



## MARINE RESEARCH

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## Background information

### Port Arthur tidal benchmark

21 January 2003

Estimates of anticipated sea level rise as a consequence of 'greenhouse' warming depend both on the increased global temperatures, and on the way in which this heat and the water formed from melting ice are absorbed in the global ocean.

Climate modelling of the way the ocean will respond to 'greenhouse' warming have shown that the increase in sea level will not be uniform worldwide.

To test these models, direct observations are required. For this, measurements of sea level change over long periods are needed.

Unfortunately, very few early sea level measurements have survived, especially in the Southern Hemisphere.

A unique series of sea level measurements, made by amateur scientist and meteorologist Thomas Lempriere at Port Arthur, Tasmania, between 1837 and 1842, and linked to a benchmark which still exists, has been used to estimate sea level changes in the region over the past 160 years.



The 160 year old tidal benchmark at Port Arthur (Photo by Bruce Miller)

### Hunt for data

The benchmark was the focus of specific investigations in 1889 by Captain Shortt (published by the Royal Society of Tasmania)\*, and in 1985 by CSIRO oceanographer Dr Bruce Hamon.

Dr Hamon spoke with descendants of Lempriere "who passed on to me the family story that many of T.J.L.'s papers were burned late last century by one of the family, who did not want others to pry into them.

Dr Hamon wrote\* that a single reading of sea level at the time when the benchmark was struck would be inadequate for mean sea level studies because of uncertainties due to the effects of ocean water density, currents and winds. "It seems unlikely that interpretation of the benchmark in terms of mean sea level change can be improved enough to make its re-discovery of real scientific value.

"The position of course would be different if Lempriere's original observations ever came to light".

A decade later, in 1995, British oceanographer and long-time tidal researcher Dr David Pugh, located many of the original observations in the archives of the Royal Society in London. More were found in the Australian archives in Hobart.

Dr Pugh and a team of scientists from CSIRO and the University of Tasmania including Dr Hunter, Dr Richard Coleman and Mr Chris Watson have reviewed Lempriere's work and established its value as a reference point for contemporary sea level analysis.

A scientific paper published in the International Hydrological Review (November, 2002) reports on analyses of measurements made at Port Arthur between 1837 and 1842, and in recent times

### Measuring sea level

At the request of the German physicist, Baron Von Humboldt, the Royal Academy of Sciences at St Petersburg in 1830 'arranged for fixed marks (indicators giving mean water level at a set epoch) to be engraved at various places by the learned physicist Lenz. Also in a supplement to the Instructions given to Captain Ross for the Antarctic

Register of Tides taken at Port Arthur, General Lempriere during Feb 4th 9 S.					
March		High Water		Low Water	
Day	Time	Height	Time	Height	Time
1	Am	5.16	6.16	11.15	3.5
	PM	5.42	5.3	11.42	4.6

A section of the original observations made by Thomas Lempriere at Port Arthur.

*expedition in 1839, I requested that wherever opportunity presented itself in the Southern Hemisphere, marks might be engraved on rocks, as in Sweden and the Caspian Sea. Had this happened in the earlier voyages of Bougainville and Cook, we would now know: whether the secular relative change in height of land and sea is a universal or local natural phenomenon; whether a pattern could be recognised in the direction of the points, which simultaneously rises and falls'.*

### Making a Mark

The main scientific purpose of the voyage under the command of Sir James Clark Ross to the southern and Antarctic regions (1839-1843) was to measure the earth's magnetic field and to locate the South Magnetic Pole.

The Royal Society and the British Admiralty also issued him with instructions to take other measurements.

While over-wintering in Hobart, the seat of Government in the island colony then known as Van Diemens' Land, Ross suggested the installation of a benchmark. Sea level measurements were initiated by the Arctic explorer Sir John Franklin during his time as Lieutenant Governor General of Tasmania, undertaking to forward observations of tidal heights to the Royal Society through the Colonial Office.

Port Arthur was selected as the site for two possible reasons – the absence of influence from freshwater and winds on the Derwent Estuary, which also had irregular tides, and the availability of a man with the necessary scientific understanding of the need for, and value of marine and atmospheric observations.

Thomas Lempriere (1796-1852) was the man given the task of carrying out the striking of a 'mark' and obtaining the observations. Described as a talented artist, part-time scientist, and diarist, he had an interest in meteorological, tidal and other environmental observations

The benchmark – consisting of a horizontal line about 50 cm long beneath a broad arrow – was fixed on July 1, 1841 in a nearly vertical rock face on the north side of the Isle of the Dead, the burial ground for the convict settlement. A plaque adjacent to the mark until about 1913 carried the following record: *"On the rock fronting this stone a line denoting the height of the tide now struck on 1st July, 1841, mean time 4h 44m pm; moon's age 12 days; height of water in tide gauge 6 ft 1 in".*



The tidal benchmark created by Thomas Lempriere at Port Arthur in 1841. The location of the mark is indicated by the red circle above and right.



A tide gauge was installed on the mainland at the settlement but neither the location or the exact type of gauge is specified in the records. Further searches of the archival records provide a clue to its location through a description of buildings by Lempriere, and coordinates given in the monthly records – Longitude 147° 51' 33"; Latitude 43° 9' 6".

The research team speculates that the tide gauge was similar to one used by James Clark Ross on his expedition – a float that is allowed to move vertically in a 'stilling well' (a vertical tube with a small connection to the sea near the bottom) which removes most of the wave motion. The position of the float can then be read against a vertical scale.

Lempriere obtained a reading of his tide gauge at the exact time when the water was at the level of the benchmark on July 1, 1841, and therefore used the sea as a 'spirit level' to relate the benchmark to his tide gauge

### 19th and 20th Century analysis

The science team digitised all records recovered from the archives records for the period between August, 1838 and December 1842. Records show the range of the tide and approximate wind force and direction.

The team focused on the 1841 and 1842 records, and after considerable error checking estimated the mean sea level for that period.

An acoustic tide gauge, similar to those in use at Hobart and Burnie, was installed in August, 1999 on a ferry jetty at Port Arthur. The instrumentation was housed in a small hut, which was about 1.2 km from the Isle of the Dead and within 300 m of the probable location of Lempriere's tide gauge.

Global Positioning System buoys were also deployed near the benchmark and the supposed site of Lempriere's tide gauge to investigate differences in level.

It was necessary to place a number of survey marks in the area, both at the Port Arthur settlement and on the Isle of the Dead using a number of surveying techniques to relate the new tide gauge measurements to the historic tidal benchmark

Two years of data – August, 1999 to August, 2001 – were analysed by the team.

### Summary

The team's observations indicated a rate of sea level rise over the period 1841 to the present of 0.8-/+0.2 mm/year relative to the local land surface. To obtain an estimate of sea level rise adjusted for vertical land movement, this figure should be increased by an amount that is of the order of 0 to 0.2 mm/year.

These observations can be compared with present estimates of global sea level rise and with long-term measurements from other Australian sites. The estimate of global sea level rise for the last century lies in the range of 1 to 2 mm/year (IPCC, 2001)

Sea level records for Fremantle (91 years) and Fort Denison (Sydney; 82 years) show rises of 1.38 and 0.86 mm/year respectively. The team's observations are therefore broadly consistent with the lower end of the IPCC estimates and with records from Fremantle and Fort Denison.

From records discovered, it appears that measurements stopped at the end of 1842, but there was acknowledgement from influential quarters. Sir John Herschel, a contemporary of Sir John Franklin and who had promoted the need for similar work at Cape of Good Hope wrote to the Tasmanian Society meeting of May 17, 1843 of the meteorological and tidal observations "conducted by Mr Lempriere in a manner which does him the greatest credit".

Sir John Franklin left Tasmania in August 1843. He died in northern Canada in June, 1847, leading the expedition to traverse the Northwest Passage. Lempriere remained at Port Arthur until 1848. He died on passage to England in 1851, and is buried in Aden.

### The Science Team



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Project leader and  
authority on tidal  
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many years studying  
tidal and sea level

observations.



Dr John Hunter,  
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Coastal modeller



The acoustic tide gauge hut at Port Arthur



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