*3rd Australasian Engineering Heritage Conference 2009*

# There's Naught to Fear for the Port of Oamaru

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***SUMMARY:*** *Because the sea was the main highway for New Zealand's colonial towns, aspiring centres that lacked natural harbours had to build artificial ports. Oamaru faced severe financial and engineering challenges, but with the aid of 'Moa', the largest full-slewing rail-mounted travelling steam crane in the world, it completed its breakwater in 1884, offering safe berthage for UK-trade meat ships. The port saw its last ship in 1974, just ahead of the container age, bequeathing us the country's best-preserved Victorian/Edwardian harbour: a concrete breakwater, completed in 1884, three concrete wharves completed between 1875 and 1879, and two wooden wharves completed in 1884 and 1907 respectively. This paper examines the history of the port and its engineering legacy.*

In the mid-1850s a small settlement grew up in the lee of Cape Wanbrow in North Otago to supply sheep stations.[1] The Cape afforded the Oamaru anchorage some protection from southerly winds but was completely exposed to the prevailing north-easterlies. The small vessels lying off the beach had to load and discharge in the open sea using surf boats. It was slow, clumsy, expensive and dangerous – ships played Oamaru roulette.

Despite that, Oamaru boomed, quickly becoming Otago's second-largest settlement. But the Otago Provincial Government had little money to spend on port development and in any case its harbourmaster preferred Moeraki to Oamaru as North Otago's port and was not shy when it came to expressing his preferences: 'sums expended in making Harbors where nature has not already provided them would be a needless expenditure', he declared.[2] A small derrick was provided to haul goods up from the beach to the provincial government's new warehouse in 1858, followed shortly afterwards by a flagstaff and some moorings out in the bay, but that was all.

**Figure 1**. The Oamaru landing service site ca 1870. – North Otago Museum 5795

It was not long before the exposed beach started claiming ships and lives. In 1860 the small schooner *Oamaru Lass* went ashore. She was recovered, but an increasing number of ships were not.[3] Insurance rates soared. In 1866, after much controversy, the provincial government authorised an iron-piled L-shaped jetty to be built near the end of Cape Wanbrow to a design by J.M. Balfour. It was ready by late 1867.

Unfortunately, the jetty was unprotected by any breakwater or seawall. In February 1868 a massive storm sank two overseas wool ships and a coaster and left the outward end of the jetty a mangled ruin. For Oamaru it was back to square one.

While the provincial harbourmaster still wanted to link Oamaru to Moeraki by rail, locals demanded their own port and persuaded the provincial government to commission engineers Edward Dobson and John Blackett to report on port options. After dismissing a deepwater port in the bay, they recommended building a small wet dock in the Brewery Lagoon capable of handling coastal vessels of up to 300 tons and drawing no more than 2.7m. The dock would be protected by long seawalls running out from the end of the Cape (450m long), approximately near the remaining 25m stump of the old jetty, and (150m) just north of the edge of the Oamaru creek, which flowed into the lagoon. Lock gates would have guarded the entrance to the basin, and sluices in the creek would have released water periodically to flush away any shingle that accumulated at the entrance.[4]

The Oamaru Dock Trust struggled badly. After Dobson and Blackett refused to oversee the project, Dobson attacked Otago Provincial Chief Engineer George Barr's plans. The Dock Trust then hired David Balfour, who drowned off Timaru, leaving John McGregor to supervise the work. Although contractors Walkem & Peyman started building concrete blocks for the south-east seawall early in 1871, money shortages forced the Dock Trust to concentrate on the south-east seawall at the Cape and to delay the wet dock. This proved a blessing in disguise, since the expensive dock if built might have doomed Oamaru to handling feeder

services only. The 1870s were a time of rapid ship size growth. The Harbour Company's steamer *Maori*, a regular trader between Dunedin and Oamaru in the 1870s, was 171 grt (gross registered tons).[5] The Union Company's *Hawea* of 1875 was 720 grt. None of the small-ship harbours between Oamaru and Port Chalmers/Dunedin – Kakanui, Moeraki, Shag Point and Karitane – would survive the 1880s as trading ports.

Walkhem & Peyman learned as they went along. At the Point, where a reef ran out a short distance, they built the first section (240m long) of the breakwater with a rubble-filled cavity between two rows of 4-high concrete blocks. As the wave action increased the further out they went, they changed to solid concrete block construction.[6] Concrete, although expensive, was essential since the rock from the quarry at the foot of the breakwater was too weak to withstand the sea; the cement was imported from Britain in casks and mixed on site. This area was originally very cramped, but it was made more practical by several small reclamations.

The early work was done by manual labour but the contractors had ordered a massive rail-mounted steam travelling crane from Dunedin engineering firm Kincaid, McQueen & Co. Described as a 'derrick crane', the 'Moa' was built of wrought and cast iron.[7] The overhang of the jib was 7.5m and the counterweight was mounted at the back end of the upper frame with square cast iron blocks fitted in between the girders, with water tanks above. The tanks were filled only when the heaviest weights were being lifted. In July 1873 the crane successfully lifted a 30-ton [27.2 tonnes] load of iron rails at the Dunedin factory. The contract price was £1,600 [ca $192,000 in 2009 values].[8]

**Figure 2**: The steam crane 'Moa' working in deteriorating weather conditions. – North Otago Museum 4058

The crane worked well and was a source of deep pride to colonial boosters. It has often been described as second only to one at Madras. In late 2008, however, Bruce Ward from the Historical Crane Society confirmed that the Madras crane was not only a later machine, but it was smaller. 'The Oamaru crane was clearly the largest full-slewing rail-mounted steam crane capable of travelling with a rated load anywhere in the world. All other large rail-mounted cranes had less reach and less lifting capacity that the Kincaid McQueen crane for at least 10 years after Oamaru.'[9]

Contracts for construction were let out in stages. Work was periodically delayed by shortages of cement or (more frequently) by bad weather. Needless to say, progress slowed the further the breakwater advanced out from the Cape as the water got deeper and the seas rougher. Divers were used to help with smoothing the seabed where the blocks were to be placed.

The trickiest part of the job was sinking the four caissons that formed the seaward end of the breakwater. The contractors built four large wooden caissons, three of them 7.62m long and 5.18m wide. These were floated out to the end of the breakwater, filled with 600-700 tonnes of concrete and then bound together with a concrete cap to 'constitute an impregnable head to the breakwater.'[10] The seabed that would form the resting place for the monoliths first had to be dredged and flattened.

Completing the end was a lengthy job. The first caisson was floated out in December 1882. The plan was to sink it in January 1883 but that year was an unusually stormy one, and since perfectly calm conditions were required for aligning and sinking the caissons, it was February 1884 before the last one was in place.

**Figure 3**: Early in 1883. A couple of surf boats are at the end of the breakwater and a wooden caisson is being towed along Macandrew Wharf to be sunk to form part of the breakwater tip. Another caisson is taking shape behind the Cross Wharf in the background. – North Otago Museum 4050

The Moa's final fate is unknown. A scathing attack on the Oamaru Harbour Board (which had replaced the Dock Trust in 1874) in the *Otago Witness* in May 1908 described 'a big steam crane that lies desolately rusting at the [presumably landward] end of the breakwater.'

As the breakwater advanced out into the bay, the Harbour Board began building wharves. The first, the 46m-long Macandrew Wharf, was completed against the landward end of the breakwater in 1875. Next year the wharf was extended to 100m and the 1875 section was widened slightly to improve operations for the Harbour Board's steam cargo cranes. For passengers on the two ferries running between Dunedin and Oamaru, being able to step on to a secure wharf was a welcome improvement on bobbing about in the old surfboats.

The next two wharves, Normanby Wharf (1878) and the short Cross Wharf (1879) running most of the way between Normanby and the breakwater, were like Macandrew Wharf, built of concrete. Their completion gave Oamaru 370m of sheltered berths. Above all, it also made it a much safer and cheaper port for merchants. With the completion of Macandrew Wharf, shipping accidents, which had made the port notorious, virtually ended. The only ships still unable to use the town's wharves were the large overseas ships that loaded wool for London.

That was about to change. In 1879 the port's prospects were improved immeasurably when Thomas Forrester made some trial bores in the bay and discovered that the seabed was not solid rock, as had been thought, but compacted shell and mud. It was tough, but it could be dredged. Forrester's discovery was a turning point for town and port. With enough money, the harbour could be dredged and made into a deepwater export port. The big ships would no longer have to moor off the breakwater.

Forrester is today best remembered as the architect from the partnership Forrester & Lemon, many of whose Oamaru Stone buildings are registered historic places. For 31 years, however, his day job was secretary/engineer to the Oamaru Harbour Board and it was this contribution that was crucial to the town's prosperity.

The harbour board, its funds shrinking as the breakwater advanced into the bay, was deeply divided. Some wanted to economise but after considerable debate the majority voted to build a deepwater port capable of handling direct shipping from Britain. The main components of this plan would include a steam dredge (1883), a large export wharf (Sumpter Wharf, completed in 1884) and a long rubble mole at the northern end of the harbour to protect moored shipping from sea surge. The mole was halted in September 1884 at a length of 489.5 m along the top – about 60 m short of the length originally planned and without the elaborate concrete tip envisaged. Completion had been delayed by the low quality of the soft rock from the board's quarry. It fragmented badly during blasting and much had to be rejected as too small to withstand the waves.

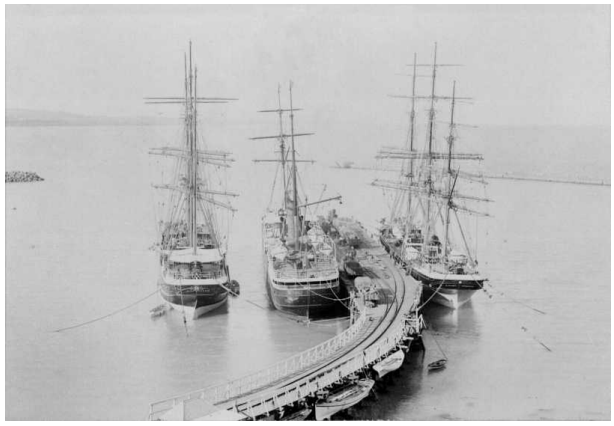

**Figure 4:** Two wool ships and a trans-Tasman steamer lie alongside Sumpter Wharf, the export pier completed in 1884. – North Otago Museum 280

1884 was a busy time for the port. The dredge *Progress*, assembled the previous year from components built in Britain, busied herself dredging the entrance channel, swinging basin and the berths alongside Sumpter Wharf, a wooden wharf connected to the shore by an elegant curved pier. Sumpter Wharf was designed to service the largest ships trading between New Zealand and the United Kingdom. In August 1884 its first user was the sailing ship *Dunedin*, which had taken the historic first shipment of frozen meat from Port Chalmers to London three years earlier. The second caller was the *Elderslie*, more than twice the *Dunedin*'s size, the first frozen meat steamer for the New Zealand trade and initially intended to trade solely between Oamaru and London. The Port of Oamaru had stolen a march on its rivals.

A newspaper from the rival town of Timaru was impressed: 'A breakwater with a mole at the end of it, a wharf with a big hole dredged alongside, and what is more satisfactory. A big steamer lying in the big hole, loading up a huge cargo of mutton: all these things indicate progress, show a spirit of enterprise and auger well for the future prosperity of Oamaru.'[11] An Oamaruvian went one better (or worse?) by composing triumphant doggerel which included the chorus:

'Oamaru, fair Oamaru; The Port of Oamaru;
We tell you here there's nought to fear
For the port of Oamaru.'

The newspaper reports, that song, they all underline the importance that colonists attached to keeping up with their rivals. Oamaru was one of James Belich's 'protein ports': 'Oamaru duelled indecisively with Timaru in the 1880s, with the two freely duplicating each other's expensive harbour works in a "notorious instance" of the costs of small-town rivalry', he noted. 'But whatever the long-term costs, in the short term two sets of port facilities created twice the progress, in jobs and business.'[12]

Ironically, by the time the breakwater was finally capped off and Sumpter Wharf was lined with ships, the local economy had nose-dived. The progress business was put on ice. For some time the Long Depression had been settling over the colony and Oamaru's growth spurt came to a sudden stop virtually at the same time as the mole, breakwater and Sumpter Wharf were finished and the grandest of the Harbour/Tyne Street precinct grain stores opened their doors. The town's population would not regain its 1881 level until the 1920s.

What caused the real pain for the Oamaru Harbour Board was a combination of the depression, the loss of some short-sea coastal trade to the new South Island Main Trunk railway (1878/9) and damage to the breakwater. The historic Dunedin-Oamaru trade fizzled out in 1891, although the carriage of coal for locomotives (Oamaru was a major station on the Main Trunk network) may have made up for its loss. The damage to the breakwater was a bigger blow. In August 1886 a massive storm punched a 100-metre gap in the structure near its outer end. It would cost £8,000 to repair and another £22,000 for the seaward armouring dropped earlier in an economy now seen as false.


**Figure 5**: A heavy sea strikes the breakwater. The low-lying structure was repeatedly damaged by storms. – North Otago Museum 294

Harbour boards financed themselves through a mixture of port charges, rental income from endowments and from levying ratepayers. Rating was always a particularly sensitive issue, so only after considerable debate were repairs authorised; they were carried out successfully over 1888/9. A year later the colony-wide Maritime Strike broke out. The employers won that dispute, but the loss of revenue, coming on top of mounting interest bills, was enough to tip the Oamaru Harbour Board over the edge. Late in 1891 it defaulted on interest payments due to London investors. By 1885 it had spent £280,000 on capital works – over $46 million in 2009 terms, over 80 per cent of that borrowed, much from Britain. A receiver was appointed and the strictest economies were implemented. The dredge spent much of its time either laid up or chartered out to other harbour boards.

**Figure 6:** An unknown tramp steamer (left) and the Home boat *Tekoa* lie alongside Sumpter Wharf during the South African War. Ships this size were beginning to tax the wharf. – North Otago Museum 2377

In 1900-2 the port received a welcome boost from the South African War as tramp steamers arrived to load grain. In fact the port's trade was quite brisk and it was really debt servicing that was dragging it down. That and the perennial problem of ship size growth. By the early 1900s the last of the old sailing ships had been taken off the NZ-UK run and even the first steamers of the mid-1880s were being replaced by larger ships too long to berth safely in high winds against Sumpter Wharf. In 1903 the 151-m-long freighter *Essex* bypassed the port and the harbour master imposed a length limit of 121.9 m on ships using the wharf.

While Sumpter Wharf could have been extended and strengthened for £4,000, the Harbour Board opted for building a new wharf on top of the mole. This could handle the biggest new overseas ships, while still leaving Sumpter free for smaller overseas, trans-Tasman and coastal vessels. Although the board was still in receivership, the court accepted that the new wharf would enable the port to trade its way out of receivership faster. It authorised spending £10,000 on the new wharf and associated dredging.

In 1906 contractors Fitzgerald & Bignell started work on the new wharf, named Holmes after the board chairman and had the initial section, 152 m long, ready by the middle of the following year. The first ship to use it, the *Waiwera*, was 6,237 grt, more than 1,000 tons more than previous callers. The port was once again in the front ranks of the export trade, able to handle all but a handful of the very biggest passenger/cargo steamers.

The port lost its UK trade for a few years during and immediately after the First World War because of wartime centralisation, but lobbying by the Harbour Board saw services restored in the early 1920s. The interwar years saw ever-larger 'Home boats', as the UK trade ships were called, visiting the port,

culminating in the 1938/39 calls by the 10,100-ton new generation motor vessels *Opawa* and *Otaio*, ships nearly ten times the size of the UK trade ships when the harbour works were planned in the 1870s. To accommodate such vessels, the Harbour Board extended the landward end of Holmes Wharf. Sumpter Wharf now handled less than 10 per cent of the port's cargo, but because a big ship completely tied up Holmes Wharf, the board also widened and modified Sumpter to serve coastal and trans-Tasman ships when a Home boat was in port.

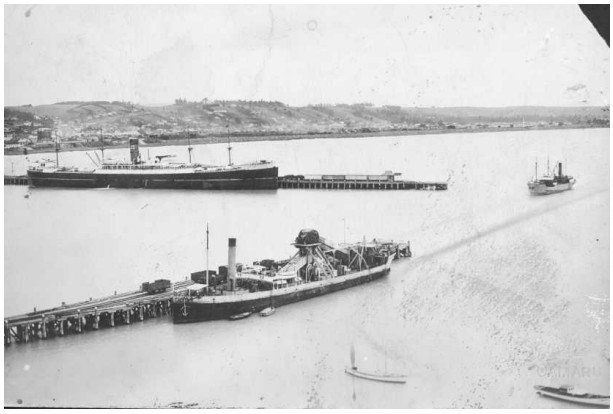

**Figure 7**: An interwar photograph showing the 9,512-ton Home boat *Westmoreland* at Holmes Wharf, built on the mole in 1917. The coaster *Holmdale* is approaching Sumpter Wharf. – North Otago Museum 2550

The Harbour Board's major programme, however, was a breakwater extension. Because the alignment of the breakwater against a coastline that curved out towards its tip ruled out a simple lengthening of the seawall, it was planned to build an extension at an angle approximately two-thirds along the length of the breakwater. This would provide protection for dredges maintaining the shipping channel out to deeper water. In 1914 Lyttelton engineer Cyrus Williams had prepared just such a plan for a 533-m arm, but a shortage of funds had prevented the board from doing anything about it.

By the early 1930s entrance depths were at record levels – about 6.4m – but the diversion of three Home boats in 1931 and the brief grounding of another two years later forced the Harbour Board to revisit its earlier plans. Ships were still getting bigger. In 1933 the board commissioned engineer F.W. Furkert to report on options. He recommended a 280-m extension as the first stage, taking the channel out to the 6.7m mark; later extensions could go out to deeper water.

Keen to use unemployed labour and to further economise by using rock from its own quarry, the board raised the height of the breakwater along the landward end in 1936 to form a relatively dry base for new work, and began dumping rock for the Ramsay Extension, as it was called, that year. G.A. Lee from Auckland was the supervising engineer.

The breakwater raising had been done with concrete. The Ramsay Extension was made from rock from the quarry near the foot of the breakwater. Although handy and cheap, the stone from this source was not very durable. The extension made only slow progress – barely 7m in 1939 – and was well short of Furkert's recommended length in 1944 when it was sealed off and abandoned.

By then its raison d'etre had gone. In 1941 the overseas shipping lines centralised calls on the main ports and the Home boats would never return to Oamaru. The Ramsay Extension was left to crumble, as it would, given the soft nature of the quarry rock. Today only a few fragments remain.

The loss of the Home boats was a deeply resented psychological blow and the Harbour Board would lobby for their return for nearly 20 years. But when it came to the port's trade, the quantity of cargo going over the wharf actually increased. From annual averages in the high 30s, cargo tipped 51,000 tonnes in the late 1950s, all from coastal and trans-Tasman ships. More cargo, less dredging, all seemed well for the port. Sumpter Wharf was used only once after the war. Holmes Wharf, which could handle two trans-Tasman ships or three small coasters, was perfectly adequate. Normanby Wharf had been given over to the fishing industry during the war and the Macandrew and Cross wharves had not seen a ship for decades.

But, although the shipping companies had rebuilt their fleets after the Second World War, the conventional (break bulk) cargo ship had reached the end of its development potential. Port congestion and escalating onshore costs were making the coastal business unprofitable as the state-owned New Zealand Railways (NZR) sought increased market share. The advent of the new Cook Strait rail/road roll-on, roll-off (RO-RO) ferries from 1962 onwards enabled NZR to eliminate the delays and the costly double handling that had previously made it uneconomic to rail goods across Cook Strait. When NZR formed alliances with private sector freight forwarders (who leased large amounts of rail space and sub-leased it to customers), the speed and flexibility offered by the train/truck combination proved too attractive to shippers. The general cargo trade to North Island ports began to wither. Some coasters were converted to bulk carriers for the grain trade, which was still able to remain competitive.

The final development work came in the late 1960s/early 1970s as the mole was widened to enable articulated grain trucks to work the wharf more efficiently and Holmes Wharf was redecked. By now the Cook Strait road/rail ferries had all but killed off conventional coastal shipping. In 1974 the last ship called and four years later the Oamaru Harbour Board was abolished, its duties taken over by a harbour committee with representatives from the borough and two neighbouring county councils. That year the port was formally closed to shipping.

The port slumbered throughout the last quarter of the twentieth century. New Zealand Cement Holdings, part of what is now the transnational cement manufacturer Holcim, had plans for a cement works at Weston, just outside Oamaru. In the late 1970s the company prepared plans for a bulk loading facility on Holmes Wharf, the demolition of Sumpter Wharf to increase the swinging basin, and for dredging the harbour down to enable 8,000-tonne capacity bulk carriers to use the port. Cement Holdings won a ministerial appeal to reopen the port against the opposition of the New Zealand Ports Authority, the Timaru Harbour Board and NZR, but the recession of the 1980s put the plans on hold. Holcim (NZ) Ltd is currently investigating the Weston options, but given the state of the port and the desire to export cement as well as supply the domestic trade, it now plans to rail cement to Timaru for shipment.

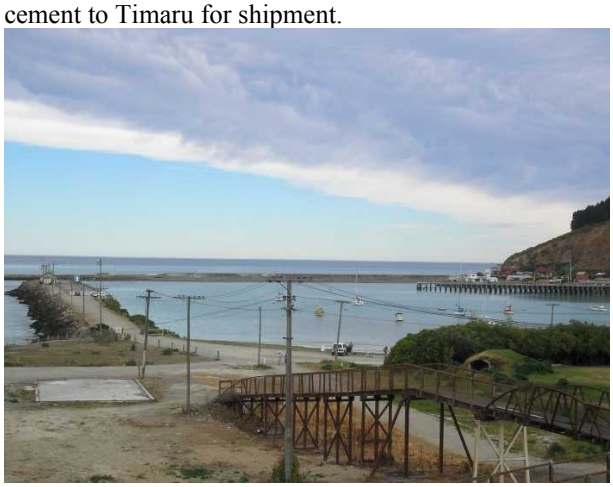

**Figure 8**: Oamaru Harbour in 2008, looking at an early 1900s railway pedestrian bridge and Holmes Wharf. – Gavin McLean

In the absence of any revenue-producing cargo, the port deteriorated gradually. Normally dredged every three years or so, the entrance shallowed badly and by the 1990s even small inshore fishing boats were having trouble entering port safely. The Oamaru Harbour Committee, from 1989 a committee of the Waitaki District Council, had little money, no long term strategy and was preoccupied by the state of the breakwater, which was damaged again in the 1980s.

The turnaround came in the mid-1990s, when the committee finally gave up on hoping for eventual rescue by the cement company and developed an asset management plan. Maintenance of the breakwater was now seen as essential to protecting part of the central business district from coastal erosion so the council decided to repair the structure. It also set a policy of maintaining the harbour entrance depth at 4-m at low water. The first dredging since 1971 took place in 1997, enabling naval patrol boats to resume port calls.

Although the nearby Harbour/Tyne Street historic precinct had been under restoration since the late 1880s, and Oamaru had rebranded itself as a 'Victorian Town at Work', little attention was paid to the heritage values of the harbour itself. The short span of the almost disused railway marshalling yards acted as a physical, but more seriously as a psychological barrier. In 2003, for example, the heritage values of part of Macandrew Wharf were damaged in a botched repair job to the breakwater – this despite the fact that the entire structure was registered Category II by the New Zealand Historic Places Trust. Shortly afterwards the port area was registered by the Trust as an historic area.

**Figure 9**: Holmes Wharf (left) and the breakwater, viewed from Cape Wanbrow in 2008. The large rocks on the seaward side are the remains of the Ramsay Extension. – Gavin McLean

In 2007 the North Otago Branch of the Historic Places trust commissioned marine engineer Nick Barber to prepare a conservation plan for Sumpter Wharf, now seen as of considerable heritage significance for its links with the first years of the frozen meat export trade. Conservation was estimated to cost about $1 million. An interpretation programme is being planned to guide visitors from the Harbour/Tyne Street precinct down to the waterfront and out to the penguin colony near the foot of the breakwater.

**Figure 10**: Shagged? Sumpter Wharf, fenced off, is a haven for seabirds while fundraising gets underway for its conservation. – Gavin McLean

The Council has dredged the entrance twice since 1997 and has completed further repairs to the breakwater and has placed further tetrapods to armour its vulnerable seaward side. The Macandrew and Cross Wharves had not been used for decades, but Normanby Wharf (which Sanford leases) and Holmes Wharf are maintained for 'commercial' (i.e., fishing industry) use. Sumpter is fenced off in the meantime.

Oamaru Harbour remains the country's best example of a Victorian/Edwardian export port. Bigger, more successful ports reconfigured themselves to gear up for the container age. Port Chalmers, for example, filled in its two graving docks and buried the old wooden finger piers beneath a massive reclamation for container handling and stacking. So did other ports as the size of ships took off and the demand for cargo storage climbed. Oamaru did not and still gives the appearance and scope of a colonial export port.

## CONCLUSION

The Port of Oamaru has been closed to commercial shipping for nearly four decades. For almost two decades of its almost 120-year-long trading life it was under the thumb of the receiver. Given that chequered past, was it worth the expenditure and the duplication that Belich mentioned earlier?

The simple answer is yes. Before the era of trains and more particularly, modern heavy trucks, towns depended on shipping to survive, let alone grow. In 1879, the main South Island settlements – Dunedin (40,880 inhabitants), Christchurch (22,946), Nelson (6,804), Invercargill (6,683), Oamaru (5,098) and Timaru (3,791) were all seaports – the largest inland settlement, Ashburton, had just 1,200 inhabitants.[13] A functioning harbour was essential to securing provincial or sub-provincial heavyweight status. Interestingly, a New Zealander in 1879, looking at Oamaru's larger population and its more successful harbour works, might have found it hard to imagine that in 2009 Timaru was handling international shipping and that its population was more than twice that of its southern rival.

Similarly, in 2009, settlements that vied with Oamaru to become the capital of the North Otago sub-region, but which failed to develop deep-water ports, Kakanui and Moeraki, are mere hamlets of a few hundred people. With nearly 13,000 inhabitants, Oamaru is still Otago's second-largest settlements. In a sense it is still living off that late Victorian investment.

The Port of Oamaru's eventual failure can be attributed to a number of factors: the small size of its hinterland, which was developed early and offered little potential for growth in the twentieth century; the absence of a low-value bulk cargo such as coal or cement to sustain it as such cargoes have done for Westport and to a lesser extent, Greymouth; the port layout, which struggled to keep pace with ship growth during the early twentieth century; and mid-twentieth century improvements to surface transport, which enabled trains and trucks to compete with conventional coastal shipping for all but the bulkiest cargoes.

## ACKNOWLEDGMENTS

I thank the North Otago Museum for permission to reproduce photographs used in this article.

[1] The main secondary sources on Oamaru Harbour are: McLean, Gavin, 2008, *Kiwitown's Port: The Oamaru Harbour Story*, Otago University Press, Dunedin; McLean, Gavin, *Oamaru Harbour: Port in a Storm*, 1982, Dunmore Press, Palmerston North, and McLean, Gavin, 'Tide of History' in Kynan Gentry and Gavin McLean (eds), 2006, *Heartlands: New Zealand Historians Write About Where History Happened*, Penguin, Auckland.
[2] Thomson, William, 1866, Harbour Report, *Otago Votes and Proceedings*, 1866-9, p. 32.
[3] For a history of Otago shipwrecks, see Collins, Bruce, 1995, Rocks, *Reefs and Sandbars: A History of Otago Shipwrecks*, Otago Heritage Books, Dunedin.
[4] McLean, *Kiwitown's Port*, pp. 37-8.
[5] Ship tonnages are expressed as gross registered tonnage (grt), which is never converted into metrics.
[6] A report in the *Wellington Independent* on 4 March 1874 said that the blocks of concrete weighed 20-30 tons, and that some to be made in situ would be 80-120 tons each. 'The concrete is in blocks 12 ft long. One row will be laid on the outside of the formation, and between it and the inner row, the space will be filled up with rubble rockwork; on the top another layer of concrete blocks being made. The total width of the structure will be 36ft, and at the top it will be 12 ft wide. The surface of the upper layer will be only 5ft 8in above water-level.'
[7] The fullest account of the crane appeared in the *Otago Witness*, 26 July 1873. In August the same plant tested a 7-ton capacity crane for the same project.
[8] *Mount Ida Chronicle*, 19 Aug 1873. Final cost of the crane, including delivery, was £2,000.
[9] Email to author forwarded by Dr Danea Cowell, Sydney, 23 December 2008.
[10] *North Otago Times*, 9 December 1882.
[11] *Timaru Herald*, quoted in the *Oamaru Mail*, 6 September 1884.
[12] Belich, James, 1996, *Making Peoples: A History of the New Zealanders from Polynesian Settlement to the End of the Nineteenth Century*, Allen Lane, Auckland, p. 372.
[13] 1879, *Statistics of New Zealand*, Government Printer, Wellington, p. 244.