The International Journal of Nautical Archaeology (1994) **23**.3: 173–188

Historic shipping on the River Murray, Australia: a guide to the shipwreck resource

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Introduction

The purpose of this paper is to describe some aspects of the shipwreck resource that is the remains of historic shipping on the R. Murray, Australia. The following assessment draws on investigations conducted as part of two projects undertaken by heritage management departments in three states: South Australia (SA), Victoria (Vic.) and New South Wales (NSW).

The combined Murray Darling Basin catchment area covers one-seventh of the Australian continent. Its course transverses 2,500 km from the Eastern Highlands in New South Wales through to the Murray Mouth in South Australia and the Southern Ocean. The extent of the combined survey region is shown in Fig. 1. Historically, the river was dubbed the 'Nile of Australia' and its potential as a major transportation network was likened to that of the Mississippi. Settlers, traders and shipbuilders were soon to realise that very different environmental and economic parameters were in operation. The period 1830–1939 defines the chronological limits of what was a dynamic but short-lived trade fraught with political intrigue and inter-state rivalry.

The archaeological sites that encompass historic shipping on the R. Murray were documented within the environment of the cultural landscape (Kenderdine, 1993a; 1993c; 1993d). This allows the matrix of terrestrially located sites such as wharves, jetties, landings, slips, docks, crossings, bridges, customs houses, locks and weirs, and even grave sites, in addition to the wreck-sites of paddle steamers, barges, punts and ferries, to be interpreted together. Given the volume of material collated on these terraqueous remains, the discussion below will be restricted to a synthesis of the shipwreck resource and includes: a review of the types of vessels employed as part of the historic shipping trade; the number of these that now appear in the archaeological record; the spatial distribution of wreck-sites along the river; the evolution of design in paddle steamers; and the adaptation of technology to the riverine environment and the economics of the trade.

The results of these projects form a basis for hydroarchaeology by providing direction for future research into a scantily documented Australian shipbuilding industry, and as opportunities for exploring management issues in a multi-state, multi-jurisdictional and multi-user environment.

Project design and methodology

The initial methodological component of each project involved the thorough research of all archival, pictorial and oral sources that could lead to the identification and historical assessment of the archaeological sites. Field methodology differed substantially in approach owing to the budget and time constraints of the subsequent survey. In South Australia an integral part of the documentation process involved extensive remote sensing (magnetometer and side-scanning sonar) (Jeffery and Kenderdine, 1994) and the verification of sites through diving. Conservation assessments (including corrosion potential measurements) were also carried out on a number of sites (Kenderdine, 1993a). The NSW/Vic. brief stipulated (only) the recording of sites visible at the time of the survey or known to exist through local knowledge or historical information. In a riverine environment with substantial fluctuations in

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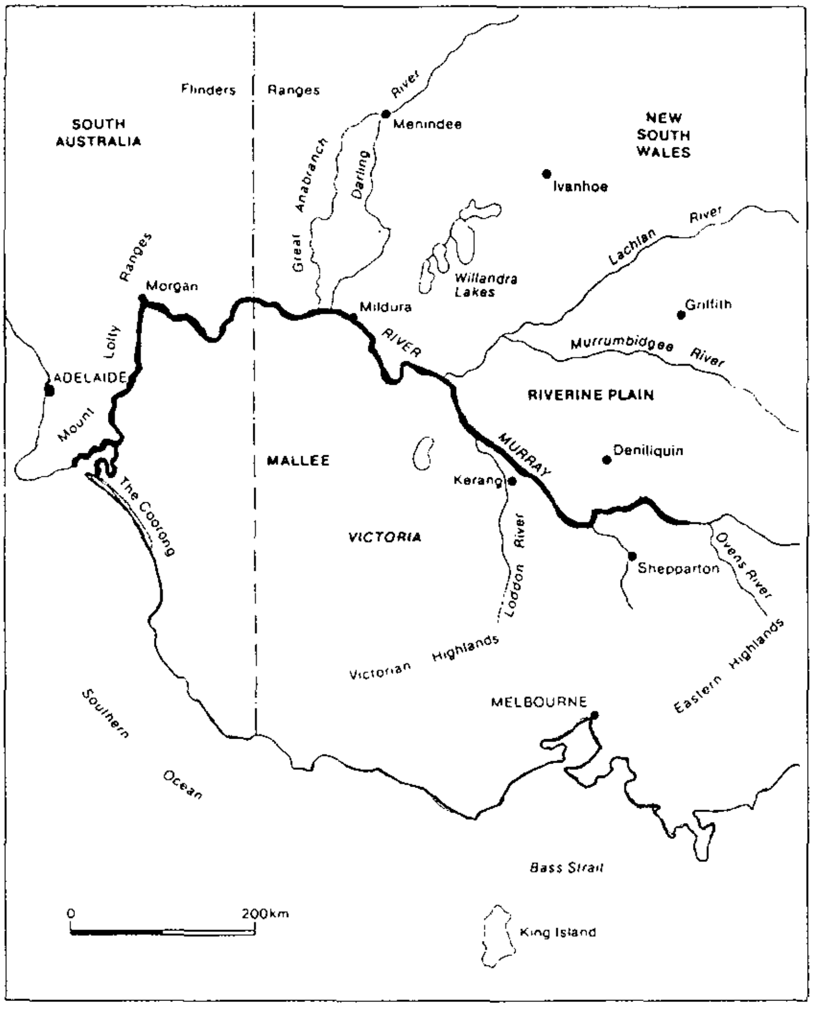

Figure 1. The extent of the combined survey region from the Murray Mouth to Albury.

level, despite the extensive lock, weir and dam system of controls, it was fortunate that field work for this project took place at a time of unseasonally low water.

The success of both projects at a field identification level was largely due to community members along the river who were able to bridge the gap between the archival sources and the actual location of sites. Many participants were either descendants of those who worked as river captains and engineers, or who were themselves involved in the latter days of operation of the trade.

Types of vessels

The wreck-sites in the R. Murray are reminders of functions performed by river boats during the historic shipping period (Fig. 2). Some were exclusively designed for a particular purpose whilst others were relegated to a number of duties. Paddle steamers were employed to hawk goods to settlers; mail steamers provided the essential service following the overland routes to Melbourne; mission boats offered the services of chapel and priest; and as passenger vessels they revived a trade in decline and offered viable service as late as the 1950s. As commercial

Figure 2. Vessels waiting to unload slightly below the Morgan Wharf. (Engineering and Water Supply photographic collection, Berri.)

trading steamers they transported wool, timber, hides and wheat from the upper reaches to railheads of downstream ports; they were used for lock building and in irrigation developments; or developed as clearance steamers for the maintenance of a navigable channel.

Barges hauled the bulk of produce from the upper river to transit points. Up to three at a time were pushed by steamers, towed or lashed alongside. They were used in lock construction, carting quarried rock along the river. They were also converted to pontoons for use in the development of irrigation.

A host of small fishing schooners supported a major fishing industry in the lower lakes system. Small motor launches were used for milk collection in pastoral districts. Ferries or punts provided vital links and, when obsolete, were often put to use transferring livestock to richer pastures.

The wreck resource of the R. Murray

At the completion of the second survey one hundred and thirty wreck-sites had been identified: New South Wales recorded sixty-five sites, South Australia sixty-one sites and Victoria four. The low number of sites recorded in Victoria is determined by a legal definition initially enacted in the *River Murray Act 1915* which gives jurisdiction over the river bed to the high water level to New South Wales. The number of vessels constructed between the 1850s and 1920s consisted of 218 paddle steamers and 147 barges; approximately one third (28%) have been identified.

The wreck-site totals show that paddle steamers and barges tend to predominate (Table 1). The basis for this analysis was rig type as recorded at the time of wrecking. Figures 3 and 4 show the location of wreck-sites identified in the two surveys, and Tables 2 and 3 detail vessel names, rig type and environmental status (for SA only) at the time the site was inspected.

Wreck-site environment

The wreck-sites surveyed reside in three basic environments (dry, part submerged or fully submerged). These largely determine the nature of the site inspection, survey, excavation and recommendations for management. It is also the determining factor in the preservation of sites. Given the fluctuations in river levels, riverine sites may be frequently exposed and then inundated. The field work programme (June, July, August 1993) for the NSW/Vic. survey was undertaken during exceptionally low water. The following October (1993) flooding in the region was recorded at levels comparable with the last historic flood of 1957,

Table 1. *Number of vessel types occurring in each State*

State	Paddle steamers	Barges	Ferries	Other
New South Wales	18	37	1	9
South Australia	27	20	6	8
Victoria	0	1	3	0

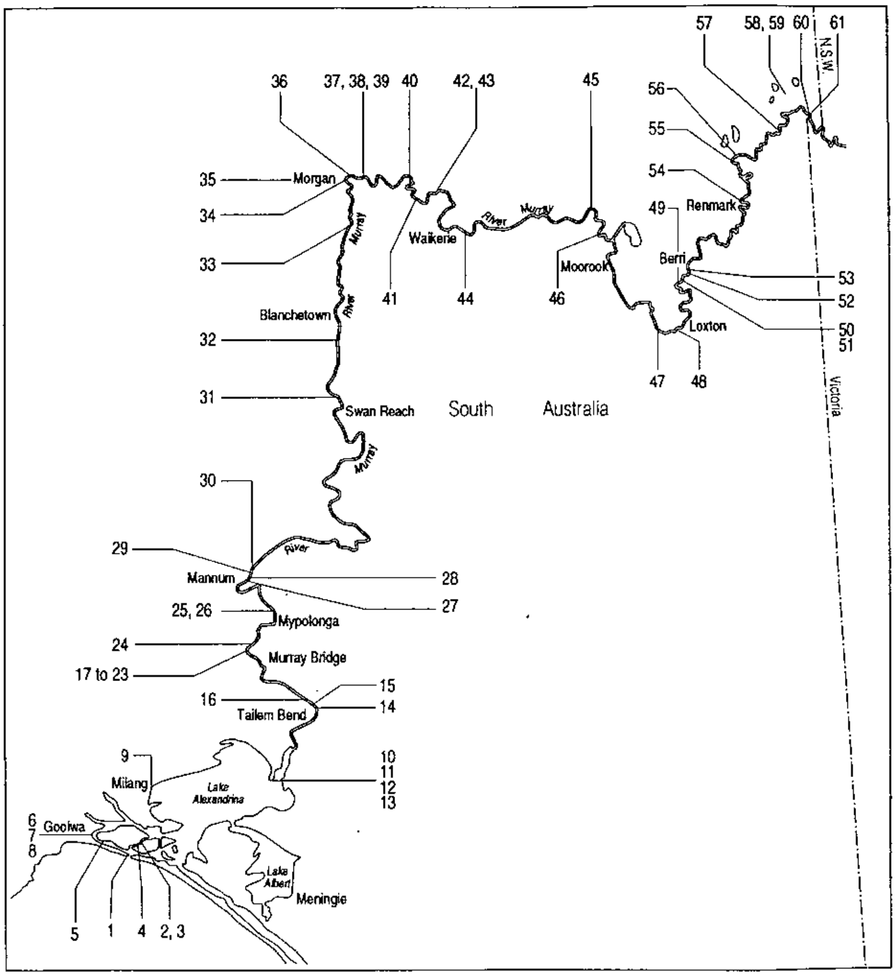

Figure 3. Wreck-sites located in South Australia.

causing millions of dollars worth of damage. As a result, all sites recorded as part of the survey, including terrestrially located sites, were inundated and subject to a new set of environmental parameters resulting in burial, siltation and possible destruction from flood waters. Given the changeable nature of wreck-site environment it is best for comparative purposes to assess the status of vessels in relation to pool level (Table 4).

Process of wrecking

In order to make a significance assessment of vessels that form part of the wreck universe, and to formulate recommendations for these, it is useful to establish the mode of deposition or process of wrecking, particularly for vessels that have not been sighted and are known only through historical records and oral sources.

The 'date of wrecking' so often applied to shipwreck sites at sea around Australia is not available in most cases for R. Murray wrecks. The majority of vessels were recorded as having been 'abandoned' or to have 'sunk'. With no absolute date for wrecking it is impossible to assess the average lifespan of vessels. Within the survey region it appears that some vessels were not lost until the late 1940s and early 1950s, several decades after their trade had finished. The use of these vessels in tourism is perhaps a reason for the extended duration of their operation.

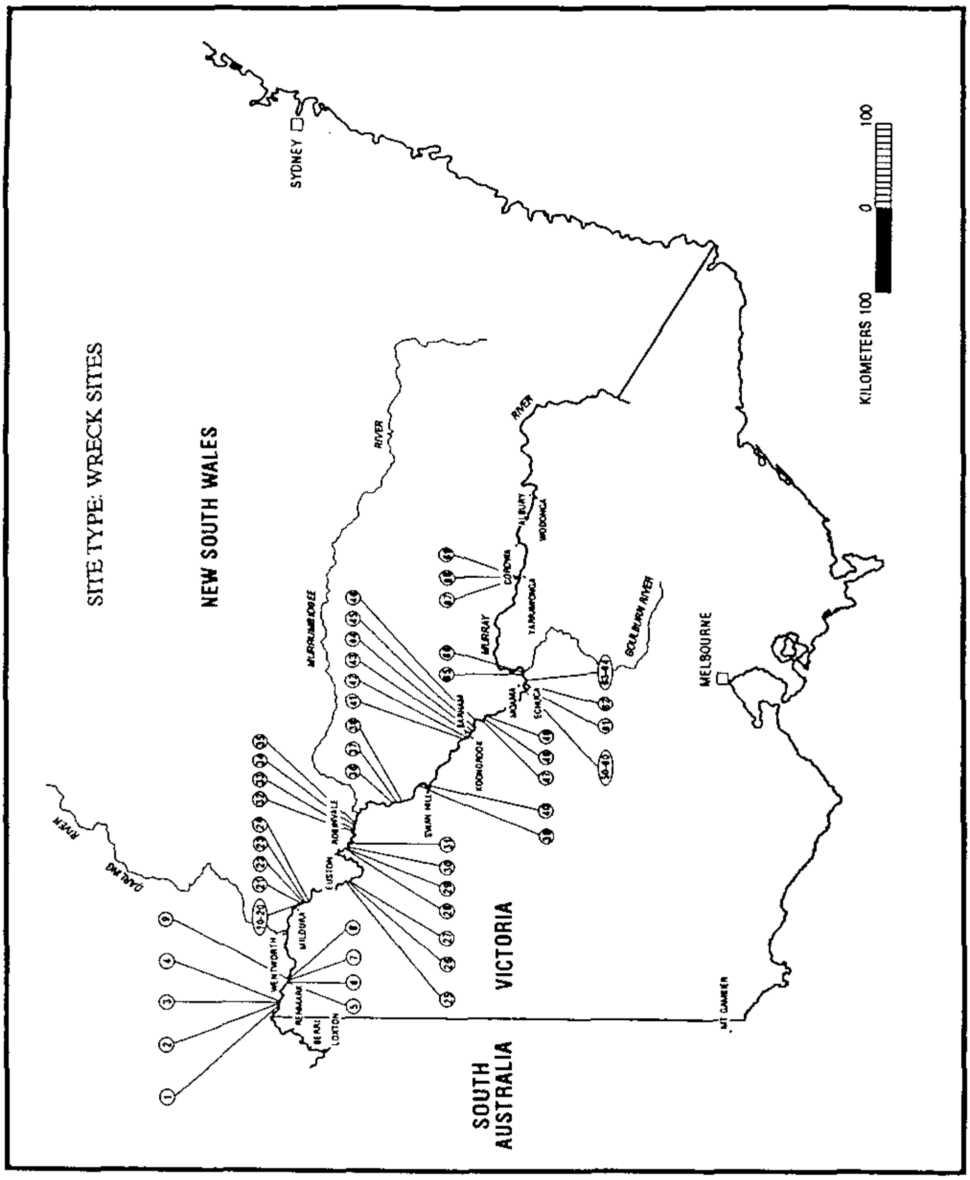

Figure 4. Wreck-sites located in New South Wales and Victoria.

Table 2. *South Australian wreck-sites*

No.	Name	Last known rig	Position
1	*Melbourne*	paddle steamer	submerged
2	*Albert*	barge	dismantled
3	*Wilcannia*	paddle steamer	dismantled
4	ex *Narrung Punt*	punt	part submerged
5	*Showboat*	twin screw motorboat	part submerged
6	*Renmark*	paddle steamer	submerged
7	*Uranus*	barge	part submerged
8	*Albion*	barge	dismantled
9	*Invincible*	paddle steamer	dismantled
10	*Waterlilly*	screw vessel	submerged
11	*Mosquito*	schooner	submerged
12	*Bullfrog*	cutter	submerged
13	*Sunbeam*	screw steamer	submerged
14	*Roma*	paddle steamer	submerged
15	Un. Id. Barge 1	barge	part submerged
16	*Pearl*	barge	submerged
17	*Murrundi*	paddle steamer	submerged
18	*William Davies*	paddle steamer	submerged
19	*Merle*	paddle steamer	submerged
20	*Eva*	paddle steamer	submerged
21	*Bijo*	paddle steamer	submerged
22	*Columbia*	barge	submerged
23	*Alfred*	stern wheel paddle steamer	submerged
24	*Tyro*	paddle steamer	submerged
25	*Bourke*	barge	submerged
26	*Queen*	paddle steamer	submerged
27	*Saddler*	paddle steamer	submerged
28	*Mary Ann*	paddle steamer	submerged
29	*Koondrook*	barge	dismantled
30	*Struggler*	paddle steamer	submerged

(*Continued*)

The process of wrecking is important because it relates to the expected condition of remains. Abandonment and eventual sinking implies that a vessel has been stripped of all moveable items, and even the difficult to move, but valuable, boiler and engines. Cargoes and material remains of the crew are unlikely to be found. However the extant remains of vessels potentially provide an accurate chronology of design and a typology of machinery, boilers and engines that reflect the environment, economy and function of these vessels.

Examination of the government documents on shipping casualties that record shipwrecks and other non-fatal accidents to vessels revealed little information of this type. Newspapers and personal accounts including oral histories and diaries, together with the records of shipping companies and the recordings on river charts, however, give an idea of the sorts of hazards that were commonly involved in vessel stranding and wrecking. These included numerous snaggings, founderings and references to wind and dust storms, boiler explosions and burning. Unexpected floods and sudden drops in the river levels could leave a vessel stranded or with broken back, and/or filled with water.

Snags were early recognized as hazards to navigation and presented a formidable danger to all riverine craft, but the lightly constructed, powerful and overloaded steam boats were especially vulnerable. It is not known how many of the registered 'sinkings' can be attributed to snags. Examination of sites could reveal such information.

Boiler explosions were especially destructive, although no wrecks in NSW and Vic. are

Table 2. Continued

No.	Name	Last known rig	Position
31	Un. Id. Punt 1	punt	part submerged
32	*Water Witch*	cutter	submerged
33	*Swallow*	screw steamer	submerged
34	*Crowie*	barge	submerged
35	*Corowa*	stern wheel paddle steamer	part submerged
36	Un. Id. Barge 2	barge	submerged
37	*Annie*	barge	part submerged
38	*Ormond*	barge	part submerged
39	*Loxton*	barge	part submerged
40	Un. Id. Punt 2	punt	submerged
41	*City of Oxford*	paddle steamer	submerged
42	*Cobar*	barge	part submerged
43	*William R. Randell*	paddle steamer	part submerged
44	*J. G. Arnold*	paddle steamer	submerged
45	*Vesta*	paddle steamer	submerged
46	*Derrick 1*	barge	submerged
47	*Jolly Miller*	paddle steamer	submerged
48	Un. Id. Punt 3	punt	part submerged
49	*Renella*	paddle steamer	submerged
50	*Archilles*	barge	part submerged
51	*Ajax*	barge	part submerged
52	*Undaunted*	ketch	submerged
53	*Ventura II*	paddle steamer	submerged
54	*Milang*	paddle steamer	submerged
55	*Jessie*	barge	submerged
56	*Kelvin*	paddle steamer	part submerged
57	*Chowilla Punt 1*	punt	part submerged
58	*Chowilla Punt 2*	punt	part submerged
59	*Bunyip*	paddle steamer	submerged
60	*Albermarle*	barge	part submerged
61	*Wardell*	steam snagging barge	part submerged

known to have been sunk from this cause. Fire was the most destructive of steam vessel disasters. Wood for the steam engine was stored in the stokehold, quite near the firebox. It was possible for sparks to settle and smoulder, and later flare (Tucker, 1985: 70). The practice of carrying flammables such as gunpowder and kerosene was common. Fire would destroy a wooden or composite vessel at least to the waterline.

Dust storms in the river region often limited visibility; navigation during these times was especially hazardous. Floods in areas where the river banks were devoid of trees also presented difficulties, and navigators would be unsure whether they were still on the main channel. Overhead cables, trees and other structures also presented hazards, especially to those barges laden several tiers high with wool.

Spatial analysis and site distribution

Some predictable but informative indicators about the process of wrecking and the development and decline of the trade can be observed in the distribution of sites along the R. Murray. An initial analysis indicates the following:

1. There are a greater number of wreck-sites found per river mile in the lower South Australian section of the survey region, perhaps suggesting that as trade declined vessels delivered their last services downstream and stayed there.
2. In the NSW/Vic. section of the river, clusters of sites occur adjacent to former sawmilling operations—a high proportion of barges were abandoned as the timber became more scarce and mills ceased to operate.

Table 3. *New South Wales and Victorian wreck-sites*

Ref No.	Name	Last known rig	State	Status
1	*Croupier*	barge	Vic.	part submerged
2	Un. Id. Ferry L1	ferry	Vic.	part submerged
3	Un. Id. Ferry L2	ferry	Vic.	part submerged
4	Un. Id. Ferry L3	ferry	Vic.	part submerged
5	*Manno*	dredge	NSW	part submerged
6	*Success*	paddle steamer	NSW	part submerged
7	*Emerald*	barge	NSW	part submerged
8	*Sapphire*	paddle steamer	NSW	part submerged
9	90FT Derrick	derrick	NSW	submerged
10	*Jane Eliza*	paddle steamer	NSW	submerged
11	*Cowirra*	barge	NSW	dismantled
12	*A.11*	barge	NSW	part submerged
13	Un. Id. Barge B1	barge	NSW	submerged
14	Un. Id. Barge B2	barge	NSW	submerged
15	Un. Id. Barge B3	barge	NSW	submerged
16	Un. Id. Barge B4	barge	NSW	submerged
17	*Alpha*	paddle steamer	NSW	submerged
18	*Fairy*	paddle steamer	NSW	submerged
19	*Victoria*	paddle steamer	NSW	submerged
20	*Reliance*	paddle steamer	NSW	submerged
21	*John Campbell*	barge	NSW	dismantled
22	*Susan*	barge	NSW	submerged
23	*Daisy*	barge	NSW	submerged
24	Un. Id. Barge RC1	barge	NSW	part submerged
25	*Moorabin*	barge	NSW	submerged
26	*Alice*	barge	NSW	submerged
27	*Florence Annie*	barge	NSW	submerged
28	*Maude*	paddle steamer	NSW	submerged
29	*Maori*	barge	NSW	submerged
30	*Alert*	paddle steamer	NSW	submerged
31	Un. Id. Wreck ER1	?	NSW	part submerged
32	Un. Id. Ferry BB1	barge	NSW	part submerged
33	Un. Id. Barge BB1	barge	NSW	part submerged
34	*Canally*	Barge	NSW	part submerged

(Continued)

3. The types of vessels in various areas of the river indicate trends in historic shipping on the river—in the lower section wrecks associated with the operation of milk boats and launches, and those involved in the lock-building and barrage construction have tended to remain where they were last used.
4. Tributaries have acted as a disposal area which did not interfere with the navigation of the main stream.
5. Clusters of sites also occur in association with major ports usually in an area that can be identified from historical sources as the 'rotten row', a section of deep water and high flow downstream or upstream from the wharf of a port, to which vessels were either relegated at the end of their economic viability or were moored during low waters, often sinking on subsequent flood waters.
6. The remains of ferries can be found in clusters in tributaries or at major crossings—those that have survived are generally found in inaccessible areas. The use of ferries in the transportation of live-stock across back waters have tended to help in their preservation.
7. Mid-stream, deep-water sites associated with major ports are another area of concentration—to maintain the navigable waterway the vessels that make up this

Table 3. Continued

Ref No.	Name	Last known rig	State	Status
35	*Hero*	barge	NSW	submerged
36	*Lil Ruby*	paddle steamer	NSW	submerged
37	*Alawein*	?	NSW	part submerged
38	*Kookaburra*	paddle steamer (SW)	NSW	part submerged
39	Un. Id. Wreck SH1	?	NSW	submerged
40	*Mundoo*	paddle steamer	NSW	submerged
41	*Banyula*	paddle steamer	NSW	part submerged
42	Un. Id. Barge KB1	barge	NSW	part submerged
43	Un. Id. Barge KB2	barge	NSW	part submerged
44	Un. Id. Barge KB3	barge	NSW	part submerged
45	Un. Id. Barge KB4	barge	NSW	part submerged
46	*Glimpse*	paddle steamer	NSW	submerged
47	Un. Id. Ferry BS1	ferry	NSW	dismantled
48	Un. Id. Barge BS1	barge	NSW	part submerged
49	Un. Id. Barge BS2	barge	NSW	submerged
50	Un. Id. Wreck E2	?	NSW	part submerged
51	Un. Id. Barge M1	barge	NSW	part submerged
52	Un. Id. Wreck E1	?	NSW	submerged
53	*Free Trader*	barge	NSW	submerged
54	*Whaler*	barge	NSW	dry
55	*Impulse*	barge	NSW	dry
56	*Clyde*	barge	NSW	part submerged
57	*Riverina*	ketch	NSW	submerged
58	*Lady Augusta*	barge	NSW	submerged
59	*B.22*	barge	NSW	part submerged
60	*Murrumbidgee*	barge	NSW	part submerged
61	*Tam O Shanter*	barge	NSW	part submerged
62	Un. Id. Barge M2	barge	NSW	submerged
63	*Australien*	paddle steamer	NSW	dry (restoration)
64	*Edwards*	paddle steamer	NSW	dry (restoration)
65	*Murray*	barge	NSW	part submerged
66	Un. Id. Barge E3	barge	NSW	submerged
67	*Pilot*	paddle steamer	NSW	submerged
68	*Federal*	barge	NSW	submerged
69	*Rita*	paddle steamer	NSW	submerged

group have often been subject to dynamite and dragging to deep water.

Wreck-site distribution tends to reflect the dynamics of the decline in the river economy and trade, the advent of the railways and the building of bridges, and the adaptation of alternative forms of technology that helped supersede the Murray steamer as a form of transport. The depletion of resources and changing value and nature of cargoes contributed to the decline. The R. Murray steamers were most suited to the transport of bulk, low cost, non-perishable goods—not the expensive wool clips destined for the overseas markets, where fast delivery was essential to successful competition.

Inefficiencies of waterborne transport were compounded by the seasonality of the operation, the difficulties of operating in a riverine environment and confusing interstate politics, parochialism and border disputes.

Decade built and number of sites

By sorting data on vessels into decade of construction it is possible to see a concentration corresponding with a peak in the volume of trade known historically. The continuing number of vessels constructed in the latter historic period is perhaps a reflection of the demands of

Table 4. *Wreck-site environments*

Environment	Number of sites
Submerged	70
Part submerged	49
Dry (dismantled)	7
Dry (restoration)	4

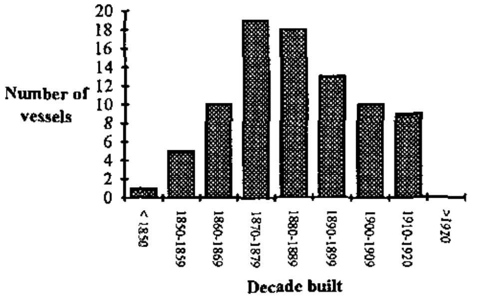

Figure 5. Number of registered vessels built per decade.

lock and weir construction, the development of agriculture and the continued demand for timber barges. The number of vessels represented in Fig. 5 are those documented in shipping registers.

Adaptation of technology

'The riverboat was a particular expression of a combination of ecological, economic and technical factors which met the needs of the trade' (Murphy and Saltus, 1981: 169).

The R. Murray steamer and barge was uniquely adapted to the conditions in which it operated. The design of the vessels was not a tradition that drew from a pre-existing knowledge of riverine shipbuilding in Australia. Vessel construction was primarily undertaken by individual craftsmen and shipwrights often came from totally unrelated professions. Many were immigrants from Europe, and those with boatbuilding experience may well have gained this in the marine tradition.

The evolution of paddle-steamer design is significant in the history of shipbuilding in Australia. Early vessel design was subject to debate:

> A proposal for navigating the Murray by means of large flat-bottomed boats, similar to the lily-boys of the Thames, and propelled by screw or paddles, worked by a windmill, was laid before several influential parties between two and three months since. I regret that your correspondent 'X' should find in me a rival claimant to the invention; and even I was disappointed in learning from Mr. Davy that the plan was actually tried in England some years since, when it was found that on smooth water the vessel might be propelled at a fair speed, even directly against the wind (*South Australian Register*, 15 July 1848).

Several patent applications proposed specifications for 'feathering floats of a paddle steamer to remove the obstruction of the back water which checks the progress of the vessel' (Department of Patents, Commonwealth, ref. no. V 63/1857).

The proposed specifications for a new 'turning and steering paddle' was described as overcoming the problems associated with operating in the riverine environment:

> In river navigation its utility may be easily understood. In the rivers of these Australian Colonies, and elsewhere, bends frequently occur and of many of these the angles are so acute that the corners are not turned without difficulty, danger and considerable delay in stowing, stopping or reversing the engine. At these turns often the stream strikes the vessel as her bow passes the point cants her head off and before she can be rounded again she is swept on the bank in the bight opposite, sometimes getting snagged and damaging cargo, all which a few strokes of the new turning and steering paddle, if adopted, might avert (Department of Patents, Commonwealth ref. no. V11/1857).

Despite the claims, both these patents were refused for reasons not stated.

Ultimately the development of a chronology of steam-boat design and construction is sought. The archaeological resource is the last place in which the information required to make such an analysis resides. Contemporary records such as newspapers do have the potential to yield some technical data. However, their systematic investigation was beyond the scope of the two projects. Several lines plans and half models are the only archival references that remain as examples of the design of these vessels. Fig. 6 shows as an example the general lay-out plan for the composite paddle steamer *Tarella*, built in 1897. The plans bear the initials of the owner of the vessel (A. H. Landseer) and are not those of the shipwright.

Given the diverse types of vessels undertaking numerous different activities on the river, and the fact that these vessels were constantly subject to alteration and repair, it is difficult to generalise about ship construction. Paddle

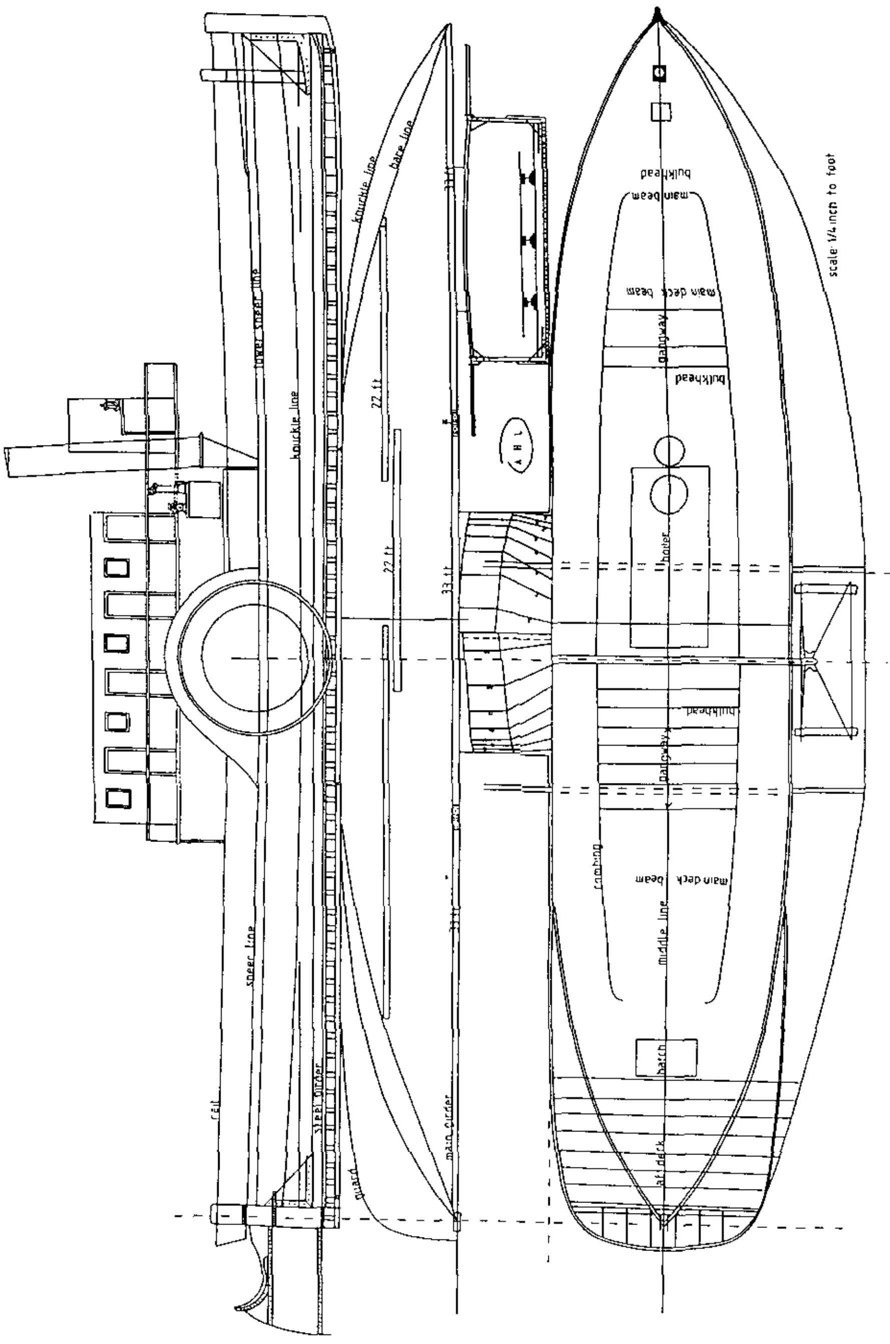

Figure 6. Lines plan for the P.S. *Tarella*, redrawn from the original plans held in the J. C. Tolley Collection. (Kenderdine, 1993.)

steamers were often converted to barges and vice versa as the demands made on them changed. Steamers were converted from side paddles to screw propulsion or were fitted out with diesel engines in the latter part of the historic period.

Adaptation to operating environment

As already stated, it was the physiological aspects of the river that had a direct influence on the operation and design of paddle steamers and barges. Most of the river's water comes from the Australian Alps at a height of 1,430 m. If this is compared with the 7,000 m drop from which the Ganges flow from the Himalayas it is possible to understand the low energy and slow flow of the River Murray. What also characterises the flow is the small catchment area compared with the size of the basin, and the fact that there are few tributaries adding to the total flow, especially as the river moves westwards through a semi-arid zone (Rutherford, 1990: 17–8).

Near the sea the river falls less than 16 mm per km. The waters are shallow and seasonal. Another of its most interesting characteristics is the meandering nature of the river form; navigators were aware that the length of their journey was often increased three times because of the torturous course dictated by the Murray. There were proposals in the 1880s that the necks of meander bends be cut through to make the trip shorter. Natural retail cuttings were formed when the force of the river in flood made a new passage for itself. These were narrow and hazardous for paddle steamers although effective in reducing travel time in a competitive and seasonally restricted trade.

Adaptation to the form of the river itself can be seen in the following basic design characteristics.

1. The steering wheel was placed at a high forward vantage point so that a watch could be kept for shoals, sand-bars and snags, and large headlamps were mounted on each side of the wheelhouse (Sexton, 1975: 139).
2. Wooden hulls were better able to absorb the impact of navigation hazards, while the development of composites and iron topsides prevented the problems of hull timber shrinkage above the waterline due to the harsh Australian sun. Complete iron hulls were avoided because of the difficulties of finding leaks between riveted plates and conducting repairs in remote locations.
3. A flat bottom was essential to keep draught to a minimum so that vessels could avoid snags and keep operating until low water finally prevented navigation. Keels would have increased the draught of the vessel and dug deeply into the numerous sand bars and banks that were the predominant navigation hazard of the R. Murray. The structural function of the keel therefore was most often served by a number of keelsons and bulkheads.
4. Paddle-wheels were almost universally adopted, their rugged simple construction endured well the heavy punishment given by numerous snags, floating logs and fixed obstructions. Broken wheel-arms and floats were easily repaired. In their simplest form the wooden floats were bolted directly on to the iron arms of the wheel. The greater the width of the float the more effective the wheel. Supporting the extra weight on the ends of the paddle shaft was a limiting factor in this design.

   In comparison with vessels on American rivers such as the Colorado and Mississippi, R. Murray steamers were much smaller and in most cases utilised side wheels. The several paddle steamers built with stern wheels following the American prototype were found not to be manoeuvrable in the twisting bends and shallow slow-moving waters of the Murray.

   The ability to be able to manoeuvre readily was an important consideration in vessels making frequent bow-on landings. Paddle-wheels had the advantage over screw propulsion in enabling a vessel to turn about a central axis. Also, fine suspended sediments in river waters would have worn down propeller glands and bearings.
5. Vessels were usually designed according to the section of the river in which they were to operate. 'Top enders' were by necessity generally the lighter and smaller vessels, while 'bottom enders' could operate with increased draft and length (Sexton, 1975: 139).
6. Early vessels were fully decked and hulls most often painted black. The searing summer

temperatures and lack of ventilation below decks led to the adoption of open engine rooms. Sponson housing over the paddle-wheels offered some protection to engines.

7. The hulls of earlier vessels were generally made quite strong. A greater understanding of the effects of the river, the seasonality of flow and techniques of navigation manifest themselves in lighter hull construction.
8. Towing-masts were set up by the funnel amidships and cables were connected to these for towing barges in a way that allowed them to navigate the bends of the river.
9. The development of the lock and weir system meant a more permanent flow and a stable pool level could be maintained. This regulation of the river environment occurred predominantly in the 1920s, however, and had little impact on design since the trade had already been displaced by the development of railways.

Economic considerations

1. Utilitarian design was a major contributing factor to the economics of operating vessels that were constantly under repair. Seasons were short and the often remote location of vessels that became snagged or holed necessitated repairs by the crew.
2. The necessity of reducing weight for speed and a shallower draught was a factor in the reduction of hull weight as a tradition of shipbuilding was developed along the river.
3. Various cargo types also had an effect on paddle steamer and barge design. The difficulties of loading wood through the small hatches of the earlier fully decked steamers contributed to the adoption of open decks.
4. The passenger trade led to the development of multi-deck steamers. In the 1910s saloons was added over the rear hold, with more access for cargo maintained in other parts of the vessel.
5. Barges were designed to be the bulk carriers of cargo and optimum strength with minimum weight and therefore draft was the most desirable feature. A strong main beam and series of bulkheads were the main design features. The earlier barges, built of timber, were narrow and had curved sides and rounded bottoms. The later-built composites were hard-chined. Iron topsides were further strengthened with iron girders and decks often projected outside the hull. Barges would be either hog or sway backed, requiring different methods of loading cargo. Barges constructed for the transport of timber were either of the 'insider' type incorporating log slides in the interior, or were of 'outrigger' type where logs were attached to transverse beams for transportation, as red gum does not float.

Figure 7. A multi-tubular boiler on the remains of the P.S. *Banyula* wreck site, NSW. (Kenderdine, 1993.)

Machinery

1. The development of steam plants in riverine trade vessels was more closely related to the agricultural and industrial steam engine than those of marine tradition. The most common types were the horizontal, diagonal/inclined or portable in single, twin high-pressure type or compound. The horizontal and diagonal-inclined engines generally used industrial locomotive boilers or multi-tubular under-fired boilers (Fig. 7). Condensing boilers were not a predominant feature of the steamer because they operated in fresh water conditions. Marshalls were the most common types used in river boats and for all makes the ease with which spares could be

Table 5. *Register details for paddle steamers*

Name	Const	Date Built	Ton (gr)	Ton (nett)	Len	Bre	Dep	L:B	B:D	L:D	Name	Const	Date Built	Ton (gr)	Ton (net)	Len	Bre	Dep	L:B	B:D	L:D
Success	Comp	1877	129	97	82·7	16·5	6	5·01	2·75	13·78	*Melbourne*	Iron	1852	153	97	134·5	17	8·3	7·91	2·05	16·20
Sapphire	Comp	1904	26	6	70·6	12·6	2·9	5·60	4·34	24·34	*Bunyip*	Wood	1858	14	10	100	123	5·7	8·30	2·10	17·54
Jane Eliza	Iron	1867	120	97	106·4	21·1	6·9	5·04	3·06	15·42	*Queen*	Comp	1865	103	75	81	18·3	4·2	4·42	4·35	19·28
Alpha	Comp	1899	43	19	72·6	13·4	3·6	5·42	3·72	20·17	*Jolly Miller*	Iron	1866	93	83	90·7	18·5	5·7	4·90	3·25	15·91
Fairy	Wood	1881	36	26	54·6	14·4	3·8	3·79	3·79	14·37	*Alfred*	Iron	1867	116	79	92·3	13·7	4·6	6·74	2·95	20·07
Victoria	Comp	1884	27	11	62·1	11·3	3·8	5·50	2·97	16·34	*Vesta*	Wood	1867	29	22	72·4	11	4·2	6·58	2·62	17·24
Daisy	Wood	1896	20	12	51·5	11·4	4	4·52	2·85	12·88	*Corowa*	Iron	1868	96		94·8	19·9	6	4·76	3·32	15·80
Florence Annie	Comp	1882	187	137	77·5	25·6	6·2	3·03	4·13	12·50	*W R Randell*	Wood	1870	63	25	84·3	16·2	4	5·20	4·05	21·08
Maude	Iron	1885	32	23	60	13·7	4	4·38	3·43	15·00	*Tyro*	Comp	1872	72	52	106·8	15·1	5·6	7·07	2·70	19·07
Albert	Wood	1879	95	60	74	15·3	6	4·84	2·55	12·33	*Murrundi*	Comp	1875	135	80	106·8	16·6	6	6·54	2·77	18·10
Canally	Wood	1907	93	53	92	21	6·4	4·38	3·28	14·38	*Wilcannia*	Wood	1875	128	88	107·3	18·2	7·5	5·90	2·43	14·31
Hero	Wood	1874	137	108	92·2	17	6·3	5·42	2·70	14·63	*Undaunted*	Comp	1875	27	23	62·7	13·5	4·2	4·64	3·21	14·93
Kookaburra	Comp	1911	350	233	141	16·8	9·3	8·39	1·81	15·16	*Saddler*	Wood	1877	92	58	70·5	15·8	6	4·46	2·63	11·75
Mundoo	Comp	1875	27	22	69·3	12·3	4	5·63	3·08	17·33	*Milang*	Comp	1878	43	33	72·4	13·6	4·5	5·32	2·96	15·74
Glimpse	Wood	1886	27	21	60	13	4	4·62	3·25	15·00	*Roma*	Comp	1884	67	58	79·4	20·9	4·2	3·80	4·95	18·90
Free Trader	Wood	1872	93	82	96·8	18·7	6	5·18	3·12	16·13	*Invincible*	Comp	1889	84	44	91	20·2	5·5	4·50	3·65	16·55
Clyde	Iron	1884	44	38	65·4	16·6	4·6	3·94	3·61	14·22	*Pearl*	Comp	1889	213	186	110	24·2	3·5	4·55	6·91	31·43
Riverina	Iron	1866	87	76	72	14·4	5	5·00	2·88	14·40	*City of Oxford*	Comp	1890	29	23	64·9	11·1	3·4	5·85	3·26	19·10
Lady Augusta	Wood	1852	90	29	97·8	11	5·4	8·89	2·04	18·11	*Eva*	Comp	1891	29	9	48	8·3	3·6	5·78	2·31	13·33
Murrumbidgee	Comp	1865	108	77	83·2	16·6	4·6	5·01	3·61	18·09	*William Davies*	Comp	1893	62	39	80	16·3	4·1	4·91	3·97	19·46
Australien	Comp	1897	58	37	78	16	5	4·88	3·20	15·60	*Sunbeam*	Comp	1895	12	9	51	9·7	3	5·26	3·23	17·00
Edwards	Wood	1875	78	27	82·8	16	5·2	5·18	3·08	15·92	*Ventura II*	Comp	1906	117	87	85	15·9	4	5·35	3·95	21·25
Murray	Comp	1867	88	34	110·1	19·3	6·4	5·70	3·02	17·20	*Kelvin*	Comp	1912	118	67	104	15·4	4·9	6·75	3·14	21·22
Pilot	Comp	1883	50	32	71·5	16·5	4·7	4·33	3·51	15·21	*Renmark*	Comp	1912	151	64	111·9	20·6	5·3	5·43	3·89	21·11
Mary Ann	Wood	1852	20		55	9·4	6·4	5·85	1·46	8·59	*J.G. Arnold*	Comp	1917	104	30	98	18·1	4·7	5·41	3·85	20·85

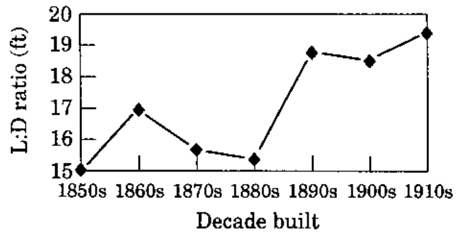

Figure 8. L:D ratio *versus* decade built for registered paddle steamers.

obtained was a factor in using semi-portables rather than marine plants; often a spare crank shaft was carried. Generally they did not have a flywheel, instead heavy cast gears and direct driven paddles provided sufficient momentum for twin cylinders. Gear shattering in the confined engine room was a considerable hazard. The occasional small boat was driven by an inefficient flat belt, and earlier vessels had multiple rope-driven belts.

2. The direct-acting engine in Australia was an inclined adoption of the horizontal direct-acting engine where a cylinder and valve assembly was placed longitudinally at each side of the hull with the paddle shaft as the crank shaft. The boiler was placed between the cylinder assemblies giving a compact engine room not much longer than the boiler itself. By the 1870s direct-acting engines were operating at paddle revolution speeds of 30 rpm, approximately, and portables at between 120 and 150 rpm geared down to 30 rpm.
3. After the 1870s most locomotive-type boilers in use did not have a wet bottom.

Evolution of design and comparative analysis

Average hull dimensions can reveal trends in the evolution of hull design. Based on the register details for those vessels appearing in the wreck universe the combination of environmental, economic and technological factors that defined the characteristics of the river vessels in response to changing trade dynamics can be analysed. Analysis reflects only some of the complex of variables and should be viewed as an indicator of the nature of the resource and future research possibilities. For this analysis the first registered rig type and dimensions of vessels have been used. The use of register details also allows for the wreck resource to be compared with the total number of registered vessels.

Table 6. *Register details for barges*

Name	Const	Date Built	Ton (gr)	Len	Bre	Dep	L:B	B:D	L:D
Bourke	Iron	1876	77	102·80	17·70	5·50	5·81	3·22	18·69
Jessie	Comp	1877	236	107·00	22·40	8·40	4·78	2·60	12·74
Albert	Comp	1882	11	41·00	11·20	3·20	3·66	3·50	12·81
Cobar	Comp	1882	113	99·90	20·10	7·20	4·97	2·79	13·88
Albermarle	Iron	1884	57	79·90	17·20	5·20	4·65	3·21	17·18
Uranus	Comp	1886	93	118·80	24·60	4·00	4·83	6·15	29·70
Annie	Comp	1894	106	85·00	20·00	5·00	4·25	4·00	17·00
Columbia	Comp	1901	23	63·00	13·60	4·00	4·63	3·40	15·75
Ormond	Comp	1908	61	81·00	16·10	4·90	5·03	3·29	16·53
Crowie	Comp	1911	290	151·70	29·90	7·90	5·07	3·78	19·20
Koondrook	Comp	1912	156	119·00	24·20	8·20	4·95	2·95	14·62
Loxton	Comp	1912	78	101·00	18·50	5·00	5·46	3·70	20·20
Croupier	Iron	1881	87	119·90	20·10	3·80	5·97	5·29	31·55
Emerald	Iron & Steel	1899	89	126·00	20·70	5·70	6·09	3·63	22·11
Cowirra	Iron	1923	235	130·90	26·80	8·10	4·88	3·31	16·16
John Campbell	Wood	1877	243	120·60	28·30	7·60	4·26	3·72	15·87
Susan	Comp	1884	59	86·00	18·00	5·00	4·78	3·60	17·20
Alice	Comp	1867	60	75·00	14·00	6·00	5·36	2·33	12·50
Maori	Comp	1883	110	94·00	21·00	5·60	4·48	3·75	16·79
Impulse	Wood	1885	95	80·00	18·00	4·60	4·44	3·91	17·39
B22	Wood	1922		82·00	17·00		4·82		
Tam O'Shanter	Wood	1872	81	73·00	16·60	5·20	4·40	3·19	14·04
Federal	Comp	1899	75	88·40	17·00	5·30	5·20	3·21	16·68

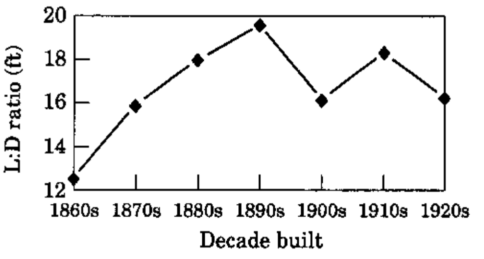

Figure 9. L:D ratio *versus* decade built for registered barges.

For paddle steamers (Table 5 and Fig. 8) it is possible to see that, in general, length and beam increased over time while draught decreased, confirming observations outlined above on design in response to economic and environmental factors. Building adapted to economic constraints, the availability of raw materials and the principle of least effort. The desire to transport produce on a least-cost basis together with the accumulated knowledge of river conditions were a stimulus for these changes. Other factors that need to be explored in the analysis of this data beyond the scope of this paper include the intended sphere of operation—that is 'top enders' versus 'bottom enders'—and vessel function (whether passenger, clearance or trading vessel).

From the analysis of details of the registered barges (Table 6 and Fig. 9) there appears an increasing length-to-depth ratio that stabilises after the peak of the trade in 1890s. Shipbuilding techniques and the increasing construction of composite barges combined with the desire to ship more produce to ports and railheads would have been factors in barge design. Stabilization of length after the 1890s may be the result of a maximum that could successfully operate in the riverine environment.

Conclusion

The documentation of the wreck resource of the R. Murray provides the foundation for riverine archaeology in Australia and a basis for future research into aspects of Australian-built vessels during the Colonial Period. The design characteristics evident in these vessels could also provide data for comparison with shipbuilding industries situated on inland waters in other parts of the world.

Acknowledgments

Research into the remains of historic shipping on the R. Murray was made possible through funding provided by the Murray Darling Basin Commission; State Heritage Branch, South Australia, Victorian Archaeological Survey and the Heritage Branch, New South Wales. Thanks are due to all colleagues and members of the community who helped make the projects successful.

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