

Introduction to the Ocean Tide and the Port of Liverpool and a Brief History of the Liverpool Tidal Institute

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National Oceanography Centre
Merseyside Maritime Museum,
11 May 2019



What is the Ocean Tide?

Rise and fall of the sea approximately twice a day (a range of 10 m sometimes at Liverpool)
Ebb and flow of tidal currents.

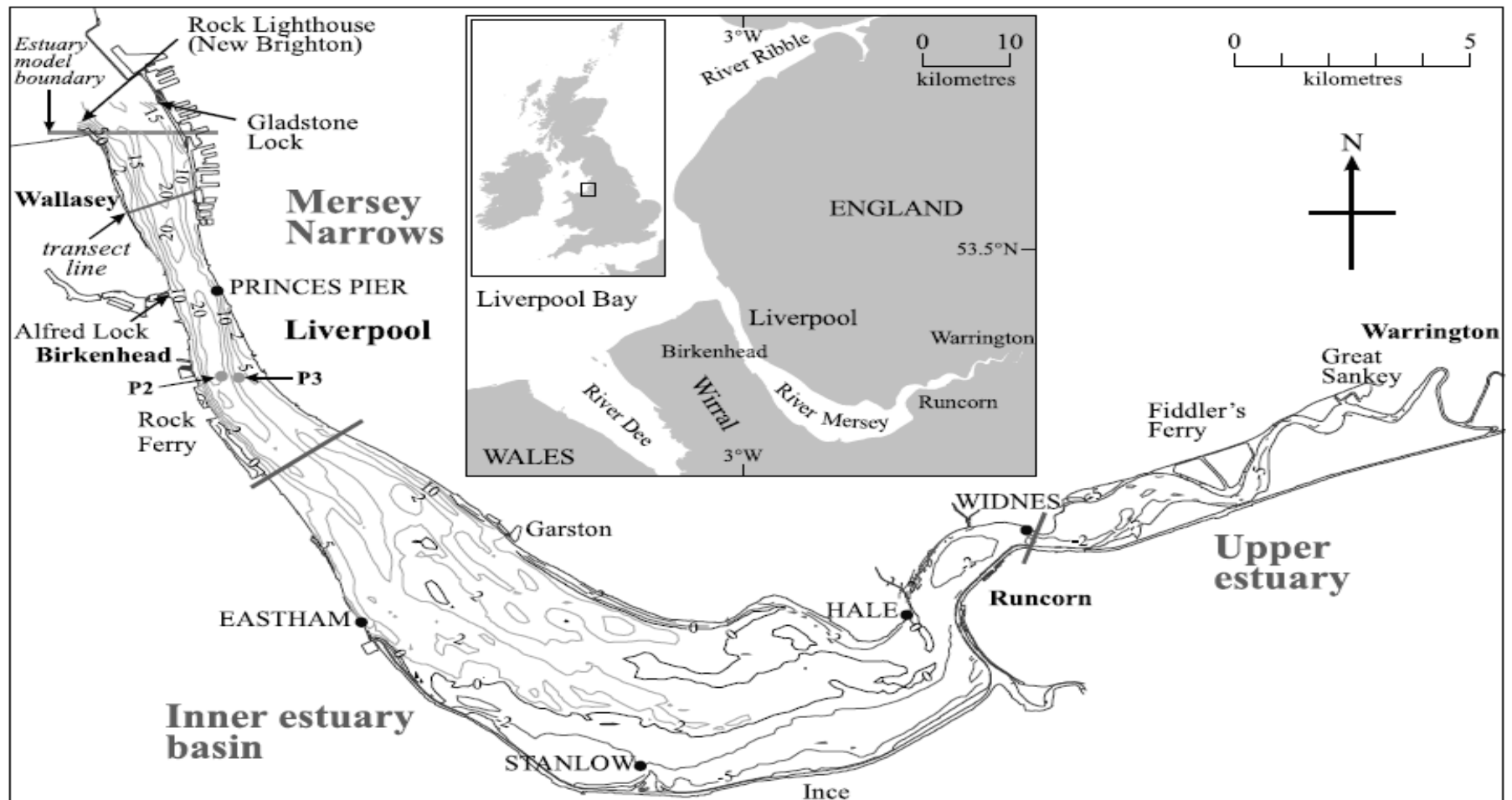




Mersey at low tide 23 April 2013



Mersey at high tide 3 January 2014 (and a storm)



Mersey Mean Tidal Range: 8.2 m at Spring Tides, 4.2 m at Neaps
Largest at Eastham. Slightly later Hilbre → L'pool → Eastham

Tidal Currents in the Narrows exceed 2 m/sec (4 knots) at Springs
River flow less than 1% of tidal flows.

Liverpool and the Tide

Unlike ports like Southampton or Felixstowe, where the tides are much smaller, Liverpool has had a large tide to live with.

Mostly that is a big commercial disadvantage.

Docks are needed to keep ships permanently afloat (at low tide) and safe from winds and currents.

Liverpool Old Dock (1715) the first 'wet dock' in the world.



Liverpool Old Dock – Ships in and out around high tide

“Getting Neaped”

Not enough water for ships to get in or out of the docks at high tide.

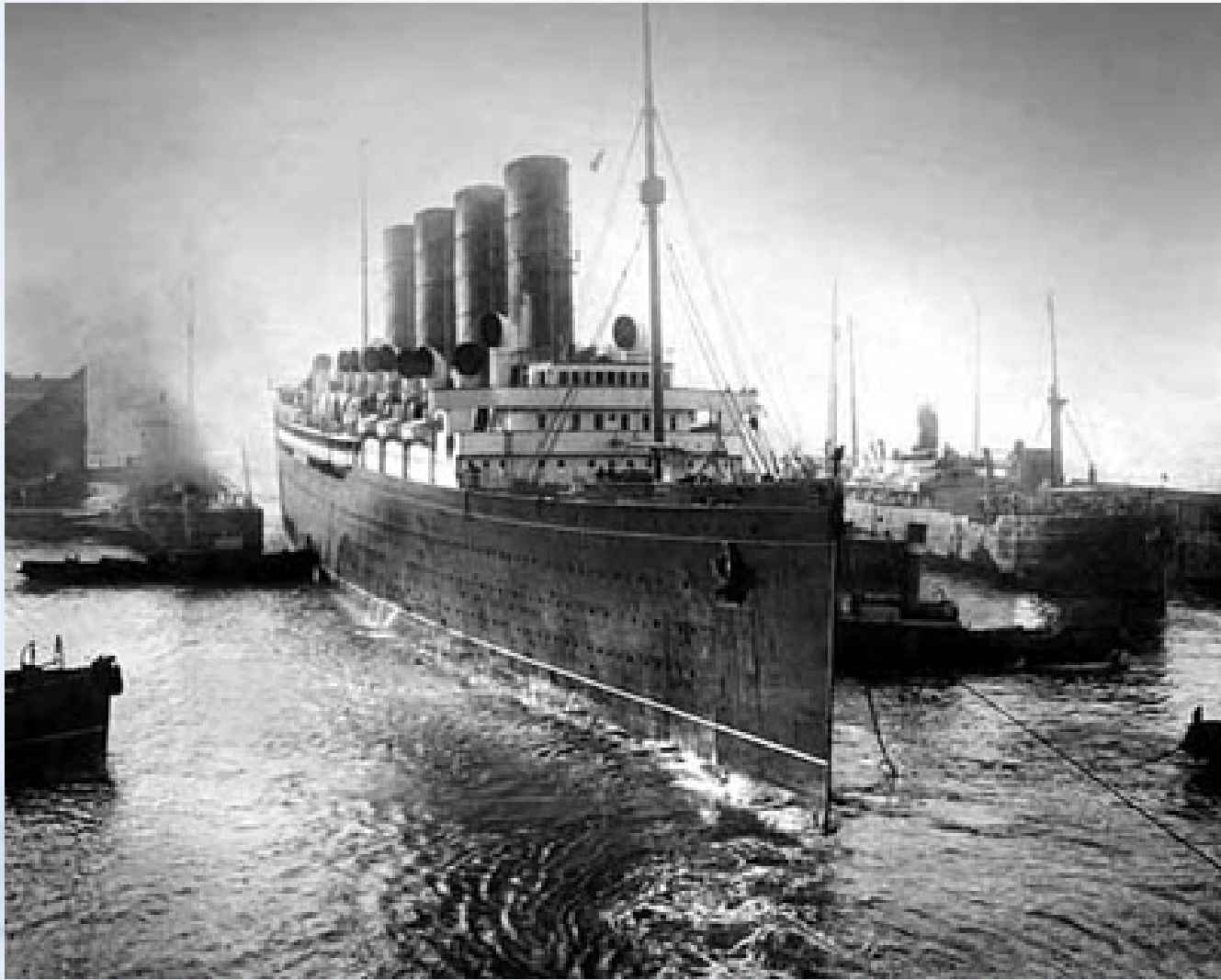
Old Dock (1715) – 16 ft water over the Sill at MHW

Canada Dock (1858) and most north docks – 22 ft of water over their sills at MHW

So it is obvious that a vessel with a draught of 22 ft could not get into the north docks on about half of high tides

e.g. Adrian Jarvis states that a vessel drawing 26.5 ft in 1890 can get in or out on only 138 days of the year

So ships had to partly unload/load in the river. Waste of time for owners. Complicated dock management.

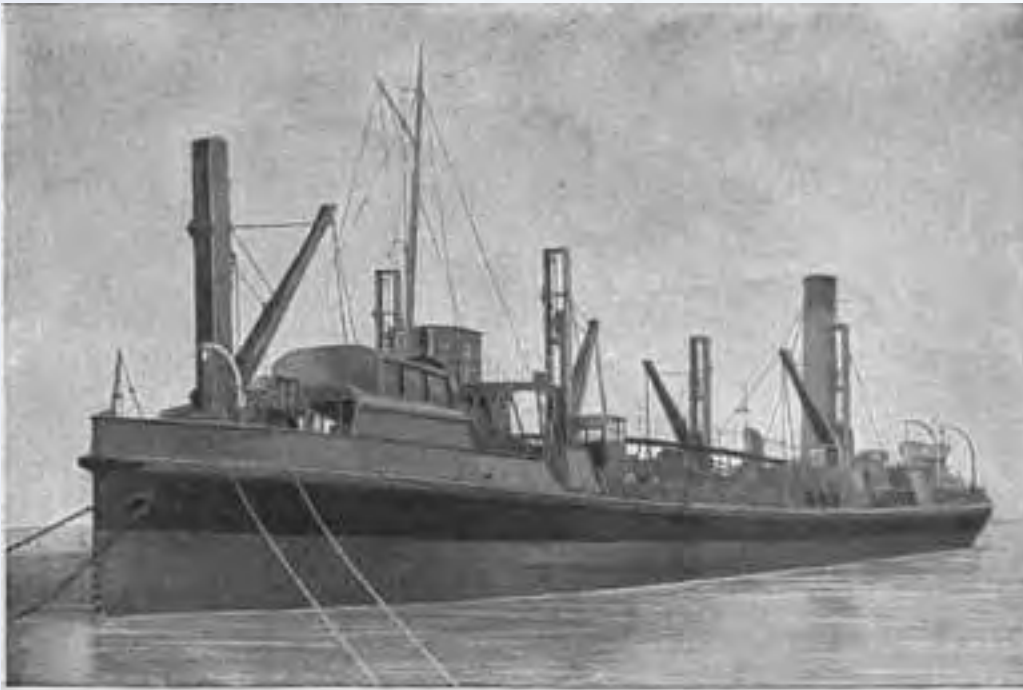


RMS Mauritania (1906) – the largest ship in the world - entering Sandon Dock. (Draught 33 ft).



Liverpool landing stage and the Lusitania (1907)





Mersey Dredging

Miles K Burton, MDHB, 1897



Shoalway, Peel Ports, 2010



Open University



RRS Sir David Attenborough

Cammell Laird, Saturday 14 July 2018 at 12 noon

“Getting Neaped”

Canada Dock (1858) – 22 ft of water at MHW

Gladstone Dock (1927) – 45 ft at MHW –
much improved but not enough for today

Panamax draught 39 ft 6 inch

New Panamax 50 ft



Liverpool Two. The Mersey approaches are being deepened to 16m (52ft) to take ships using the newly widened Panama Canal.

Tidal Science in the years before the Liverpool Tidal Institute

Liverpool had a large part in the first scientific measurements of the tide and in tidal predictions.



Some of the first measurements of the tide were made at Liverpool



**Jeremiah Horrocks observed
Transit of Venus in 1639,
made tidal measurements for
at least 3 months at Toxteth,
Liverpool in 1640**



**William Hutchinson,
Dockmaster at Liverpool,
Measured heights and times
of high tides 1764-1793**

TIDE TABLE,

Shewing the (Solar) TIMES of
HIGH WATER,

AND ALSO
The HEIGHTS of the TIDES,
AT THE
CUSTOM-HOUSE DOCK-GATES,
LIVERPOOL;

For the YEAR 1781.

WITH
Some New Astronomical PROBLEMS,
Which will be very useful at Sea.

Published by Order of
The Worshipful the MAYOR, BAILIFFS, and
Gentlemen of the COMMON-COUNCIL
of **LIVERPOOL.**

Calculated by the Rev. Mr G. HOLDEN,
And his SON,

According to the Theory of the late Mr R. HOLDEN.

[To be continued Yearly.]

Thou hast set them their Bounds, which they shall not pass.

PSAL. civ. v. 9.

PRINTED AND SOLD BY J. SIBBALD.

(Price 6d. Shilling.)

of the

JANUARY, 1781.

D. H. M. D. H. M.
First Qr. 28 1 E. Full Moon 10 8 51M.
Last Qr. 17 1 40M. New Moon 24 11 58M.

DAYS.	Morn.		Even.		Heights		Clock bef. Sun.
	H.	M.	H.	M.	2.	1.	
Monday	1	3	3	3	24	13	0
Tuesday	2	3	47	4	11	12	4
Wednesday	3	4	37	5	4	11	9
Thursday	4	5	34	6	6	11	8
Friday	5	6	38	7	10	11	10
Saturday	6	7	44	8	13	12	6
SUNDAY	7	8	41	9	7	13	5
Monday	8	9	31	9	55	14	5
Tuesday	9	10	18	10	40	15	5
Wednesday	10	11	2	11	24	16	5
Thursday	11	11	45			17	4
Friday	12	0	7	0	28	18	0
Saturday	13	0	50	1	13	18	3
SUNDAY	14	1	36	1	59	18	1
Monday	15	2	22	2	46	17	6
Tuesday	16	3	11	3	37	16	8
Wednesday	17	4	4	4	34	15	6
Thursday	18	5	4	5	37	14	6
Friday	19	6	11	6	50	13	8
Saturday	20	7	27	8	5	13	5
SUNDAY	21	8	39	9	9	13	10
Monday	22	9	37	10	3	14	4
Tuesday	23	10	28	10	50	14	11
Wednesday	24	11	10	11	29	15	6
Thursday	25	11	48			16	0
Friday	26	0	5	0	24	16	2
Saturday	27	0	41	0	57	16	2
SUNDAY	28	1	14	1	30	15	10
Monday	29	1	46	2	3	15	4
Tuesday	30	2	19	2	36	14	7
Wednesday	31	2	54	3	12	13	8

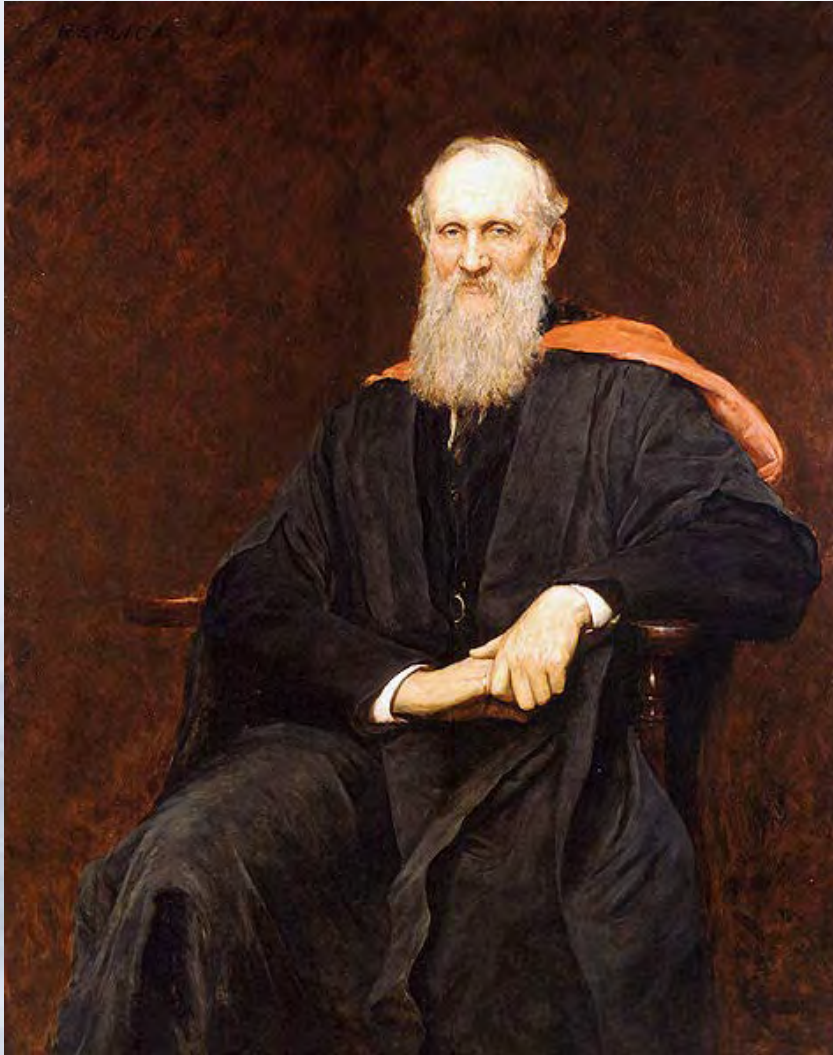
Tidal Science in the years before the Liverpool Tidal Institute

Liverpool had a large part in the first scientific measurements of the tide and in tidal predictions.

Great progress in tidal science had been made in the 19th century through the British Association for the Advancement of Science.

Evolution of Understanding of the Tide in the 19th Century

William Thomson (1824-1907)



1st Baron Kelvin

George Darwin (1845-1912)



Development of the Harmonic Representation of the Tides

Represents the tide as a sum of harmonics (or 'satellites') with frequencies that are in the tidal potential

Developed in the late 19th century and still the main method today

$$h_{total}(t) = \sum_1^N h_i \cos(\omega_i t - g_i)$$

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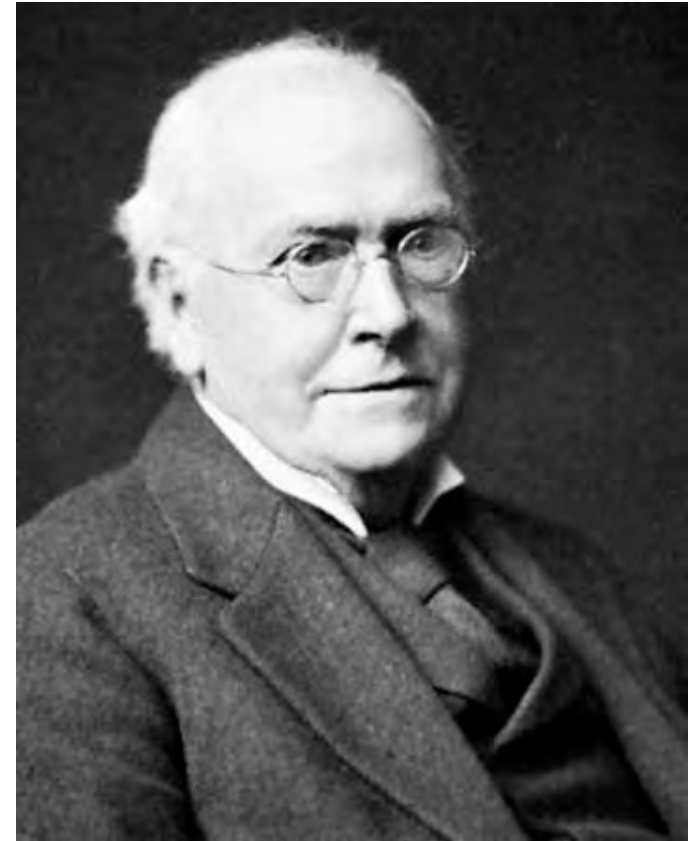
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Great progress in tidal science had been made in the 19th century through the British Association for the Advancement of Science.

But the work had stalled for some years.

Some Background to the LTI

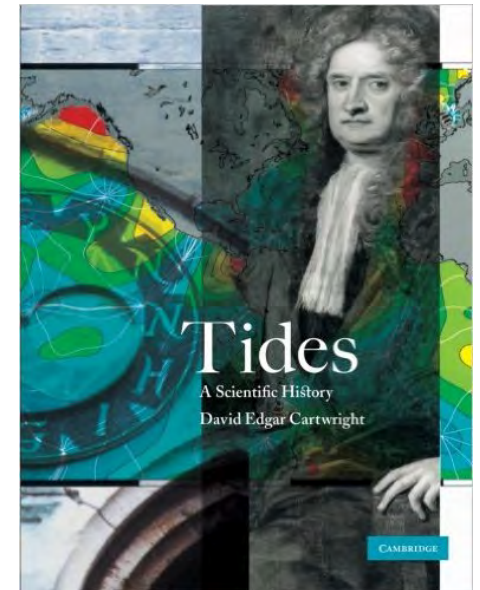
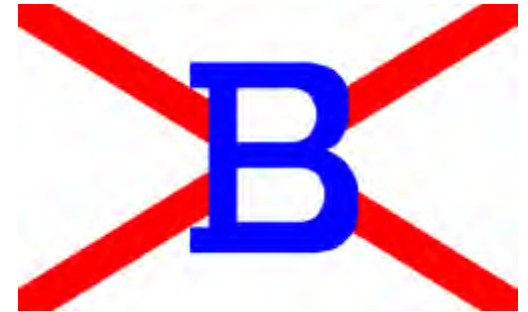
- Story can start with Sir Horace Lamb FRS, Professor in Applied Mathematics at M'ter Univ.
- Joseph Proudman had written to him around 1913 to ask advice on suitable areas for research.
- Lamb asked Proudman in 1916 to help him prepare a report for the BAAS on the state of research in ocean tides, which led to the suggestion of a special Tidal Institute.



Horace Lamb

Some Background to the LTI

- Funded by Booth Line (Alfred and Charles Booth)
- Opened March 1919
- Joseph Proudman appointed both as Honorary Director of the LTI (i.e. unpaid) and as Professor of Applied Maths.
- Secretary Arthur Doodson (paid for by Booth brothers, few 100 pounds per year).
- University provided offices and 10 pounds per year.



For more information, see David Cartwright book or thesis by Anna Carlsson-Hyslop

LTI Terms of Reference

1. To prosecute research into all aspects of the tides (incl. tidal currents for shipping lines and 'meteorological effects' on the tides)
2. To form a training school of Applied Maths
3. To form a bureau of organised information concerning the tides
4. To undertake special pieces of work for commercial purposes



The George Holt building at L'pool Univ.

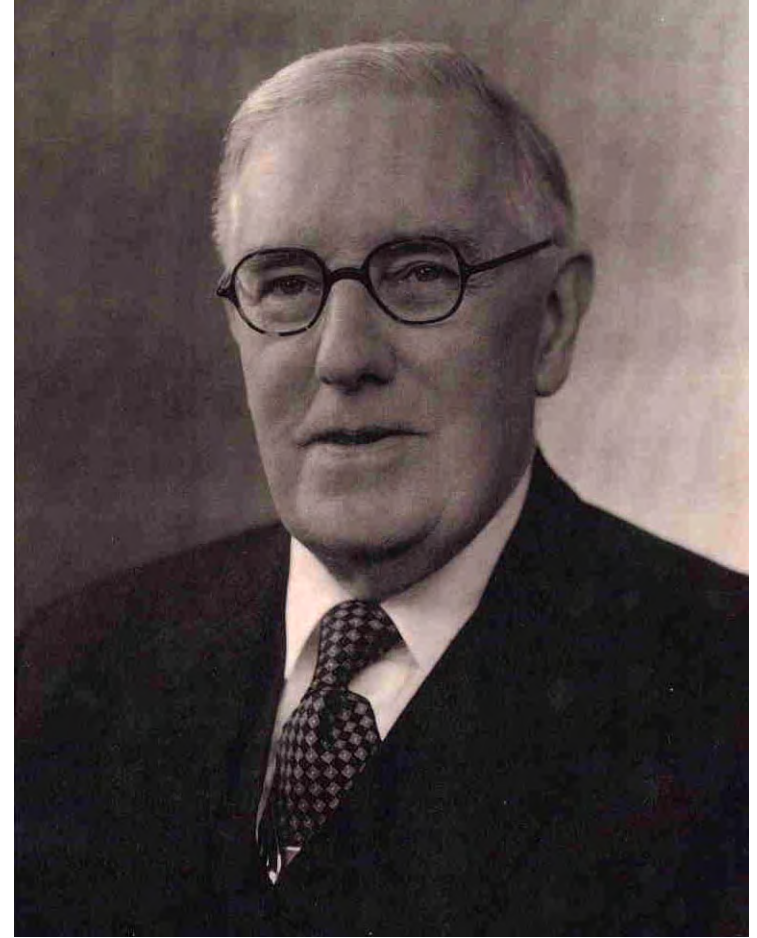
Holt provided funds for many aspects of physical science. He was the brother of Alfred Holt, founder of the Blue Funnel Line.





Joseph Proudman

Tidal dynamics



Arthur Doodson

Data manipulation/tidal predictions

Liverpool Tidal Institute

- Established in 1919 at Liverpool University where space was short
- The MDHB owned Bidston Observatory where its own work was described as 'moribund'
- So the LTI moved to Bidston in 1924
- In 1929, the Observatory and the LTI were merged to create the Liverpool Observatory and Tidal Institute



Bidston Observatory

Photo: Geoff Shannon (August2018)

Oceanography Department at Liverpool

- Sir William Herdman - first Prof. of Natural History in 1881. His second wife Jane was the daughter of Alfred Holt.
- In 1916 he endowed the Herdman chair of Geology.
- In 1919 he endowed a chair in Oceanography (the first in the UK) and became its first Professor.
- James Johnstone 1920-1932 Marine biology.
- In 1933 Joseph Proudman took over as Prof. of Oceanography until 1954.

Tidal Prediction

Tidal prediction became a speciality of the LTI and especially of Arthur Doodson.

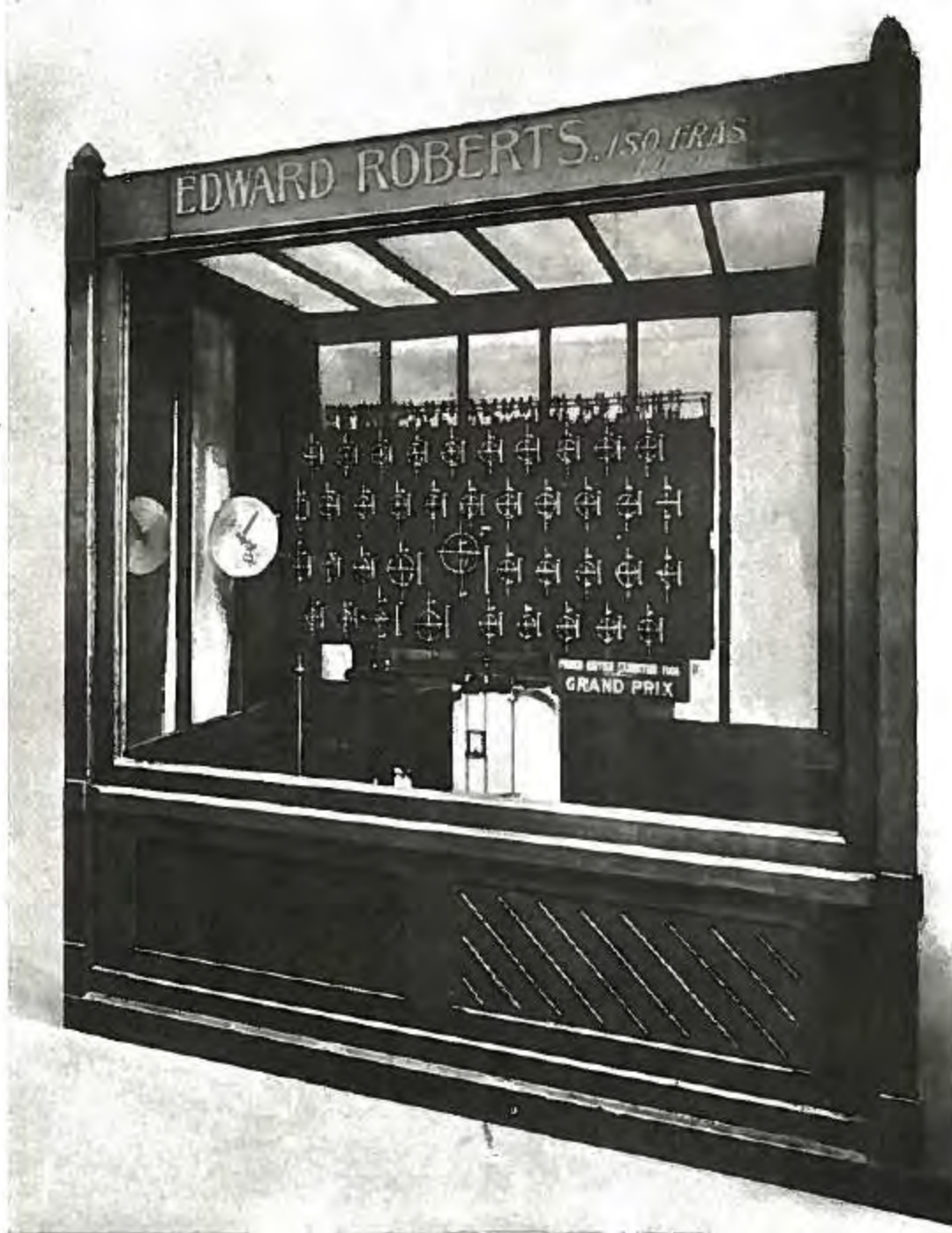


Tide Prediction Machines

- Before digital computers became available in the 1960s the tides were predicted using Tide Prediction Machines.
- These were types of analogue computers, rather like complicated clocks.
- They are sometimes called Kelvin Machines after their first inventor Lord Kelvin.
- Only approximately 30 were made worldwide and 3 of those were used at Bidston. For a list click [here](#).
- Tides were calculated for many ports around the world and for many purposes.



Bidston
Kelvin
Machine



Roberts
"Universal Tide Predictor"
of 1906, winner of the
"Grand Prix" of the Franco-
British Exhibition of 1908



Doodson-Lege Tide Prediction Machine (42 components)

For a movie showing the machine in action click [here](#)

The tide predictions for D-Day

Bruce Parker

feature
article

Based on the physics of Newton and Laplace, the big brass tide-predicting machine designed by Lord Kelvin was crucial for the success of the Normandy invasion in World War II.

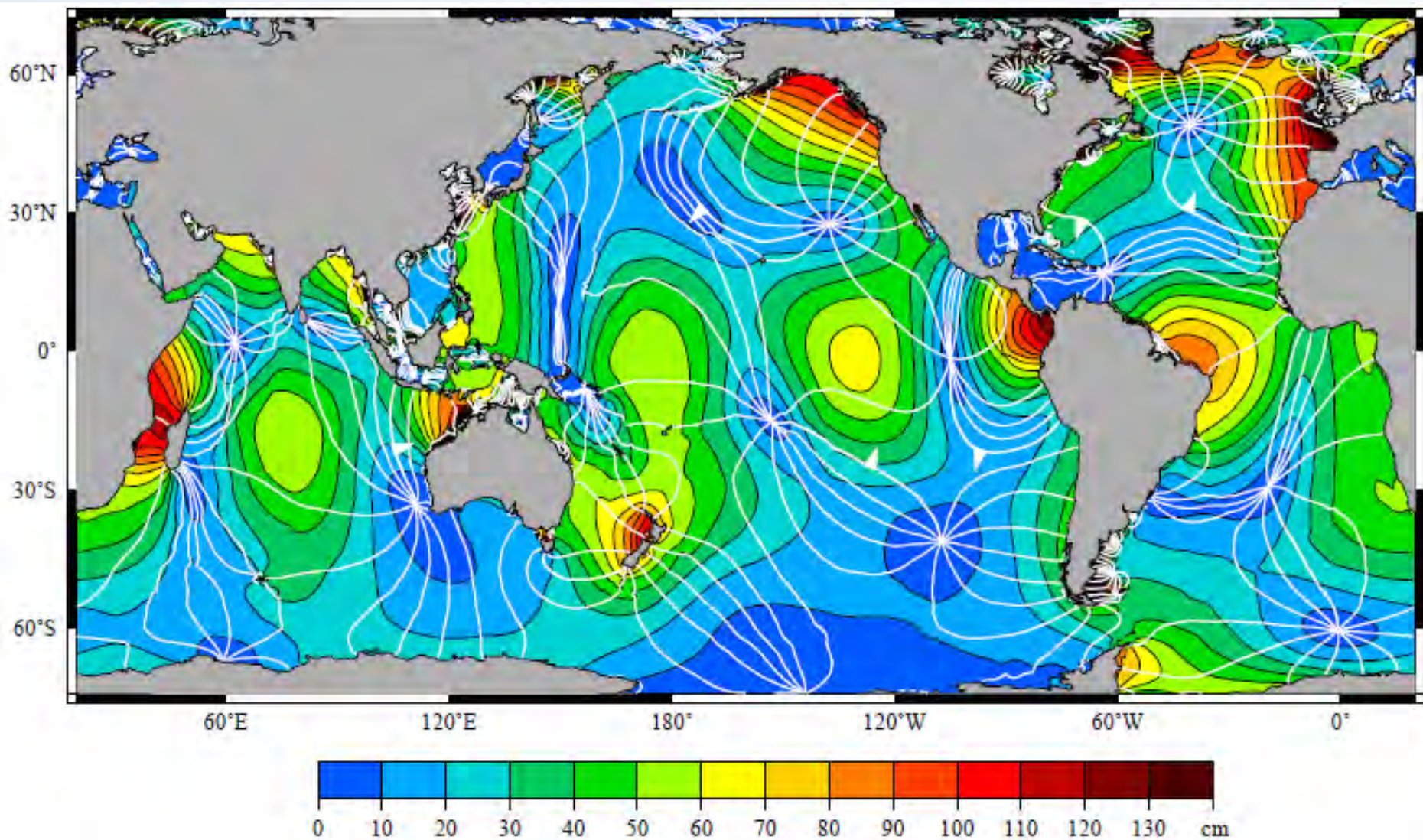


GERMAN FEDERAL ARCHIVE





Deep-sea bottom pressure recorder of the National Oceanography Centre to measure the tide in depths of as much as 5000 m.



Map of the amplitude and phase of the main lunar twice-daily tide (called M2)

Other Research at the LTI

- Storm surges and coastal protection – following the 1953 floods in the North Sea
- Long term changes in sea level
- Earth tides
- Ocean modelling for studies of water quality, ecosystems, climate change etc.
- Geodetic measurements
- Renewable energy
- Data and computer centre



North Norfolk 1953

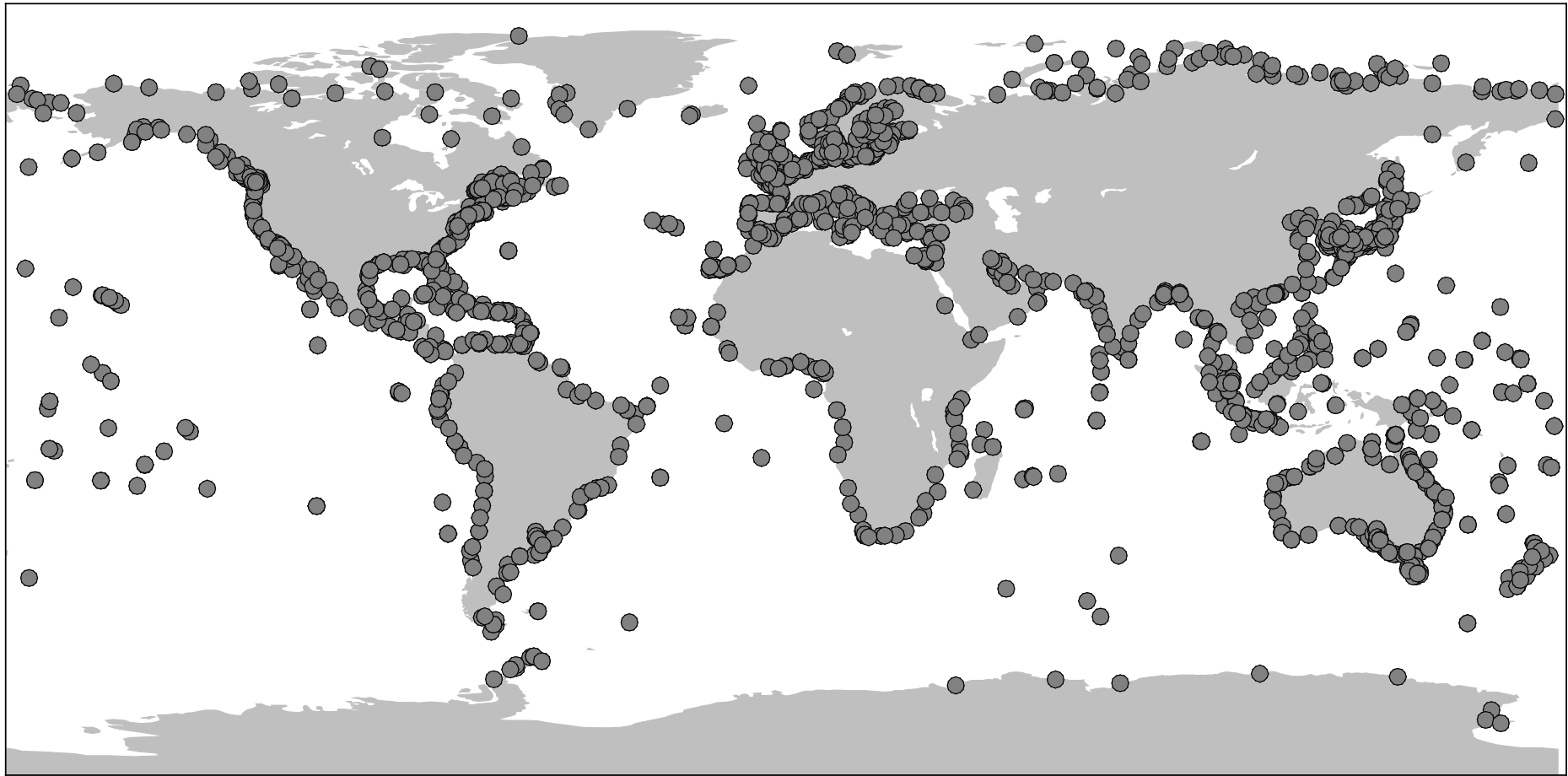


Environment Agency

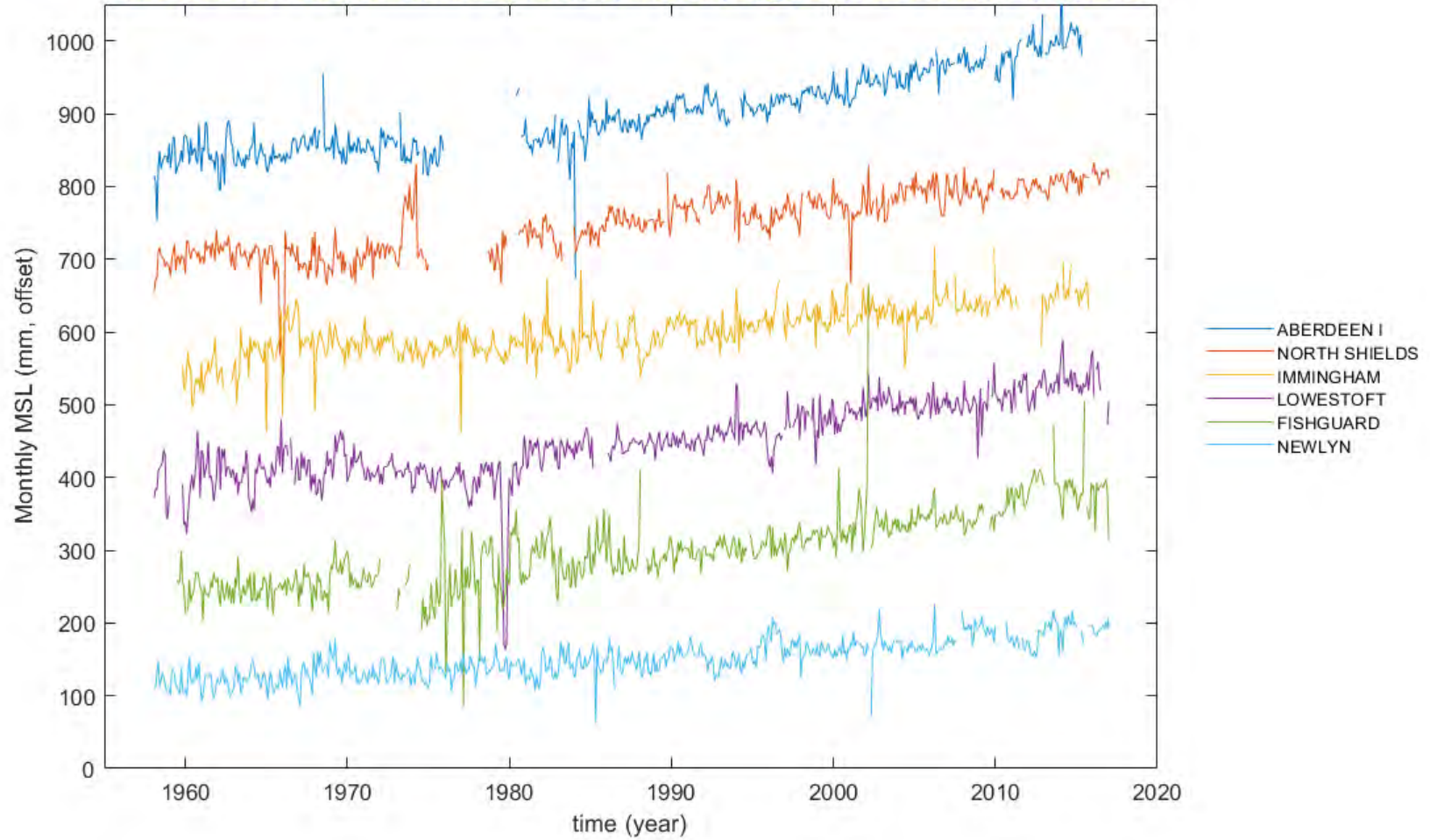
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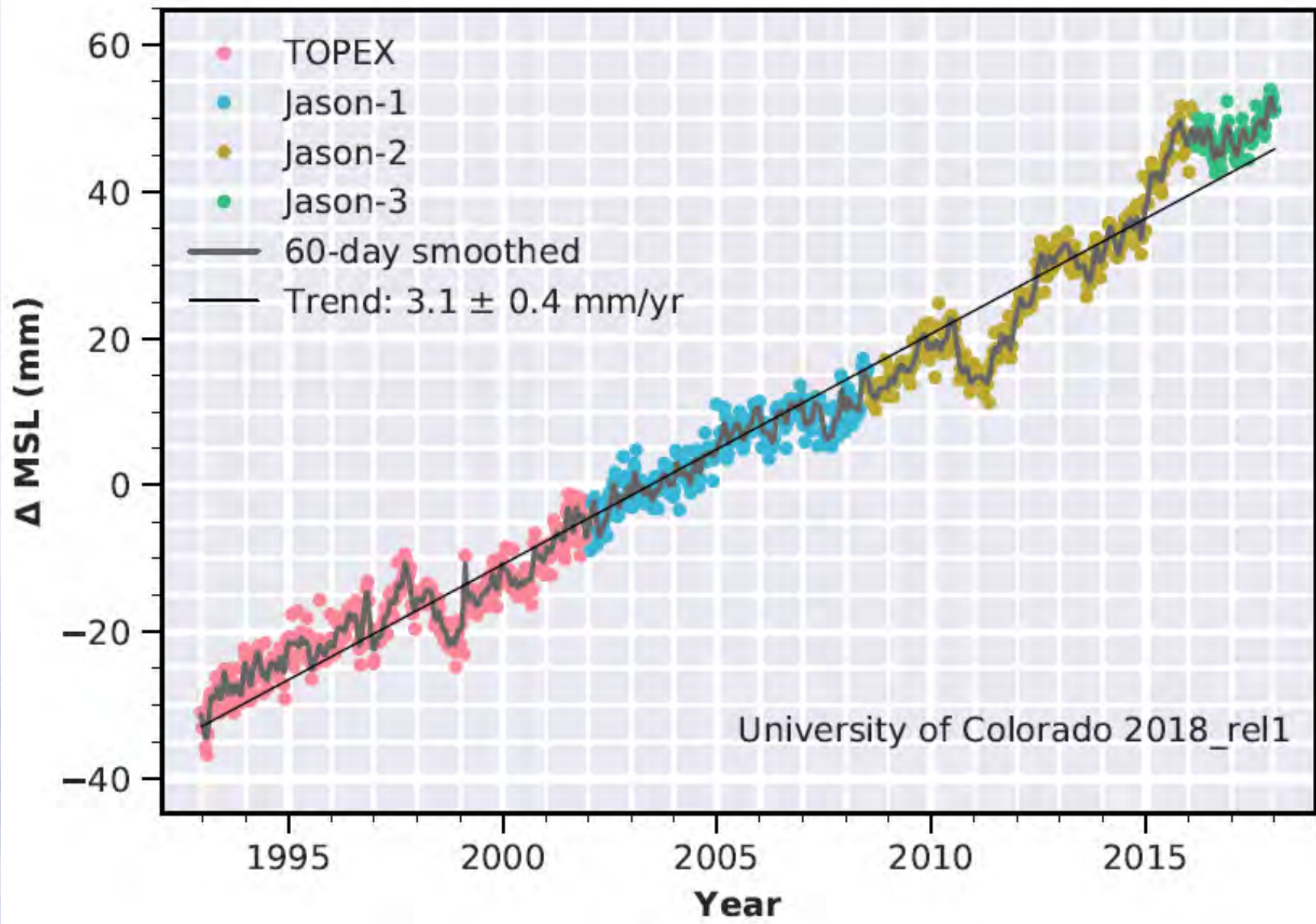
Global Sea Level Network



MSL 1958 to 2018 at 6 sites around British Isles; seasonal, surge, GIA, TGZ & datum step adjusted



Plot from Peter Hogarth (NOC)





Many Changes of Name

- Liverpool Tidal Institute (1919)
- Liverpool Observatory and Tidal Institute (1929)
- Liverpool University Tidal Institute and Observatory (1961)
- Institute of Coastal Oceanography and Tides (1969) (now part of NERC)
- Institute of Oceanographic Sciences (1973)
- Proudman Oceanographic Laboratory (1987)
- Centre for Coastal and Marine Sciences (1994)
- back to the Proudman Oceanographic Laboratory (2000)
- National Oceanography Centre (2010)

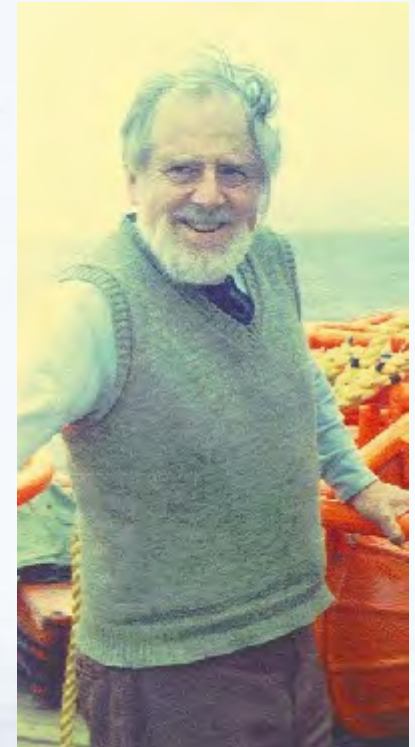
Three FRSs at Bidston Observatory



Joseph Proudman



Arthur Doodson



David Cartwright



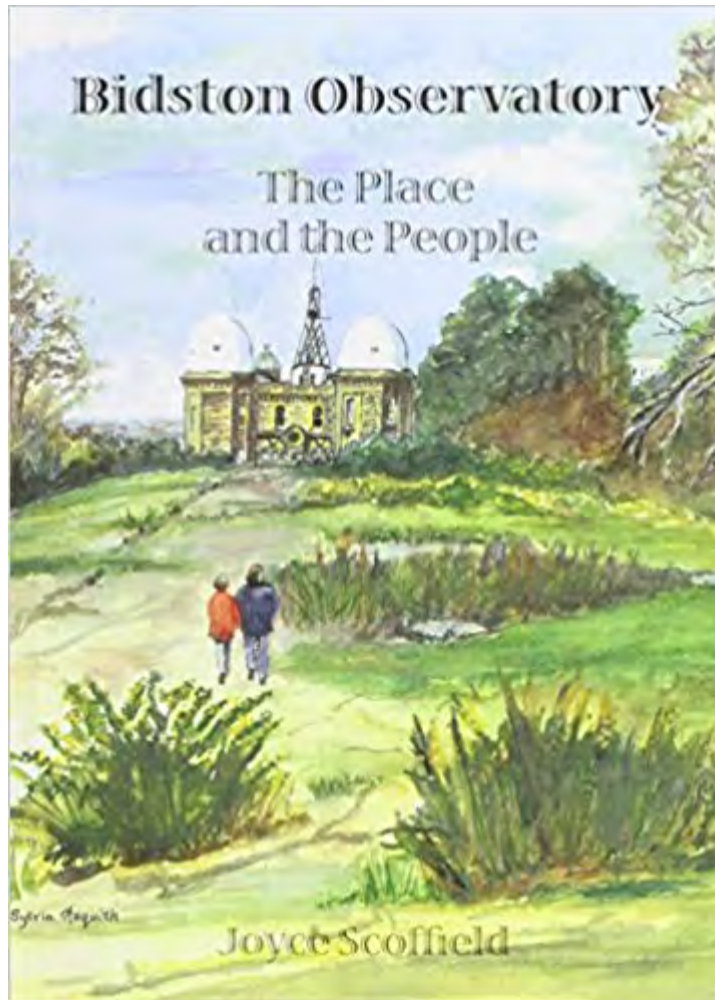
Work transferred in 2005 to the National Oceanography Centre in Brownlow Street, Liverpool

From Astronomy to Oceanography – a brief history of Bidston Observatory



J. Eric Jones

Bidston Observatory has a remarkable history. It was built 134 years ago to replace and carry on the work of the Port of Liverpool Observatory. Since then it has pursued



Bidston Observatory

The Place and the People

By

Joyce Scoffield

Agenda

10.00 Introduction to the meeting and a brief history of the Liverpool Tidal Institute – Philip Woodworth

10.30 The science behind the ocean tide - David Pugh

11.00 Opportunities for the UK in tidal energy - Judith Wolf

11.30 Coffee Break

12.00 The tides and the oceanography of our neighbouring seas - Jonathan Sharples

12.30 The large Mersey tides and the Port of Liverpool - Simon Holgate

13.00 Tides and the Earth's climate - Chris Hughes

13.30 The tides and the banks of the Mersey - Andy Plater/Jason Kirby



NOC is open today to see more aspects of its work

Tide & Time



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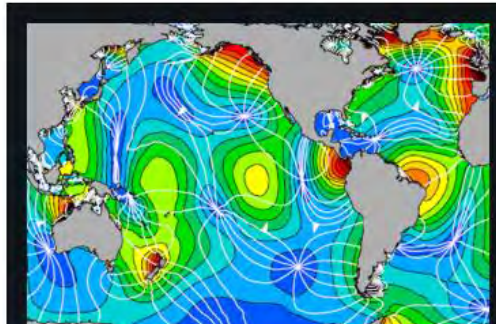


Visit Discover Exhibition

Welcome to the Tide & Time exhibition

Presenting the Doodson-Légé and the Roberts-Légé Tide Predicting Machines

Discover more →



<https://www.tide-and-time.uk>

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Centre for Port and Maritime History (CPMH)

LISCO and CPMH are activities of Liverpool University, Liverpool John Moores University, National Oceanography Centre and National Museums Liverpool

The Ocean Tide and the Port of Liverpool

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