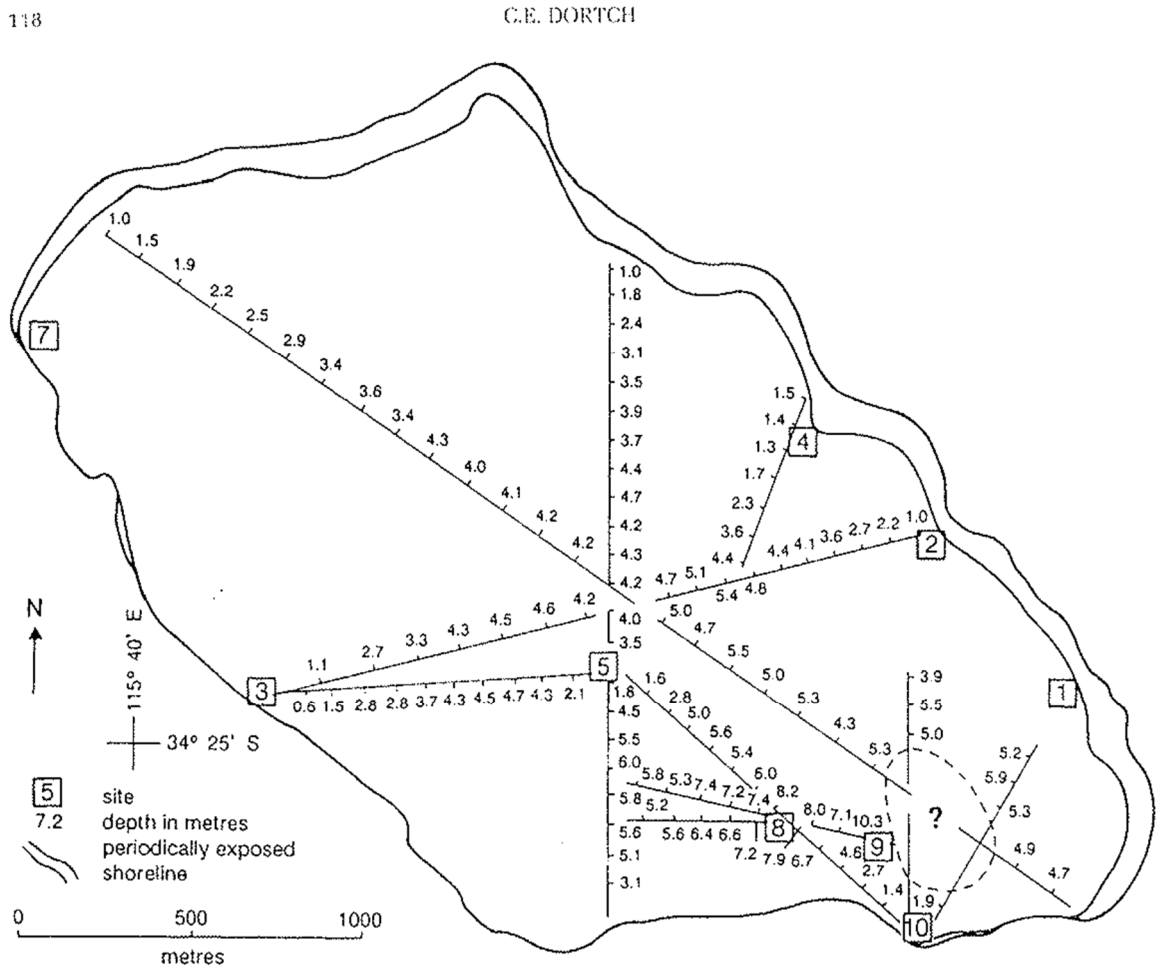


FIGURE 2. *Plan of Lake Jasper, showing sites 1–5, 7–10 and depth readings in metres. Area of erroneous depth readings marked by dashed line.*

The 'area of erroneous depth readings' was revealed by surveys to be the deepest part of the lake, with 'a massive accumulation of peat' … [marked by the dashed line] … that is by far the thickest part of a peat deposit extending over most of the present-day lake's floor'. Dortch (1996) explains that *'The original soundings recorded in this demarcated zone are now known to measure not the true depth of lake floor there, but only depths within the less dense parts of the overlying peat. This problem exists because all of the team's soundings from 1989 to 1993 were done with a marked line attached to a rectangular 1kg lead weight. Tests in 1995 showed that a small weight this shape cannot penetrate the peat deeper than 1–2m. Divers probing with steel rods in 1995 showed that this part*

of the lake floor is very much deeper than previously considered, with the deepest probes, which still did not penetrate the peat to the underlying lake floor, indicating a minimum depth of c. 16m, half being water depth and the other half [being] thickness of peat[16]*'*. In other parts of the lake floor, peat thickness ranged 1–50cm (Dortch 1996). The peat in this deepest part of Lake Jasper, Dortch (1996) estimated to be no less than 30,000 years old, and perhaps twice that age, whereas the lake 'was filling to present size no more than c. 4000 years ago'.

It appears from Dortch & Godfrey's (1990) Figure 1 and accompanying text that the maximum depth of 10.3m reported by those authors and Dortch (1996) was measured in February 1990 or perhaps in February 1989.

Note also Dortch & Godfrey's (1990) observation that '… when first investigated in [April] 1988, the lake level was 0.5m lower than in February 1989 and February 1990'.

References

Dortch, C.E. (1996), *Prehistory down under: archaeological investigations of submerged Aboriginal sites at Lake Jasper, Western Australia.* Antiquity 70: 116-123.

Dortch & Godfrey (1990) *Aboriginal sites in a submerged landscape at Lake Jasper, southwestern Australia.* Australian Archaeology 31: 28-33.

[16] Underlining by current authors.