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The role of terrestrial, estuarine, and marine foods in dynamic Holocene environments and adaptive coastal economies in Southwestern Australia

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ABSTRACT

Southwestern Australia has a Mediterranean-type climate, with hot, dry summers and mild, wet winters that support vegetation types ranging from tall closed forest and open woodland, to dense, low heath. At the Last Glacial Maximum, the coast was located as far as 100 km distant of its current location, after which rising post-glacial sea levels radically altered the southwestern coastline, drowning large tracts of the continental shelf, creating islands and rocky cliffs from areas of higher relief, and altering delicately balanced coastal ecosystems. For Aboriginal people living in southwestern Australia these changes would have substantially altered the availability and reliability of important plants and animals, both on the coastal plain and within littoral and estuarine environments, which raises the question of how we define and distinguish the economic strategies employed by people occupying these liminal, transitional landscapes. This paper reviews all available securely dated archaeofaunal records from 31 archaeological sites within the southwestern Australian coastal zone to develop a general economic model of Aboriginal occupation of the region's changing Holocene coastal zones. Faunal records were grouped by bioregion to investigate regional variation in environmental and cultural trends. Archaeological, palaeontological, and palaeoclimatic evidence indicates that people adapted as the coastal plain transformed during the Holocene, altering subsistence strategies and land management practices.

1. Introduction

Southwestern Australia's coastal margin is dynamic and resource rich, attributes likely to have been significant factors in people's colonisation and continued occupation of the region throughout millennia of environmental and cultural change (Hallam, 1987; Dortch, 1999, Dortch, 2002a; Smith, 1999). Despite this, archaeological evidence of Holocene food extraction along the southwestern coast is often described as being much scarcer than in the remainder of the continent, particularly in regards to the relative importance of littoral and estuarine versus terrestrial food resources (Dortch et al., 1984; Hallam, 1987; Nicholson and Cane, 1994; O'Connor and Sullivan, 1994; Bowdler, 1999; Hall and McNiven, 1999; Smith, 1999). Consequently, southwestern Australia has often been regarded as a coastal region without a 'coastal' (littoral) economy. This paper reviews the archaeological evidence of Holocene subsistence along southwestern Australia's Indian and Southern Ocean coasts in order to test this hypothesis, and to develop a general model of regional Holocene coastal subsistence strategies.

Colonial observations, largely from the Swan River and King George Sound regions, propagated a myth of an 'absent' or 'unimportant' Noongar littoral economy prior to European colonisation, with little observation of shellfish exploitation recorded in contrast to a considerable focus on individual and congregative freshwater and estuarine fishing practices (Nind, 1831; Grey, 1841; Moore, 1884; Dortch et al., 1984). Small, sparse shell midden scatters are dotted at intervals along the southwest coastline, challenging—but not altogether refuting—this myth, and regional studies have demonstrated consistent, small-scale exploitation of molluscan resources for both subsistence and non-food use which is incorporated into a broader, diverse coastal economy characterised by elements from marine, littoral, estuarine, terrestrial, and freshwater environments (Meagher, 1974; Dortch et al., 1984; Hallam, 1987; Smith, 1999). Some archaeologists assessing coastal activity at a continental scale have used a comparative lack of archaeological shellfish remains to argue that while marine shellfish may have been occasionally consumed in southwestern Australia, they were generally ignored and were ultimately inconsequential components of a terrestrial or 'mixed' regional economy (O'Connor et al., 1993;

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Nicholson and Cane, 1994; Beaton, 1995). However, this implication that extensive shellfish exploitation is a necessary hallmark of coastal economies belies the productivity of non-littoral elements of coastal environments (Hallam, 1987; Dortch, 1999; Smith, 1999). Further, people's ability and desire to exploit littoral and marine resources is not a straightforward function of proximity to the coast. Rather, there is a complex interplay of coastal processes such as tidal regime and sedimentation that are as critical to understanding coastal productivity as is sea level (Fa, 2008; Ward et al., 2015), and which have largely been overlooked in models that contrast littoral resource use between the microtidal regimes of southwestern Australia with meso- or macrotidal regimes elsewhere in northern and eastern Australia.

While littoral resources, and specifically shellfish, are a widely recognised component of coastal economies around the world, their relative significance varies and their presence or absence is not necessarily indicative of people's relationship with marine and other coastal resources more broadly (Jones, 1991; Fa, 2008; Erlandson et al., 2009; Colonese et al., 2011). Hallam (1987), Dortch (1997, 1999) and Smith (1999) have explored other coastal subsistence evidence from southwestern Australia, demonstrating regional variation in the archaeological evidence of terrestrial, marine, littoral, and estuarine food extraction with a particular focus on the lower southwest. Direct dietary evidence from archaeological contexts includes shells of aquatic gastropods and bivalves, mammal and fish bones, emu eggshell, and—in a single described example (Smith, 1982, 1996)—cached plant foods, while indirect evidence comes from sites associated with food procurement, such as lizard traps, possum trees, yam pits, and stone or brush weirs known locally as "fish traps" (Smith, 1999). Indirect evidence is typically more archaeologically visible, but is frustratingly difficult if not impossible to date (see for example: Dortch et al., 2006), while direct evidence relies on suitable preservation conditions and is thus restricted to certain districts such as those containing surface limestone geology. Consequently, archaeological discussion of coastal subsistence strategies in southwestern Australia has relied heavily on the recent 'snapshot' of activities documented following European colonisation, often lacking the temporal depth afforded by the preservation of stratified deposits produced by repeated site use.

Aboriginal people have lived in southwestern Australia for at least 48,000 years (Turney et al., 2001; Dortch, 2004; Balme, 2014). Noongar people persisted through multiple periods of environmental change by employing flexible foraging strategies that allowed them to exploit a broad range of ecosystems (Dortch, 2004; Dortch et al., 2012, 2014; Balme, 2014). However, most archaeological evidence of occupation patterns and diet comes from the forested Leeuwin-Naturaliste Region (LNR), a discrete district in the far southwest, which contains accessible limestone caves with ideal conditions for preserving stratified archaeological deposits. In contrast, limited evidence of organic remains has been recovered from the remainder of the southwest, including the sandplains that form the dominant landscape on the west coast. Further, much of what is preserved biases the subsistence record towards the more durable remains preserved in shell middens (Morse, 1982; Dortch et al., 1984; Monks et al., 2015) or vertebrate remains from cave deposits (Archer, 1974; Balme et al., 1978; Balme, 1980, 2014; Dortch, 2004; Dortch et al., 2014; Monks et al., 2016).

As a consequence of these spatial and taphonomic biases in subsistence records, the nature of the economic strategies employed by people occupying the liminal zones of the Holocene southwestern Australian coast is unclear. This raises the question of how we define and regard a coastal economy. Hallam (1987) demonstrated that for people occupying the coastal plain wetland and riverine resources were of equal or greater importance than littoral or estuarine ones. She further suggested that the generally accepted concept of a 'coastal economy' being one with a dominant focus on marine resources was based on records from "times and places which are atypical" for the continent's margins in general (Hallam, 1987, p. 11). In one of the few attempts to explicitly develop a continental definition for Australian coastal subsistence strategies, Beaton (1995) argued that a 'coastal economy' would be one with subsistence activity focused predominantly on the exploitation of marine foods, where archaeological markers could be expected to include "fish-hooks, barbs or gorgets, fish-traps, netting devices, pry-bars for taking sessile molluscs, watercraft, dense prey assemblages of marine fauna, or … effigies or rock-art assemblages dominated by marine-inspired motifs." The mere proximity of a site to the coast was not considered sufficient to consider it to have a coastal economy, which Beaton (1995, p. 802, emphasis in original) further attests.

> Is one where human life-ways are <u>transformed</u> by the marine factor, whilst in 'coastal use' the marine element is visible but not transforming, and in chance 'coastal location' the material and faunal components of sites are not significantly different from interior sites.

In this paper I challenge this definition, arguing that marine resources need not completely dominate cultural and economic practices year-round, and that seasonally important marine elements are equally transformative, particularly in moderate, biodiverse environments such as the Mediterranean-type environment of coastal southwestern Australia. This paper reviews Holocene archaeofaunal subsistence evidence across coastal southwestern Australia, consolidating terrestrial, riverine, estuarine, and littoral evidence from coastal sites from Kalbarri to Israelite Bay (Fig. 1).

2. Regional setting and Holocene environmental changes in coastal southwestern Australia

Southwestern Australia is a large, physically and ecologically diverse bioregion situated at the juncture of the Indian and Southern Oceans. The region has a Mediterranean climate, with a winter-wet, summer-dry pattern of rainfall that is wettest in the far southwest and follows a gradient of decreasing effective precipitation to the north and east (Hopper and Gioia, 2004). The southwestern coasts are characterised by microtidal regimes with high wave energy, associated with drowned river and barrier estuaries (Kench, 1999). The Integrated Marine and Coastal Regionalisation of Australia (IMCRA) and Interim Biogeographic Regionalisation for Australia (IBRA) regionalisation (Commonwealth of Australia, 2006; Department of the Environment, 2012) provide a spatial framework with which to investigate terrestrial landscapes and marine seascapes within the southwest, and broadly conform to three informal study areas: the Central Indian Ocean Coast, the Southern Indian Ocean Coast, and the Southern Ocean Coast (Fig. 1).

The Central Indian Ocean Coast extends from slightly north of Kalbarri southwards to Perth, and incorporates the transitional waters of the subtropical Central Western IMCRA Province (Zuytdorp (ZUY) marine subregion) and the Southwest IMCRA Transition (Central West Coast (CWC) subregion), correlating approximately with the Geraldton Sandplains and northern Swan Coastal Plain IBRA bioregions (Fig. 2). A limestone ridge forms the region's western edge, whittled away in parts by the high energy Indian Ocean swells to create low, rugged islands and rocky headlands separated by sandy bays where diverse littoral and estuarine habitats flourish. The northern end of the region is characterised by limited surface water, with low-discharge river systems typically meeting the ocean at seasonally-barred estuaries. Further south, wetlands and lakes are more abundant and the coastal sandplains widen to accommodate a series of Pleistocene and Holocene dunes.

The Southern Indian Ocean Coast broadly encompasses the transitional waters between the Indian and Southern Oceans, extending from Perth to Point d'Entrecasteaux to incorporate the Leeuwin-Naturaliste (LNE) marine subregion and the southern Swan Coastal Plain, northern Jarrah Forest, and western Warren IBRA bioregions (Fig. 3). Shaped by the igneous geology of the Leeuwin Block, as well as the overlying karstic limestone formation that is prominent along the Leeuwin-Naturaliste Ridge, the coast itself is characterised by high-energy waves and heavy swell, and features cliffy headlands interspersed by

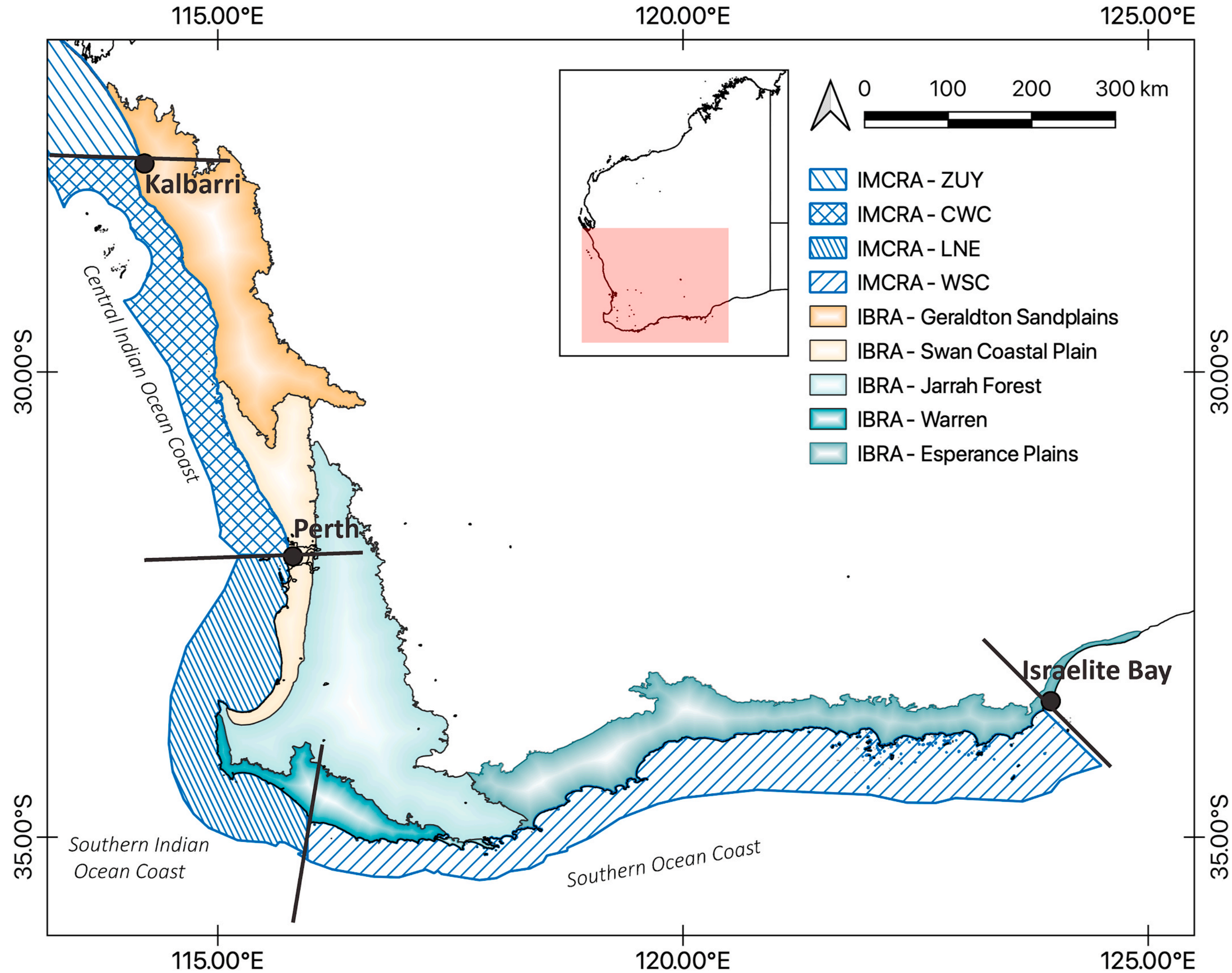

Fig. 1. Map of southwestern Australia, showing the Central Indian Ocean, Southern Indian Ocean, and Southern Ocean study areas, IBRA, and IMCRA regions discussed in text. Spatial data: Commonwealth of Australia, 2006; Department of the Environment, 2012.

wide, sandy bays. At the northern end of the region, within the southern Swan Coastal Plain bioregion, are several large, permanently open estuaries and associated wetlands.

The Southern Ocean Coast stretches from Point d'Entrecasteaux to Israelite Bay, taking in the Western Australian South Coast (WSC) marine subregion and the eastern Warren, southern Jarrah Forest, and Esperance Sandplains IBRA bioregions (Fig. 4). Heavy swell and high-energy waves are typical of the exposed beaches and granite headlands, while wide, sandy bays, inlets, and flooded estuaries provide sheltered habitat for diverse marine fauna.

3. Methods

Published and unpublished literature discussing sites in coastal southwestern Australia were surveyed to obtain subsistence records and associated radiocarbon ages from Holocene occupation sequences. The available literature included journal articles, book chapters, monographs, and PhD and Honours theses. Meta-analysis of archaeological collections is fraught with methodological issues due to inconsistent collection and documentation practices (Jones and Gabe, 2015). Accordingly, it is vital these factors be considered when compiling data for meta-analyses, particularly when combining data collected over several decades. For this study, a database was created to capture the name and location of the site, year of publication, uncalibrated age determinations and associated sample metadata, excavation methods (excavation unit thickness, sieve mesh gauge, wet/dry sieving), taxonomic identifications, and quantification data. Discussion of plant and animal subsistence evidence was common in site reports and theses, but few included raw data and/or sufficient contextual information to determine the age of the described assemblage. As one of the aims of this analysis is the investigation of subsistence changes over time, the database included only subsistence evidence associated with a secure radiometric age. Only two sites (Hastings Cave and Cheetup Rockshelter) contained plant material identified as a subsistence or cultural resource, and no macrobotanical evidence was discussed in detail. Faunal remains are therefore the sole focus of this analysis.

Excavation, quantification, and analytical methods were inconsistent between sites, because excavations and faunal identifications were made by numerous researchers over a span of some 50 years. The variation in excavation methods, particularly in sieve mesh gauge, may have influenced species identifications in some sites, and this is discussed further in section five. Analytical decisions varied considerably and were difficult to consolidate. Some studies, particularly those describing emu eggshell, shellfish and fish remains, provided only presence/absence or weight data. Where numerical quantifications were available, data were typically provided as number of identified specimens (NISP) or

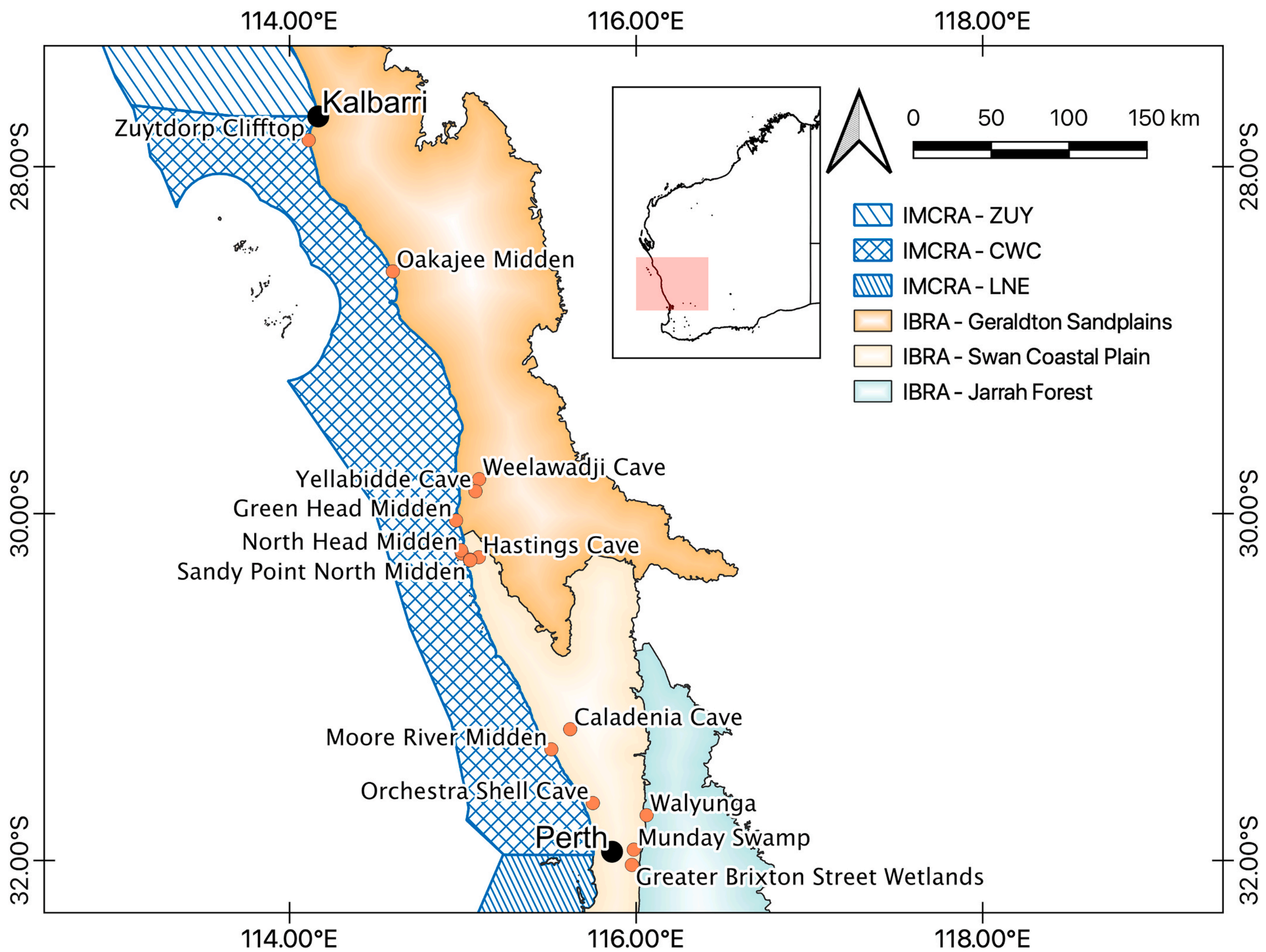

Fig. 2. Map of the Central Indian Ocean study area, showing archaeological sites discussed in text. Spatial data: Commonwealth of Australia, 2006; Department of the Environment, 2012.

minimum number of individuals (MNI), but seldom both, and methodological information about analytical decisions (for example, which skeletal elements were used to make identifications) was rarely detailed. Consequently, it is not possible to undertake detailed statistical analyses of species relative abundance. Instead, this study looks at the ubiquity of species, with the presence/absence of taxa providing a coarse but rather robust view of subsistence choices and the relative reliability of species within and between archaeological contexts.

Subsistence evidence from dated occupation sequences in caves and middens is compiled by IBRA bioregion to explore variation in subsistence evidence by landscape unit and coastal province. Radiocarbon ages are presented using calibrated ages, with calibrations performed with CALIB 7.1 (Stuiver et al., 2005), using SHCal13 (Hogg et al., 2013) for botanical and wood charcoal specimens and Marine13 (Reimer et al., 2013) for marine shell (Appendix,Table A3). Dated occupation horizons are sequenced using the median probability age into one of four time periods; Early Holocene (ca 10,000 to 8000 cal BP), Mid-Holocene (ca 8000 to 5000 cal BP), Late Holocene (ca 5000 to 1000 cal BP), and Final Holocene (ca 1000 cal BP to present day). These four periods are arbitrary, but generally conform to broad climatic phases and facilitate comparisons of people's subsistence choices and adaptation within and between temporal units.

4. Results

Thirty-one archaeological sites (19 middens and 12 rockshelters) contained faunal records associated with securely dated Holocene archaeological occupation deposits (Appendix, Tables A1 and A2). Mammals dominate the faunal record across all sites in all contexts with the exception of coastal middens, which are unsurprisingly composed almost exclusively of marine shell. Although the number of sites with subsistence evidence is low, Holocene occupation of most bioregions has been well demonstrated, providing some insight into demography and land use. Several clear trends emerge which demonstrate both spatial and temporal variation in subsistence practices throughout the Holocene, and reveal adaptative subsistence strategies employed by Aboriginal people living in the coastal southwest during this time. The following sections review occupation and subsistence evidence for each of the regions that form the southwestern Australian coast.

4.1. Central Indian Ocean coast

4.1.1. Antiquity of occupation and Holocene land use

The Central Indian Ocean coastline has been occupied by people for at least 40,000 years. Buried artefact horizons in river terraces and dunes demonstrate early occupation of the Swan Coastal Plain prior to the LGM, as do several dated isolated artefacts from Rottnest (also known by its Noongar name, *Wadjemup*) and Garden Islands (Pearce and

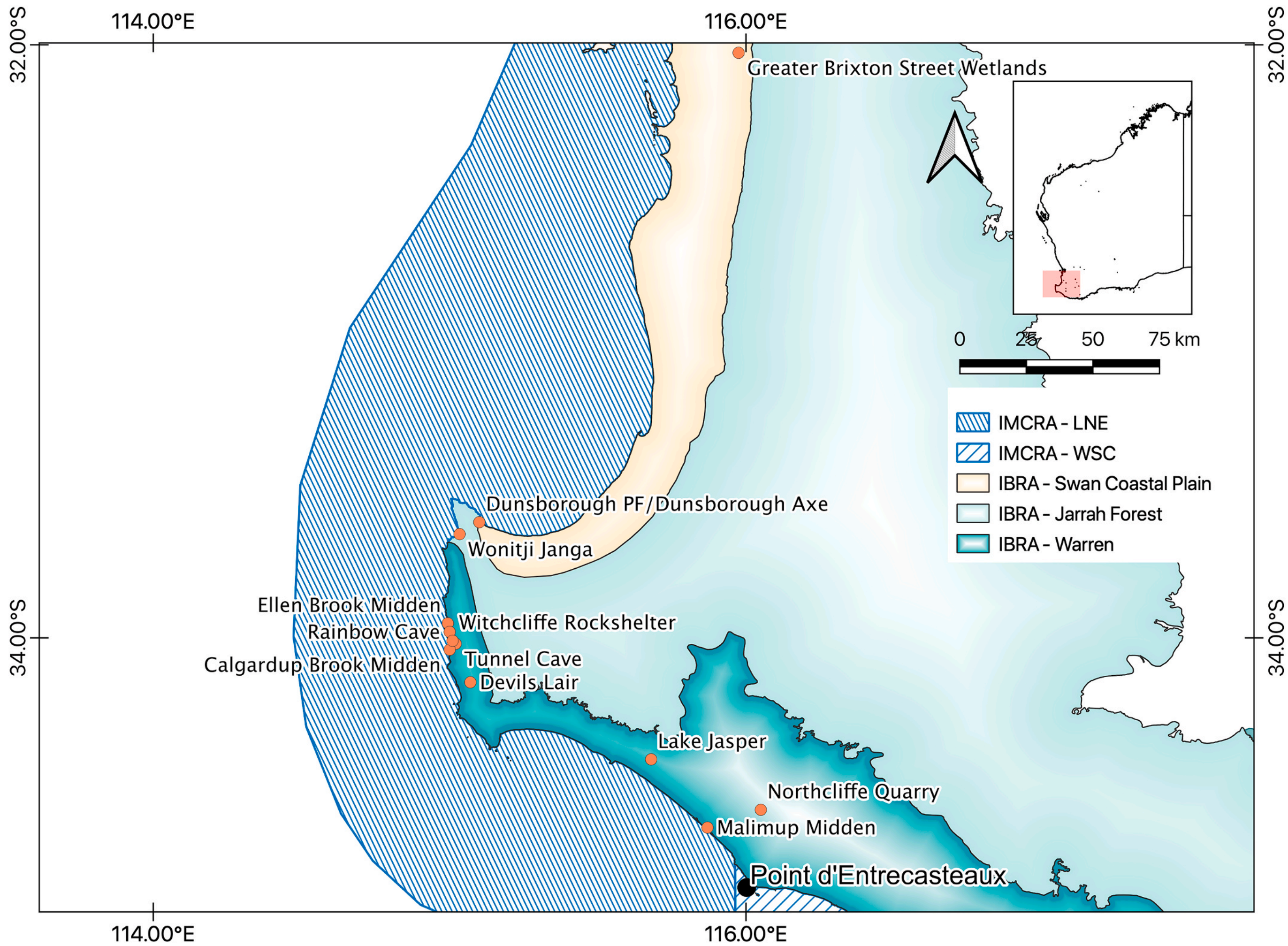

Fig. 3. Map of the Southern Indian Ocean study area, showing archaeological sites discussed in text. Spatial data: Commonwealth of Australia, 2006; Department of the Environment, 2012.

Barbetti, 1981; Schwede, 1990; Ward et al., 2016; Dortch and Dortch, 2019), and some stratified sites demonstrate repeated occupation of these sandplains throughout the Holocene, such as at Walyunga (Pearce, 1978). However, despite the presence of datable sub-surface assemblages, poor organic preservation means there is little to no subsistence evidence associated with these sites. Surface lithic artefact scatters, which form the majority of the region's archaeology, also lack this organic evidence and are not able to be securely dated. As a result, past patterns of occupation and landscape use have been inferred from the composition of these assemblages and their distribution of artefact scatters across the coastal plain (Hallam, 1987; Dortch and Dortch, 2019).

Yellabidde Cave, near Leeman, contains stone artefacts and faunal remains associated with a brief phase of human activity date to ca 25,000 cal BP (Monks et al., 2016). At the peak of the LGM, the Central Indian Ocean coastline was approximately 50–100 km west of its present location (Monks, 2018), so it is likely that people focused the bulk of their attention in areas now submerged following postglacial sea level rise. In the Greater Swan Region, centred over Perth, sites tend to be clustered around highly productive environments, such as the extensive chains of wetlands associated with the Bassendean Dunes (Hallam, 1987; Dortch and Dortch, 2019; Monks, 2019). Munday Swamp and the Greater Brixton Street Wetlands, along with their tributaries and nearby seasonal wetlands and drainage, are associated with surface artefact scatters (Dortch and Dortch, 2019; Monks, 2019). The density and diversity of artefacts, and the occasional presence of associated sub-surface deposits, indicates that many of the larger scatters reflect repeated visitation over several millennia. Wetland productivity is seasonally variable, but in the more productive warmer months these freshwater sources could have supported large groups of people who gathered to exploit the abundant plant and animal resources, and it is likely that the wetlands acted as foci for seasonal congregations (Hallam, 1987; Dortch, 2002a; Monks, 2019). Grinding tools associated with the wetlands have been implicated in the processing of wetland plants for fibre and food (Monks, 2019), but they are not dated, and no other direct archaeological subsistence evidence has been identified at these sites.

Rising sea levels brought the coast eastward during the first half of the Holocene, forming peninsulas and islands from areas of high relief within the coastal plain. Between Geraldton and Perth, midden scatters predominantly date to a relatively short period of time between ca 6600-5000 cal BP, with only two (Middle Head and Sandy Point) dating to the later Holocene (Table A3). Rockshelters also demonstrate more frequent visitation during the Mid-to Late Holocene, with Yellabidde Cave showing an increased rate of artefact discard in the Late Holocene (Monks, 2018), and other sites such as Caladenia Cave and Orchestra Shell Cave visited for the first time in the Mid-to Late Holocene (Hallam, 1974; Thorn and Baynes, 2013; Thorn et al., 2017).

4.1.2. Geraldton Sandplains bioregion

The dated subsistence record from the Geraldton Sandplains includes both littoral and terrestrial resources, with well-preserved subsistence evidence from three coastal middens and two limestone caves spanning

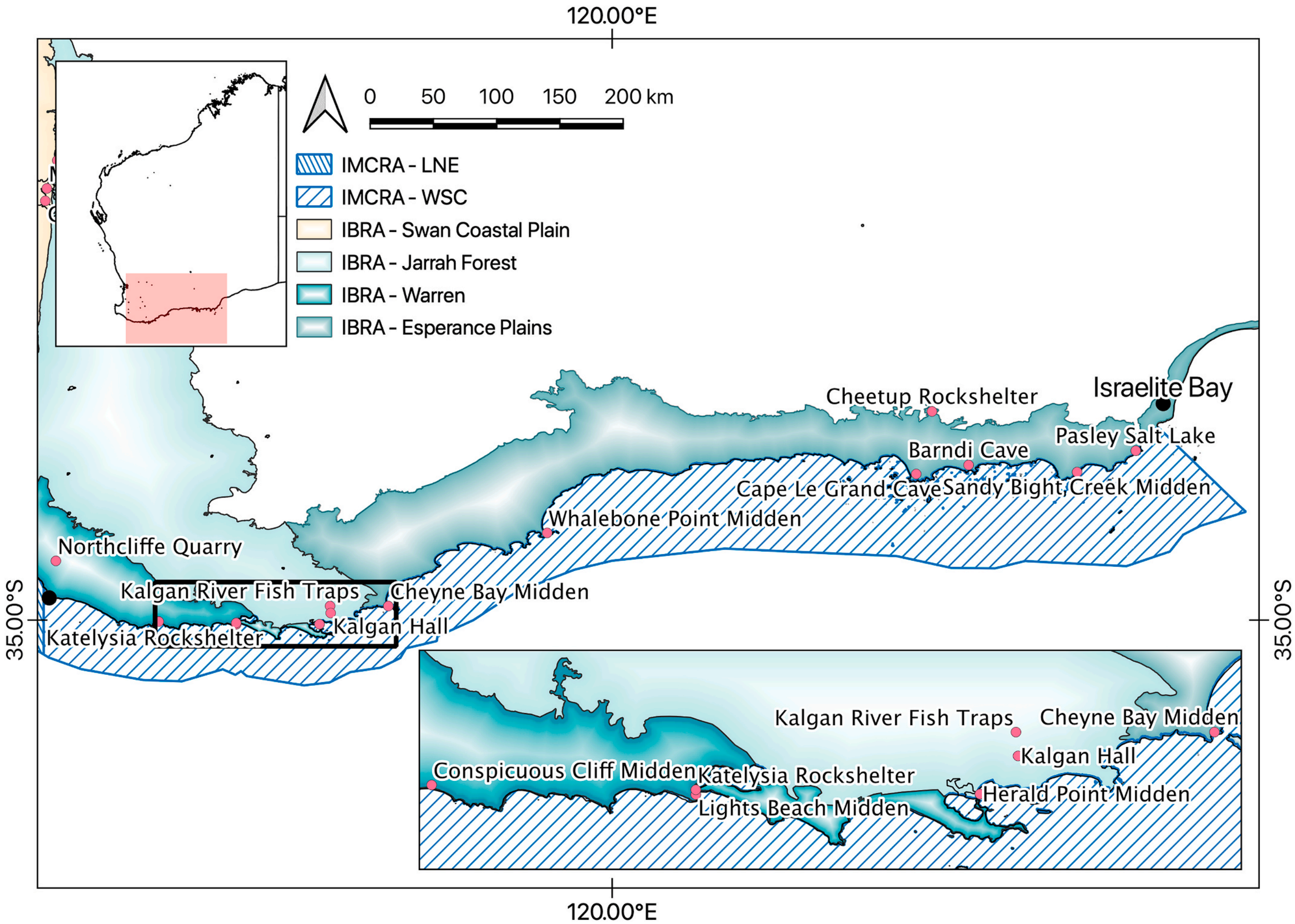

Fig. 4. Map of the Southern Ocean study area, showing archaeological sites and locations discussed in text. Spatial data: Commonwealth of Australia, 2006; Department of the Environment, 2012.

the Holocene providing insight into the exploitation of coastal plain resources away from the littoral and marine zones. Analysis of these assemblages suggests that people occupying the Geraldton Sandplains altered their behaviours and subsistence strategies in response to environmental and cultural change. These rich, "dual-patterned" archaeological and palaeontological assemblages (Dortch and Wright, 2010) result from both human and non-human predation, and include a diverse range of animals ranging from micro-mammals to large macropods. The comingled nature of these assemblages, combined with the likelihood of considerable dietary overlap between humans and non-human predators, makes analysis of human subsistence choices difficult, but still provides insight into the diverse faunal resources available to people living in the sandplains during this time.

The Early Holocene occupation of Yellabidde and Weelawadji Caves is associated with a focus on terrestrial faunal resources, including emu eggs, bandicoots (*Isoodon fuscivent er* and *Perameles bougainville*), brushtail possums (*Trichosurus vulpecula*), bettongs (*Bettongia lesueur* and *Bettongia penicillata*), hare-wallabies (*Lagorchestes hirsutus* and *Lagostrophus fasciatus*) and two large macropods (*Macropus fuliginosus* and *Petrogale lateralis*) (Tables A2 and A.3). Rodents and small marsupial carnivores are also abundant in these assemblages, but while they were probably occasionally consumed by people it is likely that their presence in the cave assemblages is largely due to non-human predation, particularly by owls (Monks, 2018). Two pharyngeal teeth of an unidentified fish species dated to this period were recovered at Yellabidde Cave (Monks, 2018), providing the earliest evidence for marine resource use in this region. The absence of dated midden sites prior to the Mid-Holocene followed by their appearance along the Central Indian Ocean coast after ca 5500 cal BP probably reflects the strongly littoral focus of activities associated with the middens, with earlier sites located in proximity to the transgressing coastline.

As sea levels rose and the coast moved closer to the caves, marine and littoral resources become more abundant and diverse in the archaeological record. At around 7000 BP, a brief highstand of +1–2m above present sea level may have been instrumental in the formation of a productive shallow marine embayment at what is now Leeman Lagoon (Arakel, 1980; Collins et al., 2006; Twiggs and Collins, 2010; Lewis et al., 2013), and the presence of non-dietary marine shell and fragmentary remains of several unidentified fish (including small sharks or rays) at Yellabidde Cave documents people's incorporation of small quantities of marine foods and resources as the coast encroached (Monks, 2018). Although there is no evidence for the consumption of marine shellfish at Yellabidde Cave during this period, midden scatters associated with low cliffs and dunes at Zuytdorp Clifftop, Oakajee, and Green Head date to ca 5500-4500 cal BP (Tables A2 and A3; Dortch et al., 1984; Morse, 1988; Monks et al., 2015). Gastropods including whelks (*Dicathis orbita*), turbans (*Turbo intercostalis*), limpets (*Patella* sp.), chiton, and abalone (*Haliotis* sp.) dominate these assemblages, indicating that people were targeting shellfish via accessible intertidal platforms and rocky shorelines (Dortch et al., 1984; Monks et al., 2015).

Despite the appearance of marine and littoral fauna in both midden and cave sites, people's selection of terrestrial fauna demonstrates little substantive variation from the earlier Holocene. Emu eggshell (indicative of autumn/winter site use) is less abundant during this period, which may reflect a change in the season of site use during this time (Monks, 2018). However, bandicoots, bettongs, hare-wallabies, and kangaroos continued to form much of the diet of people at Yellabidde Cave, as well as several previously unrepresented species associated with more humid, dense vegetation; potoroo (*Potorous* sp. cf. *Potorous platyops*), ringtail possum (*Pseudocheirus occidentalis*), tammar wallaby (*Macropus eugenii*) and western brush wallaby (*Macropus irma*) (Table A2). Together with the middens, these faunal records suggest that closer proximity to the coast resulted in dietary expansion, but no indication of a shift away from the terrestrial resources that formed the basis of the coastal plain economy.

Terrestrial mammals continued to form the basis of the regional subsistence record in the latter half of the Holocene, with minor supplementation by other animal foods including emu eggs, and marine and estuarine fish and shellfish (Table A2). After the relatively dry and warm conditions of the Early to Mid-Holocene, effective rainfall increased in the Swan Coastal Plain and Geraldton Sandplains during the Mid-to-Late Holocene (Lipar et al., 2017), resulting in the regional decline or disappearance of many 'dry-country' adapted fauna (Baynes, 1979; Thorn and Baynes, 2013). This environmental change is reflected in the archaeofaunal record, and by the Late Holocene many previously abundant dry-country mammals such as *Perameles*, *Potorous*, and *Lagorchestes* were no longer present in the Yellabidde Cave record (Monks, 2018). After ca 1 ka, greater rates of artefact discard and more intensive reduction of lithic material indicate that human activity at Yellabidde Cave increased in intensity, associated with more intensive exploitation of two mammals, quendas or southern brown bandicoots (*Isoodon fusciventer*) and western grey kanagroos (*Macropus fuliginosus*). These two species are the highest-ranking mammalian prey in the coastal plain, so their increased abundance in archaeological and non-archaeological faunal assemblages during this period may reflect the implementation of cultural practices targeting these high-ranking prey animals (Monks, 2018).

4.1.3. Swan Coastal Plain bioregion

In a recent review, Dortch and Dortch (2019) noted that with the possible exception of a single fragment of emu eggshell associated with Pleistocene occupation of Rottnest Island, there is no specific archaeological evidence for subsistence activities in the Greater Swan Region, either direct (organic remains) or indirect (such as fishing structures or hunting sites). This is generally true for most of the broader Swan Coastal Plain, with the exception of the northern third, where archaeofaunal assemblages from middens and caves demonstrate exploitation of both coastal and inland resources (Table A2).

At around 10,500 cal BP, a brief period of human activity at Hastings Cave was associated with the presence of small mammals likely preyed upon by owls and other non-human predators, and medium and large animals that may represent human prey (Tables A2 and A3). The Early Holocene Hastings Cave assemblage shows considerable overlap with economically important species identified at Yellabidde Cave (located only 50 km north of Hastings Cave): bandicoots, bettongs, brushtail possums, hare-wallabies, grey kangaroos and rock wallabies (Baynes, 1979). Infrequent human activity continued at Hastings Cave through the Mid-Holocene, and further south, Caladenia Cave also demonstrates sporadic human occupation from the Mid-Holocene (Roe, 1971; Thorn and Baynes, 2013; Thorn et al., 2017). During the Mid-Holocene, macropod diversity increased at both sites, together with greater presence thicket and wetland associated fauna (Tables A2 and A3) including quokkas (*Setonix brachyurus*), tammar wallabies (*Macropus eugenii*), ringtail possums (*Pseudocheirus occidentalis*), and potoroos (*Potorous* sp. cf. *P. platyops*). Freshwater turtle and mussel are also recorded in the Caladenia Cave assemblage (Thorn et al., 2017), further illustrating the diversity of wetland and freshwater resources in proximity to the site. At Orchestra Shell Cave, the southern-most site containing direct zooarchaeological evidence in the Swan Coastal Plain, Mid-to-Late Holocene archaeological deposits are associated with several medium and large mammals, such as quendas, brushtail possums, bettongs, quokkas, kangaroos, and wallabies (Tables A2 and A3; Archer, 1974; Hallam, 1974).

With the exception of a fragment of baler (*Melo* sp.) shell from the Early Holocene at Hastings Cave, no marine fauna is recorded at any of the Swan Coastal Plain caves. However, middens dating to the Mid-Holocene reveal ephemeral camps along the northern coastline associated with the exploitation of rocky shore gastropods including whelks, turbans, limpets, chiton, and abalone (Tables A2 and A3). Midden composition and location is almost indistinguishable from those in the Geraldton Sandplains, with sites located in areas of high relief overlooking rocky platforms, or buried in low, moderately consolidated sand dunes.

4.1.4. Summary

The Central Indian Ocean Coast contains some of the earliest subsistence evidence in southwestern Australia, with middens, rockshelters, and open artefact scatters documenting a strongly terrestrial Holocene subsistence strategy supplemented by small-scale but consistent exploitation of marine and littoral resources as they became accessible in the Mid-to-Late Holocene. Terrestrial mammals from a range of open and closed habitats comprise the majority of the region's archaeofaunal record, but from the early-Mid-Holocene, littoral and estuarine resources were regularly incorporated into people's diets. Middens along the northern half of the coastline contain predominantly rocky shore gastropods, probably reflective of briefly occupied 'dinner time' camps where shellfish were collected, processed, and consumed in a single period of site activity. Very small quantities of fish and shellfish identified in rockshelters up to 10 km inland from the current coast demonstrate the incorporation of littoral and estuarine resources into subsistence activities even when focused away from the shoreline.

4.2. Southern Indian Ocean Coast

4.2.1. Antiquity of occupation and Holocene land use

At Devils Lair, on the LNR, a hearth dated to ca 45,500 cal BP delivers the earliest evidence of human occupation in southwestern Australia, although a small number of artefacts below this layer hint at occupation pre-dating this period (Dortch, 1979, 2004; Turney et al., 2001; Balme, 2014). Occupation at Devils Lair continued into the Early Holocene (Table A3), when deposition stopped due to the collapse of the original cave entrance, until the very Late Holocene when a new entrance formed and there was a brief resurgence in activity (Balme et al., 1978; Dortch, 2004). The archaeological deposit at nearby Tunnel Cave spans the terminal Pleistocene and Early Holocene, while shallow deposits at Witchcliffe Rockshelter and Rainbow Cave provide further insight into people's activities within the LNR in the Late Holocene (Dortch, 1996, 2004).

The Warren bioregion, and in particular the LNR, has been the subject of extensive archaeological research over the past fifty years, due in part to the antiquity of occupation established by sites such as Devils Lair. As a result, excavation programs have included several open-air sites such as middens, quarries, artefact scatters, and submerged wetlands (Table A3). The Dunsborough Axe and Playing Field sites, at the interface of the Jarrah Forest and Swan Coastal Plain near Cape Naturaliste, are a cluster of small buried archaeological horizons located within the same geomorphological context, which date occupation from the Late Pleistocene to the Late Holocene (Guilfoyle et al., 2011). Nearby, at the northern end of the karstic Leeuwin Ridge, is Wonitji Janga (Fig. 3), a small limestone rockshelter which contains faunal and artefactual remains reflecting continuing occupation from the Late Holocene to some time after European colonisation (Table A3; Dortch et al., 2014). Northcliffe Quarry contains stratified archaeological deposits spanning the Mid-to-Late Holocene, and at Lake Jasper, a submerged site complex that pre-dates the lake's formation ca 4000 cal BP shows the distribution of artefact scatters relative to wetland features (Dortch and

Gardner, 1976; Dortch, 2002b; Dortch et al., 2019).

Several middens have been identified along both the Southern Indian Ocean coastline (Dortch et al., 1984), but only two have been securely dated. The Calgardup Brook and Ellen Brook middens, both located along the LNR, have been dated to ca 4300 cal BP, with a possible second phase of activity at Ellen Brook in the very recent past (Table A3).

4.2.2. Western Warren bioregion

Faunal and wood charcoal records from the caves of the LNR indicate that the region underwent marked vegetation change in the terminal Pleistocene/Early Holocene, with increasing rainfall causing the previously open jarrah forest and woodland to give way to denser tall karri forest, associated with an increase in mammal species suited to thickets and dense forest understorey (Dortch, 2004; Dortch and Wright, 2010; Faith et al., 2017). At Devils Lair and Tunnel Cave, terrestrial faunal remains linked to Early to Mid-Holocene human subsistence include quendas, possums, bettongs and potoroos, and macropods, as well as emu eggs (Table A2).

Small quantities of fish bone and unspecified "aquatic mollusc" were also recorded in the Early to Mid-Holocene units of Tunnel Cave and Devils Lair (Baynes et al., 1976; Dortch, 2004), but it is only after sea levels stabilised in the Mid-Holocene that marine resources appear in the archaeological record in any real abundance. Along the Indian Ocean coast, the Ellen Brook and Calgardup Brook middens contain whelks, nerites, turbans, limpets, and abalone, documenting similar activity along the region's rocky shores as is shown elsewhere along the southern Indian Ocean coastline. At Rainbow Cave, Witchcliffe Rockshelter, and Wonitji Janga, fish bone is recorded alongside terrestrial vertebrate remains, with bandicoots, possums, bettongs and potoroos, and macropods, emu eggshell, freshwater mussel, and unspecified aquatic mollusc and crustacea indicating that the Late Holocene occupation of these sites was associated with a broad subsistence base incorporating a range of marine, littoral, and terrestrial resources (Lilley, 1993; Dortch, 2004; Dortch and Wright, 2010; Dortch et al., 2014).

4.2.3. Summary

No sites containing dated subsistence evidence have been identified in the northern Jarrah Forest bioregion or the southern third of the Swan Coastal Plain, probably due to the lack of suitable preservation conditions as discussed in the previous section regarding the Swan Coastal Plain. In contrast, the western Warren bioregion—with its deep limestone caves and shallow dune blowouts—contains the most abundant and diverse archaeofaunal records from any of the coastal southwestern regions, with numerous midden scatters and stratified cave deposits documenting economic and environmental changes throughout the Holocene. In the Early Holocene, terrestrial resources were the primary focus of people occupying the Leeuwin-Naturaliste region, including mammals suited to the increasingly closed, moist forests. As the coastline transgressed, people rapidly incorporated estuarine and littoral resources into their diets, and estuarine fishing became a focus of activity along the Southern Ocean coast.

4.3. Southern Ocean Coast

4.3.1. Antiquity of occupation and Holocene land use

Holocene activity along the Southern Ocean coast is poorly represented in the archaeological record, with just a few dated sites providing evidence of occupation. Excavations at Kalgan Hall have produced archaeological assemblages spanning the LGM to Late Holocene with two apparent peaks in artefact discard, first around the LGM, followed by others ca 3700 BP to present (Ferguson, 1985; Dortch and Smith, 2001; Balme, 2014). Several small midden sites are recorded along this section of the Southern Ocean coast, but only the Herald Point and Conspicuous Cliff middens have been securely dated, and both to the very Late Holocene (Dortch et al., 1984). Radiocarbon age determinations made from shell at several other sites are unable to be calibrated and are effectively 'modern' (Table A3).

Although dated archaeological evidence is sparse, artefact scatters, rock art, and sites associated with granite domes and freshwater lakes indicate that people exploited diverse landscapes and resources along the Southern Ocean Coast (Dortch and Morse, 1984; Smith, 1993, 2011). Cheetup Rockshelter provides the region's earliest dated subsistence evidence, with a pit containing charred remains of zamia palm (*Macrozamia riedlei*) kernels argued to demonstrate Late Pleistocene evidence of treatment and storage of the toxic fruits (Smith, 1982, 1996). Occupation of Cheetup Rockshelter continued into the Early Holocene, with a possible occupational or depositional hiatus in the excavated areas between ca 9100 and 2600 cal BP, before archaeological deposits again formed in the Late Holocene (Table A3; Smith, 1993). Nearby, two other caves provide further evidence of Late Holocene occupation of the Esperance region; Barndi Cave, which demonstrated a brief but intense period of occupation ca. 2000 cal BP and a less intense period of activity following European colonisation, and Cape le Grand Cave, occupied within the last c. 1000 years (Table A3; Smith, 1993). No dated Mid-Holocene occupation evidence has been identified in the Esperance Sandplains and while it is possible that this absence reflects a period of regional abandonment (see Ferguson, 1985), a more parsimonious explanation is that people altered residential mobility patterns in line with fluctuating populations, resource availability, and environmental conditions (Smith, 1993).

4.3.2. Eastern Warren bioregion

Along the Southern Ocean coast, subsistence evidence is limited to Late Holocene marine and littoral fauna. A series of shell scatters and associated flaked pebbles at Malimup probably date to the very Late Holocene; radiocarbon analysis of shell and charcoal samples from one of the middens returned 'modern' ages (Table A3; Dortch et al., 1984). Periwinkles (*Austrocochlea rudis*) and nerites (*Nerita atramentosa*) are the principal species identified in this midden, along with limpets and abalone, suggesting people were targeting nearby rocky intertidal platforms (Dortch et al., 1984; Dortch, 1985). Similar species profiles are recorded at the other Southern Ocean middens, including Conspicuous Cliff (dated to ca 150 cal BP) and Lights Beach, a midden located on Wilson Inlet which has also returned a 'modern' age.

Wilson Inlet, one of several large estuaries located along this section of Southern Ocean coastline, encompasses numerous archaeological features indicative of Holocene subsistence strategies. Katelysia Rockshelter is located at the estuary mouth near the Lights Beach midden, and contains an archaeological assemblage dated to the Late Holocene (Tables A2 and A3) that consists of fish bones, marine mollusc shell, charcoal, lithics, and ochre fragments (Dortch, 1999). The abundances of fish identified at Katelysia Rockshelter are not specified, but are described generally by Barkla (1997) and Dortch (1999, p. 27) as "marine/estuarine … school fishes" including snapper, tommy ruff (herring), whiting, bream, yellow-eye mullet, sea mullet, mulloway, and tarwhine. Unlike the other Late Holocene rockshelter sites that contain fish and shellfish remains, there is little to no evidence of terrestrial foods in the Katelysia Rockshelter assemblage, which suggests that the people occupying this site were almost exclusively focused on marine and estuarine resources (Dortch, 1999). Further, while marine gastropods are the most common shellfish species identified in both rockshelter and midden assemblages in the Warren bioregion, at Katelysia Rockshelter it is *Katelysia scalarina*, a cockle found in sand flats and estuaries, that is the most abundant mollusc species along with turbans and whelks (Dortch, 1999; Smith, 1999).

Located within the same inlet are several stone weir complexes similar to those found at Broke Inlet and Oyster Harbour, which appear to have functioned as tidal weirs or fish traps. Ethnographic accounts and archaeological investigations at Oyster Harbour suggest the fish traps were constructed using boulder-sized rocks, with smaller pebbles probably used to support superstructures made of brushwood or timber (Dix and Meagher, 1976; Dortch, 1997, 1999; Dortch et al., 2006). No absolute dates have been obtained for any of these fish traps, with attempts to recover datable material from one of the Oyster Harbour traps hampered by evidence of sediment mixing (Dortch et al., 2006, p. 41). However, the functional requirements of these tidal weirs support the assumption that they post-date Mid-Holocene sea level rise, and radiocarbon ages for associated submerged tree stumps suggests the estuaries formed in the early to Mid-Holocene, ca 7000-6500 BP (Dortch, 1997, 1999). Dortch (1997, 1999; 2002a) has speculated that by ca 4000 BP, changes in sedimentological and hydrologic processes may have so reduced tidal exchange that the fish weirs were no longer used, and instead Aboriginal approaches to estuarine fishing transformed to involve more intensive, congregative fishing strategies, with people better able to predict seasonal movements and target particular species.

4.3.3. Southern Jarrah Forest bioregion

At King George Sound, Albany, the ca 500 year old Herald Point midden scatter contains whelk, chiton, and turban shell (Dortch et al., 1984), and provides the only securely dated subsistence evidence from the southern coastal Jarrah Forest bioregion. Complexes of stone structures in the Kalgan River interpreted as fish traps add further evidence for exploitation of marine and estuarine habitats. The Kalgan River fish traps, while smaller than those identified in nearby Oyster Harbour, are similar in style, with the stone structures fully submerged during high tide and exposed at low tide (Dix and Meagher, 1976).

4.3.4. Esperance Plains bioregion

Cheetup Rockshelter contains the earliest subsistence evidence in the Esperance Sandplains. Late Pleistocene plant remains include kernels of zamia palm fruit (see above) and seaweed associated with infant human remains, while grass tree (*Xanthorrhoea* sp.) resin (used for hafting) and leaf bases and other small quantities of wood and plant material were noted throughout the deposit (Smith, 1982, 1993, 1996, 1999; Freedman and Lofgren, 1983). Small quantities of faunal remains, including rodents and small dasyurids, quendas, grey kangaroos, and unspecified birds, lizards, and fish (Table A2), were attributed to the combined efforts of humans, kestrels, and owls (Smith, 1993). The coast encroached rapidly between ca 13,000 and 10,000 cal BP, from a distance of ca. 80 km south of its present position to just 11 km, which would have resulted in rapid transformation of coastal plain environments and a contraction in the territory (Smith, 1993, 2011). However, despite the greater distance from the coast, the presence of seaweed and fish bone during the earliest period of occupation at Cheetup Rockshelter indicates that the littoral was already an intrinsic component of people's cultural lives and adjustment to the changing coastal landscape may not have been particularly difficult.

Rodents, small dasyurids, quendas, and grey kangaroos constitute most of the mammal assemblage at Cheetup and Barndi Rockshelters in the later Holocene (Table A2; Smith, 1993), although several additional species are recorded including the honey possum (*Tarsipes rostratus*) and brush-tailed bettong or woylie (*Bettongia penicillata*). While rodents and other small mammals may have been occasional human prey, it is more probable that only the larger animals (quenda, woylie, and grey kangaroo) formed any substantial human dietary contribution. The only further variation in the mammal record at these sites is the incorporation of two specimens of invasive fauna (house mouse and rabbit) that post-date European colonisation. Unspecified fish and crustacea, as well as lizards and birds, are also recorded in these units at both rockshelters (Smith, 1993). Although faunal evidence is limited to the small samples identified from these two sites, there is little indication of any substantive variation in subsistence strategies or resource availability between the Early and Late Holocene. Smith (1993, p. 162) argues that this continuity may reflect the general ecological stability of the granite hills and domes.

With the exception of the unspecified fish and crustacean remains, marine resources are not well represented in the archaeological record of the Esperance Sandplains. The few shell middens identified along the coast all date to the very Late Holocene, possibly around the time of European colonisation, and are composed of rocky shore gastropods including nerites, whelks, turbans, limpets, and abalone (Table A2).

4.3.5. Summary

Subsistence evidence from the Southern Ocean Coast is sparse and covers brief periods of human activity in the Early and Late Holocene but appears to indicate a relatively consistent economic approach incorporating terrestrial, littoral, and estuarine resources. In the western half of the region estuarine fishes and sandy shore shellfish dominate the recorded subsistence evidence, both directly (at the middens and Katelysia Rockshelter) and indirectly (fish traps). To the east, there are few open estuaries and the coastal landscape is instead dominated by wide, sandy bays and associated seagrass meadows, rocky headlands, and granitic islands. Fish are less abundant in the coastal archaeological record, which is instead composed of terrestrial fauna and rocky platform shellfish. Most of these sites were only occupied at low intensity and for short periods of time, possibly by small family groups sheltering from inclement weather (Smith, 1993).

5. Discussion

In the 50,000 or so years that people have lived in southwestern Australia, coastal environments and landscapes have undergone considerable transformation. Sea level fall and rise has seen the expansion and contraction of the coastal plains, as well as altered distribution of wetlands and rivers and associated plant and animal resources (Baynes, 1979; Lewis et al., 2013; Faith et al., 2017; Lipar et al., 2017; Thorn et al., 2017; Monks, 2018). Previously fresh water sources have become brackish or saline, estuaries have developed and been inundated, and intertidal zones have been altered by changing sedimentation patterns and the erosion of limestone headlands and cliffs (Kench, 1999; Collins et al., 2006; Lewis et al., 2013; Monks et al., 2015; Ward et al., 2015, 2016). Throughout this, people have employed flexible foraging strategies in response to changing resource availability throughout the coastal zone.

The early presence of people in southwestern Australia is not necessarily an indicator of continuous or regular occupation of the region. Based on an analysis of temporal trends in artefact types and densities at several stratified open sites, Ferguson (1985) suggested that the southwestern forests were virtually depopulated during the Mid-Holocene, an hypothesis that has since been heavily criticised on re-analysis of site distribution and occupation sequences (Smith, 1993) and on taphonomic and dating grounds (Dortch and McArthur, 1985; Dortch and Smith, 2001; Dortch, 2004). More recently, Balme (2014) has examined the distribution of radiocarbon dates and artefact discard rates from the Leeuwin-Naturaliste region of the Southern Indian Ocean coast, arguing that the regional archaeological evidence indicates initial, low-density occupation increasing towards the end of the Pleistocene, followed by a period of stability in the early to Mid-Holocene and then a dramatic rise in the last few millennia. Although caution is needed when interpreting palaeodemographic trends from radiocarbon ages, it is clear that these interpretations do not support Ferguson's Mid-Holocene depopulation model. Instead, it is argued that coastal southwestern populations were relatively stable, with a general change in land use patterns and the intensity of activity at some sites in the Late Holocene (Smith, 1993; Dortch and Smith, 2001; Dortch, 2002a; Balme, 2014; Monks, 2018).

The synthesis of Holocene subsistence records presented here demonstrates not only a continuity of occupation and possibly a Late Holocene population increase, but also that people living in proximity to the changing coast engaged with new foods and environments as they became accessible. This adaptive foraging strategy included a general adoption of a small range of littoral and marine resources into an otherwise terrestrially-based diet as the coast came within a day's walk of many of the cave sites. From the Mid-Holocene onwards, there is a distinct difference between people's activities along the Indian and Southern Ocean coasts, which likely reflects regional differences in coastal processes and intertidal geomorphology (see Ward et al., 2015). Along the Indian Ocean coast, people exploited littoral shellfish earlier, but continued to focus primarily on terrestrial resources, supplementing them with aquatic resources including freshwater and marine shellfish, crustacea, and fish. In contrast, most of the Southern Ocean coast contains limited evidence of the consumption of terrestrial mammals, and instead documents a Mid-to-Late Holocene focus on estuarine fish and shellfish, with a very Late Holocene addition of littoral gastropods. The notable exception to this occurs in the southeastern end of the region, where estuarine and littoral shellfish are uncommon throughout the Holocene, and terrestrial fauna dominate the assemblages at the two recorded cave sites.

Seasonal differences in the acquisition and consumption of aquatic resources are recorded in the ethnographic literature. Marine, estuarine, and wetland resources were widely exploited in the warmer summer months (Nind, 1831; Moore, 1884; Meagher, 1974; Gibbs, 1987), while river fish traps were built in autumn and early winter and used to trap or slow freshwater fish such as mullet or bream (Nind, 1831; Moore, 1884; Dix and Meagher, 1976; Gibbs, 1987, 2011). This seasonality has been tentatively identified in some archaeological records such as at Yellabidde Cave (Monks, 2018) and Katelysia Rockshelter (Barkla, 1997; Dortch, 1999), which could reflect seasonal variation in people's activities based on the availability of marine and estuarine resources.

Across both the Indian and Southern Ocean coasts, one consistent trend is the apparent absence of fish remains in any middens, and the presence of only select species of marine shellfish and very small quantities of fish in stratified cave deposits. Several possible explanations should be considered here. Firstly, this difference may indicate that while people probably consumed shellfish close to where they were collected, fish may have been carried further inland. Secondly, this could be at least partly a consequence of taphonomy, whereby small, delicate fish bones are not preserved in open sites composed of robust shell and coarse drifting sand. Finally, the differences in the distribution of fish and shellfish between sites may simply be an effect of methodological and analytical choices by archaeologists, as the shallow, sparse nature of southwest midden scatters means most are surveyed rather than excavated, with shell collected from the surface by hand. Even excavated assemblages may be biased in their potential for the recovery of fragmentary fish bone; the use and mesh size of sieves were reported for only one of the 19 shell middens from which dated shell samples have been reported along the southwestern coast, and even this did not use a sieve mesh below 3 mm diameter. While the utility of sub-3mm sieve mesh in the recovery of fish remains has been debated (Vale and Gargett, 2002; Gargett and Vale, 2005; Zohar and Belmaker, 2005; LeFebvre and Sharpe, 2018), if screens were not used this certainly has the potential to bias interpretations of subsistence activities at the middens. A considerable contrast to this is observed in the region's stratified cave assemblages, with fish remains recovered from five of the 12 sites where excavated sediments were screened through sieves with smallest mesh apertures of 3-1.5 mm. Equally significant is the lack of taxonomic identifications made on fish bone, as the main focus of most southwestern zooarchaeological research has been mammals. This disparity may provide at least partial support for the hypothesis that methodological and taphonomic factors have reduced the archaeological visibility of marine and estuarine foods in the southwestern record, and merits further investigation.

Models of Holocene Aboriginal occupation of the lower southwest coastal districts suggest that population characteristics and residential patterns varied seasonally and over longer timeframes, with relatively fluid group size and mobility providing opportunities for people to adapt their activities to suit a range of environmental and cultural contexts (Smith, 1993, 2011; Dortch and Smith, 2001; Dortch, 2002a). Indirect archaeological evidence of food procurement—such as fish traps, lizard traps, yam gardens, and translocated plant communities—can reflect efforts to increase encounter rates and hunting success, and has been identified as a feature of pre-colonial and contemporary Aboriginal activity in many areas of the coastal southwest (Hallam, 1975; Dortch et al., 2014; Lullfitz et al., 2017; Monks, 2018). The ability to schedule and maintain staple food sources while also rapidly incorporating less abundant or reliable foods demonstrates a flexible and adaptive coastal economy that allowed Aboriginal people to maintain and possibly expand southwestern populations during periods of environmental instability. The subsistence evidence reviewed here supports this model and suggests that people rapidly and opportunistically expanded their subsistence base to incorporate low levels of littoral and marine foods as the coast encroached.

Analyses of coastal southwestern Australian subsistence strategies often downplay the role of marine resources in favour of engagement with terrestrial foods. Two factors likely combine to facilitate this bias: non-terrestrial food procurement is under-represented in the ethnographic literature, and marine resources comprise only a very minor part of the faunal evidence recorded in the sparsely distributed caves that form the region's most intensively investigated subsistence sites. When viewing the available subsistence evidence from a range of bioregions across the Mediterranean-type coasts of Western Australia, it becomes clear that there is considerable evidence documenting consistent, albeit small-scale, incorporations of marine, littoral, and estuarine elements into the southwestern coastal economy. While there is clear geographic variability, particularly regarding the differences in timing and focus of marine resource exploitation between the Indian Ocean and Southern Ocean coasts, it is also clear that it is in fact more common than not for Holocene subsistence sites to contain a marine element. Of the 31 sites included in this analysis, 93.5% ($n = 29$) contain at least fragmentary evidence of shellfish or fish. Evidence of littoral and estuarine resource exploitation outweighs terrestrial evidence only at Katelysia Rockshelter and the middens, but the ubiquity of marine foods across the region is striking and highlights the broad spectrum nature of Holocene coastal diets.

Under Beaton's criteria outlined in the introduction, 'coastal economies' most closely resemble the maritime seascapes of northern and eastern Australia, leaving the less marine-focussed economies to be described as terrestrial, or at best, 'blended'. What this characterisation of cultural and subsistence approaches fails to consider, however, is that by their very nature coastal economies are located at the interface of marine and terrestrial environments, a liminal zone that is often associated with productive and highly dynamic landscapes. For people occupying this coastal zone, terrestrial resources may be the primary caloric source for most of the year, but not for the whole population, for the whole year. This seasonal element is not easily captured in archaeological records, but ethnographic evidence from southwestern Australia describes culturally significant congregative practices that sometimes centred on the exploitation of estuarine and littoral resources en masse (Smith, 1999; Dortch and Smith, 2001; Dortch, 2002a). Estuarine fishing practices, at least by the later Holocene, were likely labour-intensive, involving the coordinated efforts of hundreds of people for several weeks at a time in order to take advantage of abundant schooling fish (Hammond, 1933; Gibbs, 1987, 2011; Dortch, 1999, Dortch, 2002a). Congregative events such as these also facilitated ceremonial and social activities, drawing disparate groups together in large numbers at reliably anticipated intervals (Gibbs, 1987; Dortch, 1999, Dortch, 2002a). In this way, the marine element *is* culturally transformative, despite its apparently minimal overall dietary contribution. Perhaps those social groups with extensive archaeological markers of marine subsistence, such as are found in Queensland and the Torres Strait (McNiven, 2003; Barker, 2004; Crouch et al., 2007; Ulm, 2011), are better distinguished as *marine specialist economies*, while dietary adaptability and flexibility is the hallmark of more generalist coastal economies that contain a culturally significant marine element at any scale.

6. Conclusion

The results of this review show that Aboriginal people occupying coastal southwestern Australia throughout the Holocene employed a flexible, broad-spectrum subsistence strategy that allowed them to rapidly integrate marine and estuarine resources as they became accessible. At the time of European colonisation, aquatic resources such as estuarine and freshwater fish were widely recognised as an intrinsic component of the coastal economy. Yet for most archaeologists, the narrative has often skirted this issue and focused on discussions of the more visible terrestrial foods, specifically mammals. Here, I highlight the combined value of these resources, and suggest that while fish and shellfish records are not as abundant in the southwestern archaeological record as they are in other coastal regions around Australia, they are still common elements of what is ultimately a sparse regional subsistence record. This study has also demonstrated that methodological considerations, such as the inconsistent use of sieves, variation in mesh gauges, and lack of interest or experience in taxonomic identification of archaeological fish specimens, may have obscured some evidence of marine resource use. With the advent and increasing accessibility of high-resolution technologies such as ancient DNA and micromorphological analysis, it may be possible to glean further insights, even from sites where macroscopic remains are poorly preserved. Future research will aim to further explore the potential for the recovery of fish remains from midden and rockshelter sites, and to identify and quantify marine fauna to understand the relative importance of these foods and the possibility of seasonal variations in people's approaches to coastal subsistence. Such work will allow for better definition of the region's Holocene coastal economy and more detailed analysis of marine and estuarine records from the Indian Ocean and Southern Ocean coasts.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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APPENDIX 1

Table A.1
Summary subsistence evidence from Holocene coastal Southwestern Australian sites.

Site	NISP (MNI)	NTaxa (Invert)	NTaxa (Vert)	NTaxa (Total)	Site Type	Method	Sieve mesh gauge	References
Geraldton Sandplains								
Zuytdorp Clifftop	NA	4	0	4	Midden	Excavation	Not described	Morse (1988)
Oakajee Midden	NA	1	0	1	Midden	Excavation	5 mm, 3 mm	Monks et al. (2015)
Green Head	NA	6	0	6	Midden	Hand collection	NA	Dortch et al. (1984)
Weelawadji Cave	1111	0	31	31	Rockshelter	Excavation	5 mm, 1.5 mm	Monks (2018)
Yellabidde Cave	10126	8	43	51	Rockshelter	Excavation	5 mm, 1.5 mm	Monks (2018)
Swan Coastal Plain								
North Head	NA	4	0	4	Midden	Hand collection	NA	Monks et al. (2015)
Sandy Point	NA	6	0	6	Midden	NA	NA	Dortch et al. (1984)
Sandy Point North	NA	3	0	3	Midden	NA	NA	Dortch et al. (1984)
Moore River	NA	3	0	3	Midden	NA	NA	Hallam, (1975); Dortch et al., (1984)
Sandland Island	NA	5	0	5	Midden	NA	NA	Dortch et al. (1984)
Middle Head	NA	8	0	8	Midden	Excavation	NA	Morse, (1982); Dortch et al., (1984)
Hastings Cave	(10122)	1	38	39	Rockshelter	Excavation	7 mm, 2.5 mm	Baynes (1979)
Caladenia Cave	11121	1	37	38	Rockshelter	Excavation	3/1 mm*	Thorn et al. (2017)
Orchestra Shell Cave	(65)	0	17	17	Rockshelter	Excavation	NA	Archer, (1974); Hallam, (1974)
Jarrah Forest								
Herald Point Midden	NA	2	0	2	Midden	Hand collection	NA	Dortch et al. (1984)
Warren								
Rainbow Cave	284	1	22	23	Rockshelter	Excavation	Not described	Lilley, (1993); Dortch, (2004)
Conspicuous Cliff	NA	5	0	5	Midden	NA	NA	Dortch et al. (1984)
Calgardup Brook	NA	4	0	4	Midden	NA	NA	Dortch et al. (1984)
Wonitji Janga	88	0	11	11	Rockshelter	Excavation	5 mm, 2 mm	Dortch et al. (2014)
Ellen Brook Midden	NA	5	0	5	Midden	Hand collection	NA	Lilley, (1993); Smith, (1999)
Witchcliffe Rockshelter	584	2	13	15	Rockshelter	Excavation	5 mm, 3 mm	Dortch, (1996), 2004
Devils Lair	(107)	0	18	18	Rockshelter	Excavation	NA	Baynes et al., (1976); Balme et al., (1978); Dortch, (2004)
Malimup Midden	NA	4	0	4	Midden	Excavation	NA	Dortch et al., (1984); Dortch, (1985); Smith, (1999)
Katelysia Rockshelter	NA	2	10	12	Rockshelter	Excavation	5 mm, 3 mm	Barkla, (1997); Dortch, (1999)
Lights Beach Midden	NA	5	0	5	Midden	Hand collection	NA	Dortch et al. (1984)
Esperance Sandplains								
Sandy Bight Creek	NA	1	0	1	Midden	NA	NA	Dortch et al. (1984)

(*continued on next page*)

Table A.1 (*continued*)

Site	NISP (MNI)	NTaxa (Invert)	NTaxa (Vert)	NTaxa (Total)	Site Type	Method	Sieve mesh gauge	References
Whalebone Point	NA	4	0	4	Midden	NA	NA	Dortch et al. (1984)
Cheyne Bay	NA	2	0	2	Midden	NA	NA	Dortch et al. (1984)
Cheetup Rockshelter (Layer 1)	276	1	14	15	Rockshelter	Excavation	4 mm, 2 mm	Smith (1993)
Barndi Rockshelter	NA	1	13	14	Rockshelter	Excavation	4 mm, 2 mm	Smith (1993)
Pasley Salt Lake	NA	1	0	1	Midden	NA	NA	Smith (1999)

Table A.2
Temporal distribution of identified subsistence evidence from Holocene occupation periods at coastal Southwestern Australian sites discussed in text. Sources: 1. Monks, (2018); 2. Monks et al., (2015); 3. Dortch et al., (1984); 4. Smith, (1993); 5. Morse, (1982); 6. Thorn et al., (2017); 7. Baynes, (1979); 8. Archer, (1974); 9. Lilley, (1993); 10. Dortch, (2004); 11. Baynes et al., (1976); 12. Dortch et al., (2014); 13. Dortch, (1999); 14. Smith, (1999); 15. Morse, (1988); 16. Barkla, (1997).

		GERALDTON SANDPLAINS				SWAN COASTAL PLAIN				JARRAH FOREST				WARREN				ESPERANCE PLAINS			
Taxon	**Common Name**	10-8k	8-5k	5-1k	1-0k	10-8k	8-5k	5-1k	1-0k	10-8k	8-5k	5-1k	1-0k	10-8k	8-5k	5-1k	1-0k	10-8k	8-5k	5-1k	1-0k
Mammals																					
Thylacinus cynocephalus	Thylacine		1					6													
Antechinus flavipes	Mardo/Yellow-footed antechinus	1	1	1	1	7	6, 7	6, 7	6, 7					10	10	9	9, 10				
Dasycercus sp. indet.	Mulgara	1	1	1	1	7	6, 7	6, 7	7												
Dasyurus geoffroii	Chuditch/ Western quoll	1	1	1	1	7	6, 7	6, 7, 8	7				12	10	10		10				
Parantechinus apiclis	Dibbler	1	1	1	1	7	6, 7	6, 7, 8	6, 7									4		4	4
Phascogale calura	Red-tailed phascogale	1	1	1	1	7	6, 7	6, 7	6, 7												
Phascogale tapoatafa	Brushtailed phascogale						6	6													
Sarcophilus harrisii	Devil		1					6													
Sminthopsis sp. indet.	Dunnart	1	1	1	1	7	6, 7	6, 7, 8	6, 7, 8							9	9, 10	4		4	4
Isoodon fusciventer	Quenda	1	1	1	1	7	6, 7	6, 7, 8	6, 7				12	10	10	10	9, 10	4		4	4
Perameles bougainville	Marl/Western barred bandicoot	1	1	1		7	6, 7	6, 7									9, 10				
Cercartetus concinnus	Western pygmy possum		1				6, 7	6									10				
Trichosurus vulpecula	Brushtail possum	1	1	1	1	7	6, 7	6, 7, 8	6, 8				12	10	10	10	9, 10				
Tarsipes rostratus	Noolbenger/ Honey possum																10			4	4
Bettongia lesueur	Boodie/ Burrowing bettong	1	1	1	1	7	6, 7	6, 7, 8	7, 8					10	10	10					
Bettongia penicillata	Woylie/Brush-tailed bettong	1	1	1	1	7	6, 7	6, 7, 8	7				12	10	10	9, 10	9, 10			4	
Potorous sp. cf. *Potorous platyops*	Broad-faced potoroo		1	1			6, 7	6, 7													
Potorous sp. cf. *Potorous gilbertii*	Gilbert's potoroo												12	10	10	10, 19	9, 10				
Lagorchestes hirsutus	Mala/Rufous hare-wallaby	1	1	1	1	7	6, 7	6, 7													
Lagostrophus fasciatus	Munning/ Banded hare-wallaby	1	1		1	7			7												
Macropus eugenii	Tammar wallaby		1		1		6, 7	6	7				12	10	10	10	10				
Macropus fuliginosus	Western grey kangaroo	1	1	1	1	7	6, 7	6, 7, 8	6, 7, 8				12	10	10	10	9, 10	4		4	4
Macropus irma			1	1					6					10	10	10	10				

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Table A.2 (*continued*)

		GERALDTON SANDPLAINS				SWAN COASTAL PLAIN				JARRAH FOREST				WARREN				ESPERANCE PLAINS			
	Western brush wallaby						6, 7	6, 7													
Setonix brachyurus	Quokka						6	6, 8					12	10	10	9, 10, 16	9, 10				
Petrogale lateralis	Black-footed rock wallaby	1	1	1	1	7	6, 7	6, 7, 8	7, 8					10	10	10	9, 10				
Onychogalea lunata	Crescent nail-tail wallaby							8													
Pseudocheirus occidentalis	Western ringtail possum		1				6, 7	6, 8	6				12	10	10	9, 10	9, 10				
Hydromys chrysogaster	Rakali								6												
Leporillus apicalis	Lesser stick-nest rat	1	1	1		7	7	7													
Leporillus conditor	Greater stick-nest rat		1	1			7	7													
Mus musculus	House mouse				1				6, 7												4
Notomys sp. indet.	Hopping mouse	1	1	1	1	7	6, 7	6, 7	6, 7												
Pseudomys albocinereus	Ash-grey mouse	1	1	1	1	7	6, 7	6, 7	6, 7					10	10	9	9, 10			4	4
Pseudomys fieldi	Shark Bay mouse	1	1	1	1	7	6, 7	6, 7	6, 7								9, 10				
Pseudomys nanus	Western chestnut mouse			1	1		6	6, 7	7												
Pseudomys occidentalis	Western mouse	1	1	1	1	7	6, 7	6, 7	6, 7									4		4	4
Pseudomys shortridgei	Heath mouse	1	1	1	1	7	6, 7	6, 7	6, 7					10	10	9	9, 10			4	4
Rattus fuscipes	Bush rat	1	1	1	1	7	6, 7	6, 7	6, 7					10	10	9, 16	9, 10	4		4	4
Rattus tunneyi	Pale field rat	1	1	1	1	7	6, 7	6, 7	6, 7, 8							9	9, 10				
Tadarida sp. indet.	Free-tailed bat		1				7														
Chaelinolobus gouldii	Gould's wattled bat		1				7														
Chaelinolobus morio	Chocolate wattled bat				1		6	6	6, 7												
Falsistrellus mackenzei								6	6												
Nyctophilus sp. cf. *Nyctophilus geoffroyi*	Lesser long-eared bat	1	1	1		7	6, 7	6, 7													
Nyctophilus gouldi							6	6													
Macroderma gigas	Ghost bat	1	1	1		7	6, 7	6, 7	6												
Canis familiaris	Dog/dingo				1				7												
Vulpes	Red fox				1																
		GERALDTON SANDPLAINS				**SWAN COASTAL PLAIN**				**JARRAH FOREST**				**WARREN**				**ESPERANCE PLAINS**			
Taxon	**Common Name**	10-8k	8-5k	5-1k	1-0k	10-8k	8-5k	5-1k	1-0k	10-8k	8-5k	5-1k	1-0k	10-8k	8-5k	5-1k	1-0k	10-8k	8-5k	5-1k	1-0k
Ovis/Capra	Sheep/Goat				1				7												
Oryctolagus cuniculus	Rabbit												12								4
Birds																					
Dromaius novaehollandiae	Emu	1	1	1	1								12	10	10		10				
Reptiles																					
Unspecified marine turtle	Marine turtle																				
Fish																					
Chrysophrys auratus	Snapper															16					
Acanthopagrus butcheri	Black bream															16					
Agryrosomus hololepidotus	Mulloway															16					
Mugil cephalus	Sea mullet															16					

(*continued on next page*)

Table A.2 (*continued*)

		GERALDTON SANDPLAINS				SWAN COASTAL PLAIN				JARRAH FOREST				WARREN				ESPERANCE PLAINS			
Aldrichetta forsteri	Yellow-eye mullet															16					
Arripis georgianus	Tommy Rough															16					
Sillaginodes punctata	King George whiting															16					
Rhabdosargus sarba	Tarwhine															16					
Unidentified fish		1	1	1	1								12		11	13	9, 10	4		4	4
Bivalves																					
Family Tellinidae	clam				1																
Family Cardiidae	cockle				1																
Katelysia scalarina	Sand cockle															13, 16					
Fragum erugatum			1																		
Brachidontes sp. cf. *Brachidontes erosus*	Beaked mussel			1	1																
Family Ostreidae	Oyster			15																	
Westralunio sp.	Freshwater mussel						6										10				
Unidentified bivalve			3	1	1				3							3					
Gastropods																					
Family Neritidae	Nerite snail															14	3				3, 14
Dicathis orbita	whelk		3	15	1		3, 5	3	3				3			3	3				3, 14
Family Tonnidae	tun shell				1																
Turbo intercostalis	Turban shell		2, 3	2			2, 3, 5	3, 5	3				3			3, 14	3				3, 14
Melo sp.	baler			1			7														
Patella sp.	limpet		2, 3	15			2, 3	3	3							3, 14, 16	3				3, 14
Chiton sp.	Chiton		2, 3	15			2, 3		3				3				3				
Haliotis sp.	Abalone		2, 3	15			2, 3		3							3, 14	3				3, 14
Other invertebrates																					
Unspecified 'aquatic mollusc'													12		10	10	10				3, 14
Unspecified 'crustacean'																	10			4	4

Table A.3
Radiocarbon age determinations for all sites with dated Holocene subsistence evidence within coastal Southwestern Australia, expanded from the AustArch1 (Williams et al., 2008) and AustArch3 (Williams and Smith, 2013) datasets. Calibrated with CALIB 7.1 (Stuiver et al., 2005), using SHCal13 (Hogg et al., 2013) for botanical and wood charcoal specimens, and Marine13 (Reimer et al., 2013) for marine shell.

Site	Site Type	Lab code	Material	14C age	14C err	ΔR	ΔR err	ΔR Ref.	Calibration Curve	95.4% (2σ) cal age BP	Median probability	Source
Geraldton Sandplains												
Green Head	Midden	SUA-1471	Shell (*Turbo intercostalis*)	5260	90	54	30	Squire et al. (2013)	Marine13	5314–5769	5565	Dortch et al. (1984)
Weelawadji Cave	Rockshelter	Wk-43719	Charcoal	6869	20	N/A	N/A	N/A	SHCal13	7594–7700	7657	Monks (2018)
Weelawadji Cave	Rockshelter	Wk-43718	Charcoal	7505	20	N/A	N/A	N/A	SHCal13	8198–8359	8282	Monks (2018)
Weelawadji Cave	Rockshelter	Wk-43720	Charcoal	8511	22	N/A	N/A	N/A	SHCal13	9449–9530	9493	Monks (2018)
Yellabidde Cave	Rockshelter	OZT010	Charcoal	995	25	N/A	N/A	N/A	SHCal13	799–922	856	Monks (2018)
Yellabidde Cave	Rockshelter	OZT011	Charcoal	1055	25	N/A	N/A	N/A	SHCal13	816-865, 903-961	929	Monks (2018)
Yellabidde Cave	Rockshelter	OZT013	Charcoal	1220	30	N/A	N/A	N/A	SHCal13	982-1032, 1046-1180	1087	Monks (2018)
Yellabidde Cave	Rockshelter	Wk-44280	Charcoal	1950	20	N/A	N/A	N/A	SHCal13	1754-1766, 1819–1912	1858	Monks (2018)
	Rockshelter	OZT014	Charcoal	4870	25			N/A	SHCal13		5535	Monks (2018)

(continued on next page)

Table A.3 (*continued*)

Site	Site Type	Lab code	Material	14C age	14C err	ΔR	ΔR err	ΔR Ref.	Calibration Curve	95.4% (2σ) cal age BP	Median probability	Source
Yellabidde Cave						N/A	N/A			5474-5550, 5573-5613, 5631-5642		
Yellabidde Cave	Rockshelter	OZT015	Charcoal	6195	30	N/A	N/A	N/A	SHCal13	6950–7162	7062	Monks (2018)
Yellabidde Cave	Rockshelter	OZT012	Charcoal	7955	30	N/A	N/A	N/A	SHCal13	8601-8797, 8827-8869, 8881-8976	8730	Monks (2018)
Oakajee Midden	Midden	Wk-32861	Shell (*Turbo intercostalis*)	4531	27	54	30	Squire et al. (2013)	Marine13	4536–4798	4672	Monks et al. (2015)
Oakajee Midden	Midden	Wk-32860	Shell (*Turbo intercostalis*)	4538	34	54	30	Squire et al. (2013)	Marine13	4534–4806	4680	Monks et al. (2015)
Oakajee Midden	Midden	Wk-32859	Shell (*Turbo intercostalis*)	4553	35	54	30	Squire et al. (2013)	Marine13	4552–4817	4698	Monks et al. (2015)
Zuytdorp Clifftop Site	Midden	Beta 22534	Shell (*Patella laticostata*)	5080	80	54	30	Squire et al. (2013)	Marine13	5134-5158, 5175-5578	5380	Morse (1988)
Swan Coastal Plain												
Hastings Cave	Rockshelter	GaK-2646	Bulk wood and charcoal	400	70	N/A	N/A	N/A	SHCal13	297–517	406	Baynes (1979)
Hastings Cave	Rockshelter	GaK-2645	Bulk wood and charcoal	1090	80	N/A	N/A	N/A	SHCal13	773-1107, 1140-1171	952	Baynes (1979)
Hastings Cave	Rockshelter	GaK-3894	Bulk wood and charcoal	1440	100	N/A	N/A	N/A	SHCal13	1076-1082, 1087-1517	1305	Baynes (1979)
Hastings Cave	Rockshelter	GaK-2651	Bulk charcoal	3520	120	N/A	N/A	N/A	SHCal13	3454-4012, 4027-4083	3754	Baynes (1979)
Hastings Cave	Rockshelter	GaK-2649	Bulk charcoal	3880	100	N/A	N/A	N/A	SHCal13	3930-3944, 3966-4453, 4461-4520	4243	Baynes (1979)
Hastings Cave	Rockshelter	GaK-3892	Charcoal	5590	160	N/A	N/A	N/A	SHCal13	5943-5972, 5985-6675	6344	Baynes (1979)
Hastings Cave	Rockshelter	GaK-2647	Charcoal	5650	150	N/A	N/A	N/A	SHCal13	6009-6082, 6102-6159, 6170-6739	6410	Baynes (1979)
Hastings Cave	Rockshelter	GaK-3893	Charcoal	6100	120	N/A	N/A	N/A	SHCal13	6658–7246	6926	Baynes (1979)
Hastings Cave	Rockshelter	GaK-2648	Charcoal	6300	150	N/A	N/A	N/A	SHCal13	6759-6761, 6783-7439	7150	Baynes (1979)
Hastings Cave	Rockshelter	GaK-2965	Charcoal	7700	200	N/A	N/A	N/A	SHCal13	8049-8123, 8128-8143, 8150-8995	8486	Baynes (1979)
Hastings Cave	Rockshelter	GaK-2650	Charcoal	7780	200	N/A	N/A	N/A	SHCal13	8070-8083, 8160-9092	8581	Baynes (1979)
Hastings Cave	Rockshelter	GaK-2966	Charcoal	9270	200	N/A	N/A	N/A	SHCal13	9829-9839, 9869-9871, 9887-11108, 11117-11121	10437	Baynes (1979)
Middle Head	Midden	SUA-1661	Shell (*Turbo intercostalis*)	3450	90	54	30	Squire et al. (2013)	Marine13	2987–3480	3254	Dortch et al., (1984); Smith, (1999)
Middle Head	Midden	SUA-1660	Shell (*Nucella orbita*)	6290	100	54	30	Squire et al. (2013)	Marine13	6432–6936	6685	Dortch et al., (1984); Smith, (1999)
Sandland Island	Midden	SUA-1472	Shell (*Turbo intercostalis*)	5330	90	54	30	Squire et al. (2013)	Marine13	5452–5871	5646	Dortch et al., (1984); Smith, (1999)
Sandy Point	Midden	SUA-1629	Shell (*Turbo intercostalis*)	1390	80	54	30	Squire et al. (2013)	Marine13	691–1057	877	Dortch et al., (1984); Smith, (1999)
Sandy Point North	Midden	SUA-1667	Shell (*Turbo intercostalis*)	4860	90	54	30	Squire et al. (2013)	Marine13	4836–5306	5089	Dortch et al. (1984)
Moore River	Midden	SUA-1853	Shell (*Patella laticostata*)	5220	80	54	30	Squire et al. (2013)	Marine13	5313–5693	5521	Dortch et al., (1984); Smith, (1999)
Orchestra Shell Cave	Rockshelter	ANU-622	Charcoal	1730	85	N/A	N/A	N/A	SHCal13	1382-1389, 1403-1752, 1767-1817	1599	Hallam (1974)
Orchestra Shell Cave	Rockshelter	ANU-623	Charcoal	3310	150	N/A	N/A	N/A	SHCal13	3080-3092, 3112-3125, 3140-3885	3503	Hallam (1974)
	Rockshelter	ANU-624	Charcoal	3820	100			N/A	SHCal13	3876–4424	4160	Hallam (1974)

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Table A.3 (*continued*)

Site	Site Type	Lab code	Material	14C age	14C err	ΔR	ΔR err	ΔR Ref.	Calibration Curve	95.4% (2σ) cal age BP	Median probability	Source
Orchestra Shell Cave						N/A	N/A					
North Head Midden	Midden	Wk-39699	Shell (*Turbo intercostalis*)	5178	41	54	30	Squire et al. (2013)	Marine13	5331–5582	5492	Monks et al. (2015)
North Head Midden	Midden	Wk-39698	Shell (*Turbo intercostalis*)	5200	40	54	30	Squire et al. (2013)	Marine13	5334-5336, 5348-5369, 5383-5607	5511	Monks et al. (2015)
Caladenia Cave	Rockshelter	Wk-37157	Charcoal	2803	68	N/A	N/A	N/A	SHCal13	2705-3009, 3011-3036, 3051-3056	2868	Thorn and Baynes (2013)
Caladenia Cave	Rockshelter	Wk-37158	Charcoal	2986	58	N/A	N/A	N/A	SHCal13	2894-2902, 2924-3253, 3294-3327	3099	Thorn and Baynes (2013)
Caladenia Cave	Rockshelter	Wk-37159	Charcoal	3544	43	N/A	N/A	N/A	SHCal13	3641-3672, 3677-3894	3773	Thorn and Baynes (2013)
Caladenia Cave	Rockshelter	Wk-37160	Charcoal	3812	45	N/A	N/A	N/A	SHCal13	3978-4296, 4333-4347	4140	Thorn and Baynes (2013)
Caladenia Cave	Rockshelter	Wk-37161	Charcoal	4256	56	N/A	N/A	N/A	SHCal13	4549-4554, 4568-4867	4731	Thorn and Baynes (2013)
Jarrah Forest												
Herald Point	Midden	SUA-1812	Shell (*Nucella orbita*)	1010	80	72	55	Ulm (2006)	Marine13	362–691	543	Dortch et al., (1984); Smith, (1999)
Warren												
Ellen Brook Complex	Midden	SUA-1621	Shell (*Patella laticostata*)	550	80	71	47	Squire et al. (2013)	Marine13	0–272	126	Bindon and Dortch (1982)
Ellen Brook Complex	Midden	Wk-1881	Shell	4250	70	71	46	Ulm (2006)	Marine13	4015–4491	4259	Lilley (1993)
Wonitji Janga	Rockshelter	Wk38503	Charcoal	1350	20	N/A	N/A	N/A	SHCal13	1184–1280	1224	Dortch et al. (2014)
Calgardup Brook	Midden	ARL-134	Shell (*Nerita* sp.)	4310	110	71	47	Squire et al. (2013)	Marine13	3986–4684	4336	Dortch et al., (1984); Smith, (1999)
Conspicuous Cliff	Midden	SUA-1811	Shell (*Patella laticostata*)	580	80	72	55	Ulm (2006)	Marine13	0–310	147	Dortch et al., (1984); Smith, (1999)
Lights Beach	Midden	SUA-1809	Shell (*Patella laticostata*)	500	80	72	55	Ulm (2006)	Marine13	NA	NA	Dortch et al., (1984); Smith, (1999)
Malimup	Midden	SUA-1622	Shell (*Nerita atramentosa*)	330	80	71	47	Squire et al. (2013)	Marine13	NA	NA	Dortch et al., (1984); Smith, (1999)
Tunnel Cave	Rockshelter	Wk-3626	Charcoal	1370	40	N/A	N/A	N/A	SHCal13	1122-1126, 1177-1309	1244	Dortch (1996)
Tunnel Cave	Rockshelter	Wk-4516	Charcoal	4280	60	N/A	N/A	N/A	SHCal13	4572-4892, 4899-4916, 4925-4960	4750	Dortch (1996)
Tunnel Cave	Rockshelter	Wk-3625	Charcoal	8270	80	N/A	N/A	N/A	SHCal13	9014–9422	9204	Dortch (1996)
Witchcliffe RS	Rockshelter	Wk-3954	Charcoal	400	50	N/A	N/A	N/A	SHCal13	317–500	408	Dortch, (1996); Smith, (1999)
Witchcliffe RS	Rockshelter	Wk-3955	Charcoal	680	90	N/A	N/A	N/A	SHCal13	511–726	611	Dortch, (1996); Smith, (1999)
Katelysia rockshelter	Rockshelter	ARL-158	Charcoal	1580	160	N/A	N/A	N/A	SHCal13	1094-1144, 1165-1756, 1762-1822	1454	Dortch et al., (1984); Dortch, (1999); Smith, (1999)
Katelysia rockshelter	Rockshelter	Beta-21756	Charcoal	1890	60	N/A	N/A	N/A	SHCal13	1611-1678, 1691-1925	1785	Dortch (1999)
Katelysia rockshelter	Rockshelter	Wait-96	Charcoal	2310	180	N/A	N/A	N/A	SHCal13	1890–2745	2293	Dortch (1999)
Devils Lair	Rockshelter	SUA-342	Charcoal	325	85	N/A	N/A	N/A	SHCal13	0-21, 71-84, 87-92, 104-113, 139-229, 242-507	352	Dortch, (1979); Gillespie and Temple, (1979)
Devils Lair	Rockshelter	SUA-364	Charcoal	6490	145	N/A	N/A	N/A	SHCal13	7006-7133, 7139-7592	7351	Dortch, (1979); Gillespie and Temple, (1979)
Devils Lair	Rockshelter	O-654	Charcoal	8500	160	N/A	N/A	N/A	SHCal13	9019-9822, 9845-9869, 9872-9887	9435	Lundelius, (1960); Dortch and Merrilees, (1973)
Devils Lair	Rockshelter	SUA-102	Charcoal	11960	140			N/A	SHCal13	13461–14091	13758	

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Table A.3 (*continued*)

Site	Site Type	Lab code	Material	14C age	14C err	ΔR	ΔR err	ΔR Ref.	Calibration Curve	95.4% (2σ) cal age BP	Median probability	Source
						N/A	N/A					Dortch and Merrilees, (1973); Dortch, (1979); Gillespie and Temple, (1979)
Rainbow Cave	Rockshelter	Wk-1875	Charcoal	340	45	N/A	N/A	N/A	SHCal13	292-474, 478-486	387	Lilley, (1993); Dortch, (2004)
Rainbow Cave	Rockshelter	Wk-1876	Charcoal	790	50	N/A	N/A	N/A	SHCal13	567-596, 633-761	686	Lilley, (1993); Dortch, (2004)
Rainbow Cave	Rockshelter	Wk-1877	Charcoal	830	45	N/A	N/A	N/A	SHCal13	658-774, 782-787	709	Lilley, (1993); Dortch, (2004)
Esperance Plains												
Sandy Bight Creek	Midden	SUA-1914	Shell (*Nerita atramentosa*)	420	80	72	55	Ulm (2006)	Marine13	NA	NA	Dortch et al., (1984); Smith, (1999)
Whalebone Point	Midden	SUA-1810	Shell (*Nerita atramentosa*)	390	80	72	55	Ulm (2006)	Marine13	NA	NA	Dortch et al., (1984); Smith, (1999)
Cheyne Bay	Midden	SUA-1808	Shell (*Nerita atramentosa*)	500	70	72	55	Ulm (2006)	Marine13	NA	NA	Dortch et al., (1984); Smith, (1999)
Barndi			Rockshelter						Rockshelter	ARL-248	Charcoal	1930
100	N/A	N/A	N/A						SHCal13	1580–2058	1829	Smith (1993)
Barndi			Rockshelter						Rockshelter	ARL-247	Charcoal	2080
100	N/A	N/A	N/A						SHCal13	1749-1770, 1809-2213, 2218-2308	2013	Smith (1993)
Cheetup			Rockshelter						Rockshelter	BA-2845	Not specified	220
40	N/A	N/A	N/A						SHCal13	0-27, 59-116, 136-233, 237-306	192	Smith (1993)
Cheetup			Rockshelter						Rockshelter	GX-6606	Charcoal	410
20	N/A	N/A	N/A						SHCal13	328-376, 392-401, 439-497	456	Smith (1993)
Cheetup			Rockshelter						Rockshelter	SUA-1875	Plant	(*Macrozamia* sp. kernel)
1430	330	N/A	N/A	N/A					SHCal13	675–2001	1313	Smith (1993)
Cheetup			Rockshelter						Rockshelter	BA-2844	Charcoal	2540
40	N/A	N/A	N/A						SHCal13	2380-2393, 2426-2741	2583	Smith (1993)
Cheetup			Rockshelter						Rockshelter	BA-2842	Charcoal	8200
70	N/A	N/A	N/A						SHCal13	8799-8826, 8870-8879, 8977-9325, 9345-9401	9117	Smith (1993)
Cheetup			Rockshelter						Rockshelter	BA-2843	Charcoal	10660
160	N/A	N/A	N/A						SHCal13	12007–12787	12787	Smith (1993)
Pasley Salt Lake	Midden	Wk-3334	Shell	450	45	72	55	Ulm (2006)	Marine13	NA	NA	Smith (1999)

References

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