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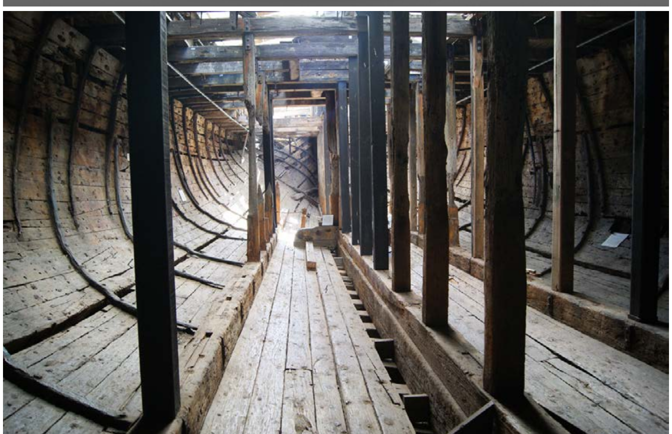

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Timber Selection in Tasmanian Colonial Shipbuilding: A Preliminary Predictive Model

RICK BULLERS

Abstract

Timber selection is an important area of research for understanding colonial Australian shipbuilding, and yet archaeological research of such has been relatively sparse. This study builds on previous work on predictive modelling of timber usage in shipbuilding by testing the hypothesis that colonial shipbuilders primarily sourced native timber from the region wherein their shipyard was located. The study is based on the currently available dataset of wood species identified in the archaeological hull remains of vessels built in southeastern Tasmania during the colonial period (1788–1900), comprising eight vessels from five shipbuilding regions. It also includes a review of shipbuilding timbers in Tasmania and describes specific uses for them in shipbuilding. Only half of the sampled vessels in the study support the hypothesis. This may be due to (1) the small sample size (only eight vessels); (2) the generally long service life of these vessels and subsequent likelihood that they were repaired or modified at some point, probably at some yard other than where they were built; (3) the shipbuilders' specific economic circumstances or personal preferences for particular wood species; (4) erroneous contemporary descriptions of the vessels and their timber utilisation; and/or (5) issues with timber sampling leading to incorrect species identification. While it is not yet possible to make generalisations about timber usage with any confidence, it is hoped that such work will result in renewed interest in timber sourcing for shipbuilding and stimulate further research..

INTRODUCTION

Timber selection is an important area of research in colonial Australian shipbuilding (Bullers 2006, 2007; O'Reilly 2007; Staniforth and Shefi 2014). It has often been remarked that vessels built in Tasmania were built of timbers sourced locally, and that shipbuilders moved into a particular area to exploit the timbers of that region (Chambers 2011; Kerr 1987; Lawson 1949; O'May 1959; Orme 1988). Of course, timber availability alone did not guarantee success; sometimes those localised industries were short-lived and ephemeral, while elsewhere they were prolific and prospered over the long-term.

Archaeological research into broader trends in the selection of timber in colonial Australian shipbuilding has been relatively sparse, due largely to the small number of Australian vessels available for research and the comparatively high cost of wood species identification. To the author's knowledge only 14 Australian-built vessels have had some of their hull timbers sampled for wood species identification and the results of these investigations published (Bullers 2007; Bullers and Shefi 2008, 2014; Clayton 2012a; Colvin 2011; Davison 2014; Jeffrey 1987, 1992; Nash 2004; O'Reilly 2007) or are available in Government reports (Harvey 1989; Petraccaro 2014).

Kellie Clayton (2012b) developed a predictive model for wood species used in shipbuilding based on a study of timbers identified in archaeological studies of shipwrecks and then comparing them to shipbuilding timbers described by economic botanists in historical literature, which was an early contribution to this field of research. This paper takes an alternative approach to predictive modelling for the wood species of hull timbers used in Australian colonial shipbuilding by taking the archaeological dataset and comparing it to vegetation communities that grow naturally in the regions where the vessels were built. If the inference that the timbers used in the construction of these vessels were locally sourced is accurate, then it follows that the wood species identified in the hull of a known vessel should match the local species found in the region in which the vessel was built. In other words, we can develop a predictive model about the timbers that may be expected to be present on a known wreck site. Conversely, the model could potentially be reverse-tracked to identify a shipwreck based on the wood species present, and tracking these species to known shipbuilding regions or locations or, indeed, to specific shipbuilding yards. This approach was used successfully to assist with identifying Shipwreck X on the Gold Coast as the schooner *Heroine* (Davison 2014).

This paper looks at a subset of the currently available archaeological data to test the hypothesis that shipbuilders used locally sourced timbers for construction, using southeastern Tasmania as a case study.

METHODOLOGY

This preliminary predictive model comprised a review of the currently available dataset of wood species identification of timber samples obtained from vessels built in southeastern Tasmania compared to the published vegetation species of the location or region where they were built. Southeastern Tasmania was chosen as a case study for several reasons: (1) Tasmania was one of the more prolific shipbuilding colonies in 19th-century Australia; (2) a comparatively large proportion (roughly half) of the available archaeological dataset is from vessels built in southeastern Tasmania; (3) a large proportion of the published literature on historical shipbuilding in Australia is devoted to the industry in Tasmania, and historical descriptions of the Tasmanian timber-getting industry also are extensive; and (4) the published vegetation data and mapping of the relevant Tasmanian shipbuilding regions are readily available.

The dataset

A total of eight vessels from five shipbuilding 'regions' in southeastern Tasmania were included in this study (Fig. 1; Table 1). Inclusions were restricted to Tasmanian-built, colonial-period (1788–1900) wooden commercial sailing vessels that had already been located and identified, or extant vessels that fitted the same criteria. The one exception is the wooden steamer *Victoria*, but this vessel originally was designed and laid down as a ketch, so it is likely to have the same design characteristics as a sailing vessel (Bullers 2006).

Wood species data for the cutter *Water Witch* (Jeffrey 1987), ketch *Dianella* (O'Reilly 2005) and ketch *Hawthorn* (Petraccaro 2014) were obtained from archaeological surveys and timber samplings conducted by other researchers. The wood species data for the schooner *Zephyr* (Bullers 2007), ketch *Alert* (Bullers and Shefi 2014), ketch *Annie Watt* and steamer (ex-ketch) *Victoria* (Bullers 2006) came from surveys and samplings conducted by the author. This is the first publication of the wood identification results for the latter two vessels. In addition, the ketch *Thomas and Annie* originally was sampled and the species identified by Rebecca O'Reilly (2007), but, for the sake of consistency, the timbers from this vessel were resampled and their wood species identified by Jugo Ilic.

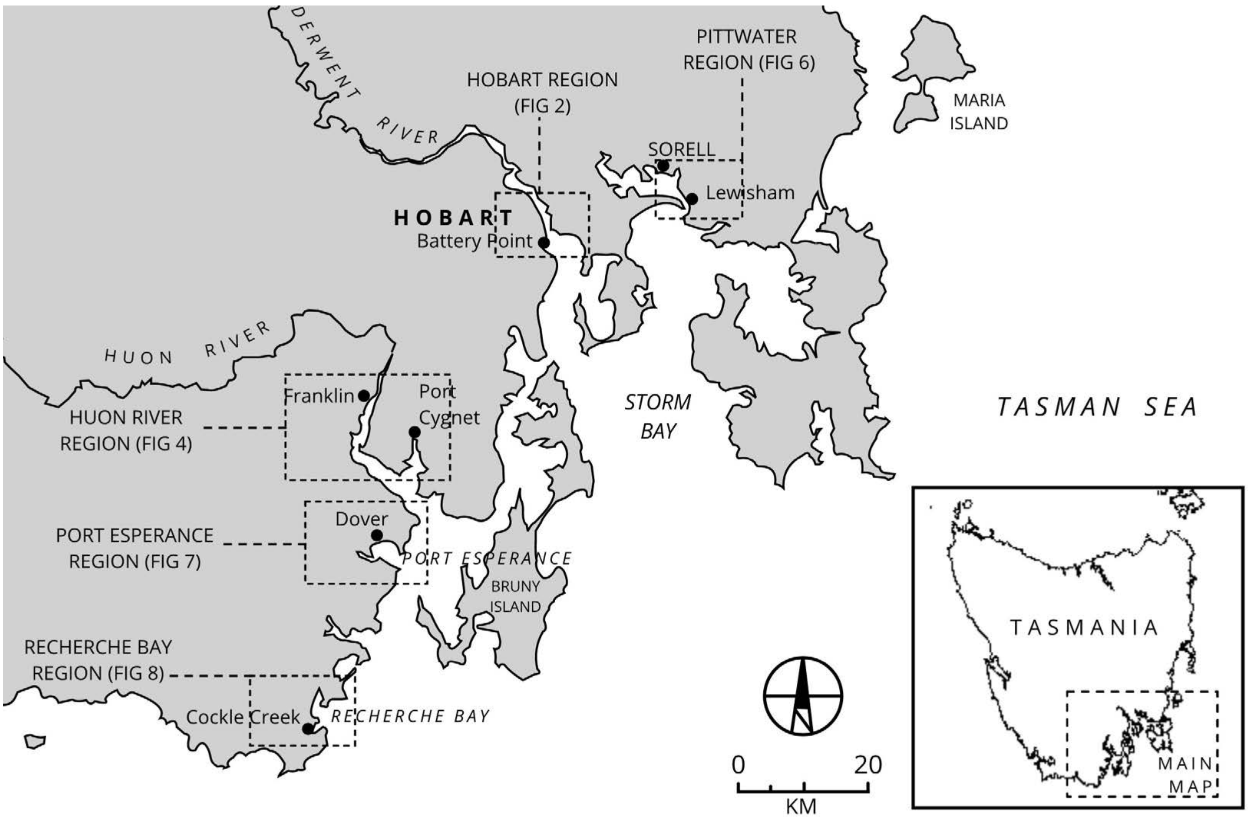

Fig. 1. Shipbuilding regions of southeast Tasmania mentioned in the text.

Table 1. Shipbuilding Regions and Vessels in the Sample Dataset

Region	Vessel	Location
Hobart	*Alert* (1872–1959)	Battery Point
	Water Witch (1835–1842)	Old Wharf
Huon River	*Hawthorn* (1875–1949)	Franklin
	Thomas and Annie (1874–1945)	Port Cygnet
	Victoria (1888–1918+)	Martins Point, Port Cygnet
Pittwater	*Zephyr* (1851–1852)	Unknown – Lewisham?
Port Esperance	*Annie Watt* (1870–)	Dover
Recherche Bay	*Dianella* (1872–1909)	Rocky Bay

Vegetation surveys

Published ecological/botanical reports for the study areas were examined with the assumption that the current native species in a given area will not have altered significantly in composition, only in range (typically due to local distribution retractions or extinctions due to land clearance).

Vegetation data were obtained initially from the extensive mapping of vegetation communities across Tasmania (TASVEG) conducted by the Tasmanian Department of Primary Industries, Parks, Water and Environment (DPIPWE), which can be viewed online via LISTmap (2019), with reference to community descriptions compiled by Kitchener and Harris (2013). Areas of local silviculture are mapped separately and are excluded from the vegetation mapping for this study to avoid confusion about natural and artificial species distribution (Williams and Potts 1996). A list of relevant vegetation communities, i.e. those with species known to be used in Australian shipbuilding, and their primary species is provided in Table 2, and the relevant communities for each shipbuilding region are discussed in detail below. To account for species that are present in a region, but are not listed as a specific community or within another community in TASVEG, reference to additional genera-specific texts is made (e.g., Peterson 1999; Williams and Potts 1996).

For each shipbuilding region, a predictive statement is made about the wood species of timbers most likely to have been used in vessels built there, which then is compared to the results of actual species identified in vessels archaeologically investigated and known to have been built the region. Where the results do not conform to the prediction, potential reasons are discussed, including a review of historical records (primarily newspaper accounts) about the vessel and what timbers reported were used in its construction.

With the exception of the samples from *Dianella*, which were identified by a student archaeologist, all timber samples were identified for wood species by wood scientist Jugo Ilic (Know Your Wood).

PUBLISHED DESCRIPTIONS OF TIMBERS USED IN TASMANIAN SHIPBUILDING

Pemberton (1979:20) considered that Tasmania's shipbuilding industry was probably the most significant of all those of the Australian colonies. Published accounts of the timbers used in Tasmanian shipbuilding vary. According to Pemberton (1979:2–3, 16), ships in Tasmania were built mainly of "blue gum" or "Tasmanian pine," although what species the latter refers to is not clear. Orme (1988:31) states that Tasmanian blue gum (*Eucalyptus globulus*) was particularly suitable for keel construction and brown stringybark (*E. obliqua*) was used for other structural components, as both timbers were prized for their durability. Planking and decking, on the other hand, were usually constructed of Huon pine.

By contrast, Kerr (1987:40–41) says that "earlier" Tasmanian vessels were commonly planked with blue gum, stringybark being used only when blue gum was scarce. A common practice was to use either of these hardwoods for the majority of planking, but Huon pine at the turn of the bilge. Another variation was to plank a vessel in hardwood below the waterline, and either Huon pine or Oregon (the Australian trade name for Douglas fir) above the waterline to minimise weight. Planking on "older" Tasmanian fishing vessels was Huon pine, as were the fish wells (Kerr 1974:123). Decking on larger Tasmanian ketches and schooners was usually Oregon, celery top pine or sometimes Huon pine, and masts usually were made from hardwood, although Oregon and spruce were used occasionally (Kerr 1987:41).

Table 2. Communities of the Southeastern Tasmanian Shipbuilding Regions (Kitchener and Harris 2013)

Community	Dominant Tree Species	Secondary Tree Species	Understory Species	Location	Shipbuilding Region*				
					H	HV	PW	PE	RB
Acacia dealbata forest	*A. dealbata*	–	Often pre-disturbance species regenerate	Generally small stands, occurring on sites disturbed by fire, clearing or floods, or along watercourses.		✓		✓	
Eucalyptus amygdalina forest	*E. amygdalina* *E. viminalis*	*E. obliqua* and *E. delgatensis*, sometimes *E. globulua* and *E. tenuiramis*	*A. dealbata* and many others	Can grade into *E. tenuiramis* forest	✓	✓	✓	✓	
Eucalyptus delegatensis dry forest and woodland	*E. delegatensis,* sometimes with *E. dalrympleana* and/or *E. globulus*	*E. pulchella*, *E. tenuiramis*, *E. cordata*	Variable, but may include: *A. dealbata*, *A. melanoxylon*, *Banksia marginata* and *Olearia viscosa*	This community forms an open canopy, with a highly variable understorey. It occurs mainly on well-drained dolerite from 300–900 m altitude.	✓				
Eucalyptus globulus dry forest and woodland	*E. globulus*	*E. amygdalina*, *E. pulchella*, *E. viminalis*, *E. ovata*, *E. obliqua*	Native grasses and *Lomandra longifolia*	This community grows on dolerite ridges, slopes and flats in coastal areas of east and southeast Tasmania and in sub-coastal areas between Buckland and Oaklands.	✓	✓	✓	✓	
Eucalyptus globulus wet forest	*E. globulus*	*E. ragnans* or *E. obliqua*, sometimes co-dominant.	Broad-leaved shrub layer and ferny understorey	This community is uncommon and occurs mainly in well-drained gullies and lower south-facing slopes in Tasmania's south-east	✓	✓	✓	✓	✓
Eucalyptus obliqua dry forest	*E. obliqua*	*E. delegatensis at higher altitudes*	Heath shrubs, inc. *A. dealbata* and *A. melanoxylon*	This community grows on dolerite, mudstone, granite and sandstone substrates, and is widespread and extensive in northeast and south-east Tasmania from sea level to 600 m.	✓	✓	✓	✓	✓
Eucalyptus obliqua wet forest	*E. obliqua*	*E. globulus* or *E. viminalis*, sometimes *E. nitida* and/or *E. regnans*	*Leptospermum* spp., *Melaleuca* spp. and broad-leaved shrubs	The most widespread, and consists of several community types with a range of co-dominants and understorey species	✓	✓	✓	✓	✓
Eucalyptus pulchella forest and woodland	*E. pulchella* (usually)	*E. globulus*, *E. viminalis*, *E. amygdalina*, *E. ovata* *E. barberi, Callitris rhomboidea*	*Banksia marginata*, *A. dealbata*, *A. mearnsii*, *Allocasuarina*, *verticillata*, native grasses and *Lomandra longifolia*	This community almost always grows on dolerite ridges, often on northwest facing slopes subject to drought stress. Widespread in southeast Tasmania at lower elevations.	✓	✓	✓	✓	
Eucalyptus regnans forest	*E. regnans*	Occasionally intergrades with *E. obliqua*	*A. dealbata*, *A. melanoxylon*	Tall single-species forest, with a dense, shrubby or forested understorey, from sea level to about 600 m.	✓	✓		✓	
E. *viminalis* grassy forest & woodland	*E. viminalis*, sometimes *E. globulus*	*E. rubida*, sometimes *E. dalrympleana*, *E. amygdalina* or *E. ovata*	Grassy/rocky, sometimes *A. dealbata*, *Banksia marginata* and/or other woody shrubs	Low to medium height forest to 700 m elevation	✓	✓	✓	✓	

* Regions: H = Hobart; HV = Huon Valley; PW = Pittwater; PE = Port Esperance; RB = Recherche Bay

Table 3. Southeastern Tasmanian Timber Species Used/Usable in Shipbuilding, as Reported by Economic Botanists (adapted from Clayton 2012b:tables)

Timber species	Common name*	Botanist	Shipbuilding uses
Acacia dealbata	Silver wattle	Maiden (1989)	Used for treenails in Tasmania
A. melanoxylon	Blackwood	von Mueller (1870s)	Most valuable for boat building
		Maiden (1889)	Boatbuilding (stem, sternpost, ribs, rudder)
		Baker (1919)	Interior joinery work of ships' cabins, blocks, ribs or bent timbers, stern timber, joinery
Dacrydium franklinii	Huon pine	von Mueller (1870s)	Highly esteemed for shipbuilding
		Baker (1919)	Ships' planks
		Maiden (1889)	Whaleboats are built of it, being peculiarly adapted for boat building
Eucalyptus amygdalena	Black peppermint	von Mueller (1870s)	Well adapted for keelsons and planking
		Maiden (1889)	Well adapted for keelsons and planking
E. delegatensis (syn. *E. gigantea*)	Gum-topped stringybark	Laslett (1875)	Employed in the colonies for shipbuilding (planking, beams, keels and keelsons)
		Baker (1919)	Gratings, gunwales, handles for boat hooks, oars, planks, bent ribs or timbers, spars and masts, targets
E. globulus	Tasmanian blue gum	von Mueller (1870s)	Used extensively for keels, planking and many other parts of the ship
		Laslett (1875)	Largely employed in shipbuilding in Australia, for keels, keelsons, beams and planking
		Nilson (1884)	Eminently useful in shipbuilding
		Maiden (1889)	Eminently useful in shipbuilding
		Baker (1919)	Gunwales, bent ribs or timbers
E. obliqua	Brown stringybark	Laslett (1875)	Employed in the colonies for shipbuilding (planking, beams, keels and keelsons)
		Maiden (1889)	No specific uses listed
		Baker (1919)	Ships' flooring
E. regnans	Giant ash	Baker (1919)	Planks
E. rubida	Candlebark	Baker (1919)	Oars
E. urnigera	Urn gum	Baker (1919)	Should be suitable for shipbuilding
E. viminalis	Manna gum	Baker (1919)	Oars

* Common names of eucalypts are the modern accepted Tasmanian variants (Williams and Potts 1996), which often differ from names used by the contemporary economic botanists.

Clayton (2012b) provides an overview of Australian shipbuilding timbers described by the economic botanists von Mueller, Laslett, Nilson, Maiden and Baker, and their descriptions of specific uses of various Tasmanian timbers in shipbuilding is presented in Table 3.

SHIPBUILDING TIMBER SPECIES IN TASMANIA

Tasmania supports extensive forest ecosystems, which led to regional timber-getting industries that flourished on an industrial scale during the late 19th and early 20th centuries (Dargavel 1982). Tasmania and the Bass Strait Islands are home to a total of 29 eucalypt species (Williams and Potts 1996). In the southeast, where the study area is located, the species present is fairly consistent, although the range and spread of each community varies from region to region. The most widespread species is brown stringybark, with generally smaller proportions of the ubiquitous Tasmanian blue gum, the endemic black peppermint (*E. amygdalina*), white peppermint (*E. pulchella*), silver peppermint (*E. tenuiramis*), giant ash (*E. regnans*), mountain white gum (*E. dalrympleana*), Smithton peppermint (*E. nitida*), swamp gum (*E. ovata*) and manna gum (*E. viminalis*).

Many species of eucalypts that appear as independent vegetation communities in Kitchener and Harris' (2013) descriptions, such as snow peppermint (*E. coccifera*), and some species listed by Williams and Potts (1996), such as cider gum (*E. gunnii*) and varnished gum (*E. vernicosa*), are, in general, not of a suitable form for shipbuilding purposes and have been excluded from the mapping for this study. Many of the species listed above (mountain white gum, Smithton peppermint, swamp gum, white peppermint and silver peppermint) do not appear in lists of suitable shipbuilding timbers prepared by the contemporary economic botanists (Table 3). Consequently, these species were excluded from the predictive statements, despite widespread availability. Other tree species in southeastern Tasmania used in shipbuilding include the endemic Huon pine (*Dacrydium franklinii*), blackwood (*Acacia melanoxylon*) and silver wattle (*A. dealbata*), with the two acacia's often present in both the tree and/or shrub layers.

HOBART

Vegetation communities

The vegetation communities on the ranges either side of the Derwent River are amongst the

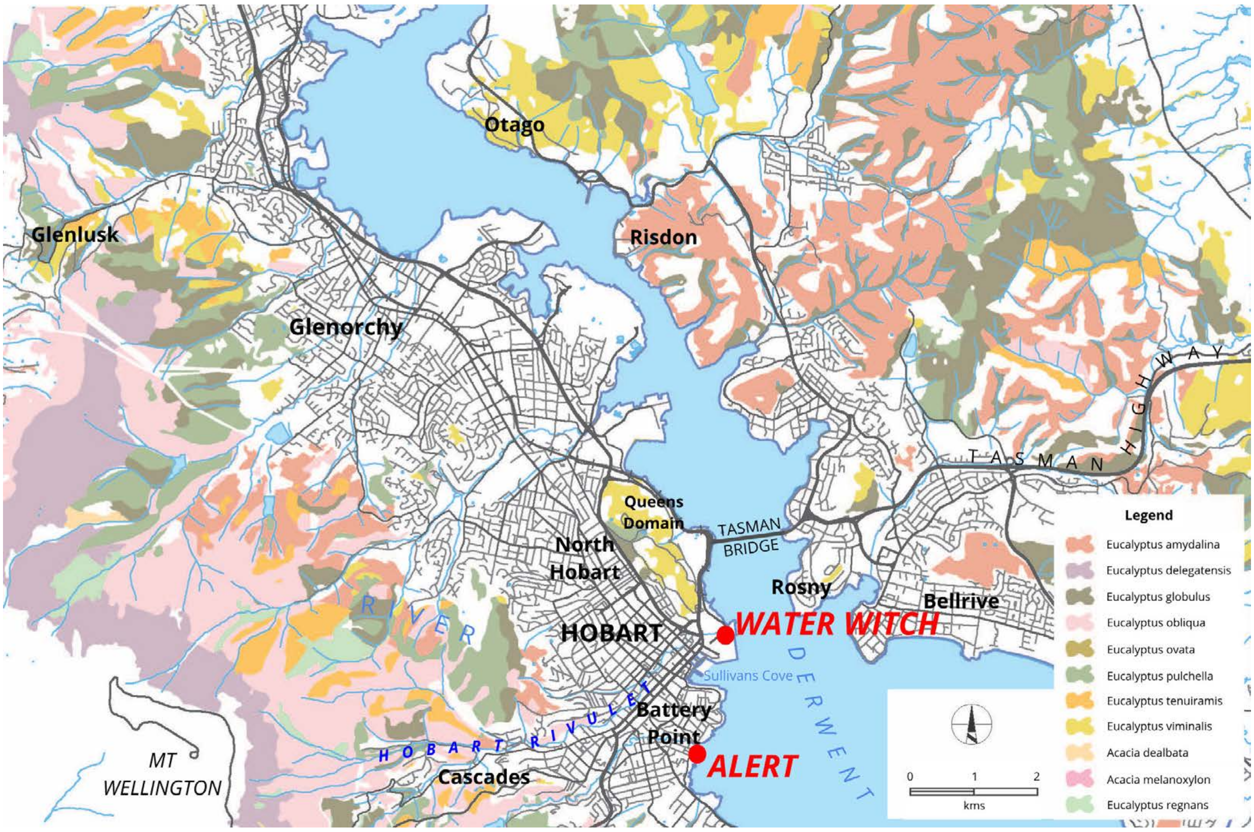

Fig. 2. Vegetation communities around Hobart (DPIPWE LISTmap).

most diverse in the study area (Fig. 2). To the west of Hobart, the lower slopes are dominated by black peppermint and white peppermint forests, with smaller stands of Tasmanian blue gum dry forest. Extensive communities of brown stringybark dry forest populate the higher elevations, with smaller stands of brown stringybark wet forest in the damper gullies, interspersed with smaller areas of giant ash and silver peppermint forest. The upper slopes of Mt Wellington are ringed by gum-topped stringybark (*E. delegatensis*) dry forests and woodlands. The Queens Domain, on the eastern edge of the Hobart CBD, supports manna gum grassy forest and woodland. Today, it forms a vegetation island surrounded by urban development, so it is unclear how extensive this vegetation community was during the 19th century.

The prediction for vessels built in the Hobart region, then, is that they should be made primarily from brown stringybark and/or Tasmanian blue gum, although giant ash, black peppermint, manna gum and gum-topped stringybark also may be present.

Samples

Two vessels in the study were built in Hobart. The cutter *Water Witch* (1835–1842) was built in 1835 by shipbuilder John Gray, who had established a boatbuilding yard at the Old Wharf on Hobart Town's waterfront and launched vessels into the Hobart Rivulet (Jeffrey 1987; Lawson 1949:58). The vessel transferred to South Australian interests in late 1837, and later sank at its moorings at Moorundie on the lower River Murray in December 1842 (Jeffrey 1987).

During excavations on the site in 1984, samples were taken from nine hull timbers and their wood species identified. The published results indicate that the timber used to build the vessel included both softwoods and hardwoods, comprising seven different native Australian species and one possibly international species. Three floors were made from brown stringybark (*E. baxteri*), tallowwood (*E. microcorys*) and yellow gum (*E. leucoxylon*). A fourth floor and the keel were made from river red gum (*E. camaldulensis*), the keelson from northern grey ironbark (*E. siderophloia*), outer planking from Tasmanian blue gum, and an unidentified fitting from Indian mangrove (*Avicennia officinalis*). In addition, at least one unidentified timber was made from hoop pine (*Araucaria cunninghamii*) (Jeffrey 1987, 1992).

Brothers James and David Mackey (aka, McKay or Mackay) launched the ketch *Alert* (1873–1959) on 6 May 1873 at their long-established shipyard at Battery Point, Hobart (Fig. 3) (Mays 2014). The vessel had been commissioned for the South

Fig. 3. Aerial view of Battery Point slipways overlaid with the 1874 map of Battery Point, showing the location of the Mackey Brothers shipyard (orange) and Mackey residential blocks (yellow) (Tasmanian Archives AF394/1/104).

Australian gulf trade, where it served for more than 80 years before being abandoned in the late 1950s, then demolished and burned to the waterline at Ethelton, near Port Adelaide, in the early 1960s (SARHS 2019). During a baseline survey of the remains in 2005, followed by further survey and a test excavation in 2007 by the author and others, a total of 10 timber samples were collected and their species identified. Eight of the samples (two sister keelsons, inner sternpost, aft deadwood, floor, cant frame, planking and centreboard) were made from Tasmanian blue gum, the centreboard casing was made from river red gum and the keelson was made from brown stringybark (Bullers and Shefi 2014).

Discussion

Five of the six eucalypt timber species identified on *Water Witch* and one of the non-eucalypt species are endemic to the Australian mainland, but not to Tasmania, let alone to the Hobart region. Additionally, the other non-eucalypt (mangrove) seems to have an Asiatic distribution rather than Australian, although the published literature is not consistent on this point (see discussion below).

Why then, with the naturally available shipbuilding timbers of southeastern Tasmania, did John Gray choose to use primarily non-endemic timbers in his vessel? As the major town in Van Diemen's Land, Hobart Town was the central export terminal for timber extracted from the forests of southern Tasmania, but also the point of import of other timber. Therefore, a larger variety of timber would have been available over and above the natural resources of the region. It seems market forces were at play. According to Jeffrey (1987:75), Gray often took timber instead of money as payment for vessels he built, possibly as a means of keeping stock on hand to ensure materials were available for ongoing work. Jeffrey (1987) provides a thorough analysis of the reasons for using imported woods, but little attention is given to the presence of the mangrove species.

The identification of Indian mangrove in the sample set provides an interesting case study on species distribution and potential taxon confusion. When Jeffrey (1983:33) published the results of his wood sample identifications, he stated that this species is commonly found around Australia, which was probably a correct assumption at the time. However, subsequent published literature appears to be confused on this point. Some sources say Indian mangrove occurs from the Indian subcontinent, through Southeast Asia and into Australia, with some saying as far south as New South Wales (e.g., Duke 1983, 2017; Fern 2014 and Tomlinson 1986). However Duke (1991) clarified this by stating the range extended "…to Austral*asia,*" [emphasis added] rather than Australia, with the southern limits restricted to the southern coastline of Papua New Guinea.

Other publications support this and do not include Australia in the species' distribution (Duke 2006; Vanden Berghe 2020). Both ALA (2020) and ANBG (2020) list 18th- and 19th-century records of Indian mangrove in Australia as being misidentifications of the ubiquitous grey mangrove (*A. marina*), which occurs in every Australian mainland state. In 1988, soon after Jeffrey published his findings, the occurrence of Indian mangrove in the Northern Territory was found to be erroneous, and the species occurring there is taxonomically distinct (Duke 1988, Wightman 2006). This newly described species was named *A. integra*, a species that apparently does not yet have a common name. In the same paper, Duke (1988) also states that neither Indian mangrove, nor *A. integra*, occur in the floristically rich region of northeastern Queensland. If Indian mangrove does not occur in the Northern Territory or northeastern Queensland, it seems unlikely that it would be found in New South Wales. The National Herbarium of NSW's Flora Online database does not include *A. officinalis* (PlantNet 2020).

The Australian distribution of Indian mangrove now appears to be erroneous, and consequently, its identification may be suspect. Was the sample from *Water Witch* actually Indian mangrove, and therefore potentially imported from an international source, or was the sample misidentified at a time when Indian mangrove was thought to be an Australian species, and is actually something else?

Conversely, an historical description of *Alert*'s construction indicates that it was built primarily of species that were available in the Hobart region, stating that the vessel's "framework and bottom planking are of the best blue gum" and its "topsides and decks are planked with Huon pine", although its masts were "made of Kauri pine", an imported timber (*The Mercury* 1873). The timber species identifications support this, as the majority of sampled components were made from Tasmanian blue gum, although brown stringybark was used for the keelson. Only the centreboard casing was made from a non-local species. In 1891, the vessel underwent a major renovation at Port Adelaide, during which its length was increased substantially.

The archaeological evidence suggests that changes were made to the centreboard casing, probably as part of this refit, which may account for the use of a mainland species in the casing (Bullers and Shefi 2014).

Evaluation of prediction

Comparison of the archaeological results from two shipwrecks to the predicted timber use is inconclusive. Of all the vessels in the case study, *Alert* best matches the predictive statement, while *Water Witch* is the vessel that tallies with it the least. Different shipwrights built these vessels nearly four decades apart, and it is likely that different economic conditions, differences in personal business approaches, and improvements and expansions in the local timber-getting industries may account for the different wood types used in their constructions.

HUON RIVER

Much of the landscape around Port Cygnet and Franklin has been cleared for agricultural purposes, but the hills, slopes and flats are scattered with both wet and dry sclerophyll forests and woodlands dominated by brown stringybark forest or woodland communities, with lesser areas of Tasmanian blue gum or silver wattle (*Acacia dealbata*) forest communities (Fig. 4). In the ranges west of Franklin, brown stringybark forest is the most prevalent, although larger remnant stands of Tasmanian blue gum are still present, particularly around Castle Forbes Bay and Rivulet. These stands form virtual islands surrounded by agricultural land, so it is possible that the Tasmanian blue gum communities were once much larger, but have been felled for timber and agricultural clearing. The Tasmanian blue gum communities sometimes have representatives of black peppermint, white peppermint, manna gum, swamp gum and brown stringybark present in the canopy layer, and drooping sheoak (*Allocasuarina verticillata*) and others present in the shrub layer (Kitchener and Harris 2013).

A large number of small stands of giant ash forest are also present, particularly west of Franklin and frequently in close proximity to the Tasmanian blue gum stands. Giant ash forests are often single species communities, but also can co-occur with brown stingybark (Kitchener and Harris 2013).

Silver wattle and blackwood typically are present in the shrub layer of all these communities, with silver wattle often occurring in the tree layer with brown

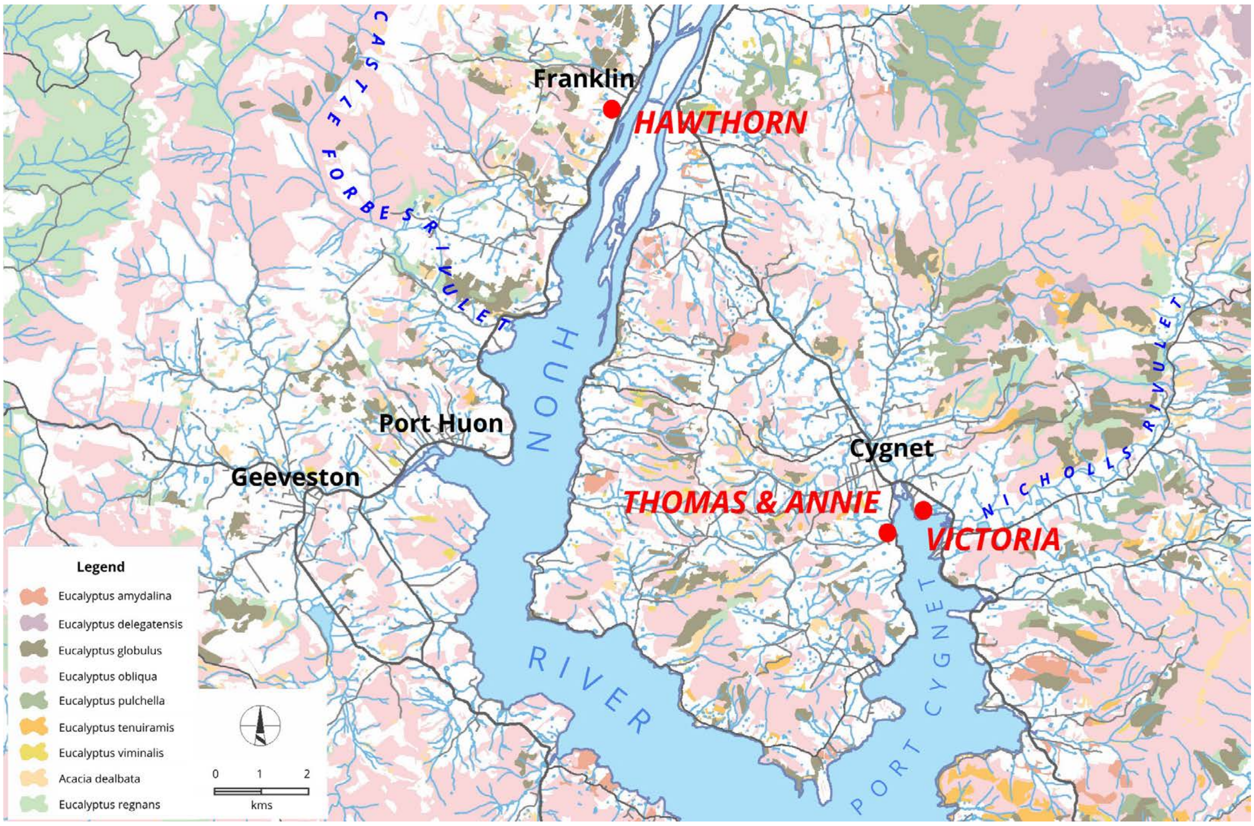

Fig. 4. Vegetation communities around Port Cygnet and Franklin, Huon River (Tasmanian Government, DPIPWE LISTmap).

stringybark (Kitchener and Harris 2013). Huon pine, the iconic softwood of this region, is not listed as a separate vegetation community. It is assumed to be a component of other vegetation communities, but is not listed in any of Kitchener and Harris' (2013) descriptions. Mapping of virgin stands of Huon pine by Peterson (1999) shows that they occur in the upper reaches of the Huon River and its tributaries, from around the small townships of Glen Huon and Judbury westwards to the river's source near Lake Pedder.

The prediction for vessels built in the Huon River is that they will be made principally from brown stringybark and/or Tasmanian blue gum, with componentry potentially made from black peppermint, Huon pine, silver wattle and blackwood. Giant ash also may have been used, particularly around Franklin.

Samples

The ketch *Hawthorn* (1875–1949) was commissioned in 1875 by John Philp and built at Franklin, on the upper navigable reaches of the Huon River, under the supervision of Joseph Mason (incorrectly referred to as Mann in some newspaper accounts), who also designed the vessel (*The Mercury* 1875). This was apparently Mason's first foray into shipbuilding. His prior experience and qualifications are unknown, but it is assumed he had some form of carpentry skills. Despite his inexperience in shipbuilding, the vessel was said to be handsome and finely built. Philp must have been impressed, as immediately he commissioned Mason to build a second vessel at Franklin, which was launched in 1876 as *Trucanini* (*The Mercury* 1876). During a survey in 2014, a total of seven timber samples were collected from *Hawthorn* (Fig. 5). Two frames and one outer plank were made from Tasmanian blue gum, a ceiling was made from jarrah (*E. marginata*), another outer plank was made from western red cedar (*Thuja plicata*), a treenail was made from red ironbark (*E. sideroxylon*) and the centreboard was made from river red gum (*E. camaldulensis*) (Petracarro 2014).

Fig. 5. Ketch *Hawthorn* wreck site (courtesy of the Government of South Australia, Department for Environment and Water).

Two vessels in the dataset were built at Port Cygnet, in the lower reaches of the Huon River. *Victoria* (1888–post 1918) was built in 1888 by noted shipbuilder John Wilson at Martins Point, on the northeastern shores of Port Cygnet (Fig. 4). The vessel originally was laid down as a ketch, but during construction was converted to a steamer (Graeme-Evans and Wilson 1996). Sometime after 1918, the vessel was abandoned at Ida Bay, on Tasmania's southern coast between Port Esperance and Recherche Bay, apparently still tied up to the jetty (Bullers 2006). During an archaeological survey of the vessel in 2005, the author collected seven timber samples. The stem, cutwater, ceiling and a lodging knee were all made from brown stringybark, the sister keelson from Tasmanian blue gum, the mast from blackwood and an outer plank from white pine (*Pinus strobus*).

The ketch *Thomas and Annie* (1874–1945) was built by Colin Walker at Port Cygnet and launched on 14 July 1874 (*The Mercury* 1874). The location of the vessel's construction site is unknown at present, but it is possible that Walker used the Wilson yard at Martins Point (Fig. 4). Walker had assisted John Wilson with some of his earlier vessels, was in a de facto relationship with Wilson's mother, Ellen, and at the time *Thomas and Annie* was being built, Wilson was away building the ketch *Good Templar* at Southport Narrows (Graeme-Evans and Wilson 1996). Furthermore, Gillespie (1994) incorrectly attributes the construction of *Thomas and Annie* to Wilson.

In 1945, the vessel was abandoned inshore of other derelict hulks at the Garden Island Ships' Graveyard in Port Adelaide, South Australia (SARHS 2019). During an archaeological survey of the vessel in 1999, five wood samples were collected. The sampled futtock (frame) and treenail were identified as blackwood, the outer plank as giant ash and the centreboard case as candlebark (*E. rubida*). The sample taken of the stem was not identified (O'Reilly 2007).

Since O'Reilly identified the wood species of *Thomas and Annie* timber samples herself, the author

Table 4. Comparison of Wood Species Identifications for *Thomas and Annie*

Component	1999 Sampling (O'Reilly 2007)		2019 Sampling	
	Sample ID	Wood Species	Sample ID	Wood Species
Treenail	W5a	*A. melanoxylon* (blackwood)	-	-
Stem	W5b	not identified	TA4	*E. ?camaldulensis* (river red gum)
Frame	W5c	*A. melanoxylon* (blackwood)	TA2	*Corymbia maculata* (spotted gum)
Plank	W5d	*E. regnans* (giant gum)	TA1	*E. marginata* (jarrah)
Centreboard case	Wfe	*E. rubida* (candlebark)	TA3	*E. ?propinqua* (grey gum)

A '?' before the species name indicates that the identification was not conclusive, but that the species listed was considered the best match.

collected additional samples and sent them to Jugo Ilic for consistent identification of their species. As seen in Table 4, the results differ markedly: the stem was identified as river red gum, the frame as spotted gum (*Corymbia maculata*), the plank as jarrah and the centreboard case as *E. ?propinqua* (grey gum). No treenails were found for sampling.

Discussion

Hawthorn was said to be built of "gum, stringy bark and pine… and… fitted with… [a] Huon pine cabin" (*Tasmanian Tribune* 1875). Elsewhere, construction timbers were described as "gum, with Huon pine topsides" and a stateroom in which the "fittings are made from the real Huon pine, a very pretty wood when polished" (*The Mercury* 1875). These appear to be Mason's timbers of choice, as his next vessel, the ketch *Trucanini*, also built at Franklin, was described similarly as being "built of gum with pine topsides and decks" (*The Mercury* 1876). The wood samples generally confirm the historical description, with framing and at least some planking made from locally sourced Tasmanian blue gum. The other components sampled were made from trees that are not endemic to Tasmania. *Hawthorn* was sold to South Australian interests in 1876 and spent the next 73 years working the gulf trade and latterly as a fishing vessel. It is likely that the non-Tasmanian timbers were the result of maintenance or alterations during its long working life.

Historical accounts of the timbers used in *Victoria*'s construction have not been located to date. Due to the difficulties of the wreck site for solo-survey (Bullers 2006), timber sampling was limited to components that were within relatively easy reach, around the forward half of the vessel, and exposed above the thick oozy mud encasing it. The sampling shows that much of the main structure was made from timbers readily available around Port Cygnet. It is known that John Wilson used to roam the hills around his home there to find suitable timbers, which often were fashioned on-site and then transported to the yard (Graeme-Evans and Wilson 1996). Only the outer plank sampled was made from a non-endemic timber—white pine, native to the northeast coast of North America. As only a single planking sample was obtained, it is possible that it was a replacement piece during the ship's long working life; other planks may prove to be a local species.

A newspaper account of *Thomas and Annie*'s first arrival in Hobart states the vessel was built of "blue gum, strongly fastened throughout" (*The Mercury* 1874), which would fit the predictive statement. However, none of the wood species identified were Tasmanian in origin. While river red gum is found in all Australian mainland states, the sampled plank is jarrah from Western Australia, the frame is spotted gum from NSW and the centreboard case is grey gum from northern NSW or southeastern Queensland. None of the samples conform to the historical statement that it was built of blue gum (assumed to mean *E. globulus*). While the use of mainland timbers in the planking and possibly the centreboard case could be attributed to repairs during its South Australian service, the use of such timbers for the stem and frames suggests deliberate use of non-endemic timbers. It appears that despite the readily available supply of Tasmanian timber around Port Cygnet and the Huon Valley, Colin Walker chose to use imported timber. The use of river red gum in the stem is interesting; although *Annie Watt* was not built at Port Cygnet (see below), the ship's builder, John Wilson, was from there and also chose river red gum for the ship's stem.

Evaluation of prediction

Comparison of the archaeological results from three shipwrecks to the predicted timber use again is inconclusive. The species identified in the

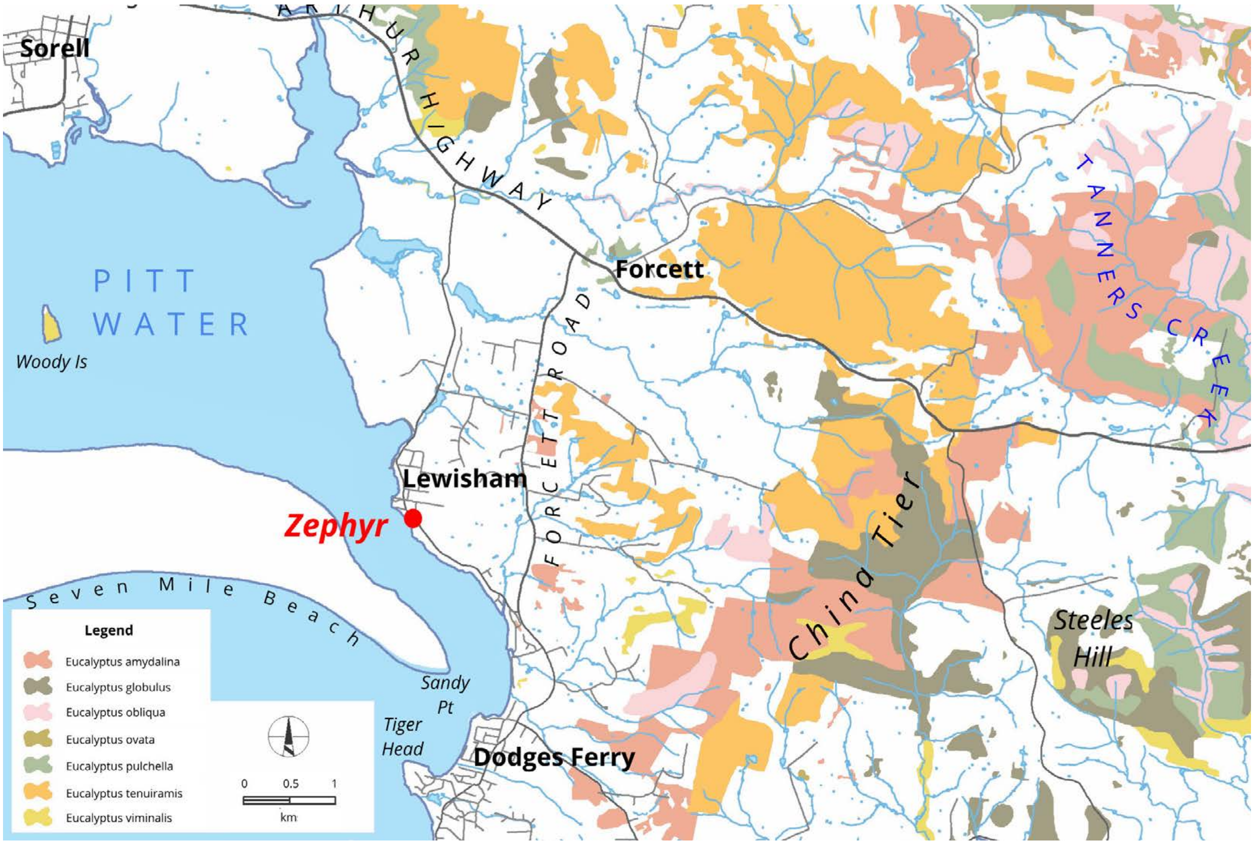

Fig. 6. Vegetation communities around Lewisham, Pittwater (Tasmanian Government, DPIPWE LISTmap).

samples tend to confirm the historical accounts and prediction of timbers used for *Hawthorn* and *Victoria*, but not for *Thomas and Annie*. Thus, the predictive statement is supportive for two of the three ships.

PITTWATER

Vegetation communities

Pittwater is a largely enclosed embayment to the east of Hobart, with the town of Sorell as its major centre on the northern shore. Much of the landscape around Pittwater has been cleared for agriculture, silviculture, small farming and some urbanisation. The range to the east of Lewisham, known as the China Tier, supports large stands of silver peppermint, black peppermint and Tasmanian blue gum, with smaller stands of brown stringybark and manna gum nearby (Fig. 6). Most of these comprise dry sclerophyll communities, although some of the Tasmanian blue gum and brown stringybark stands are wet sclerophyll forest. The extent of land clearance means that some or all of the smaller communities (particularly brown stringybark) may have been much more extensive in closer proximity to Pittwater.

Thus, vessels built at Pittwater should be built using primarily brown stringybark and Tasmanian blue gum. Some componentry may also be made from black peppermint and manna gum.

Sample

The schooner *Zephyr* (1851–1852) was built by John Thompson at Pittwater in 1851. The vessel wrecked the following year at Marion Bay on Tasmania's east coast (Broxham 1996; Broxham and Nash 1998; Bullers 2006). The exact location where *Zephyr* was built is unknown, but it may have been at Lewisham, where Thompson also built *Lewisham Belle* in 1865 while employed as a shipwright by the vessel's owners. Instead of working from an established yard, he appears to have set up a yard wherever it was needed. He built at least three other vessels at Pittwater, including *Red Rover* at Bluff Ferry in 1833, *Harriet* in 1848 and *Mary Ann* in 1850, as well as *Recherche* at Port Davey in 1841 (Graeme Broxam pers. comm. 2019).

During an opportunistic survey of the site in 2004, three timber samples were taken: one from a knee, one from a futtock (frame) and one from an outer plank (Bullers 2007). All three samples were Tasmanian blue gum, which occurs naturally in small pockets east and north of Pittwater. Brown stringybark is the most prevalent species to the north of Pittwater.

Discussion

No historical accounts of Zephyr's construction have been found as yet. All three samples were Tasmanian blue gum, which today is present only in fairly small stands to the north of Lewisham, but in larger stands to the east, where the vessel may have been built. Although brown stringybark is the most prevalent species in the region today, particularly to the north, none of the samples were this species; however, limited exposure of the wreck during the opportunistic survey meant that few samples could be taken. It is possible that other componentry on the vessel were made from this species.

Evaluation of prediction

The species identified from the samples tend to support the predictive statement that the vessel was built from local Tasmanian timbers. Nevertheless, while limited sampling of a single shipwreck was supportive of the predictive statement, additional survey and sampling of the vessel is needed and could alter this.

PORT ESPERANCE

Vegetation communities

The coastal flats around Dover have been cleared for agriculture, but the hills and slopes on the north side of Port Esperance still have extensive dry and wet sclerophyll forests. These consist of white peppermint, brown stringybark and Tasmanian blue gum. Surrounding these communities, particularly in the hills to the west and north of Raminea, are extensive brown stringybark wet sclerophyll forests (Fig. 7). Thus, vessels built in and around Port Esperance should be built from Tasmanian blue gum, brown stringybark and giant ash, with some components made from silver wattle and/or blackwood.

Sample

The ketch *Annie Watt* (1870–present) also was built by John Wilson, at Dover, and launched on 27 October 1870 (*The Mercury* 1870). It enjoyed a long career in South Australia's mosquito fleet and is noted as the last working ketch in the fleet. The vessel is still largely intact and currently is stored in a wharf shed at Port Adelaide (Bullers 2014; O'Reilly 2007). The exact construction location in

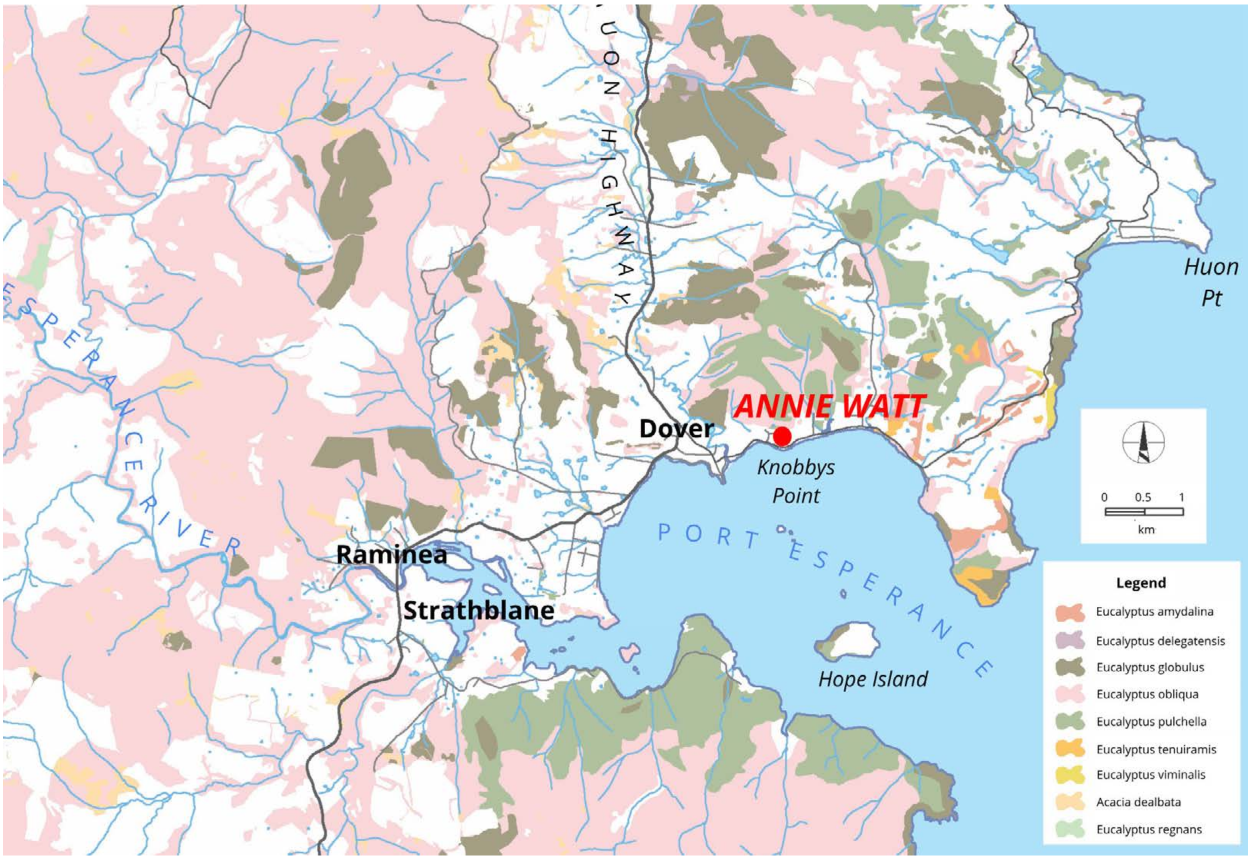

Fig. 7. Vegetation communities around Port Esperance (Tasmanian Government, DPIPWE LISTmap).

Port Esperance has not been identified, but Graeme-Evans and Wilson (1999) states that it was at Dover (called Port Esperance until 1895), so it is assumed to be on the northern side of the bay. *Annie Watt* is one of the earliest vessels for which Wilson is credited as being sole builder.

During a survey of the vessel by the author and others in 2007, 14 timber samples were taken. The keel, keelson, sister keelsons and gripe were made from jarrah, the stem and stern post from river red gum, a cant frame, deck beam and deck planks from brown stringybark and treenails from brown mallet (*E. astringens*). The single outer plank sampled was made from Oregon/Douglas fir (*Pseudotsuga menziesii*). Samples from the sternson and a counter timber were eucalypts, but could not be identified to species level. The stem head was made from kauri (*Agathis* sp.), a tree native to either north Queensland or New Zealand, depending on the species.

Discussion

Why Wilson chose the species used in the construction of *Annie Watt* is unclear. Of the 14 timber samples, only the cant frame, deck beam and deck planks were made from a species that grows naturally around Port Esperance (brown stringybark). Indeed, soon after its launch, the vessel was reported to be "constructed principally of red gum and pine with decks of Kauri pine" (*The Mercury* 1870). The use of brown stringybark in the deck planking does not point towards local timber sourcing. The historical timber description clearly states that the deck planks were kauri; however, with a working life spanning nearly 100 years, mostly in South Australian waters, it is highly likely that most if not all of the deck was replaced, and brown stringybark is a species readily available in South Australia.

The historical description of "red gum" is really a catchall name and demonstrates the difficulties for researchers relying on common names (or descriptors) to describe tree species. Both river red gum (*E. camaldulensis*), used for the stem and sternposts, and jarrah (*E. marginata*), used for the keel assembly, are deep red-coloured woods and could be described as "red gum" by non-botanists.

River red gum grows in all mainland states, but not Tasmania, while jarrah and brown mallet grow only in southwestern Western Australia. How they ended up in Dover to form the vessel's main structural components is perplexing, particularly given that Port Esperance was one of the main centres for timber-getting in southern Tasmania.

The historical description also includes the use of kauri for the deck planks, and the presence of this species in the sample set, albeit for a part of the stem, tends towards further confirmation. The historical description also describes the use of "pine" in the construction. The only pine identified in the samples was Oregon, which is native to western North America. Its use for planking could be further confirmation of the historical description (i.e., part of the original structure), or it could mean that some or all of the planking was replaced during the vessel's working life. All Australian colonies imported Oregon in huge quantities from the 1860s onwards, and so it was readily available (Bell 2002).

Evaluation of prediction

The species identified from the samples tend to confirm the historical account of timbers used, and these appear to be largely timbers imported from the mainland or elsewhere. Although the presence of brown stringybark in one of the frames and a deck beam does at least point to some local timber sourcing for *Annie Watt*'s construction, the samples taken as a whole do not support the predictive statement that the vessel was built from local Tasmanian timbers.

RECHERCHE BAY

Vegetation communities

The coastal areas of Recherche Bay are characterised by gently rolling hills interspersed by poorly drained plains that support brown stringybark forests and woodlands, with much smaller areas of scrub, heath and coastal vegetation communities. The area still retains areas of old growth forest with rainforest understorey, which is uncommon in southeastern Tasmania. Many vegetation specimens were collected in Recherche Bay during the 1792–1793 French expeditions under Bruny D'Entrecasteaux, and many of these were made type specimens when the species were formally described (Kitchell and Kingdom 2007).

The extensive brown stringybark forests span the full spectrum of community classes, from dry heathy forest to wet forest types (Fig. 8). The main change within these forests is the understorey, which comprises either dense broad-leaved shrubs, rainforest, or woolly tea-tree (*Leptospermum lanigerum*) and/or scented paperbark (*Melaleuca squarrosa*), sometimes with prickly mimosa (*Acacia verticillata*), and often these intergrade (Kitchener and Harris 2013). In relatively dry areas, manna

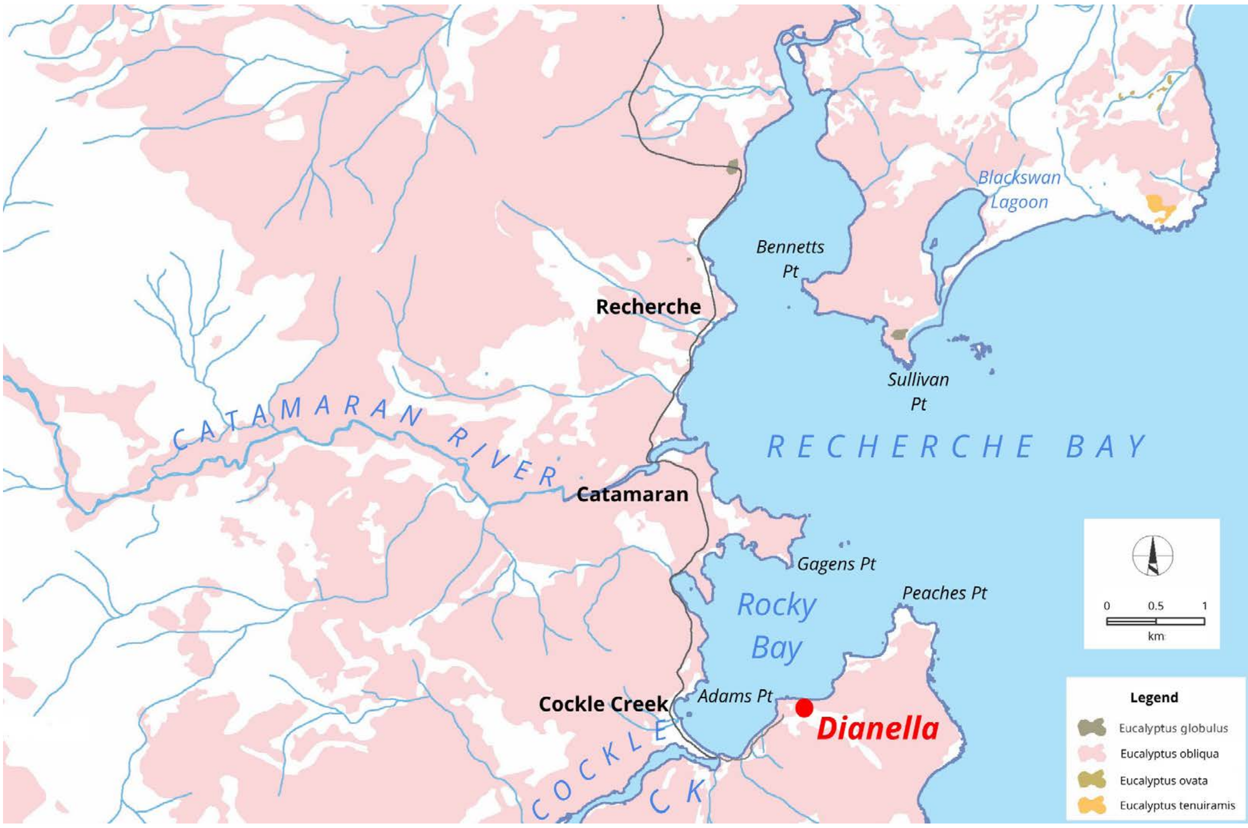

Fig. 8. Vegetation communities around Recherche Bay (DPIPWE LISTmap).

gum is a frequent co-dominant species that is either replaced or co-occurs with Tasmanian blue gum, but these are relatively minor occurrences. At altitudes above 300 m, such as on the ranges to the west, mountain white gum becomes the co-dominant species. At 600 m, brown stringybark is replaced by gum-topped stringybark (Kitchener and Harris 2013).

Vessels built in and around Recherche Bay should be built primarily from brown stringybark, although Tasmanian blue gum may also be found wholly or partially within the vessel.

Sample

The ketch *Dianella* (1872–1909) was built by Thomas Williams at Recherche Bay, and launched on 10 August 1872. Williams apparently built the vessel during his spare time over a 10-year period, with the assistance only of a boy (*The Mercury* 1872a, 1872b). Williams was allocated two parcels of land totalling nearly 20 acres on the southern side of Rocky Bay, near Adams Point, just east of the Cockle Creek entrance (Fig. 9). Although not verified, it is assumed that he built *Dianella* there. In 1909, the vessel wrecked about 2.7 km northwest of Moonta jetty, in South Australia's Spencer Gulf (SARHS 2019).

During a survey of the wreck site in 1999, three timber samples were taken: one from a frame, one from an outer plank and one from a treenail. The plank and frame were identified as giant ash and the treenail as blackwood (O'Reilly 2007).

DISCUSSION

The timbers used in *Dianella*'s construction were described in a newspaper report shortly after the vessel's launch, stating that the "framework and planking of the vessel are of blue gum, and the fittings are of Huon pine" (*The Mercury* 1872b). This clearly indicates that at least a large part of the main structure of the vessel was built from *E. globulus*. This is interesting given that current mapping shows that the vast majority of wet and dry sclerophyll forest in the region comprises brown stringybark, and Kitchener and Harris (2013) do not list Tasmanian blue gum as either a co-dominant or even co-occurring species within brown stringybark forests. Only a small, isolated stand of blue gum wet sclerophyll forest occurs around the northern end of the bay.

The identification of giant ash in both the frame and planking is non-conformant with both the historical description and vegetation mapping. The nearest stands of giant ash are located north of Southport, approximately 18 km away; there are none in the immediate environs of Recherche Bay or in the interior to the west.

O'Reilly (2007) self-identified the timber samples collected from *Dianella*, as she also did for those from *Thomas and Annie* (see pp. 12–13, above). The *Dianella* samples are the only ones in the dataset not identified by Jugo Ilic, and as such the results may be considered inconsistent with the others, and possibly suspect until further examination of timber samples from this vessel can be performed.

Evaluation of prediction

The wood species identified on the wreck site do not conform with either the historical accounts of timbers used in the construction nor to the known timber resources of the region, and therefore do not conform to the predictive statement of timber usage. The results are not supportive, but suspect sample identification means additional sampling and species determinations are required.

Discussion

Does the preliminary predictive model work? The archaeological evidence shows inconsistencies in the generally accepted notion that Tasmanian vessels were built from Tasmanian timbers. A preliminary comparison of wood species identified in the few archaeological shipwreck surveys to date reveal that a variety of structural timbers from all over Australia were used in Australian shipbuilding (Bullers 2006:33). Of the eight vessels in this case study, only half—*Alert*, *Victoria*, *Hawthorn* and *Zephyr*—support the predictive model (Table 5). The other four vessels do not support the timber modelling, but one of these is considered inconclusive due to questions about the species identification of its timber samples.

Two of the vessels that utilised non-Tasmanian timber, *Water Witch* and *Annie Watt*, were built by highly experienced shipwrights in areas where plentiful supplies of Tasmanian timbers were available. John Gray's acceptance of timber as partial payment is one possible explanation for this.

Other Tasmanian shipbuilders did use timbers that were readily available in the wooded hills near their yards. For example, Graeme-Evans and Wilson (1996:31–32) describe how John Wilson, and subsequently his sons, used to roam the hillsides around Port Cygnet looking for a suitable tree to work on—one that was "large, sound and free of faults, and situated so that it could easily be dragged to a road or riverside" (Fig. 10). Nevertheless, the

Fig. 9. Aerial image of Cockle Creek, Recherche Bay, overlaid with 1854 map showing Thomas Williams' landholdings (Lots L and N) outlined in yellow (Tasmanian Archives AF819/1/282).

Table 5. Summary of Results from the Predictive Model

Region	Vessel	Location	Prediction
Hobart	*Alert* (1872–1959)	Battery Point	Supportive
	Water Witch (1835–1842)	Old Wharf	Not-supportive
Huon River	*Victoria* (1888–1918+)	Martins Point, Port Cygnet	Supportive
	Hawthorn (1875–1949)	Franklin	Supportive
	Thomas and Annie (1874–1945)	Port Cygnet	Not-supportive
Pittwater	*Zephyr* (1851–1852)	Unknown – Sorrell?	Supportive
Port Esperance	*Annie Watt* (1870–)	Dover	Not-supportive
Recherche Bay	*Dianella* (1872–1909)	Rocky Bay	Not-supportive, but suspect sample identification

archaeological evidence from *Annie Watt* shows that that such timber was not always exploited, even by Wilson.

In certain circumstances, reverse-tracking the wood species on a wreck site may assist with a vessel's identification by narrowing down the region of construction; however, care needs to be taken using this approach. For example, if the identities of *Water Witch* and *Thomas and Annie* were not already known, analysis of their timbers might lead to an erroneous assumption that the vessels were built on the mainland, most likely in NSW.

Issues with timber sampling

A review of the various sampling strategies used in the archaeological surveys of the case study sites and the results of species identifications highlight a number of lessons; although self-evident, they bear mentioning:

- Identification of wood species should be done by recognised experts. Conclusions based on identifications by non-professionals are suspect and can lead to inaccurate interpretations of the results.
- Eucalypt timbers are identified by wood colour, density and the arrangement and shape of the cellular structure. Although cell structure remains unchanged, physical properties can be affected by environmental conditions and/or length of time exposed (Jugo Ilic pers. comm. 2019). Even expert species identification can result in an incorrect or questionable identification if the quality of the samples are poor.
- A robust sampling strategy should include, if possible, taking at least two samples of any particular structural component type (e.g., sample at least two frames, two planks, etc.) at sufficient distance from each other to (1) allow for problems with identification due of a poor sample condition and (2) provide a better chance of identifying an original component instead of a replacement part.

Issues with use of common names

The use of common names for wood species in historical descriptions of timber types used in shipbuilding can be misleading and skew interpretations of individual vessels or of industry practices, but so too can ambiguous reporting of botanical names. For example, *E. amygdalena* is a prolific species that grows in large communities in several of the shipbuilding areas within this study. It was described in the 1870s by von Mueller as being "well adapted for the keelson and planking of ships," a statement repeated by Maiden in 1889 (cited in Clayton 2012b). Regrettably, he also states that it "might be called *regnans*," which introduces confusion as to which of the species, *E. regnans* or *E. amygdalena*, he was actually referring.

Fig. 10. John and Walter Wilson preparing a keel on site in the foothills near Cygnet, c. 1890s (Graeme-Evans and Wilson 1996:32).

Selective use of timber species

The economic botanists list a number of species that grow prolifically in the shipbuilding regions of the study area, but are not represented in the vessels sampled. These include black peppermint (*E. amygdalina*), gum-topped stringybark (*E. delagatensis*), urn tree (*E. urnigera*) and manna gum (*E. viminalis*). This may be due to the small number of vessels sampled, an inadequate number of samples from each vessel, the locations on each vessel from where the samples were taken, or simply that although they are considered suitable for shipbuilding, they are not favoured by individual shipwrights compared to other species.

Replacement versus original timbers

The length of a vessel's working life and its location of service will affect the predictive model, as the longer the working life the greater the likelihood of non-original timbers due to maintenance or alterations. If the works are conducted somewhere other than the original construction region, either because the vessel is based elsewhere or undergoes the works whilst on a voyage, then the replacement timbers may be those readily available at the maintenance port, and could be native or imported timbers.

FURTHER RESEARCH

At least seven other Australian-built vessels, constructed in NSW and Victoria, have been located, identified, surveyed and sampled. These include the schooners *Alert*, built in NSW in 1846 (Nash 2004), *Alma Doepel* (Clayton 2012a) and *Clarence* (Harvey 1989), the ketches *Dorothy S*, *Lady Daly* (O'Reilly 2005) and *Mary Ellis* (Bullers and Shefi 2008), and the cutter *Caprice* (Colvin 2009). The same generalisation for Tasmanian vessels using local timbers also has been postulated for timber selection in other Australian colonies, notably NSW (Evans 1988; Nutley 2003; Tracey 2009). A similar exercise therefore could be carried out to broaden the predictive model to the mainland. Continued investigation of Australian-built wooden vessels, including analysis of the types of timber used in their construction, should be a priority for maritime archaeological research in order to expand the available dataset on which to draw conclusions.

Another important avenue of further research is the extent of timber trade among, and into, the Australian colonies, with particular reference to the species traded, quantities, and chronological period. This may have direct implications for timber selection when a vessel is built, and would influence the outcomes of a predictive model such as this one.

CONCLUSION

With only eight vessels in the study, each offering differing results, it is difficult to make any definitive conclusions with respect to the predictive statements. Only half the sampled vessels in the study support the statement that Tasmanian vessels used locally available timbers. Although these statements may be correct in general, the current archaeological dataset cannot be said to support it, and therefore the predictive model is problematic.

Such a low percentage may reflect (1) the very low number of vessels in the assemblage; (2) the generally long service life of these vessels, often leading to rebuilds, refits and/or reconfigurations using timbers available where the work is carried out; (3) personal preferences of builders for certain species or even their economic circumstances; and/or (4) issues with timber sampling leading to incorrect species identification. Additionally, in some cases there are discrepancies between the local timbers available, the archaeological assemblage and historical descriptions of timbers used in the vessel, indicating that even contemporary descriptions of vessels may be questionable.

Until we are much further down the path of research into early Australian shipbuilding, and have analysed a much larger sampling of Australian-built vessels, we cannot make generalisations about timber usage with any confidence. Nonetheless, as Coroneos (1991:11) astutely notes, "hypotheses based on available evidence should be postulated so as to stimulate debate and further research".

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19th-century Sealing Vessels in the Southern Oceans: An Introduction to their History, Wrecks and Archaeological Potential

MICHAEL PEARSON

Abstract

This paper serves as an introduction to the ships and boats used by sealers in the southern oceans in the 19th century. The material remains of these vessels and sealing operations range from ship remains to cooking utensils to remnants of sealer huts and castaway shelters, all of which can shed light on the living and working conditions of the sealers and their adaptation to some of the harshest and most isolated conditions in the world. Despite the important connections these sites have with the discovery and exploration of the Antarctic, and to sealing and whaling and the global economy of the 19th century, they have as yet garnered little attention. Their research potential, on the other hand, is significant. This paper reviews documentary evidence for sealing voyages to the southern oceans; the ships, shallops and small boats that supported those ventures; the anchorages where ships could moor while sealing operations were carried out; and the sites of shipwrecks, abandoned vessels and shipbuilding activities. The need for more archaeological survey and excavation of shipwrecks and related sites ashore also is highlighted and some potential research benefits examined. Studies of sealing ships and related sites potentially can address such questions as the relationship between sealers and whalers and the differences between their operations aboard ship; the involvement of indigenous peoples in the sealing and whaling industries; shipwreck survivors, the psychological stress to which they were subjected and their strategies for survival and escape; the construction of pre-fabricated shallops and their operational use; and the use of land-based infrastructure at long-term anchorages.

INTRODUCTION

This paper presents an introductory exploration of the range of sealing vessels in the southern oceans and the archaeological potential for wreck remains and survivor camps. The 'southern oceans' refers to the Southern Ocean and the southern parts of the Atlantic, Indian and Pacific Oceans where Antarctic and sub-Antarctic sealing took place. Seals and whales were being taken around the Falkland Islands by 1766, and in the South Shetland Islands off Antarctica from 1819, by which time sealing spanned the islands and continental edges of the southern oceans.

Material remains of these ventures, studied through terrestrial archaeology, include the ruins of huts, sealers' refuges and castaway shelters (see Lewis-Smith and Simpson 1897; Pearson 2018b; Pearson and Stehberg 2006; Pearson et al. 2010; Senatore 2018; Senatore and Zarankin 2011; Stehberg 2003; Zarankin and Senatore 2005, 2007); try-works and try-pots (Pearson et al. 2010:59; Senatore and Zarankin 2011:54; McGowan and Lazer 2018:55–57; Townrow 1989:73–84, 96–99, 110–119, 142); foodstuffs and cooking utensils (Cruz 2018; Moreno 2000; Muñoz 2000; Soares 2016; Soares et al. 2016; Zarankin and Senatore 2007:133–143); a sledge and other timber artefacts (Pearson et al. 2008; Stehberg et al. 2009); clothing and other personal items (Salerno 2006, 2009, 2011; Zarankin et al. 2018:114 fig. 7); shipwreck remains (Boshoff, van Niekerk and Wares 2015; Cooper et al. 2018; Martín-Cancela 2018); graves (Pearson 2011:675) and inscriptions. Documentary evidence suggest the locations of numerous wrecked or abandoned vessels in the South Shetland Islands, Kerguelen Islands, Crozets, Prince Edward Islands and other peri-Antarctic islands. There also is evidence of where prefabricated ships were assembled, and where shipwreck survivors camped and constructed makeshift emergency vessels.

Despite the important connection that these sites have with the discovery, exploration and history of the Antarctic, and what they might tell us about the people and ships that braved these inhospitable environs, for reasons outlined in the paper they have as yet attracted little maritime archaeological research. Nevertheless, their potential is significant. The South Shetlands maritime sites, for example, are of particular interest as they relate to the first human interaction with the Antarctic environment in the 1820s, in which sailors and sealers using basic maritime technology of the 19th century had to

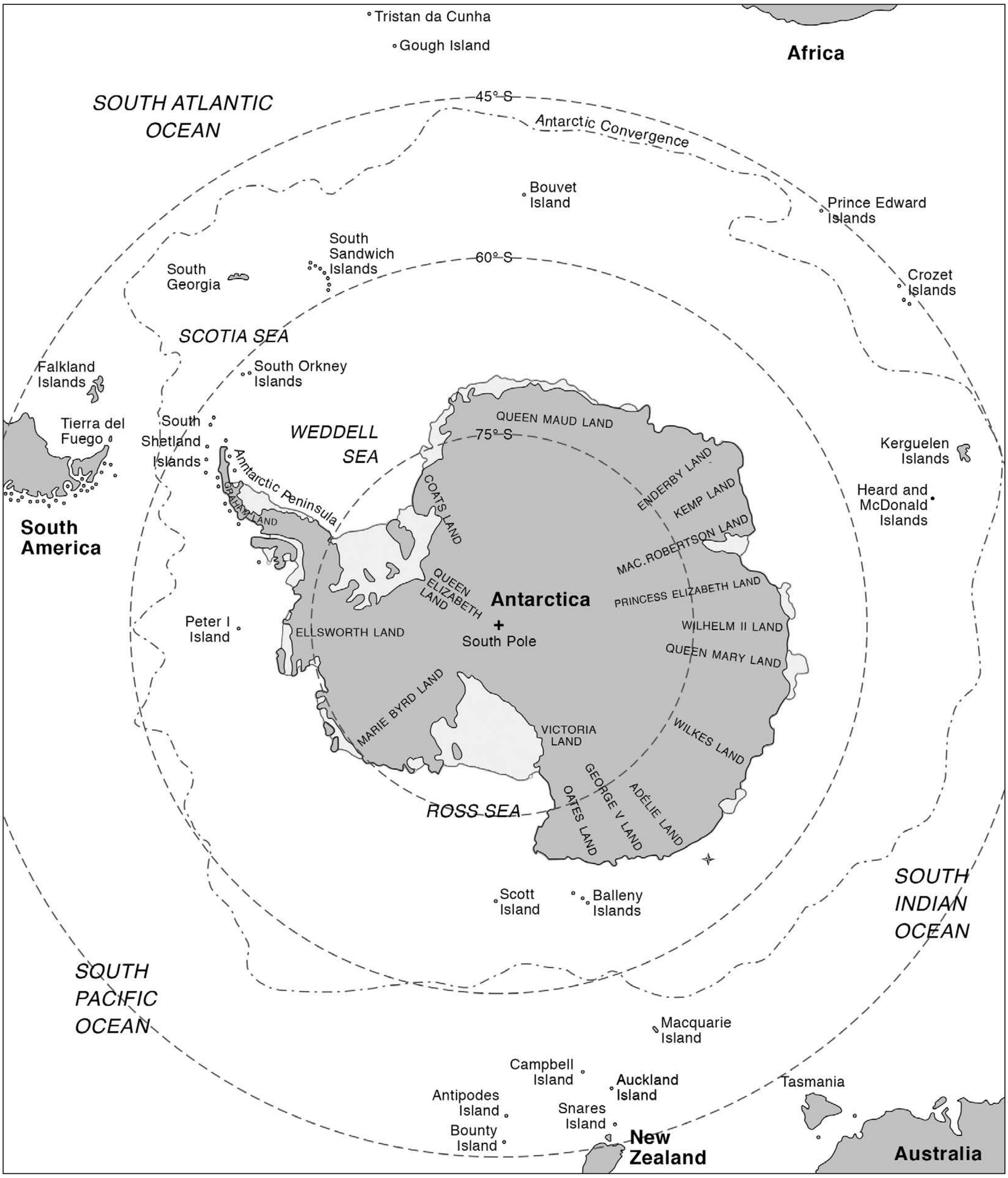

Fig. 1. Antarctica and the sub-Antarctic islands.

contend with one of the harshest and most isolated environments in the world. Some were wrecked, adding the pressures associated with survivor camps and potential abandonment at the bottom of the world. The exploitation of the marine life of the sub-Antarctic islands was similarly challenging, and was part of the expansion of the sealing and whaling industries that had global implications, but has been little studied outside of documentary and economic history contexts. The lives and survival strategies of the sealers, reflected in the archaeological remains, have largely been ignored.

While the sealing sites in the Antarctic, both on land and in water, are of great historical and archaeological importance, they have been mostly overlooked within the protective mechanisms of the Antarctic Treaty (see Senatore and Zarankin 2014). No terrestrial sealer site has yet been added to the

Historic Sites and Monuments (HSM) list, and only one maritime site, wreckage on Elephant Island believed to be that of the sealing ship *Charles Shearer*, has been HSM listed. Maritime archaeological work might provide evidence to prompt the protection of important sites through the HSM system. Maritime archaeological analysis has the potential to provide new data and address different questions that can help put sealing and sealers into broader historical, economic, political, socio-cultural and environmental contexts.

THE PATTERN OF SHIP OPERATIONS IN SOUTHERN SEALING IN THE 19TH CENTURY

Sealing in the southern oceans was supported by three types of vessels. The largest was the so-called mother ship, which brought sealers from their homeport and returned them there. The shallop was a smaller shallow-draught schooner, cutter or sloop that served as a tender (Fig. 2). These vessels would either accompany the mother ship from homeport or be carried in frame and constructed at a safe harbour closer to the sealing grounds, such as in the Falkland or Kerguelen (Desolation) Islands. Finally, small boats ferried the sealing crews between the shallop and shore, and ranged from light double-ended whaleboats to ships' skiffs.

Sealing vessels comprised a broad cross-section of the working sailing vessels of their day. Typical of the large mother ships were *Norfolk* (650 tons), a French prize on which Thomas Smith sailed to South Georgia in 1815 (Smith 1844:121), and *Corinthian* (505 tons) of New London (Richards and Winslow 1971). On the other end of the spectrum were small schooners, sloops and cutters, such as *Norfolk*'s two shallops (24 and 36 tons), shallop *Henry* (43 tons), sloop *Pomona* (57 tons) and cutters *Beaufoy* (65 tons) and *Lady Francis* (63 tons), both of which were under 60 ft (18 m) in length (Jones 1985:83).

A listing by classification of the 72 ships known to be sealing in the South Shetlands in 1820–1821 gives some idea of the variety of ship types used for sealing in the early 19th century (Table 1). Undoubtedly, this list represents a conservative estimate of the shipping at the South Shetlands during that time. The brig and closely related snow, together with ship-rigged vessels, make up 68% of the total reported shipping. Most of the remaining vessel types were smaller craft, most probably serving as 'shallops', which could safely approach the rocky shores and shallow waters of the

Fig. 2. The small sealing brig *Jane* (160 tons) and her shallop, the cutter *Beaufoy* (65 tons), in the Weddell Sea, February 1823. Drawing by A. Masson, from a sketch by Captain Weddell (Weddell 1827:facing 34).

Table 1. Types of Vessels Used for Sealing in the South Shetlands, 1820–1821 (compiled by the author from multiple sources)

Vessel type	**Number of Vessels in South Shetlands 1820–1821**
Brig	23
Ship	16
Snow	10
Schooner	8
Sloop	3
Shallop (generic)	3
Smack	3
Brigantine	1
Cutter	1
Unspecified	4
Total	72

sealing islands. These vessels appear to be underrepresented in the figures, based on descriptions of the methods of sealing that suggest a great reliance upon such craft.

A small number of written sources help describe ship and boat operations. A common practice was to moor the ship in a protected harbour. For example, in December 1815, the British ship *Norfolk* entered a safe harbour on South Georgia, anchored and struck down masts for the season (Smith 1844:123–125). The same year, the American ship *Volunteer* spent three months at Port Lewis in the Falkland Islands (Fanning 1833:360–361). The ship *Royal Sovereign*, at Kerguelen in 1825, was anchored in a safe harbour and unrigged, while the shallop was used to transport gangs around the islands (Clarke 1850:18–19). Another approach was to establish local camps and for the ship then to go off on other ventures. The brig *Pickering*, for example, in 1817 found no safe harbour on Marion Island, one the Prince Edward Islands, so instead of the ship staying there, crews were left on different islands to gather fur and elephant seal oil, and the ship went off to established ports seeking cargo for a freighting voyage (Phelps 1871:25). The ship *Volunteer* left the Falklands after its crew had built a shallop, to be manned by an officer and eight men in order to take fur seals, while *Volunteer* went on a sandal wood gathering expedition into the Pacific (Fanning 1833:360–361); an ambitious program indeed. The master of the American sealer ship *Julius Caesar*, at Kerguelen Island in 1851, intended to leave his two shallops there gathering elephant seal oil, while he took the ship off on a whaling voyage (Taylor 1929: 54–55).

Shallops, as mentioned, were a key feature of southern ocean sealing. American historian Edouard Stackpole explained their use:

> The ships and brigs usually had the frames and planking of smaller craft carefully packed on board, which were assembled in the Falklands and then accompanied the larger vessel to the sealing location selected. These tenders were called 'shallops' and were usually schooner-rigged. The Stonington, New York and Boston sealing fleets, however, included schooners which sailed with them. Nantucket, New Haven, Salem and New Bedford craft usually carried the knocked-down shallops aboard [Stackpole 1955:14].

This clearly was not a hard and fast rule, however, as the Boston brig *Pickering* had a 50-ton schooner aboard, in frame, for later construction as a shallop, along with five whale boats (Phelps 1871:46).

British sealer Thomas Smith, working on South Georgia between 1815 and 1820, speaks of the British use of shallops: the ship *Norfolk* with a crew of 52 had eight boats and two shallops, one of 24 tons "half-built" and one of 36 tons in frame. While at harbour in South Georgia, the crew completed the half-built shallop and started constructing the other shallop ashore, at 'Shallop Point', where such work generally was done, and where sealing gear and supplies were stored. Building the larger shallop took four weeks (Smith 1844:123–125).

At Kerguelen Island in particular, and possibly in other sealing grounds, shallops were left ashore at the end of a season and re-used by later sealers. The ship *Julius Caesar*, for example, having built two shallops from frame, purchased a third, the 30-year-old schooner *Diana*, from the ship *Peruvian*. The shallop had stayed on the islands its entire career, changing hands regularly between homeward-bound and newly-arrived sealers (Taylor 1929:76–77). John Nunn, a British sealer on *Royal Sovereign*, working at Kerguelen from 1825 to 1829, says that it was common practice to leave shallops ashore at the end of a season. He and his crewmates repaired the shallops left by the sealer *Francis* in 1819, which had been carried out in frame from Britain and constructed in Greenland Bay, and by the ship *Favourite*, constructed from frame at Maryanne's Straits near Cape Louis the year prior:

> Both shallops were hauled up upon the beach at Greenland Bay and scuttled by the crew of *Frances* previous to their leaving for England in August, 1820. […] Arrangements were made for stopping the scuttle holes and recaulking such parts as appeared defective, and both vessels were well beamed, and 'paid' with a

Fig. 3. The sealing cutter *Lively* operating at Kerguelen Island in the late 1820s, typical of smaller ships and shallops (Clarke 1850:147).

> good coating of pitch upon their quarter rails and upper works, and in about eight or nine days they were refitted and made ready for sea [Clarke 1850:19–20].

The process of leaving a shallop safely ashore at the end of a season could be quite complex, as described by Nunn. A length of timber was buried high on the beach as a 'dead man' or anchor, to which a stout rope (a 'warp') was attached and led down to the beach along a trench and secured firmly around the shallop, which was then hauled ashore as high as would make the ship safe, using a tackle on the warp. A small hole was cut into the hull with a mallet and chisel to allow water to enter, so the ship did not float away. The rigging was stowed in barrels, and the mast laid safe above the high-water level (Clarke 1850:108). The shallop crews were experienced in doing running repairs to their sometimes aging vessels. Nathaniel Taylor recounts how the false keel of the shallop *Marcia* was badly damaged in a grounding on Kerguelen, and how the crew emptied the ship of cargo and ballast, hove it down, and repaired the keel in seven days with timber carried on board and iron work forged at a bellows and anvil erected ashore (Taylor 1929:162).

The operations of the shallops varied depending on the number and spread of sealing crews and the location of the mother ship. The shallops worked close inshore, dropping off sealing gangs, providing them with supplies, and collecting skins and blubber or oil (Fig. 3). They often worked considerable distances from the moored sealing ship, or operated independently if the mother ship sought employment away from the sealing islands. On Kerguelen, Nunn indicates that the try works for boiling down the elephant seal blubber into oil was set up ashore at a central location. The blubber was rafted off the sealing grounds to the shallop, and taken back to the try-works, where it was again rafted ashore for boiling down (Clarke 1850:18–19). This pattern was echoed on South Georgia during Thomas Smith's stay (1815–1820), where shallops were sent east and west of the ship centrally moored in Royal Bay. Two to three boats worked with each shallop, delivering blubber from the beaches, the shallops taking blubber to the ship and returning with supplies (Smith 1844:129–130).

Many accounts describe the harsh and dangerous conditions faced by the sealers working on the beaches. Gangs often slept under their upturned boats for weeks or even months at a time (Smith 1844:129–130; Ames 1830), and Cyrene Clarke, an American working on Elephant Island in the South Shetlands in 1853, describes rafting blubber out to a shallop as "the most unpleasant of all occupations connected with the voyage" (Clarke 1854:38). Charles Goodridge, working aboard the small sealer *Prince of Wales* (75 tons) on the Îles Crozet in 1820, describes how: "We used to visit the sealing party every seven of eight days, take on board the skins collected, supply them with a fresh stock of provisions, and again return to the other island, employing ourselves in the meantime, in salting the skins procured…" (Goodridge 1832:18–19, 23–24). Beach landings on rocky shores with kelp beds in heavy seas was dangerous work, and the accounts contain many instances of overturned boats, submerged men and a number of deaths. William Phelps tells of the deaths of the mate, Mr Chapman, and two crewmen and the loss of two boats in a boating accident during the establishment of the camp on Marion Island in 1817 (Bush 1980:31–32). Captain Joseph Fuller records the death of four men when their boat was swamped while trying to land on the Crozets in 1873 (Phelps 1871:46, 55–57). The strategy of living under the whaleboats and the archaeology of such sites are described elsewhere (Pearson 2018a).

SHIPWRECKS, ABANDONED VESSELS AND SHIPBUILDING SITES IN THE DOCUMENTARY SOURCES

The most up-to-date and authoritative listing of Antarctic sealing voyages (Headland 2018b) lists some 73 shipwrecks on the coasts of sealing islands in the southern oceans up to 1922. The majority

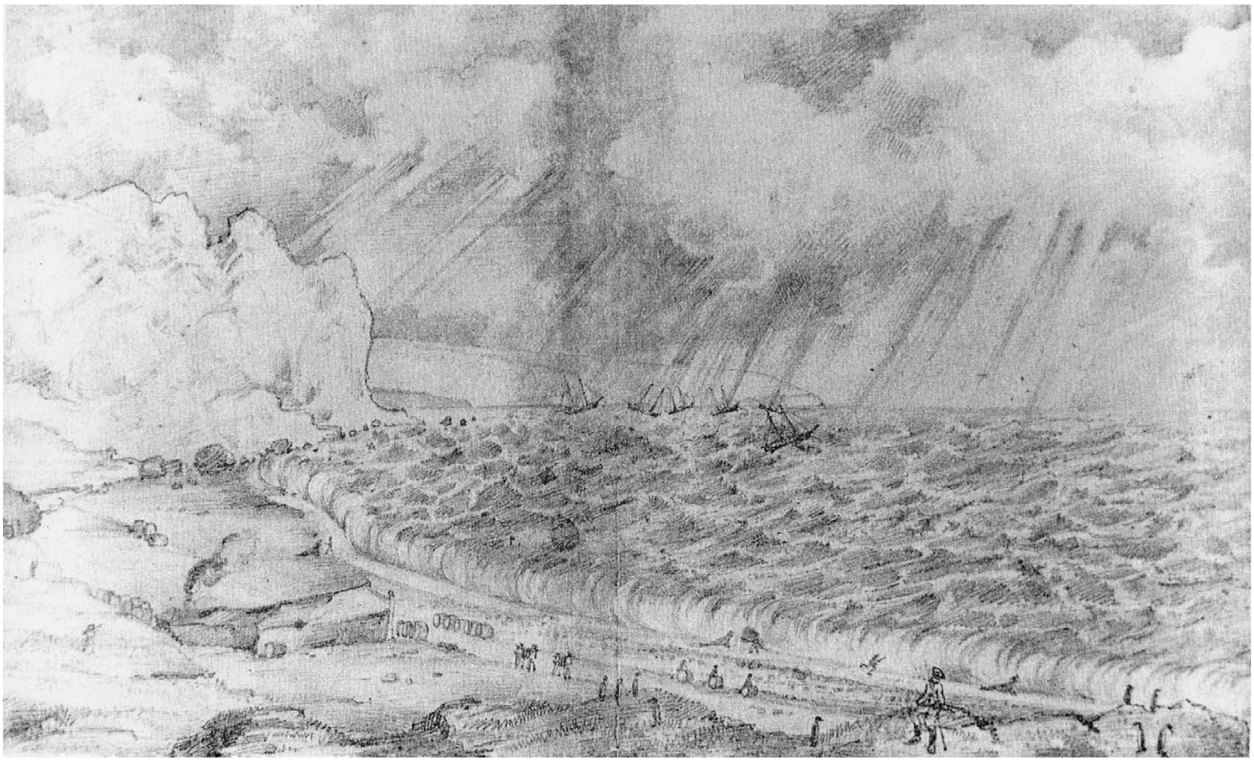

Fig. 4. Heard Island, c. 1858. W.T. Peters, 'View at Hurd's Island with schooner *Eliza Jane* dragging her anchors' (Taylor 1929:126).

of these, however, have very generalised locational information, and further research would be needed to pinpoint more accurate positions for potential wrecks. This section outlines a number of first-hand accounts that indicate the location of wrecks and associated land-based infrastructure with more accuracy.

British captain Robert Fildes records that "on the North side of King Georges Island [in the South Shetland Islands] was found part of the hulls & floor timbers of two vessels and a mast step. They appeared to have belong'd one to a vessel of 80 & the other to one of 200 tons" (Fildes 1821:60 *verso*). The two ships were the brig *Lady Troubridge* (Capt. Richard Sherratt, Liverpool) and the ship *Hannah* (Capt. James Johnson, Liverpool, 320 tons), both blown ashore at Wreck Beach in Destruction Bay, north of Cape Melville on the northeastern coast of King Georges Island on 25 December 1820.

Nathaniel Ames visited the wrecks in early 1821 aboard the brig *Esther* of Boston:

> […] we found part of the crew of the two above mentioned ships, engaged in building a small schooner of about fifteen tons, which they called the 'Sailors' Relief', in which they intended to go to Rio de la Plata. […] The *Lady Trowbridge*, a stout new vessel, was apparently uninjured, and at low water we could walk round her; but the *Hannah* had gone to pieces immediately [Ames 1830:155].

The crews of the ships were picked up by John Davis in *Huron* and taken to British ships moored at Rugged Island (Stackpole 1955).

Charles Goodridge, on the sealer *Prince of Wales*, recounts the wreck of that ship on Île de la Possession in the Îles Crozet in 1821. The ship was blown out from shore by a gale, then in a subsequent calm was driven back onto the island by the current, and struck the rocks at midnight. The sealing crew was still working on Île de l'Est, some 20 km to the east, and was marooned there after the wreck. The ship-based crew got ashore after four hours in the rain, but the boat was swamped in the process. Once ashore, they overturned the boat to use it as a shelter (Goodridge 1839:46–50).

Eventually re-united on Île de la Possession, the combined party of 15 survivors determined to build a 29-ft (8.8-m) vessel in which to escape. The sealing gangs split, with Goodridge and four others returning to the other island to spread out demand on resources. The remaining party built another house of stone so they could salvage the timber used in the original hut for the new boat, in which five were to put to sea. The boat was completed in January 1822, with sealskin sails, elephant pup skin water bags and salted elephant tongues and penguin eggs for provisions; however, just before the boat was to be launched, a sealing ship appeared, the American schooner *Philo* (Capt. Perceval) (Goodridge 1839: 75–97). The survivor's recently completed rescue boat seems to have been abandoned at the site.

In May 1817, Thomas Smith sailed on *Admiral Colpoys* (Capt. James Todrig) from London to South Georgia (Smith 1844:155). The ship was moored for the season at a bay called The Rookery, on the southern side of South Georgia, and its boats dispatched for elephant seals. Ten weeks later, an iceberg was blown into the harbour during a gale and cut *Admiral Colpoys*' anchor cable; the ship subsequently was blown ashore and bilged on the rocks (Smith 1844:156). The crew abandoned the wreck and journeyed 60 miles north in the boats to join fellow sealing ship *King George*, on which they eventually returned to England.

The sealer *Prince of Saxe-Cobourg* (Capt. Matthew Brisbane) wrecked at Fury Beach at the southern end of the Barbara Channel in Tierra del Fuego on 16 December 1826. The crew was rescued in March 1827 by Captain Pringle Stokes in HMS *Beagle*, who found one man perished and the ship bilged (Campbell 2007:230–231).

Headland (2009, 2018) documents a number of ships wrecked at specifically named bays on Macquarie Island and Heard Island (Fig. 4). These may be discoverable by extended survey, but Heard Island in particular has a very unstable shoreline that may lessen the likelihood of wreckage surviving there. While sealing and whaling at Heard Island in the Hobart ship *Offley*, Captain William Robinson described some of the ships he saw or heard of lost on Heard Island in the period 1858–1860. These include the schooners *B.B. Coleman*, *Frank*, *Mary Powell* and *Alfred*, all lost by being driven ashore while taking off oil or because of anchor failure (Nash 2009:79–80, 90–91).

Fig. 5. The shallop *Loon*, left ashore on Kerguelen in the 1820s for the use of later sealing parties (Clarke 1850:69).

The location of the sealer *Regulator*, wrecked on South Georgia in 1799, may be locatable, as a figurehead that may come from this ship was found at Right Whale Bay in 1970 (Headland 2018b).

Wrecks of modern iron vessels from the Norwegian whaling station at Deception Island in the South Shetlands include the whale catcher *Bransfield*, capsized off the station in 1924, and the catcher *Southern Hunter*, steel hull sections of which are still visible on the shore of Neptune's Bellows entrance to Foster Harbour, where it wrecked in 1956 (Headland 2018b:277, 350). A number of timber water boats also survive on the beach at the former whaling station within Foster Harbour. The wreck of the whaling factory ship *Guvernøren*, burnt and sunk in 1915 in Foyn Harbour, Wilhelmina Bay, on the west coast of Graham Land, Antarctica, is still visible (Headland 2018b:265).

Because they worked close inshore, there also were many shallops wrecked. One of *Admiral Colpoys*' shallops was lost at Cooper's Harbour on South Georgia, having taken on board 20 tuns of blubber. The shallop was driven ashore in a gale, with the loss of the mate and another man. A new shallop had been purchased from another ship, *Lovely Nancy*, but it too was lost in the Bay of Isles, along with a full load of 60 or 70 tuns of blubber on board (Smith 1844:144–153).

The shallop *Francis* was itself wrecked on 3 November 1825 on Saddle Island by the side of Three Boat Passage, near Maryanne's Straits, on the west coast of Kerguelen. The crew of four got ashore with some of the stores, as well as sails and a spar, which they used to construct a shelter beneath a rock overhang. They left a notice for other crews on the bow of the shallop *Loon* (abandoned ashore by an earlier party) at the entrance to Maryanne's Straits (Fig. 5), and were picked up a fortnight later by the shallop *Favourite* and returned to Greenland Bay (Clarke 1850:52–55).

Subsequently, on 26 December 1825, *Favourite* sank in a cove at the western end of Saddle Island due a bad leak. The crew took shelter in the hull of the grounded shallop *Loon*. After removing the ballast to make a repair to the hull, an attempt was made to raise and repair *Favourite*, but the tidal range was too limited to lift the vessel out of the sand. The mast and rigging were cut away and removed for re-use (Clarke 1850:66–71, 93–94). Instead, the party decided to repair *Loon*, in which they had been sheltering. Over a matter of about four months, they managed to re-caulk *Loon* using oakum teased from the cable of *Favourite* and some pitch found ashore. After finishing the caulking and digging around the ship to drop it below sea level, they succeeded in refloating, re-masting and rigging the vessel, then sailed it to Greenland Bay on 26 December 1826 (Clarke 1850:96–103). During the voyage, they looked for the abandoned shallop *William and Duncan* at Table Bay, but it had drifted offshore and sunk. The abandoned shallop *Emily*, believed to be in Swain's Bay, also is mentioned, as is a shallop wreck at the Rocks of Despair.

Other wrecks were well documented, but with few firsthand accounts. The sealer *Betsey and Sophia* (Capt. Thomas Fotheringham) was wrecked in Rocky Bay on Kerguelen on 16 March 1831. The crew managed to get the boats and stores ashore before the ship finally sank (Savours 1961:317). They waited for a passing ship until the stores ran low, and then built an 18-tons sloop, which they named *Liberty*, from wreckage prized from the sunken wreck. Fourteen of the 19 crew set sail in the sloop on 6 December 1831, together with a cargo of 130 seal skins, and reached Macquarie Harbour in Tasmania on 20 January 1832. They then sailed to Hobart, from where a rescue ship was sent to Kerguelen for the remaining crew. Unbeknownst to them, the five crewmen had already been rescued in March by the ship *Ocean* and taken to Mauritius (Savours 1961:318–319).

Also common was the loss of boats, as has been seen above. At New Plymouth (called President's Harbour by the Americans), between Livingston and Rugged Islands in the South Shetlands, Fildes (1821:49 *verso*) mentions the poor anchorage and the loss of many anchors and cables, stating that "there is a boat passage call'd Hells Gates where many boats & lives have been lost". Hell's Gates lies off Devil's Point on Livingston Island, where a campsite (Punta Diablo 1) has been found that could have been occupied by such wrecked sealers (see Zarankin and Senatore 2007:81).

HARBOURS

As well as shipwreck sites, there were a number of harbours and safe anchorages where sealing ships are known to have been based. In the South Shetlands, Cora Cove on Desolation Island was the site of the wrecking of the brig *Cora* in 1821 (Fildes 1821:40–41). Captain Robert Fildes drew a map of the cove showing a lake for fresh water, near which a well had been sunk, and the grave of his cooper, and described setting up camp at this location after the wrecking (Fildes 1821:46). Chilean archaeologist Rubén Stehberg undertook an archaeological survey and excavation at Cora Cove in 1995, but at that time the Fildes episode was unknown to the researchers, so the correlation was never made (Stehberg 2003:106–129).

Fildes also drew a map of Johnson's Dock, on the south coast of Livingston Island, that shows how a ship was moored bow and stern within the small bay (Fildes 1821:55).

Fildes (1821:59) identifies Potter's Cove on the southern side of King George's Island as "by far the best Harbour on this coast, […] here good water can be procur'd expeditiously, and in a small Cove in the Harbour a vessel may be laid aground and her bottom overhaul'd which in this dreary part of the world is a great object". Clarke (1854:36–37) described Potters Cove in 1853, when the crew of the brig *Parana* anchored there to unload and reload their stores so as to stow barrels of elephant oil:

> The inner circle of the harbour where we lie is one vast glacier, about three miles in extent, in the form of a horse shoe, and rising above the vessel's masts. The entrance to the harbour is about one quarter of a mile in width. In a soft clay bottom our anchors take deep hold, and unless our cables are sundered, we can ride in safety. […] This harbour is so secure that our brig lies at anchor within a few rods [1 rod = 5 m] of a smooth beach near the entrance […].

The graves of several sealers were observed near the mooring site. An inspection of Potter's Cove by the author in 2017, as part of Andres Zarankin's long-term research of the region for Argentina and Brazil, failed to identify any archaeological sites related to ship-based activities, but noted that the land area adjacent to the main anchorage has been disturbed extensively by the construction and operation of the Argentine research station *Carlini* (formerly *Jubany*).

Esther Harbour, on the north coast of King George's Island, is marked on Powell's 1822 map of the island (as Ester's Harbour), and also is mentioned in Fildes's sailing guide to the islands (Fildes 1821:60 *verso*; Powell 1822). Named after the Boston ship *Esther*, which used it as a base, the harbour also sheltered several crews from wrecked ships. The sealer *Emerald*, also out of Boston, rescued the crew of the New York schooner *Venus*, which had wrecked there on 7 March 1821. That same year, a sealing gang of the snow *Lord Melville* (London) overwintered at or near Esther Harbour, becoming the first recorded wintering in the Antarctic (Headland 2018a; Jones 1985).

Fildes (1821:58) described Clothier Harbour, on the north shore of Robert Island, as "the safest Harbour on the North side of Shetland that is clear of Ice". His assessment notwithstanding, the ship *Clothier* (Capt. Abraham B. Clark, 284 tons, Nantucket) dragged anchors and wrecked there on 9 December 1820. The ship's equipment and stores were auctioned to the captains of at least six other sealing vessels on 28 January 1821 (Stackpole 1955:59). Fildes continued:

> On the eastern side of Clothier Harbour is a small inner harbour that you can warp into like going through Dock Gates. Here I moored the Brig *Robert* under my command head and stern with cables on shore and springs round the bowsprit and stern frame of the *Clothier*'s wreck which lays scuttled here, by keeping good fenders out she made an excellent wharf. She is well sunk in the mud that is impossible for her to move. Even if you should break adrift you can't hurt for the mud will bring you up before you touch the rocks.
>
> In this situation I hung the Brig *Mellona* [Capt T. Johnson] of Newcastle nearly a whole season after she had lost all her anchors & cables. From this circumstance this place received the name of Robert Dock.
>
> Here we had our tryworks and casks on shore and built a shallop of 20 Tons. The *Robert* & *Mellona* lay so snug in this place that all hands where away for many days together leaving only a little boy as Shipkeeper to take care of the vessells [Fildes 1821:58].

Fildes subsequently lost his own brig, *Robert*, at Clothier Harbour on 7 March 1822 (Headland 2009:136). A figurehead found on Robert Island in 1980, currently on display at the Institute of Patagonia in Punta Arenas, may be from *Clothier* or *Robert* (Fig. 6).

Yankee Harbour, on the McFarlane Strait coast of Greenwich Island, is mentioned numerously by American and British sealers as a safe harbour, and no major wrecks have been recorded there, although Christopher Burdick, captain of the schooner *Huntress* (80 tons, Nantucket), reported on 6 January 1821 that, during winds of hurricane force, "a large boat as big as two whale boats which was hauld up on shore was blown about 30 or 40 rods [150–200 m] and stove to pieces" (Burdick 1821). Remains surviving at Yankee Harbour include a try-works site and a broken try-pot relating to the rendering of elephant seal oil there (Fig. 7).

SURVIVING EVIDENCE OF SHIP REMAINS

A limited amount of research has been undertaken on surviving remains of shipwrecks and associated land-based sites, due largely to the substantial logistical and funding constraints on undertaking research in this region. Challenges include the relative paucity of site-specific documentary evidence, the general absence of previous survey work to locate sites, the logistical difficulties in accessing sites, the uncertainty of achieving sufficient time on-site due to short summer seasons and frequently changing shipping schedules that service a wider research program and station resupply, and working in severe climatic conditions that can dramatically reduce work efficiency. An added complication in the case of the Antarctic Treaty area (south of latitude 60° S) is the unusual geopolitical context within which research has to be planned, approved and carried out, with research projects being absorbed into annual national party programs that require substantial lead time to plan and are subject to frequent changes in their implementation. While terrestrial archaeology has been supported to a certain extent by land management agencies or universities of nations that have territorial control of sub-Antarctic islands or are parties to the Antarctic Treaty, only on three occasions has this extended to work on maritime archaeological sites.

Although not related to sealing, the search team for the wreck of the frigate *San Telmo* experienced some of the difficulties outlined above. In 1819, Ferdinand VII of Spain sent a flotilla of warships to Peru to support his Viceroy in the face of a local insurrection. The 74-gun ship *San Telmo* (Capt.

Fig. 6. Ship's figurehead, possibly from *Clothier* or *Robert*, retrieved from Clothier Harbour in 1980. Institute of Patagonia, Punta Arenas (M. Pearson, 2017).

Fig. 7. Yankee Harbour, Greenwich Island, South Shetlands. The spit that protects the harbour is visible in the upper left background, and a broken iron try-pot from an elephant seal try-works is on the shore at centre left (M. Pearson, 2008).

Don Joaquin Toledo), with 644 men aboard, sailed from Cadiz for Peru in company with *Primerosa Mariana* and *Prueba*. The fleet encountered bad weather south of Cape Horn and San Telmo lost its masts and rudder. *Primerosa Mariana* attempted unsuccessfully to take the stricken vessel in tow, but finally had to abandon *San Telmo* in Lat 62º S on 4 September 1819 (Aragón 1991; Campbell 2000:26; Jones 1985:10; Pinochet de la Barra 1991).

In 1820, remains were found at Half Moon Bay on the east coast of Cape Shirreff on Livingston Island, in the South Shetland Islands, that may have come from the lost *San Telmo*. This raises the possibility that survivors from the crew may have been the first to land on the South Shetlands, up to a month before William Smith made the first recorded landing in the archipelago. Fildes (1821:48) states that "Here was found half of an anchor-stock of a 74, iron hooped and copper-bolted, studsail booms and other spars were found here likewise; the Melancholy remnants of some poor fellows Misfortune". A footnote at the end reads, "This anchor stock Capn Smith brought home to have a coffin made of, it has been identified and proved to have belonged to a Spanish 74 that was bound round Cape horn with 1400 men against the Patriots and has never since been heard of."

James Weddell (1827:120, 144) also mentions the finding of the remains, as does Nathaniel Ames:

> […] in the course of our cruises [1820–1821], we picked up a piece of a lower mast, about 10 feet long, to which was lashed a three-fold block, which bore no mark but '16 In' so that it could not have belonged to either an English man of war or East Indiaman, as both of which have the king's or company's mark upon every thing portable belonging to them. The mast was as large as the mizzen mast of one of our heaviest frigates, and the strap of the block and the lashing were both as fresh as if just from the rope-walk [Ames 1830:137–138].

Ames deducted from the nature of the lashing of the block that the ship had been in distress, possible from the loss of the upper mast and the need for a makeshift backstay on the lower mast. A Spanish team carried out an extensive land and water archaeological survey for the remains of *San Telmo*, as did a Chilean team in 1993–1994. Although wood samples were collected for analysis and magnetometer surveys identified five anomalies for future investigation, no definitive evidence of the wreck site was found, and no subsequent field research has been undertaken (Martin-Bueno 1995a, 1995b, 1996; Martín-Cancela 2018).

Another collection of potentially identifiable shipwreck remains has been found on the west coast of Elephant Island in the South Shetlands. In 1998, the British Royal Navy's ice patrol ship, HMS *Endurance*, surveyed an area of wreckage of a large wooden sailing vessel in a small cove on the southwest coast of Elephant Island. Wood species identification of timber samples taken from the wreckage indicated that the hull timbers were not of Scandinavian origin, and therefore were not from a British vessel. Preliminary assessment has suggested that the wreckage may be that of the sealing ship *Charles Shearer*, which on 3 July 1877 sailed from Stonington, Connecticut, for Antarctica under the command of James Appleton (or Appleman). The ship left a sealing gang on Islas Diego Ramirez in October 1877 before continuing south to the South Shetland Islands, where it disappeared without trace. The sealing gang on Diego Ramirez was rescued six months later. Despite searches in 1879–1880, no evidence of the ship's fate was found (Antarctic Treaty Committee Meeting minutes: XXII ATCM/WP21). There is a strong possibility that the wreck located on Elephant Island is that of *Charles Shearer*; the site (HSM no. 74) is the only early-19th-century sealing site yet recognized on the Antarctic Historic Sites and Monuments list.

The remains of the Norwegian sealing vessel *Solglimt*, wrecked on 16 October 1908 at Ship's Cove on the northeast side of Marion Island in the Prince Edward Islands, and an associated survivor's camps site have been investigated by South African researchers. The crew was rescued by two Canadian sealing schooners from Nova Scotia, *Agnes G. Donahue* and *Beatrice L. Corcom*, which arrived on 14 November and took the shipwrecked party to Durban. Land-based investigations of the remains were undertaken in 1989 and 2013, and maritime archaeological surveys in 2011 and 2014. The *Solglimt* study is the first conducted of a shipwreck in both a marine and terrestrial environment in the sub-Antarctic (Boshoff et al. 2015; Cooper et al. 2018). There also is a reference to a stove-in cutter at Triegaardt Bay on Marion Island, still visible but "almost totally buried" in 1986 (Cooper and Avery 1986:16).

POTENTIAL FOR FUTURE RESEARCH

The terrestrial and maritime sites in the South Shetland Islands date back to the first human interaction with the Antarctic environment in the 1820s, while the exploitation of the sub-Antarctic islands was part of the expansion of the sealing and whaling industries that had global implications. In both cases, the archaeological resource is often well preserved, with little or no subsequent human intervention and favourable environmental conditions for materials conservation. The sites offer outstanding research potential, particularly in that the archaeological evidence, unlike most of the documentary evidence, relates to the living and working conditions of the sealers themselves, rather than to the interests of the owners and officers who wrote most of the literature (see Zarankin et al. 2018:113–116; Senatore 2019). Archaeological work on the sealer shelters has shown substantial adaptation of material culture and foodways by the sealers, responding to extreme isolation, the limited range of tools, clothing, food and fuels landed with them, and to the need to find their own shelter for extended periods of time (Pearson 2018b; Pearson and Stehberg 2006; Pearson et al. 2010; Senatore 2018; Senatore and Zarankin 2011; Stehberg 2003; Zarankin and Senatore 2005, 2007).

Investigation of some wrecks in the sub-Antarctic islands could throw further light on sparsely researched aspects of the mid-19th-century whaling industry. It became common for American whalers to top up their oil cargo by taking elephant seals, in particular at Kerguelen and Heard Islands, and a number of the known wrecks there are of whalers engaged on sealing expeditions (Downes and Downes 2006; Downes 2010). The investigation and comparison of sealing and whaling operations aboard ship (and with respect to the use of shallops and boats) might reveal interesting insights into shipboard life, the people employed in the industries, the organisation of labour and the economic strategies of shipowners.

Another potential for maritime archaeological research in this region is to shed further light on the involvement of indigenous peoples (Australian, South and North American, New Zealand and other Pacific islanders, and Portuguese African Cape Verde Islanders) in the sealing and whaling industries. The involvement of indigenous men and women is documented in the literature and in archaeological remains at Heard Island and Livingston Island in the South Shetlands (Downes 2010:18; Russell 2012, 2018; Stehberg 2003; Torres 1999).

The documented existence of wreck survivor camps in the South Shetland Islands and several sub-Antarctic islands provides the opportunity to extend the study of such sites of disaster and psychological stress undertaken elsewhere (Cooper et al. 2016; Gibbs 2002, 2003). Sites such as the *Lady Troubridge* and *Hannah* wrecks location and its associated survivor camp and rescue boat construction sites, referred to above, have great potential for combined terrestrial and underwater archaeological research.

As can be seen from this brief survey of the historical and archaeological literature, there are many potentially locatable wrecks and related shore-based sites that would repay more intensive research. To date, the author has located references to only three maritime archaeological surveys in the Antarctic and sub-Antarctic: to locate the wreckage of the frigate *San Telmo*, to record the probably remains of the sealer *Charles Shearer* and to survey the sealer *Solglimt*.

The collaboration of terrestrial and maritime archaeologists would be an extremely useful addition to the future research into sealing in the southern oceans. Such research could address the operational use of the small shallops, which has received little attention in the past. Nautical archaeologists could seek to study the construction of pre-fabricated shallops, which is only described in a general way in the documentary accounts. The use by ships of land-based infrastructure at long-term anchorages could be studied. The distribution of functions between ship and shore has not been covered systematically by documentary sources, and the potential exists for archaeology to expand our knowledge and understanding of the ship/shallop/boat/shore relationships that are only hinted at in the written sources.

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Watercraft Depicted in the Art of Odisha, East Coast of India

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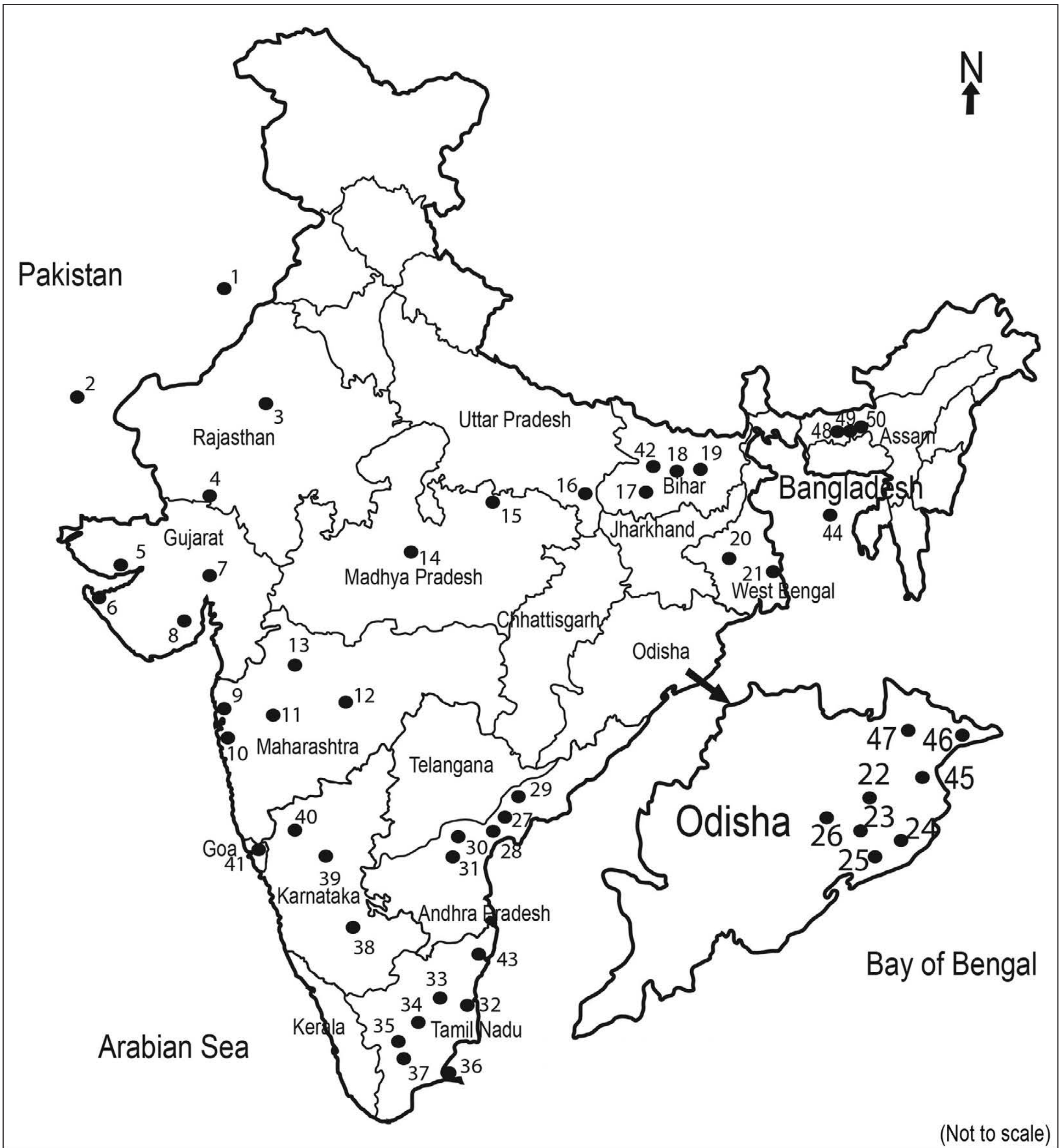
Abstract

The Indian state of Odisha, with its long coastline facing the Bay of Bengal, extensive riverine network and convenient anchorages, has enjoyed a sustained maritime history. Nevertheless, the lack of archaeological excavation of ancient watercraft has meant that evidence for water transport in Odisha has come from other sources. This article examines iconographical representations of watercraft found in temples across Odisha, as well as some from palm leaf manuscripts of the 18th and 19th centuries. The vessels depicted are both riverine and seagoing, and sport different types of planking and constructional features—some unique to Odisha. This iconography emphasises the intimate association between the royal families, deities and mariners of Odisha, and the important role that boats and ships traditionally have had in Odishan trade, transportation and warfare, and as a visual symbol of prestige. The traditional boats of Odisha are unique in design and style, but traditional boatbuilding in the region is declining due to rapid industrialisation and incorporation of modern materials. It is urgent, then, to document such craft and their depictions in ancient art, both for posterity and to aid in understanding and interpreting the rich maritime history of the region.

INTRODUCTION

Maritime archaeological studies involve the investigation of water transport, cargoes, port installations, material remains and submerged landscapes and throw light on maritime heritage and culture contacts throughout the centuries. Ancient watercraft, such as dugouts and canoes, were used on the Indian subcontinent since at least Mesolithic times, but so far no material remains of such craft have come to light (Blue et al. 1997:189). To date, the oldest vessel to be excavated archaeologically in India is a flat-bottomed, double-planked boat discovered on the Kerala coast and dated to the 13th–15th century AD (Tomalin et al. 2004). The earliest evidence of any kind for watercraft in India is found in rock paintings from the Mesolithic period. Textual references to the use of watercraft in India are known from the Harappan period (2600–1900 BC) onwards (Bowen 1956; Deloche 1994, 1996; Konishi 1985; Rao 1973). Depictions of boats and ships on pottery, seals and sealings, paintings and other art, hero stones and other types of sculpture, amulets, coins, stupa, temple walls and other architectural structures elucidate the use of watercraft for trade, warfare, fishing, animal transport, ferrying, pleasure and festivals. Such iconography has been recorded throughout peninsular India, including the interior, from Assam in the east to Rajasthan in the west, as well as in the nearby regions of Harappa and Mohenjo-Daro in present-day Pakistan (Fig. 1). The watercraft represented in Indian art include canoes, dugouts and planked boats (Blue et al. 1997; Deloche 1996; McGrail et al. 2003, 2015; Swamy 1997; Tripathy 2002). Such watercraft not only provide information about seafaring activities in different regions, but also reflect attributes and the importance of social life and culture contacts in India throughout its long and storied history.

The Indian state of Odisha (formerly Orissa) lies on the upper eastern littoral and has a 485-km-long coastline facing the Bay of Bengal (Fig. 1). The region has a sustained maritime history, despite having been ruled by numerous dynasties and cultures. Odisha is drained by 11 major rivers and their tributaries. This riverine network, along with convenient anchorages and landing facilities, has enabled an active regional and transoceanic trade from the 8th–6th centuries BC onwards (Behera 1994; Mookerji 1912). Despite the lack of evidence for water transport in Odisha from archaeological excavation (Blue et al. 1997:189), there are ample examples of watercraft depicted on sculptural panels decorating temple walls across Odisha, namely at the Ratnagiri Mahavihara in Jajpur (8th–9th century), Brahmeswar Temple in Bhubaneswar (10th century), Jagannath Temple in Puri (12th century), the Sun Temple in Konark (13th century), Suvadia in Bhadrak district (14th–15th century), Marichi Temple in Ajodhya, Balasore district (15th century) and Jagannath Temple in Deokund, Mayurbhanj district (19th or 20th century). Each



1. Mohenjodaro	11. Inamgaon	21. Chandraketugarh	31. Guntur	41. Goa
2. Harappa	12. Aurangabad	22. Ratnagiri	32. Tirubhuvanai	42. Vaisali
3. Kishangarh	13. Ajanta	23. Bhubaneswar	33. Tirumangalam	43. SirKali
4. Mt Abu	14. Sanchi	24. Konark	34. Madurai	44. Wari Bateshwar
5. Bhuj	15. Bharhut	25. Puri	35. Tirukukurankudi	45. Suvadia
6. Armada	16. Kaimur hill	26. Naraj	36. Alagankulam	46. Ayodhya
7. Lothal	17. Aphsad	27. Amaravati	37. Tirupputai Martur	47. Deokund
8. Charmardi	18. Bodhgaya	28. Buddham	38. Mysore	48. Jalukbari
9. Eksar	19. Basarah	29. Vidyadharapuram	39. Hampi	49. Guwahati
10. Kanheri	20. Bishnupur	30. Chebrolu	40. Aihole	50. Dumrajhar

Fig. 1. Map showing the locations of watercraft depictions in Indian Art (S. Tripati and R. Behera).

of these representations is described and discussed in this article, along with those decorating Odishan palm leaf manuscripts of the 18th and 19th centuries.

Although a number of scholars have studied these representations, their findings have been limited to descriptions of the sculptures with little or no interpretation (Nayak 2010; Patnaik and Tripathy 1993; Patra 2013). Thus, this paper focuses on the various watercraft depicted in the iconography of Odisha and attempts to classify them, understand their construction, compare them with other known Indian watercraft and explicate the role they played in the maritime history of Odisha.

WATERCRAFT ASSOCIATED WITH ASTAMAHĀBHAYA TĀRĀ OF RATNAGIRI

Excavations at Ratnagiri (Fig. 1:22) has brought to light more than two dozen large Buddha heads, monolithic stupas, bronze images of Buddha and other Buddhist sculptures, including two life-size sculptures of *Astamahābhaya* Tārā, the supreme goddess of the Vajrayāna pantheon and one of the so-called White Tārās. The nucleus of Ratnagiri dates to the early fifth century, and the site continued until the 13th century. One of the two Tārā images, dated to the late eighth century (Donaldson 2001:1:238), is exhibited now at the entrance of the Archaeological Survey of India (ASI) Museum in Ratnagiri (Fig. 2; see also Tripati 2011:1080 fig. 6), while the other, dated some two centuries later, is on display at the Patna Museum in Bihar (Fig. 3). Both sculptures depict the goddess, associated with compassion and mercy, standing with her right hand lowered in *varada* and her left hand raised chest-high and holding a lotus-flower (*nīlotpala*). *Astamahābhaya* Tārā is the saviouress of her followers from eight great perils, or *astamahābhayas*, which are depicted in four scenes flanking either side of the goddess figure. Tārā is depicted in miniature form above each peril, seated cross-legged in *vajraparyanka*. Beginning at the top, the perils shown to the Tārā figure's sinister (proper left) side are: (i) being attacked by a wild elephant (*hasti-bhaya*); (ii) being

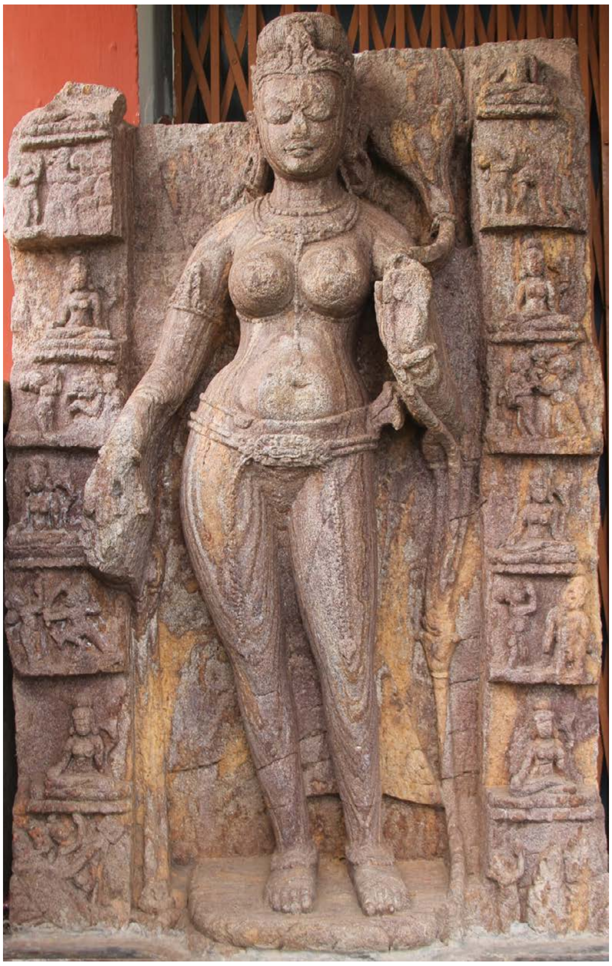


Fig. 2. *Astamahābhaya* Tārā of Ratnagiri, Archaeological Survey of India Museum, Ratnagiri (S. Tripati, 2018).

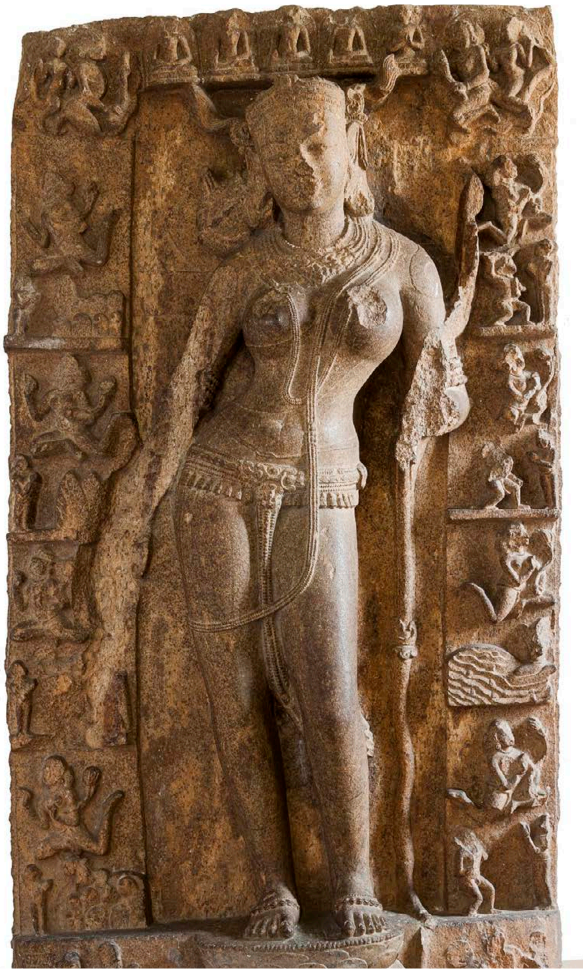


Fig. 3. *Astamahābhaya* Tārā of Ratnagiri, Patna Museum, Bihar (courtesy of the Patna Museum).

Fig. 4a. Detail of the *jalārnava-bhaya* panel of *Astamahābhaya* Tārā, Archaeological Survey of India Museum, Ratnagiri (S. Tripati, 2018).

Fig. 4b. Photograph of the *jalārnava-bhaya* panel taken less than a year later, showing significant damage and degradation (S. Tripati, 2018).

fettered and menaced by a man brandishing a sword (*nigala-bhaya*); (iii) being attacked by a goblin or demon (*piśāca-bhaya*); and (iv) being threatened by fire (*agni-bhaya*). From top to bottom again, the four perils depicted to the figure's dexter (proper right) side are: (i) being attacked by a snake (*sarpa-bhaya*); (ii) being attacked by a lion (*simha-bhaya*), (iii) being robbed by a brigand with a bow and arrow (*taskara-bhaya*); and (iv) sinking in a boat at sea (*jalārnava-bhaya*) (Donaldson 2001:1:237–238; 2:fig. 283; Mitra 1983; Nayak 2010; Tripati 2000).

This last panel, depicting distress at sea, is the scene of interest here (Figs 4a,b). The boat is pictured sinking from the bow, causing the stern to rise up. Unique among the boat sculptures of Odisha, this vessel sports a single prominent mast, set at the centre of the vessel without sail and supported by both forestay and backstay. The boat is manoeuvred by a helmsman manning a steering oar on its starboard aft quarter. Two other persons are shown on board: a large figure with headdress is shown just forward of the helmsman, with clasped hands raised in supplication to the goddess; and a sailor who is adjusting or holding the forestay firmly in an attempt to save the vessel and its occupants from impending disaster. The bow of the boat is portrayed as a human head with a necklace of round beads strung around its neck.

The *Astamahābhaya* Tārā sculpture in the Patna Museum, dated to the late 10th–early 11th century (Donaldson 2001:1:238, 2:fig. 284), is similar to the former example, but with a few variations. In this case, the miniature Tārā above each peril panel is shown flying to rescue her follower, rather than sitting, and the perils themselves are depicted in a different order. Here, the *jalārnava-bhaya* is shown in the third sinister panel from the top (fig. 3) (Donaldson 2004:1:238, 2:fig.284; Ray 2003, 2014). Unfortunately, the outer edge of the stone is damaged in this area and so few details of the ship are discernible.

A third *Astamahābhaya* Tārā figure, dated to the 11th–12th century, is under worship as Ugra-Tārā at Shergarh in Balasore district. The main Tārā figure here is seated, as are the eight miniature figures, next to the distressed followers in peril. The *jalārnava-bhaya* is depicted in the bottom panel on the sinister side, but the boat is not visible (Donaldson 1994; 2004:1:239)

BOAT ON A STONE PANEL OF BRAHMESWAR TEMPLE

The earliest representation of a boat in Odishan art is from the 10-century Brahmeswar Temple in Bhubaneswar (Fig. 1:23), but the panel currently is housed in the Odisha State Museum in Bhubaneswar (Fig. 5) (Panigrahi 1981). Both sides of the panel are broken and presumed missing, and the left end also is severely worn. The panel portrays two boats;

Fig. 5. Boat relief from a stone panel of Brahmeswar Temple, Bhubaneswar (S. Tripati, 2018).

the first (to the left) is fully represented, while only the forward-most portion of the second boat is preserved. An elephant is standing towards the bow in the first boat, but its head is mostly missing. To its right stands a woman whose head too is severely eroded. Next, a woman is crouching on her knees at the feet of a man, her right hand resting on his left leg; the man is reclined against a pillow, his left arm supporting his torso and his right hand holding a tree branch. Both have long earlobes, ornaments and bangles with Buddhist connotations. These figures likely are the prince and princess of Odisha,

Fig. 6. Boat relief on the *Bhoga Mandap* of Jagannath Temple, Puri (S. Tripati, 2018).

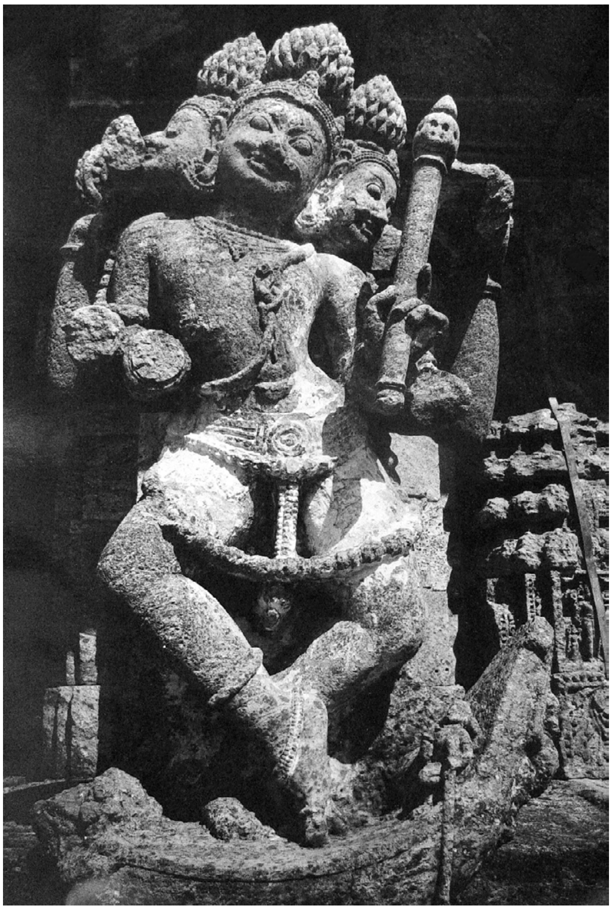


Fig. 7. Martanda Bhairava dancing on a boat, Sun temple, Konark (courtesy of the Archaeological Survey of India).

and the branch that of a banyan (*vat* or *bargad*) tree. The scene evokes the story of King Asoka, who, accompanied by Sangamitra and Mahendra, transported a banyan sapling to Sri Lanka; in later period, elephants also were sent to Sri Lanka. Two boatmen next are depicted at the stern of the vessel; one is paddling with a long oar with an oval blade, while the other pilots the boat with a steering oar from atop the curved stern. Both crewmen have long earlobes and wear a headdress. Facial details of all the figures on board are mostly worn away.

As for the second boat, only the bow is preserved, along with the head of an elephant, as the rest of the stone relief is missing. Both the prow of the second boat and the elephant aboard are larger than those of the first, suggesting that it is a larger vessel.

Both vessels are open and without a mast. Each has a high, upward curving bow terminating in some type of animal-head device, whilst the first boat at least has a low and short stern with what might be some type of extension, upon which the steersman sits. A single row of regularly spaced protruding thwarts—likely deck beams—runs the visible length of each hull just below the gunwale. No other construction or decorative feature is visible on either of the boats.

The space below the boats is filled with rows of an undulating wave pattern populated with five aquatic creatures. From left to right, these are: a crab; an octopus, with round body, three arms and one eye depicted; the scaley body and tail of a fish; a *makara*, a water-monster in Hindu mythology, but today typically understood as a crocodile; and a squid, with an elongated round body and six short arms. The distinctive scales on the fish likely mean that it is a coastal or estuarine type, rather than a deepwater variety. Likewise, the *makara*-crocodile, which bears close resemblance to the same creature depicted on the ninth-century Borobudur temple in Java (Mookerji 1912), also indicates that this is a coastal or riverine scene.

BOAT ON THE BHOGA MANDAP OF JAGANNATH TEMPLE

A relief from the 12th-century *Bhoga Mandap* (pillared offerings hall) of the Jagannath temple in Puri, centrally located on the Odisha coast (Figs 1:25), depicts a ceremonial boat (Fig. 6). A royal personage is seated under a canopy, supported by caryatid type pillars, in what looks like a cradle or rocker suspended from two rings attached to the roof and supported by short legs resting upon a raised platform. The figure holds a knotted loop in his right hand, while his left rests on his left knee, that leg being folded in the normal position while the right leg is pendent. Four attendants accompany the royal person; one holds a parasol, while the other three stand at the ready with food, beverage or other offerings.

This is the detailed depiction of an indigenous tradition of reverse-clinker boats in India. The

Fig. 8. Boat relief, Indian Museum, Kolkata (courtesy of the Indian Museum).

carving of the boat, particularly the reverse-clinker planking pattern, is extremely precise. The boat has a raised and elongated bow and nine or 10 prominent planking strakes, along with a caprail. Four women are rowing the boat with oars, while the helmsman stands at the bow. The oars worked by the women are shorter in length than the steering oar used by the helmsman, and are fitting in ring-like sockets. Water is indicated beneath the boat with a scallop pattern. In the rear end of the boat, a man is standing with a parasol (*chhatra*). Nine to ten overlapping planks of the boat can be seen clearly. The boat has a high raised bow and a short stern. This boat may be classified as a *madhyamandirā* type, as referred to by King Bhoja in the *Yuktikalpataru* (Mookerji 1912).

Unlike the boat of the Jagannath temple, the reverse clinker boat of Odisha is known as the *patia*, which combines both ordinary and reverse clinker techniques of planking (Bhattacharya and Varadarajan 2001). The reverse clinker tradition is native to the northern coast of Balasore (Fig. 1:46) and to coastal Bangladesh, and has been the subject of detailed study (Blue et al. 1997; McGrail et al. 2003; Mishra 2000).

MARTANDA BHAIRAVA DANCING ON A BOAT, SUN TEMPLE, KONARK

In the lowest tier of the 13th-century *jagmohan* (assembly hall) of the Sun temple (*Surya Mandira*) at Konark (Fig. 1:24), Martanda Bhairava, the composite manifestation of Shiva and Surya, is shown eight times dancing on a boat (Fig. 7). This depiction symbolises the crossing of the world sea by the grace of the god (Behera 1996), but here it also represents the maritime glory of ancient Odisha. Two Martanda Bhairavas are sculpted at the corner of each side of the *jagmohan*, representing the four cardinal directions, but the two on the western side are now missing. Each version has three heads with long canines, hair fashioned as flames, six arms, a snake for the *upavīta* (sacred thread) and a *kapala mala* (garland of skulls) hanging to mid-thigh. The deity holds a *trishula* (trident), *sula* (skull staff/cup), *khatavanga* (staff), *kapala* (skull cup), *cakra* (discus) and *damaru* (drum) and is shown dancing in the *lalita* pose (Behera 1996:216).

Precise details of the boats of Konark temple are difficult to discern, as the surviving sculptures are quite eroded and otherwise damaged. The boats have high, pronounced sterns, lower bows and are relatively long and narrow. These boats almost assuredly represent reverse clinker vessels. There are two boatmen on each boat: one rowing while standing at the bow and a second rower sitting in the stern.

BOAT RELIEF IN THE INDIAN MUSEUM

The collection of the Indian Museum in Kolkata (Fig. 1:21) includes a detailed relief of an Odishan boat, dated between the 12th and 13th centuries and most likely from the Sun Temple at Konark (Fig. 8). The scene again is dominated by a royal figure seated on a raised platform under a canopy set near amidships. The royal person wears a crown and holds a bow in one hand and arrows in the other. Two attendants hold parasols, one at the bow and the other in the stern. Also in the stern stands an elephant, along with a person standing behind it and another person squatting. The boat is rowed by three women, along with the presumed helmsman, who holds the same type of oar. The now familiar features of this boat indicate that it is another example of a *madhyamandirā*, or royal pleasure craft.

BOAT MODEL IN THE VICTORIA AND ALBERT MUSEUM

The Victoria and Albert Museum in London has in its collection another sculpted stone *madhyamandirā* boat model with similar features (Fig. 9). The boat has a canopy set just aft of amidships and held aloft by substantial, more column-like supports. Under the canopy sits a royal figure again holding a bow. There are three oarsmen and a helmsman, each with conical headgear (Guy 1999) and manning an oar with a lozenge-shaped

Fig. 9. Indian boat model, Victoria and Albert Museum, London (courtesy of the Victoria and Albert Museum).

blade. Behind the helmsman are musicians, while at the bow is another figure holding a fly-whisk (*chaamor*). An elephant is depicted in the prow, a common feature on Odishan boats. Behind the elephant and attendant is an uncertain object, which Guy (1999:107) suggests could be a *pūrna kalaśa* (an urn or a jewel vase).

The boat is depicted with a high, up-turned stern, four reverse-clinker strakes, a caprail and a keel. The ends of through-thwarts protrude along the shear strake from bow to stern and a garland is strung over them. The strake below the shear also is decorated, with trefoil and diamond-shaped ornaments.

BOAT DEPICTED ON HERO STONE

During recent explorations in Suvadia (Fig. 1:45), in Chandbali Tahasil of Bhadrak district, close to the Matai River, two hero stones and a goddess idol were noticed on an open platform still under worship (Fig. 10). One of the stones depicts the hero riding a horse followed by a band of musicians and attendants, including one holding a parasol. The hero holds a spear in the throwing position and has a dagger tied at the waist. The other hero stone, and the one of interest here, depicts the large hero figure in a dynamic pose, with shield held forward in his

Fig. 10. Boat depicted on a hero stone, Suvadia (S. Tripati and B. Swain, 2018).

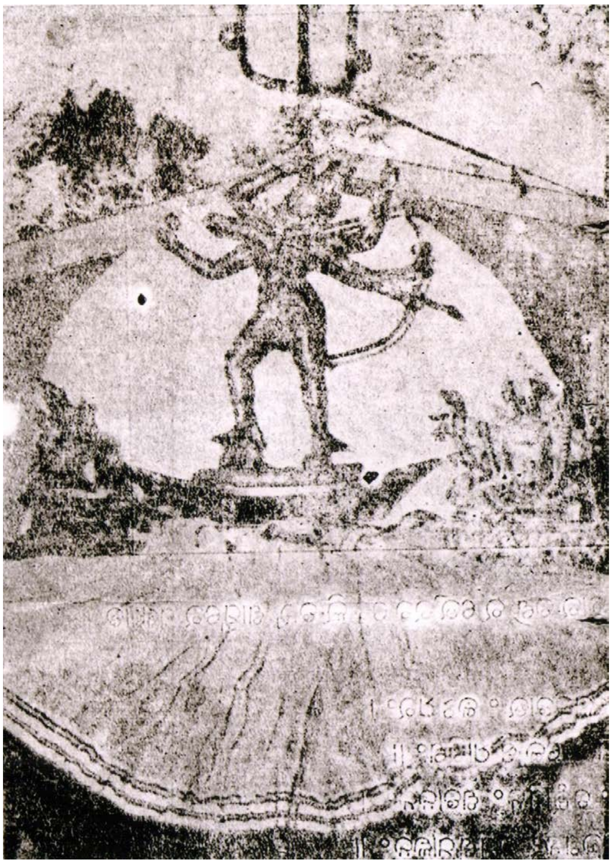


Fig. 11. Metal idol depicting Ambika Devi on a boat, Deokund (R.N. Padhy, 2018).

left hand, sword raised to strike in his right, and again a dagger tied at his waist. The hero stands on a boat, facing astern, along with an attendant holding a parasol. The boat itself has an elongated bow and a flat stern, resembling the boats described above. Six oars with leaf-shaped blades are visible along the side of the boat, although there may be additional ones that are obscured by another figure, only partially preserved, kneeling alongside the boat and likely praying to the hero. The only other discernible feature of the boat is a prominent caprail. There is no indication of planking seams or through-beams, although the poor state of preservation may have obscured original details. This hero stone is made of locally available sandstone, and the image can be attributed iconographically to the late 14th or early 15th century.

MAHISHAMARDINI ON A BOAT AT BHUBANESWAR

There is a sculpted stone slab in Bhubaneswar, dated to the ninth century, which bears an image of the goddess Mahishamardini with eight arms, each hand holding a weapon (Behera 1977:115). Originally lying under a banyan tree near the Brahmeswar temple, the sculpture has since been moved and is now worshipped at another small temple nearby. A boat is depicted below the pedestal of the goddess, who is engaged in a fierce sea battle with a demon. Such a scene is rare in Indian art.

GODDESS AMBIKA ON A BOAT AT DEOKUND

There are five *kundas*, or ponds, at Deokund in Mayurbhanja district of Odisha (Fig. 1:47), which are considered as five allegorical seas. Ambika Devi (Durga, mother goddess) is worshipped in Devi Kunda temple of the *pancha tirtha*—five sacred bathing spots of pilgrimage (Parida 1983). In one particular metal idol, which unfortunately was stolen in 1971, the goddess is shown standing upon a platform or pedestal on a boat, with a lion under her right foot (Fig. 11). The sculpture, made from an alloy of eight metals, stands approximately 50 cm tall and weighs between 18 and 20 kg. The goddess has four hands, which hold a bow and arrow, skull and trident; the arrow is drawn and she looks wrathfully towards her enemy. Two other deities, Tripuri Sundari and Bhagamalini, are depicted to the left and right of the boat. The boat itself is a flat-bottom riverine craft with sharp, outward raking extremities. Similar looking boats still are used locally on the rivers of Odisha.

RĀDHĀ KRISHNA ON THE BOAT AT AJODHYA

A sandstone sculpture was reported in Ajodhya village, in the Nilagiri block of Balasore district (Fig. 1:46), known for Brahmanical, Buddhist and Jain remains from the early medieval period. The sculpture is now missing, but it depicted the Rādhā and Krishna standing on a boat with a raked bow and stern. Under the influence of Gaudiya Vaishnavism, a Hindu religious movement founded by Bengali spiritual leader Chaitanya Mahaprabhu (1486–1534), the Rādhā-Krishna cult developed in Bengal and Odisha in the 16th century. Nevertheless, sculptural representation of Rādhā-Krishna in Odisha do not appear earlier than the 17th century, even though there are references to their dual image in earlier Sanskrit and Oriya literature (Bhattacharya 1996:13–22).

MISCELLANEOUS BOAT REPRESENTATIONS

A fragment of a circular terracotta seal bearing a depiction of a boat was found at Gourangapatna, on (the bank of Chilika Lake—the first such discovery in Odisha. The boat appears to be a seagoing vessel. Associated finds include terracotta beads and various pottery, including spouted vessels, red ware, black ware and other types (Mishra 2002).

A loose stone sculpture of a boat has been kept in the Lingaraj temple complex at Bhubaneswar. A woman is depicted steering the boat with an oar. The sculpture could be dated to the 11th century (J.K. Patnaik pers. comm. 2018). Scholars differ in their opinions of this piece, but to date it has not been subjected to thorough study.

The Jayadev Museum of Bhubaneswar has many palm leaf manuscripts, among which four contain a total of eight representations of boats. The information and illustrations of the boat are found in the 16th-century epic *Ushabhilasha* by Sisu Sankar Das, which depicts the love story of Usha and Aniruddha. Among the boats, six have similar prows, while those of the other two bear the face of a bird and an elephant, respectively. Five of the boats appear to be built in similar fashion, but the construction of the other three are each different. It is noteworthy also that four of the eight boats are crewed by women (Tripati 2000).

Finally, a drawing of a watercraft has been found on a rock boulder close to the riverbank in Naraj, which is located at the confluence of the Mahanadi, Kathajodi and Prachi Rivers. Adjacent to the vessel are two people with unusual appearances; they each hold a pole and a round object in their hands, while another two round objects are shown suspended in the air. There is a ladder near the boat, which probably is for climbing aboard. Although the boat is depicted in a rudimentary form, a detailed study is required to fully understand this rock art. During the historical period, this region served as a trade centre connecting Sisupalgarh (Bhubaneswar) and other coastal sites (Pradhan 2014:166).

DISCUSSION AND CONCLUSIONS

Watercraft are an integral part of maritime trade. Studies of boats and ships are essential to understanding not only such trade, but also shipping and shipbuilding, cultural contacts and knowledge exchange. Most of the watercraft found in India provides some insight, whether directly or indirectly, to these aspects of their respective societies. The watercraft of Odisha represent an incomparable assortment of types, but none of their pictorial representations are accompanied by an inscription that might facilitate their adscription to a precise period or specific type. Only in Odisha is the Tārā figure found associated with boats—in this case, as the protector of her followers from maritime disasters. The fact that shipwrecking or other maritime disaster is one of the eight specific perils depicted on the two Tārā sculptures is indicative of the importance of seafaring to the local population. It also indicates that Buddhists were engaged in overseas trade and commerce.

The long boats depicted on the panel of Brahmeswar Temple are a type not seen in any other representations in India. The aquatic life shown on the panel also is rare in Indian art. Crabs, cephalopods and scaly fish are abundant in coastal and estuarine waters along the Indian coast, and the combination of these and the lack of sail suggests that the vessel is a riverine or coastal craft. The portrayal of elephants on board gives some indication of the size of these boats that were capable of transporting such large beasts. The earliest evidence for the maritime transport of elephants comes from the Ajanta paintings, which date from the second century BC to the fifth century AD (Mookerji 1912; Schlingloff 1988). Moreover, Odisha is well known for its elephants, to which the *Arthasastra* of Kautilya refers. Hiuen Tsang, as well as Arab and Persian travellers, makes mention of the elephants of Odisha, which were exported to foreign countries. Similarly, the *Periplus of the Erythraean Sea* refers to the ivory of Dosarene of Odisha (Schoff 1974:47, 253; Warmington 1974:63).

The boat model of Jagannath Temple, originally housed in the Sun Temple of Konark, may have been brought to Puri in the last quarter of the 18th century, at the same time as the *arun stambha*, or sun pillar. The latter is dated to the early part of the 13th century, and was relocated from Konark and installed in front of the main gate (the lion gate, or *simha dwara*) of Jagannath Temple (Patra 2015:18–24). The *Bhoga Mandap* of Jagannath Temple contains many niches wherein small sculptures are placed; the boat model among them. The women rowers, the attendant holding a parasol and the royal personage sitting in the cabin all suggest that a pleasure trip is depicted.

The dancing Bhairava images of Konark are unique from an iconographic perspective. Rarely has this type of Martanda Bhairavas been recorded. Earlier examples were identified as Brahma until Sivaramamurti correctly recognised them (Behera 1996). The boats of Konark and Puri all belong to the reverse clinker tradition, and are shown with the helmsman standing in the bow. Unfortunately, most of the boat sculptures associated with Martanda Bhairava are damaged, due to their material and environmental degradation, so it is difficult to

Fig. 12. Sisupalgarh hero stone, 11th century, Ravenshaw University, Cuttack (S. Tripati, 2018).

discern many details of the boats' construction features.

The three boat models from Puri have no provision for a mast, and are propelled solely by oar. All of these boats have similar features, are similarly constructed, have attendants holding parasols and rowers, confirming that they are royal pleasure boats. An elephant, a regal symbol associated with royal families, is depicted on each vessel as well. These boats can be dated to between the 11th and 12th centuries (Guy 1999; McGrail et al. 2003).

The deity Ambika is shown with a lion (her normal vehicle) on a boat in what could be a medieval idol (Parida 1983:124). It is significant that this representation is found in Odisha, as rarely is the goddess depicted in association with watercraft. The original Ambika idol of Deokund was stolen long ago, so the local Prince and legislator, Prafulla Chandra Bhanja Deo, had another idol of Ambika installed, which is the subject of discussion her (unfortunately, that image too was stolen in 1971). Bhanja Deo provides details of Deokund in his booklet *Pancha Sagar Tirtha* (Five Sacred Seas). This work deals primarily with the deities worshipped at Deokund and the locations of the five *kunda*, or bathing spots. Ambika is positioned as the principal deity, and her depiction on a boat shows the importance of watercraft to the local population.

Reverse clinker boats are found exclusively in Bangladesh, West Bengal and northern Odisha, but not in the Puri-Konark region. Reverse-clinker construction is visually more distinctive than other types, and perhaps for this reason, when commissioned to install boat models in the newly constructed temples at Puri and Konark, sculptors preferred reverse-clinker designs. The rowing pattern and high prow of the boat on the hero stone of Suvadia resemble those of reverse-clinker boats, but the precise method of planking is unclear. For several centuries, reverse clinker boats have been used in northern Odisha for ferrying and fishing in nearshore zones, whereas other regional boat types tend to be used exclusively in riverine settings. The earliest use of reverse clinker construction in Odisha is not known, and much still needs to be learned about how the technology came to this region, its history and its dissemination. During a recent field trip to study the reverse-clinker boats of Balasore (Baleswar), in northern Odisha, one of the authors (ST) was dismayed to find that few such boats still exist, and that fibreglass boats slowly are replacing them.

The hero stone of Suvadia, depicting a naval battle, is the first of its kind found in Odisha and touts the naval power of Kanika. The Suvadia area was under the control of the Raja (king) of Kanika, who maintained a strong naval force to safeguard maritime activities from attacks by the Mughals, Marathas and British. Because of this, the Mughals were never able to consolidate their hold on Kanika. Even the Marathas, who had a powerful naval force commissioned by their ruler Shivaji, could hardly match the Kanika navy (Sridharan 1982). Walter Hamilton (1820:2:46–47) reports on the naval strategy of the Kanika Rajas in his report on Hindostan (Hindustan) of 1790:

> …the Raja of Kunka [Kanika], who possessed this inundated and unhealthy tract of the country, had long baffled the Maharatta generals in all their attempts to subdue him. The Maharattas had been accustomed to embarking troops and artillery on large unwieldy flat bottomed boats, unmanageable in large streams or near the sea, in consequence of which, their ill-constructed fleets always fell a prey to the Raja's light-armed vessels, which were long, narrow with barricadoes to cover the men, and some of them having 100 paddles or oars. When these squadrons met, the Ooria [Oriya] boats moved quickly round the heavy Maharatta armada and picked off the men with their matchlocks, until the remaining were compelled to surrender, when they were carried into captivity from whence they seldom returned, the pernicious atmosphere of these morasses permitting none to live but the aborigines.

The *Paika Kheda* (Book of the Soldier), a text on Odishan martial tradition written by Kanhai Champati Roy in the late 16th or early 17th century, discusses naval warfare, the organization and training of the Odishan navy and the nine types of war vessels in the navy's employ (Mund 2020:37). From the seventh century onwards, many battles were fought along the Odisha coast, and hero stones were erected to the memory of the heroes of those conflicts. Hero stones depicting battle scenes have been found also at Kanas, on the bank of Chilika Lake (Tripati and Patnaik 2008). The standing posture of the hero of Suvadia is comparable to another displayed on a hero stone at Ravenshaw University, in Cuttack (Fig. 12). The latter stone, originally from Sisupalgarh, to the northeast, has been dated to the 11th century.

Both reverse-clinker and carvel-built watercraft are depicted in the sculptures of Odisha, the former used to transport cargo and passengers, and the latter in conjunction with a flat-bottom riverine craft. Both types surely were used to move products and people along rivers, to near-coastal regions, and across open sea, as well as for warfare (McGrail 2015; Tripati 2000). In reverse-clinker construction, each upper strake overlaps inboard the strake below and is fastened to it with iron nails driven through the overlap. Of the Odishan watercraft discussed in this article, the Deokund boat most closely resembles riverine craft found elsewhere in India. On the other hand, the boats depicted on the stone panel of Brahmeswar Temple have a feature—a stern extension—that is found in no other boat depiction in India. The boat models emphasise the intimate association between royal families, deities and mariners of Odisha and watercraft—and water, whether rivers or the ocean, more broadly. Riverine and coastal craft have played an important role in the history of Odisha, facilitating trade and transportation, serving to protect from invasion and as a visual symbol of prestige. Nevertheless, the number of documented watercraft depictions is limited, especially in comparison with the rest of the sub-continent, and so further research is needed. The boats of Odisha are unique in design and style, being a product of the local environment and the needs of the region's populations. Some of the boat types portrayed in Odishan art are still built and used today; however, their numbers are declining, as is the use of traditional building techniques and materials, due to rapid industrialisation and the advantages of fibreglass and steel. It is urgent, then, not only to continue the documentation of ancient boat iconography, but also to record contemporary forms, both for posterity and to aid in understanding and interpreting historical depictions.

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Indigenous Maritime Investigations at the Western Australian Museum's Department of Maritime Archaeology: An Overview After Nearly 50 Years

MICHAEL MCCARTHY

Abstract

Since 1968, the Western Australian Museum's Department of Maritime Archaeology has investigated Indigenous maritime activities as part of its Wreck Inspection Program and shipwreck excavations and studies. Over the decades, these investigations have become increasingly integral to most every shipwreck study the Department has carried out, have grown in sophistication and have become more interdisciplinary. They have involved not only Department staff, but also members of the public, external scholars and researchers and, most importantly, Indigenous scholars and informants. They have been part of both foreign and colonial shipwreck investigations, ranging from VOC ship *Zuytdorp* (1711) to *Shunsei Maru* (1931), as well as downed aircraft, such as the Junkers seaplane *Atlantis* (1932). The studies have involved rock art depictions of European ships and activity, Indigenous participation in the Western Australian pearling industry, European sealing and whaling and the often forced involvement of Indigenous people, the trepang industry, Indigenous interactions with European shipwreck survivors and the documentation and interpretation of cultural seascapes. The evidence examined goes well beyond shipwrecks, and includes Indigenous oral histories, legends and accounts of shipwrecks, Indigenous sites and secondary use of shipwreck materials, rock art, genetic investigations and activities of Indigenous and European station hands. The results of these investigations have been disseminated widely to both scholarly and public audiences. The Department's Indigenous maritime investigations have been pioneering in many respects, but also have revealed the great potential for future research. Perhaps most importantly, they have demonstrated clearly that shipwreck investigations in colonial settings can no longer be deemed credible if they do not incorporate Indigenous perspectives—and, indeed, Indigenous scholars.

INTRODUCTION

As an ancillary to its shipwreck studies program, the Western Australian Museum's Department of Maritime Archaeology (the Department) began investigating Indigenous maritime activities on the coast of Western Australia in 1968. What follows is a description of the work that followed. It is, in effect, the ad hoc precursor to recent studies that focus primarily on Indigenous people in the maritime trades (e.g. Fowler et al., 2014, 2015a, 2015b; Roberts et al. 2013, 2017). This overview also serves to illustrate the gradual development and evolution of the Department's shipwreck-based studies of Indigenous activities at a time when few other institutions were on a similar path. It presents the vast breadth of the subject matter and the potential for others seeking to engage in similar work and expand their own research, well beyond the beginnings outlined here.

Any examination of the Department's maritime Indigenous studies must begin with Colin Jack-Hinton and Ian Crawford, two influential leaders in the Museum's hierarchy in the Department's formative years. In 1968, Jack-Hinton made press headlines when he examined the mysterious ship painting at Walga Rock (Walghana), near Cue, Western Australia (Fig. 1). According to a Daily News (25 November 1968:4) article at the time, he believed that it "could be the first definite link found with survivors of Dutch shipwrecks during

Fig. 1. The Walga Rock Steamship (I. MacLeod, 2005).

the 17th and 18th centuries". In his opinion, the image was "most likely" painted by either a survivor or a descendant of a survivor, or was the work of "an Aboriginal who had some contact with old ships". He also advised that the four lines of 'writing' beneath the image were "not writing at all but a series of symbols in pattern form" that "either contain a message or are the attempts of an illiterate".

Ian Crawford joined the Western Australian Museum in 1961 as a curator of Anthropology and Archaeology after completing his PhD focussed on Indigenous and Macassan studies in the Kimberley region. He was promoted eventually to Head of the Division of Human Studies, within which the Department of Maritime Archaeology functioned, and remained in that position until retiring in 1993. Crawford became a well-known figure, especially in the Kimberley, where he worked closely with Aboriginal communities. His research interests focussed on Indigenous art and mythology, the Macassans and their heirs, and Indonesian and Malay fishermen of the early 20th century. Much of his work was to have a seminal influence on his colleagues and subordinates, and led to a deep appreciation of the importance of Indigenous oral history. He became acknowledged amongst Australasian maritime archaeologists and historians as being responsible for the "integration of European historical accounts [and] Indigenous oral tradition and material" in maritime studies (Souter 2010:14).

THE WRECK INSPECTION PROGRAM AS A CATALYST FOR INDIGENOUS STUDIES

As with the military-related studies described previously in this journal (McCarthy 2016), the Department's involvement with Indigenous maritime studies commenced under the auspices of the Museum's Wreck Inspection Program as an adjunct to its better-known shipwreck excavations and research. The first instance occurred in early 1976 with the transcription of an oral history describing events that occurred near Eucla, well before the explorers Eyre and Baxter transited the area. It emanated from rabbit trapper A.J. Carlisle, who had lived there for nearly five decades and, as a result, had many Indigenous connections and informants. Legend (possibly from the Mirning community) referred to a ship seen lying close inshore and billowing smoke. A small boat left its side and head for the shore, which caused the Aborigines to hide. When they returned, the boat was found beached, with two or three figures walking nearby and others lying down. Later, the ship itself came ashore. Of the five that had come ashore, three died (perhaps from burns), one was killed by the locals, and the fifth was allowed to live "having fair hair or blond hair", something they had never encountered previously (Henderson 1980:74). This sole survivor lived with the local Aborigines for a considerable time and was believed eventually to have joined an adjoining group to the east. The Museum's then Inspector of Wrecks, Scott Sledge, took a team to the site with Carlisle and, with the aid of a metal detector, found deck knees buried in the intertidal zone. Subsequently, Martin Gibbs, a student of early whaling and sealing on the coast, conducted an investigation into a possible connection with a hitherto dismissed mid-19th-century account by William Jackman describing his "forced residence of a year and a half among the cannibals of Nuyt's Land on the coast of the Great Australian Bight" after he was wrecked on an English whaler (Jackman 1853). While finding it a "strange mix of verifiable facts" and "difficult to corroborate references" (Gibbs 2002:7), with the usual sensationalism of that era throughout, Gibbs concluded that the account was based on a "true story" (Gibbs 2002:16). He also found that, despite its failings, the work offered "a valuable insight into the "nature of contact between Europeans and indigenous groups" (Gibbs 2002:18). This theme, and the importance of Indigenous accounts, will resonate throughout this work.

The 1978 Wreck Inspection North Coast (WINC) expedition, also led by Sledge, is the prime example illustrating that the Department's wreck inspection program was the catalyst for its Indigenous studies. In this instance, amongst those joining Sledge were Indigenous guides/informants Richard Hunter (Broome phase), 'Left Handed' Jack Karrada (Kalumburu phase), Martin Clark (Oombulgurri phase), Peter Yu (Wyndham/Broome phases) and Jimmy Chi. As a result of the involvement of these local identities, the WINC expedition and the ensuing report were to prove an important benchmark for the Department's recording of Indigenous maritime cultural heritage generally. Sledge reports, for example, that Richard Hunter, whose family once had a *bêche-de-mer* (trepang) camp in Admiralty Gulf, introduced the team to the famous DC3 'Diamond Plane' downed during WWII (See Tyler 1987; Wills and Van Velzen 2006), adding details known only to his own Indigenous informants, such as the burial of those killed in the attack. Hunter also showed early pearling camps and referenced many vessels, including one owned by his father, Robin. In addition, he took the team to caves containing Aboriginal art that had been described earlier by Ian Crawford. In a section titled 'A Spirit Place called Langgi', Sledge (1979:33–36) reiterated Crawford's belief that the Aboriginal Kaiara (or Sea Wandjina) legends may have been inspired by, or recalled the activities of, early mariners (Crawford 1968, 2001:112).

After examining the remains of the failed European settlement at Camden Harbour, the team travelled north and examined cave paintings at Bigge Island. Following Crawford's work again, Sledge (1979:77–78) there described five depictions of European-type vessels, including pipe-smoking figures in a oared boat propelled with rowlocks and two individuals smoking pipes inside a two-masted vessel.

Continuing on their journey they met the Reverend Fr Perez, from Kalumburu Mission, who advised them that a vessel had wrecked at nearby Mary Island in 1920. According to Fr Perez, six Kulari people, including a woman, had killed two white men reported to be Germans. After throwing the bodies into the sea, they plundered and destroyed the lugger. Discrepancies are evident in this instance (see excerpt, following): first, about which of two nationalities (German or Japanese) were involved, and, second, between the European (Fr Peres') and Indigenous accounts, as Sledge shows in recording Jack Karada's version of the same event:

> They took two Gambré women from the group resident on the island and kept them aboard several nights. Then their men came to the lugger and said 'Where's our wives?' The Japanese replied that they would keep them one more night. The Gambre men protested, but the sailors would not return the women. When one of the Japanese who was scrapping the hull put down his tomahawk one of the Gambre seized it and chopped him. When the other Japanese came up they chopped him too. Then they took the women, clothes and other gear from the lugger, but did not burn it [Sledge 1979:67–68].

The team also examined a then unidentified iron wreck at the Osborne Island group in the Admiralty Gulf, noting its intact state and recording as much as they could see in the conditions then prevailing (Sledge 1979:70–71). Further north, one of Sledge's team sighted an abandoned seaplane float found partially buried at Cape Bernier. It was a relic of the epic 1932 'Flight into Hell' of German aviators Hans Bertram and Adolph Klausman (Bertram 1985), when their Junkers W 33 seaplane, *Atlantis*, force landed after it ran out of fuel. Sledge later returned to collect it, thereby re-opening interest and further studies into the crucial role of the Miwa and Yiiji groups in rescuing the two men (See Strangers on the Shore, p. 5 below). A 1988 exhibition at the Shipwreck Museum in Fremantle and a website (McCarthy and Davison 2002) featuring the float and Indigenous contribution to the aviators' rescue also resulted from that work.

Another instance where wrecks and Indigenous cultures intersected, or in this case were initially believed to do so, and were investigated under the wreck inspection program occurred in 1989. In this instance, Jeremy Green, an expert in early gunnery, examined a report from C.G. von Brandenstein, a retired anthropologist from the University of Western Australia (on von Brandenstein, see Thieberger 2006). Based solely on what he claimed were stone shot (for cannons) collected by Indigenous people at Depuch Island, and by the appearance of Portuguese 'loan words' in the regional dialect, Von Brandenstein claimed there was a pre-settlement Portuguese wreck nearby. The report was proved spurious (Green 1990). Conversely, an example where shipwreck materials proved of value to Indigenous people appeared during the 1991 inspection of a small wreck in the mangroves on Mardie Station (established in 1866) in the Pilbara. The vessel appeared to be a pearling lugger washed far inland during a cyclone, with shell scattered amongst the remains. An unusual find in the wreckage was a worked bottle that suggested that the remains had been utilized by Indigenous people travelling through or working on Mardie Station (McCarthy 1991:5). Conversely the bottle may already have been worked by someone on the vessel when the cyclone hit and was kept as a source of further implements.

INDIGENOUS ACCOUNTS OF SHIPWRECKS

When the author assumed responsibility for the wreck inspection program, one focus of attention was the schooner *Emma* (McCarthy 2011b). It disappeared with all hands in 1867, along with a third of the entire European population of the northwest and a number of Aboriginal convicts and their guards. Believed to lie somewhere near Point Cloates on the Ningaloo Reef, the remains had been searched for unsuccessfully on numerous occasions. Local Indigenous people also were quizzed on what they knew, but their accounts, reproduced below, were dismissed largely as fanciful, partly because there were no known instances of any missing ship in the region that had women on board.

> An account of a shipwreck…is told by an intelligent native whose tribe inhabits the country… Coming from such a source there may be some hesitation in giving the story credence, but it is accompanied by such detail and circumstance that some truth at least appears to attach to it… [T]he passengers landed, at night, in the boats, and as they had no means of defending themselves the natives had no difficulty in making them prisoners. There was a large number of persons, and amongst them were some females. The natives were not 'sulky' with them, but nevertheless they killed and ate all of them, the narrator partaking of some of the flesh. Two other vessels were also stated by the native to have been lost about the same spot—a large vessel and a smaller one, and he was able to point out where the wrecks lay. The crew of the larger vessel took to their boats and proceeded southward… [Honniball 1961:21–22; Smoje 1978:37].
>
> As in the Eyre instance, where one man was killed and another was given shelter after the barque *Stefano* was lost near Point Cloates on the Ningaloo Reef in 1876, two of its survivors also were taken in by coastal Aborigines. They lived with them for a considerable time and travelled through a number of tribal boundaries as they headed north for a rendezvous with a pearler known to the Aborigines. Taken down to Fremantle, the survivors became famous in the colony and their saviours were roundly praised. When the survivors returned home to Dalmatia (now Croatia), an account of an extensive sojourn with the Aborigines was commissioned, together with a votive painting giving thanks for their deliverance [Scurla 1876; Skurla 2009].

In the interim, a government official, Pemberton Walcott, who was investigating wreckage believed to be from *Stefano*, was advised by an Indigenous man known to the Europeans as 'Tony' that "about two winters ago a very large steamer had been wrecked down at his country and all hands lost including a woman" (Walcott 1876). Another reference appears in the diaries of 19th-century ornithologist Thomas Carter, founder of Ningaloo Station. In the context of skeletons of the *Stefano* crew being seen in a cave near the beach, he wrote that:

> […] some of the elderly natives spoke of a white man, woman and little girl who landed in a boat years ago, evidently having been shipwrecked, and after living quietly with the natives for a long time had started to walk south along the coast. No one ever knew who they were or how they died… Some of the natives at Boolbarty [a large encampment], especially three of the young women, were quite light coloured, with regular features and light brown hair, and doubtless they had a strain of white blood in them derived from Europeans shipwrecked at the time [Carter 1987:123].

Until recently these three reports were not linked to each other and, like many other Indigenous accounts, were considered at best an agglomeration of stories unable to be fixed in time and possibly fanciful, given that the descriptions did not fit any of the known losses. We now know that this perception was wrong.

After an extensive search over a number of years, *Stefano* was found in 1997. Nearly a decade later, the remains of the Portuguese China Trader *Correio Da Azia* (wrecked 1816) and an as-yet-unidentified wreck also were found a few hundred metres from each other and less than a kilometre south of *Stefano*. They had not previously been listed amongst the known losses in the region (e.g., Henderson and Henderson 1988). While *Correio Da Azia* was identified from contemporary sources, all that could be deduced about the other site was that its anchors, rudder fittings, an uninscribed bell and some fastenings all indicated a late-19th-century wooden-hulled sailing vessel of about 400 tons (Anderson 2005). This find also posed the questions: did men and women get ashore, and was it the one referred to by 'Tony' in 1876? Clearly, Indigenous accounts should have been given far more credence, both at the time and by modern scholars.

In an allied case from the same region, the wreck of the iron-hulled sailing ship *Benan* in 1888 provided proof of the rapidity with which news can travel long distances through tribal boundaries. According to Thomas Carter, who later owned the Ningaloo Station, but who at the time of writing was at Wandagee Station inland:

> About this time some of the Wandagee natives said that the natives on the coast had signalled across to them—presumably by means of smoke—that a 'flock of white men were walking about the beach at Point Cloates', which would be about 120 miles distant in a straight line. We all took little heed of what they said… but some days later word came from Julius Brockman that the barque *Benan*, bound from Cardiff to Hong Kong with a load of coals, was wrecked on Point Cloates reef, and the crew of twenty-nine had landed there [Carter 1987:120].

Another unexpected feature linking shipwrecks to Indigenous studies is the ability of the events surrounding a particular wreck to fix certain Indigenous groups in time and place. When *Shunsei Maru* became stranded on Ningaloo Reef in 1931, for example, the Japanese crew refused to come ashore for fear of a group of Aborigines who were fishing and spearing turtles on the beach opposite. Maurice MacBolt, chief engineer for the nearby Norwegian Bay, boarded the ship and on his return recounted the story to the Aborigines, who treated the fears of the Japanese as a 'huge joke'. In another important observation, MacBolt records that their group was led by a man known as 'Dingo Charlie' and that all twenty in the group were "full-blood" and all could speak English (MacBolt 1976). This was significant, because at the time it was believed by some that the Indigenous inhabitants of the North West Cape region were extinct or had been driven out before *Shunsei Maru* came ashore (McCarthy 2011a:213–215).

STRANGERS ON THE SHORE: THE AUSTRALIAN CONTACT SHIPWRECKS PROGRAM

These stories, together with the author's work on the wreck of VOC ship *Zuytdorp* (1712), became the catalyst for the Australian Contact Shipwrecks Program, or 'Strangers on the Shore program, which commenced in 1997. This initiative was designed to document all known interactions between Indigenous people and shipwrecked sailors and, by including the *Atlantis* incident mentioned above, downed aviators. It was also intended to provide insights into Indigenous attitudes towards survivors who arrived on their land destitute, without armament, sometimes injured and almost always at a distinct physical and psychological disadvantage to the Indigenous inhabitants. This compares with exploratory or acquisitive landings conducted with all the associated trappings of power (ships, boats, arms, uniforms, etc.) that invariably swung the balance towards the visitors. The program, which the author initiated and supervised and post-graduate student Lesley Silvester conducted, resulted in a comprehensive hard-copy database in three volumes (Silvester 1998). This became the basis of a searchable electronic database, hosted on line, comprising 52 wrecks, ranging from 1628 to 1956, and orgainsied into three major sections: 'Verified Contact', covering all known shipwreck survivor contact incidents; 'Contact Art', being Indigenous depictions of a particular shipwreck; and 'Possible Contact', where survivors were forced to walk long distances to reach safety and where it seemed highly likely that they encountered Indigenous people along the way.

One remarkable example from this database is SS *Sunbeam*, formerly the Osborne Island Unidentified wreck, examined during the WINC expedition and later identified by Scott Sledge (fig. 2). According to contemporary European accounts, it sank due to a tear in its ageing hull. Gamberra legend, on the other hand, tells that *Sunbeam* was sunk by a Snake Spirit called on to intervene when Aboriginal women, who went aboard at the request of the sailors and with the permission of their menfolk, were not returned at the agreed upon time. The Spirit held the ship under as the tide rose, causing it to flood and allowing the women to escape and swim

Fig. 2. Inspecting SS *Sunbeam* at low water (I. Crawford, 1978).

ashore. On that basis, the wreck is now protected by both Commonwealth shipwreck legislation and as an Indigenous sacred site, precluding its possible recovery for conservation and exhibition as was once mooted (Crawford 2001:149–151).

Recently, Corioli Souter completed a four volume series examining 'unlocated wrecks' in the Kimberley Region, many with Indigenous connotations (Souter 2009). As more is learned of these sites, many are expected to add further to those studies described above. Souter also recorded a number of oral histories in the region, examining Indigenous reactions to the WWII Japanese air raid on Broome.

After Stage One of Strangers on the Shore was completed and the results published (McCarthy and Silvester 2000), other states followed suit with similar strategies, reports of which appear in past editions of this journal (then *Bulletin of the Australasian Institute for Maritime Archaeology*). Then, in March 2006 the Strangers on the Shore title was appropriated for a conference at the Australian National Museum (Veth et al. 2008). One seminal highlight was Nyoongar Elder Len Collard's account of his people's encounters with early French explorers, which he delivered entirely in his parent language; later to be followed by an English translation. Although focussing on the impact that European exploration had on Indigenous cultures, the effects across Australia of landings due to shipwreck also were presented to the conference (McCarthy 2008). An organiser of this forum was the prolific author, activist and researcher (Indigenous and exploration studies) Rupert Gerritsen. He is a prime example of external scholars to whom the Department has provided assistance, including those whose conclusions it might not necessarily support (Gerritsen 1994). Conversely, it also must be stated that Gerritsen provided great assistance and advice to the Department in its work, without necessarily agreeing with its stance either.

While the Indigenous perspectives at *Sunbeam* in the Kimberley (Ian Crawford) and at Eyre on the south coast (A.J. Carlisle) were provided by knowledgeable Europeans trusted by their informants, an unfiltered Indigenous perspective on any wreck remained to be received. This situation changed with the appearance of publications, websites, seminars, exhibits and public events that ensued after the finding of the *Stefano* wreck. One international seminar at the Maritime Museum in Fremantle, for example, included a visit from descendants of the survivors and the exhibition of a votive image celebrating the boys' rescue by the Aboriginal people.

Phillip Moncrieff, a descendent of the Paiyungu people, was present at that seminar and provided his recollections. This information was subsequently incorporated into panels being readied for a Strangers on the Shore exhibit, which included the *Stefano* and *Correio Da Azia* shipwrecks, as well as the unidentified wreck mentioned above. Later, Ann Preest and Maureen Dodd, who both trace their ancestry to the North West Cape people, visited the Department accompanied by Murdoch University academic Leonie Ferrier. Preest and Dodd were adamant that Thalanyji people had a role in saving the two castaways, and naturally sought an explanation for why the exhibit contained no mention of them. The disagreement caused some concern to all and led to a re-examination of the records, including Tindale's (now outdated) maps of Tribal Boundaries, a modern map of the ATSIC centres and regions, and maps appearing in Horton's *Encyclopedia of Aboriginal Australia* (1994:803) and elsewhere. The differences between the various maps were quite marked. In Horton's work, and allowing for scale, it is evident that the *Stefano* wreck lies opposite Yinkutira (Jinigudera) country, and almost directly opposite the Paiyungu/ Thalanyji boundary (as shown in that work). In essence, this short visit and Phillip Moncrieff's earlier contribution represented the much-awaited commencement of Stage Two of the Strangers on the Shore program by Indigenous scholars and those tertiary institutions supporting them. As indicated, this stage was designed to correct, or at least augment, the Stage One European record of the study by adding Indigenous perspectives and insights. In that context, Dodd advised the author at the time that, as far as she was concerned in the *Stefano* case, the Thalanji must have been primarily responsible, since crossing a boundary unescorted was not possible, as the intruders would have been killed. References to this protocol and to the safe landing of shipwrecked men, women and children, only to be killed, also appear in some European accounts. One example is the diary of 19th-century pastoralist Julius Brockman, who was prominent in the Ningaloo area (Brockman 1987:120). Containing accounts of cannibalism, of Aborigines dressing in European clothes, of broaching casks of rum and food and of encountering what to them were strange objects, such as boots, shoes and gold doubloons, it and other similar narratives were given little credence by modern-day scholars. Nevertheless, there is one source of agreement in all the contemporary Indigenous sources referenced above—the survival of women and children. This is a complex and often controversial matter requiring the input of expert anthropologists. In the interim, scholars such as Josko Petkovic of Murdoch University independently have built on the Department's work with considerable effect through seminars, publications and websites (see, e.g., Petkovic 2016).

Allied to and building upon the Strangers on the Shore program and its database of Indigenous shipwreck art was the Department's Indigenous watercraft depictions study, completed in 2006. The study was initiated and supervised by the author and was conducted by MA student Nicolas Bigourdan. It provided a catalogue and description of all 26 known watercraft depictions in Western Australia. Bigourdan's work also utilised C.E. Dortch's 2000 underwater survey for rock engravings and other sea-floor sites in the Dampier Archipelago in the Pilbara region of Western Australia to model the survival potential of submerged rock art. By this means, Depuch Island, in the Pilbara region, was predicted to have the best possible conditions for the survival of submerged rock art (Bigourdan 2006; Bigourdan and McCarthy 2007). In 2013, the author served as Editor-in-Chief of a Maritime Rock Art Special Edition of *The Great Circle* (the journal of the Australian Association for Maritime History), assisted by guest editors Paul Taçon and Sally K. May. Amongst the six papers published were an update and analysis of recent developments in rock art (Bigourdan 2013), a study of ship and boat depictions in the Pilbara (Paterson and van Duivenvoorde 2013) and an analysis of watercraft and crew depictions in the Kimberley regions (Ross and Travers 2013).

Although Dortch had been unsuccessful in locating submerged rock art over the course of 14 dives at various locations in the Dampier Archipelago, he and Bigourdan had pointed towards the future. In earlier precursory work, Dortch had been facilitated by the Department and by WA Museum conservation staff in the underwater archaeological examination of deposits in the waters of Lake Jasper in the southwest of the state, identifying submerged Indigenous sites to a depth of 10 m and taking radiocarbon samples. As the authors then noted:

> The Lake Jasper project is the first successful use in Australia of underwater archaeological techniques in the location and recording of submerged prehistoric sites… The research potential for underwater projects similar to this must be enormous continentally, with numerous other archaeological sites and prehistoric land surfaces submerged beneath inshore marine waters, estuaries, lakes and swamps [Dortch and Godfrey 1990:32].

SHIPWRECK STUDIES AS A CATALYST FOR INDIGENOUS STUDIES

After initially focussing on the wrecks and relics of the Dutch and English East India Companies and then those of the colonial period, a change occurred within the Department that saw the advent of the study of material remains and places associated with early explorers. This new focus crystallised at the 1999 Tricentennial celebration of William Dampier's landing held at Shark Bay, where interest centred on locating the remains of two of Western Australia's best known early exploration vessels, Their Majesties' (William and Mary) Ship *Roebuck* (wrecked 1701) and the French corvette *L'Uranie* (wrecked 1820). Both shipwrecks were found in 2001, at Ascension Island and in the Falkland Islands, respectively. In attempting to understand the recovered remains, the ships' principals, William Dampier and Louis and Rose de Freycinet, were studied extensively as well. This led to the detailed examination of many aspects of their lives and activities, including their interaction with Indigenous peoples encountered on their voyages. Many works (e.g., McCarthy 2015:6–12) have resulted from the Department's renewed focus on the explorers and those with whom they reacted rather than just their ships. From an Indigenous point of view, the thrust of these recent re-assessments of Dampier and the de Freycinets can be characterised perhaps best by the title of the chapter that the author contributed to the book *European Perceptions of* Terra Australis; namely, Who do you trust? Discrepancies between the 'official and unofficial' sources recording explorers' perceptions of places and their people (McCarthy 2011d). There, the real and the perceived racial bias of each of the explorers was examined, together with their motives (or lack thereof) in publishing their work along with the influence and motives of the publishers in further skewing the result.

EXCAVATIONS AS A CATALYST FOR INDIGENOUS STUDIES

The anomalous nature of SS *Xantho*—a 10-year-old former Royal Navy gunboat engine installed in a 23-year-old paddle-driven passenger ferry designed and built for the inland waters of Scotland, but employed in the Australian pearling industry—

prompted a broad study of the ship and its principals, Charles and Eliza Broadhurst. The archaeological and historical research, resulting so far in a MMA thesis (Kilpa 2012), book (McCarthy 2002), website (McCarthy 2017a), public lectures (e.g., McCarthy 2011c) and the continuing exhibition 'From Steamships to Suffragettes' at the Western Australian Museum (Bigourdan et al. 2016), manifest their entrepreneurship, feminism and social activities and bring them to life.

Integral to all these has been the examination of Broadhurst's role as an early pearler and the effect he and his often-ruthless colleagues had on the Indigenous inhabitants. In the process, a great deal was learned and published about Indigenous and 'Malay' pearl shell diving in the formative years (1866–c. 1890) of the European pearling industry, prior to the 'Broome era' (see, e.g., McCarthy 1995). Rock art that is believed to have emanated from Indigenous and 'Malay' reactions to SS *Xantho* and its activities also was examined in detail, with the Walga Rock image now known to represent a steamship (McCarthy 2017b:71–73), contrary to Jack-Hinton's earlier assertions. Displaying features known to reflect the configuration of an early steamship with rectangular scuttles and believed to be the product of Sammy Malay (also known as Sammy Hassan), who joined an Aboriginal group at Walghana in 1917, many researchers (including anthropologist Esmee Webb, who presented her findings at a recent UWA seminar) believe it represents *Xantho*. Similarly, images clearly showing a steamship appearing at Inthanoona Station inland of Cossack also now are believed to represent *Xantho* (Paterson and Wilson 2009; Paterson and Van Duivenvoorde 2013). Having carried sheep, general goods, passengers and four Aboriginal convicts home from the prison at Rottnest Island, there would have been ample reason for *Xantho* to appear alongside other manifestations of an increasingly disruptive European presence on Indigenous lands. The technical reports and articles on the subject are examined and summarised in a work detailing all aspects of the *Xantho*-Broadhurst study, including pearling and the Indigenous depictions (McCarthy 2017b).

Studies into the many depictions of European activity in northwestern Australian rock art are ongoing, and include post-graduate student research utilising records from the Department, The University of Western Australia and State archives to re-examine those at Inthanoona (e.g., Rogers 2015). Recently, it was an industry source, rather than an academic, who solved the question about

Fig. 3. Rock art painting of a steamship at Inthanoona (A. Paterson, 2009), with inset photograph showing a method once used to lift stock.

the identity of a figure suspended above the stern of the vessel in the Inthanoona rock art depiction (fig. 3). In 2018, after the author presented on the SS *Xantho* and the Inthanoona images at the WA Museum—Geraldton, an audience member went home and returned with a photograph he had taken while working on board a stock ship only a few decades earlier (fig. 3, insert). Presented here alongside the Inthanoona image, there can be little doubt that it represents an animal being lifted by the horns, something few academics would every have conceived possible, let alone desirable.

In another development, Malaysian tourists visiting the SS *Xantho* exhibit at the Shipwreck Museum expressed their opinion that the four lines appearing below the Walga Rock ship depiction (fig. 1) represented a form of *Jawi*, a Malay-Arabic script. Hoping to lay the foundation for future collaborative research, Switzerland-based scholar K.C. Mühl (2018) recently presented to the Department a discussion paper entitled 'Decoding the inscription below the ship depicted on Walga Rock'. Seeing similarities between it and the way Suras are depicted in the Quran, Mühl arranged for the images to be examined by scholars in Malaysia and Indonesia, including a Malay Manuscript Analyst and a *Jawi* specialist. So far, no link has been established, but work is ongoing.

As mentioned already, previous departmental activity concerning the VOC shipwrecks concentrated on the European aspects of their demise, with little or no attention paid to their impact (if any) on Indigenous inhabitants. This situation changed in 1986, when the aims of the *Zuytdorp* project were expanded to include examination of Indigenous sites in the vicinity of the wreck, seeking evidence to determine if the survivors interacted or lived with the local Aborigines and to facilitate genealogical–medical research aimed at ascertaining whether the survivors and locals interbred (McCarthy 1998). As a result, many scholars, specialists (including pre-historians and an historical archaeologist) and Indigenous stakeholders were joined in an interdisciplinary program designed to locate and examine all wells, soaks and major encampments in the hinterland. Given his background in the subject, researcher Phillip Playford also was invited onto the team specifically to provide the benefit of his knowledge about the wreck and the Indigenous groups living in the hinterland (Playford 1996). Oral histories were collected from both European and Indigenous informants, and the possibility of a genetic link between the *Zuytdorp* crewmen and local Aborigines, potentially indicated by introduced diseases, was examined and ultimately disproved by external specialists (McCarthy 2006). Furthermore, an examination of the Indigenous sites adjacent the wreck showed them to be thousands of years old (Morse 1988), and none of the glassware or ceramics found on the cliff top adjacent the wreck site were 'worked', as one would expect had Nhanda or Malgana people visited the remains. Research continues, and has extended into examining the activities of the Indigenous-European station hands who lived on Tamala and Murchison House stations in the hinterland of the *Zuytdorp* wreck.

RECENT STUDIES

Building upon her expanding interests in northernmost Western Australia (see p. 6, above), Souter lead a multi-disciplinary team that revisited the failed 1864 Camden Harbour pastoral settlement in West Kimberley in 2009. They were assisted by the Kimberley Land Council and Dambimagari Traditional Owners. The site had been inspected a number of time prior, but always with a focus on the extant historical structures of the colonial camps. Souter's research pursued an "intercultural interpretation" of the site based on an understanding that "historical and Indigenous heritage values of the region intersect". She expanded the scope of the survey to beyond the settlement and sought to document the range of cultural material to inform future research approaches. Of particular importance was material evidence that might help to better understand the impact of the settlement on the Indigenous population in the region, and shed light on Aboriginal, European and Indonesian culture contact—a category of material culture not previously examined (Souter 2013:87).

At the far other end of the state, Ross Anderson joined a multi-disciplinary team, including Wudjari representatives, in a study program designed to document and interpret the cultural seascapes of the Recherché Archipelago along Western Australia's central southern coast. This research complimented earlier investigations of the region in which Department staff participated (e.g., Green et al. 2001; Paterson and Souter 2008). Paraphrasing Anderson's report (2012) and PhD thesis (2016), the study was broad, encompassing the changing social landscape and traditional creation stories, along with contemporary spiritual relationships, all integrated into a database of archaeological information with environmental modelling. The cultural seascapes included early British, French and American explorations, as well as pre-colonial and colonial sealing and whaling and post-British colonial settlement. Research also examined the impact of sealers and whalers on Indigenous peoples, including their use as labourers, sometimes compliant, but more often forced and involving abduction. The team examined a number of terrestrial and maritime archaeological sites, including whaling and sealing sites, shipwrecks and Indigenous rock art. Conducted within the framework of Anderson's wreck inspection responsibilities, these studies take the Western Australian Museum's Department of Maritime Archaeology full circle back to the seminal wreck inspection work of Scott Sledge. It also shows how far the Department has come from those early beginnings.

Lastly, this paper and the works it discusses illustrate the now widely-acknowledged fact that a shipwreck is but a relatively small event, but one that can lead those prepared to look to vastly broader horizons indeed; with but one example being the people involved and those with whom they interacted over time and place. As flagged a decade ago when presenting the Department's Strangers on the Shore initiative to an Australia-wide audience, any mature Indigenous maritime studies program must involve Indigenous scholars and the many and varied Indigenous perspectives on shipwrecks and the people, commodities, industries and societies represented in their stories.

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Quantifying the Effects of Site Conditions on the Long-term Corrosion of Bronzes on Historic Shipwreck Sites

IAN D. MACLEOD

Abstract

A comparison of the extent of corrosion of shipwreck bronzes from the wrecks of the French-built *Lively* (c. 1808) and the American-built *Rapid* (1811) shows that the topography and depth of a wreck site have a much greater impact on the corrosion rate than the amount of tin in the bronze. The *Lively* artefacts are scattered in a reef gully at depths down to 8 m, and the surge from wave action provides a constant flux of oxygen-saturated sea water, which promotes corrosion. The *Rapid* site has flat topography and is protected from ocean surge by an offshore reef, with 80% oxygen saturation at 7 m. The bronzes from the reef site are much more corroded than those from the inshore reef environment of the *Rapid* site. The impact of iron impurity, often associated with poor quality casting, also is significant, as galvanic corrosion removes particulate iron from the structures and creates pockets of high chloride and acidity, which breaks down the passivating copper (I) oxide film. Erosion corrosion in the *Lively* gully increased the extent of decay, while burial of copper alloys in coralline or sandy sediment changes the corrosion mechanism, leaving behind a crumbly, corroded, tin-rich matrix. The practical consequences for treatment times for the stabilisation of recovered artefacts also are discussed. Despite differences in microenvironments within a wreck site, bronze and copper artefacts on the *Lively* shipwreck experienced much more severe corrosion than did similar objects on the *Rapid* wreck site.

INTRODUCTION

The maritime archaeological investigations of the Western Australian Museum have resulted in the recovery of many thousands of bronze artefacts from 20 major historic shipwreck sites off the Western Australian coast. Some objects have been heavily eroded, such as the bronze swivel guns from the wreck of *Zuytdorp* (1711). Originally cast at 100 Amsterdam pounds (50 kg), some were so eroded that they had lost up to 90% of their initial mass when recovered from the wreck site, which lies at the base of the eponymously named cliffs. In order to investigate how bronze objects corrode on undersea sites, it is necessary to eliminate the gross effects of time on the extent of corrosion, it was necessary to have sets of artefacts recovered from wrecks that had foundered roughly contemporaneously. The two wrecks chosen for this study came from the pre-colonial settlement period in Western Australia. The first wreck was that of *Lively*, which originally was built as *La Duchesse d'Aiguillon* at Saint-Malo, France, in 1765, but was renamed *L'Abeille* after the French Revolution (Stanbury 2015:240). Following its capture by the English, it was renamed *Lively* and served as a trading vessel as well as a whaler before it sank around 1808 on Mermaid Reef in the Rowley Shoals, some 296 km west of Broome. The shoals present as the *Mermaid*, *Clerke* and *Imperieuse* coral reefs, which rise from the Scott Reef/Rowley Shoals platform on their landward sides and, on their seaward sides, drop to between 300 and 700 m (Stanbury 2015:13). The American ship *Rapid* was built in Braintree, Massachusetts, in 1807 using fittings supplied by J. Davis, a local ships' chandler. In the time between its commissioning and sinking in 1811, *Rapid* made a successful return voyage to China. It sank on its outward-bound voyage approximately 1.6 km seaward of Point Cloates, inside Ningaloo Reef, in 7 m of water (Henderson 2007:100–106).

BRONZE FASTENINGS FROM *LIVELY* AND *RAPID*

Owing to the unknown nature of the *Lively* at the time of the initial fieldwork the prefix RS (Rowley Shoals) was used in the registration of the fastenings. The anchors are located on top of the reef, which indicates that the vessel struck the reef bow first and debris associated with its operational life, such as whaling trypots, are scattered along the gully floor. Initial examination of the artefacts indicated that although the site was in a well-oxygenated gully on the edge of the reef the burial microenvironment exhibited a range of corrosion products. An initial attempt to quantify the factors controlling the degradation processes involved Ari Antonovsky, a contract electron microscopist, who studied several objects from the *Lively* and the *Rapid* wrecks (Antonovsky 1985:1–9). A detailed examination of a 3 mm square bronze nail (RS112) involved longitudinal and transverse sections for metallurgical analyses. The nail came from the middle of the gully at Mermaid Reef, which ranges from 12 to zero metres in depth. The material from *Rapid* (RP5363) was a composite object that consisted of a piece of lead sheet (4 mm thick × 17.5 mm wide) originating from a bronze bilge pump spear. All samples were mounted in epoxy resin (Ciber Geigy, Araldite D®) and polished to a flat surface using sequential grinding with silicon carbide discs from 150 to 1200 grit and then diamond polished on laps down to a ¼ micron. They were then carbon-coated for examination in the Philips 505 scanning electron microscope (SEM) at the University of Western Australia. Semi-quantitative elemental analyses were made using the EDAX 9100 X-ray analysis system.

Lively *bronze sheathing tacks RS112 and RS48: corrosion in a different microenvironment*

In order to gauge how alloying elements are mobilised from the parent alloys and migrate across the original surface interface, it is essential to look at the distribution of the component metals in the concretion layer and in the body of the uncorroded metal. The first insight into the selectivity of the corrosion processes can be seen by inspecting the SEM images of the interfacial region between the marine growth and the interior of bronze sheathing tack RS112 (Fig. 1). Figure 1A shows the topographical features of the polished section in a secondary electron (SE) image, which gives an overall view, while Figure 1B shows an atomic number contrasting image, which is obtained by processing the backscattered electron (BSE) images. The latter type of image is particularly useful for understanding the concentration and distribution of elements, as the differing atomic numbers of the elements present are represented by varying shades of grey. Lower atomic number elements appear darker, while higher atomic number elements appear lighter; heavy (high atomic number) elements, such as lead, appear almost white. The reported analysis for the RS112 concretion is shown in Table 1, while the wet chemical analysis of the metal of another bronze sheathing tack of the same type (RS48) shows that the parent alloy is a zinc bronze containing 3.0% zinc and 8.5% tin. The data (from the quantitative analysis performed by the software associated with the electron microscope) demonstrates that the bronze has undergone selective corrosion of the zinc-rich phase, since the zinc concentration in the concretion is more than three times higher than that in the parent metal, indicating that the corrosion microenvironment was only partly oxygenated. This is supported further by the amount of copper present in the concretion, which is roughly one-third less than would be predicted if there was uniform corrosion of the zinc bronze. Lead, which is present in all the *Lively* bronzes, was not trapped by the concretion, but was leached into the sea as a soluble lead chloride complex ion ($PbCl_3^-$). This behaviour is common on high-energy wreck sites, such as the *Zuytdorp* (1711) and HMS *Sirius* (1790) on Norfolk Island (MacLeod and Wozniak 1996).

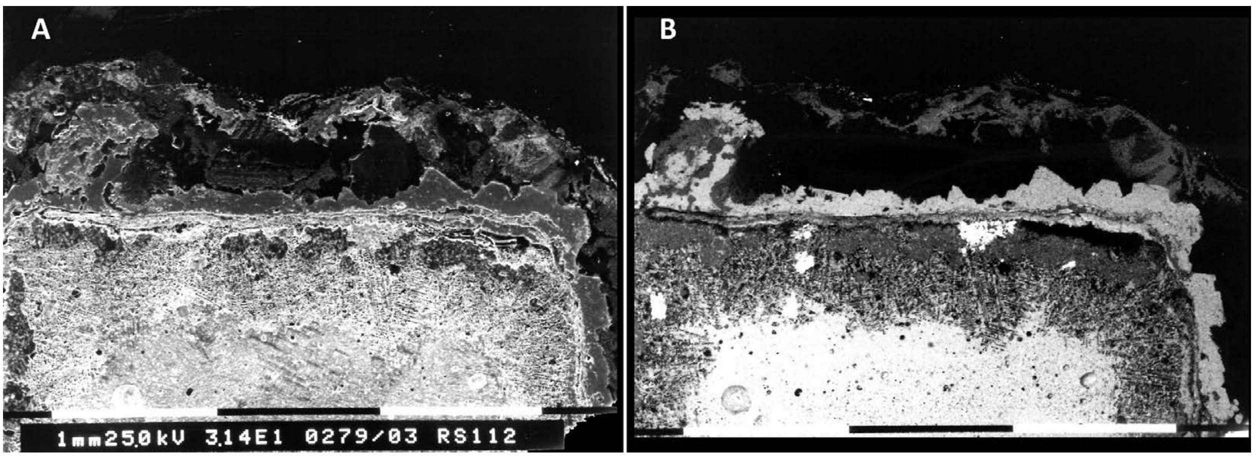

Fig. 1. (A) SE image of top edge of squareed shank of bronze sheathing tack RS112 from *Lively* showing the metal layer (lower half) and corrosion/concretion layer (upper half); (B) atomic number contrasting BSE image of the same area. SEM 30× micrographs (25 kV).

Table 1. Composition of Bronzes and Concretions from the *Lively* and the *Rapid* Shipwrecks (weight %)

Wreck	Cu	Zn	Sn	Pb	Ca	S	Cl	Fe
Lively RS112 concretion	62.7	10.0	7.2		9.6	4.9	3.8	2.0
Lively RS48	87.1	3.0	8.5	0.8				0.1
Rapid RP5363 SEM corrosion	55.7	17.7	13.8	10.0				2.7
Rapid RP5363 drilled assay[1]	72.7	8.2	11.9	6.5				0.7

[1] Drilled from a solid section of the pump spear and analysed by atomic absorption spectroscopy (MacLeod 1987).

Table 2. Composition of Primary Corrosion Layers on RS112 (weight %)

Layer	Cu	Zn	Sn	Pb	Ca	S	Cl	Fe
A (next to metal)	18.7	56.9	2.5	0.0	4.3	13.1	2.9	1.6
B (interdendritic phase)	31.9	2.3	34.8	0.0	0.0	10.5	13.1	7.4
C (Sn-Zn-Pb phase)	2.7	26.5	56.8	10.1	0.0	2.8	0.0	1.0

Due to the high tin content of the *Lively* sheathing tacks, the alloy can best be viewed as being equivalent to a modern Admiralty bronze, like 6 Bronze C90500, which has 9–11% tin, 1–3% zinc and 0.3% lead in terms of its overall strength and corrosion resistance (INC 1982:8). Tin is added to copper to increase strength and wear resistance and the zinc acts metallurgically as if it was tin, so the structure of the sheathing tacks is like an 11.5% tin bronze. Zinc is added to a bronze to increase the fluidity of the liquid metal, which results in improved casting since the molten metal flows into the moulds better and creates less gas porosity. A considerable amount of zinc has leached into the concretion (dezincification), while calcium, sulphur, chlorine and iron from the sea water have diffused into the metal. A review of the site distribution maps (Stanbury 2015:24 fig. 20, 81 fig. 58 and 112 fig. 85) shows a proliferation of iron objects throughout the wreck site. Thus, an increased concentration of iron in the concretion is not unexpected; however, this artefact has not corroded in the way expected of a zinc-bronze in a fully aerated microenvironment, which indicates that it had been buried under coral debris in the bottom of the gully.

This microenvironment is reflected in the unusual nature of this concretion, as shown in Table 2 and Figure 2, which gives a closer view of the corrosion layer. The concretion image shows that the matrix consists of various layers of copper-rich and zinc-rich corrosion products, particularly sulphides, oxides and hydroxychlorides (MacLeod 1982). This is the first example of a marine bronze where zinc sulphide has been found on what ostensibly is an aerobic high-energy wreck site. In the first layer outside the metallic material (Fig. 2, layer A), the dominant phase is zinc sulphide, with other zinc and copper compounds lying above it, closer to the seaward surface at the time of recovery. This layer consists of a 150 μm band around the outside of the remaining metal of the nail layer and is easily identified in the SEM by its cathodoluminescence (emission of light in an electron beam), confirming it as a zinc sulphide phase.

At the outside of this layer there is a lead inclusion remaining from the original alloy and a dark band indicating the presence of a low-atomic number phase. Although there is some copper present, the bulk of the material is of organic origin from the

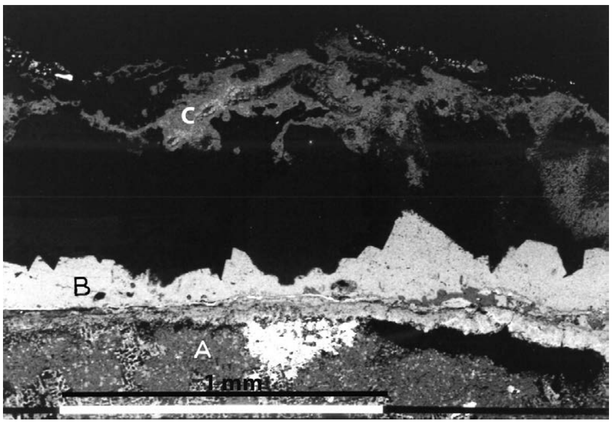

Fig. 2. BSE image of corrosion and marine concretion layers on bronze sheathing tack RS112. Layers: (A) zinc sulphide and other copper and zinc corrosion products; (B) copper and zinc oxides and hydroxides; (C) copper and zinc sulphides, tin phases and pockets of CaCO3. SEM micrograph (25 kV).

interactions of the bronze nail with the surrounding sea water. The concreted surface is consistent with the primary corrosion layer on the fastening being a tin-zinc oxide, since these minerals are much less toxic to marine organisms than the cuprite (Cu_2O) layer that forms on well-oxygenated alloys. The next layer (Fig. 2, layer B) consists of copper and zinc compounds, primarily oxides and hydroxides, and sulphur is not present in great quantities. Layer C contains copper and zinc as sulphides, with isolated pockets of calcium carbonate and high-tin phases. A large amount of organic matter must also be present to produce the dark contrast with the other copper and zinc phases. The presence of zinc sulphides shows that the fastening must have become buried under at least 50 cm of sediment, coral rubble and other debris in order for fully anaerobic conditions to develop (Richards and MacLeod 2007). Sulphate reducing bacteria provide the sulphide ions, the presence of which results in the precipitation of ZnS as a corrosion product. At some point in time, the site conditions changed and the object became exposed once more to the aerobic surge, which produced the final layers of oxidized tin, zinc and copper corrosion products.

Between the uncorroded metal and the corrosion product layers visible in Figure 1, there is a layer of partially attacked (dezincified) metal. The effect of removing zinc and copper from the alloy to leave a Cu/Sn inter-metallic phase is shown in Figure 3. The interdendritic structure results from pure α-copper-tin-zinc dendrites freezing out, leaving inter-metallic compounds and other impurities between the dendrites. Analysis of the un-attacked interdendritic phase gives the ε phase as Cu_3Sn. Contrasting this analysis with analysis of the parent metal in Table 1 confirms the selective corrosion of the zinc-rich phase relative to that of the Cu/Sn phase. The occurrence of lead in the alloy is shown in Figure 4 as a massive 125 μm diameter inclusion, which is seen clearly in the SE and BSE images. Lead essentially is insoluble in copper alloys, but is added to improve the ease of fabrication (die pressing and drawing for tacks or nails) and almost invariably appears as globules in the microstructure. The lead appears in this part of the sheathing tack as the sulphide, with some copper present in an approximate ratio of 80Pb-16S-2.5Cu. An interesting 57Sn-27Zn-10Pb phase appears as dark spots in the lead sulphide, analysed as a complex layer of ternary phases of the interdendritic areas (see Table 2). Both of these phases appear to be resistant to leaching by sea water relative to the surrounding Cu-Zn-Sn alloy, and may indicate the preserved extent of the original metal (Fig. 1B), which has a complex microstructure.

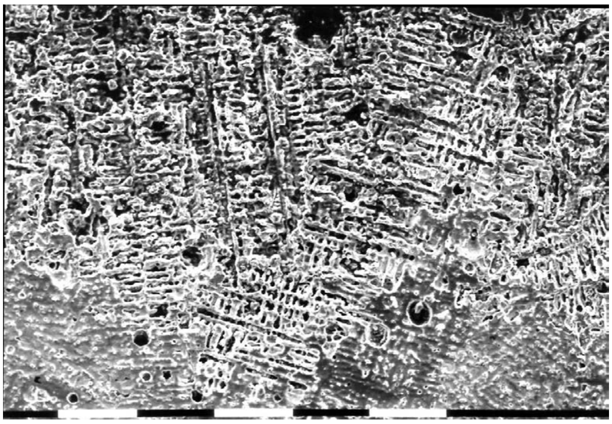

Fig. 3. BSE image showing the Cu-Sn interdendritic phase remaining after leaching of copper and zinc from the matrix. SEM 150× (scale bar is 100 μm).

Lively *bronze sheathing nails RS113 and RS178*

The polished cross-section of the bronze sheathing nail RS113 showed a less pitted and coarser dendritic pattern of the different phases of copper alloys than RS112. There were also bright spots of lead-rich areas in the light grey copper-tin-zinc alloy, which can be seen in the back-scattered micrograph in Figure 5. The darker grey areas were mainly composed of copper with zinc and tin. A third bronze sheathing nail (RS178) looks superficially very like RS112 and RS113, as seen in the SEM image in Figure 6. As has been reported for the two previous samples of bronzes, there were small amounts of zinc and tin dissolved in solid solution in the lead, along with moderate amounts of copper. The polished cross-section showed a

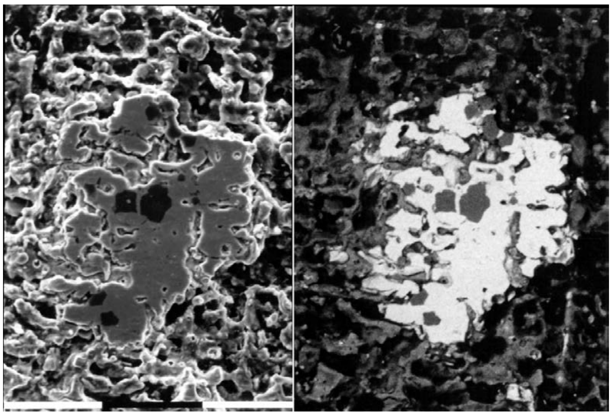

Fig. 4. SEM (left) and BSE (right) images of lead sulphide inclusion in bronze nail RS112. SEM 390× (scale shows 50-micron units).

close resemblance to sample RS113, but the cast nail had less gas porosity. The irregular patterns and light grey areas have inclusions that contain trace amounts of arsenic, which inhibits the pitting corrosion of cold- or hot-worked bronze alloys. Since cast bronze nails undergo mechanical stress as they are driven through the metallic sheathing and into the hull timbers, the outer zones undergo a metallurgical change from as-cast dendritic to a granular structure which is associated with increased work hardness and better materials performance. An SEM image of the nail is shown in Figure 6.

Having reviewed the ability of the *Lively* fastenings to resist the corrosive forces of the gulley on the edge of the reef, it was decided to assess the structural capacity of the fastenings through a series of micro-hardness measurements. By placing the polished bronze sections under a diamond anvil with known weights attached to the indenter, it is possible to determine the hardness of the different parts of an alloy (hence micro-hardness). Such tests are useful for determine if the fastenings were fit for purpose for adhering the protective non-ferrous metals to the wooden hull. For RS112, with its high porosity, the mean HV (Vickers Hardness) for the interdendritic areas with their higher tin content was 125±4, while the HV for the copper-rich α-phase was 115, which is normal owing to the softer nature of the copper-rich phase. For bronze sheathing tack RS113, hardness measurements were taken 125 μm from the edge, with the dendritic areas having a slightly higher mean hardness of 143±1 HV (owing to the increased tin content) and the copper-

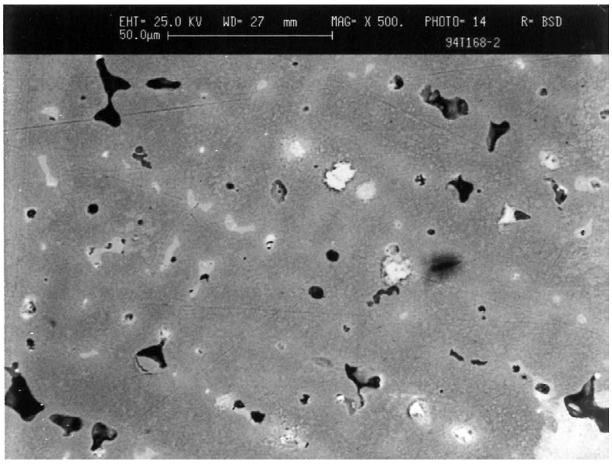

Fig. 5. BSE image of *Lively* sheathing tack RS113 showing uncorroded Cu-Sn-Zn leaded bronze with white Pb particles (some have fallen out), the light grey eutectoid phase rich in Cu-Zn-Sn and also containing lead, and the darker grey copper-rich alpha phase. SEM micrograph (25 kV).

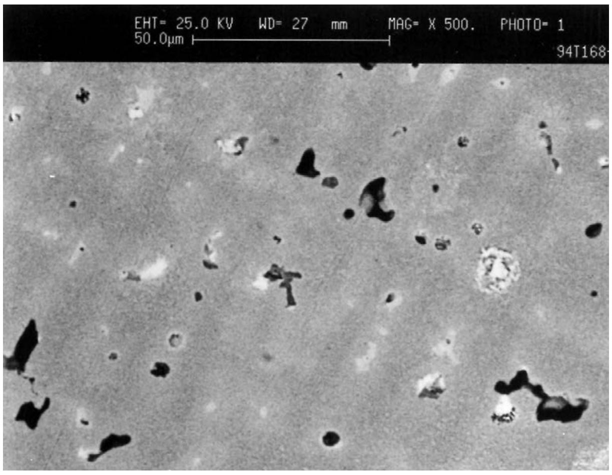

Fig. 6. BSE image of bronze sheathing tack RS178 from *Lively*. The circular holes relate to lead globules lost due to the surface preparation methods. SEM micrograph.

rich α-phase measuring 153 HV, indicating that it has a significantly greater tin content present as a solid solution. Sheathing tack RS113 had a much lower gas porosity than RS112, and this seems to have improved the overall micro-hardness of the alloy. Within the third bronze sheathing tack, RS178, there was a significant gradient in hardness as measurements moved from the centre of the pin towards the leading edge, with the delta phase having a hardness that increased by 51.4 HV/mm in the final 3 mm. The central core of the nail had a mean hardness of 148±5 HV, with a maximum of 187 found 400μm in from the head of the nail. These measurements clearly show that the fastenings were indeed fit for purpose, and there were no signs on the heads of the sheathing tacks of damaged edges associated with collapse during the process of being driven through the sheathing layer into the timbers. The variation in micro-hardness from 125±4 to 148±5 HV over the three bronze sheathing tacks gives an indication that, although the composition of the sheathing tacks is roughly the same, the actual distribution of tin in the alloys brings about subtle changes in the microstructure of around 18%.

Rapid *leaded bronze pump spear RP5363: effects of burial and exposure*

Bilge pumps are subjected to an aggressive and corrosive microenvironment due to the rapid movement of sand, dunnage and other debris that is sucked into the pump with the bilge water. Bilge pump failure can have serious operational impact in the marine environment and imperil a vessel. For this reason, the bronze typically was cast with a high alloying zinc and lead content to make the pumps,

Table 3. Metal composition of samples from *Rapid* leaded bronze rudder pin RP5348 (weight %)

Layer	Cu	Zn	Sn	Pb	As	Sb	Fe	Ca	Mg	Si
RP5348 core	93.1	0.05	5.7	0.68	0.15	0.14				
RP5348 tin rich microprobe	82.4	0.74	12.3	0.49	0.59	1.00				
RP5348 concretion	87.2	0.82	11.7	0.60	0.73	0.72	0.24	0.43	0.21	0.22

which are long and narrow, easier to fabricate, but also more durable, with minimal gas porosity in the metal. The object was recovered from the middle of the wreck site, which means it was close to its original location on the vessel. Although it is known that a cyclone impacted on the *Rapid* wreck site in 1812 (MacLeod and Killingley 1982) and transported the bronze rudder fittings to roughly amidships, the site generally is perceived as being calm, since it is sheltered by an offshore reef and lies on a flat seabed at a depth of seven metres. An SEM image of a portion of sample RP5363 (3.5 mm of a 17.5 mm wide piece) is shown in Figure 7. This image shows that the object has suffered severe internal corrosion of the (α+δ) eutectoid. This alloy has a microstructure similar to that of the fastenings from *Lively*, in that it is a ternary Cu-Zn-Sn alloy with a considerable quantity of added lead. The composition is shown in Table 1 with the drilled solid metal having 11.9% tin, 8.2% zinc, 6.5% lead and copper making up the balance.

The alloy can be regarded as a heavily leaded zinc bronze, since tin is present at a greater quantity than zinc. It should be remembered that, in terms of the microstructure of the binary copper-tin alloys, zinc acts as though it was tin. The total tin equivalent of the parent metal (Sn+Zn) is 20.1 wt.%, which

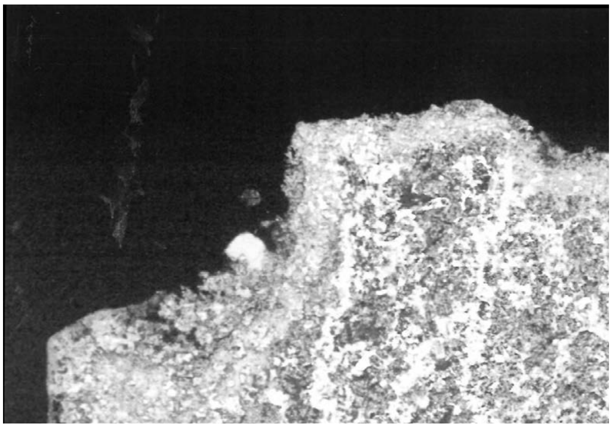

Fig. 7. BSE image of part of bronze/lead sheet RP5363 from *Rapid* showing leached and unleached areas. SEM 20× (scale bar 1 mm).

is similar to bell metal at 20% tin, so the pump spear would be mechanically tough and not readily damaged by impact or by abrasion from sand being aspirated by the pump. The SEM data indicates that the corroded zone has a total tin equivalent of 31.5%, which is another way of saying that there has been selective corrosion of copper-rich α-phase. The added lead content of 6.5% in the drilled sample is close to the SEM results, but the real difference is in the zinc content, which is twice as high in the corroded broken section as in the solid metal core from which the original sample was taken. This difference points out the dangers of interpreting original compositions from the corrosion matrices. This selective mobilisation of zinc out of a ternary Cu-Zn-Sn alloy was observed in the aerobically exposed bronze sheathing tacks on the *Lively* wreck site, so the result is consistent with the *Rapid* pump spear having spent part of its post-deposition life lying proud of the seabed, where it was exposed to flowing oxygenated sea water.

Analysis of the area around the outside of the solid metal shows that there is a tin-rich layer, which indicates selective corrosion of the (α+δ) eutectoid phase, which thermodynamically is the least stable of the major phases, since the higher copper content of the alpha phase makes it less prone to corrosion under low oxygen conditions. These conditions dominate the upper sediments on the *Rapid* wreck site and relate to 5–10 cm of sand or coral debris over the objects. Previous studies (MacLeod and Taylor 1985) have shown that bronzes on the *Rapid* wreck site are highly sensitive to the amount of dissolved oxygen, with the copper-rich phases being kinetically attacked in flowing seawater. A closer view of the internal structure of the metal is seen in Figure 8. Image A shows leached and unleached phases in the metal, while image B (of the same area) shows the relative compositional differences between the remaining phases. To assist in understanding the complex arrangement of the degraded structure of the pump fitting, the identified phases in Figure 8B are Pb (white), Sn-Zn (light grey), Cu-Sn-Zn+PbS (dark grey) and CuS (black). Close inspection of

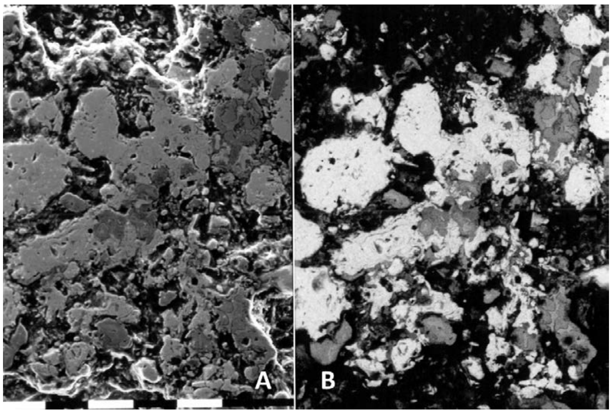

Fig. 8. SE (A) and BSE (B) images of the mixture of bronze and lead phases in *Rapid* bronze/lead sheet RP5363, illustrating severe attack on the tin-rich phases in the ternary alloy. SEM 170X (scale bar is 50 μm).

image A reveals a filamentous light-coloured area in the upper central section, as well as at the bottom, which the BSE image in image B shows to be copper sulphide. Given the magnification of the images, the secondary electron image is consistent with the light filamentous areas being microbiological in origin and a sure sign that there was little dissolved oxygen present. Accordingly, it is likely that they were copper-stained sulphate reducing bacteria present in the corrosion matrix. The lead phase appears to be almost pure lead in the form of globules, as also seen in the bronze nail from the *Lively* wreck site in Figure 4. It is apparent then that the *Rapid* pump spear has experienced the same periodic burial and exposure as bronze sheathing nail RS112 from *Lively*. It has been reported previously that the *Rapid* wreck site has been subjected to at least six major changes in burial and exposure from cyclonic impact on the wreck (MacLeod 1987a).

Rapid *leaded bronze rudder pin RP5348; half buried bronze*

Previous studies on the susceptibility of copper sheet to corrode on shipwreck sites has shown that both antimony and arsenic have a strong inhibiting effect on inter-granular corrosion (MacLeod 2016). The impact of these minor alloying or impurity metals on cast bronze corrosion is very different, especially for bronzes that have corroded in a low-oxygen environment. The differences arise primarily from the fact that the shipwreck bronzes generally have an as-cast structure of cored dendrites rather than a re-crystallized or grain structure arising from hot working or being cold-worked. The wet chemical and SEM analyses are shown in Table 3, which also reports on the electron-microprobe analysis of the tin-rich phase. A comparison of the distribution of antimony with copper shows it is concentrated in the (α+δ) eutectoid phase and that, under conditions of low oxygenation, both antimony and arsenic are mobilised with the tin-rich eutectic phase and report to the concretion surrounding the object. A comparison of the microprobe analysis of the tin-rich phase with the elements in the concretion shows that the tin-rich phase has been selectively corroded and 'captured' in the concentration. As was observed with the bronze nails from *Lively*, there was strong mobilisation of both zinc and lead from the eutectic phase, with the same situation occurring in the bronze rudder pin from *Rapid*. Zinc was present in the concretion at 16 times the amount in the core metal phase. The selective corrosion or mobilisation factor for lead as a chloride complex was high at 5.6 times. Analysis of the concretion also indicates that the lead was present as laurionite (lead hydroxy chloride, PbCl(OH)), and that the iron had been incorporated as a jarosite-type mineral of the general form $KFe_3(OH)_6(SO_4)_2$.

DESALINATION AND CHARACTERISATION OF CORRODED ARTEFACTS

Over a period of more than 25 years, the author desalinated some 1,483 copper alloy artefacts from *Rapid* and 3,779 artefacts from *Lively* using standard conservation methods of treatment in either sodium sesquicarbonate or in alkaline dithionite solutions (MacLeod 1987a). For interpretation of the rate at which the stated amount of chloride was extracted, as a measure of the extent of corrosion, only like treatments were compared. This was an essential step, since the alkaline dithionite treatment, which reduces the cuprite (Cu_2O) film to metallic copper and so opens the interdendritic and intergranular spaces, increases the desalination rate by more than an order of magnitude compared to sesquicarbonate treatment (MacLeod 1987b, 1987c, 1991). The principal difference between the dithionite and the sesquicarbonate treatments is essentially kinetic. Dithionite treatments typically took a month, whereas the sesquicarbonate desalinations took up to two years to reach equilibrium. The difference provides a measure of the protective capacity of the cuprite layer, which controls both the ingress and egress of chloride ions. Tests on the residual chloride contents in the metal showed that both methods gave essentially the same result, in terms of the total extraction of the chlorides originally present in the bronze, brass and copper objects.

For the *Rapid* artefacts, the mean amount of chloride extracted from the bronzes, which had corroded in a fully aerobic environment, was 0.014±0.007 wt%. The mean amount of chloride extracted from artefacts that had been buried under a shallow layer of sediment, such that the solution was aerobic, but with little flux of dissolved oxygen, was significantly higher at 0.067±0.013 wt%. The increase is judged to be significant, since the difference between the two mean values is more than two-and-a-half times the sum of the standard deviations. The increased amount of entrained chloride in the thermodynamically controlled low-oxygen corrosion of the bronzes was more than four-and-a-half times that of the same or similar alloys corroded in a fully aerobic microenvironment. In simple terms, the low-oxygen environment had sediment coverage of 2–12 cm, while the fully oxygenated microenvironment corresponded to objects found lying proud of the seabed. One of the reasons why bronze corrosion in a low-oxygen environment is associated with higher chloride contents is that corrosion of copper-rich phases is dominated by formation of copper (I) products, principally cuprite (Cu_2O). Corrosion of the tin-rich phases is controlled by the primary oxidation to Sn^{2+} as well as Sn^{4+} chlorides, which undergo hydrolysis as the tin (II) and tin (IV) oxides precipitate. In addition, any zinc and lead present in the tin-rich (α+δ) eutectoid from the as-cast structures are going to be present in the divalent state.

It is known from the x-ray diffraction studies on corrosion products found on bronzes from a low dissolved oxygen microenvironment that the *Rapid* bronzes are dominated by the formation of cassiterite (SnO_2). Thus, there are four times as many electrons per mole produced in the corrosion of this eutectoid phase than for the primary α-phase, and this is reflected in the ratio of chlorides released in the two types of corrosion being greater than 4:1. These oxidation (corrosion) and hydrolysis reactions are shown below in equations 1–4:

$$Sn\text{-}(\alpha+\delta)_{eutectoid} + 2\,Cl^- \rightarrow SnCl_2 + 2\,e^- \quad (1)$$
$$SnCl_2 + H_2O \rightarrow SnO + 2\,Cl^- + 2\,H^+ \quad (2)$$
$$Sn\text{-}(\alpha+\delta)_{eutectoid} + 4\,Cl^- \rightarrow SnCl_4 + 4\,e^- \quad (3)$$
$$SnCl_4 + 2\,H_2O \rightarrow SnO_2 + 4\,Cl^- + 4\,H^+ \quad (4)$$

The extent of decay of the original metal surface is measured by mini-excavation of the corroded matrix and determining the depth of decay, measured in mm over the 175 years of immersion in sea water. The data from the profiles was compared with information obtained from electrochemical corrosion simulation experiments. Six sections of *Rapid* bronze, brass and copper artefacts were converted into electrodes by soldering insulated copper wires to the metal and casting the assembly into epoxy resin mounts. Surfaces were prepared using the same method employed by Antonovsky, as described already. Corrosion rates were deduced from polarisation resistance measurements (MacLeod and Pennec 1990) and corrected for long-term exposure (Taylor and MacLeod 1985) to enable calculation of the equivalent corrosion profile after 175 years of immersion on the wreck site. The simulation experiments were for fully oxygenated conditions, which gave a corrosion profile of 0.8±0.5 mm, matching recovered artefacts from the wreck site. Bronzes corroded in a low dissolved oxygen microenvironment have a mean depth of 3.1±0.8 mm, or 3.9 times that of the fully exposed bronzes. This ratio is experimentally identical to the ratio of extracted chloride ions from the two microenvironments found on the *Rapid* wreck site. Comparison of the difference between the two data sets and their standard deviations shows that the difference is 1.8 times the sum of the errors and so it is a statistically significant measurement.

For the *Lively* artefacts, recovered from the surging sea water in the reef gully, the average amount of extracted chloride from the copper alloys was 0.31±0.10 wt% for aerobically corroded artefacts, while, for those corroded under a cover of coral debris, the mean was 1.03±0.10 wt% of chloride ions. The differences between the two mean values of extracted chloride is statistically significant, since the difference is 2.8 times the sum of the standard deviations of the data. The variability of the data from *Lively* is much the same as that from *Rapid*. For the *Lively* site, the low dissolved oxygen environment is associated with 3⅓ times the amount of chloride from the fully surging site because of the combined impact of the increased water movement and the greater mean temperature as compared to the *Rapid* wreck. The USSR *World Ocean Atlas* (1977) gives the mean site temperature for *Lively* as 26.7±1.7°C, while that for the *Rapid* site is 24.4±2.0°C. This data was collected from average monthly readings and agrees with information from coral reef studies by Hatcher (1991), which recorded a mean temperature of 23.7±2.1°C for the *Rapid* site. The higher temperature is significant for the *Lively* site, as it means that the kinetics of hydrolysis reactions, such as shown in equations 2 and 4, compared with the oxidation of tin to the divalent state (equation 1) favours the formation of tin (II) corrosion products, and so the amount of chlorides ‘sucked into’ the corrosion matrix is less than that from the slower reactions that take place in the *Rapid* site. Cooler sites favour formation of tin (IV) corrosion products (MacLeod 1981).

CONCLUSIONS

This report presents the first quantified comparative analysis of two shipwrecks off the Western Australian coast: *Lively* and *Rapid*. The metallurgical structures of the three sheathing tacks from the *Lively* wreck all show significant gas porosity, but the condition of nails within the collection varies. The closeness of their composition indicates that they were all cast in the same batch, but that the more porous sections took metal from the top of the pour, while the more sound parts of the castings were most likely from the middle of the melt, as they were free of the dross at the bottom of the crucible. Nevertheless, the primary reason why nails RS113 and RS178 are less degraded than RS112 is due to their microenvironments on the wreck site.

The compositions of the bronze sheathing tacks from *Lively* and *Rapid* are similar, which is not unexpected, given the similar periods in which the vessels were built in France and the United States, respectively. Although *Lively* was built in 1784, it was refitted in England before being renamed and rebadged, so the time of casting of all the bronze sheathing tacks is likely to be quite close to that of the tacks from *Rapid*. The large proportion of lead added to the *Rapid* bronze pump spear alloy would have decreased its mechanical strength significantly, but also would have made the metal less prone to 'stickiness' when suctioning the bilge water, which also would have contained significant amounts of fine debris, such as sand and small pieces of fragmented dunnage. The sheathing nail, on the other hand, needed mechanical strength more than minimisation of abrasion, and so the lower lead content was beneficial. The strength of this sheathing nail would be greater than that of lead sheet, while its ease of fabrication and resistance to corrosion would be superior to those of the bronze pump spear.

The rates of corrosion on the two wrecks, due to their different environments (especially temperature and water movement), are manifested in the ratios of chloride found in the bronzes from the sites. For the corrosion of the copper-rich α-phase, the *Lively* artefacts had 22 times the average amount of chloride in them, so clearly the effects of increased water movement and temperature have a marked impact on the decay of the objects, compared to the relatively benign *Rapid* wreck site. In similar fashion, objects from the *Lively* site, a lower dissolved oxygen environment, have just over 15 times as much chloride as the *Rapid* artefacts. Thus, regardless of whether the bronzes are in fully oxygenated sea water or buried under a covering of marine debris, the higher surge environment of the *Lively* site results in much more extensive corrosion of the objects.

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Report on the Rescue and Preservation of *Daring*, a Mid-19th-century Schooner Built in Aotearoa/New Zealand

KURT BENNETT, ISAAC H. MCIVOR AND LARRY PAUL

Abstract

This paper reports on the recording, identification, recovery and ongoing conservation of the remains of *Daring*, a schooner built in Aotearoa/New Zealand in 1863 by Donald McInnis. It also discusses the heritage legislative regime under which the remains are protected, the vessel's history and archaeological significance and future research and public interpretation plans for the remains.

INTRODUCTION

In May 2018, a shipwreck reappeared on Te Oneone Rangatira Beach near the southern end of the Kaipara Harbour Entrance and approximately 67 km northwest of Tamaki Makaurau/Auckland, Aotearoa/New Zealand (Fig. 1) (*New Zealand Herald* 2018). The ship also sat within the protected area of the New Zealand Defence Force (NZDF) Kaipara Weapons Range (Lot 1 DP 138525). Archaeologists from Auckland Council and Heritage New Zealand visited the site to identify the vessel and to record the exposed hull structure (Fig. 2). As current legislation provides statutory protection only for vessels shipwrecked prior to 1900, identifying this ship was of high priority (Brassey 2018:9). Researchers determined the vessel to be *Daring*, a schooner constructed in 1853, and recorded the wreck as ArchSite[1] Q09/1221 located at NZTM: N5961202 E1704586. In the months leading up to December 2018, the ship was exposed to tidal and storm surges and illegal fossicking. As a result of these natural and cultural processes, it left the ship in a highly degraded state. Fortunately, through the generous financial and logistical support of local

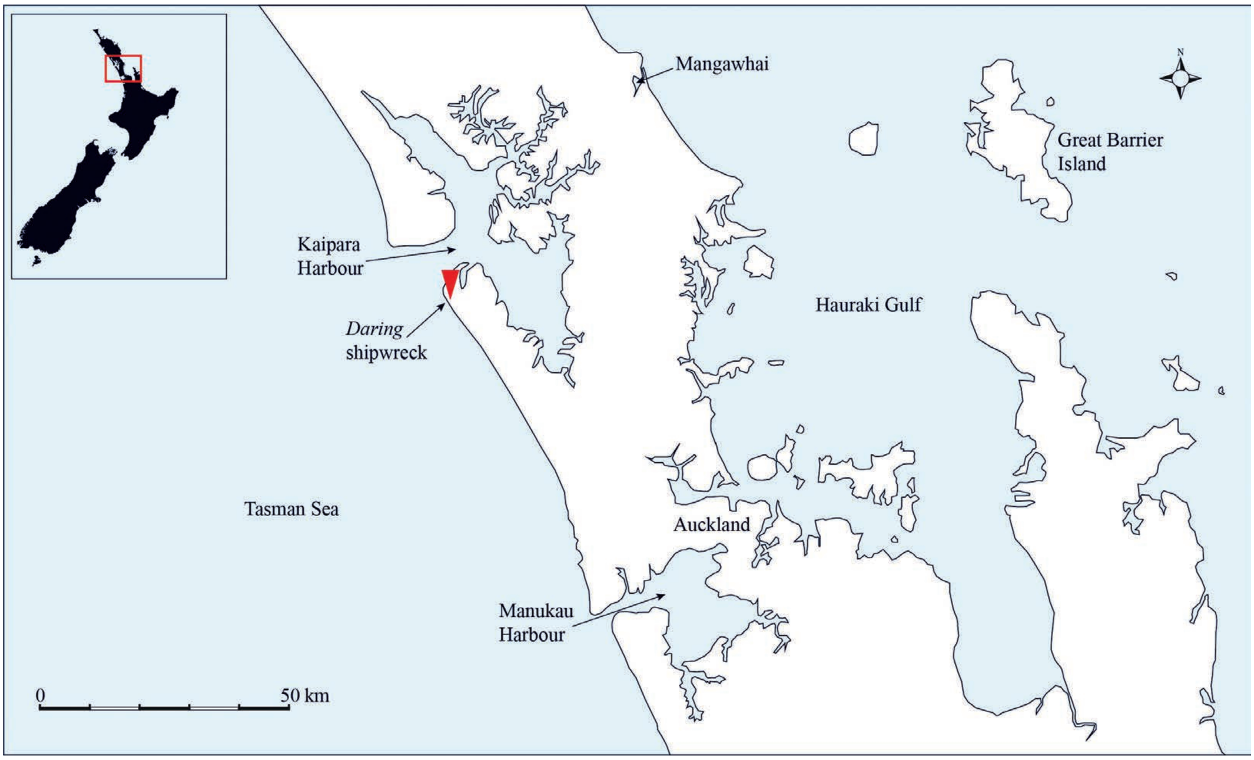

Fig. 1. Location of *Daring* on Te Oneone Rangatira Beach (K. Bennett).

Fig. 2. Aerial view of *Daring*, June 2018. Bow orientated 255° WSW (Recon Ltd, 2018).

enthusiasts, businesses and agencies, *Daring* was rescued for future generations.

HISTORICAL BACKGROUND

In 1863, boatbuilder Donald McInnis constructed *Daring* in Mangawhai for owners John Matheson and John Rattray. Donald's sister launched the vessel into Mangawhai estuary on 1 September 1863. The vessel was a carvel planked coastal schooner measuring 53 ft (16.15 m) in length, 16 ft 7 in (5.05 m) in beam, 6 ft 10 in (2.07 m) in depth and 31 tons in displacement (Ingram et al. 2007:110). The ship sailed first to Auckland for survey and registration (26/1863) before continuing on to Canterbury with a cargo of 25,000 ft of timber. Upon arriving, the vessel was advertised immediately for sale, freight or charter (*Albertland Gazette* 1863; *The Press* 1863). In the months following October 1863, *Daring* had mixed commercial success and returned to Auckland in January 1864. There it was sold to David Kirkwood, who owned several coastal traders operating out of Manukau Harbour on the west coast of New Zealand's North Island.

Daring sailed from Auckland on 3 February 1864 to the Port of Taranaki (now New Plymouth) with a full cargo of supplies for the growing settler population and soldiers involved in the New Zealand Wars. Over the following months, the vessel sailed between the ports of Taranaki, Kāwhia, Raglan, Port Waikato and Onehunga in Manukau Harbour until being wrecked on the bar at the Port Waikato entrance on 1 June. The vessel was reported to be a total wreck, but an insurance payment of £500 enabled subsequent repair and re-floating. The rugged west coast and treacherous harbour entrances took their toll on many vessels during this era and *Daring* was no exception. On 21 February 1865, the ship ran aground again, this time on Te Oneone Rangatira Beach north of Muriwai Beach (Ingram et al. 2007:110). Having been caught on a lee shore during a westerly storm, Captain Samuel Phipps eased the ship, under anchor, through the surf and onto the beach in the hope of re-floating it in more favourable conditions (*Lyttelton Times* 1865).

Owner David Kirkwood and a rescue party of some 30 persons spent 10 days levering, jacking and manoeuvring the ship on rollers into deeper water. While successful at first, the ship was driven back onto the beach by pounding surf with total loss of the uninsured vessel and its £400–500 cargo of grass seed (Ingram et al. 2007:110). The vessel's remains subsequently became buried beneath the iron sands of Te Oneone Rangatira Beach, where it remained until re-emerging in May 2018 in a remarkably good state of preservation.

LEGAL FRAMEWORK AND HERITAGE MANAGEMENT

Under the *Heritage New Zealand Pouhere Taonga*

Act 2014 (www.legislation.govt.nz/act/public/2014/0026/latest/DLM4005414.html) it is unlawful to modify or destroy an archaeological site, whether it has been recorded previously or not, without authority from Heritage New Zealand/Pouhere Taonga (the administering body of the act). Section 6(a) of the Act defines an archaeological site as:

> any place in New Zealand, including any building or structure (or part of a building or structure), that—(i) was associated with human activity that occurred before 1900 or is the site of the wreck of any vessel where the wreck occurred before 1900; and (ii) provides or may provide, through investigation by archaeological methods, evidence relating to the history of New Zealand.

Archaeologists identified *Daring* based on its location and visible dimensions, and later confirmed its identification by the exposed original registration number, 46541 (Certificate of Survey, 7 October 1863, Schooner, *Daring*, Registration 46541, Aukland: New Zealand Archives). *Daring* thus fell within the definition of an archaeological site and under the provisions of the Act.

The newly formed Daring Rescue Group approached Heritage New Zealand to secure their support for excavating and transporting *Daring* to a secure location inland for conservation, research, community engagement and education. Heritage New Zealand supported this goal, while requiring compliance with the *Heritage New Zealand Pouhere Taonga Act 2014* and general principles of the 2001 UNESCO *Convention on the Protection of the Underwater Cultural Heritage*, the ICOMOS *Charter on the Protection and Management of Underwater Cultural Heritage (1996)* and the *Maritime Archaeological Association of New Zealand (MAANZ) Principles 2013.*

The general principles of the aforementioned UNESCO, ICOMOS and MAANZ policy documents state that shipwrecks should be left in situ with non-invasive recording considered as a first option, and that any invasive investigation should be undertaken by professional archaeologists and conservators with long-term project planning and funding. The continued beach erosion, oxidation of metal fastenings, fossicking and dynamic wave action were rapidly degrading the site week by week. In the first few days of the wreck becoming exposed, someone removed the stern railing with a chainsaw. By November 2018, despite the wreck being in a NZDF protected area, fossickers and wave action had removed all of the decking. Thus, in this case, leaving the vessel in situ would not have preserved it, but only let it be dismantled and destroyed (McIvor 2018).

Daring Rescue Group, with support from Heritage New Zealand, consulted conservators from Heritage Preservation and Field Support Solutions (HPFS, https://www.hpfssolutions.com) and S45 archaeologist Simon Best to plan for rescuing the ship. While project planning was underway, preliminary excavations were undertaken to assess the archaeology in and around the hull structure. Trenches were excavated by hand inside the hold, which confirmed the preservation of in-situ archaeological deposits, including preserved grass seed cargo. Archaeologists also selectively sampled timbers from different elements of the vessel to confirm the hypothesis of local boat builders that it had been constructed from indigenous timbers (Baden Pascoe pers. comm. 2018).

THE RECOVERY

In June 2018, the Daring Rescue Group, along with small public interest groups, recognised the importance of this vessel to New Zealand's maritime history and immediately contracted security personnel to monitor and protect the vessel from local souvenir hunters and tree logs carried by storm surges. Working in concert with Heritage New Zealand, a conservation and recovery plan was developed. The rescue was a logistical challenge given the isolated location and land-holding interests, which included the NZDF bombing practice range, Māori Iwi archaeological sites, Department of Conservation protected rare nesting bird sites and private forestry road access.

The excavation was carried out using a bulldozer and mechanical excavators (four large and one small). The machines operated between tides over a four-day period to remove sand from around and inside the vessel. Lifting straps were water-jetted under the hull and connected to pairs of the large excavators on the port and starboard sides of the vessel (Fig. 3). On the morning of 12 December 2018, the excavators successfully lifted the vessel and moved it above the high tide mark. The following day, a specially designed boat transport truck carried *Daring* 40 km south along the beach to Muriwai. Best, one of the authors (IHM) and supporting volunteer archaeologists monitored the mechanical excavation with assisted hand excavation of the hull prior to the lift. They recorded stratigraphy and artefacts as they became exposed, and then recovered the artefacts. The lift also was documented by extensive media coverage.

Fig. 3. Mechanical excavators lifting *Daring* from the beach at low tide, 12 December 2018. (K. Bennett, 2018).

ARCHAEOLOGICAL SIGNIFICANCE

To date, there has been no comprehensive archaeological survey of a 19th-century New Zealand-built vessel. *Daring* and its remarkable preservation present an opportunity to investigate mid-19th century domestic colonial shipbuilding practices. Study of the ship's hull can shed light on ship timber selection, hull form, construction and antifouling technologies. The ship's hull structure is virtually complete, with only the top decking, hatch combings and railings missing, along with the masts, rudder and steering mechanism. In a wider geographical context, future archaeological recordings of *Daring* can contribute to previous shipbuilding studies from other colonial contexts more generally. Australian colonial ships studied archaeologically include *Clarence* (Harvey 1986), *Alert* (Bullers and Shefi 2014; Nash 2004), *Zephyr* (Bullers 2007), *Active* (Bullers and Shefi 2009), *Mary Wadley* (Lester 1984) and the broader study of shipbuilding in colonial South Australia and Tasmania (Bullers 2006). Comparisons with these early colonial-built vessels can better elucidate the development of shipbuilding processes in Australasia. The ship's remains can support myriad other research avenues, such as metal and fibre analyses, chemical analysis, timber resource studies, dendrochronology and interpretations of hull markings and inscriptions. Furthermore, questions relating to the adoption of foreign and local shipbuilding techniques can be explored.

Over 1,100 artefacts were recovered from the *Daring* shipwreck, including personal items (clothing, shoes, leather belt, vulcanite nit comb, clay pipe stems, shaving mug, knife sheath and coin), alcohol bottles (black beer bottle tops with in-situ corks and a complete ring-seal bottle containing hop flower petals), other ceramic and bottle fragments, various nautical tools (ship's chip log, sailmaker's fid, brushes, homemade wooden tools), cargo material (grass seed and sacking, brick fragments, coal), ballast rocks, ropes, cordage and more. Such remains provide a new window into 19th-century life on board a coastal trading vessel.

From the range of artefacts recovered, it is clear that the wreck's significance relates not only to the hull structure and shipbuilding practices, but also to the amount and diversity of information that may be gleaned about life aboard. At present, the ship is the earliest and best-preserved example available for maritime archaeological studies. It is globally significant in that it can contribute to broader studies of early colonial-built vessels (in Australasia, the Americas and elsewhere) and provide insights into local adaptation of foreign shipbuilding techniques. Quite simply, *Daring* is one of New Zealand's most significant maritime archaeology finds ever. It offers valuable information on the nation's colonial shipbuilding industry and about those who worked at sea.

FUTURE DIRECTIONS

With the vessel positively identified, *Daring* offers a unique and significant opportunity to expand our knowledge of mid-19th-century New Zealand shipbuilding and the coastal trading industry. The vessel currently sits under a scaffold and plastic shed and is kept wet by an automatically timed water misting system until the final conservation treatment plan is completed. Planned next steps are:

1. Finalise archaeological excavation reports (NZHPT archaeological authority 2019/290).
2. Finalise the full conservation plan.
3. Construct a permanent support cradle that accommodates transporting, reassembly of loose timbers recovered from site, conservation treatment and final public display.
4. Commence conservation treatments for metal, organic and timber materials.
5. Agree on and secure the final museum location for public exhibition.
6. Finalise the design for and construction of a dedicated museum display.
7. Conduct ongoing conservation assessments of timber and metals.
8. Conserve and prepare the artefacts found in the hull for museum display.
9. Secure funding for ongoing conservation, research and public education.

The final archaeological report from the rescue operation is due for completion in 2020.

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NOTES

[1] Archsite is a national online database for registered archaeological sites in New Zealand.

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Laser Scanning the Historic *Edwin Fox* Hull for Digital Preservation, Waitohi/Picton, Aotearoa/New Zealand

KURT BENNETT

Abstract

This paper describes the 3D laser scanning of the historic *Edwin Fox* hull in December 2016 at Waitohi/Picton, Aotearoa/New Zealand. Prompted by a powerful earthquake that struck the Te Waiponamu/South Island the month prior, the project was a response to potential damage to the vessel by seismic events and subsequent loss of significant historical information. The scanning served as a digital record of the hull that will assist in the vessel's curation and ongoing preservation and aid in the continuing research of the ship. 3D laser scanning as a tool for maritime archaeology also is discussed, along with other comparable projects.

INTRODUCTION

When natural disasters occur, they have major impacts on geological and cultural landscapes. Specifically, earthquakes and their unpredictable nature can threaten significant cultural heritage. Recent earthquake activity in Aotearoa/New Zealand exposed the risk of potential future damage and loss to the Edwin Fox Maritime Museum and its main exhibit, the hull of the historical ship *Edwin Fox* (Bennett and McLeod 2018).

Aotearoa/New Zealand is an island nation located in the southwest Pacific Ocean and represents the southern extent of Oceania. It comprises three main islands, orientated northeast to southwest: Te Ika-a-Māui/North Island, Te Waiponamu/South Island and Rakiura/Stewart Island (Fig. 1). The islands straddle the boundaries of the Pacific and Australian tectonic plates, forming the southwestern end of the Circum-Pacific Belt, also commonly referred to as the Pacific Ring of Fire. The plate boundaries follow parallel with the east coast of the North Island in a southerly direction, then intersect the northeast coast of the South Island and extend to the southwest coast. The position of these major plate boundaries exposes the Te Waiponamu/South Island to seismic activity, which has been occurring more frequently in the last decade.

On 14 November 2016, GeoNet recorded a magnitude 7.8 earthquake 15 km northeast of Culverden and 60 km southwest of Kaikōura (Fig. 1). The shock caused major damage in the tourist town of Kaikōura and minor damage in Te Whanga-nui-a-Tara/Wellington, Aotearoa/New Zealand's capital city. The force of the earthquake uplifted the sea floor in parts along the east coast of Te Waiponamu/South Island and triggered major landslides, which blocked State Highway One (the main national highway) and the national rail line. The power of the earthquake also threatened to destroy European and Māori cultural heritage sites in the area. In particular, Waitohi/Picton experienced the force of

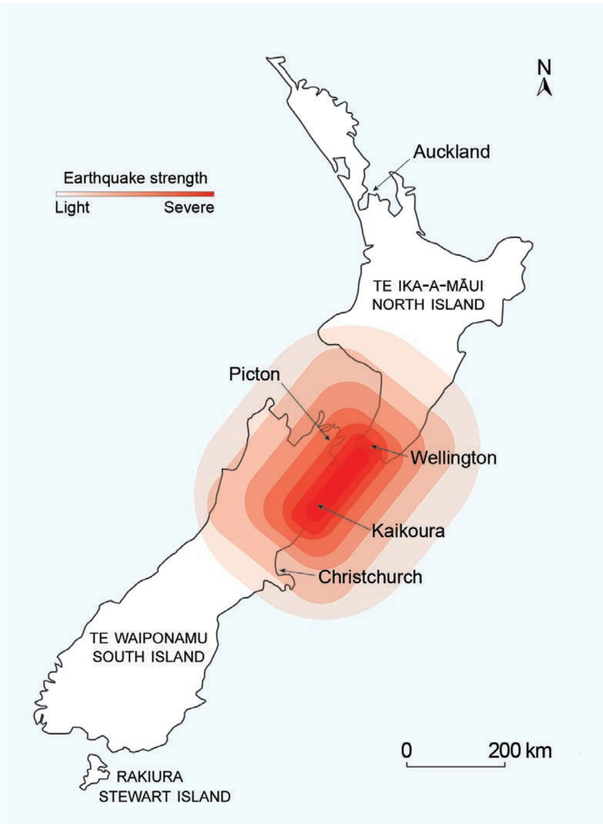

Fig. 1. Waitohi/Picton in relation to the earthquake epicentre.

Fig. 2. Waitohi/Picton, showing the location of *Edwin Fox*.

the seismic event and the earthquake threatened to damage or destroy the historic *Edwin Fox* hull (Fig. 2). This event was of concern to the Edwin Fox Maritime Museum, as management were worried that a future natural disaster could cause the loss of significant historical information. Therefore, it was necessary to preserve *Edwin Fox* and its contextual information.

This paper describes how the museum's centrepiece exhibit, the *Edwin Fox* hull, was digitally preserved using three-dimensional (3D) laser scanning to minimise any potential loss caused by future seismic events. The scan data also is aiding ongoing research of the vessel and its design and construction technologies. The field of maritime archaeology and heritage management has witnessed a steady rise in the application of 3D technologies, including laser scanning, in its practice, made possible in part by the increase in available computing power (McCarthy et al. 2019). This project provides another example and contributes to the discussion of recording large, historically significant tangible ship heritage by preserving contextual information for museum patrons and future researchers (Atkinson et al. 2019; Cooper et al. 2018).

EDWIN FOX

In 1853, a team of British and Indian shipwrights completed construction of *Edwin Fox* in the Reeves and Foster shipyard in Sulkea, India (Costley 2004:28). On 9 December of that year, the vessel was issued with certificate number 12/1853 and registered at 836 tons, measuring 157 ft (47.85 m) in overall length, 29 ft (8.83 m) in breadth at midships and 21 ft 6 in (6.55 m) draft (Costley 2004:33). The hull was constructed of teak (*Tectona grandis*) and saul (*Shorea robusta*) timber and sheathed in Muntz metal (Mortiboy et al. 2003). Originally, the ship was full-rigged, but was changed to a barque rig in 1878 (Locker-Lampson and Francis 1979).

Upon arriving in London on its maiden voyage, the British Royal Navy contracted the ship and converted it into a troop carrier. In 1854, the vessel transported soldiers during the Crimean war and was stationed there as a floating barracks. Following the ship's employ in the war effort, its interior was converted a second time to accommodate prisoners. During the late 1860s and early 1870s, the British government contracted the vessel to serve as a convict ship and used it to transport prisoners to Western Australia. In 1873, the vessel continued as a transport ship, but for a different class of passengers. The ship's accommodations were upgraded for paying customers and it transported immigrants between the United Kingdom and Aotearoa/New Zealand until 1880 (Locker-Lampson and Francis 1979:30–31; Costley 2014:140). Shortly after its final voyage in this employ, the ship was converted into a refrigerated meat store and moored in ports around the country. It served as a store ship in Port Chalmers, Ōtepoti/Dunedin, Ōhinehou/Lyttelton, and Tūranga-nui-a-Kiwa/Gisborne (Costley 2014: 152–153). Towards the end of the vessel's working life, the New Zealand Refrigeration Company cut down the rigging, as it was no longer needed, and converted the vessel into a storage ship: first for frozen animal carcasses and then for coal. Around the turn of the century, *Edwin Fox* became a permanent feature in Waitohi/Picton (Fig. 3). Sometime in the 1920s, the refrigeration equipment was removed from the ship and installed in the Company's adjacent factory. The ship then served as a coal hulk to fuel the freezer boiler systems (Locker-Lampson and Francis 1979:30–31).

The Maritime Transport Authority inspected the hulk in 1965, assessing the vessel to be unseaworthy and condemning it. Fortunately, local enthusiasts identified the historical significance of the vessel and formed the Edwin Fox Society to save the ship. The society purchased *Edwin Fox* for one shilling (less than NZD 2.00) from the New Zealand Refrigeration Company and pursued restoration options. Over the ensuing 16 years, the Society and the Marlborough Council discussed where to display the ship. It was

Fig. 3. *Edwin Fox* moored as a hulk at Picton, c. 1900 (L.J. Daroux, courtesy of the Alexander Turnbull Library, Wellington, NZ, Photographs of New Zealand and the Pacific, 1/1-039355-G. Retrieved 15 April 2018 from <https://natlib.govt.nz/records/23160152>).

not until 1986 that the ship's hull gained statutory approval and was moved to its final location along Picton's foreshore and adjacent to the InterIslander Ferry terminal. During the same year, construction of the associated museum building started and was designed to replicate historic offices from Dunbar Wharf in London (Costley 2014:186). The vessel was moored next to the museum and remained floating until 1999. On 19 May of that year, construction of a purposely-designed dry dock was completed and *Edwin Fox* became a static and dry display—ending its 146 years of marine service. The ship currently forms the main exhibit for the museum and is accessible for the public to view both the interior and exterior of the hull (Figs 4 and 5).

SIGNIFICANCE

In 1999, Heritage New Zealand/Pouhere Taonga (formerly New Zealand Historic Places Trust), the government agency that manages historic places, registered the hull and associated windlass as Category 1 heritage, registration no. 7450. Category 1 status is awarded to places or objects with special or outstanding historical or cultural significance or value. The ship's historical significance was recognised internationally in 2013, when the Edwin Fox Maritime Museum was awarded the International World Ships Trust award for preservation (Mateparae 2013). The award recognised the significant role of this type of ship in the history of humanity and the advancement of public education that its preservation and display provides. As of 2018, *Edwin Fox* is the only surviving 19th-century example of a British East Indiaman, the only surviving example of the 1,040 Australian convict ships, and the only historic vessel located in New Zealand to be assigned Category 1 status, which further reflects its current historical significance.

PREVIOUS SHIP INVESTIGATION

In 1987 and 1988, the *Edwin Fox* hull underwent a comprehensive survey. Earthwatch International

Fig. 4. *Edwin Fox* exterior, viewed from the port bow (K. Bennett, 2016).

Fig. 5. Interior of the *Edwin Fox* hull, looking aft (K. Bennett, 2018).

funded the project, which invited volunteers to contribute to the survey and recording of the vessel (Costley 2014:182). The project's objectives were to measure and record the hull dimensions to produce ships lines and to accurately record all construction features. In addition, the recorded information about the vessels dimensions and deteriorated areas enabled the team to develop a full restoration plan. The goal of restoration has since been abandoned, with preservation of the hull now the main focus. Plans and drawings produced from the Earthwatch survey are stored at the Marlborough Museum in Blenheim and provide a record of the ship's condition during the late 1980s.

LASER SCANNING

3D laser scanning recently was considered an "emerging method" (Sanders 2011:308), but is rapidly becoming more widely utilised in the field of maritime archaeology (McCarthy et al. 2019). In the past two decades, researchers have employed 3D laser scanning to document large remains of shipwrecks and entire hull structures (Atkinson et al. 2019:105–110). Laser scan data also has proven useful for producing traditional lines-plans (see Tanner 2012). Even so, the use of laser scanning in the marine environment still has limitations. Good quality scans are currently obtained where vessel remains are either above the water line or have been recovered and are presented in a dry state. Nevertheless, underwater laser scanners are currently being developed and trialled, which will allow access to submerged sites (see, e.g., 2G Robotics Inc., https://www.2grobotics.com).

In 2000, *H.L. Hunley* (1863–1864), a submarine of the Confederate States of America, was the first shipwreck to be digitally scanned, in this case using a Cyrax© 3D laser scanner (Schafuri et al. 2014:252; van Duivenvoorde 2005:3). Two years later, in 2002, Sweden's 17th-century flagship, *Vasa*, constructed for King Gustavus Adolphus, underwent laser scanning of both its interior and exterior hull structure (Jacobson 2003). Both of these scans produced an accurate 3D digital model of the vessels and aided researchers in capturing their size and shape, as well as providing data for future management. In 2005, the Batavia Hull Reconstruction Project employed the use of an IQ-Sun laser scanner to record *Batavia*'s hull remains (van Duivenvoorde 2005:3). *Batavia* was a 17th-century Dutch East Indiaman that shipwrecked on the Abrolhos Islands off the coast of Western Australia in 1629. The scanning of the wooden hull remains provided the researchers with valuable information relating to the ship's design and construction.

More recently, 3D laser scanning has been applied to other historic ships in Australia. In 2013, researchers spent two days laser scanning the Australian colonial navy's light cruiser *Protector* (Hunter et al. 2019; Hunter and Jateff 2016). *Protector* was an Australian naval vessel that saw service in both world wars. In 1944, the vessel was condemned and towed to Heron Island, QLD, to be installed as a breakwater (Hunter and Jateff 2016:424). To record the ship, the research team used a Faro Focus 3D laser scanner. They scanned the vessel during peak low tide, when the maximum area of both external and internal structure was exposed above the waterline. From the resulting data, the team produced an accurate 3D digital record of the current condition of the vessel's fabric, which they used for archaeological interpretation and as a benchmark for future site management.

3D laser scanning is still limited in its use in marine environments. At present, it has been completed only above the waterline or in dry environments, although scanning has been used in combination with a multibeam echosounder survey of the seafloor and photogrammetry to enhance the visual representation of an underwater site (Firth et al. 2019). Where scanning has been used for recording individual ship timbers, researchers argue the digital point cloud created from scanning lacks interpretation and requires extensive post-processing (Nayling and Jones 2014:244). Limited computer processing power and technology also limits the post processing of large files. For example, the scanning of *Vasa* produced 25 Gigabytes (GB) of data, which, at the time of scanning, could not be processed as a single file; researchers had to break the file into smaller data sets in order to process the information (van Duivenvoorde 2005:3). Keeping these limitations in mind, practitioners must apply 3D laser scanning to suitable ship sites and have access to the appropriate computing hardware and software.

METHODOLOGY

During 17 and 18 December 2016, Auckland based initiative 3DScans Ltd (https://www.facebook.com/edwinfox3d/) collaborated with the Edwin Fox Maritime Museum and the author to digitally scan and create a dataset for production of a 3D digital model of *Edwin Fox*. The 3DScans team used a FARO Focus 130 laser scanner to scan the external and internal hull structure (Fig. 6). The exterior was scanned first, and required six scanning locations. The interior scan required nine separate scanning locations to capture the entirety of the ship. The scanning took two days to complete and produced 370 million polygons with an accuracy of ±1 mm. To further increase data accuracy, the Faro machine captured high definition images at the same time of scanning. This provided a photographic record of the ship that could be aligned with the scanned data points.

The scanned information was post-processed using a number of different computer software. First, the raw laser scan data was uploaded into CloudCompare, which consolidated all of the data points collected from the scan (Fig. 7). The file size of the combined exterior and interior raw data was 77.2 GB. CloudCompare is an open source program that manages 3D mesh data sets. Due to the manner in which the ship was scanned and the large file sizes involved, the scan data was uploaded in two parts: external hull and internal hull. The consolidation process integrated the data points and created one combined image of both the external and internal hull structures. At the same time of processing, textured mapping was applied to the points. This resulted in a 3D digital colour image of the scanned ship.

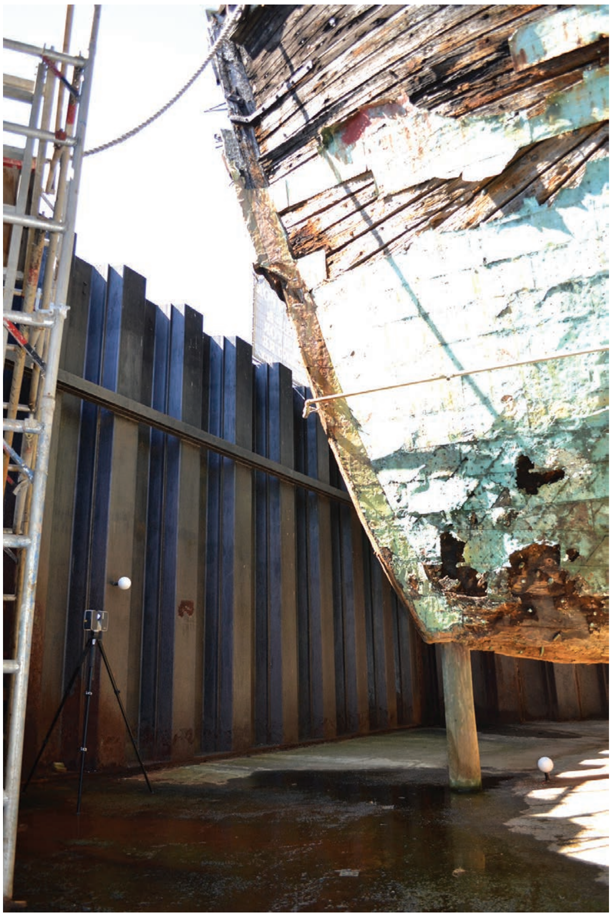

Fig. 6. Faro laser scanning positioned near the bow (K. Bennett, 2016).

The entire digital model then was saved as a Wavefront 3D object (OBJ) file (file extension .obj) and uploaded into MeshLab, a 3D mesh editing software that helps with the cleaning, converting and management of data. Specifically, this software was used to reduce the overall file size and scale of the 3D digital model. The model was scaled using the Quadric Edge Collapse Decimation function to 10% of the original size while retaining texture quality. This reduced the total file size to a manageable 1.17 GB, which allowed for more user-friendly manipulation across different platforms and programs (Fig. 8).

Flinders University's Digital Archaeology Laboratory supplied the computer used for this processing. Its specifications included two Intel® Xeon® CPU E5-2680 v3 2.5 GHz processors, 256 GB of RAM and 64-bit architecture. The computer was running Windows 10 Enterprise operating software.

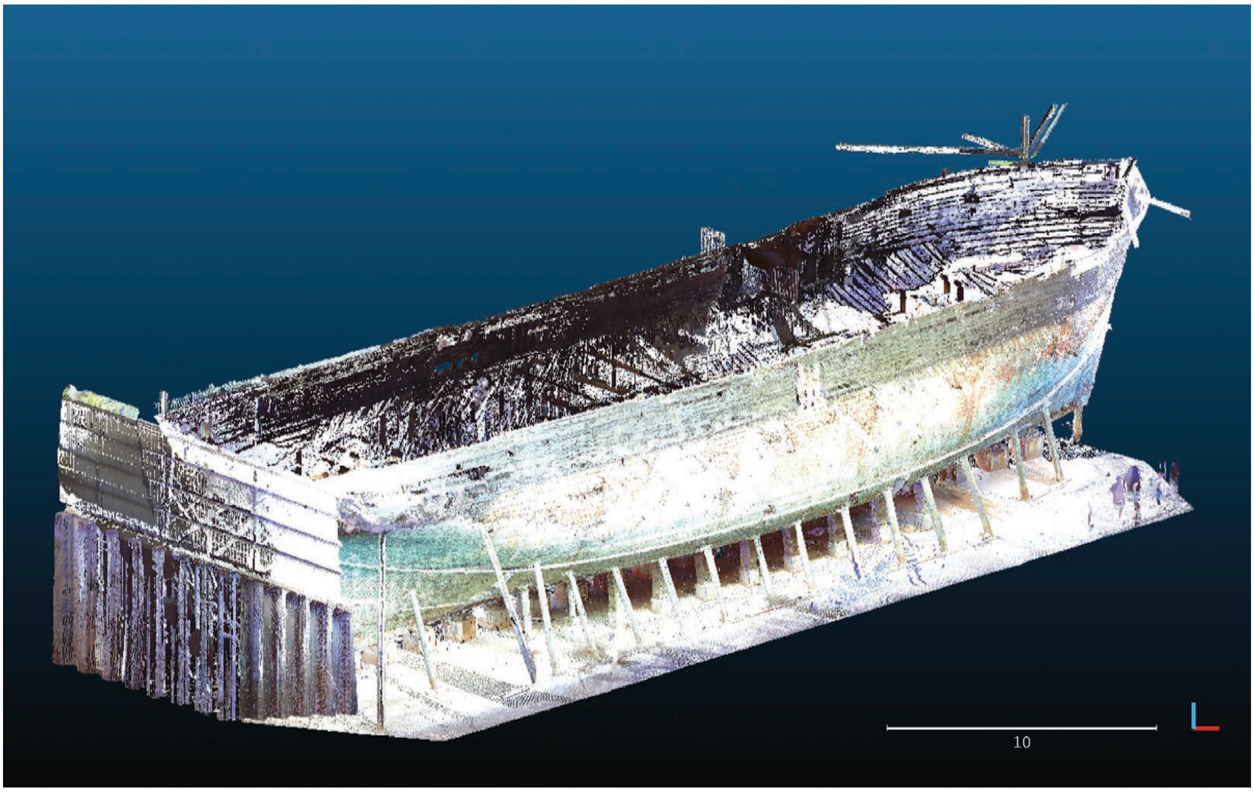

Fig. 7. Consolidated point cloud data shown in CloudCompare.

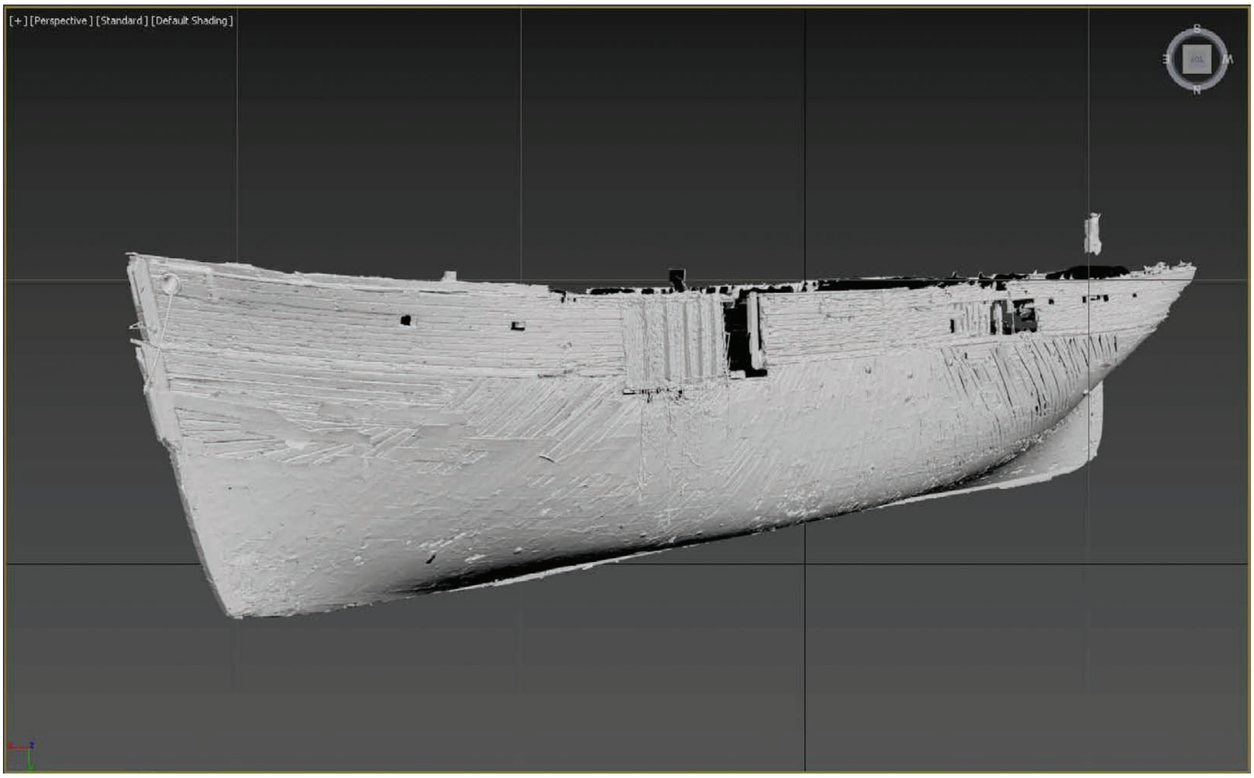

Fig. 8. Textured mesh of *Edwin Fox* (port side showing) created using AutoDesk 3ds Max®.

The processing power offered by this computer is substantially more than the average household computer and allowed for quicker processing times for the large 3D scan data files.

CONCLUSIONS

The 2016 Kaikōura earthquake threatened to damage or destroy the historically significant *Edwin Fox* hull and highlighted the potential risk from future seismic events. In response, the vessel's remaining hull structure was laser scanned to produce a 3D digital model. This step to preserve the hull in a digital format is consistent with the museum's current policy of "preservation, not restoration" (Karen McLeod pers. comm. 2016), and now provides another medium for accessing information regarding *Edwin Fox*.

The scanned data was used to produce a 3D digital model of the *Edwin Fox* hull with an accuracy of ±1 mm. According to the digital model, the hull measured 47.89 m in length at the time of scanning. This agrees remarkably well with the original registered length of 47.85 m and shows that the hull has retained its original dimensions; a true testament to the skill of the ship's builders. The textured mapping applied to the point cloud also provides details of individual construction features. This complete model represents an accurate record of the existing hull structure as recorded in 2016.

The museum will keep a copy of this digital record in its archives to provide staff with a baseline condition and precise record of the ship with which to actively monitor *Edwin Fox* going forward. Curators can compare future scans of the hull with the 2016 model to assess any changes in dimensions, shape or condition caused by environmental factors, corrosion, decay, seismic or other activities. This will increase the museum's ability to maintain the ship, evaluate conservation treatments and plan for on-going preservation work.

While the scanning of the ship took only two days and is considered to be a quick recording method when compared to traditional (manual) ship recording methods, the processing of data required a significant investment of time and computing capabilities. Using the high-powered computer provided by the Department of Archaeology at Flinders University, the processing of data and production of a basic model required two weeks to complete. Without such equipment and associated specialist software (and know-how), the post-processing would have taken considerably longer. Researchers planning to utilise 3D laser scanning for other ship projects need to consider the large investment of time, computing power and specialist software that is required. Nevertheless, laser scanning, like photogrammetry or other computer-aided recording methods, not only reduces the overall time required to record a structure, but it also shifts time from on-site data acquisition to post-processing in the office or lab. This is beneficial, since access to the ship typically will be limited, and because it will always be more convenient and cost effective to work in the office or lab rather than in the field. The end result is an accurate digital record of both the overall structure (macro) and individual features and details (micro) that will serve researchers and conservators alike.

In addition to scanning and digital modelling, the author's ongoing research includes detailed recording of specific materials, components and construction features to aid in identifying and documenting building methods and construction techniques; timber sampling for species identification and dendrochronology; and sampling of the copper sheathing for chemical analysis and metallurgical studies. Additionally, the author is using the computer aided design (CAD) program Rhinoceros (v4.0) to take the lines of the hull from the 3D model. Altogether, this research will result in the virtual preservation of *Edwin Fox*, with its digital archive to include the 3D digital model, new lines drawings, details of the vessel's design and construction and an assessment of the timber and metal materials used in its build. This will help preserve important information for future generations.

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The Story of Gerhard Droste and the Loss of Dornier Do 24K *X-28*: A Piece of the Broome Flying Boat Puzzle Revealed

SILVANO JUNG

Abstract

For the first time in 74 years, Flight Sergeant Gerhard Droste's incredible story related to Broome's flying boats has emerged. Published in John Thompson-Gray's book, *Love, Luck and Larceny* (2015), Droste recounts the loss of his Dornier flying boat *X-28* during the 1942 Japanese air raid on Broome, Western Australia. The attack resulted in the loss of more than 100 people and left behind a battlefield landscape. Prior to the book's publication, Droste was not recorded even as being in Broome at the time. With this new piece of the Broome flying boat puzzle, a predictive model is developed to determine where missing flying boats might lie and how they might be identified. Ten of the 15 wreck sites have been discovered, six of which are exposed during perigean spring low tides. This paper argues that there are at least four more deep-water wrecks that may have survived, and that one of these might be Droste's *X-28*.

INTRODUCTION

In light of new historical evidence, a predictive model is developed to answer a piece of the Broome flying boat puzzle: the location and identification of missing flying boat wrecks. For the first time in the 74 years since the Japanese air raid at Broome, Western Australia, on 3 March 1942, another piece of evidence has emerged: an account by a Dutch airman that may have significant bearing on the disposition of the archaeological resource in Broome's Roebuck Bay. A story by *Sergeant Vliegtuigmaker*/Sergeant Aircraft Mechanic (SGTVGMR) Gerhard Droste of the *Marineluchtvaartdienst*/Royal Netherlands Naval Air Service (MLD) adds another dimension (Fig.1). Published in John Thompson-Gray's (2015) book *Love, Luck and Larceny*, Droste gives an account of the loss of his flying boat, the three-engine Dornier Do 24K *X-28*, while anchored in Roebuck Bay. Previously, there was no information about the destruction of this flying boat, as the only crewmember on board at the time was killed, and it was believed that no survivor of the air raid saw the aircraft sink. There are no known photographs of *X-28*, but another of the Do 24Ks lost in the Broome raid, *X-3*, is shown in figure 2. Droste's account details the site formation process of the wreck site and adds to our understanding of what happened during the air raid (Jung 2009).

The Japanese air raid left behind a synchronous archaeological seascape at the bottom of Roebuck Bay, where more than 100 people and 22 Allied aircraft were lost, including 15 flying boats from four different nationalities. In the confusion after the air raid, no complete passenger and crew list was compiled. It is likely, therefore, that many more fatalities associated with the air raid have never been

Fig. 1. Gerhard Droste (left) with unknown comrade (courtesy A. Neilsen).

Fig. 2. The Dornier Do 24K flying boat *X-3* at *Marine-vliegkamp*/naval airbase Morokrembangan, Surabaya, c. 1938 (courtesy of the Broome Historical Society Museum).

recorded. Droste's account of the loss of *X-28* is the first to emerge, and it adjusts what archaeologists might expect to find in Roebuck Bay.

A photograph of the aftermath of the air raid on Roebuck Bay emerged in 2008. It was taken from the shore, at Kennedy Hill, overlooking Buccaneer Rock. Archaeologists have a reasonable understanding of which aircraft are depicted on fire in what is described as the 'main wreck group'. Nevertheless, the Kennedy Hill photograph clearly shows an outlying smoke column, designated Outlier 2, well away from the main group of flying boats (Fig 3). A previously known outlier, designated Outlier 1, was recorded in a Japanese aerial photograph. What is remarkable about Droste's story, apart from the fact that he was 105 years old when he recounted it to Thompson-Gray, is that it may be connected to the Kennedy Hill photograph—Outlier 2 may, if fact, be the missing *X-28*.

Ten of the 15 flying boat wrecks have been located, six of which are exposed during the perigean spring low tides (i.e., low tides that occur when the moon is either new or full and closest to Earth). Only five exposed wreck sites have been identified. This paper argues that there are at least four deep-water wrecks that may have survived. HMAS *King Bay* salvaged at least two wreck sites in late 1942: Dornier *X-20* and an unknown aircraft wreck thought to be Dornier *X-3* (Outlier 1), lying to the west of Broome's old jetty. There are another three possible candidates for Outlier 2 in the Kennedy Hill photograph: a Liberator transport, a Zero fighter, or one of two Dornier flying boats that were well away from the main group of flying boat at the time of the air raid. Whatever the case, verification of identity will require additional remote sensing surveys of the deep-water sites.

GERHARD DROSTE

Gerhard Henri Droste was born on 15 November 1909 in Soerabaja (Surabaya), Indonesia, what then was the Netherlands East Indies. During the war, Droste was an aircraft mechanic and instructor in the MLD. He later worked on the RAAF Dornier flying boats that had managed to escape to Australia prior to the Japanese invasion of Indonesia and the subsequent air raid on Broome. On a couple of occasions, he flew on *X-8* (A49-3) with only two, instead of three, engines! He later flew with 321 Squadron RAF in Trincomalee. The Supreme Allied Commander in the East, Lord Louis Mountbatten, visited the squadron late in the war. During inspections, he paused to talk to *X-1* pilot Henk Hasselo, another Broome air raid survivor, and then also to Droste, standing two rows back (Thompson-Gray 2015:110). Unfortunately, Droste and Hasselo never met; if they had, Droste's story surely would have been recorded much sooner.

Droste married Elisabeth Welter on 18 August 1936 in Surabaya. While many MLD pilots brought their families out of Java with them to Broome, Droste's aircraft group did not. His family

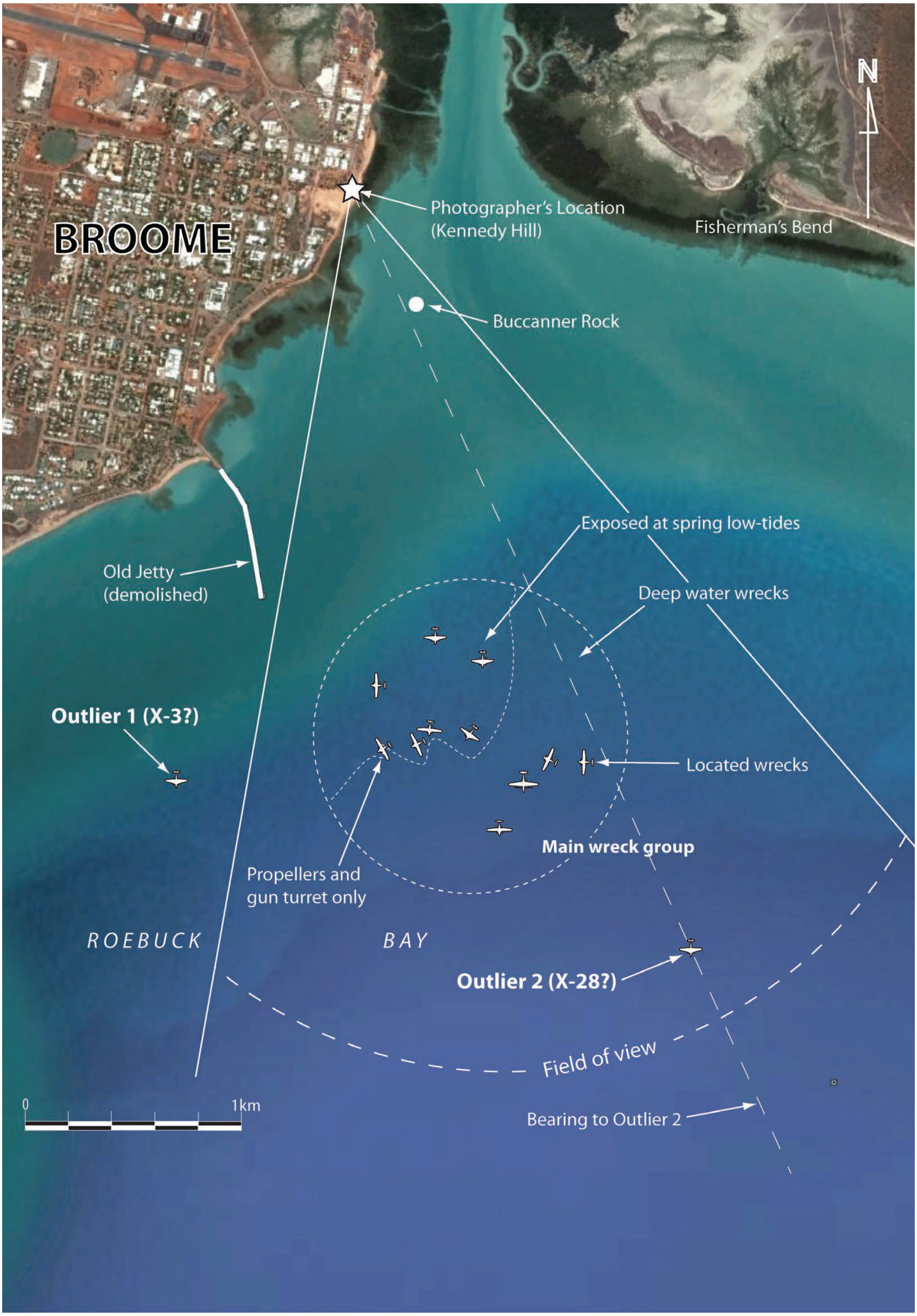

Fig. 3. Inferred location of two outlying flying boat wrecks (Outliers 1 and 2) in Roebuck Bay, Darwin (from NIMH Naam 018019).

Fig. 4. Photograph of Gerhard Droste from his Application for Registration in Australia, c. 1952 (DICA 1953–1985).

subsequently spent the occupation in the prisoner of war camp at Karangpanas in central Java. Droste thought that his family had died when he heard that a Japanese submarine had torpedoed the ship on which they were meant to be leaving Java, and he did not reunited with them until after the war. On 11 December 1950, Droste (Fig. 4), his wife and four children, Ingrid, Robert, Kitty and Gerhard Jr, arrived in Brisbane (DICA 1950, 1953–1985).

Fig. 5. Gerhard Droste and family on his 106th birthday, 15 November 2015, Brisbane (Courtesy of A. Neilsen).

Elisabeth would give birth to two more children, Antoinette and Eric, in Australia. Despite having flown 3,600 hours, almost two-thirds (2,200 hours) of which were flown in wartime operations, Droste did not speak much of the war and worked as a mechanic in his adopted country until his retirement (Robert Droste pers. comm. 2017). He died in Brisbane on 27 May 2016 in his 107th year (Fig. 5).

BACKGROUND TO THE AIR RAID AT BROOME

On 3 March 1942, the Japanese launched a surgical strike from Kupang, in modern-day Timor (East Nusa Tenggara), with nine Mitsubishi Zero fighters and one reconnaissance Mitsubishi C5M2 'Babs' monoplane. Two Zeros were lost: one was shot-down, although no-one witnessed it crash, and the other was ditched near an unknown island off Timor on its return flight to base. The Japanese destroyed 15 flying boats in Roebuck Bay and six aircraft on Broome's aerodrome, and shot down a B-24A Liberator off Broome's Gantheaume Point. Additionally, a DC-3 Dakota was shot down at Carnot Bay, just north of Broome, by the departing Japanese. The downed Liberator and Zero are of particular interest in this paper, as they are two of the four possible contenders for Outlier 2.

The Babs reconnaissance aircraft took a photograph of Roebuck Bay looking north, which shows a concentration of smoke columns on the bay and at the aerodrome (Fig. 6). The photograph is held at the Netherlands Institute for Military History (NIMH) in The Hague, along with several others that show the aftermath of the air raid at the aerodrome. In 2008, another photograph of the air raid on Roebuck Bay came to light, but this time the photograph was taken from the shore, at Kennedy Hill, near the Mangrove Hotel (Figs 7 and 8). It was shown to the author by NIMH aviation historian Nico Geldhof. No information about this photograph exists, but it provides a new clue as to the air raid: to the left of frame, between the main wreck group and Buccaneer Rock, is the smoke column from Outlier 2. Its position suggests that it belongs to a flying boat that was moving away from the main group when it was destroyed.

DEPOSITION THEORIES

Theory 1: Flying boat X-3

At first, Outlier 2 was thought to be the Dornier *X-3* (Outlier 1), whose pilot, *Sergeant Vlieger*/Flight

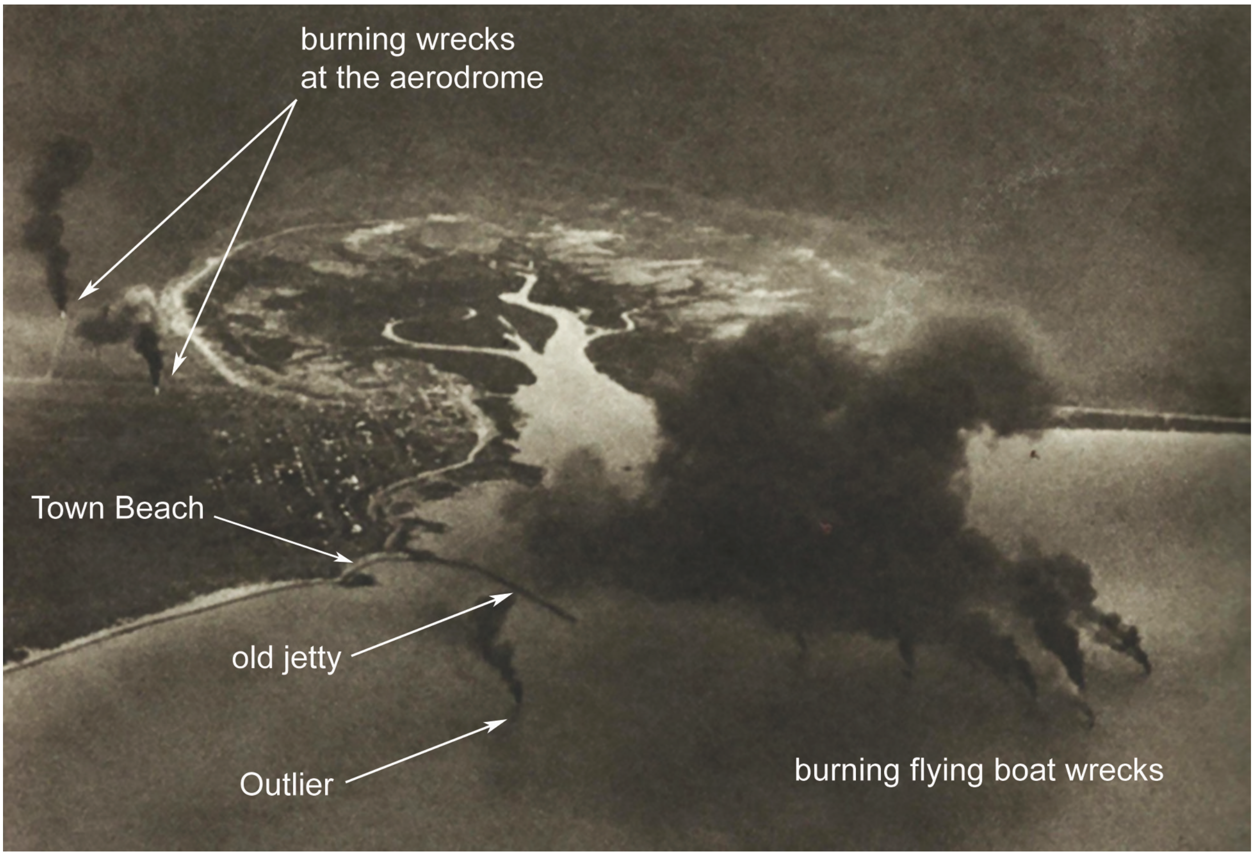

Fig. 6. Post-raid aerial photograph of Darwin and Roebuck Bay, taken by the Japanese Bab reconnaissance aircraft 3 March 1942 (A. Shinbum).

Sergeant (SGTV) E.J.H. Smitshuysen, said that any wreck found farthest out from the main group of flying boats would be his aircraft (Jung 2008:161). If in fact Outlier 2 is *X-3*, what aircraft then is Outlier 1? The author surveyed the site in 2003, but found no trace of any aircraft. Even at the lowest of spring tides, it is always submerged. It is possible that the wreck is completely buried on the seabed, but none of the other exposed wrecks is. The most probable explanations for the lack of evidence at the Outlier 1 location is that the wrecked aircraft was salvaged in its entirety, or the search was conducted in the wrong location and simply missed the wreck.

On the morning of 3 March 1942, when the *X-3* crew went to board their aircraft, they found it no longer where they had left it anchored the night before, unmanned; it had drifted off its anchor and was heading out of the bay. Luckily—or unluckily, perhaps—the anchor caught the bottom again, ending the *X-3*'s unmanned departure. Smitshuysen and two engineers rowed a dinghy out to the aircraft. This and the description of the *X-28*'s loss now provide two accounts of aircraft drifting off their anchor with the incoming tide. Both aircraft were separated from the main group when the attack occurred, accounting for two outliers.

Theory 2: Liberator transport

Kaigun-chūi/Sub-lieutenant (Lieutenant junior grade) Osamu Kudõ of the Imperial Japanese Navy shot down a United States Army Air Force B-24A Liberator (Serial No. 40-2374) while it was taking off over Cable Beach. The aircraft is generally believed to have crashed off Gantheaume Point (Prime 2004). Only one of the 20 persons on board survived, a Sergeant Melvin Donoho. His recollection of the incident suggests that the aircraft had just gotten airborne when he saw:

> [s]omething like an electric charge from a welding arc jumping, coming in one side of the fuselage above my head. It kept hitting the wall with splattering fire. When the flames caught, the people above me tried to get back to the tail in order to keep from being burned [Weller 1943:10].

The fully laden Liberator was operating an aero-medical evacuation to Perth. After taking off to the west of the aerodrome, the aircraft banked to the left and headed south when it is believed to have crashed off the lighthouse at Gantheaume Point. But, what if instead it kept banking left, turning to the south and then back to the east such that it crashed into Roebuck Bay? The size of the smoke column coming

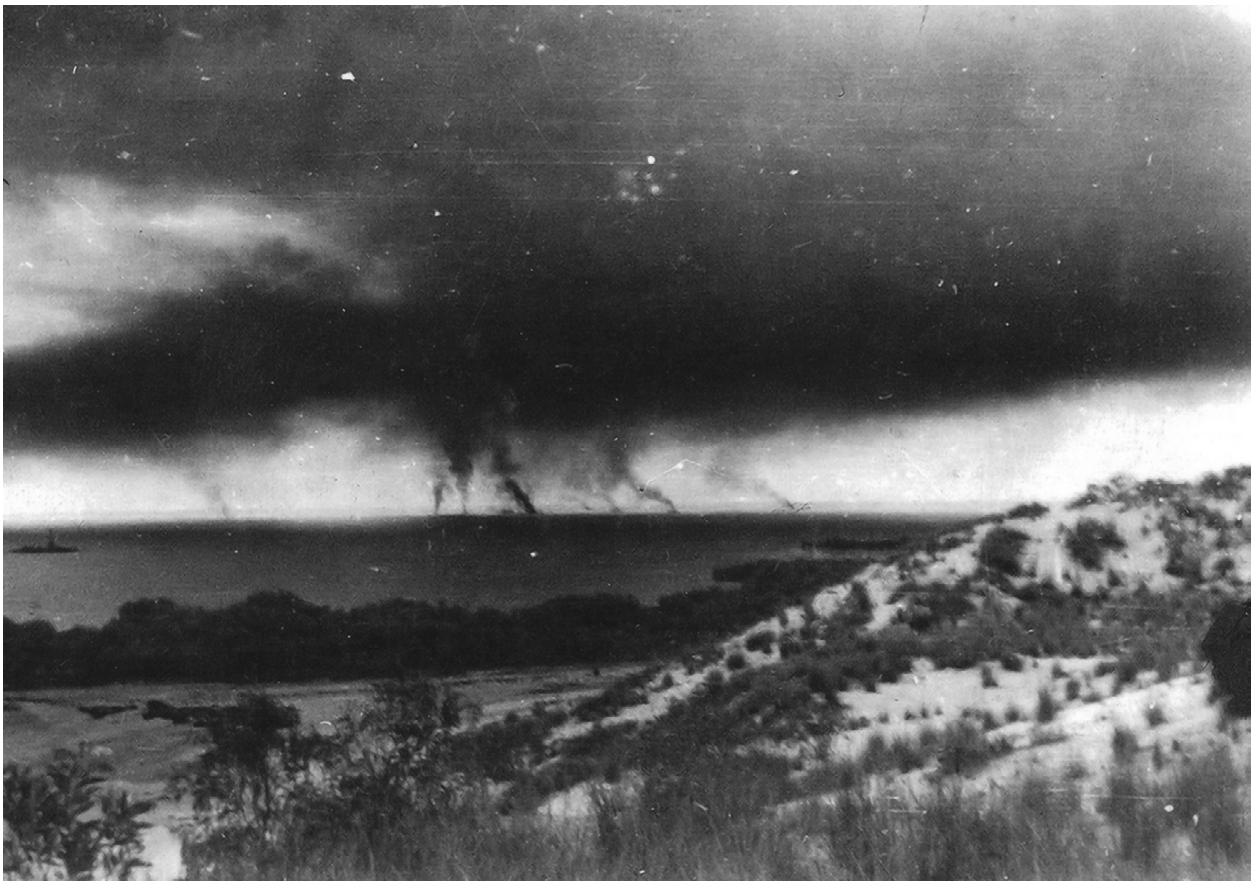

Fig. 7. Photograph of Roebuck Bay, taken from Kennedy Hill, showing flying boats on fire (courtesy of Nico Geldhof, National Institute for Military History, the Hague, Naam_018019).

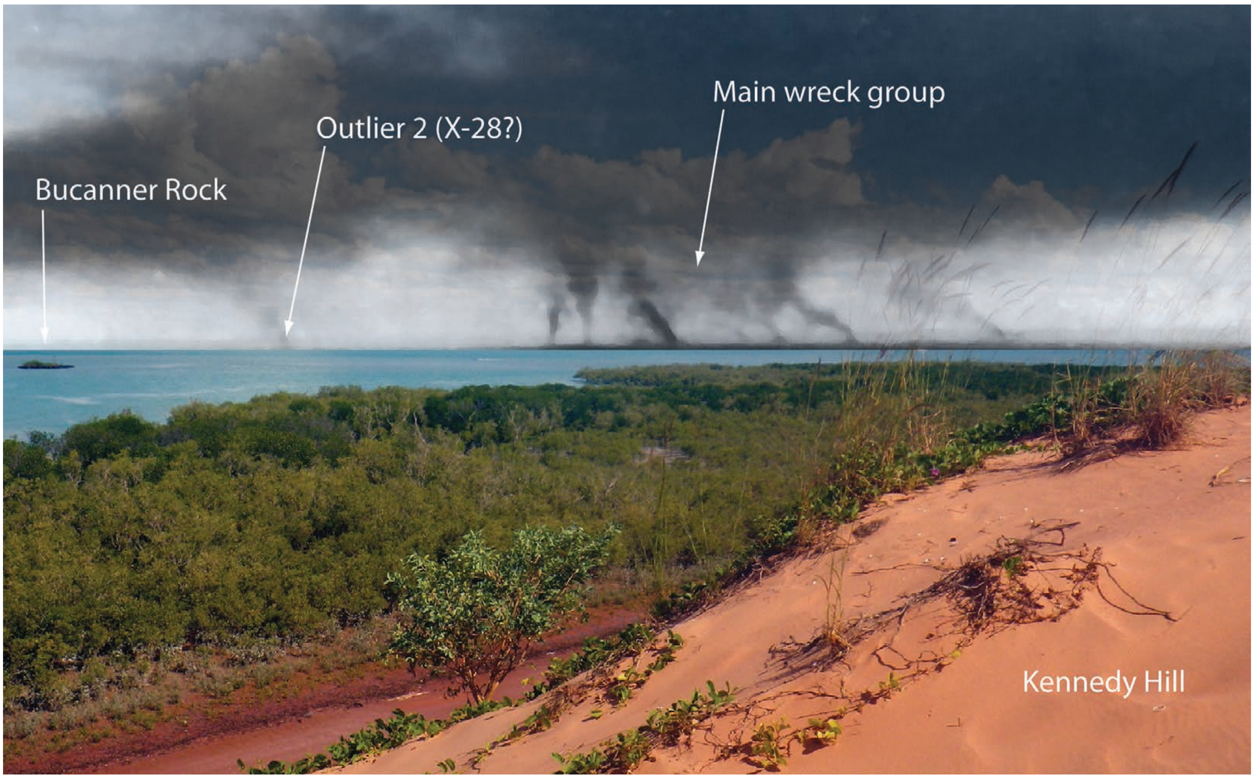

Fig. 8. Recreating the photographer's location at Kennedy Hill, with superimposed smoke columns (S. Jung, 2013).

from Outlier 2 certainly suggests the wrecking of a large aircraft.

Theory 3: Zero fighter

Kudõ was himself shot down while flying low over the aerodrome. Credit for the kill goes to Lieutenant (Lt) 'Gus' Winckel (deceased 17 August 2013 at age 100), who was fighting at the aerodrome at the time. No-one witnessed the Zero crash, though, to verify the kill.

There is another claim to the Zero's fate. Lt Cecil Knudson, co-pilot of *Arabian Knight*, another Liberator parked at the aerodrome, was in a slit trench nearby. He was firing a .30-caliber machine gun and "saw a Zero going down to the west that he believed he had hit" (Bartsch 2010:434). Once again, though, no one saw it crash.

Could Kudõ have crashed into Roebuck Bay? Does the outlier point to his grave? According to local Broome folklore, the indigenous Yawuru people of Broome found Kudõ's body hanging in a parachute caught in trees at Fisherman's Bend to the east. The Yawuru are said to have cut him down and buried him nearby (Jung 2013). The reported gravesite has never been excavated to determine if someone is buried there, but a group of stakeholders comprising Yawuru informant Jim Edgar, Broome Police, members of the Broome Historical Society's Museum and a delegation from the Japanese Ministry of Health, Labour and Welfare did inspect the site in 2016. Unfortunately, the gravesite was vandalised and disturbed since being reported, and the ministry assessed that it was too badly disturbed to warrant further investigation. Given that Kudõ is said to have been killed after bailing from his shot Zero and then buried at Roebuck Bay, could his pilotless aircraft have crashed into Roebuck Bay and be Outlier 2? There is no evidence as yet that Kudõ did in fact crash in the bay, and such an outcome would be at odds with Lt Knudson's account that the aircraft went down to the west of the aerodrome.

Theory 4: Flying boat X-28

Until the discovery of the Kennedy Hill photograph, Dornier *X-3* was the only known outlier from the main flying boat group (Fig. 3, 'Outlier 1'), and so it was thought to have sunk west of the jetty, as attested by the Babs photograph (Fig. 6, 'Outlier'). The jetty and Outlier 1 smoke column to its west are out of frame in the Kennedy Hill photograph (Fig. 7). Droste's account indicates that *X-28* also was standing well off the main wreck group when attacked, so Outlier 2 could be the wreckage of *X-28*, rather than *X-3*.

THE LOSS OF DORNIER *X-28*

Prior to Droste's account coming to light, all that was known of the loss of Dornier flying boat *X-28* was that a single crewman, *Milicien Matroos Telegraphist*/Militia Guard Telegraphist (MILMATRTLG) Henri Rudolf de Sera, was on board on anchor watch and was killed when the aircraft was destroyed. He is officially listed as missing, presumed dead (Crommelin 1948). The only other information on the aircraft is the crew list from its final flight (Table 1). Dornier Do 24K flying boats had a nominal crew

Table 1. *X-28* crew and passenger list at time of loss (Geldhof and Staal 2017:160)

No.	Name	Rank	Serial No.	Birth date	Birth place
1	CROMMELIN, R.M.	LTZ 1		19/04/1908	Leiden
2	DROSTE, Gerhard Henri	SGTVGMR	04561 (new) 291091D (old)	15/11/1909	Soerabaja
3	GREGORIUS, M.C.	MILSGTW	24411/D		
4	KEIMPEMA, P.A. van	VGMRMT	13410		
5	KEMPER, W.J.F.	SGTVGMR	7353		
6	KOPIJN, Th.	VGMRMT	20283		
7	MEULEN, Th. van der	SGTVGMR	11034	02/01/1909	
8	NYDAM [NIJDAM?], A.	LTZ 2 KMR			
9	SERA, Henri Rudolf de †	MILMATRTLG	20120/D	06/09/1920	Bandoeng
10	STEGEMAN, J. G.	LTZ 1		10/06/1912	
11	WASSENBERG, J.P.	SGTV	14305		

† = Killed during the air raid.

of seven; given that 11 people are recorded to have been on *X-28*, four persons must have been military passengers. According to van Wijngaarden and Staal (1992:98), *X-28* was ordered from Batavia (Jakarta) to Lengkong Lake on 1 March 1942, then left there the following day for Broome, where it arrived on 3 March. Other sources put the arrival of *X-28* at Lengkong on Saturday, 28 February 1942:

> As a result of the worsening situation, Do 24s *X-23* and *X-28* of GVT-6 were flown from Tanjong Priok to a hiding place at Lengkang [sic] on the Brantas River near Modjokarta, in the Sourabaya area, leaving there next night for Broome (29th), while the surviving aircraft of GVT-11 and GVT-12 also departed for Broome during the day [Shores et al., 1992:248].

> On 1 March the *X-3*, *X-23* and the *X-28* departed their flying base for shelter at Lengkong and the following night deviated to Broome where they were strafed and caught fire during a Japanese air raid [Geldhof 1987:69; translation by N. Heijm].

The aircraft arrived in Broome with Groep Vliegtuigen/Aircraft Group 6 (GVT-6), consisting of aircraft *X-3*, *X-23* and *X-28*. None of the aircraft in GVT-6 are recorded as having carried civilian passengers, only military personnel.

Droste's account is at odds with the current understanding of the aircraft's loss. It places civilian passengers on board together with the aircraft's entire crew, not just de Sera:

> The passengers were unable to find accommodation in town and returned in the early afternoon. This may have been a case of poor local management. With all the Japanese arrested and transported to the south eastern state, there had to be abundant vacancies at the Japanese boarding house in Short Street… [Thompson-Gray 2015:99].

Furthermore, Droste does not mention that de Sera had been killed. Just like *X-3*, *X-28* also drifted off its anchor on the incoming tide. Its drift to the southeast of the main wreck group is consistent with the approximate location of Outlier 2:

> Dornier type DO-24 serial number *X-28* had drifted off its anchor and was staging downstream from—and east of—the other flying boats in Roebuck Bay. Gerry Droste, Flight Engineer, was checking the anchor chain while some of the passengers and crew were sitting around enjoying the sunshine. They suddenly saw the Japanese planes coming in and heard gunfire and screams.
>
> Gerry remembers, 'No ammunition so it was time to get out. The noise of shooting, of small gunfire followed by slower cannon; noise of people screaming; sight of seaplanes burning, all the seaplanes burning; I had no way of returning fire but I had time to get out; tracer was running along the plane; no time to be frightened; no time to think about being killed; or who would be killed, and killed they were. The plane splintered open, caught fire and sank'.
>
> Treading water was no problem for a water polo player. Dornier *X-28* was strafed to death, sinking farthest from the wharf and farthest from the rescue vessels. Gerry started the long swim to shore. He would have made it despite being tired from four days of physical effort and lack of sleep. It was some time before Harold Mathieson and Charlie D'Antoine saw him and scooped him up in their refueling ketch, *Nicole* [sic] *Bay*. Gerry watched the crew at work, picking up survivors, cool temperaments, weaving amongst the wide patches of burning fuel [Thompson-Gray 2015:101].

X-28 had no ammunition, as it was involved with interdicting the Japanese invasion fleet heading towards Java on 26 February 1942:

> *X-28* attacked landing craft with bombs and cannons, exchanging machine gun fire between the beach and enemy aircraft … with its strike power spent, *X-28* slipped out of the battle unnoticed and returned to the Lengkong [Thompson-Gray 2015:96–97].

Survival was a miracle, which makes Droste's absence from the historical record of the battle, or even having been in Broome at the time, all the more strange. After being landed at the old Broome jetty from *Nicol Bay*, Droste was exhausted:

> Gerry was too spent to jostle for a seat in the passenger car. Instead, he laid back and closed his eyes for a recovery sleep on the unused flattop. As the train swept off the wharf at Town Beach, the official, believing Gerry dead didn't record his name. When the train stopped near the small Broome Hospital, Gerry sat up. Some passengers alighted for medical attention while the dead were unloaded. A few patients joined the train before it pressed on to meet a bus running from Streeter's to the airfield. Gerry waited with others in a medical centre next to military headquarters on the airfield…
>
> Gerry wasn't officially recorded to have been in Broome until 2014 when the author invited Kasper Kuiper, Netherlands Consul General, Queensland, to a 105th birthday lunch for Gerry at Compton Gardens in Brisbane (Thompson-Gray 2015:102–103).

In recognition for his continuous service in the East from 1938 to 1947, Droste was bestowed his service pin in 2014.

DISCUSSION

A smoke column outlier in the only known photograph of the air raid taken from the shore is now linked to another possibility as to what aircraft it might belong. Droste's account of the loss of his flying boat to the southeast of the main wreck group fits with the general area of Outlier 2. Figure

3 maps the main wreck and extrapolates the likely location of Outlier 2 to the southeast according to the photographer's field of view. Table 2 shows the archaeological matrix of Roebuck Bay. The data can be broken down thus:

1) 10 of the 15 destroyed flying boats have been found;
2) of the 10, only five have been identified; and
3) five wrecks are still missing. This number includes the empennage from a Catalina flying boat found in deep water (Jung 2008:236). This tail section does not necessarily delineate a main wreck site, as Catalina empennages have been found to move a considerable distance. In Darwin Harbour, for example, a Catalina tail was found in between two wrecks some two kilometres apart. Outlier 1 (*X-3*) is counted as missing as well and presumed salvaged.

It is interesting to note that neither of the US Navy's two Catalinas appears to have been located. The only conclusive evidence of a salvaged flying boat is a debris field found with objects stencilled with Dornier *X-20*'s serial number. If salvaged, then a debris field must exist similarly at the Outlier 1 site, but to date nothing has been found.

Artefacts have been a key indicator in identifying aircraft wrecks in Broome. The *X-1* wreck site was identified on the basis of tools marked with the aircraft's serial number having been found on the wreck site. Another example is Catalina *Y-59*, the subject of the first archaeological excavation of an aircraft site in Australia, conducted by the Western Australian Museum in 2001. That work yielded dinning forks marked with the aircraft's serial number. These are a poignant reminder of the many personal artefacts recovered, including children's toys, from wrecked aircraft known to have been carrying civilian passengers. If *X-28* was carrying civilian passengers, as Droste indicated, it too may have an assemblage of artefacts reflecting the accoutrements of civilian life.

CONCLUSION

Droste's account of the loss of his flying boat is but another piece of the Broome flying boat puzzle. It is the one and only account of the loss of the Dornier *X-28*. His account links a smoke column outlier to the wreck of *X-28*. Nevertheless, there are inconsistencies with his account of the air raid and others. Previously, it was thought that only one crewmember was on board *X-28* at the time of its loss; it is known now that there were at least two. Other crew and passengers from the aircraft must have found accommodation in town for the night. It is unlikely any civilians were on board, because, if there were, they would have been the families of the

Table 2. Broome Flying Boat Wrecks and Possible Contenders for Outlier 2 (Jung 2008)

No.	Aircraft wreck sites	Status*	Identified	Comments
1	Dornier Do 24K *X-1*	L	Yes	
2	Dornier X-3	M		West of jetty? Possibly salvaged
3	Dornier Do 24K *X-20*	L	Yes	Debris only. Possibly salvaged
4	Dornier Do 24K *X-23*	L	Yes	
5	Dornier X-28	M		West of jetty?
6	PBY-5 Catalina *Y-59*	L	Yes	
7	PBY-5 Catalina *FV-N*	L	Yes	
8	PBY-5 Catalina (Site 10)	L		*Y-67*?
9	PBY-? Catalina (Site 13)	L		
10	PBY-4? Catalina (Site 20)	M		USN - tail only, #6 or #7?
11	PBY-4 Catalina	M		USN - #6 or #7?
12	PBY-5 Catalina (Site 23)	L		*Y-60*, *Y-67*, *Y-70* or *FV-W*?
13	PBY-5 Catalina (Site 24)	L		*Y-60*, *Y-67*, *Y-70* or *FV-W*?
14	Short S.23 Empire Flying Boat	L		BOAC *Corinna* or RAAF *A18-10*.
15	Short S.23 Empire Flying Boat	M		BOAC *Corinna* or RAAF *A18-10*.
	Totals	10 located (5 identified), 5 missing		

* L = located; M = missing/not yet located; shaded = contender for Outlier 2.

crew. With Droste's account, we know now of at least one other person who was there. It is remarkable that Droste survived the air raid, and that it took until 2014 for his story to be recorded finally. Despite the wait, it well may help archaeologists identify one of the missing WWII flying boats sunk in Broome's Roebuck Bay.

Given that Droste's account of an event 72 years ago was recorded when he was 105 years old, it should be treated with caution. Why have there been no accounts of the other crewmembers of *X-28*? Droste was a survivor who saw his flying boat sink, and his description of how it was destroyed provides new insight into its site formation process. Droste stated that the aircraft caught fire; finding *X-28* at Outlier 2 will corroborate his story.

The Western Australian Museum has had an ongoing research programme at Broome since the 1970s (McCarthy 2017), but their last field survey and excavation was in 2001. The result of this paper establishes a research strategy for further fieldwork in Broome. The likelihood that Outlier 2 is the *X-28* is the most plausible explanation for the smoke column. The Liberator probably crashed off Gantheaume Point; the Zero likely crashed somewhere in the Timor Sea as it attempted to limp back to base; and *X-3* was wrecked at Outlier 1. Based on Droste's account, if future field surveys locate a wreck at Outlier 2, it is predicted to be that of the Dornier flying boat *X-28*. One may only imagine what other stories of Western Australia's worst air raid of WWII are yet to be uncovered, and what the archaeology of the wreck site might reveal.

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A Sheep in Wolf's Clothing: A Review of Ben Cropp's "Mystery Bomber" Wreck

DANIEL J. LEAHY

Abstract

In 2005, diver and filmmaker Ben Cropp visited an underwater aircraft wreck off the eastern coast of Queensland's Cape York Peninsula. It has been claimed that the wreck is that of an American four-engine B-17 bomber that went missing in 1943 with an air force General on board. A desk-based study of Cropp's video footage of the wreck by aviation enthusiasts has confirmed that it is not such an aircraft. Additional historical research and further analysis of the wreck footage has unearthed information that may suggest that the wreck is, in fact, an Australian transport aircraft that was ditched in the vicinity with no loss of life.

INTRODUCTION

In December 2005, Australian media reported that wreck diver and filmmaker Ben Cropp had located a large aircraft wreck off northern Queensland (Bilowol 2005). Following a later dive to film the site, Cropp stated that he was "99 percent" sure that the wreck was that of an American B-17 Flying Fortress that went missing in 1943 during a transport flight from Papua (current-day Papua New Guinea, or PNG; Fig. 1) (*The Age* 2007). Footage of the wreck subsequently was released in the documentary, *Search for the Mystery Bomber* (Cropp 2007), part of *Ben Cropp's Wild Australia* DVD series, in which Cropp declares that the wreck is "definitely a B-17".

Since 2007, there has been some disagreement between aviation enthusiasts and Cropp about the type and identity of the wrecked aircraft (see Pacific Wrecks 2018b). This paper presents the results of a study proving that the wreck is not a B-17 bomber, as described in media reports, and speculates on a potential candidate for its actual identity.

HISTORY OF B-17F 41-24384

Boeing B-17F Flying Fortress serial number 41-24384 was delivered to the United States Army

Fig. 1. The crew of an American B-17F Flying Fortress in front of their aircraft, similar to one that went missing on 23 March 1943 (National Archives 2007).

Air Forces (USAAF) on 22 June 1942 and arrived in Australia in August of that same year. Initially operated by the 19th Bombardment Group, the aircraft eventually was reassigned to the 63rd Bombardment Squadron of the 43rd Bombardment Group and modified for use on long-range reconnaissance missions (Birdsall 1998:7). The aircraft was referred to as 'Pluto', due to its painted nose art depicting the Disney cartoon character of the same name (Bowman 2003:42).

At 0915 on 23 March 1943, B-17F 41-24384 with twelve crewmen and passengers departed Port Moresby for a round-trip flight to Merauke and Horn Island to conduct aerial reconnaissance (Fig. 2). After a radio transmission from the aircraft approximately 20 minutes into the flight, nothing further was heard from its crew and the aircraft failed to arrive at any of its intended destinations (Musumeci 2014:558).

One of the passengers on board the aircraft was Brigadier General Howard K. Ramey, who only recently had been made commanding officer of the Fifth Bomber Command after the previous commander, Brigadier General Kenneth N. Walker, went missing in action over Rabaul in January 1943 (Kenney 1949:176, 181). General Ramey had received the American Distinguished Service Cross (DSC) for his leadership between January and March 1943, which included the Battle of the Bismarck Sea. He and the other eleven American servicemen on board the B-17 are still listed as missing (Pacific Wrecks 2018a).

BRIEF DESCRIPTION OF THE WRECK SITE

The wreck site as it appears in Cropp's documentary includes the centre wing section, with nacelles and engine mounts visible, and two radial engines, both detached and lying forward of the wing. The engines appear to be covered by round cowlings and each is fitted with a three-blade propeller. A tyre can be seen in a vertical position, still attached to its retracted undercarriage within the nacelle located behind where the detached engine was once mounted. There is a large notch cut out of the upper edge of the ring visible on the front of the engine mount. The positions of the wheel and undercarriage and ring notch indicate that the wing section is sitting upright on the ocean floor.

In the documentary, Cropp and his son, Dean, seek to identify the engine type by counting the number of cylinders. They tether one of the detached engines to their boat and roll it onto its back to expose the cylinders, after which the younger Cropp counts out nine cylinders.

The location of the wreck has been described

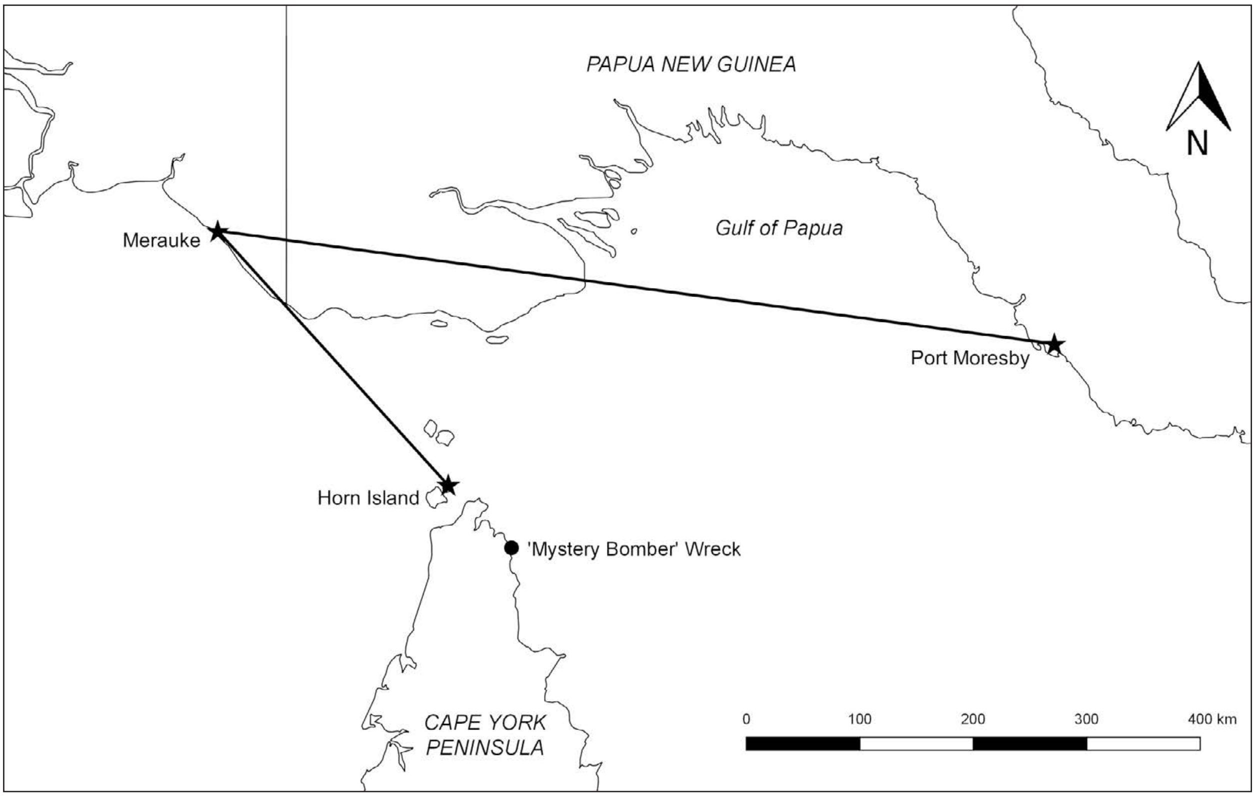

Fig. 2. Approximate flight plan of B-17F 41-24384 from Port Moresby to Horn Island via Merauke.

as both "55 km south of Albany Passage" (The Age 2007) and "30 miles [48.3 km] south of Albany Passage" (B. Cropp pers. comm. 2015). For the purpose of this report, these will be designated waypoints WP2007 and WP2015, respectively. The wreck has been entered into the Australian National Shipwreck Database (ANSD) with Aircraft ID Number 11178 (DEE 2017), but to date no one has conducted an archaeological investigation of the site.

DISCUSSION

If the aircraft indeed is B-17F 41-24384, then the wreck location would mean that the plane successfully flew from Port Moresby to Merauke, but then overshot the Horn Island airfield by more than 70 km to the southeast before crashing. While such overflights are possible, the fact that nothing was heard from the crew after the initial radio transmission and the aircraft was not sighted at either Merauke or Horn Island suggests that it was probably lost while enroute over the Gulf of Papua.

The source of the confusion over the type of aircraft may have been Cropp's initial assessment that the wreckage contained three engines (Bilowol 2005). An allied aircraft with three or more engines lost in this area would almost certainly be a B-17 Flying Fortress or a B-24 Liberator, both of which were powered by four radial engines. The undercarriage on B-17 aircraft retracted into the nacelle behind the engine, whereas the undercarriage on B-24 aircraft retracted into the undersurface of the wing. Cropp has used this feature to potentially identify the aircraft type (*The Age* 2007; Cropp 2007); however, while such an assessment might have been appropriate for a four-engine aircraft, it does not appear to have been revised to allow for other—smaller—aircraft types once Cropp began reporting that only two engines were present at the wreck site (*The Age* 2007).

Soon after imagery of the wreck was released through Australian media in 2007, a number of aviation enthusiasts concluded that the wrecked plane was not a Boeing B-17 Flying Fortress and published their findings online (see Pacific Wrecks 2018b). The most telling piece of evidence was footage of the x-shaped undercarriage leg retracted inside the nacelle. Although the undercarriage on B-17 bombers did retract into the nacelle, its design was markedly different to that found on the wreck. On the other hand, the x-shaped bracing of the undercarriage leg found on the wreck perfectly matches that of the Douglas DC-3 family of aircraft, which includes the C-47 Dakota military transport

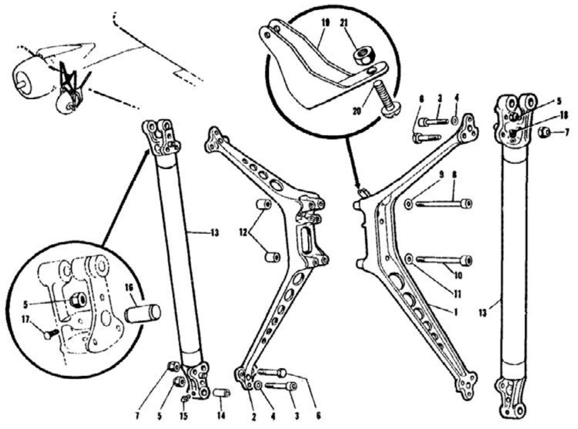

Fig. 3. Landing gear assembly of the Dakota C-47 (reproduced from USAF 1956:308).

(Fig. 3); in fact, it is a diagnostic feature of the type (Leahy 2018:2–3).

The notch previously described in the ring on the engine mount also is indicative of a C-47 type aircraft, as it perfectly matches those shown in technical manuals for the type (see, e.g., USAF 1956:328) and such a feature does not appear on the same ring structure on B-17 type aircraft (USAAF 1944:183–184). Finally, the fact that the wing section sits upright on the ocean floor suggests that the aircraft may have been ditched deliberately prior to sinking, rather than having met its demise in a more catastrophic way (e.g., crashing into the ocean in poor weather).

Although the documentary states that the engine had nine cylinders, supporting its identification as a Wright R-1820 Cyclone engine as used on B-17 type aircraft (White 1995:331–337), the methodology employed appears to have been conducted in an extremely hurried manner for the benefit of the camera. While early DC-3 type aircraft are known to have used R-1820 engines (White 1995:216), it is believed that a more systematic and thorough examination of the engines would determine that they have an additional five cylinders. This would indicate that the engines are Pratt & Whitney R-1830 Twin Wasps, which had a two-row, 14-cylinder, air-cooled radial design with seven cylinders on a row. In doing so, this, along with the other evidence presented in this paper, would confirm that the aircraft is in fact a Douglas DC-3 type aircraft.

The Douglas DC-3 was a twin-engine civilian aircraft operated by numerous airlines prior to World War II. At the outbreak of the conflict, a number of the civilian aircraft were pressed into military service, while a military equivalent, the C-47 Dakota, was developed for the war effort (Fig. 4). Over ten

Fig. 4. Ex-RAAF C-47 Dakota A65-64 on display at Mulwala, New South Wales (D.J. Leahy, 2014).

thousand C-47 type aircraft were produced by the United States, with 124 being operated by the Royal Australian Air Force (RAAF), the last of which was retired in 1999 (RAAF Museum 2009).

Despite these conclusions being published online since 2007 (see Pacific Wrecks 2018b), the *Search for the Mystery Bomber* documentary was uploaded to the Timeline channel on YouTube in February 2018 (see Cropp 2018). The continued release of the unedited version of the documentary in this way has perpetuated the false identity of the wreck. Such actions are irresponsible, especially considering that the misidentification might raise the hopes of those related to missing aircrew.

A possible identity

On 13 December 1943, RAAF C-47 Dakota serial number A65-3 was to have departed Townsville for a flight to Merauke via Cooktown and Horn Island (RAAF 1943c). Having remained grounded at Cooktown overnight due to severe weather, the aircraft took off at 0631 hours the following morning with three crewmembers, a number of passengers and cargo bound for Horn Island. After about two hours, the aircraft's port engine failed and, due to its weight and the inclement weather, the aircraft was forced to ditch in the sea at a point initially reported as being "40 miles [64.4 km] south of Horn Island" (waypoint WP1943a) (Kelly 2006:463–464; RAAF 1943a).

All of those on board the aircraft survived the ditching and managed to stay afloat using the aircraft's sole dinghy, which was located later that day by an RAAF Beaufort bomber searching for the overdue aircraft. The servicemen subsequently were picked up by an RAAF search and rescue vessel and taken to Horn Island (Kelly 2006:464; RAAF 1943a, 1943c). One member of the crew, Flight Sergeant Thomas Henry Dennis, was later awarded the George Medal (GM), the British Commonwealth's second highest non-combatant award for bravery, for "Outstanding courage & devotion to duty after [an] aircraft crash" (Australian War Memorial N.D.; Kelly 2006:464).

The aircraft was declared as a "total loss" and approval was given to "write off" the aircraft just six days after the ditching. The position of the wreck was reported as being one mile offshore at a point "10 miles [16.1 km] South [of] Turtle Head, N[orth] Queensland" (waypoint WP1943b) (RAAF 1943b, 1943c, 1943d). There is no reference in the historical record of any attempt to salvage the aircraft. A third

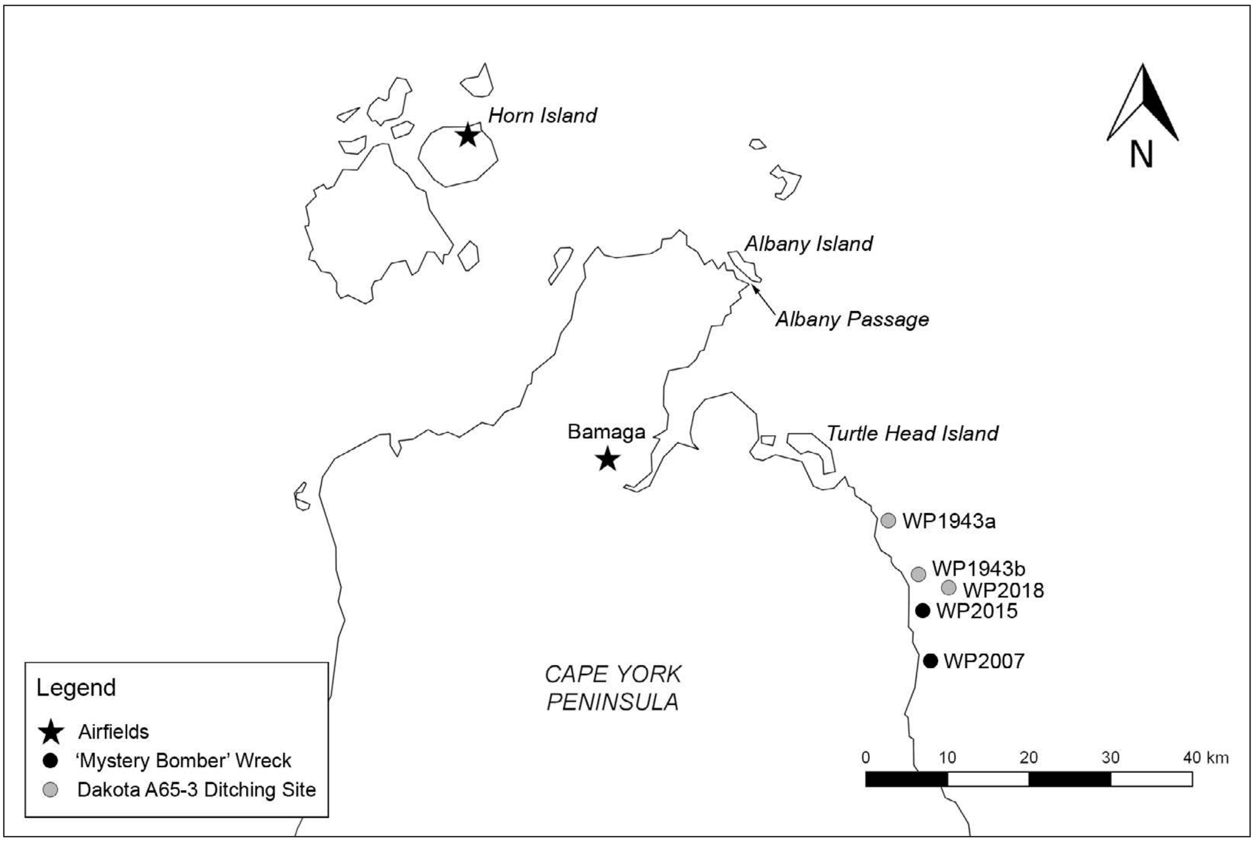

Fig. 5. Map of Cape York Peninsula showing the approximate reported locations of the 'Mystery Bomber' wreck site and ditching site of Dakota A65-3.

reported location for the ditching of Dakota A65-3 (waypoint WP2018) is 11° 05' S, 142° 50' E (-11.0833, 142.8333) (Birkett 2018).

Built at the Douglas Aircraft Company's plant at Long Beach, California, this aircraft was originally delivered to the USAAF on 31 January 1943 with serial number 42-32786, before being delivered to the RAAF and re-numbered as A65-3 on 4 March 1943 (Baugher 2018; RAAF 1943b). During its short service with the RAAF, the aircraft was operated by No. 36 Squadron in Australia and New Guinea (RAAF 1943c).

Dakota A65-3 was the same type of aircraft that had been identified through analysis of Ben Cropp's wreck footage (Pacific Wrecks 2018b). Furthermore, documentary evidence has confirmed that, at the time of its loss, the aircraft was fitted with Pratt & Whitney R-1830 Twin Wasp radial type engines (RAAF 1943b). As the approximate locations for the wreck provided by Cropp (waypoints WP2007 and WP2015) are within kilometres of the approximate locations reported for the loss of Dakota A65-3 (waypoints WP1943a, WP1943b, and WP2018), it is quite possible that the wreck visited by Cropp was actually that of RAAF Dakota A65-3 (Fig. 5).

Although Dakota A65-3 is a likely candidate for the identity of the wreck, it should also be noted that other Douglas DC-3 type aircraft are still missing in the waters between Queensland and Papua New Guinea. These include, but may not be limited to, C-49 41-7694, lost on 8 April 1943, and C-47 43-16011, lost on 27 March 1945 (Musumeci 2014:566–568; Pacific Wrecks 2018b).

CONCLUSIONS

A desk-based study of the wreck site by aviation enthusiasts based on information and footage obtained by Ben Cropp has demonstrated that the wreck comprises the remains of a Douglas DC-3 (or similar) type aircraft and not of a B-17 Flying Fortress, as was claimed by Cropp and the media in 2007. This study has further confirmed that assessment and provided what the author believes may be a good potential identity for the wreck based on the historical information currently available. Ultimately however, providing an exact identity for the aircraft will not be possible without an archaeological investigation being conducted at the wreck site. It is hoped that this study will raise interest in the wreck and encourage a formal investigation to both make an accurate identification and properly document and protect the site from further disturbance.

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CONTENTS

Number 42 **2018**