



Aboriginal uses of seaweeds in temperate Australia: an archival assessment

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Abstract

Global demand for seaweed has increased dramatically over recent decades and the potential for seaweed aquaculture to address issues around food security and climate-change mitigation are being recognised. Australia is a global hotspot for seaweed biodiversity with a rich, diverse Indigenous history dating back 65,000 years, including an extensive traditional knowledge of Australian natural resources. In our present review of archival literature, we explored the contemporary and historical uses and cultural significance of seaweeds to Indigenous Australians. We found records of seaweed use by Indigenous Saltwater Australians (Australian Aboriginal peoples from coastal areas across the nation who are the Traditional Owners/Guardians and custodians of the lands and waters characterised by saltwater environment) for a variety of purposes including cultural activities, ceremonial activities, medicinal uses, clothing, cultural history, food, fishing, shelter and domestic uses. Species-specific records were rarely recorded (and/or accurately translated) in the archival literature, with the exception of the use of the fucoid bull kelp, *Durvillaea potatorum*, which was prevalent. Our research is a step forward in the important task of recovering and conserving Indigenous Australian knowledge and customary traditions surrounding coastal resource use. Unlocking this knowledge creates opportunities for the continuance and revitalization of traditional customary practises that may enable innovative Indigenous business activities and product creation, based around food, sustainable natural-fibre technologies and health. Such research also has the potential to enhance a developing Australian seaweed industry by guiding species selection, preparation, use and sustainable resource management. We recommend our findings are used to inform the direction and locations of further research conducted in conjunction with Indigenous coastal communities in Australia's temperate regions, to explore in more detail the Indigenous Australian's historical heritage associated with coastal seaweed resources and their uses.

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Introduction

Increasing recognition in Western cultures of the health and nutritional benefits of eating seaweeds (Cornish et al. 2015), alongside growth of the Western wholefood movement and seaweed-based hydrocolloid industry (Bouga and Combet 2015; Mouritsen 2017; Porse and Rudolph 2017), have driven in part a dramatic increase in global production of seaweed. There is also growing recognition that the production of seaweeds for food and other commercial applications represents part of a viable solution for climate-change mitigation, without compromising the availability of agricultural land and water resources (Duarte et al. 2017; Sondak et al. 2017a, b). Annual production of seaweeds has more than doubled in the past 10 years, with global harvests now exceeding 28 Mt wet weight

(83% for human consumption (Loureiro et al. 2015)) valued at > US\$6 billion (FAO 2016). Whilst production is firmly centred on the Asian Pacific and species found in this region (Sondak et al. 2017a, b), the taxonomically-related northern hemisphere seaweed flora of Western European countries, the USA and Canada, has facilitated rapid expansion of seaweed aquaculture into these regions, with application of culture techniques developed in Asia (Redmond et al. 2014; Kim et al. 2017).

Southern Australia is a global hotspot of seaweed biodiversity with the highest level of endemism (~60%) globally (Phillips 2001 and Bryan Womersley's extensive works cited therein), yet none of the commercially cultured seaweed species occur naturally in Australia. Increasing concerns about global food security (Godfray et al. 2010), climate change (Schmidhuber and Tubiello 2007; Sondak et al. 2017a, b) and increasing demand for seaweed products (Mohamed et al. 2012; Porse and Rudolph 2017), suggests further investigation into the aquaculture potential of the diverse southern Australian seaweed flora is warranted (Lee 2010; Winberg et al. 2011; Skrzypczyk et al. unpublished data). However, an incomplete knowledge of the palatability, culture techniques, viable markets, nutritional value and potential toxicity of Australian species currently limits commercial exploitation.

Research from around the world has shown that the inclusion of traditional ecological knowledge in modern natural resource management leads to an increase in favourable economic, environmental and social outcomes for industries and communities involved (Berkes et al. 2000; Horstman and Wightman 2001; Ross et al. 2011). Australian Aboriginal culture is a living culture, not a historical culture. It includes Indigenous knowledge and traditional ecological knowledge. 'Indigenous knowledge', in Australia, is both a philosophy and a way of thinking by Indigenous peoples, as well as Indigenous environmental knowledge (Berndt et al. 1993; Briggs 2008; Clarke 2015a, b, c; Ens et al. 2015, 2017; Jones et al. 2017; O'Brien 2017; Jones and Clarke 2018). Over the past few decades, Indigenous knowledge systems in Australia have been described using various descriptors, such as 'traditional knowledge' (TK), 'traditional ecological knowledges' (TEK) and 'local knowledges' (Hutchings and Morrison 2017). Writing on First Nation knowledge in Canada, ethnolinguist Mailhot (1994) explains, that this is '...the sum of the data and ideas acquired by a human group on its environment as a result of the group's use and occupation of a region over very many generations'. Similarly, the International Council of Science (ICSU 2002) defines 'traditional knowledge as "... a cumulative body of knowledge, know-how, practices and representations maintained and developed by peoples with extended histories of interaction with the natural environment. These sophisticated sets of understandings, interpretations and meanings are integral to a culture that encompasses language, naming and classification systems, resource use practices, ritual, spirituality and worldview. We also view that research with

Indigenous peoples in Australia is an avenue towards conserving their living cultural knowledge, rather than preserving their cultural knowledge" (Australia ICOMOS 2013)'.

Many Indigenous Australians, often termed 'Saltwater people', resided in Australia's coastal areas and represent the longest continuous cultural history in the world, dating back 65,000 years (Clarkson et al. 2017). The term 'Saltwater people' does not relate only to Indigenous peoples from northern Australia, but rather, under Indigenous Australians' interpretations, the terminology refers to Australian Aboriginal peoples from coastal areas across the nation who are the Traditional Owners/Guardians and custodians of the lands and waters characterised by saltwater environments. There are over 250 known Australian Indigenous languages across the nation (AIATSIS 2017), and as a consequence each saltwater Indigenous culture group has a country-specific relationship to their particular lands and waters of which language is integral in this relationship (e.g. the *Gunditjmarra* peoples will have different words and cultural associations to seaweed as distinct from the *Boon Wurrung* peoples some 250 km away). Thus there is both extensive diversity in seaweeds and extensive diversity of Indigenous culture groups (centred around language groups) in Australia, and with this diverse Indigenous history comes a culture of rich traditional ecological knowledge. Further, because traditional ecological knowledge varies from one Indigenous country to another, a generic 'Indigenous Australian' language does not exist and similarly generic knowledge about seaweed will not exist because it is country-specific.

The contemporary and historical uses and cultural significance of coastal resources, such as shellfish, marine mammals and finfish, to Aboriginal communities have been studied in a variety of locations around Australia (e.g. Barker and Ross 2003; McNiven and Feldman 2003; Fleming et al. 2015); however, Aboriginal uses of seaweeds have been less documented. Australia also has a long history of devaluing and dismissing Indigenous knowledge as 'simple' or 'primitive' (Lewis 1989), and marginalising and discriminating against Indigenous peoples (Hunter 2007). As a result, much traditional knowledge surrounding coastal resource use has been lost from Indigenous communities. Examination of archival sources is thus one route to rediscovering and subsequently conserving Indigenous knowledge. Unlocking this knowledge may also create opportunities for the continuance or revival of traditional customary practises that can enable innovative Indigenous (and Indigenous + non-Indigenous co-operative) business activities and product creation, based around food, sustainable natural-fibre technologies and human and animal health. Finally, a developing temperate Australian seaweed industry may benefit from understanding the species of seaweeds that were traditionally used by Saltwater peoples, what they were used for and how they were prepared, and how the resources were managed.

We hypothesise that Australia's Aboriginal Saltwater peoples used abundant and easily accessible temperate seaweed

species for a variety of purposes related to nutrition, healing and domestic needs. Assuming these uses occurred, we expect these to be recorded in the archival records of early Western explorers and settlers in coastal regions, and/or for these uses to have continued in contemporary Indigenous activities. As seaweed diversity and abundance is highest in temperate Australian coastal waters, and European settlement occurred in these regions first, we expect a predominance of accounts from these regions. This paper represents some of the first steps in valuing and learning from Indigenous Australians' use of seaweeds by reviewing and collating contemporary scientific and anthropological data, as well as archival and historical literature, in relation to types of seaweeds used and their application by Australia's Aboriginal Saltwater peoples.

Methods

Sources searched

Searches for descriptions of Australian Indigenous uses of seaweed were conducted using online databases, state and academic library catalogues. Subject-specific knowledge of several co-authors (DJ, JD, EC) was also used to identify additional references that may include seaweed-related uses by Indigenous Australians, but which do not have an online presence (e.g. unpublished academic/archival collections), or which would likely be missed using seaweed/macroalgal-related keyword searches. References searched in these contexts included unpublished ethnobotanical inventories, unpublished academic theses, and Aboriginal writings known to the authors. To maximise early observations of Indigenous activities, our searches specifically aimed to include non-academic sources such as newspapers, books and personal accounts such as diaries. Search terms were chosen that reflected the type of articles held by each online database (e.g. scientific, anthropological or popular media articles) and that were deemed most likely to elicit articles relevant to Indigenous use of seaweeds, past and present, including historical spelling variations (Table 1; Table S1). Only Australian Indigenous uses were catalogued for this study; non-Indigenous use or reference to Indigenous use in other nations were disregarded. Both primary (e.g. direct observations) and secondary sources (e.g. reference to an earlier publication or records of observations by another party) were collated, but where possible, secondary sources were traced back to the primary source and the original publication substituted. Where it was obvious that an earlier observation was being repeated without appropriate referencing of the primary source, the earliest-dated observation was used and later or indirect reference(s) discarded. All results returned from the searches were explored in full, with the exception of Google Scholar. In this case, articles were sorted by 'relevance' and article exploration was halted when

Table 1 Terms used in search of online databases

Database	Database type	Search terms
Environment Complete Web Of Science	Scientific	Indigenous seaweed* ethnobotany seaweed* Aboriginal seaweed* ethnobotany alga* Aboriginal alga* traditional seaweed* traditional alga*
Anthropology Online AnthroSource Australian Institute of Aboriginal and Torres Strait Islander Studies Informit: Indigenous Collection	Anthropological	Marine botany Seaweed* Ethnobotany
National Library of Australia Google Scholar	Popular/scientific	(Aboriginal OR aborigine OR native OR savage) AND (seaweed OR algae OR sea-weed OR seaweed)

no new information had been extracted from 50 consecutive individual article searches.

Categorisation of articles

Once individual articles had been collated, the descriptive information was categorised using a content analysis approach. For each article, the activity/activities referring to the use of seaweed were extracted and categories were subsequently developed to capture the range of seaweed-related uses and/or activities mentioned in the archival sources. Locations where the observation occurred were identified where possible (most commonly to state-level, but occasionally Indigenous nation/group/clan names were provided). Where physical descriptions and/or names of seaweeds were provided, these were used to identify the family, genus or species being used by the last author (AB), a macroalgal specialist, with reference to Womersley (1987) and AlgaeBase (Guiry and Guiry 2017), and assistance from highly regarded phycologists in Australia (JA Lewis and GT Kraft).

Results

Literature sources examined

Existing literature references can be broken into colonial narratives and recollections, contemporary syntheses, contemporary Aboriginal writings and *Land and Sea Country* management plans. Period inquiries tended to be included within diaries, travel journals and popular media such as newspapers and narratives often involving direct observations of, and

conversations with, Aboriginal people harvesting and using plant materials, and inventories of Indigenous names and words. Contemporary disciplines that have explored Aboriginal natural resource use include archaeology, the social sciences, landscape architecture, ethnobotany and anthropology. Whilst recorded uses of terrestrial plants by Aboriginal peoples are numerous and knowledge of specific Indigenous nations/peoples are widely recorded (e.g. Hope and Coutts 1971; Sullivan 1981; Gaughwin and Sullivan 1984; Rhodes and Bell 2004 on *Boon Wurrung Country*; Niewójt 2009 on *Gadubanud Country*; Terra Culture 2012; Dearnaley 2014, 2015 on *Wadawurrung Country*; Clarke 2008a, b, 2015a, b, c; Jones and Clarke 2018 on *Kaurna* and *Ngarrindjeri Country*; Oates 1977; Oates and Seeman 1979; Gott 1985; Gott and Conran 1991; Zola and Gott 1992; Bonney 1994, 2004), with occasional exceptions (e.g. Lane 1975 (unpublished), 1980 (unpublished), 1996 (unpublished); Heyes 1999), seaweed is rarely mentioned in this literature.

Contemporary academic Aboriginal-authored or direct-participatory recollections, narratives and ‘yarning circles’ (Arbon 2008; Martin 2008; Wilson 2008; Yunkaporta 2010; Smith 2012; Rose 2017), and *Land and Sea Country* management plans (FAT, WMAC 2004; Jones and Clarke 2018) also offered little insight into the history and current relationships and practises to seaweed. *Sea Country* management plans, a recent recognition of the *Sea Country* custodian responsibilities of various communities, have prioritised sustainable management of sea resources and waters aligned to traditional perspectives (National Ocean Office 2002). Strategies by the *Ngarrindjeri* people of The Coorong region in South Australia (Ngarrindjeri Tendi et al. 2006) and *Gunditjmarra* people of south-western Victoria (FAT, WMAC 2004), that includes the Budj Bim National Heritage Landscape (Australian Government 2017), offer narratives of close relationships to their respective *Sea Countries* but little specific guidance as to seaweed use, harvesting or management. The *Gunditjmarra* (FAT, WMAC 2004) have noted that ‘Indigenous organisations are investing in and operating commercial ventures based on currently unexploited marine resources such as velvet crabs, sea urchins, kelp, sea weed and sea grasses, bait aquaculture and whale tourism’ but have little explained the significance of seaweed in their country.

Indigenous seaweed use recorded in the literature

In total, co-authors’ subject-specific knowledge and the database searches uncovered 77 sources that provided descriptions or recorded observations of Indigenous Australian seaweed use and nomenclature (SOM 2). Nearly half (49%) of these records were sourced from newspaper reports or magazines. The rest were sourced from academic literature (published and unpublished), popular narratives, online resources or monographs. Once categorised, these provided 92 descriptions of

seaweed-related uses, names and/or activities involving seaweed. Publications spanned 183 years, from 1834 to 2017, although a source from as early as 1791 was referenced by one author. Sources included descriptions from early explorers, anthropologists, natural scientists and contemporary Indigenous authors. However, Indigenous voices were not represented within the historical literature, which was instead dominated by observations of Indigenous use and subsequent interpretations by colonial authors, the vast majority of which were male (Table 2). All Australian states and territories (with the exception of the Australian Capital Territory) were represented. Activities mentioning seaweed use were most commonly reported for South Australia and Tasmania (30 and 24% of reports, respectively). Activities/reports of seaweed use were sorted into the following categories: cultural activities, ceremonial activities, medicinal use, clothing, cultural history, diet, fishing, language/nomenclature and shelter/domestic use. These categories are explored in detail below.

Cultural activities and cultural history

Early anthropological investigations in the coastal regions of South Australia recognised that the peoples of *Moandik* (*Meintangk*) and *Potaruwutj* (*Bodaruwitj* or *Bindjali*) communities both articulated a common narrative about a Supreme Male Ancestor called *Ngurunderi* (Clarke 1995), which mentions seaweed:

‘Alf Watson said reference was being made indirectly to the area of still water in the sea at Cape Jaffa. Great mats of sea-weed calm the waves along the shore at Kingston and at Cape Jaffa. This sea-weed has still on it the ‘ears’ left by the nephews of Ngurunderi.’ Tindale (1934–37).

In this narrative content, *Moandik* man Watson believed that seaweed represents the ‘cloak’ of *Ngurunderi*’s “sons”. Similar references to Aboriginal mythology occurred in both early writings (1840s, Table 2) and contemporary sources. References to Indigenous cultural history (within which we include mythology and sacred songs) comprised 11% of the articles found during our searches. It is not clear from any of these records of particular species of seaweed being of significant importance to cultural activities/histories, although the citation above may refer to *Ecklonia radiata*, a laminarian kelp found in southern Australia, or even an accumulation of drift-plant matter such as detached blades of the seagrass *Posidonia australis*, both commonly observed in this location today.

Ceremonial activities

References to ceremonial activities ranged from the year 1933 to 2013, comprising 8% of articles. Seaweed was recorded as

Table 2 Examples of uses of, activities and nomenclature involving seaweed

Category	Quote and citation
Culture and cultural history	<p>“Kuraŋje and Kamhari became small fish. The latter was dressed in a good kangaroo skin, and the former only a mat made of seaweed, which is the reason they say, that the kamhari contains a great deal of oil under the skin.” (Meyer 1846).</p> <p>“Everything that exists in the sea has a place in the sacred songs... Seaweed, floating anemones, turtle, fish etc. The songs follow them out from the deep water into the beach” (from Yunpingu and Muller 2009). (Yunpingu and Muller 2009).</p> <p>“Now the old man was a raimaker. He took a bamboo tube, stuffed it loosely with seaweed, and set fire to it. Soon it smoked like a smoke screen warship, with the old man chanting magic words over it”. Daily News 11 Nov 1933.</p> <p>“Fragments of a seaweed cloak containing the remains of a two-year-old Aboriginal child have been presented to the South Australian Museum... It had been the custom of coastal tribes, he said, to bury their dead in seaweed cloaks”. The Advertiser 24 Apr 1954.</p> <p>“As soon as the baby is born, he is subjected to a daily rite called Wudur... Its purpose is to ensure the child learns to abide by the code of behaviour established by the Wandjina and maintained through wunan. Djalum (seaweed or freshwater algae) is placed over a fire in a pit. The child’s hands are warmed over the fire...” (Layton 1992).</p>
Ceremonial activities	<p>“Nearly every tribe has its own doctor, who has but one remedy for every disease; but every doctor has a different one, and this is the object, animal or vegetable, which he regards as his friend and protector - thus one has a snake, another an ant, another seaweed, etc. etc.” (Meyer 1846).</p> <p>“Wet, tight bandages of plant leaves and seaweed were used to relieve pain and to stop bleeding” (Bryden 1974).</p> <p>“A man of the Milimendura tribe, wearing the Seaweed Cloak”. (Angas 1847).</p>
Medicinal use	<p>“Some tribes use seaweed and rushes for temporary clothing or to make a blanket...” Albury Banner and Wodonga Express 19 Apr 1918.</p> <p>“In 1802, Baudin noted of the Tasmanians, ‘Their drinking vessels are made from a type of seaweed with very broad thick leaves. These they also use as shoes when they have sore feet’.” (Akerman 2005).</p>
Clothing	<p>“Tasmanians were able to gather the large sheets of bull kelp to make drinking cups, larger water-carrying vessels and shoes for sore feet.” (Clarke 2012).</p>
Diet/cooking	<p>“Bound by rock and washed by salt water, is a sea-weed, known by the name of ‘Bull Kelp’ it varies in length and substance, according to its local position, — it has a thick stem, and flat oval-shaped leaf, and is about the thickness of sole leather. The aborigines of this country, New South Wales, and New Zealand, and probably those of every sea-girl shore, highly prize this weed as an article of food; they estimate it, indeed, as highly nutritious and palatable...” Cornwall Chronicle 15 Oct 1853.</p> <p>“... birds, native honey, shellfish, native fruits, eggs, seals, edible plants and roots, and seaweeds all formed part of the diet...” (Bryden 1974).</p> <p>“Labillardiere reported “on 9 February 1793, a party of natives seated by their fires were making a meal of mussels, and eating with them pieces of the seaweed (<i>Fucus palmatus</i>), which had been softened by cooking...” (McFarlane 2002).</p>
Fishing	<p>“Some of the women went into the water among the large sea-tangle, to take Cray-fish. These women seem quite at home in the water, and frequently immerse their faces to enable them to see objects at the bottom. When they discover the object of their search, they dive, often using the long stems of the kelp to enable them to reach the bottom: these they handle as dexterously in descending, as a sailor would a rope, in ascending.” (Backhouse 1843).</p> <p>“... the native fishermen of South Australia make rope, twine, and most durable fishing nets from the local varieties [of seaweed]”. Evening News 21 Jun 1922.</p> <p>“The seaweed would come in and up the channel, and go down as far as the Bonney Reserve. We’d pull out rolls of it, and the fish... would be there.” (Bell 1998).</p> <p>“Coorong fish traps also made use of natural barriers other than stone. Tindale described a trap at Nijenu where seaweed formed the entrance and one guiding wall of the trap, while the shore was used as the opposite wall of the trap (Tindale 1934–1937: 5–7). The same talaiapar basket ware trap was placed at the bottom of the V to collect fish. It is possible that the wall of seaweed was formed by the weed adhering to a calcareated dune remnant, although Tindale made no reference to this.” (Ross 2009).</p>
Language/nomenclature	<p>“Language of Van Diemens Land: <i>Fucus palmatus</i> = “nugona”, seaweed = “roenan, inu”, seaweed dried for eating = “tort”.” (Ogle 1839).</p> <p>“This is Ljigwidgi Tucaninni, who is still under the tender care of Mr. and Mrs. Dandridge, and whose name, so apparently unpronounceable, means simply “seaweed by the river’s side.” Weekly Examiner 20 Sept 1873.</p> <p>“The Port Fairy tribe is called ‘Peek whuurong’, and a member of it Peek whuurong kuurndit’. Its language, ‘Peek whuurong,’ ‘kelp lip,’ is taken from the broad-leaved seaweed so very abundant on the sea shore.” (Dawson 1881).</p>
Shelter/domestic use	<p>“Some of the kelp or sea-weed, washed up on this shore, is of gigantic magnitude; a palmate species has a stem thicker than a man’s arm, and proportionately long. The flat portion between the stem and the ribbon-like appendages, is so large as to be converted by the Blacks, into vessels for carrying water. For this purpose, they either open an oblong piece, so as to form a flat bag, or run a string through holes in the margin of a circular piece, so as to form a round one...” (Backhouse 1843).</p> <p>“Native huts, made from the boughs of trees, and in winter strongly constructed, of a dome shape, and capable of holding from six to a dozen persons. Near whaling stations, the ribs of whales are employed as the framework, and the divisions filled up with boughs and seaweed.” (Cawthorne 1858).</p> <p>“When out fishing the ‘dusky crew’ not infrequently made a fire, (on a little head of sand and seaweed) and cooked their dinner in these canoes.” Register 29 Jul 1913.</p> <p>“Péron was also intrigued to find some caverns that were clearly used as shelters, for they had ledges carved out of the walls to store ‘household utensils’, and were ‘carpeted with a thick layer of seaweed’.” (Konishi 2008).</p>

being burned or being used to make smoke during ceremonial events, and was also burnt during daily rituals (Table 2). Whilst most references to these activities did not explain their significance, one contemporary source referred to the ritualistic use of smoke (generated by either green leaves or seaweed being placed on top of a fire) to ‘eliminate strange scents from the visitors which allows the country to recognise them’ (Vigilante et al. 2013). This smoking is analogous to the Australian Aboriginal contemporary and historical burning of *Eucalyptus* spp. leaves to cleanse the air of evil spirits before an event or meeting commenced or commences.

Medicinal use

Aboriginal medicinal knowledge and the activities of medical practitioners were written about by Meyer (1843) in *Ngarrindjeri Country*, in South Australia, who noted the term *parraitye-orn*, which he translated as ‘sea-weed man’ or ‘doctor’. This person was said to:

[pretend] to cure diseases by chewing a small piece of a red-coloured species of sea-weed, which he gives to the patient, bidding him to conceal it about his person. As soon as the seaweed becomes dry it is supposed the disease will have evaporated with the moisture’. (Meyer 1843).

Seaweed was recorded as being used for medicinal purposes in 4% of articles, and included references to the use of seaweeds as bandages, as well as seaweed being used to line ‘birthing holes’ so that women could maintain connections to their land by giving birth directly upon it (Table 2). Records exist of the *Wadawurrung* people (Victoria) using ‘pink seaweed’ as medicinal jelly poultice for reducing painful jellyfish stings (Lane 1980, unpublished).

Clothing

References to clothing span the years 1846–2013, and comprise 13% of discovered articles. References to the use of seaweed or rushes (likely seagrasses such as *Posidonia*, *Amphibolis* or *Zostera*) to make garments were most common, although it is likely that a number of the references draw upon a limited number of primary sources.

Angas (1847) produced a drawing of an Indigenous man from South Australia wearing an ornately designed cloak reported to be made of seaweed, but the species was not mentioned and it is unclear if the cloak was made from seaweed or seagrass (or a combination of both). The authors respect Indigenous Australian protocols about reproducing images and names of Aboriginal people whom have passed so whilst the image is not reproduced in this article, the following open access link leads to the image being discussed: [https://](https://collections.slsa.sa.gov.au/resource/B+15276/18/continue)

collections.slsa.sa.gov.au/resource/B+15276/18/continue. In Tasmania, references were made to shoes made from seaweed, almost certainly bull kelp (*Durvillaea potatorum*) (Table 2).

Diet

The use of seaweed in diet and cooking was referenced in 13% of articles, once again spanning early European history to the present day (1834–2007). The majority of these references pertained to Tasmania and eating of bull kelp (presumed *D. potatorum*). Records indicate that this species was prepared for eating by initial sun-drying, followed by careful roasting over a fire where it was turned frequently and then finally soaking for 10–12 h in freshwater before eating alone or with meat or fish (Table 2). Once bull kelp was dried and roasted it could be preserved for many months. Other references to species used for food in Tasmania included *Durvillaea antarctica* (Irvine 1957), not known to occur in Tasmania (Fraser et al. 2010); *Cystophora porulosa* (Hiatt 1967), presumably a misspelling of *Cystophora torulosa*; *Cystophora paniculata* (Hiatt 1967), now known as *Acrocarpia paniculata* (Guiry and Guiry 2017); and *Fucus palmatus* (Hiatt 1967), now known as *Palmaria palmata* (Guiry and Guiry 2017); however, this species has no known distribution in Australia, and Australian records are apparently synonymous with *D. potatorum* (Plomley et al. 1990). *Eucheuma speciosa* (assumed *Eucheuma speciosum* now *Betaphycus speciosus* (Guiry and Guiry 2017) was recorded as being used by Indigenous Australians for jelly in Western Australia (Irvine 1957), but the original source (Maiden 1889) is ambiguous as to whether this use was by Indigenous Australians or European settlers. Research on the *Wadawurrung* people recorded that *Ulva lactuca* and *Porphyra* sp. (or possibly *Pyropia*, Sutherland et al. 2011) were foraged as vegetables, and “strings of sea grapes” (the name not given, but most likely referring to *Hormosira banksii*—Neptune’s Necklace or *Chaetomorpha coliformis*—Mermaids Necklace) were eaten as an accompaniment to seafood (Lane 1980, unpublished).

Fishing

In addition to being eaten directly, seaweed was also used in the capture of fish and invertebrates, referenced in 10% of articles from 1846 to the present day. Ropes and fishing nets were observed being made from seaweed by Indigenous peoples in South Australia, whilst in Tasmania, Indigenous women were observed using the attached fronds of kelp to help pull themselves underwater whilst diving for crayfish (Backhouse 1843). Seaweed was also used to line fish traps, or in some cases were likely the principal component of fish traps, constructed to form the entrance and guiding wall of the trap

(Ross 2009, Table 2). Specific references to species are not given for these uses.

Language/nomenclature

Twenty one percent of articles referred to Indigenous names for, or nomenclature highlighting the presence of, seaweed in an area. Words for seaweed were extracted for all coastal states, although we cannot be sure that the European interpretation of these Aboriginal words was always accurate, particularly when these were found in popular media articles without an original reference. Words included place names attributed to the presence or smell of seaweed, the given names of individuals, and a variety of names referencing seaweed directly, including (in Tasmania) different names for seaweed when raw or once dried for eating (Table 2). For example, in contemporary *Boon Wurrung* language, ‘buath wareeny’ (-pronounced as ‘boo-art wha-reen’) means ‘grass of the sea’ (Stewart-Muir 2017, *pers. comm.*). In the *Dhauwurd Wurrung* language of the *Gunditjmarra*, ‘ngapanyoong’ means ‘air vessel of seaweed’ (pneumatocysts); ‘ngapanyoong peek koorrook’ means ‘weed’ in/of ‘water’; ‘peek koorrook peek’ means ‘kelp’ and also ‘saltwater algae’ but ‘peek peekoy’ is also used for ‘kelp’. The word ‘peekoy’ is also given as ‘saltwater algae’ (Wright 2017, *pers. comm.*).

Shelter/domestic use

Seaweed, particularly kelp, was recorded being used for a variety of domestic uses (18% of articles), spanning the years 1842–2016. In Victoria and South Australia, seaweed was used in the construction of Aboriginal coastal shelters (Cawthorne 1858, Table 2). Some shelters in South Australia were recorded as being constructed from whale bones with seaweed used as a waterproof and windproof covering. In the early 1800s, seaweed ‘carpeting’ was observed in a cavern shelter (Konishi 2008). The red seaweed, *Eucheimia speciosa* (assumed *Betaphycus speciosus* as above, Guiry and Guiry 2017) was used in construction for size and cement in Western Australia, but the archival records are ambiguous in attributing this use to Australian Aboriginal people (Maiden 1889; Irvine 1957). However, there are records of stone, permanent dwellings being constructed by Indigenous Australians across the volcanic plains of Victoria. This occurred during a period of hunter-gatherer intensification between 3000 and 1000 BCE (Lourandos 1983), characterised by population growth, an increase in human manipulation of the environment (e.g. the construction of Short-finned Eel (*Anguilla australis*) traps in Victoria), an increase in trade between groups, a more elaborate social structure, and other cultural changes (Lourandos 1977).

In Tasmania, kelp (most records referring to bull kelp or *D. potatorum*) was observed being used to construct water

carriers or baskets (Fig. 1) as early as 1791 (Mortimer 1791), a craft that continues today (National Museum of Australia 2017). Lane (1975, unpublished), in surveying the *Wadawurrung* ethnobotany, and interchangeably using ‘bull’ and ‘giant’ kelp in her writings to describe what is certainly *D. potatorum*, records a ‘water pitcher made from a broad, hollow root-stock [holdfast] of a giant kelp’, thus differing from the vessels/baskets made from the blade of this alga (Backhouse 1843, Fig. 1).

Several references were made to seaweed being routinely used in the cooking or preservation of fish. Seaweed was observed to form the base of fires in canoes, allowing the fish to be cooked directly upon capture. Fish and invertebrates were also wrapped in seaweed to keep them cool and preserve them for longer (Panangharry 1903).

Discussion

Seaweed uses by Indigenous Australians

Seaweed use by Indigenous cultures outside of Australia is well known but often indifferently documented, with some contemporary Indigenous cultures maintaining and reviving traditional customs and knowledge relating to seaweed (e.g. the First Peoples of coastal British Columbia, Turner 2003; the Wailaki of California, Nelson 2013). In some regions Indigenous knowledge and use of seaweeds has been incorporated into contemporary management. For example, sustainable harvest strategies for seaweed stocks in New Zealand have been tested using traditional harvesting techniques used for generations by Māori communities (O’Connell-Milne and Hepburn 2015).

In contrast to these examples, we know relatively little about the use and significance of seaweeds to Indigenous Australians. As anticipated, we found that the archival records of early Western explorers and settlers in coastal regions recorded use of seaweeds by Indigenous Saltwater peoples from around Australia. Although our archival literature searches only brought up a limited number of reports of Indigenous seaweed use, it is clear from these results that seaweed played a role in the day-to-day life of Indigenous Australians across different regions of coastal Australia. Seaweed was clearly exploited as a versatile resource for a variety of uses. Additionally, the wide geographical spread of reported Indigenous Australian names for seaweed (across all states) is an indication that in pre-colonial times, Indigenous coastal communities harboured some level of traditional knowledge related to seaweed resources (Turner 2003). Our research thus points to the value of further exploration of Australian Indigenous seaweed use via oral histories for greater depth than is available in published accounts.

Fig. 1 Kelp water container from Tasmania made from bull kelp (*Durvillaea potatorum*), dated 1850. Source: National Museum of Australia, © Trustees of the British Museum



The variety of uses, wide range of locations and period of time over which seaweed use was documented in the literature, in addition to the variety of Indigenous names for seaweed, suggests that the low frequency of archival results stems not from a lack of use of this resource historically, but instead a lack of written documentation on seaweed use. This most likely stemmed from colonial attitudes towards the (in)significance of Indigenous knowledge and resource use more broadly, as well as the perceived insignificance of seaweed in relation to other coastal resources, such as shellfish or finfish, by predominately English settlers (with likely little traditional use of seaweeds themselves). Another driving factor is likely to be the early dispossession of coastal Indigenous people relative to inland nations. Coastal Indigenous groups were often affected by settlement in the earliest years of occupation, prior to the broad-scale publication of print media, and prior to the emergence of scientific and anthropological interest in Indigenous peoples and their activities (Berndt et al. 1993; Pascoe 2007).

Links between historical and contemporary uses of seaweed by Indigenous Australians are still maintained, however. These include the use of seaweeds in contemporary Indigenous art (Matson-Green and Maiden 2008; Aboriginal Art Directory 2014), and the continued use of seaweeds in traditional activities (e.g. modern versions of seaweed water carriers; National Museum of Australia 2017) and surviving cultural heritage (e.g. Indigenous mythologies). These continuing practises highlight the likelihood that further traditional knowledge exists within Indigenous communities, particularly those communities who maintain unbroken links and strong connections to their ancestral lands and traditional practises.

Relevance of historical data for contemporary aquaculture/sustainable industries

South-eastern Australia has a diverse and unique seaweed flora (Phillips 2001) but naturally lacks the species that are most commonly commercially harvested or cultured in other parts of the world (FAO 2016), posing both opportunities and challenges for the development of a temperate Australian seaweed industry. On the one hand, the opportunities to discover Australian seaweeds with unique flavour and nutritional profiles, medicinal and pharmaceutical qualities (Reichelt and Borowitzka 1984), or applications in the phycocolloid (Chiovitti et al. 2001) or innovative natural-fibre technologies (e.g. flame-retardant textiles, Zhang et al. 2011), for example, are vast. But on the other hand, in a contemporary industry sense, we are starting from a limited knowledge base (e.g. Madgwick and Ralph 1972; Reichelt and Borowitzka 1984; Lie et al. 1990; Chiovitti et al. 2001), and working out which species to start looking at, how they may be used and how we might sustainably harvest or modify existing methods to bring them into aquaculture are particular challenges. Exploring the historical uses of seaweeds in the Australian context, by the Indigenous peoples who have inhabited this land for at least 65,000 years (Clarkson et al. 2017) before European settlement, provides an opportunity to conserve aspects and values of Indigenous knowledge that have been largely overlooked by researchers, and that are likely to be at risk of being further lost from Indigenous communities without concerted efforts to record and conserve such knowledge. If conservation efforts are successful and communities are empowered to take ownership of this knowledge, it may be that it can help inform a sustainable temperate Australian seaweed industry in the future, one

that ideally provides Indigenous training, employment and business opportunities in coastal communities (Lee 2010).

Although the records are few, our expectation that Indigenous use would be focussed on species that were easily accessible is confirmed, with shallow-water species and common contributors to beach wrack (Kirkman and Kendrick 1997) predominating records. *D. potatorum* (bull kelp) had the broadest reported application, with uses in roofing material for shelters, footwear, moulding of cups and water-carriers, and a ‘highly nutritious’ food that was suitable for preservation and transport. The shallow-subtidal species *Cystophora torulosa* and *Acrocarpia paniculata* (as *Cystophora paniculata* (Guiry and Guiry 2017)) were also mentioned. Recent preliminary research has shown both *D. potatorum* and *C. torulosa* scored highly on palatability tests and are nutritionally rich, warranting further investigation as potential contemporary food sources (Skrzypczyk et al. unpublished data) and *C. torulosa* has promising antimicrobial properties (Reichelt and Borowitzka 1984). *D. potatorum* has also been harvested from beach wrack on King Island, Tasmania, since 1973 for commercial extraction of alginates (Kirkman and Kendrick 1997). Whilst attribution to use by Indigenous Australians is ambiguous in the archival records (Maiden 1889; Irvine 1957), the red algal carrageenophyte *Betaphycus speciosus* (as *Eucheuma speciosa* (Guiry and Guiry 2017)) was recorded as being used in the late 1800’s as a food for making jelly, and in construction for size and cement; presumably by virtue of the gelling capacity of the sulphated polysaccharides in the cell walls of this species that would assist in bonding the cement and rendering walls of dwellings. Recent preliminary trials to use alginates derived from Australian brown algae in carbon-sequestering-bricks for construction effectively build on this premise (ABC Catalyst *Can seaweed save the world?*).

Future research needs

This research is a first step in understanding the historical uses and significance of seaweed to Indigenous Australian societies. Given our methodological approach the results, however, were largely limited to Western, colonial perspectives, with Indigenous perspectives only being recorded in more recent literature. Given the limitations in the archival sources, and that ecological knowledge in Indigenous Australian cultures is traditionally handed down through oral teachings (Horstman and Wightman 2001), interviews with Traditional Owners/Guardians and the collation of oral histories using established methods (Arbon 2008; Martin 2008; Wilson 2008; Yunkaporta 2010; Smith 2012; Rose 2017) is a clear next step towards eliciting a comprehensive understanding of the nature and variety of uses of seaweed by Indigenous Australian peoples. The historical

dispossession of Indigenous nations from their ancestral lands may mean that much traditional ecological knowledge has already been lost from many communities. Moreover, historical devaluation of traditional ecological knowledge has also resulted in researchers recording or using Indigenous knowledge without appropriate consent or acknowledgement (Wynberg et al. 2009). Therefore, documentation and synthesis of remaining knowledge should be performed with Indigenous communities’ informed consent, and preferably with the communities as active, equal partners in the process of data collection and distribution (Horstman and Wightman 2001), and subsequent potential commercial application of their knowledge (e.g. Ball and Janyst 2008; Hudson 2009). As the importance and use of seaweed was likely to vary among communities (depending on the availability of other resources and geographical distributions of temperate seaweed species (Phillips 2001)), further research could initially be focused upon communities and/or language groups that have known words for seaweed, or who maintain traditional cultural practises focused upon seaweed. Moreover, given that the currently increasing interest in expanding the temperate Australian aquaculture industry to include seaweeds (including in an integrated multi-trophic aquaculture setting) is focused around Victoria, Tasmania and South Australia (with financial and in-kind support from the shellfish and fin-fish growers, State governments and regulators), involving Indigenous communities in the seaweed-industry development stages in these regions has the greatest potential to lead to both positive outcomes for the industry and business/economic opportunities for coastal Indigenous communities in south-eastern Australia.

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References

- Aboriginal Art Directory (2014) Jenny Crompton wins Victoria's richest Indigenous art award. <https://news.aboriginalartdirectory.com/2014/08/jenny-crompton-wins-victorias-richest-Indigenous-art-award.php>. Accessed 10 Oct 2017
- Akerman K (2005) Shoes of invisibility and invisible shoes: Australian hunters and gatherers and ideas on the origins of footwear. *Aust Aborig Stud* 2:55–64
- Angas G (1847) *South Australia illustrated*. Thomas McLean, London
- Arbon V (2008) *Arlathirnda Ngurkamda Ityimda: being-knowing-doing: de-colonising Indigenous tertiary education*. PostPressed, Teneriffe
- Australia ICOMOS (2013) *The Burra Charter: the Australia ICOMOS charter for places of cultural significance*. Australia ICOMOS. <http://australia.icomos.org/publications/charters/>. Accessed 15 December 2017
- Australian Government (2017) National heritage places—Budj Bim national heritage landscape. <http://www.environment.gov.au/heritage/places/national/budj-bim>. Accessed 15 December 2017
- Backhouse J (1843) *A narrative of a visit to the Australian colonies*. Adams and Co., London
- Ball J, Janyst P (2008) Enacting research ethics in partnerships with Indigenous communities in Canada: “do it in a good way”. *J Empir Res Hum Res Ethics* 3:33–51
- Barker T, Ross A (2003) Exploring cultural constraints: the case of sea mullet management in Moreton Bay, South East Queensland, Australia. In: Haggan N, Brignall C, Wood L (eds) *Putting fishers' knowledge to work*, University of British Columbia, Vancouver, 2003. Fishers Centre research report 11, British Columbia, Vancouver, pp 290–305
- Bell D (1998) *Ngarrindjeri Wurruwarrin: a world that is, was, and will be*. Spinifex Press, North Melbourne
- Berkes F, Colding J, Folke C (2000) Rediscovery of traditional ecological knowledge as adaptive management. *Ecol Appl* 10:1251–1262
- Berndt R, Berndt C, Stanton J (1993) *A world that was: the Yaraldi of the Murray River and the lakes, South Australia*. Miegunyah Press / Melbourne University Press, Melbourne
- Bonney N (1994) *Uses of native plants in the south east of South Australia by the Indigenous peoples before 1839*. South East Book Promotion Group, Naracoorte
- Bonney N (2004) *Common native plants of the Coorong region: identification, propagation, historical use*. Australia plants society (SA region) Inc., Unley
- Bouga M, Combet E (2015) Emergence of seaweed and seaweed-containing foods in the UK: focus on labeling, iodine content, toxicity and nutrition. *Foods* 4:240–253
- Briggs C (2008) *The journey cycles of the Boonwurrung: stories with Boonwurrung language*. Victorian Aboriginal Corporation for Languages, Melbourne
- Bryden W (1974) *Aborigines*. In: Williams WD (ed) *Biogeography and ecology in Tasmania*. Springer, Dordrecht, pp 417–433
- Cawthorne W (1858) *The legend of Kupirri or the red kangaroo: an Aboriginal tradition of the Port Lincoln tribe*. JH Lewis Printer, Adelaide
- Chiovitti A, Kraft GT, Bacic A, Liao M-L (2001) Gelling polysaccharides from Australian seaweeds: research and potential. *Mar Freshw Res* 52:917–935
- Clarke P (1995) Myth as history: the Ngurunderi mythology of the Lower Murray, Kenthurst. *Rec S Aust Mus (Adel)* 28:143–157
- Clarke P (2008a) Aboriginal healing practices and Australian bush medicine. *J Anthropol Soc S Aust* 33:3–38
- Clarke P (2008b) *Aboriginal plant collectors: botanist and Australian Aboriginal people in the nineteenth century*. Rosenberg Publishing, Dural
- Clarke P (2012) *Australian plants as Aboriginal tools*. Rosenberg Publishing, Kenthurst
- Clarke P (2015a) The Aboriginal ethnobotany of the south east of South Australia region. Part 1: seasonal life and material culture. *Trans Roy Soc S Aust* 139:216–246
- Clarke P (2015b) The Aboriginal ethnobotany of the south east of South Australia region. Part 2: foods, medicines and narcotics. *Trans Roy Soc S Aust* 139(2):247–272
- Clarke P (2015c) The Aboriginal ethnobotany of the south east of South Australia region. Part 3: mythology and language. *Trans Roy Soc S Aust* 139:273–305
- Clarkson C, Jacobs Z, Marwick B, Fullagar R, Wallis L, Smith M, Roberts RG, Hayes E, Lowe K, Carah X, Florin SA, McNeil J, Cox D, Arnold LJ, Hua Q, Huntley J, Brand HEA, Manne T, Fairbairn A, Shulmeister J, Lyle L, Salinas M, Page M, Connell K, Park G, Norman K, Murphy T, Pardoe C (2017) Human occupation of northern Australia by 65,000 years ago. *Nature* 547:306–310
- Cornish ML, Critchley AT, Mouritsen OG (2015) A role for dietary macroalgae in the amelioration of certain risk factors associated with cardiovascular disease. *Phycologia* 54:649–666
- Dawson J (1881) *Australian aborigines: the languages and customs of several tribes of aborigines in the western district of Victoria*. George Robinson, Melbourne
- Deamaley J (2014) *Wathaurong medicinal plant walk*. Deakin University, Geelong
- Deamaley J (2015) Obituary: librarian became expert in Indigenous culture—Louis lane, Amateur archaeologist 29–8-1919 - 4-1-2015 *The Age* 7 April,
- Duarte CM, Wu J, Xiao X, Bruhn A, Krause-Jensen D (2017) Can seaweed farming play a role in climate change mitigation and adaptation? *Front Mar Sci* 4(100). <https://doi.org/10.3389/finars.2017.00100>
- Ens EJ, Pert P, Clarke PA, Budden M, Clubb L, Doran B, Douras C, Gaikwad J, Gott B, Leonard S, Locke J, Packer J, Turpin G, Wason S (2015) Indigenous biocultural knowledge in ecosystem science and management: review and insight from Australia. *Biol Conserv* 181:133–149
- Ens E, Walsh F, Clarke P (2017) Aboriginal people and Australia's vegetation: past and current interactions. In: Keith D (ed) *Australian vegetation*, 3rd edn. Cambridge University Press, Cambridge, pp 89–112
- FAO (2016) *FAO yearbook. Fisheries and Aquaculture statistics 2014. Food and Agriculture Organization of the United Nations, Rome*. http://www.fao.org/fishery/static/Yearbook/YB2014_CD_Master/navigation/index_intro_e.htm
- FAT, WMAC (2004) *Kooyong Sea country plan*. Framlingham Aboriginal Trust (FAT) and Winda Mara Aboriginal Corporation (WMAC), Purnim
- Fleming A, Petheram L, Stacey N (2015) Australian Indigenous women's seafood harvesting practices and prospects for integrating aquaculture. *J Enterp Communities: People Places Global Econ* 9:156–181
- Fraser CI, Winter DJ, Spencer HG, Waters JM (2010) Multigene phylogeny of the southern bull-kelp genus *Durvillaea* (Phaeophyceae: Fucales). *Mol Phylogeny Evol* 57:1301–1311
- Gaughwin D, Sullivan H (1984) Aboriginal boundaries and movements in Western Port, Victoria. *Aborig Hist* 8:80–98
- Godfray H CJ, Beddington JR, Crute IR, Haddad L, Lawrence D, Muir JF, Pretty J, Robinson S, Thomas SM, Toulmin C (2010) Food security: the challenge of feeding 9 billion people. *Science* 327:812–818

- Gott B (1985) Plants mentioned in Dawson's "Australian Aborigines". *Artefact* 10:3–14
- Gott B, Conran J (1991) Victorian Koorie plants. Aboriginal Keeping Place, Hamilton
- Guiry MD, Guiry GM (2017) AlgaeBase. World-wide electronic publication. National University of Ireland. <http://www.algaebase.org>. Accessed 1 September 2017
- Heyes S (1999) The Kaurna calendar: seasons of the Adelaide Plains. University of Adelaide, Adelaide
- Hiatt B (1967) The food quest and the economy of the Tasmanian Aborigines. *Oceania* 38:99–133
- Hope G, Coutts P (1971) Past and present food resources at Wilson's promontory. *Mankind* 8:104–114
- Horstman M, Wightman G (2001) Karpanti ecology: recognition of Aboriginal ecological knowledge and its application to management in north-western Australia. *Ecol Manag Restor* 2:99–109
- Hudson M (2009) Think globally, act locally: collective consent and the ethics of knowledge production. *Int Soc Sci J* 60:125–133
- Hunter A (2007) The origin and debate surrounding the development of Aboriginal evidence acts in Western Australia in the early 1840s. *Univ Notre Dame Australia Law Rev* 9:115–146
- Hutchings S, Morrison A (2017) Indigenous knowledges: introduction. In: Hutchings S, Morrison A (eds) *Indigenous knowledges: proceedings of the water sustainability and wild fire mitigation symposia 2012 and 2013*. University of South Australia, Adelaide, pp 1–21
- ICSU (2002) Science and traditional knowledge: report from the ICSU study group on science and traditional knowledge. International Council for Science (ICSU) / Conseil international pour la science, Paris
- Irvine F (1957) Wild and emergency foods of Australian and Tasmanian aborigines. *Oceania* 28:113–142
- Jones D, Clarke P (2018) Aboriginal culture and food-landscape relationships in Australia: Indigenous knowledge for country and landscape. In: Zeunert J, Waterman T (eds) *Routledge handbook to landscape and food*. Routledge, London, pp 41–60
- Jones D, Low Choy D, Tucker R, Heyes S, Revell G, Bird S (2017) Indigenous knowledge in the built environment: a guide for tertiary educators. Australian Government Department of Education and Training, Canberra
- Kim JK, Yarish C, Hwang EK, Park M, Kim Y (2017) Seaweed aquaculture: cultivation technologies, challenges and its ecosystem services. *Algae* 32:1–13
- Kirkman H, Kendrick GA (1997) Ecological significance and commercial harvesting of drifting and beach-cast macro-algae and seagrasses in Australia: a review. *J Appl Phycol* 9:311–326
- Konishi S (2008) "Inhabited by a race of formidable giants": French explorers, aborigines, and the endurance of the fantastic in the Great South Land, 1803. *Aust Humanit Rev* 44:7–22
- Layton R (1992) *Australian rock art: a new synthesis*. Cambridge University Press, Cambridge
- Lee B (2010) Cultivated seaweed and seaweed industry development in Australia, Publication No. 10/164, Project No PRJ-004681. Rural Industries Research and Development Corporation, Canberra
- Lewis H (1989) Ecological and technological knowledge of fire—Aborigines versus park rangers in northern Australia. *Am Anthropol* 91:940–961
- Lie YA, Stuetz RM, Madgwick JC (1990) Australian brown seaweeds as a source of polysaccharide and inorganic elements. *Australian J Biotech* 4:279–281
- Lourandos H (1977) Aboriginal spatial organisation and population: south-western Victoria reconsidered. *Archaeol Phys Anthropol Oceania* 12:202–225
- Lourandos H (1983) Intensification: a late Pleistocene-Holocene archaeological sequence from southwestern Victoria. *Archaeol Ocean* 18: 81–94
- Loureiro R, Gachon CMM, Rebours C (2015) Seaweed cultivation: potential and challenges of crop domestication at an unprecedented pace. *New Phytol* 206:489–492
- Madgwick JC, Ralph BJ (1972) Free amino-acids in Australian marine algae. *Bot Mar* 15:205–209
- Maiden J (1889) *The useful plants of Australia (including Tasmania)*. Turner and Henderson, Sydney
- Mailhot J (1994) *Traditional ecological knowledge: the diversity of knowledge systems and their study* (translated Harvey, A). Great whale environmental assessment - background paper no 4. Great Whale Public Review Support Office, Montréal
- Martin K (2008) *Please knock before you enter: Aboriginal regulation of outsiders and the implications for research and researchers*. PostPressed, Teneriffe
- Matson-Green V, Maiden S (2008) Bernice Condie keeps her ancestors' traditions alive. ABC <http://www.abc.net.au/local/stories/2008/07/09/2298488.htm>. Accessed 10 October 2017
- McFarlane I (2002) *Aboriginal society in north west Tasmania: dispossession and genocide*. University of Tasmania, Tasmania
- McNiven I, Feldman R (2003) Ritually orchestrated seascapes: hunting magic and dugong bone mounds in Torres Strait, NE Australia. *Camb Archaeol J* 13:169–194
- Meyer H (1843) *Vocabulary of the language spoken by the aborigines of South Australia*. Allen, Adelaide
- Meyer H (1846) *Manners and customs of the aborigines of the Encounter Bay tribe*. South Australian Government, Adelaide
- Mohamed S, Hashim SN, Rahman HA (2012) Seaweeds: a sustainable functional food for complementary and alternative therapy. *Trends Food Sci Technol* 23:83–96
- Mortimer G (1791) *Observations and remarks made during a voyage to the Islands of Teneriffe, Amsterdam, Maria's Islands near Van Diemen's Land; Otaheite, Sandwich Islands; Owhyhee, the Fox Islands on the north west coast of America, Tinian, and from thence to Canton, in the Brig Mercury, commanded by John Henry Cox Esq. Cadell*, London
- Mouritsen OG (2017) Those tasty weeds. *J Appl Phycol* 29:2159–2164
- National Museum of Australia (2017) *Collection explorer*. National Museum of Australia. [http://collectionsearch.nma.gov.au/ce/?f\[0\]=obj_party_name%3AVicki%20West&solrsort=random%20asc](http://collectionsearch.nma.gov.au/ce/?f[0]=obj_party_name%3AVicki%20West&solrsort=random%20asc). Accessed 9 October 2017
- National Ocean Office (2002) *Sea country—an Indigenous perspective: south-east regional marine plan assessment reports*. National Oceans Office, Hobart
- Nelson N (2013) Protecting the sanctity of native foods. In: *Worldwatch Institute (ed) State of the World 2013*. Island Press, Washington, DC., pp 201–209
- Ngarrindjeri Tendi, Ngarrindjeri Heritage Committee, Ngarrindjeri Native Title Management Committee (2006) *Ngarrindjeri Nation Yarlular-Ruwe Plan: Caring for Ngarrindjeri Sea Country and Culture - Kungun Ngarrindjeri Yunnan (Listen to Ngarrindjeri People Talking)*. Ngarrindjeri Tendi, Ngarrindjeri Heritage Committee & Ngarrindjeri Native Title Management Committee, Meningie, SA
- Niewójt L (2009) Gadubanud society in the Otway ranges, Victoria: an environmental history. *Aborig Hist* 33:175–199
- O'Brien L (2017) Aboriginal ways of thinking and sustainability. In: Hutchings S, Morrison A (eds) *Indigenous knowledges: proceedings of the water sustainability and wild fire mitigation symposia 2012 and 2013*. University of South Australia, Adelaide, pp 22–33
- Oates A (1977) *Plant food utilization by Victorian aborigines*. LaTrobe University, Bundoora
- Oates A, Seeman A (1979) *Victorian aborigines: plant foods*. National Museum of Victoria, Melbourne
- O'Connell-Milne SA, Hepburn CD (2015) A harvest method informed by traditional knowledge maximises yield and regeneration post harvest for karengo (Bangiaceae). *J Appl Phycol* 27:447–454

- Ogle N (1839) The Colony of Western Australia: a manual for emigrants to that settlement or its dependencies. James Fraser, London
- Panangharry (1903) Early recollections of Glencoe, Lake Leake, and the South-East No.5. Border Watch, 1 August
- Pascoe B (2007) Convincing ground: learning to fall in love with your country. Aboriginal Studies Press, Canberra
- Phillips JA (2001) Marine macroalgal biodiversity hotspots: why is there high species richness and endemism in southern Australian marine benthic flora? *Biodivers Conserv* 10:1555–1577
- Plomley B, Cornell C, Banks M (1990) Francois Péron's natural history of Maria Island, Tasmania. *Rec Queen Vic Mus* 99:1–50
- Porse H, Rudolph B (2017) The seaweed hydrocolloid industry: 2016 updates, requirements, and outlook. *J Appl Phycol* 29:2187–2200
- Redmond S, Green L, Yarish C, Kim J, Neefus C (2014) New England seaweed culture handbook-nursery systems. Connecticut Sea Grant CTSG-14-01,
- Reichelt JL, Borowitzka MA (1984) Antimicrobial activity from marine algae: results of a large-scale screening programme. *Hydrobiologia* 116/117:158–168
- Rhodes D, Bell J (2004) Shire of Cardinia urban growth corridor Aboriginal heritage study: report to the Shire of Cardinia. Heritage Insight, Richmond
- Rose M (2017) The black academy: a renaissance seen through a paradigmatic prism. In: Ling I, Ling P (eds) *Methods and paradigms in education research*. IGI Global, Philadelphia, pp 326–343
- Ross P (2009) Ngarrindjeri fish traps of the Lower Murray Lakes and Northern Coorong Estuary, South Australia. M Maritime Archaeol Thesis, Flinders University, South Australia
- Ross A, Pickering Sherman K, Snodgrass J, Delcore H, Sherman R (2011) Indigenous peoples and the collaborative stewardship of nature: knowledge binds and institutional conflicts. Left Coast Press, Routledge., Walnut Creek
- Schmidhuber J, Tubiello FN (2007) Global food security under climate change. *Proc Nat Acad Sci* 104:19703–19708
- Smith L (2012) *Decolonising methodologies: research and Indigenous peoples*, 2nd edn. Zed Books, London
- Sondak CFA, Ang PO, Beardall J, Bellgrove A, Boo SM, Gerung GS, Hepburn CD, Hong DD, Hu Z, Kawai H, Largo D, Lee JA, Lim P-E, Mayakun J, Nelson WA, Oak JH, Phang S-M, Sahoo D, Peerapornpis Y, Yang Y, Chung IK (2017a) Carbon dioxide mitigation potential of seaweed aquaculture beds (SABs). *J Appl Phycol* 29:2363–2373
- Sondak CFA, Ang PO, Beardall J, Bellgrove A, Boo SM, Gerung GS, Hepburn CD, Hong DD, Hu Z, Kawai H, Largo D, Lee JA, Lim P-E, Mayakun J, Nelson WA, Oak JH, Phang S-M, Sahoo D, Peerapornpis Y, Yang Y, Chung IK (2017b) Erratum to: carbon dioxide mitigation potential of seaweed aquaculture beds (SABs). *J Appl Phycol* 29:2375–2376
- Sullivan H (1981) An archaeological survey of the Mornington Peninsula, Victoria. Ministry for Conservation, Victoria
- Sutherland JE, Lindstrom SC, Nelson WA, Brodie J, Lynch MDJ, Hwang MS, Choi H-G, Miyata M, Kikuchi N, Oliveira MC, Farr T, Neefus C, Mols-Mortensen A, Milstein D, Müller KM (2011) A new look at an ancient order: generic revision of the Bangiales (Rhodophyta). *J Phycol* 47:1131–1151
- Terra Culture (2012) *Aboriginal cultural heritage conservation manual: GORCC crown land reserves between Torquay and Lorne*. Terra Culture, Northcote
- Turner NJ (2003) The ethnobotany of edible seaweed (*Porphyra abbottae* and related species; Rhodophyta : Bangiales) and its use by First Nations on the Pacific coast of Canada. *Can J Bot* 81:283–293
- Vigilante T, Toohey J, Gorrang A, Blundell V, Saunders T, Mangolamara S, George K, Oobagooma J, Waina M, Morgan K, Doohan K (2013) Island country: aboriginal connections, values and knowledge of the Western Australian Kimberley islands in the context of an island biological survey. *Rec West Aust Mus Suppl* 81:145–182
- Wilson S (2008) *Research is ceremony: Indigenous research methods*. Fernwood Publishing, Black Point
- Winberg PC, Skropeta D, Ullrich A (2011) Seaweed cultivation pilot trials—towards culture systems and marketable products. RIRDC Publication No. 10/184. PRJ - 000162
- Womersley HBS (1987) *The marine benthic flora of southern Australia, part II*. South Australian Government Printing Division, Adelaide
- Wynberg R, Schroeder D, Chennells R (2009) *Indigenous peoples, consent and benefit sharing: lessons from the San-Hoodia case*. Springer, New York
- Yunkaporta T (2010) Our ways of learning in Aboriginal languages. In: Hobson J, Lowe K, Poetsch S, Walsh M (eds) *Re-awakening languages: theory and practice in the revitalisation of Australian's Indigenous languages*. Sydney University Press, Sydney, pp 37–49
- Yunupingu D, Muller S (2009) Cross-cultural challenges for Indigenous sea country management in Australia. *Australas J Environ Manag* 16:158–167
- Zhang J, Ji Q, Shen X, Xia Y, Tan L, Kong Q (2011) Pyrolysis products and thermal degradation mechanism of intrinsically flame-retardant calcium alginate fibre. *Polym Degrad Stab* 96:936–942
- Zola N, Gott B (1992) *Koorie plants Koorie people: traditional Aboriginal food, fibre and healing plants of Victoria*. The Koorie Heritage Trust, Melbourne

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