

## 1 **Aboriginal uses of seaweeds in temperate Australia: an archival assessment**

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40

41 **Abstract:** Global demand for seaweed has increased dramatically over recent decades and the  
42 potential for seaweed aquaculture to address issues around food security and climate-change  
43 mitigation are being recognised. Australia is a global hotspot for seaweed biodiversity with a  
44 rich, diverse Indigenous history dating back 65,000 years, including an extensive traditional  
45 knowledge of Australian natural resources. In our present review of archival literature, we  
46 explored the contemporary and historical uses and cultural significance of seaweeds to  
47 Indigenous Australians. We found records of seaweed use by Indigenous Saltwater  
48 Australians for a variety of purposes including: cultural activities, ceremonial activities,  
49 medicinal uses, clothing, cultural history, food, fishing, shelter and domestic uses. Species-

50 specific records were rarely recorded (and/or accurately translated) in the archival literature,  
51 with the exception of the use of the fucoid bull kelp, *Durvillaea potatorum*, which was  
52 prevalent. Our research is a step forward in the important task of recovering and conserving  
53 Indigenous Australian knowledge and customary traditions surrounding coastal resource use.  
54 Unlocking this knowledge creates opportunities for the continuance and revitalization of  
55 traditional customary practices that may enable innovative Indigenous business activities and  
56 product creation, based around food, sustainable natural-fibre technologies and health. Such  
57 research also has the potential to enhance a developing Australian seaweed industry by  
58 guiding species selection, preparation, use and sustainable resource management. We  
59 recommend our findings are used to inform the direction and locations of further research  
60 conducted in conjunction with Indigenous coastal communities in Australia's temperate  
61 regions, to explore in more detail the Indigenous Australian's historical heritage associated  
62 with coastal seaweed resources and their uses.

63 **Keywords:** historical ecology, Indigenous knowledge, macroalgae, traditional ecological  
64 knowledge, TEK, seaweed industry

## 65 **Introduction**

66 Increasing recognition in Western cultures of the health and nutritional benefits of eating  
67 seaweeds (Cornish *et al.* 2015), alongside growth of the Western wholefood movement and  
68 seaweed-based hydrocolloid industry (Bouga and Combet 2015; Mouritsen 2016; Porse and  
69 Rudolph 2017), have in part driven a dramatic increase in global production of seaweed.  
70 There is also growing recognition that the production of seaweeds for food and other  
71 commercial applications represents part of a viable solution for climate-change mitigation,

72 without compromising the availability of agricultural land and water resources (Duarte et al.  
73 2017; Sondak et al. 2017a, b). Annual production of seaweeds has more than doubled in the  
74 past 10 years, with global harvests now exceeding 28 Mt wet weight (83% for human  
75 consumption (Loureiro et al. 2015)) valued at > US\$6 billion (FAO 2016). While production  
76 is firmly centred on the Asian Pacific and species found in this region (Sondak et al. 2017a,  
77 b), the taxonomically-related northern hemisphere seaweed flora of Western European  
78 countries, the USA and Canada, has facilitated rapid expansion of seaweed aquaculture into  
79 these regions, with application of culture techniques developed in Asia (Redmond et al. 2014;  
80 Kim et al. 2017).

81 Southern Australia is a global hotspot of seaweed biodiversity with the highest level of  
82 endemism (~ 60%) globally (Phillips 2001 and Womersley's extensive works cited therein),  
83 yet none of the commercially cultured seaweed species occur naturally in Australia.  
84 Increasing concerns about global food security (Godfray et al. 2010), climate change  
85 (Schmidhuber and Tubiello 2007; Sondak et al. 2017a, b) and increasing demand for seaweed  
86 products (Mohamed et al. 2012; Porse and Rudolph 2017), suggests further investigation into  
87 the aquaculture potential of the diverse southern Australian seaweed flora is warranted (Lee  
88 2010; Winberg et al. 2011; Skrzypczyk et al. in review). However, an incomplete knowledge  
89 of the palatability, culture techniques, viable markets, nutritional value and potential toxicity  
90 of Australian species currently limits commercial exploitation.

91 Research from around the world has shown that the inclusion of traditional ecological  
92 knowledge in modern natural resource management leads to an increase in favourable  
93 economic, environmental and social outcomes for industries and communities involved  
94 (Berkes et al. 2000; Horstman and Wightman 2001; Ross et al. 2011). Australian Aboriginal

95 culture is a living culture, not a historical culture. It includes Indigenous knowledge and  
96 traditional ecological knowledge. ‘Indigenous knowledge’, in Australia, is both a philosophy  
97 or a way of thinking by Indigenous peoples, as well as Indigenous environmental knowledge  
98 (Berndt et al. 1993; Briggs 2008; Clarke 2015a, b, c; Ens et al. 2015; Ens et al. 2017; Jones et  
99 al. 2017; O’Brien 2017; Jones and Clarke 2018). Over the past few decades, Indigenous  
100 knowledge systems in Australia have been described using various descriptors, such as  
101 ‘traditional knowledge’ (TK), ‘traditional ecological knowledges’ (TEK) and ‘local  
102 knowledges’ (Hutchings and Morrison 2017). Writing on First Nation knowledge in Canada,  
103 ethnolinguist Mailhot (1994 ) explains, that this is “...the sum of the data and ideas acquired  
104 by a human group on its environment as a result of the group’s use and occupation of a region  
105 over very many generations”. Similarly, the International Council of Science (ICSU 2002)  
106 defines ‘traditional knowledges’ as “... a cumulative body of knowledge, know-how,  
107 practices and representations maintained and developed by peoples with extended histories of  
108 interaction with the natural environment. These sophisticated sets of understandings,  
109 interpretations and meanings are integral to a culture that encompasses language, naming and  
110 classification systems, resource use practices, ritual, spirituality and worldview. We also view  
111 that research with Indigenous peoples in Australia is an avenue towards conserving their  
112 living cultural knowledge, rather than preserving their cultural knowledge” (Australia  
113 ICOMOS 2013).

114 Many Indigenous Australians, often termed ‘Saltwater people’, resided in Australia’s coastal  
115 areas and represent the longest continuous cultural history in the world, dating back 65,000  
116 years (Clarkson et al. 2017). The term ‘Saltwater people’ does not relate only to Indigenous  
117 peoples from northern Australia, but rather, under Indigenous Australians’ interpretations, the  
118 terminology refers to Australian Aboriginal peoples from coastal areas across the nation who

119 are the Traditional Owners/Guardians and custodians of the lands and waters characterised by  
120 saltwater environments. There are over 250 known Australian Indigenous languages across  
121 the nation (AIATSIS 2017), and as a consequence each saltwater Indigenous culture group  
122 has a *Country*-specific relationship to their particular lands and waters of which language is  
123 integral in this relationship (e.g. the *Gunditjmara* peoples will have different words and  
124 cultural associations to seaweed as distinct from the *Boon Wurrung* peoples some 250  
125 kilometres away). Thus there is both extensive diversity in seaweeds and extensive diversity  
126 of Indigenous culture groups (centred around language groups) in Australia, and with this  
127 diverse Indigenous history comes a culture of rich traditional ecological knowledge. Further,  
128 because traditional ecological knowledge varies from one Indigenous *Country* to another, a  
129 generic ‘Indigenous Australian’ language does not exist and similarly generic knowledge  
130 about seaweed will not exist because it is *Country*-specific.

131 The contemporary and historical uses and cultural significance of coastal resources, such as  
132 shellfish, marine mammals and finfish, to Aboriginal communities have been studied in a  
133 variety of locations around Australia (e.g. Barker and Ross 2003; McNiven and Feldman  
134 2003; Fleming et al. 2015); however, Aboriginal uses of seaweeds have been less  
135 documented. Australia also has a long history of devaluing and dismissing Indigenous  
136 knowledge as ‘simple’ or ‘primitive’ (Lewis 1989), and marginalising and discriminating  
137 against Indigenous peoples (Hunter 2007). As a result, much traditional knowledge  
138 surrounding coastal resource use has been lost from Indigenous communities. Examination of  
139 archival sources is thus one route to rediscovering and subsequently conserving Indigenous  
140 knowledge. Unlocking this knowledge may also create opportunities for the continuance or  
141 revival of traditional customary practices that can enable innovative Indigenous (and  
142 Indigenous + non-Indigenous co-operative) business activities and product creation, based

143 around food, sustainable natural-fibre technologies and human and animal health. Finally, a  
144 developing temperate Australian seaweed industry may benefit from understanding the  
145 species of seaweeds that were traditionally used by Saltwater peoples, what they were used  
146 for and how they were prepared, and how the resources were managed.

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

## 158 **Methods**

### 159 **Sources searched**

160 Searches for descriptions of Australian Indigenous uses of seaweed were conducted using  
161 online databases, state and academic library catalogues. Subject-specific knowledge of  
162 several co-authors (DJ, JD, EC) was also used to identify additional references that may  
163 include seaweed-related uses by Indigenous Australians, but which do not have an online  
164 presence (e.g. unpublished academic/archival collections), or which would likely be missed

165 using seaweed/macroalgal-related keyword searches. References searched in these contexts  
166 included unpublished ethnobotanical inventories, unpublished academic theses, and  
167 Aboriginal writings known to the authors. To maximise early observations of Indigenous  
168 activities, our searches specifically aimed to include non-academic sources such as  
169 newspapers, books and personal accounts such as diaries. Search terms were chosen that  
170 reflected the type of articles held by each online database (e.g. scientific, anthropological or  
171 popular media articles) and that were deemed most likely to elicit articles relevant to  
172 Indigenous use of seaweeds, past and present, including historical spelling variations (Table  
173 1; Table S1). Only Australian Indigenous uses were catalogued for this study; non-  
174 Indigenous use or reference to Indigenous use in other nations were disregarded. Both  
175 primary (e.g. direct observations) and secondary sources (e.g. reference to an earlier  
176 publication or records of observations by another party) were collated, but where possible,  
177 secondary sources were traced back to the primary source and the original publication  
178 substituted. Where it was obvious that an earlier observation was being repeated without  
179 appropriate referencing of the primary source, the earliest-dated observation was used and  
180 later or indirect reference(s) discarded. All results returned from the searches were explored  
181 in full, with the exception of Google Scholar. In this case, articles were sorted by ‘relevance’  
182 and article exploration was halted when no new information had been extracted from 50  
183 consecutive individual article searches.

#### 184 **Categorisation of articles**

185 Once individual articles had been collated, the descriptive information was categorised using  
186 a content analysis approach. For each article, the activity/activities referring to the use of  
187 seaweed were extracted and categories were subsequently developed to capture the range of



188 seaweed-related uses and/or activities mentioned in the archival sources. Locations where the  
189 observation occurred were identified where possible (most commonly to state-level, but  
190 occasionally Indigenous nation/group/clan names were provided). Where physical  
191 descriptions and/or names of seaweeds were provided, these were used to identify the family,  
192 genus or species being used by the last author (AB), a macroalgal specialist, with reference to  
193 Womersley (1987) and AlgaeBase (Guiry and Guiry 2017), and assistance from highly  
194 regarded phycologists in Australia (JA Lewis and GT Kraft).

195 **\*Table 1 here**

## 196 **Results**

### 197 **Literature sources examined**

198 Existing literature references can be broken into colonial narratives and recollections,  
199 contemporary syntheses, contemporary Aboriginal writings and *Land and Sea Country*  
200 management plans. Period inquiries tended to be included within diaries, travel journals, and  
201 popular media such as newspapers and narratives often involving direct observations of, and  
202 conversations with, Aboriginal people harvesting and using plant materials, and inventories  
203 of Indigenous names and words. Contemporary disciplines that have explored Aboriginal  
204 natural resource use include archaeology, the social sciences, landscape architecture,  
205 ethnobotany and anthropology. While recorded uses of terrestrial plants by Aboriginal  
206 peoples are numerous and knowledge of specific Indigenous nations/peoples are widely  
207 recorded (e.g. Hope and Coutts 1971; Sullivan 1981; Gaughwin and Sullivan 1984; Rhodes  
208 and Bell 2004 on *Boon Wurrung Country*; Niewójt 2009 on *Gadubanud Country*; Terra  
209 Culture 2012; Dearnaley 2014; 2015 on *Wadawurrung Country*; Clarke 2008a, b, 2015a, b, c;

210 Jones and Clarke 2018 on *Kaurna* and *Ngarrindjeri Country*; Oates 1977; Oates and Seeman  
 211 1979; Gott 1985; Gott and Conran 1991; Zola and Gott 1992; Bonney 1994, 2004), with  
 212 occasional exceptions (e.g. Lane 1975, 1980, 1996; Heyes 1999), seaweed is rarely  
 213 mentioned in this literature.

214 Contemporary academic Aboriginal-authored or direct-participatory recollections, narratives  
 215 and ‘yarning circles’ (Arbon 2008; Martin 2008; Wilson 2008; Yunkaporta 2010; Smith  
 216 2012; Rose 2017), and *Land and Sea Country* management plans (FAT and WMAC 2004;  
 217 Jones and Clarke 2018) also offered little insight into the history and current relationships and  
 218 practices to seaweed. *Sea Country* management plans, a recent recognition of the *Sea*  
 219 *Country* custodian responsibilities of various communities, have prioritised sustainable  
 220 management of sea resources and waters aligned to traditional perspectives (National Ocean  
 221 Office 2002). Strategies by the *Ngarrindjeri* people of The Coorong region in South Australia  
 222 (Ngarrindjeri Tendi et al. 2006) and *Gunditjmarra* people of south-western Victoria (FAT and  
 223 WMAC 2004), that includes the Budj Bim National Heritage Landscape (Australian  
 224 Government 2017), offer narratives of close relationships to their respective *Sea Country*’s  
 225 but little specific guidance as to seaweed use, harvesting or management. The *Gunditjmarra*  
 226 (FAT and WMAC 2004) have noted that “Indigenous organisations are investing in and  
 227 operating commercial ventures based on currently unexploited marine resources such as  
 228 velvet crabs, sea urchins, kelp, sea weed and sea grasses, bait aquaculture and whale tourism”  
 229 but have little explained the significance of seaweed in their *Country*.

### 230 **Indigenous seaweed use recorded in the literature**

231 In total, co-authors’ subject-specific knowledge and the database searches uncovered 77  
 232 sources that provided descriptions or recorded observations of Indigenous Australian seaweed

233 use and nomenclature (SOM 2). Nearly half (49%) of these records were sourced from  
 234 newspaper reports or magazines. The rest were sourced from academic literature (published  
 235 and unpublished), popular narratives, online resources or monographs. Once categorised,  
 236 these provided 92 descriptions of seaweed-related uses, names and/or activities involving  
 237 seaweed. Publications spanned 183 years, from 1834 to 2017, although a source from as early  
 238 as 1791 was referenced by one author. Sources included descriptions from early explorers,  
 239 anthropologists, natural scientists and contemporary Indigenous authors. However,  
 240 Indigenous voices were not represented within the historical literature, which was instead  
 241 dominated by observations of Indigenous use and subsequent interpretations by colonial  
 242 authors, the vast majority of which were male (Table 2). All Australian states and territories  
 243 (with the exception of the Australian Capital Territory) were represented. Activities  
 244 mentioning seaweed use were most commonly reported for South Australia and Tasmania  
 245 (30% and 24% of reports, respectively). Activities/reports of seaweed use were sorted into  
 246 the following categories: cultural activities, ceremonial activities, medicinal use, clothing,  
 247 cultural history, diet, fishing, language/nomenclature and shelter/domestic use. These  
 248 categories are explored in detail below.

#### 249 **Cultural activities and cultural history**

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

254 *“Alf Watson said reference was being made indirectly to the area of still water in the sea*  
 255 *at Cape Jaffa. Great mats of sea-weed calm the waves along the shore at Kingston and*

256           *at Cape Jaffa. This sea-weed has still on it the 'ears' left by the nephews of Ngurunderi."*  
 257           Tindale (1934-37).

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

### 267   **Ceremonial activities**

268   References to ceremonial activities ranged from the year 1933 to 2013, comprising 8% of  
 269   articles. Seaweed was recorded as being burned or being used to make smoke during  
 270   ceremonial events, and was also burnt during daily rituals (Table 2). While most references to  
 271   these activities did not explain their significance, one contemporary source referred to the  
 272   ritualistic use of smoke (generated by either green leaves or seaweed being placed on top of a  
 273   fire) to "eliminate strange scents from the visitors which allows the country to recognise  
 274   them" (Vigilante et al. 2013). This smoking is analogous to the Australian Aboriginal  
 275   contemporary and historical burning of *Eucalyptus* spp. leaves to cleanse the air of evil spirits  
 276   before an event or meeting commenced or commences.

### 277   **Medicinal use**

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

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

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

## 290 **Clothing**

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

295 Angas (1847) produced a drawing of an Indigenous man from South Australia wearing an  
 296 ornately designed cloak reported to be made of seaweed, but the species was not mentioned  
 297 and it is unclear if the cloak was made from seaweed or seagrass (or a combination of both).

298 The authors respect Indigenous Australian protocols about reproducing images and names of  
 299 Aboriginal people whom have passed so while the image is not reproduced in this article, the

300 following open access link leads to the image being discussed:

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

#### 304 **Diet**

305 The use of seaweed in diet and cooking was referenced in 13% of articles, once again  
306 spanning early European history to the present day (1834 – 2007). The majority of these  
307 references pertained to Tasmania and eating of bull kelp (presumed *D. potatorum*). Records  
308 indicate that this species was prepared for eating by initial sun-drying, followed by careful  
309 roasting over a fire where it was turned frequently and then finally soaking for 10-12 hours in  
310 freshwater before eating alone or with meat or fish (Table 2). Once bull kelp was dried and  
311 roasted it could be preserved for many months. Other references to species used for food in  
312 Tasmania included *D. antarctica* (Irvine 1957), not known to occur in Tasmania (Fraser et al.  
313 2010); *Cystophora porulosa* (Hiatt 1967), presumably a misspelling of *Cystophora torulosa*;  
314 *C. paniculata* (Hiatt 1967), now known as *Acrocarpia paniculata* (Guiry and Guiry 2017);  
315 and *Fucus palmatus* (Hiatt 1967), now known as *Palmaria palmata* (Guiry and Guiry 2017);  
316 however, this species has no known distribution in Australia, and Australian records are  
317 apparently synonymous with *D. potatorum* (Plomley et al. 1990). *Euchemia speciosa*  
318 (assumed *Eucheuma speciosum* now *Betaphycus speciosus* (Guiry and Guiry 2017) was  
319 recorded as being used by Indigenous Australians for jelly in Western Australia (Irvine  
320 1957), but the original source (Maiden 1889) is ambiguous as to whether this use was by  
321 Indigenous Australians or European settlers. Research on the *Wadawurrung* people recorded  
322 that *Ulva lactuca* and *Porphyra* sp. (or possibly *Pyropia*, Sutherland et al. 2011) were

323 foraged as vegetables, and “strings of sea grapes” (the name not given, but most likely  
 324 referring to *Hormosira banksii* – Neptune’s Necklace or *Chaetomorpha coliformis* –  
 325 Mermaids Necklace) were eaten as an accompaniment to seafood (Lane 1980).

### 326 **Fishing**

327 In addition to being eaten directly, seaweed was also used in the capture of fish and  
 328 invertebrates, referenced in 10% of articles from 1846 to the present day. Ropes and fishing  
 329 nets were observed being made from seaweed by Indigenous peoples in South Australia,  
 330 while in Tasmania, Indigenous women were observed using the attached fronds of kelp to  
 331 help pull themselves underwater while diving for crayfish (Backhouse 1843). Seaweed was  
 332 also used to line fish traps, or in some cases were likely the principal component of fish traps,  
 333 constructed to form the entrance and guiding wall of the trap (Ross 2009, Table 2). Specific  
 334 references to species are not given for these uses.

### 335 **Language/nomenclature**

336 21% of articles referred to Indigenous names for, or nomenclature highlighting the presence  
 337 of, seaweed in an area. Words for seaweed were extracted for all coastal states, although we  
 338 cannot be sure that the European interpretation of these Aboriginal words were always  
 339 accurate, particularly when these were found in popular media articles without an original  
 340 reference. Words included place names attributed to the presence or smell of seaweed, the  
 341 given names of individuals, and a variety of names referencing seaweed directly, including  
 342 (in Tasmania) different names for seaweed when raw or once dried for eating (Table 2). For  
 343 example, in contemporary *Boon Wurrung* language, ‘buath wareeny’ (pronounced as ‘boo-art  
 344 wha-reen’) means ‘grass of the sea’ (Stewart-Muir 2017, *pers. comm.*). In the *Dhauwurd*  
 345 *Wurrung* language of the *Gunditjmarra*, ‘ngapanyoong’ means ‘air vessel of seaweed’

346 (pneumatocysts); ‘ngapanyoong peek koorrook’ means ‘weed’ in / of ‘water’; ‘peek koorrook  
 347 peek’ means ‘kelp’ and also ‘saltwater algae’ but ‘peek peekoy’ is also used for ‘kelp’. The  
 348 word ‘peekoy’ is also given as ‘saltwater algae’ (Wright 2017, *pers. comm.*).

#### 349 **Shelter/domestic use**

350 Seaweed, particularly kelp, was recorded being used for a variety of domestic uses (18% of  
 351 articles), spanning the years 1842 – 2016. In Victoria and South Australia, seaweed was used  
 352 in the construction of Aboriginal coastal shelters (Cawthorne 1858, Table 2). Some shelters  
 353 in South Australia were recorded as being constructed from whale bones with seaweed used  
 354 as a waterproof and windproof covering. In the early 1800s, seaweed ‘carpeting’ was  
 355 observed in a cavern shelter (Konishi 2008). The red seaweed, *Euchemia speciosa* (assumed  
 356 *Betaphycus speciosus* as above, Guiry and Guiry 2017) was used in construction for size and  
 357 cement in Western Australia, but the archival records are ambiguous in attributing this use to  
 358 Australian Aboriginal people (Maiden 1889; Irvine 1957). However, there are records of  
 359 stone, permanent dwellings being constructed by Indigenous Australians across the volcanic  
 360 plains of Victoria. This occurred during a period of hunter-gatherer intensification between  
 361 3000 and 1000 BCE (Lourandos 1983), characterised by population growth, an increase in  
 362 human manipulation of the environment (e.g. the construction of Short-finned Eel (*Anguilla*  
 363 *australis*) traps in Victoria), an increase in trade between groups, a more elaborate social  
 364 structure, and other cultural changes (Lourandos 1977).

365 In Tasmania, kelp (most records referring to bull kelp or *D. potatorum*) was observed being  
 366 used to construct water carriers or baskets (Fig. 1) as early as 1791 (Mortimer 1791), a craft  
 367 that continues today (National Museum of Australia 2017). Lane (1975), in surveying the  
 368 *Wadawurrung* ethnobotany, and interchangeably using ‘bull’ and ‘giant’ kelp in her writings



369 to describe what is certainly *D. potatorum*, records a “water pitcher made from a broad,  
370 hollow root-stock [holdfast] of a giant kelp”, thus differing from the vessels/baskets made  
371 from the blade of this alga (Backhouse 1843, Fig. 1).

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

376 \*Table 2 here

## 377 **Discussion**

### 378 **Seaweed uses by Indigenous Australians**

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

387 In contrast to these examples, we know relatively little about the use and significance of  
388 seaweeds to Indigenous Australians. As anticipated, we found that the archival records of  
389 early Western explorers and settlers in coastal regions recorded use of seaweeds by

390 Indigenous Saltwater peoples from around Australia. Although our archival literature  
391 searches only brought up a limited number of reports of Indigenous seaweed use, it is clear  
392 from these results that seaweed played a role in the day-to-day life of Indigenous Australians  
393 across different regions of coastal Australia. Seaweed was clearly exploited as a versatile  
394 resource for a variety of uses. Additionally, the wide geographical spread of reported  
395 Indigenous Australian names for seaweed (across all states) is an indication that in pre-  
396 colonial times, Indigenous coastal communities harboured some level of traditional  
397 knowledge related to seaweed resources (Turner 2003). Our research thus points to the value  
398 of further exploration of Australian Indigenous seaweed use via oral histories for greater  
399 depth than is available in published accounts.

400 The variety of uses, wide range of locations and period of time over which seaweed use was  
401 documented in the literature, in addition to the variety of Indigenous names for seaweed,  
402 suggests that the low frequency of archival results stems not from a lack of use of this  
403 resource historically, but instead a lack of written documentation on seaweed use. This most  
404 likely stemmed from colonial attitudes towards the (in)significance of Indigenous knowledge  
405 and resource use more broadly, as well as the perceived insignificance of seaweed in relation  
406 to other coastal resources, such as shellfish or finfish, by predominately English settlers (with  
407 likely little traditional use of seaweeds themselves). Another driving factor is likely to be the  
408 early dispossession of coastal Indigenous people relative to inland nations. Coastal  
409 Indigenous groups were often affected by settlement in the earliest years of occupation, prior  
410 to the broad-scale publication of print media, and prior to the emergence of scientific and  
411 anthropological interest in Indigenous peoples and their activities (Berndt et al. 1993; Pascoe  
412 2007).

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

#### 421 **Relevance of historical data for contemporary aquaculture/sustainable industries**

422 South-eastern Australia has a diverse and unique seaweed flora (Phillips 2001) but naturally  
423 lacks the species that are most commonly commercially harvested or cultured in other parts  
424 of the world (FAO 2016), posing both opportunities and challenges for the development of a  
425 temperate Australian seaweed industry. On the one hand, the opportunities to discover  
426 Australian seaweeds with unique flavour and nutritional profiles, medicinal and  
427 pharmaceutical qualities (Reichelt and Borowitzka 1984), or applications in the phycocolloid  
428 (Chiovitti et al. 2001) or innovative natural-fibre technologies (e.g. flame-retardant textiles,  
429 Zhang et al. 2011), for example, are vast. But on the other hand, in a contemporary industry  
430 sense, we are starting from a limited knowledge base (e.g. Madgwick and Ralph 1972;  
431 Reichelt and Borowitzka 1984; Lie et al. 1990; Chiovitti et al. 2001), and working out which  
432 species to start looking at, how they may be used and how we might sustainably harvest or  
433 modify existing methods to bring them into aquaculture are particular challenges. Exploring  
434 the historical uses of seaweeds in the Australian context, by the Indigenous peoples who have  
435 inhabited this land for at least 65,000 years (Clarkson et al. 2017) before European

436 settlement, provides an opportunity to conserve aspects and values of Indigenous knowledge  
437 that have been largely overlooked by researchers, and that are likely to be at risk of being  
438 further lost from Indigenous communities without concerted efforts to record and conserve  
439 such knowledge. If conservation efforts are successful and communities are empowered to  
440 take ownership of this knowledge, it may be that it can help inform a sustainable temperate  
441 Australian seaweed industry in the future, one that ideally provides Indigenous training,  
442 employment and business opportunities in coastal communities (Lee 2010).

443 Although the records are few, our expectation that Indigenous use would be focussed on  
444 species that were easily accessible is confirmed, with shallow-water species and common  
445 contributors to beach wrack (Kirkman and Kendrick 1997) predominating records. *D.*  
446 *potatorum* (bull kelp) had the broadest reported application, with uses in roofing material for  
447 shelters, footwear, moulding of cups and water-carriers, and a “highly nutritious” food that  
448 was suitable for preservation and transport. The shallow-subtidal species *Cystophora torulosa*  
449 and *Acrocarpia paniculata* (as *Cystophora paniculata* (Guiry and Guiry 2017)) were also  
450 mentioned. Recent preliminary research has shown both *D. potatorum* and *C. torulosa* scored  
451 highly on palatability tests and are nutritionally rich, warranting further investigation as  
452 potential contemporary food sources (Skrzypczyk et al. in review) and *C. torulosa* has  
453 promising antimicrobial properties (Reichelt and Borowitzka 1984). *D. potatorum* has also  
454 been harvested from beach wrack on King Island, Tasmania, since 1973 for commercial  
455 extraction of alginates (Kirkman and Kendrick 1997). Whilst attribution to use by Indigenous  
456 Australians is ambiguous in the archival records (Maiden 1889; Irvine 1957), the red algal  
457 carrageenophyte *Betaphycus speciosus* (as *Euchema speciosa* (Guiry and Guiry 2017)) was  
458 recorded as being used in the late 1800’s as a food for making jelly, and in construction for  
459 size and cement; presumably by virtue of the gelling capacity of the sulphated

460 polysaccharides in the cell walls of this species that would assist in bonding the cement and  
461 rendering walls of dwellings. Recent preliminary trials to use alginates derived from  
462 Australian brown algae in carbon-sequestering-bricks for construction effectively build on  
463 this premise (ABC Catalyst *Can seaweed save the world?*).

#### 464 **Future research needs**

465 This research is a first step in understanding the historical uses and significance of seaweed to  
466 Indigenous Australian societies. Given our methodological approach the results, however,  
467 were largely limited to Western, colonial perspectives, with Indigenous perspectives only  
468 being recorded in more recent literature. Given the limitations in the archival sources, and  
469 that ecological knowledge in Indigenous Australian cultures is traditionally handed down  
470 through oral teachings (Horstman and Wightman 2001), interviews with Traditional  
471 Owners/Guardians and the collation of oral histories using established methods (Arbon 2008;  
472 Martin 2008; Rose 2017; Smith 2012; Wilson 2008; Yunkaporta 2010) is a clear next step  
473 towards eliciting a comprehensive understanding of the nature and variety of uses of seaweed  
474 by Indigenous Australian peoples. The historical dispossession of Indigenous nations from  
475 their ancestral lands may mean that much traditional ecological knowledge has already been  
476 lost from many communities. Moreover, historical devaluation of traditional ecological  
477 knowledge has also resulted in researchers recording or using Indigenous knowledge without  
478 appropriate consent or acknowledgement (Wynberg et al. 2009). Therefore, documentation  
479 and synthesis of remaining knowledge should be performed with Indigenous communities'  
480 informed consent, and preferably with the communities as active, equal partners in the  
481 process of data collection and distribution (Horstman and Wightman 2001), and subsequent  
482 potential commercial application of their knowledge (e.g. Ball and Janyst 2008; Hudson

483 2009). As the importance and use of seaweed was likely to vary among communities  
 484 (depending on the availability of other resources and geographical distributions of temperate  
 485 seaweed species (Phillips 2001)), further research could initially be focused upon  
 486 communities and/or language groups that have known words for seaweed, or who maintain  
 487 traditional cultural practises focused upon seaweed. Moreover, given that the currently  
 488 increasing interest in expanding the temperate Australian aquaculture industry to include  
 489 seaweeds (including in an integrated multi-trophic aquaculture setting) is focused around  
 490 Victoria, Tasmania and South Australia (with financial and in-kind support from the shellfish  
 491 and fin-fish growers, State governments and regulators), involving Indigenous communities  
 492 in the seaweed-industry development stages in these regions has the greatest potential to lead  
 493 to both positive outcomes for the industry and business/economic opportunities for coastal  
 494 Indigenous communities in south-eastern Australia.

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777 **Table 1. Terms used in search of online databases.**

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

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780 **Table 2. Examples of uses of, activities and nomenclature involving seaweed.**

Category	Quote and citation
Culture and cultural history	<p>“Kuratje and Kanmari became small fish. The latter was dressed in a good kangaroo skin, and the former only a mat made of <b>seaweed</b>, which is the reason they say, that the kanmari 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... <b>Seaweed</b>, floating anemones, turtle, fish etc. The songs follow them out from the deep water into the beach” (from Marika 1999). (Yunupingu and Muller 2009).</p>
Ceremonial activities	<p>“Now the old man was a rainmaker. He took a bamboo tube, stuffed it loosely with <b>seaweed</b>, 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 <b>seaweed</b> 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 <b>seaweed</b> 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.</p>

	<p>Djalum (<b>seaweed</b> or freshwater algae) is placed over a fire in a pit. The child's hands are warmed over the fire..." (Layton 1992).</p>
Medicinal use	<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 <b>seaweed</b>, etc. etc." (Meyer 1846).</p> <p>"Wet, tight bandages of plant leaves and <b>seaweed</b> were used to relieve pain and to stop bleeding" (Bryden 1974).</p>
Clothing	<p>"A man of the Milmendura tribe, wearing the <b>Seaweed Cloak</b>". (Angas 1847).</p> <p>"Some tribes use <b>seaweed</b> 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 <b>seaweed</b> with very broad thick leaves. These they also use as shoes when they have sore feet'." (Akerman 2005).</p> <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 <b>sea-weed</b>, known by the name of '<b>Bull Kelp</b>' it varies in length and substance, according to its local position, — it has a thick stem, and flat oval-shaped leaf, and is</p>

	<p>about the thickness of sole leather. The aborigines of this country, New South Wales, and New Zealand, and probably those of every sea-girt 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 <b>seaweeds</b> 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 <b>seaweed</b> (<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 <b>kelp</b> 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 <b>seaweed</b>].” Evening News 21 Jun 1922.</p> <p>“The <b>seaweed</b> 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</p>



	<p>there.” (Bell 1998).</p> <p>“Coorong fish traps also made use of natural barriers other than stone. Tindale described a trap at Najenu where <b>seaweed</b> 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 taláipar basket ware trap was placed at the bottom of the V to collect fish. It is possible that the wall of <b>seaweed</b> was formed by the weed adhering to a calcreted dune remnant, although Tindale made no reference to this.” (Ross 2009).</p>
Language / nomenclature	<p>“Language of Van Diemens Land: <i>Fucus palmatus</i> = “rugona”, <b>seaweed</b> = “roenan, inu”, <b>seaweed</b> dried for eating = “rori”.” (Ogle 1839).</p> <p>“This is Ligwidgi Trucaninni, 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 whurrong kuurndit'. Its language, ' Peek whurrong,' 'kelp lip,' is taken from the broad-leafed <b>seaweed</b> so very abundant on the sea shore.” (Dawson 1881).</p>
Shelter/domestic use	<p>“Some of the kelp or <b>sea-weed</b>, 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</p>

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).

“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).

“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.

“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).

781 **Figures**

782 Figure 1. Kelp water container from Tasmania made from bull kelp (*Durvillaea potatorum*),  
 783 dated 1850. Source: National Museum of Australia.



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785 **Supplementary materials**

786 Table S1. Databases and web-sources utilized for gathering information on Indigenous  
 787 seaweed use.

Database Title	URL
Anthropology Online	<a href="http://alexanderstreet.com/products/anthropology-online">http://alexanderstreet.com/products/anthropology-online</a>
AnthroSource	<a href="http://anthrosource.onlinelibrary.wiley.com">http://anthrosource.onlinelibrary.wiley.com</a>

Australian Institute of Aboriginal and Torres Strait Islander Studies	<a href="http://aiatsis.gov.au/">http://aiatsis.gov.au/</a>
Environment Complete	<a href="https://www.ebsco.com/products/research-databases/environment-complete">https://www.ebsco.com/products/research-databases/environment-complete</a>
Google Scholar	<a href="https://scholar.google.com.au">https://scholar.google.com.au</a>
Informit: Indigenous Collection	<a href="http://search.informit.com.au/search;res=IELIND">http://search.informit.com.au/search;res=IELIND</a>
National Library of Australia	<a href="http://trove.nla.gov.au/newspaper/">http://trove.nla.gov.au/newspaper/</a>
Web of Science	<a href="http://webofknowledge.com">http://webofknowledge.com</a>

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