Received: 28 December 2022 | Revised: 23 May 2023 | Accepted: 2 June 2023

DOI: 10.1002/rra.4176

SPECIAL ISSUE PAPER

WILEY

My father put them up there: Anthropogenic environmental change associated with abandoned river vessels in the Clarence River, NSW, Australia

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Abstract

The Clarence River (New South Wales, Australia) was the main transport corridor for the timber and sugar cane industries operating in the catchment from the 1860s to the 1970s. Using archaeological, documentary, and oral historical resources we explore some of the anthropogenic impacts of these industries upon the fluvial geomorphology of the lower Clarence River. In particular, the deliberate abandonment of obsolete vessels on the river system is a focus. These discarded former cane and timber barges have been used as erosion control devices in several areas around the Harwood Island sugar mill, resulting in the accumulation of sediments and the establishment of mangrove environments in what were degraded areas.

KEYWORDS
archaeology, feedbacks, oral histories, social-ecological systems

1 | INTRODUCTION

Anthropogenic activities have long been recognised as a factor influencing river channel stability. The effects of social dynamics and cultural interactions with rivers on a localised and site level are less understood, with individuals and communities occupying and using rivers differently in subtle ways that can often cumulatively affect riverine flows and viability. These interactions can be revealed through social science approaches such as archaeological, historical documentary and oral historical analyses, although too often these are excluded as legitimate data sources because of the perception that they are qualitative in nature and lack scientific rigour. We argue that such information can provide significant insights into biophysical impacts on river ecosystems.

In this manuscript, we use a series of case studies along the lower reaches of the Clarence River (New South Wales, Australia) in the vicinity of Harwood Island to explore how localised activities intentionally or accidentally impacted upon river morphology at multiple spatial levels.

2 | MARITIME CULTURAL LANDSCAPES AND ARCHAEOLOGICAL SITE FORMATION PROCESS MODELS

Riverine archaeology has long had a place in Australian maritime archaeology (e.g., Jeffery, 1987; Scrimshaw, 1981). However, it has traditionally focused on single vessels or elements of infrastructure rather than on understanding wider cultural systems. In 2010 the Australian Waterways Cultural Landscapes project (AWCL) was established, following Swedish archaeologist Christer Westerdahl's argument for a holistic 'cultural landscape' approach in investigating networks of maritime sites, including for rivers and inland waterways (Westerdahl, 1992). This framework extends the disciplinary

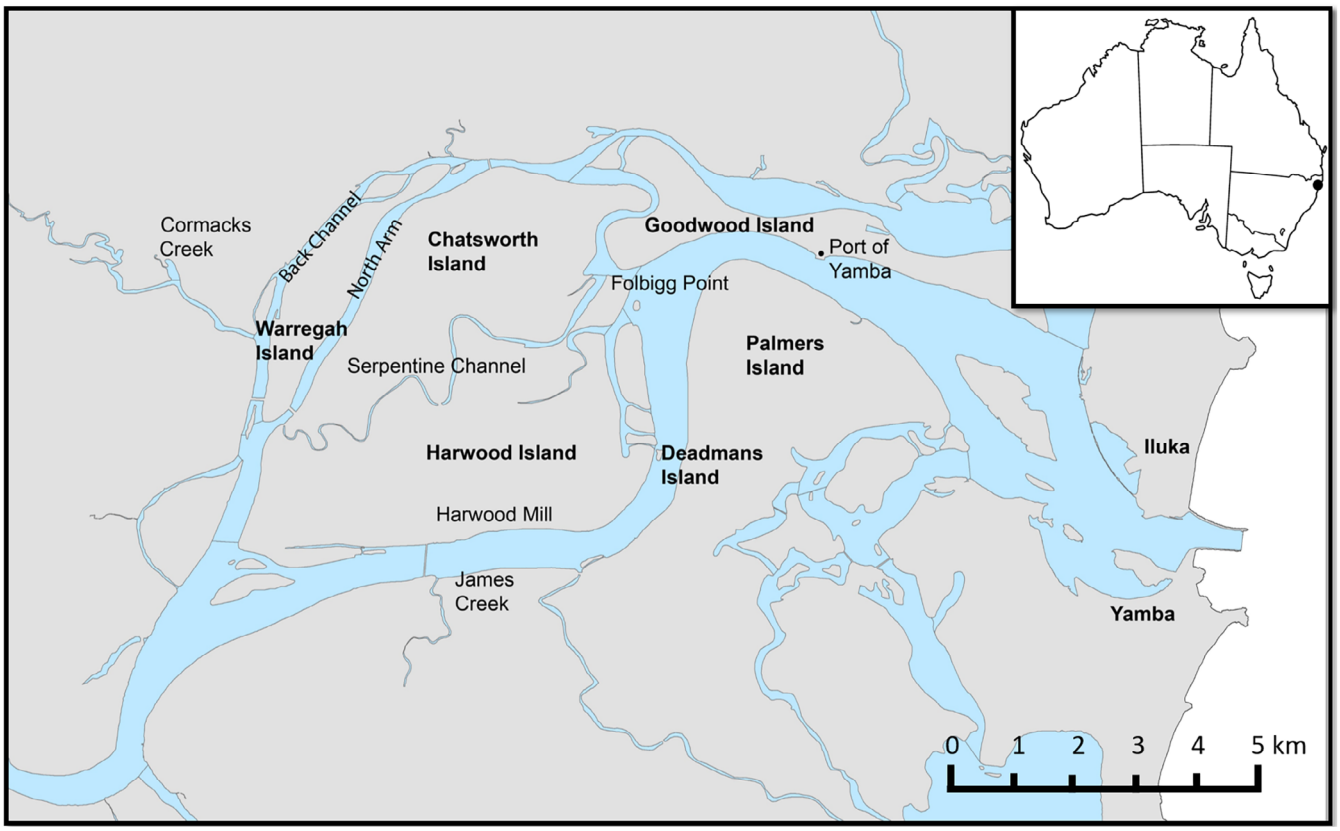

FIGURE 1 Map of Clarence River study area (Image: B. Duncan 2022). [Color figure can be viewed at wileyonlinelibrary.com]

'catchment' for maritime archaeological research beyond a narrow focus on sites within marine settings to encompass relationships and connection between sites with maritime associations, whether on land, underwater, within intertidal zones, or far beyond (Kenderdine, 1994; van Popta et al., 2018; Westerdahl, 2011). Moreover, the approach embraces the concept of the Archaeology of Flow (cf. Edgeworth, 2011) that views rivers as cultural artefacts which must be understood as a combination of artefact and natural (wild) forces. The Archaeology of Flow concept is based upon Actor-Network theory which emphasizes the intertwined or recursive nature of social–ecological relationships; where rivers have shaped human activity (and vice versa), which in turn have modified rivers, with consequences for future human use and understanding (or misunderstanding). AWCL attempts an integration of these closely aligned approaches, marrying them into a conceptualisation of a new approach to river archaeology in Australia. Several other studies have also been influential, including Price and Richards' (2009) central place study of the Roanoke River in the United States.

The Clarence River on the central coast of New South Wales (NSW, Figure 1) has been one of the AWCL project's main case studies, with a particular interest being the cultural decisions behind the discard of former industrial vessels, as well as the ways in which this was done. This part of the investigation has several avenues: understanding the economic and technological drivers behind vessel abandonment, the decisions on where abandonment would occur, the processes by which vessels were deposited and how they break down over time, and the long-term environmental consequences of these actions.

Understanding how shipwrecks (including non-catastrophic abandonments and placements) are created and transform over time falls into the field of archaeological site formation studies (Schiffer, 1987). Early maritime archaeological studies tended to focus on the natural (physical, chemical and biological) factors and the processes that moved or extracted structure or objects from shipwreck sites (Muckelroy, 1978; Riley, 1988; Hardy, 1990; Ward, Veth and Larcombe 1999). This included understanding the impacts of shipwrecks upon the surrounding physical environment such as through sediment deposit, vegetation growth or hydraulic flows (Elliget & Breidahl, 1991; Harvey, 1996; Hosty, 1988; Steyne, 2010; Stieglitz & Waterson, 2013; Ward et al., 1999). More recently, there has been attention given to the cultural processes that created and modified shipwrecks (Duncan, 2006; Duncan & Gibbs, 2016; Gibbs, 2006; MacLeod & Viduka, 2011). This includes understanding the decisions behind discard or re-use of vessels as structures for land reclamation, training walls, wharfage, erosion control, or fish aggregation (Gibbs & Duncan, 2016; Koivikko, 2017; Richards, 2011). It also considers the processes of preparing a former vessel for this re-use, such as filling with heavy material, scuttling, the use of placement assurance devices (e.g., driving a pile through the hull), or a combination of these (Delgado, 2009; Duncan, 1994; Duncan, 2006; Richards, 2008; Richards, 2011). The Clarence River wrecks provide opportunities to explore both the cultural and natural aspects of the wrecks and the consequences of their discard.

A final element of the AWCL project's maritime cultural landscape approach is the use of oral histories, informed by a established

literature on their use in archaeological research (Gazin-Schwartz & Holtorf, 1999; Murray, 2010; Purser, 1992; Schuyler, 1977). While there is a rich documentary record of the post-1788 use of the Clarence River, information on the specific locations of archaeological sites and especially abandoned vessels is difficult to obtain. Interviews with local informants knowledgeable in the industries, boat building, riverine shipping practices and environmental changes has been pivotal to understanding the nature, extent, and context of the archaeological resource. The AWCL project has collected new oral histories and re-analysed earlier studies (e.g., Lee, 2003; McAulay, 2011; McFarlane, 2005; McNamara, 2010; Richards, 1996) with great success, such that the authors identified over 100 additional vessels through these processes, the majority being located during an initial five-day fieldwork investigation. The observations of local informants have also led to characterisations of features that identify archaeological sites and assist in the understanding of what they are, why they are there, when they were deposited and the consequences of their deposition.

3 | THE LOWER CLARENCE RIVER–A HISTORICAL CONTEXT

The Clarence River is the longest coastal river in NSW, flowing 394 km from the McPherson Range to the Pacific Ocean. The lower 67 km of the Clarence River is navigable (Burgess & Woolmington, 1981; Mashiah, 2009) and is the focus of this study (Figure 1). The study area is characterised by a large lowland fluvio-lacustrine flood plain (>830 km^2) that is dissected by numerous tidal channels, anabranches and connected lagoons, and has an extensive estuarine ecosystem. Bed sediments of the area are dominated by a mixture of organic rich muds, well-sorted fluvial sandy sediments and marine sand. There are numerous paleo-channels and paleo-floodplain surfaces in the lower Clarence (Haq, 1995) the morphology of which suggest the Clarence River channel avulsed multiple times in the mid to late Holocene. River levels in the lower Clarence River can vary from 5 to 18 metres because of tidal variations and flooding. The floodplain inundates once in every 2–3 years (Longworth and Mckenzie, 1980) and during these flood events fine nutrient enriched sediments are dispersed over the floodplain.

Indigenous groups owned and used the river and floodplains of the lower Clarence River in various ways. The mosaic of river channels was associated with the Yaygir (Yaegl) people (Hoff, 2006; Lee, 1994). European occupation of the region commenced in the 1830s, initially focussed on the extraction of Australian red cedar (*Toona ciliata*) (Vader, 2002: 84). The Clarence, referred to in contemporary accounts as "Big River", quickly became the principal transport conduit for industry, commerce and settlement. Logs were floated down to the timber mills for processing, with the lumber then loaded on to barges for transport downstream to the river mouth where they were transferred on to ocean-going vessels at the developing port of Yamba (Anon, 1972; Toghill, 1984). The environmental impact of this early clearance of the upland catchment and logging industry activities is still evident today (Dargavel et al., 1995; Rose et al., 2010), and it undoubtedly initiated early anthropogenic changes to the river system in combination with the removal of large timber obstructions from the main river channel and channel modifications to facilitate river transport (Lee, 2003: 65). Similar river system adjustments: increased post-settlement alluviation, increased riverbank stability and degradation of river channel and floodplain aquatic habitats, have been recorded in other coastal river systems of NSW (e.g., The Nambucca River – Doyle, 2003).

Catchment surfaces were progressively cleared of timber, and logging activities were replaced by agriculture, dairying, mining and other commercial ventures over time, all of which used the river as a transport conduit (Lee, 2003: 10). Although the first non-indigenous vessels to ply the Clarence were sailing ships, in 1839 the steamer *King William IV* navigated the river (returning regularly) and was soon joined by other paddlewheel vessels (Lee, 2003: 7). By the 1850s roads remained woefully poor, and the Clarence River hosted several companies operating fleets of vessels associated with the different industries and commercial activities (Lee, 2003: 71). Riverside infrastructure developed accordingly, with log slides, wharfs, jetties and piers, mills, ship and boat yards, ferry crossings, settlements and maritime services (McSwan, 1976; McSwan, 1978).

From the mid-1860s sugar cane was a commercial crop that utilised the fertile riparian zones of the Clarence, with a number of small (sometimes short-lived) sugar mills opening (Lee, 2003: 261). In 1869–1870 The Colonial Sugar Refining Company (CSR) constructed mills at Southgate and at Belmore on the floodplain, although flooding and other problems led to establishment of a new and larger mill on Harwood Island on the northern bank of the river, where it remains in operation today (Higman, 1968: 701; Lee, 2003: 261). The river channels of the lower Clarence River continued to form the basis for transport, moving sugar cane from the plantations to the mills, and then the final products on to the port at Yamba.

CSR initially engaged two steam tugs (*Chatsworth* and *Mary Queen*) to haul 40-ton timber punts to the mill at Southgate. In 1873, an ocean-going steamer service was introduced to carry coal from Newcastle, along with a steam launch to tow cane punts into and out of creeks. In 1874 the former sugar cane mill service vessel *Darkwater* was transferred to the Clarence from the Macleay River. The side paddle wheeler tug *Iluka* was then introduced in 1879, along with maintenance facilities in the form of a floating dock in 1880 and later a dedicated slipway (Lee, 2003). By 1881, four steam launches were operating on the Clarence River, towing up to six punts at a time, leaving them moored adjacent to the plantations along the banks of the Clarence and its many minor tributaries. The cane cutters initially loaded these punts by hand, although later many plantations installed riverside derrick cranes. Diesel powered tugboats (Figure 2) were later introduced and allowing strings of punts to be towed through often narrow waterways (e.g., Serpentine Channel) which were then towed to the refinery mill at Harwood (Figure 3).

After unloading at the Harwood Mill, these vessels were taken to the opposite (southern) bank of the Clarence River at James Creek, where the detritus of the cut cane and silt was emptied into the water. Strings of vessels were often moored in this area, until such

FIGURE 2 Harwood Island Tug and punt String along the Clarence (Image: David Greenhalgh Collection). [Color figure can be viewed at wileyonlinelibrary.com]

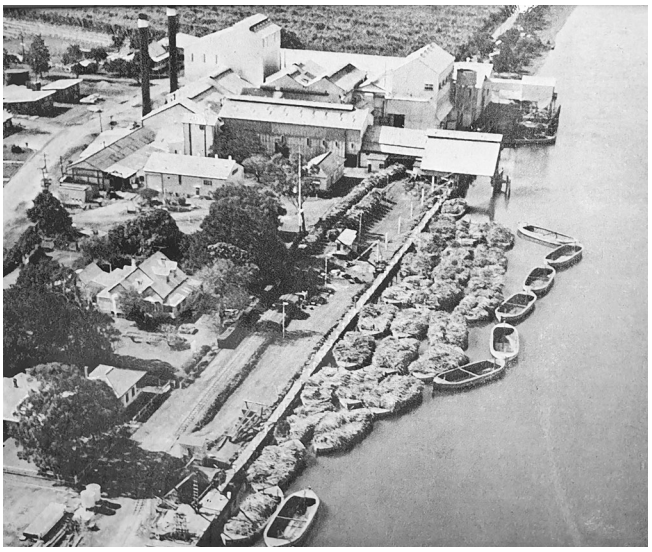

FIGURE 3 Stringer for unloading punts at Harwood Mill (Image: Raydie Moloney Collection).

time that they were cleaned and ready to be redistributed to the farms in the neighbourhood (Cameron pers. comms). The molasses and refined sugar produced by the mill would then be loaded onto ships for transport to Sydney and other destinations (McKillop & Browning, 2000).

Over time, technological improvements in shipbuilding techniques and the reduced availability of suitable timber forced changes to the design and construction of the double-ended cane punts. Early vessels were constructed entirely of timber, with subsequent innovations including the introduction of iron frames to secure timber planks, then iron topsides on top of timber planked lower hulls by the last decades of the 19th century, to be replaced from c 1938 turn by steel hulls (first riveted and then welded). Flat-topped steel pontoon barges were also used in later periods. With these changes came increased capacity, from 20 to 30 tons to between 70 and 150 tons. As new technologies were introduced the obsolescent older punts were often abandoned or sold for recycling or reuse. From 1974 to 1976, the introduction of road and tramway networks to the mill led to the replacement of punts with cane cages, which were towed or carried disarticulated by truck or tramway cane carts (Lee, 2003: 7). This development led to the wide-scale abandonment of waterborne cane transportation and with it the punts. This period was associated with a different set of river system adjustments. Extensive channel instability, bank erosion and channel enlargement were a feature of the lower Clarence River and associated floodplain channels in the 1970s and 1980s (Hydrosphere Consulting, 2022). This was a result of many factors including the cumulative effects of riparian vegetation clearance, channel modification and swash from increased recreational boat traffic.

4 | ARCHAEOLOGICAL SURVEYS

Archaeological surveys of abandoned vessels in the lower Clarence River as part of the AXCL project have occurred intermittently since 2018. This has involved several strands of investigation, including: review of historical documentary evidence of vessel losses, analysis of aerial photography from *aerial photography*, collection of oral histories from local informants, ground-truthing of potential sites identified by these processes and archaeological surveys along the river channels to identify additional sites, undertaken by boat or from the shore. It is worth noting that the archaeological surveys generally involve local informants participating in the field recording while also providing additional oral history on-site. At the time of the 2018 survey, only low-resolution LiDAR imagery was available, which is inadequate for identifying semi-submerged vessels.

In the following section we identify the different types of vessel discard activity (wreck, abandonment, and placement) in the immediate vicinity of the Harwood Mill (Figure 4) and consider the environmental consequences of these actions. We also examine the situation where local oral history has provided explanation of environmental change as a consequence of vessel loss.

4.1 | Strategic placements

Analysis of *Google Earth* imagery from 2010 revealed a number of abandoned cane punts around the north-eastern extremity of Harwood Island, known as Folbigg Point. The vessels lined the eastern edge of the island along the Clarence River (c. 27 vessels aligned north/south), but also extended west along the island towards the narrower Serpentine Channel (c. 16 vessels). Archaeological investigation (Figure 5) showed that the vessels were in a remarkably good state of repair and exhibited changes in construction across several phases, with older timber and iron framed vessels in the southern extremity, iron topside vessels towards the Folbigg Point, and then predominantly iron and steel vessels to the west side of the peninsula.

FIGURE 4 Location of wrecks, abandonments, and placements (W), ships graveyards (SG) and derrick cranes loading areas (D) around the Harwood Island locality (Image: Brad Duncan 2019). [Color figure can be viewed at wileyonlinelibrary.com]

FIGURE 5 Folbigg Point Cane Punt Graveyard (western side) in 2018 (Image: Brad Duncan 2018). [Color figure can be viewed at wileyonlinelibrary.com]

Historical investigations confirmed that vessels had been placed in the area up until to the late 1970s (the latest being placed on the western side of Folbigg Point) when the river transport industry using cane punts had been abandoned (Richards, 1996; Shortt, 1980). There is no evidence of placement assurance devices such as driving one or more posts through the hulls to keep them in place, although it may be that scuttle holes were cut into hulls but are now below the water line and/or covered in sediment. The specific spatial arrangement of the cane punts with very little spacing between them, or overlaps between the extremities of each subsequent vessel, supported the conclusion that these craft were deliberately positioned to limit erosion along the foreshore in this area, which currently stands at less than 0.5 m above normal river levels. This was confirmed through discussion with local informants (Greenhalgh, 2021; Lamont, 2020) who reiterated that these vessels had been placed in this area to protect the edge of the island, which had been subject to extensive scouring and erosion. Photographs taken soon after their deposition show the vessels moored into place on the intertidal shoreline adjacent to what were severely eroded sections of the riverbank (Figure 6; Shortt, 1980). However, the areas behind the hulks now exhibit significant sediment accretion and mangrove development.

4.1.1 | Goodwood Island

Five wrecks were discovered on the southern side of Goodwood Island using aerial imagery, one being close to shore c. 180 m west of the Port of Yamba Breakwater. These vessels were not inspected

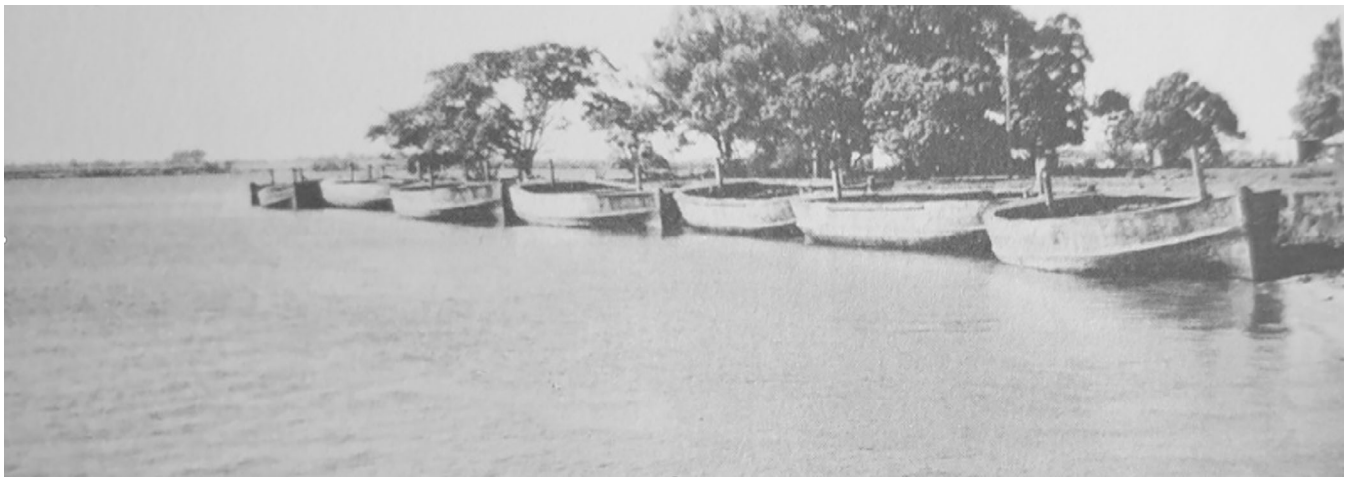

FIGURE 6 Cane punts on Northwest side of Folbigg Point in the 1970s (Image: Shortt, 1980: 189).

underwater but were surveyed with a sidescan sonar unit. The easternmost vessel is of iron frame and timber hull plank construction, and so are of an early type. Anecdotal information suggests they were strategically placed to stop the narrowest point of the island breaking through during major flooding (Moloney, 2020). However, the sidescan survey suggests that the vessels were possibly being towed at the time they were lost, so the prospect remains that they were sunk accidentally as large choppy seas as a result of the wind fetch in this area.

The area around the wrecks at Goodwood Island demonstrates a sand and mud bank that extends to the west (upstream) for at least 500 m long and up to 60 m offshore. This area was formerly known for experiencing extensive erosion as it lies on the northern side of the main river channel, and archaeologically is evident by extensive rock beaching installed in this area. Pockets of mangrove are also beginning to populate this region. It is currently unclear whether the wrecks in this region are actually assisting in stabilising the area and have been exposed due to strong river currents, or are contributing to the destabilisation of the bank by speeding up the current (i.e., acting as a training wall) whenever they are exposed.

4.2 | Warregah Island

Three timber and iron frame punts were reported at Warregah Island, with one of these located during the survey after additional local anecdotal advice provided a precise location at the confluence of the Back Channel and the North Arm [Moloney, 2020]. According to local sources the punts had become obsolete and were placed at this location as a means of reinforcing the southern extremity of the island which was in danger of washing away after flooding. When inspected in 2018, this edge of the island was previously protected by trees, but (then) recent flooding had again eroded the foreshore and exposed one of the wrecks.

4.3 | Abandonments and ship graveyards

4.3.1 | James Creek

It is known locally that a number of vessels were located in the mangrove swamp at James Creek opposite the Harwood Mill, including the remains of the former iron paddle steamer PS *Cakobau*, which had later been converted to a barge before being wrecked or abandoned c. 1914. In 2016, the remains of at least two previously unknown punt wrecks were discovered nearby, with further archaeological inspection of this area revealing at least another 18 punts (Figure 7).

The vessels in this area are early designs, constructed with iron frames supporting timber planked hulls, all of which are now almost completely subsumed with the mangrove swamp. The dumping or wrecking of hulks appears to have been clustered around *Cakobau*, which lies approximately 3 m from the main road. The position of the road is significant, as it probably indicates the original location of the foreshore. Another group of punts were observed c. 40 m to the west of the initial cluster c 30–40 m from the road, some of which were still secured with a towline, suggesting that these vessels were towed at the same time into this area. A solitary iron punt was found c. 80 m from the road on the seaward edge of the river at the edge of the mangrove swamp. Two other punts are located c. 120 m to the west and c. 20 m from the road. The remains of a vernacular pier made of bent mangrove trunks were also located close to the first group of wrecks on the eastern side, but leading out to the current river edge of the swamp where a possible mooring pile or derrick crane pole was located.

Archaeological interpretation of the locations of the vessels suggest that this was not a singular dumping event, but an accumulation across three (and possibly four) abandonment episodes, in effect utilising this area as a ships' graveyard. The *Cakobau* and four nearby punts appear to have been the first dumped in this area as they are closest to the road. The two westernmost punts were

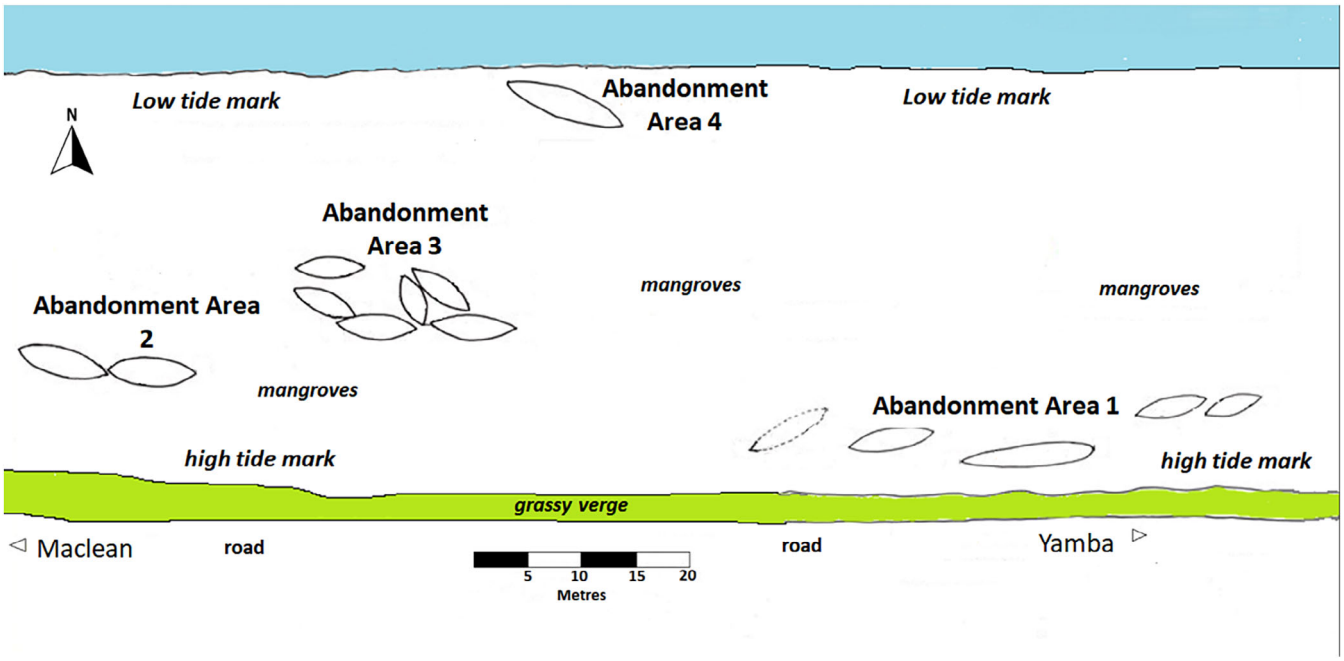

FIGURE 7 Plan of hulk locations at James Creek punt (barge) graveyard as surveyed in 2018. Note that further hulks have been discovered in subsequent surveys of the area (Image: After Greg Jackson 2018). [Color figure can be viewed at wileyonlinelibrary.com]

abandoned after this, as the shoreline accreted and shallowed up further out into the river. The third group of timber punts were deposited sometime later. The timber punts in the middle group are almost sunk up to their gunnels, suggesting that that they were sunk in shallow water at the edge of the river (at that time), and that mangroves were not present in this area at that stage. Archaeological characterisation of the wrecks suggests that the possible dates for the abandonment of the middle and western punts groups was between 1914 and 1934. The appearance of a solitary iron punt 40 m northward (also sunk to its gunnels) suggest that the vessel sank at the river's edge and probably sometime after the introduction of steel punts, post-1938 and possibly as late as 1942 when welded steel punts were introduced (Lee, 2003: 7). It is hard to determine the total number of punts in this area, with more wrecks being found each survey as river conditions change and reveal vessels sunk buried in the mud up to the tops of their hulls (Figure 8).

It appears that mangroves became established along this foreshore because of these dumping events, and that the intertidal mangrove area prograded forward towards the river as silt gradually built up in this locality. Understanding the geomorphological processes at this location is further complicated by the use of this area for cleaning the organic debris from punts, as described above. Given the volume of material that was being dumped into this area, it appears that this discard may also have affected the river flow and subsequent siltation rates at this location, possibly leading to the generation of conditions that were favourable for mangrove vegetation generation.

To further obscure the situation, local anecdotal sources have indicated that oyster farmers also used the area to collect 'sticks' for the oyster aquaculture farms: tar coated sticks that were used for oyster spats to adhere to and for protection from fish whist they were growing (Wells, 2021).

Several other vessels associated with the sugar cane industry were also identified in the immediate vicinity of Harwood Island Mill. One punt has been used to block off the end of the former punt maintenance slipway, resulting in the accretion of sediment and establishment of a small stand of mangroves. There has also been a report of more hulks in the water close to the boat ramp on the western side of the Harwood Island Bridge (within 800 m of the mill) and another possible punt abandonment in the Serpentine Channel. Whether these represent wrecks, abandonment or placements remains to be determined through survey.

4.3.2 | Cormacks/Mangrove Creek

Three iron or steel punts have been identified a small channel close to the confluence of Mangrove Creek and Cormacks Creek on the westerns side of the north arm near Ashby. These relatively intact punts were abandoned in this area probably around the same time as the Folbigg Point vessels and are nested against a dense mangrove stand in the dead end offshoot of the creek. Although the wrecks are in the dead end of Cormacks Creek, they also appear to have been responsible for partially blocking the stream on the western side.

FIGURE 8 Ghost Image of iron cane punt wreck at James Creek, with the walkway deck inhibiting mangrove growth (Image: Brad Duncan 2018). [Color figure can be viewed at wileyonlinelibrary.com]

4.4 | Wrecks and accidental losses

As described above, several of the cane punts recorded during the archaeological survey may have been accidental if not catastrophic losses (i.e. 'wrecks'). Catastrophic wrecks were not uncommon along the Clarence River for a variety of reasons (Richards, 1996). However, the loss of small barges was far less likely to generate the sorts of historical paperwork/news or create an imprint on local consciousness in the way that the catastrophic loss of a larger vessel might, meaning that archaeology and in some instances oral history is sometimes the only viable source of information.

4.4.1 | Harwood Island sailing shipwreck

During this research the authors encountered a more difficult example of how oral history might illuminate the impact of a wrecked vessel upon river morphology, or alternatively how changes to river morphology are ascribed to a wreck event. There are several versions of a local story about an unnamed sailing ship that in the 1860s had reportedly attempted to escape dangerous floodwaters in the main Clarence River by seeking shelter in a short deep-water creek (formerly Eggins Creek) on the south-eastern end of Harwood Island. When two logs were swept into the creek the vessel was supposedly crushed. It is suggested that the wreck then effectively blocked the small creek and led to sediment accumulating over time. This blockage created a new area of land to the northeast of the former creek location that extended to Deadman Island and eventually joined this to Harwood Island. Variant versions of the story associate the vessel with Capt. Bully Hayes, a notorious South Seas Islands labour trader and blackbirder (Shortt, 1980: 79), or suggest the vessel was wrecked while loading illegal alcohol (rum) disqctilled by local farmers from sugar cane (Ryan, 2020). In these versions the vessel was hiding in the creek to avoid unwanted attention from the authorities when the accident happened. These accounts attempt to provide an explanation for a change in the physical landscape, while introducing a fascinating conflation of assorted historical events. The latter include the catastrophic 1863 flood where vessels were endangered by floating logs (Anon, 1863), a high-profile historical personality who may or may not have visited the area (Clune, 1970), and a popular trope of illicit and anti-authoritarian activity. This does not necessarily mean that any component is immediately incorrect or fanciful, but it does provide a range of avenues for investigation and clarification.

Descendants of the adjacent landowners initially reported the possible wreck site in 2013. Their father had related the story of the wreck and had shown them copper sheathing that he indicated was often dug up from the cane field in that area. At an initial investigation into the site in 2018 the informants identified the possible wreck site as being represented by an area of densely compacted sand c. 60 m long × 30 m wide with minimal low vegetation: an anomaly in an area of otherwise silty mud substrate. In 2021, the authors undertook a Ground Penetrating Radar (GPR) survey of the indicated sandy area and surrounds to search for evidence of a buried vessel or any associated wreckage. No definite archaeological evidence could be identified, although during the survey process additional oral information indicated that later salvage of the vessel by local farmers had been extensive and included burning of the wreck as a means to recover nails and fittings (Richards, 1996). The GPR survey did, however, show that the sandy area was within a now buried relict channel, as demonstrated by the sharp fall of the substrate at the edge of the former islands on each side of it.

Leaving aside the accuracy of the historical circumstances, NSW Lands Department maps (Six Maps) indicate that there was once a channel between Harwood Island and the small islet named Deadman's Island, now subsumed by Harwood Island or significantly silted over (NSW Department of Lands, 1919). Local oral histories suggest the name came from its early use as a graveyard and had formerly been subject to extensive erosion leading to exposure of graves and bodies after riverine erosion events. Further research is required to pin down the dates for the closure of the channel, since many historical maps simply duplicate earlier base maps with limited modification, and hence are not reliable. However, finding the date of designation of the newly formed land as Crown Land may provide some clues. Curiously the name Deadman Island remained gazetted as late as 1973 as part of the NSW Geographical Names Act of 1966 (NSW

FIGURE 9 Aerial image overlaid with cadastral lot boundaries (shown as dotted white lines) showing the loss of land experienced at Marsh's Farm on right and accretion of land around islands on left. Note also location of the Harwood Island Sailing Ship suggested by local informants (Image: After Six Maps, 2022). [Color figure can be viewed at wileyonlinelibrary.com]

Government Gazette, 1973). Figure 9 demonstrates the level of land accretion on the western side based on cadastral land boundary mapping information along Harwood Island south of the former Deadman's Island.

Local sources have reiterated that the changes outlined above further contributed to erosion on Palmers Island, directly opposite this area on the other side of the river, as a result of narrowing of the channel. Fay Greenhalgh (Greenhalgh, 2022) recalled:

> *Around 1940 my family and I would go swimming and fishing in the river at the Palmers Island property. There was a fairly high steep bank leading to a narrow sandy beach about 2–3 m wide. The beach dropped off quickly into very deep water and many fish were lost trying to pull them up over the edge of the drop off. The property was eroding quite quickly and over the years a road and some bananas was lost.*

4.5 | Anthropogenically caused geomorphological change in the Clarence River and traditional knowledge networks

Since the 1870s, the sugar cane industry has resulted in a range of impacts upon the environment of the Clarence River. While documentary records enumerate the returns of harvest and sugar production, it has only been through the collection of oral histories and archaeological survey that the scale of the industrial landscape and patterns of river usage over time have become clear. Informants have described how punts and tugboats were not only using the main channels of the Clarence River, but were also accessing much smaller channels, creeks and tributaries (e.g. Palmer Channel, Shark Creek, Serpentine Channel, North Arm, Back Channel, Ashby Channel, Mangrove Creek, etc.). Some were not much wider than the punts themselves. This required the clearance of impeding bankside vegetation and de-snagging of submerged tree trunks and branches to facilitate safe traffic and access to the riverbank for loading purposes, a situation also documented for the Murray Darling River (e.g. Anon, 1858; Anon, 1867). These clearances would have accelerated the water flowing through these areas, in addition to removing habitat for fauna and flora.

The repeated actions of using motorboats in shallow waterways arguably also maintained the depth required for vessel navigability, due to the fluidisation of the riverbed sediments by their propellers. This phenomenon was also recorded in oral histories from Port Phillip Bay (Victoria) where shallow-draft steam powered vessels aided in keeping the West Channel open to shipping whilst they were using them. The channel started to sand up after these powered vessels no longer operated there (Duncan, 2006: Appendix D4-26, F4-29). Similarly, increased wash from vessel passage in formerly low energy environments, the effects of the propeller driven tugboats close to the riverbanks, and the direct mechanical effect of driving the punts against them for loading also affected the stability of the banks and kept the channels flowing. Rutherfurd et al. (2020) observed comparable conditions caused by the effects of boat generated waves in the Murray River. When river-based sugar cane transport ceased, the smaller tributaries began to silt up again, with some formerly navigable channels now almost impassable even for small boats (e.g. Serpentine Channel).

The combination of archaeological, documentary and oral historical sources shows that while some of the barges and punts recorded during the survey may have been lost due to mishaps during periods of flooding or other accidents (i.e. as 'wrecks'), the vast majority were disposed of due to end of use life, technological obsolescence, or change in modes of transport. There is some evidence of abandonment or discard within 'ships graveyards' and without any specific ongoing purpose, such as at James Creek, Cormacks/Mangrove Creek and possibly at Goodwood Island. However, most of the punts surveyed were strategically placed and re-purposed as environmental control devices up and down the river, with a smaller number being re-used as structures, such as to block off the Harwood Mill slipway ramp.

FIGURE 10 Aerial image of eastern side of Folbigg Point showing the alignment of the hulks against the mangroves and sand accretion (Image: Nearmap 28 May 2016 [Nearmap, 2016]). [Color figure can be viewed at wileyonlinelibrary.com]

The 45 or more strategically placed vessels at Folbigg Point on Harwood Island have had a marked effect on the geomorphology of the island in this area. Prior to the installation of the vessels, local oral histories and contemporary photography detail how the island was subject to scouring, bank failure and intense erosion after flooding events due to the extensive length of the reach in this area. However, the systematic placement of the punts, end on end or overlapping at their extremities, formed an almost impenetrable wall against the river currents on the eastern side of the island, leading to accretion of sand levels in this area (see Figure 10). It is clear from the extensive sank and mud banks which are now present that this barrier has been effective, slowing down riverine currents and leading to the deposition of sand and silt as suspended sediments drop to the riverbed behind the hulks. The same outcomes have been achieved at several of the other sites where vessels have been placed, such as at Warregah Island and Cormacks/Mangrove Creek. Whether the resulting environments and vegetation have re-established a version of the earlier pre-erosion landscape is unknown. A contrasting case is the northern side of Harwood Island, on the western side of Folbigg Point at the eastern entrance of the Serpentine Channel, where flood and tidal waters are concentrated. In this location the alignment of the wrecks appears to have accelerated river flows by acting as a training wall, as evidenced by extensive erosion and the marked breakup of the wrecks in this area. However, whether the cumulative effects of

vessel discard, and placement also have an impact on larger processes of river meander remains to be seen.

The oral history regarding the closure of the channel between Harwood Island and Deadman's Island presents an interesting insight into local perception of the links between vessel loss and environmental change. Although this information cannot as yet be verified by documentary or archaeological sources, some credence is provided by the visible consequences of the partial blockage of Cormacks/Mangrove Creek by the punts abandoned in that channel.

While the focus of this article has been on abandoned and placed vessels, the wider impacts of sugar industry infrastructure might also be briefly considered. With the lack of viable road transport, each plantation often constructed piers and wharves along the main river and channels associated with loading their cane. These structures potentially added to erosion and/or siltation, although in some cases they acted as training walls or sand groynes respectively. Some farms did not use wharves at all, but simply moored the punts to the bank for loading by hand or derrick cane, possibly further exacerbating embankment degradation and causing subsequent erosion. Given that up to 10 punts at a time might be moored in narrow creeks and channels when loading from individual farms, the potential impacts in slowing down natural currents also warrants further investigation.

The position of Harwood Mill on the bank of the Clarence River has also produced changes to the immediate riverine environment. The riverside location has always been integral to its operation, not just for transportation purposes, but also because the mill plant is still powered by steam combustion engines which rely heavily on water drawn from the river. This water, heated by burning waste cane products as the principal fuel source, is then pumped back into the river at the end of the process. Over time the evolving mill operation has also required modification of the shoreline, with the installation of industrial scale wharfage, unloading/loading facilities, water-cooling system, and shipbuilding and maintenance facilities. The archaeological evidence suggests the embankment has at various times been subject to erosion, with the dumping of detritus from the factory (including old boilers and other structural material) across the waterfront in front of the refinery in an attempt to attenuate the collapse of the banks and exposure of the mill to inundation. Conversely, the discard of nutrient rich organic cane waste from the barges on the opposite side of the river close to James Creek may have exacerbated shoreline sedimentation and assisted in the establishment of the mangrove forest.

5 | CONCLUSION

Evidence of the long-term impacts of colonial activities on river systems is increasing (Davies et al., 2018; Lawrence & Davies, 2018; Rutherfurd et al., 2020). In this manuscript, a combination of documentary, archaeological and oral information is used to show how the loss, abandonment or strategic placement of sugar cane industry-related vessels, along with the installation of historic riverine infrastructure, has produced a range of impacts on the fluvial geomorphology of the major and minor channels of the lower Clarence River system. In many instances, the presence of these cane punts would appear to have resulted in the accretion of sediments and the establishment or regeneration of vegetation, including along what were severely eroded areas of riverbank. In some circumstances the hulks appear to be acting as training walls that have increased erosion in those areas. In doing so, we have highlighted the previously unrecognised effects of how various actions associated with the sugar industry (including riverside infrastructure, removal of large timber obstructions or modification of river channels to facilitate vessel movement, as well as the discard of nutrient rich wastes have on riverine processes.

Cane punts were the workhorses of the sugar cane industry: their loss or discard was undramatic and largely overlooked. So too was their 'afterlife', not only the archaeological site formation processes of their own structural collapse, but also their ongoing intended and unplanned impacts upon the surrounding environment. Harnessing community knowledge and oral histories provided a variety of locations where the archaeological remains of vessels and especially punts were located, such that the authors have identified over 100 wrecks and/or hulks in the Clarence River, with the majority found during the initial five-day field investigation. This was also a rich source of information into how the various vessel abandonments and placements had affected surrounding environments over long periods, with informants sometimes drawing on multi-generational knowledge. These insights were pivotal to understanding local riverine geomorphology and some of the causes and processes of change, providing avenues for scientific testing. That said, the interplay between oral, documentary and archaeological evidence and the 'ambiguities' between these data sets, whether elisions, absences or conflicts, requires constant and careful consideration.

The oral histories employed in this manuscript were primarily from those community members with some connection to or knowledge of the sugar cane industry. Many couched their observations in terms of how the changes to the industry and its shipping had affected their lives and families, as well as altered the cultural and natural landscape of the river itself. However, the Australian Waterways Cultural Landscapes Project has also recorded oral information relevant to the many other riverine focused industries that have operated along the Clarence since the 1840s. These include timber extraction and milling, fishing, granite extraction, dairying, commercial trading and other transport-focused professions (ferries, transport vessels and road/rail services). These bodies of knowledge present different perspectives on the role of the river in their respective cultural landscapes, and the changes that these different groups have experienced regarding their particular profession or industry. For instance, professional (and often multi-generational) fishing families have provided insights into how their industry operated along the Clarence River, as well as the effects that changes to the river environment have had on fish and resource availability. Similarly, local informants also anticipated future changes, commenting on the likely effects of the new bridge to Harwood Island upon local river levels, suggesting the diversion or holding back of water drainage during the next major flood event, something that came to fruition during the 2022 floods in this area.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the assistance and detailed knowledge of the area provided from the following people, without whom this project would not have been possible: Ros Ryan; Mark and Bernie Ryan; David Greenhalgh; John Wells; Raydie Moloney (Sugar Cane Tugboat Captain); Kevin Betteridge (Shipwright); Colin Harvey; Kathleen Werry; Maclean Historical Society; Iluka Historical Society; Frank Greenhalgh, Ian Braun (former Manager, Harwood Sugar Mill); Alan Lamont (owner Folbigg Point); and Yaeygl Traditional Owners Aboriginal Corporation. We would also like to all those who have assisted in fieldwork, including: Greg Jackson; Pam Forbes: Toni Massey; John Gilbert; Edmond Schillam; Paul Hundley; Irini Malliaros; Miranda and Derek Firman; Dave Clark; Bob Edgar; Peter Wood; Deborah Wray; Alexandra Slucky; Glenda Macphail and Ferlin Laurie. Open access publishing facilitated by University of New England, as part of the Wiley - University of New England agreement via the Council of Australian University Librarians.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in Maritime Heritage Online Database at https://www.environment.nsw.gov.au/topics/heritage/search-heritage-databases/maritime-heritage-database.

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How to cite this article: Duncan, B., Gibbs, M., Thoms, M., Greenhalgh, D., & Ryan, R. (2023). My father put them up there: Anthropogenic environmental change associated with abandoned river vessels in the Clarence River, NSW, Australia. *River Research and Applications*, 1–13. https://doi.org/10.1002/rra.4176