

**DIRECT RADIOCARBON DATING OF FISH  
OTOLITHS FROM MULLOWAY  
(*ARGYROSOMUS JAPONICUS*) AND BLACK BREAM  
(*ACANTHOPAGRUS BUTCHERI*) FROM  
LONG POINT, COORONG, SOUTH AUSTRALIA**

---

Morgan C.F. Disspain<sup>1,2</sup>, Lynley A. Wallis<sup>3,4</sup>, Stewart J. Fallon<sup>5</sup>,  
Major Sumner<sup>6</sup>, Claire St George<sup>7</sup>, Christopher Wilson<sup>8,9</sup>,  
Duncan Wright<sup>10</sup>, Bronwyn M. Gillanders<sup>1</sup> and Sean Ulm<sup>11,12</sup>

<sup>1</sup> Southern Seas Ecology Laboratories, School of Biological Sciences, University of Adelaide, SA 5005, Australia

<sup>2</sup> Department of Archaeology and Palaeoanthropology, University of New England, Armidale, NSW 2351, Australia

<sup>3</sup> Wallis Heritage Consulting, 1B Swan Street, Brighton, SA 5048, Australia

<sup>4</sup> Nulungu Research Institute, The University of Notre Dame Australia, PO Box 2287, Broome, WA 6725, Australia

<sup>5</sup> College of Physical and Mathematical Sciences, The Australian National University, Acton, ACT 2601, Australia

<sup>6</sup> Dapung Talkinjeri Aboriginal Corporation, PO Box 126, Meningie, SA 5264, Australia

<sup>7</sup> Ecology and Heritage Partners, 292 Mount Alexander Road, Ascot Vale, VIC 3032, Australia

<sup>8</sup> Department of Archaeology, Flinders University, GPO Box 2100, Adelaide, SA 5001

<sup>9</sup> Office of Indigenous Strategy and Engagement, Yunggorendi Mande, Flinders University, GPO Box 2100, Adelaide, SA 5001

<sup>10</sup> College of Arts and Social Sciences, The Australian National University, Acton, ACT 2601, Australia

<sup>11</sup> College of Arts, Society and Education, James Cook University, PO Box 6811, Cairns, QLD 4870, Australia

<sup>12</sup> ARC Centre of Excellence for Australian Biodiversity and Heritage, James Cook University, PO Box 6811, Cairns, QLD 4870, Australia

**Abstract**

---

Accelerator Mass Spectrometry (AMS) radiocarbon dates (n=20) determined on fish otoliths from mulloway (*Argyrosomus japonicus*) and black bream (*Acanthopagrus butcheri*) are reported from five sites at Long Point, Coorong, South Australia. The dates range from 2938–2529 to 326–1 cal. BP, extending the known period of occupation of Long Point. Previous dating at the sites indicated intensive occupation of the area from 2455–2134 cal. BP. Results provide a detailed local chronology for the region, contributing to a more comprehensive understanding of Aboriginal use of Ngarrindjeri lands and waters. This study validates the use of fish otoliths for radiocarbon dating and reveals how dating different materials can result in different midden chronologies.

## Introduction

---

The Coorong is a shallow saline lagoon, >100 km in length, at the terminus of the largest river in Australia, the Murray. This water body is separated from the Southern Ocean by a narrow strip of sand dunes and with Lakes Alexandrina and Albert located at its northern extremity (Figure 1). In its natural state, prior to European alteration and the construction of barrages, the Coorong estuary comprised fresh, brackish and saline environments influenced by both marine and freshwater (river) inflow. Increased human regulation of the Murray has resulted in significantly increased salinity ranges, with hypersaline conditions existing in some areas of the Coorong (Jones et al. 2002; Scheltinga et al. 2006). Together, the Coorong and Lower Lakes support 78 species of fish, including mulloway, *Argyrosomus japonicus*, and black bream, *Acanthopagrus butcheri* (Geddes 2000).

*A. japonicus* is a large predatory teleost fish belonging to the Sciaenid family. It is a fast growing, relatively long-lived species, attaining a maximum age of 41 years and size of ~1800 mm (Ferguson et al. 2014; Scott et al. 1974). Juveniles inhabit estuarine environments, and adults typically aggregate around estuary mouths during the summer months, attracted by freshwater outflows and an abundance of food (Ferguson et al. 2014). *A. butcheri*, a member of the Sparidae family, is common in river mouths and estuaries where it prefers overhanging banks, snags and dead trees on the bottom of low salinity pools (Norriss et al. 2002). It is a slow growing, relatively long-lived species, reaching a maximum age of 29 years and length of 400 mm (Cashmore et al. 2000).

For thousands of years the area of the Lower Lakes and Coorong in South Australia (SA) has comprised the traditional *ruwe* (Country) of the Ngarrindjeri people (Ngarrindjeri Tendi et al. 2007). At the time of European invasion, 1836, it is reputed to have been among the most densely populated areas in Australia owing to the richness of natural resources (Jenkin 1979; Taplin 1879). Archaeological research in the area has documented hundreds of middens, testament to thousands of years of Ngarrindjeri resource use and occupation in the region (Luebbers 1978, 1981, 1982; St George 2009; St George et al. 2013; Wallis 2007a, 2007b; Wallis and Disspain 2008; Wilson et

al. 2012). Luebbers (1978, 1981, 1982) suggested that the Coorong experienced an intensive settlement phase from 2000 BP–AD 1840s. St George et al. (2013) supported this proposed chronological framework with 29 radiocarbon dates (charcoal and shell) from sites at Long Point, which suggested continued use from 2500 cal. BP to the recent past.

Temporal shifts in fish populations in the Lower Lakes and Coorong are expected to provide important information about fluctuating Aboriginal subsistence, with archaeological otoliths a useful environmental proxy (Disspain et al. 2016; Scartascini et al. 2016). However, these studies were originally temporally constrained by the use of dates on associated materials (shell and charcoal) from the same sites (Disspain et al. 2011, 2012). Despite a strong preference for using shell or charcoal samples for radiocarbon dating in archaeology, fish otoliths have been successfully dated in numerous studies (e.g., Favier Dubois and Scartascini 2012; Hufthammer et al. 2010; Scartascini and Volpedo 2013). Here we present the results of direct radiocarbon dating of Long Point otoliths, and compare them with charcoal and shell dates reported by St George et al. (2013).

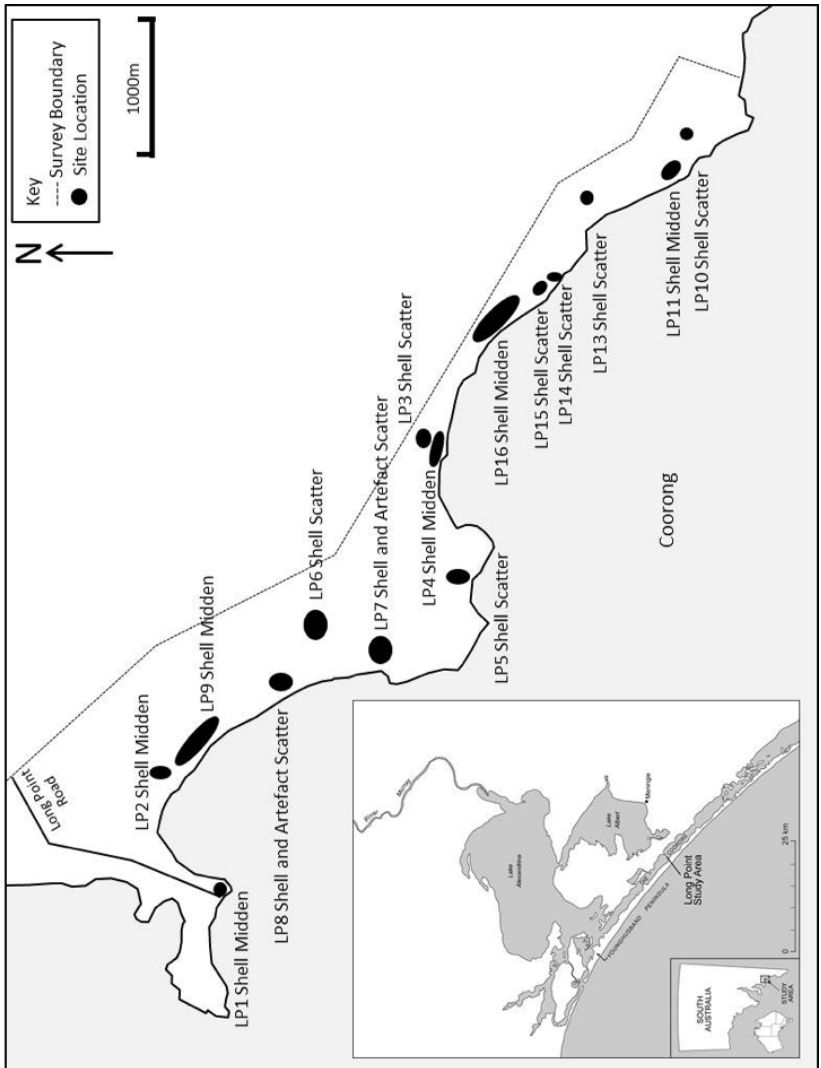
## **Methods**

---

In 2008 four middens in the Long Point area of the northern Coorong were excavated: LP4, LP9, LP11 and LP16 (Figure 1) (see St George 2009; St George et al. 2013; Wallis and Disspain 2008, for details). Additional surface material was collected from a deflated cultural lens in a sand dune blowout (LP8). All four middens were excavated to culturally sterile sediment using arbitrary 5 cm spits (unless otherwise dictated by a stratigraphic change). The excavated materials from each spit were weighed and passed through 7 mm and 3 mm nested sieves, with the retained sieve residues examined to recover cultural materials.

A total of 23 otoliths from *A. japonicus* and *A. butcheri* were recovered from the aforementioned five sites. Of these, 20 were selected for radiocarbon dating; two samples (otoliths LP09 and LP19) were not dated because they were small fragments that could not be identified to species (Disspain et al. 2011), while one sample (otolith LP23) was identified within the assemblage after the radiocarbon dating samples were sent to the laboratory.

Approximately 10 mg of material was removed from the margin of each otolith with a Dremel® rotary tool and stored in a clean glass vial. At the Australian National University Radiocarbon Dating Laboratory, samples were ground to a powder, transferred to evacuated ( $<10^{-3}$ Torr) Vacutainer® tubes and acidified with phosphoric acid (0.5 ml, 85%, 80°C) until the reaction was complete. The CO<sub>2</sub> generated was collected and purified cryogenically before reaction with H<sub>2</sub> over an iron catalyst at 570°C. Water was removed during the reaction by Mg(ClO<sub>4</sub>)<sub>2</sub>. The graphite was pressed into a target and analysed for <sup>14</sup>C using a Single Stage Accelerator Mass Spectrometer (Fallon et al. 2010). Radiocarbon values were calibrated using the CALIB (v7.0.2) program (Stuiver and Reimer 1993), using the Marine13 calibration dataset (Reimer et al. 2013) with a  $\Delta R$  value of  $61 \pm 104$  as calculated for the nearby Gulf St Vincent (Ulm 2006). Although it has been shown that the life histories of the fish include periods of fresh, marine and mixed environment habitation (Disspain et al. 2011),  $\delta^{13}\text{C}$  values (Table 1) average  $-2.0$  (range  $-5.9$ – $-1.9$ ), close to the value of marine water of  $0.0 \pm 2$  reported by Stuiver and Polach (1977). If there was more freshwater influence, the reservoir age would probably be less, meaning that the calibrated ages here are probably a minimum age. Calibrated age ranges are reported at two-sigma.



**Figure 1** Map of Long Point study area showing the location and general extent of recorded sites.

## Results

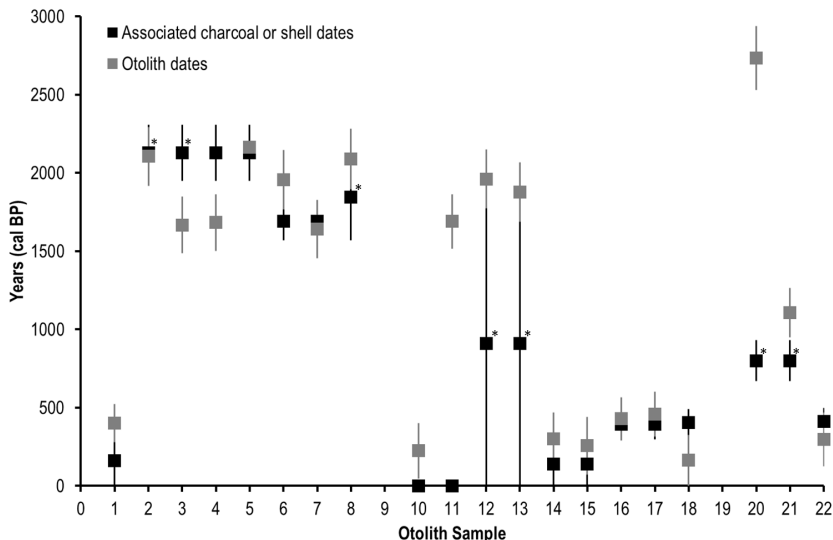
---

The radiocarbon dates obtained from the fish otoliths from Long Point range from 2938–2529 to 326–1 cal. BP (Table 1). Two distinct clusters of dates are evident, one from ca 500 cal. BP to the present, and another centred around 2000 cal. BP (Figure 2). From site LP4, only one otolith (otolith LP01) was recovered; this originated from approximately 16–20 cm below the surface, and was dated to 523–280 cal. BP. Eleven otoliths from site LP9 were dated, with a maximum age of 2295–1917 cal. BP (otolith LP02), and a minimum of 401–47 cal. BP (otolith LP10). From site LP16, two otoliths (otoliths LP16 and LP17) were recovered from the same spit (21–25 cm below surface), and dated to 566–291 cal. BP and 601–314 cal. BP, respectively. Dating of the otoliths recovered from site LP11 showed it to have the longest span of occupation, from 2938–2529 (otolith LP20) to 326–1 cal. BP (otolith LP18). The two otoliths from the LP8 surface scatter site both returned similar dates, 468–134 cal. BP (otolith LP14) and 442–70 cal. BP (otolith LP15).

The majority of otolith dates are within ca 300 years of the original associated charcoal and shell dates from the same provenance (Table 1, Figure 2). Considering the complexity of shell midden taphonomy and the small size of otoliths and charcoal fragments this consistency is surprising. Two anomalies/inversions were observed. Otolith LP11 from site LP9, Square AD, Spit 1, was directly dated to 1864–1515 cal. BP, while the associated charcoal date from the same provenance was dated as modern (St George et al. 2013). A charcoal sample from Spit 4 (20 cm below surface) of the same test pit was dated to 1816–1569 cal BP (S-ANU6620) (St George et al. 2013). This is possibly due to site disturbance or reworking of the top 20 cm of sediment. The other inverted date was that of otolith LP20 (2938–2529 cal. BP), from the LP11 test pit (Square B, Spit 2). This sample was stratigraphically positioned above a shell sample (site LP11, Square B, Spit 3), which was associated with the lowest cultural material from the test pit and dated to 930–671 cal. BP (S-ANU6632) (St George et al. 2013). This anomaly may be the result of bioturbation, where the shell or otolith may have moved within the site matrix.

**Table 1** Radiocarbon ages for fish otoliths from Long Point based on direct dating of otoliths and dating of charcoal or shell material (St George et al. 2013). \*Indicates no radiocarbon determination was available from the same excavation unit, and an age range was assigned based on the nearest available ages.

OTOLITHS										CHARCOAL/SHELL			
Otolith Code	Lab Number	Site	Sq.	Sp.	D.B.S. (cm)	Species	$\delta^{13}C$	$^{14}C$ Age (BP)	(cal. BP)	Lab Number	Material	(cal. BP)	
LP01	S-ANU-16706	LP4	AK14	4	16-20	<i>A. japonicus</i>	-3.9±0.6	885±30	523-280	S-ANU-6614	Charcoal	321-modern	
LP02	S-ANU-16707	LP9	Y	2	6-10	<i>A. japonicus</i>	-1.0±0.4	2510±30	2295-1917	S-ANU-6617	Charcoal	<1951-2306*	
LP03	S-ANU-16709	LP9	Y	2	6-10	<i>A. japonicus</i>	1.2±0.4	2140±30	1848-1486	S-ANU-6617	Charcoal	<1951-2306*	
LP04	S-ANU-16710	LP9	Y	5	21-25	<i>A. japonicus</i>	1.9±1.0	2155±35	1864-1501	S-ANU-6617	Charcoal	2306-1951	
LP05	S-ANU-16711	LP9	Y	5	21-25	<i>A. japonicus</i>	-5.4±0.9	2310±35	2171-2161	S-ANU-6617	Charcoal	2306-1951	
LP06	S-ANU-16712	LP9	AD	4	16-20	<i>A. japonicus</i>	4.9±0.4	2395±30	2146-1768	S-ANU-6620	Charcoal	1816-1569	
LP07	S-ANU-16713	LP9	AD	4	16-20	<i>A. japonicus</i>	-2.7±0.4	2125±30	1829-1456	S-ANU-6620	Charcoal	1816-1569	
LP08	S-ANU-16714	LP9	AD	5	21-25	<i>A. japonicus</i>	-1.1±0.5	2490±30	2283-1894	S-ANU-6620 and S-ANU-6621	Charcoal	1569-2121*	
LP10	S-ANU-16716	LP9	AD	1	0-5	<i>A. butcheri</i>	-0.8±0.4	655±30	401-47	S-ANU-6619	Charcoal	Modern	
LP11	S-ANU-16716	LP9	AD	1	0-5	<i>A. japonicus</i>	-0.8±0.5	2165±30	1864-1515	S-ANU-6619	Charcoal	Modern	
LP12	S-ANU-16718	LP9	AY12	12	56-60	<i>A. japonicus</i>	-0.7±0.4	2400±30	2151-1772	S-ANU-6623 and S-ANU-6625	Charcoal	1822-modern*	
LP13	S-ANU-16719	LP9	AY12	11	51-55	<i>A. butcheri</i>	-5.9±0.4	2325±30	2067-1687	S-ANU-6623 and S-ANU-6625	Charcoal	1822-modern*	
LP14	S-ANU-16720	LP8	E1	M1	Surface	<i>A. japonicus</i>	0.9±0.5	730±30	468-134	Wk-21217	Shell	276-modern	
LP15	S-ANU-16721	LP8	E1	M2	Surface	<i>A. japonicus</i>	-2.1±0.3	690±30	442-70	Wk21217	Shell	276-modern	
LP16	S-ANU-16723	LP16	L8	5	21-25	<i>A. japonicus</i>	-5.0±0.6	890±30	566-291	S-ANU-6627	Charcoal	491-298	
LP17	S-ANU-16724	LP16	L8	5	21-25	<i>A. japonicus</i>	-0.6±0.4	910±30	601-314	S-ANU-6627	Charcoal	491-298	
LP18	S-ANU-16725	LP11	A	4	16-20	<i>A. japonicus</i>	-1.0±0.5	620±30	326-1	S-ANU-6629	Charcoal	490-318	
LP20	S-ANU-16726	LP11	B	2	6-10	<i>A. japonicus</i>	-1.8±0.5	3035±35	2938-2529	S-ANU-6632	Shell	<930-671*	
LP21	S-ANU-16727	LP11	B	2	6-10	<i>A. japonicus</i>	-4.5±0.6	1620±35	1265-951	S-ANU-6632	Shell	<930-671*	
LP22	S-ANU-16729	LP11	C	5	21-25	<i>A. japonicus</i>	-2.3±1.1	725±35	471-124	S-ANU-6633	Charcoal	499-322	



**Figure 2** Direct otolith dates compared with associated charcoal or shell dates (St George et al. 2013) from Long Point. \*Indicates no radiocarbon determination was available from the same excavation unit, and an age range was assigned based on the nearest available ages. Note that otoliths LP09 and LP19 were not dated.

## Discussion

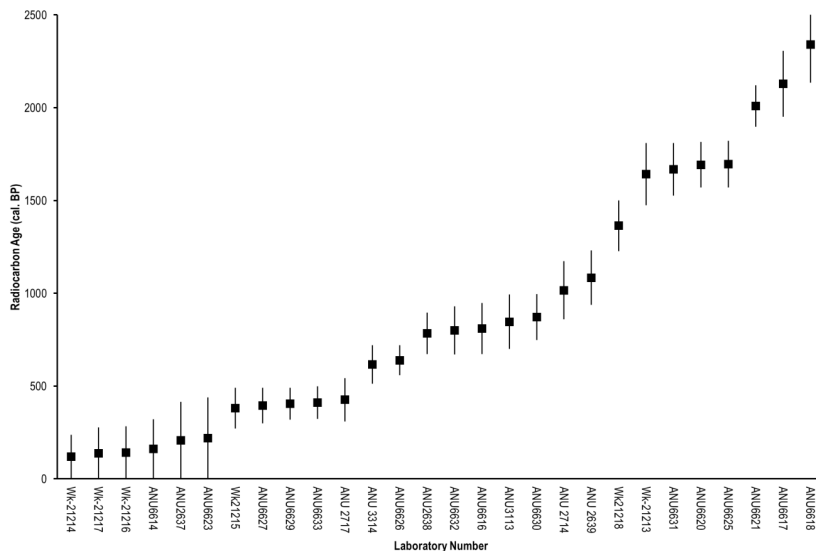
Based on the new radiocarbon chronology established from the Long Point otoliths, occupation at the sites, while still confined to the late Holocene, may extend several hundred years earlier than was indicated by shell and charcoal dates (St George et al. 2013). Unfortunately, no otolith samples were excavated from the same provenance as the oldest associated material date (LP9/Y/10 2455–2134 cal. BP ANU6618 2340±55 BP; St George et al. 2013) to provide a direct comparison between materials in that excavation unit. All previous dates fell after the range of these values, while in this study, one otolith—otolith LP20—from site LP11 was dated to 2938–2529 cal. BP. Conservatively, at two-sigma, this otolith is between 74 and 804 years older than the oldest charcoal/shell date; this value is broad owing to the lack of a local marine reservoir correction value. The regional value used had wide error margins, resulting in a broad



calibrated age-range. Mulloway can live in a wide range of salinities; subsequently, if a fish had inhabited a freshwater environment for the majority of its life, the reservoir correction value would differ from that of a fish that had inhabited a predominantly marine environment. As such, these dates could be more precisely defined through the use of trace analysis to investigate the ambient salinity experienced by each individual fish throughout its life. One outlying date may not provide sufficient evidence to confidently extend the antiquity of the site. Considering that another otolith (otolith LP21) from the same spit was dated to 1265–951 cal. BP, taphonomic site processes may contribute to this inconsistency, and further dating of samples from this square could help to confirm this finding. Should this otolith be a remnant of anthropogenic activities, as opposed to non-anthropogenic activities (such as mass fish death or deposition by a prey species), its presence in the site could indicate that this location was occupied during the initial coastal settlement phase (4500–2000 BP) of the suggested phases of occupation in the region (Luebbers 1978, 1981, 1982).

The pattern of date clusters, one at <500 cal. BP and another ca 2000 cal. BP, differs from the pattern evident in the charcoal and shell dates as presented in Figure 3 (St George et al. 2013), which spread fairly consistently over the period of occupation. These clusters could be artefacts of taphonomic site processes and preservation, or an indication of processing methods whereby fish were processed and discarded away from the midden sites from 500 cal. BP to 1500 cal. BP. Fish bone in general was recovered from the Long Point sites in relatively small quantities, especially when compared with shellfish, which has been attributed to the deliberate targeting of shellfish at this particular location (St George 2009). This is despite numerous ethnographic sources asserting that Ngarrindjeri diets traditionally consisted mainly of fish (Beveridge 1883; Hawdon 1952; Krefft 1865; Sturt 1982), a view reiterated today by community members (Ngarrindjeri Tendi et al. 2007). As such, it is possible that these clusters of dates reflect times when there was a more focused effort on fishing at these sites, but without a larger sample size, the exact cause cannot be determined.

The provision of direct ages for the otoliths has implications for previous analyses conducted on these samples (Disspain 2009; Disspain et al. 2011). Fish otoliths were assigned dates either from radiocarbon dating of charcoal or shell from the same excavation unit or, if no dates were available, by using an age range from the nearest available excavation units. Initially, otolith LP13 (*Acanthopagrus butcheri*) had been assigned an uncalibrated, inverted date of  $190 \pm 40$  (Disspain et al. 2011). After further dating was carried out, the age of the otolith was estimated to fall between 1822 cal. BP and a modern date (St George et al. 2013). This study has produced a direct date for otolith LP13 of 2067–1687 cal. BP. The scarcity of otoliths from *A. butcheri* at Long Point, combined with the samples' estimated recent ages (Table 1), had previously been assumed to indicate that they did not preserve well within the site (Disspain 2009). The new results indicate that otoliths of *A. butcheri* are in fact capable of surviving significantly long periods of time in archaeological deposits, and alternate causes for the scarcity of specimens may be preferential targeting of the larger species, *A. japonicus*, either through capture or sampling of midden material.



**Figure 3** All radiocarbon dates from charcoal or shell at Long Point as presented in St George et al. (2013).

Changes in fish age and size through time were previously examined using only ages determined on associated materials (Disspain 2009). After reanalysing the trends over time using direct dates, we determine that, despite a number of direct dates being significantly different to the original associated dates, the overall patterns that were reported essentially remain the same. This indicates that associated dates are useful when examining broad-scale patterns in data, but when more precise information is required, direct dating is preferable.

### **Conclusions**

---

Direct radiocarbon dating of fish otoliths from midden sites at Long Point may extend the period of Aboriginal occupation of the area by 74–804 years from previous dating projects. The addition of otolith AMS radiocarbon dates to the archaeological information for the sites has refined previous research results that originally relied on associated dates of charcoal and shell with the same provenance. We recommend comprehensive direct dating, targeting multiple material types, in order to investigate anomalies and site disturbance common in midden deposits. Further dating studies could establish the extent to which contamination exists through replication of radiocarbon dates for independent samples. Cross-dating otoliths with other material types (shell or charcoal) is expected to provide important data, enabling regional  $\Delta R$  values to be determined. In combination, the data provide us with a growing level of insight into broad patterns of human-environment relationships in the region.

## Acknowledgements

The authors wish to thank the Ngarrindjeri Regional Authority and members of the Ngarrindjeri community who granted permission to conduct this research. Steve Hemming made it possible for this project, and many more, to be conducted within Ngarrindjeri *ruwe*. This study was supported by funds from the Australian Institute of Aboriginal and Torres Strait Islander Studies (grant number 09/7435) awarded to BMG and MCFD, a Sir Mark Mitchell Research Foundation Grant awarded to LW, and Indigenous Heritage Programme funding. BMG acknowledges support from an Australian Research Council Discovery Grant (DP110100716) and an Australian Research Council Future Fellowship (FT100100767). SU is the recipient of an Australian Research Council Future Fellowship (project number FT120100656).

## References

- Beveridge, P. 1883 Of the Aborigines inhabiting the great lacustrine and riverine depression of the Lower Murray, Lower Murrumbidgee, Lower Lachlan and Lower Darling. *Journal and Proceedings of the Royal Society of New South Wales* 17:19–74.
- Cashmore, S., S. Conron and I. Knuckey 2000 *Black Bream - 1998. Fisheries Victoria Assessment Report*. Queenscliff: Marine and Freshwater Resources Institute.
- Disspain, M.C.F. 2009 Using Archaeological Otoliths to Determine Palaeoenvironmental Change and Ngarrindjeri Resource Use in the Coorong and Lower Murray, South Australia. Unpublished BA(Hons) thesis, Department of Archaeology, Flinders University, Adelaide.
- Disspain, M.C.F., L.A. Wallis and B.M. Gillanders 2011 Developing baseline data to understand environmental change: a geochemical study of archaeological otoliths from the Coorong, South Australia. *Journal of Archaeological Science* 38(8):1842–1857.
- Disspain, M.C.F., C.J. Wilson and B.M. Gillanders 2012 Morphological and chemical analysis of archaeological fish otoliths from the Lower Murray River, South Australia. *Archaeology in Oceania* 47(3):141–150.
- Disspain, M.C.F., S. Ulm, and B.M. Gillanders 2016 Otoliths in archaeology: methods, applications and future prospects. *Journal of Archaeological Science: Reports* 6:623–632.
- Fallon, S.J., L.K. Fifield and J.M. Chappell 2010 The next chapter in radiocarbon dating at The Australian National University: status report on the single stage AMS. *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms* 268(7–8):898–901.

- Favier Dubois, C.M. and F.L. Scartascini 2012 Intensive fishery scenarios on the north Patagonian coast (Río Negro, Argentina) during the mid-Holocene. *Quaternary International* 256:62–70.
- Ferguson, G.J., T.M. Ward, A. Ivey and T. Barnes 2014 Life history of *Argyrosomus japonicus*, a large sciaenid at the southern part of its global distribution: implications for fisheries management. *Fisheries Research* 151:148–157.
- Geddes, M.C. 2000 Fish and invertebrates. In A. Jensen, M. Good, P. Harvey, P. Tucker and M. Long (eds), *River Murray Barrages Environmental Flows*, pp.43–50. Canberra: Murray-Darling Basin Commission.
- Hawdon, J. 1952 *The Journal of the Journey from New South Wales to Adelaide*. Melbourne: Georgian House.
- Hufthammer, A.K., H. Høie, A. Folkvord, A.J. Geffen, C. Andersson and U.S. Ninnemann 2010 Seasonality of human site occupation based on stable oxygen isotope ratios of cod otoliths. *Journal of Archaeological Science* 37(1):78–83.
- Jenkin, G. 1979 *Conquest of the Ngarrindjeri*. Adelaide: Rigby.
- Jones, G., T. Hillman, R. Kingsford, T. McMahon, K. Walker, A. Arthington, J. Whittington and S. Cartwright 2002 *Independent Report of the Expert Reference Panel on Environmental Flows and Water Quality Requirements for the Murray River System*. Canberra: Murray-Darling Commission, Cooperative Research Centre for Freshwater Ecology.
- Kreffit, G. 1865 On the manners and customs of the Aborigines of the Lower Murray and Darling. *Transactions of the Philosophical Society of New South Wales* 1862 65:357–374.
- Luebbers, R.A. 1978 Meals and Menus: A Study of Change in Prehistoric Coastal Settlements in South Australia. Unpublished PhD thesis, Department of Prehistory, Research School of Pacific Studies, The Australian National University, Canberra.
- Luebbers, R.A. 1981 The Coorong Report: An Archaeological Survey of the Southern Younghusband Peninsula. Unpublished report prepared for the South Australian Department for Environment and Planning.
- Luebbers, R.A. 1982 The Coorong Report: An Archaeological Survey of the Northern Coorong. Unpublished report prepared for the South Australian Department for Environment and Planning.
- Ngarrindjeri Tendi, Ngarrindjeri Heritage Committee and Ngarrindjeri Native Title Committee 2007 *Ngarrindjeri Nation Sea Country Plan: Caring for Ngarrindjeri Country and Culture*. Meningie: Ngarrindjeri Land Progress Association.
- Norriss, J.V., J.E. Tregonning, R.C.J. Lenanton and G.A. Sarre 2002 *Biological Synopsis of the Black Bream, Acanthopargus butcheri (Munro) (Teleostei: Sparidae) in Western Australia with Reference to Information from other States*. Perth: Department of Fisheries.

- Reimer, P.J., E. Bard, A. Bayliss, J.W. Beck, P.G. Blackwell, C. Bronk Ramsey, C.E. Buck, H. Cheng, R.L. Edwards, M. Friedrich, P.M. Grootes, T.P. Guilderson, H. Hafliðason, I. Hajdas, C. Hatté, T.J. Heaton, A.G. Hogg, K.A. Hughen, K.F. Kaiser, B. Kromer, S.W. Manning, M. Niu, R.W. Reimer, D.A. Richards, E.M. Scott, J.R. Southon, C.S.M. Turney and J. van der Plicht 2013 IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal. BP. *Radiocarbon* 55(4):1869–1887.
- Scartascini, F.L. and A.V. Volpedo 2013 White croaker (*Micropogonias furnieri*) paleodistribution in the southwestern Atlantic Ocean: an archaeological perspective. *Journal of Archaeological Science* 40(2):1059–1066.
- Scartascini, F.L., M. Saez and A.V. Volpedo 2016 Otoliths as a proxy for seasonality: the case of *Micropogonias furnieri* from the northern coast of San Matías Gulf, Río Negro, Patagonia, Argentina. *Quaternary International* 373:136–142.
- Scheltinga, D.M., R. Fearon, A. Bell and L. Heydon 2006 *Assessment of Information Needs for Freshwater Flows into Australian Estuaries*. Canberra: Fisheries Research and Development Corporation, and Land and Water Australia.
- Scott, T.D., C.J.M. Glover and R.V. Southcott 1974 *The Marine and Freshwater Fishes of South Australia*. Adelaide: A.B. James, Government Printer.
- St George, C. 2009 Ngarrindjeri Ruwe: Investigating the Mid- to Late Holocene Occupation of Long Point, Coorong, South Australia. Unpublished BArch(Hons) thesis, Department of Archaeology, Flinders University, Adelaide.
- St George, C., L.A. Wallis, B. Keys, C. Wilson, D. Wright, S. Fallon, M. Sumner and S. Hemming 2013 Radiocarbon dates for coastal midden sites at Long Point in the Coorong, South Australia. *Australian Archaeology* 77:141–147.
- Stuiver, M. and H.A. Polach 1977 Discussion: reporting of 14C data. *Radiocarbon* 19:355–363.
- Stuiver, M. and P.J. Reimer 1993 Extended 14C database and revised CALIB radiocarbon calibration program. *Radiocarbon* 35:215–230.
- Sturt, C. 1982 *Two Expeditions into the Interior of Southern Australia During the Years 1828, 1829, 1830 and 1831 with Observations on the Soil, Climate, and General Resources of the Colony of New South Wales*. Sydney: Doubleday.
- Taplin, G. 1879 The Narrinyeri. In J.D. Woods (ed.), *The Native Tribes of South Australia*, pp.1–156. Adelaide: E.S. Wigg and Son.
- Ulm, S. 2006 Australian marine reservoir effects: a guide to  $\Delta R$  values. *Australian Archaeology* 63:57–60.
- Wallis, L.A. 2007a Long Point Indigenous Cultural Heritage Survey: Archaeological Results (Stage One, Section 571). Unpublished report prepared for the Dapung Talkinyeri Aboriginal Corporation.

- Wallis, L.A. 2007b Long Point Indigenous Cultural Heritage Survey: Archaeological Results (Stage Two, Section 572). Unpublished report prepared for the Dapung Talkinyeri Aboriginal Corporation and Ngarrindjeri Heritage Committee.
- Wallis, L.A. and M. Disspain 2008 Archaeological Investigations of Midden Sites at Long Point April 2008. Unpublished report prepared for the Dapung Talkinjeri Aboriginal Corporation, Ngarrindjeri Heritage Committee and Ngarrindjeri Regional Authority.
- Wilson, C., S. Fallon and T. Trevorrow 2012 New radiocarbon ages for the Lower Murray River, South Australia. *Archaeology in Oceania* 47(3):157-160.