National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

Data Archaeology (or Data Rescue)

Philip L. Woodworth
National Oceanography Centre, Liverpool

and thanks to Liz Bradshaw (BODC), Pat Caldwell (NOAA/Univ. Hawaii) and Guy Wöppelmann (Univ. La Rochelle)

PSMSL-80 Workshop, 28 October 2013

What is Data Archaeology?

- Attempts to convert old measurements of sea level, recorded in various paper archives, into computer-accessible form so we can analyse them using modern methods
- Paper records include tide gauge charts, tabulations in port ledgers, libraries, museums, academic departments, private notebooks, even newspapers etc.

To be precise

- Data Archaeology – process of seeking out, restoring, evaluating, correcting and interpreting historical data sets
- Data Rescue – effort to save data at risk by digitising manuscript data in electronic form

- Reference: UNESCO-IOC-IODE “Global Oceanographic data Archaeology and Rescue (GODAR) project”

Why Data Archaeology Now?

- We want to extend the instrumental record of sea level (which is mostly 19th-20th century) as far back as possible, complementing measurements by other methods (salt marshes etc.)
- A constant worry is that, if data archaeology (or 'data rescue') is not undertaken now the data may be lost for ever

Tabulations

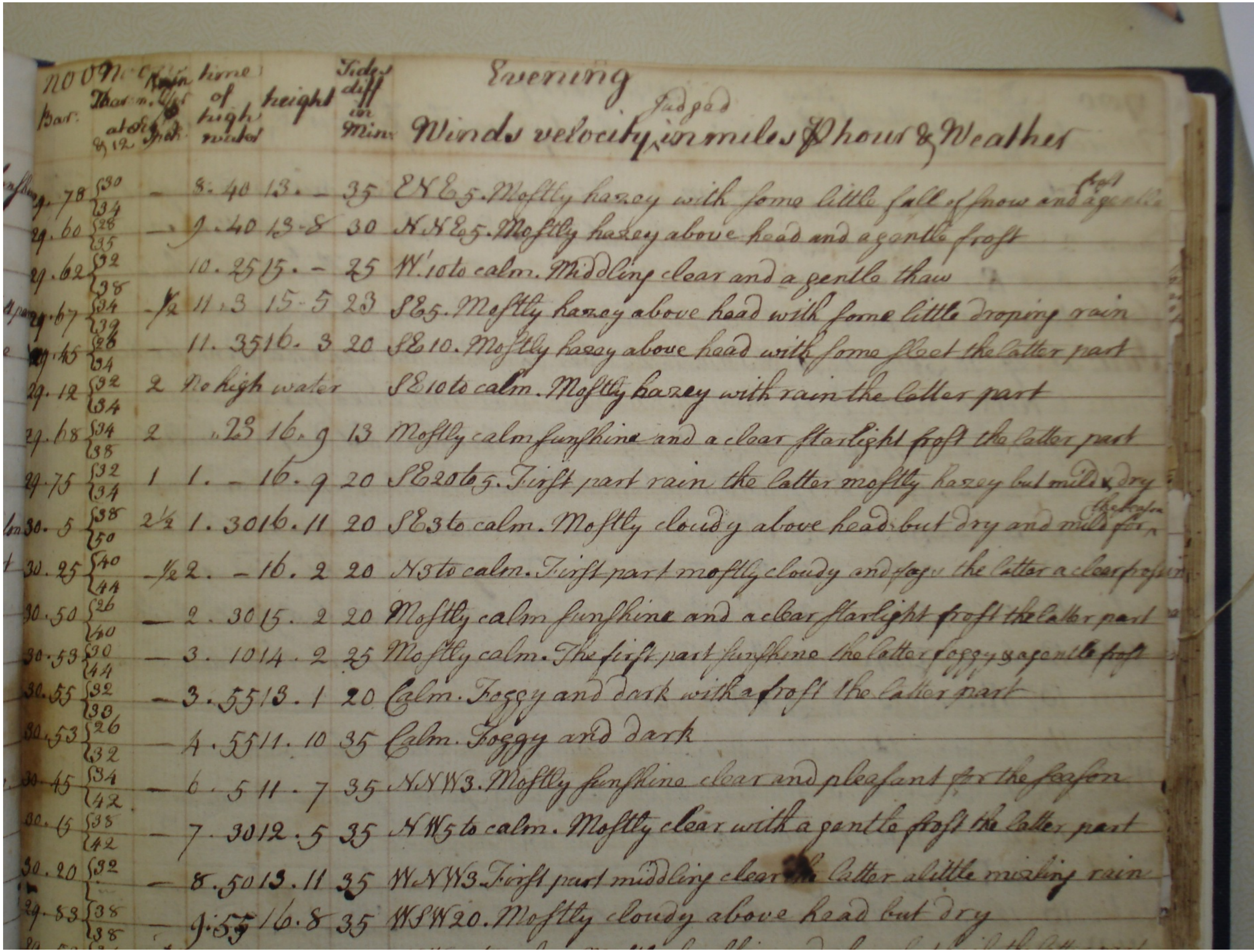
- Automatic (self-registering) tide gauges did not exist before the 1830s. Before then sea levels were recorded as heights and times of high water (and sometimes of low water).

Local Hero

William Hutchinson

Dockmaster at Liverpool

Measured heights and times of high waters 1764-1793



Noon Bar.	Ther. Noon at 8 & 12	Rain in ...	Time of high water	height	Tides diff in Min.	Evening Winds velocity judged in miles ⅌ hour & Weather
29.78	30 / 34	—	8.40	13. —	35	ENE5. Moſtly hazey with ſome little fall of ſnow and a gentle froſt
29.60	28 / 35	—	9.40	13.8	30	NNE5. Moſtly hazey above head and a gentle froſt
29.62	32 / 38		10.25	15. —	25	W.10 to calm. Middling clear and a gentle thaw
29.67	34 / 39	½	11.3	15.5	23	SE5. Moſtly hazey above head with ſome little droping rain
29.45	28 / 34	—	11.35	16.3	20	SE10. Moſtly hazey above head with ſome ſleet the latter part
29.12	32 / 34	2	No high water			SE10 to calm. Moſtly hazey with rain the latter part
29.68	34 / 38	2	.23	16.9	13	Moſtly calm ſunſhine and a clear ſtarlight froſt the latter part
29.75	32 / 34	1	1. —	16.9	20	SE20 to 5. Firſt part rain the latter moſtly hazey but mild & dry
30.5	38 / 50	2½	1.30	16.11	20	SE3 to calm. Moſtly cloudy above head but dry and mild for the ſeaſon
30.25	40 / 44	½	2. —	16.2	20	N3 to calm. Firſt part moſtly cloudy and foggy the latter a clear froſt
30.50	26 / 40	—	2.30	15.2	20	Moſtly calm ſunſhine and a clear ſtarlight froſt the latter part
30.53	30 / 44	—	3.10	14.2	25	Moſtly calm. The firſt part ſunſhine the latter foggy & a gentle froſt
30.55	32 / 38	—	3.55	13.1	20	Calm. Foggy and dark with a froſt the latter part
30.53	26 / 32	—	4.55	11.10	35	Calm. Foggy and dark
30.45	34 / 42	—	6.5	11.7	35	NNW3. Moſtly ſunſhine clear and pleaſant for the ſeaſon
30.15	38 / 42	—	7.30	12.5	35	NW5 to calm. Moſtly clear with a gentle froſt the latter part
30.20	32 /	—	8.50	13.11	35	WNW3. Firſt part middling clear the latter a little mizling rain
29.83	38 / 38	—	9.55	16.8	35	WSW20. Moſtly cloudy above head but dry

A page of Hutchinson’s Tide and Weather Journal

Two Remarks from Hutchinson's Data Set

- Until the mid-1990s I had no idea these data existed – they were buried in the archives of Liverpool Public Library. Now computerised catalogues are making data sets more visible.
- We have absolutely no idea of how Hutchinson made his measurements. (Although we know that only he, and one colleague were involved for 30 years and we know where his gauge was.)

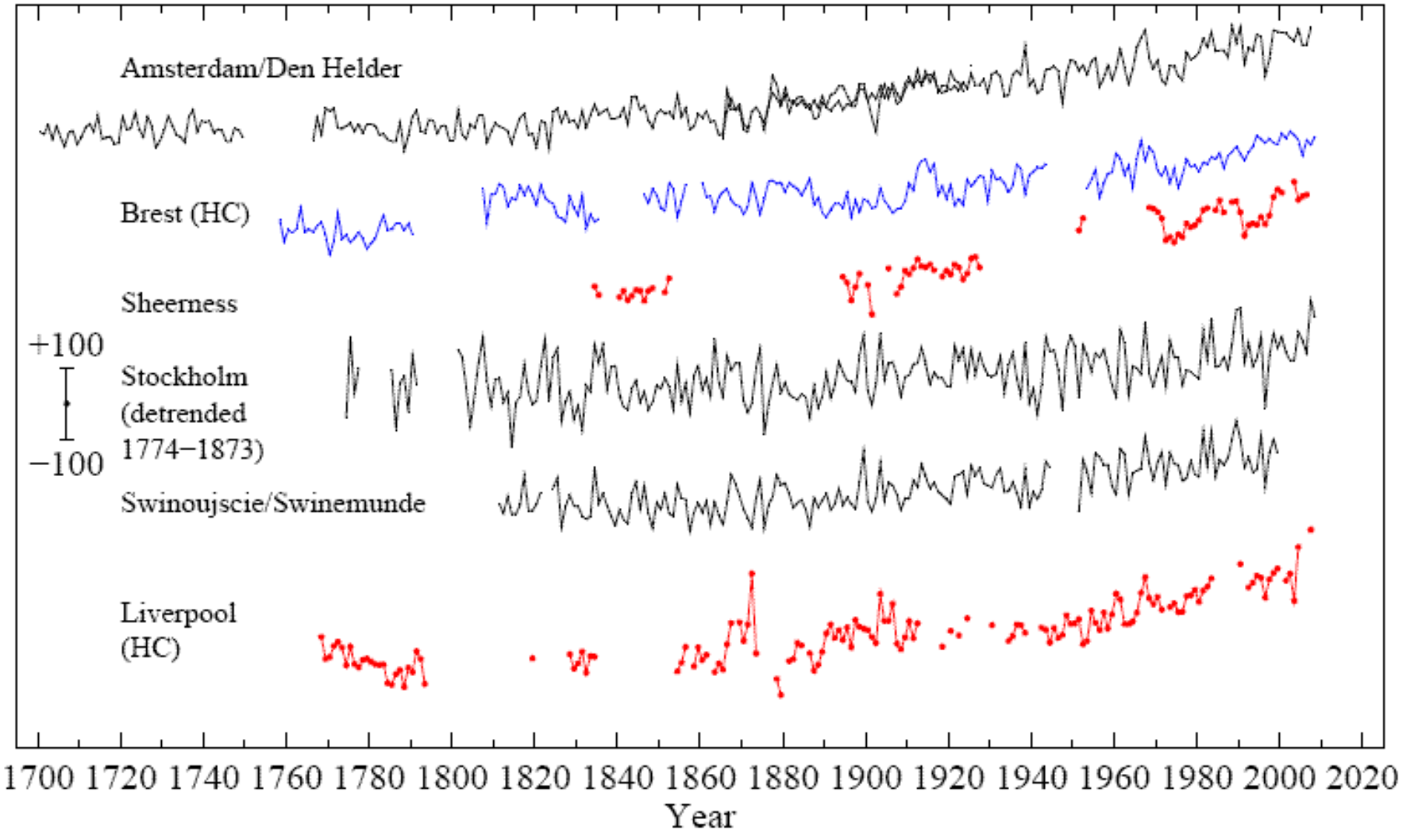
Liverpool Old Dock – Usable only around high tide

Data Archaeology Problems

- You need to know how and why the measurements were made and who made them. This can lead to a lot of research into local history.
- Most older measurements were not made for ‘science’ but for operational and other reasons.
- So how do you know how good the data is? Are there other data nearby? Did they measure other parameters, and how well?

Other People who have done Similar Work in Europe

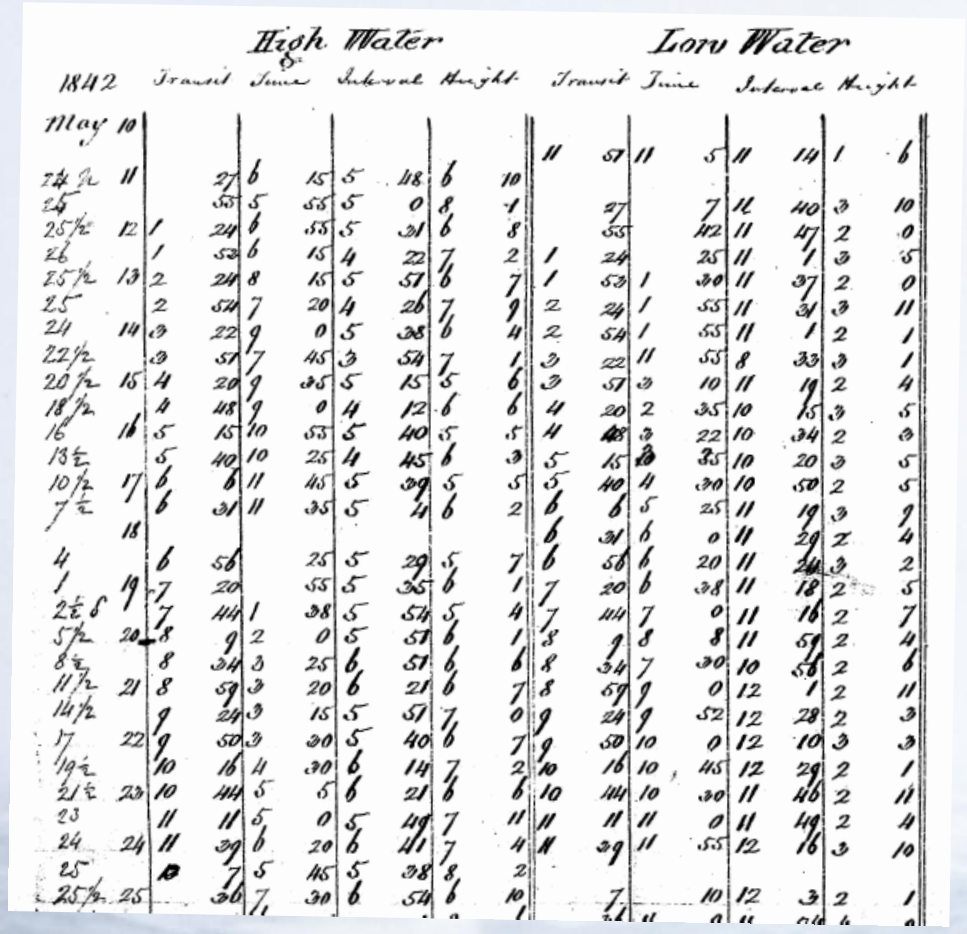
- Martin Ekman – Stockholm
- Guy Wöppelmann – Brest and other Atlantic stations (and composite records thereof). Also Marseille
- Marta Marcos – Cadiz
- Sometimes the data rescue is for only a few 10s of years but provides a useful extension to an existing record e.g. Fabio Raicich – Trieste.


Amsterdam/Den Helder
Brest (HC)
Sheerness
+100
Stockholm
(detrended
1774–1873)
−100
Swinoujscie/Swinemunde
Liverpool
(HC)
1700 1720 1740 1760 1780 1800 1820 1840 1860 1880 1900 1920 1940 1960 1980 2000 2020
Year

Use of Short Historical Tabulations

- Sometimes even short tabulations can be of scientific interest
- e.g. short records from Port Arthur and Port Louis around 1840 (unique southern hemisphere records)
- e.g. short records from Kerguelen and Saint Paul (Laurent Testut)

- When combined with modern measurements they can provide insight into recent sea-level acceleration.

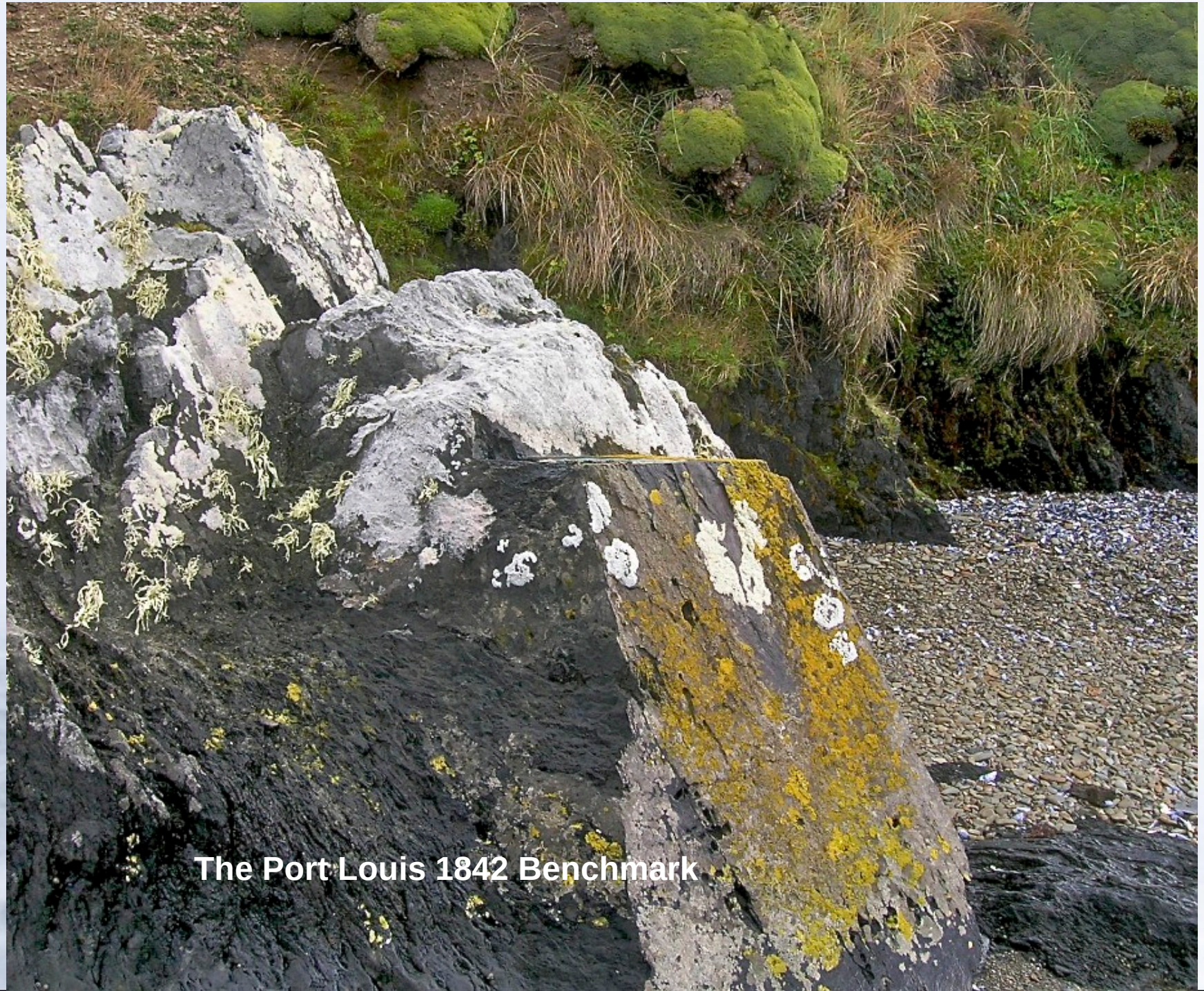


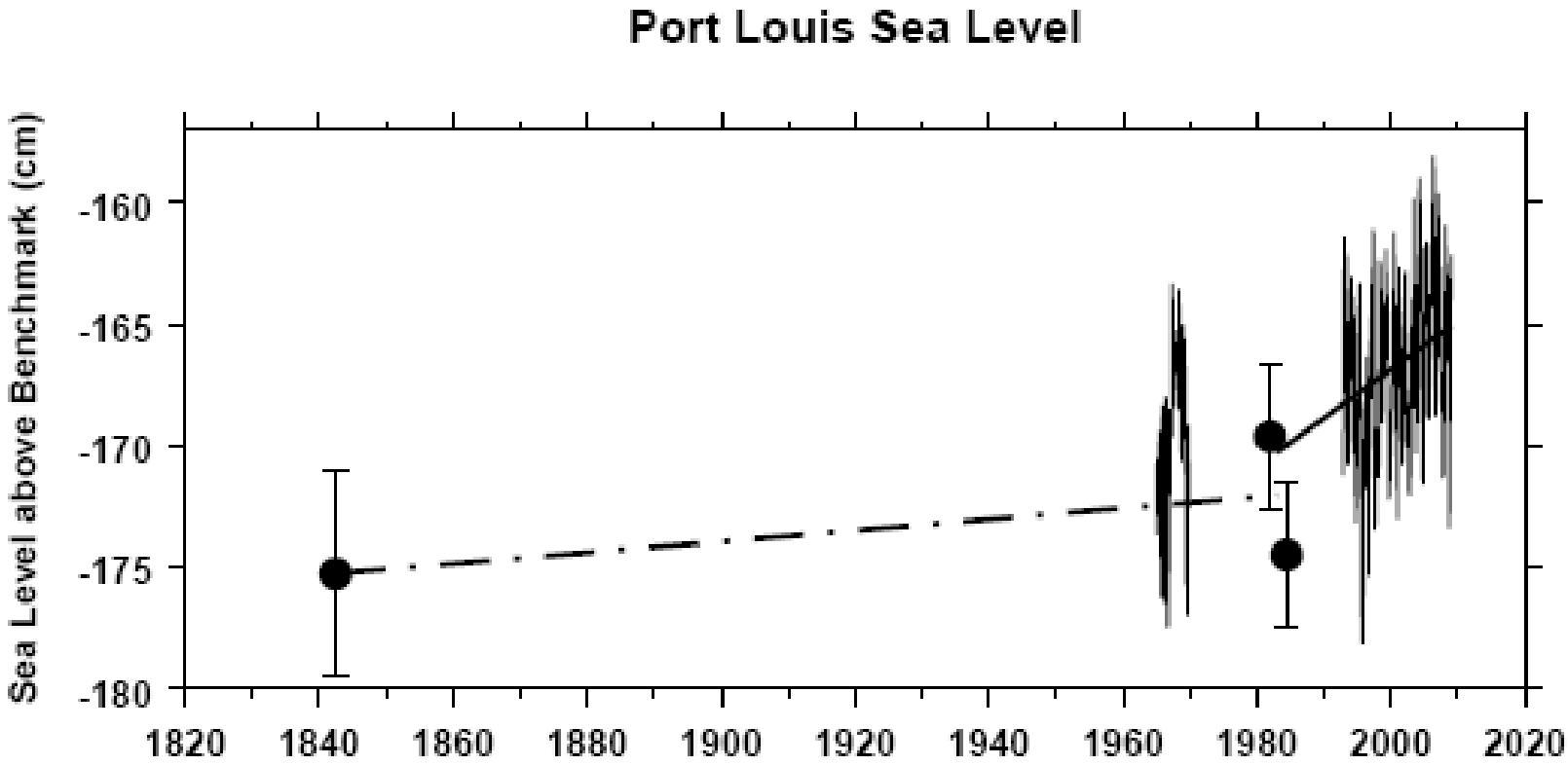
1842	High Water Transit	High Water Time	High Water Interval	High Water Height	Low Water Transit	Low Water Time	Low Water Interval	Low Water Height
May 10					11 57	11 5	11 14	1 6
11		27	6 15	5 18	6 10			
		53	5 58	5 0	8 1	27	7 11	40 3 10
12	1	24	6 55	5 31	6 8	55	12 11	47 2 0
	1	52	6 15	4 22	7 2	1 24	25 11	1 3 5
13	2	24	8 15	5 51	6 7	1 53	1 30 11	37 2 0
	2	54	7 20	4 26	7 9	2 24	1 55 11	31 3 11
14	3	22	9 0	5 38	6 4	2 54	1 55 11	1 2 1
	3	51	7 45	3 54	7 1	3 22	11 55 8	33 3 1
15	4	20	9 35	5 15	5 6	3 51	3 10 11	19 2 4
	4	48	9 0	4 12	6 6	4 20	2 35 10	15 3 5
16	5	15	10 53	5 40	5 5	4 48	3 22 10	34 2 3
	5	40	10 25	4 45	6 3	5 15	3 35 10	20 3 5
17	6	6	11 45	5 39	5 5	5 40	4 30 10	50 2 5
	6	31	11 35	5 4	6 2	6 6	5 25 11	19 3 3
18					6 31	6 0	11 29	2 4
	6	56	25	5 29	5 7	6 56	6 20 11	24 3 2
19	7	20	55	5 35	6 1	7 20	6 38 11	18 2 5
	7	44	1 38	5 54	5 4	7 44	7 0 11	16 2 7
20	8	9	2 0	5 51	6 1	8 9	8 8 11	59 2 4
	8	34	3 25	6 51	6 6	8 34	7 30 10	58 2 6
21	8	59	3 20	6 21	6 7	8 59	9 0 12	1 2 11
	9	24	3 15	5 51	7 0	9 24	9 52 12	28 2 3
22	9	50	3 30	5 40	6 7	9 50	10 0 12	10 3 3
	10	16	4 30	6 14	7 2	10 16	10 45 12	29 2 1
23	10	44	5 5	6 21	6 6	10 44	10 30 11	46 2 11
	11	11	5 0	5 49	7 11	11 11	11 0 11	49 2 4
24	11	39	6 20	6 41	7 4	11 39	11 55 12	16 3 10
25		7	5 45	5 38	8 2			
25	25	36	7 30	6 54	6 10	7	10 12	3 2 1

High and Low Waters in Trinity College, Cambridge Library from Measurements at Port Louis, Falkland Islands in 1842

“5 Feet 8 Inches above the mean level of the Ocean. August 1842. H.B.M. Ships *Erebus* and *Terror*”

(the mean calculated from four months of data)


The Port Louis 1842 Benchmark



Sea level change at Port Louis, Falkland Islands

Woodworth, Pugh and Bingley, JGR, 2010

Another example – Hourly measurements by Lampriere at Port Arthur, Tasmania 1837-1842

It is important in almost all of this work that historical benchmarks should survive

Hunter et al., GRL, 2003

Comparison of Port Arthur and Port Louis Findings

Port Arthur, Tasmania

1841-2002	1.0+/- 0.3 mm/year
1991-on	3.3 +/- ??? mm/year (at Spring Bay)

Port Louis, Falkland Islands

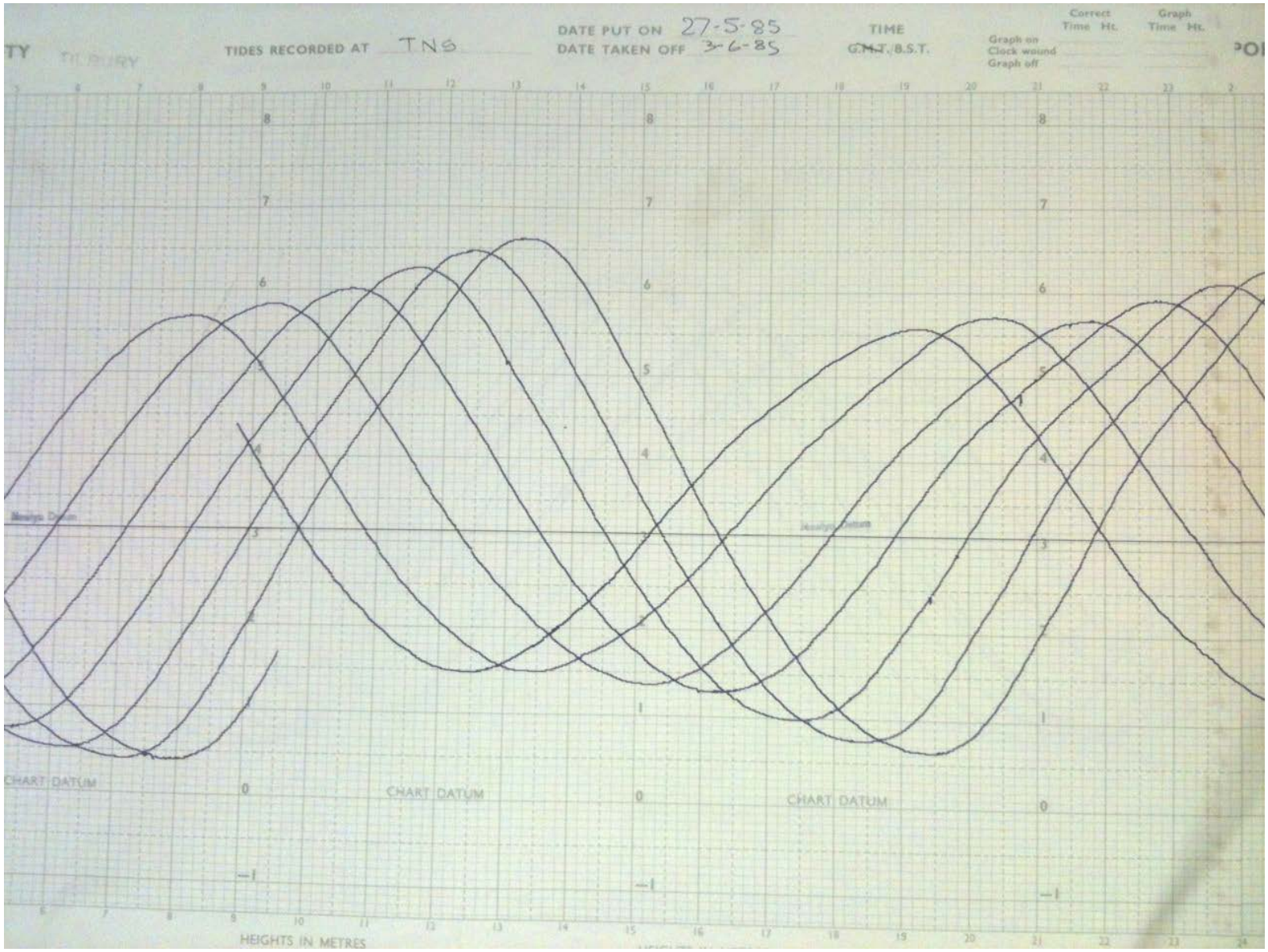
1842-mid 1980s	0.75 +/- 0.35 mm/year
1992-on	2.51 +/- 0.58 mm/year (at Port Stanley)

The recent rates of sea level change at both of these locations are significantly in excess of the long-term value.

Digitising Tide Gauge Charts

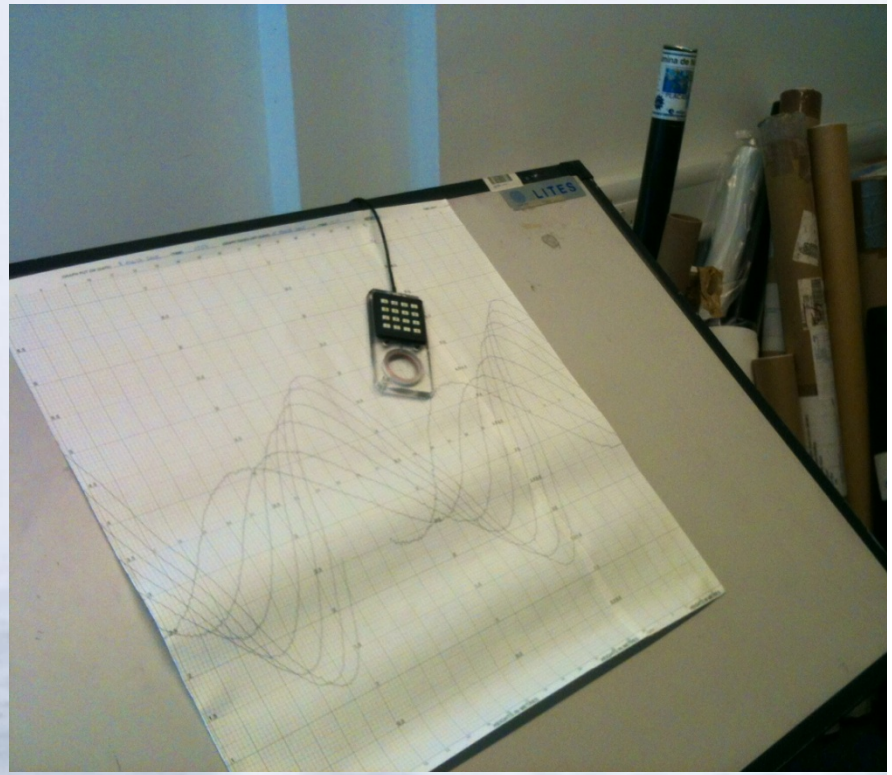
- Automatic (self-registering) tide gauges from 1830s.
- Most charts (e.g. UK) were changed every week or fortnight.
- Main issue is identifying which charts exist and which are a priority for rescue e.g.

1. Periods with interesting events e.g. tsunamis
2. Larger sets of charts for which the BM datum information is clearly known ➔ MSL studies



Tilbury weekly chart from May-June 1985

Digitising Tide Gauge Charts



- Once charts have been identified then digitising is then in most cases technically straightforward
- Commercial companies can do the scanning
- Software exists from several groups to convert images to data
- A report reviewing methods is available from Liz Bradshaw who is in charge of scanning and digitising all of BODC's paper records dating from 1853

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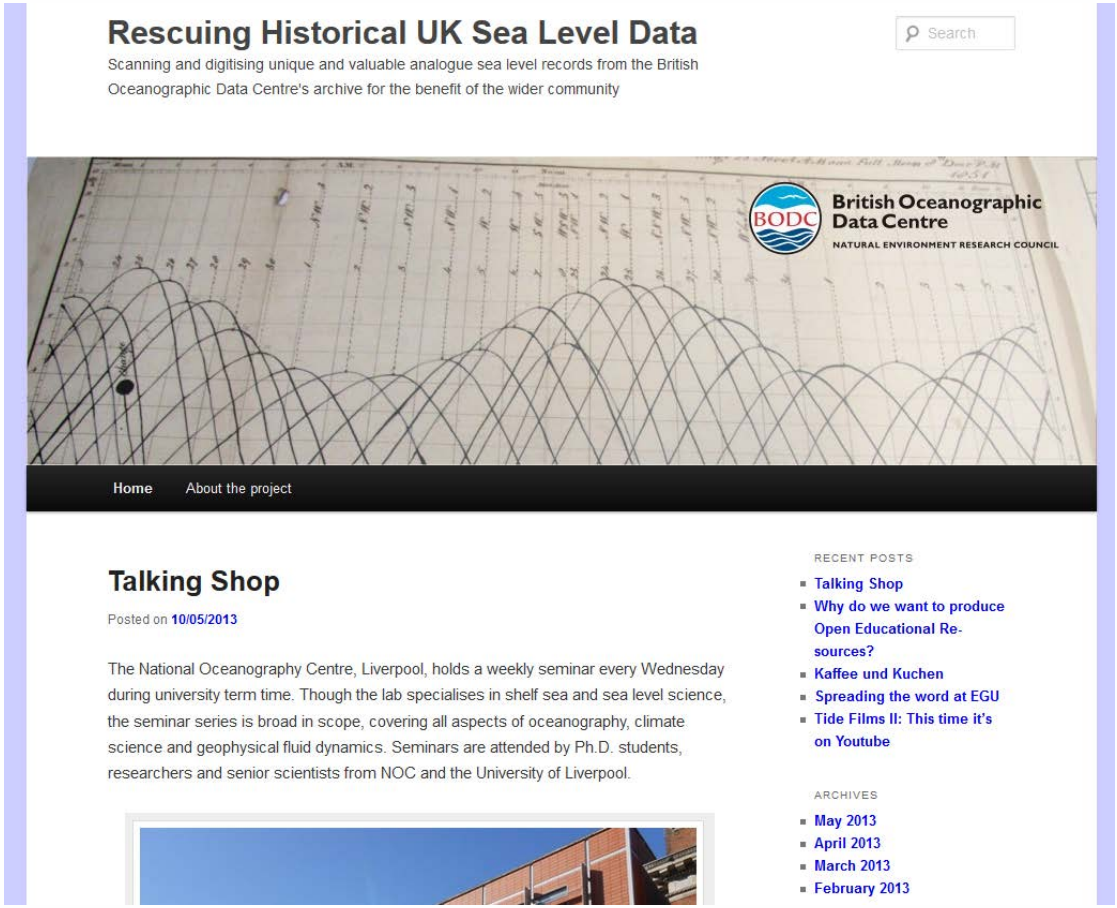


www.historicsealevel.wordpress.com

JISC

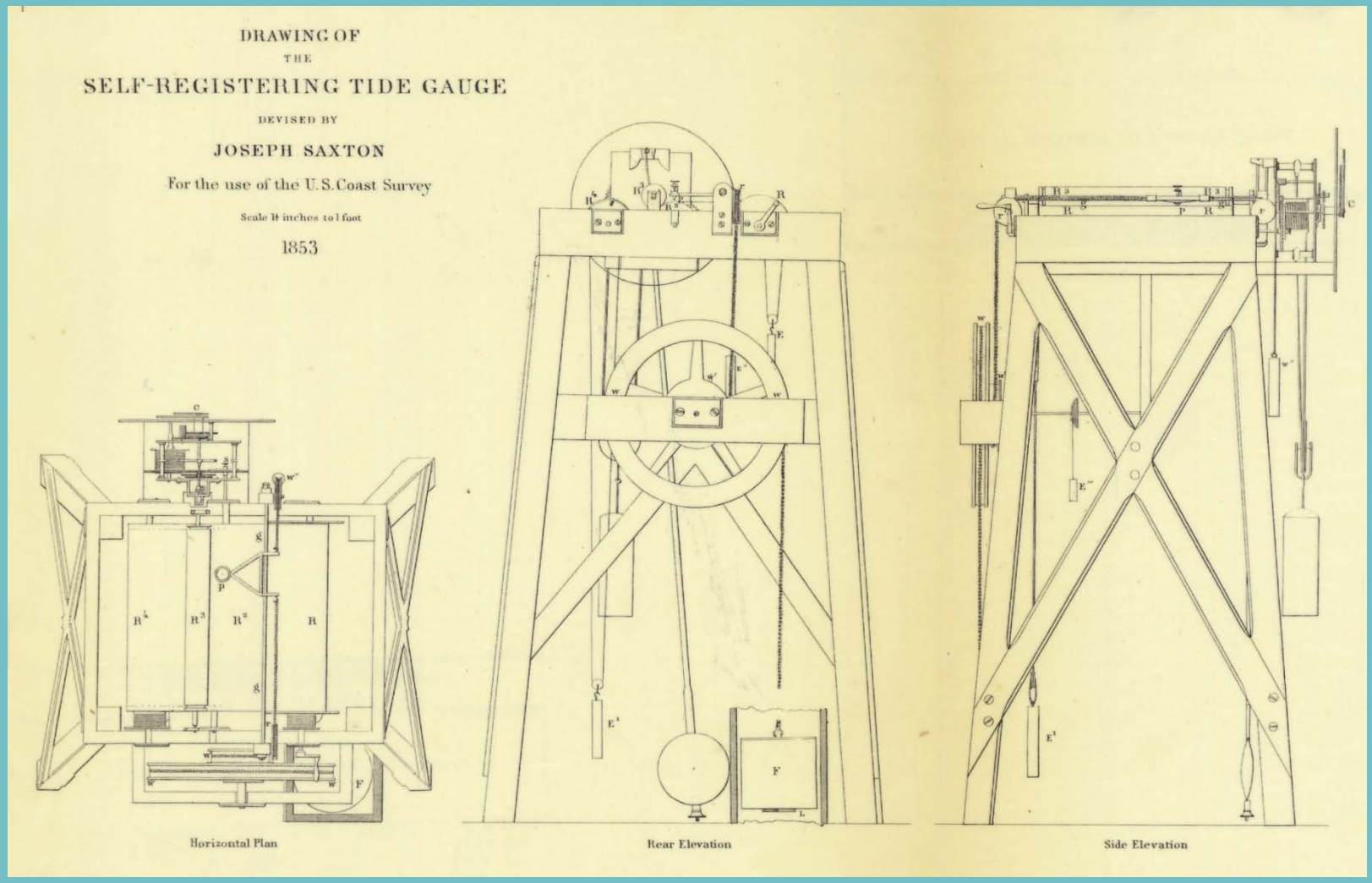
The digitisation of the charts and scanning of the ledgers has been funded through the JISC Content programme 2011-13

Other Groups Digitising Charts

- Julian Orford et al, (Belfast), Phil. Trans. 2006
- Ivan Haigh and Niel Wells, (English Channel ports), Cont. Shelf Res. 2009
- Chris Watson et al, (Macquarie Is), GJI 2010
- Isabel Araújo et al, (Leixões), J. Hydrology 2013
- Marta Marcos et al, (Tenerife), JGR 2013

- And probably many others.

Sometimes the digitisation presents a major technical challenge



Joseph Saxton gauge for the US Coast Survey (20 m charts)

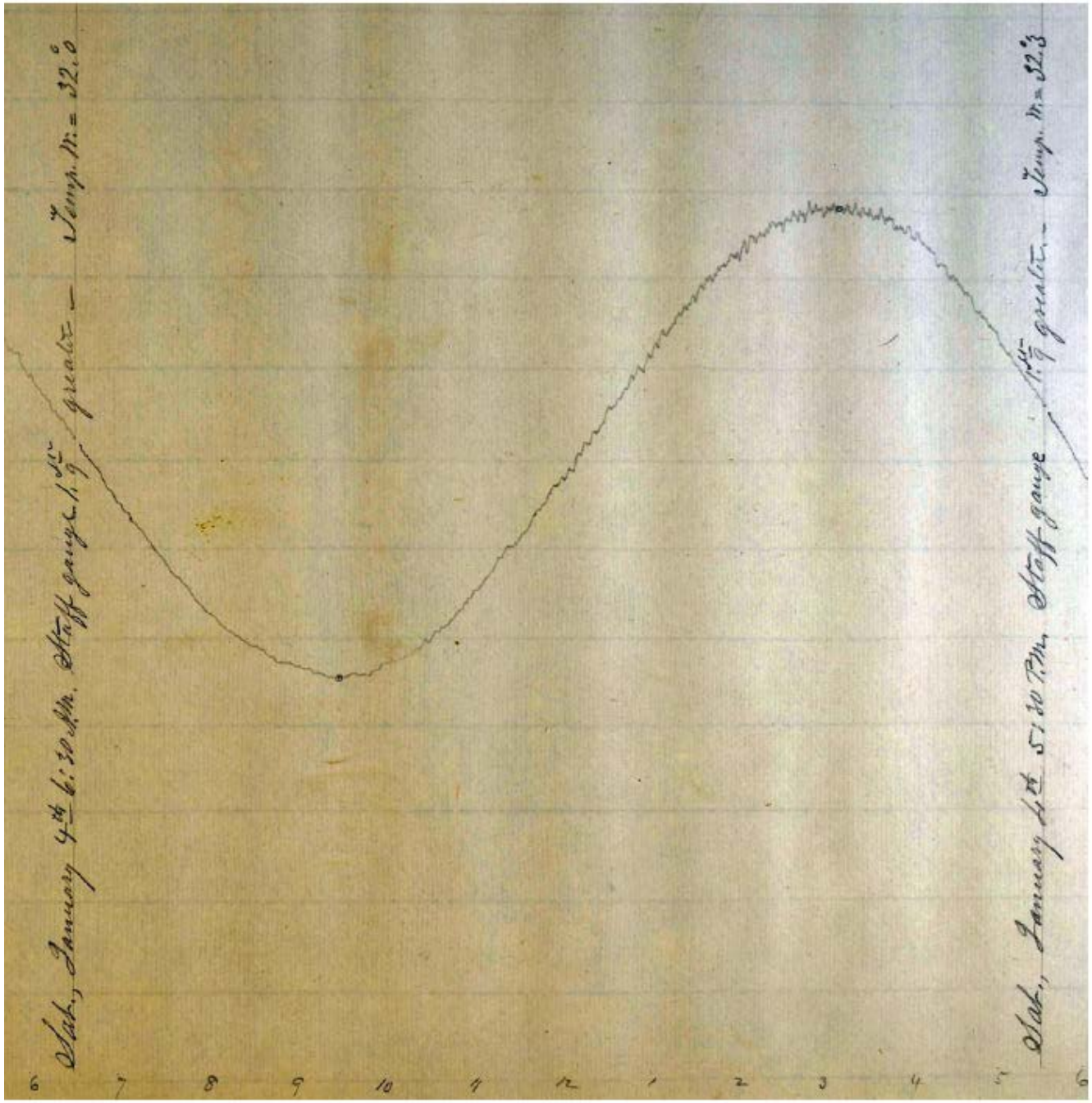


Chart from a Saxton gauge at Astoria, Oregon 4 January 1862

Note – twice daily gauge checks and remarks

From StefanTalke and David Jay, Journal of Coastal Research, 2013

How Much Data Is Out There?

- We have to assess the magnitude of work required i.e. how much old data is out there in libraries etc., which could be rescued if we had resources
- Then we can assess the potential improvements to the global data sets
- Good compilations exist in some countries (e.g. France, based on Nicolas Pouvreau thesis)
- A combined UK catalogue (mostly BODC and UKHO) would be nice

Historic tide gauge data in non-digital form - Refmar - Windows Internet Explorer

http://refmar.shom.fr/mesures-maregraphiques/french-historic-tide-gauges-data-in-non-digital-form

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Refmar > Data > historical data

Historic tide gauge data in non-digital form

REFMAR is not just about the provision of current sea level observations but is also about the ability to obtain sets of measurements covering several decades for certain stations. In order to achieve that, it is essential to save and digitize historical tide gauge data, all the more so as French has an extremely rich fund of historical records, both in terms of stations and in the volume of the data held, which bears witness to a past that is now over, to which it is impossible to return (to conduct measurements) but which it is interesting to examine in order to understand the present fluctuations in the sea level. Annex A - N.Pouvreau's thesis (fr) gives an idea of the wealth of this heritage. Do not hesitate to contact us in order to inform us of your own tide gauge scientific assets and thus contribute to increasing the value and sharing these unique measurements.

Devant l'importance que revêt ces données historiques - et de la même manière que le sauvetage et la digitalisation des enregistrements météorologiques - une action, sous l'égide de GLOSS (lettre disponible ici) appuyée par l'OHI (lettre disponible ici) est lancée depuis le mois de décembre 2011 afin de

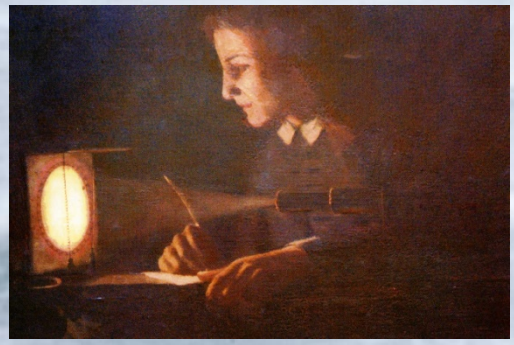
Done Internet 100%

start figs gloss woodworth_dat... woodworth_cha... Home - Refmar ... Historic tide gau... Search Desktop EN 14:26

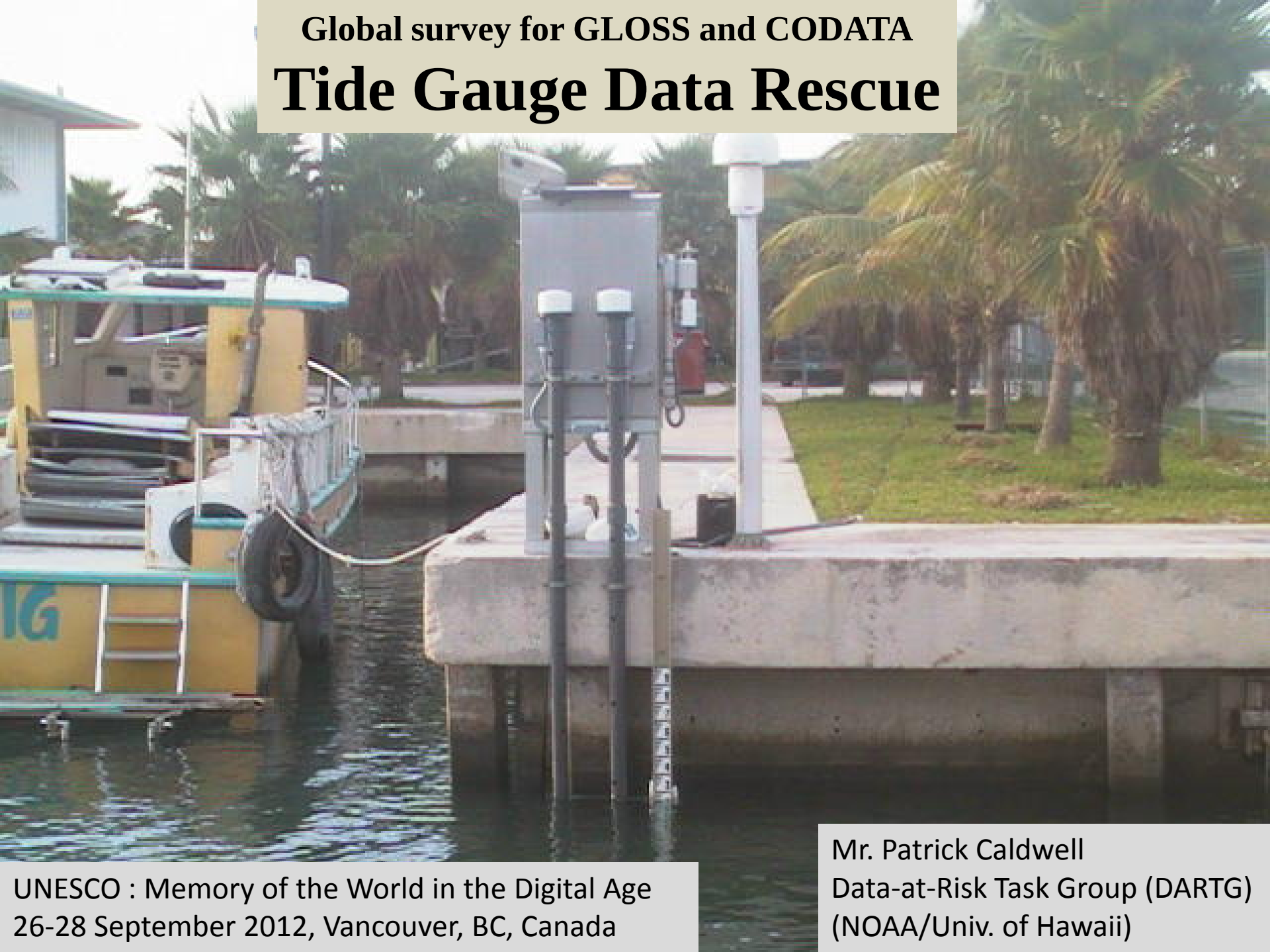
http://refmar.shom.fr/mesures-maregraphiques/

UK Catalogue Needed

- A combined UK catalogue (mostly BODC and UKHO) would be nice (including Royal Society etc.)
- Local libraries are almost unexplored
- Several holy grails e.g. Jeremiah Horrocks measurements in 1640. Records lost in the Civil War – but maybe not?



Horrocks, famous for observing the Transit of Venus in 1639, made tidal measurements for at least 3 months at Toxteth, Liverpool in 1640.



Global survey for GLOSS and CODATA

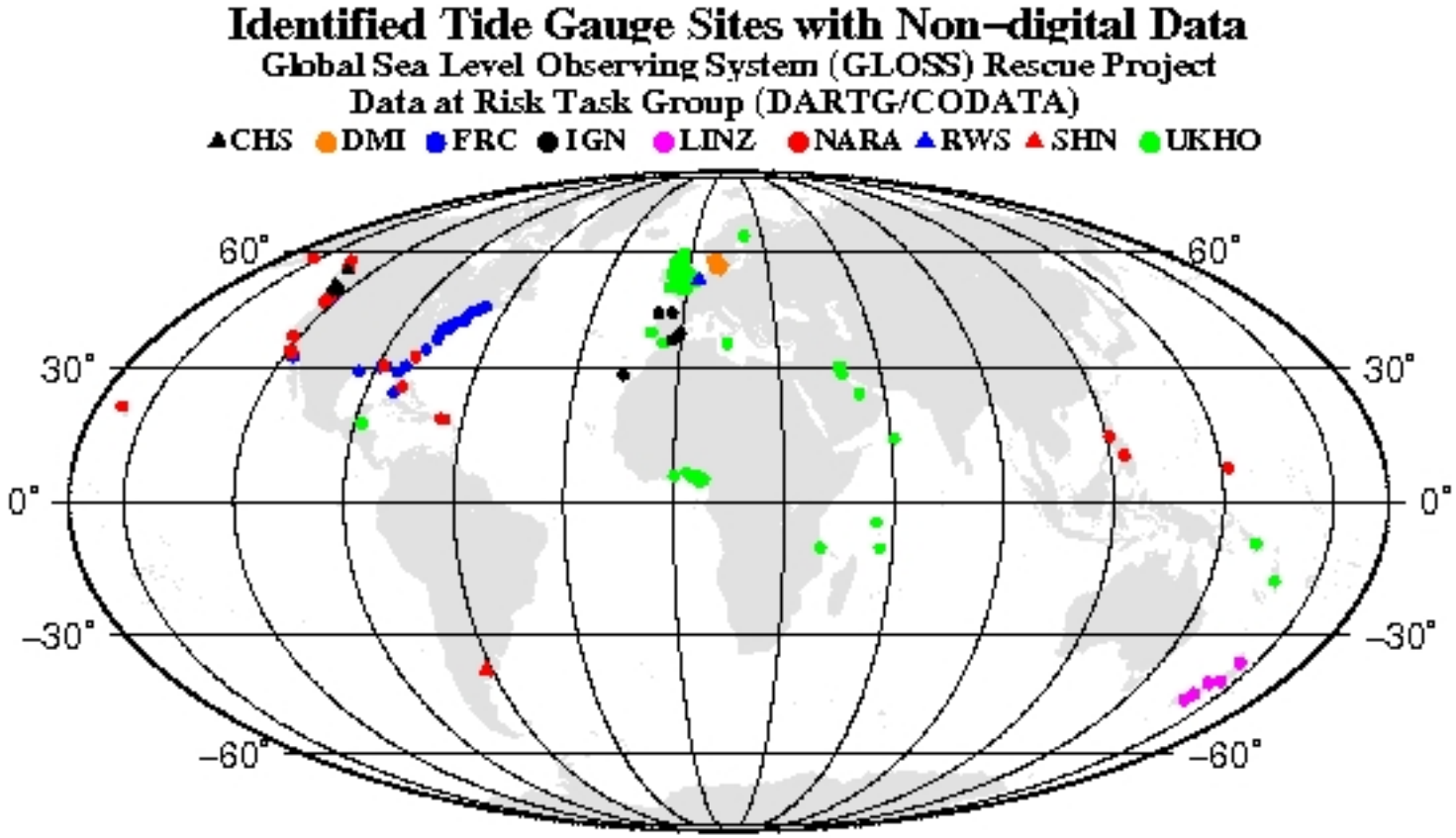
Tide Gauge Data Rescue

UNESCO : Memory of the World in the Digital Age
26-28 September 2012, Vancouver, BC, Canada

Mr. Patrick Caldwell
Data-at-Risk Task Group (DARTG)
(NOAA/Univ. of Hawaii)

GLOSS Questionnaire Results

-18 replies from 14 countries
-169 tide stations identified (23 GLOSS sites)
- Time spans:1800s-1900s
- 4,103 total years (~3,259 excluding gaps)
- If digitized: add 2,824 years to JASL (324 GLOSS sites)



Repeat Global Surveys

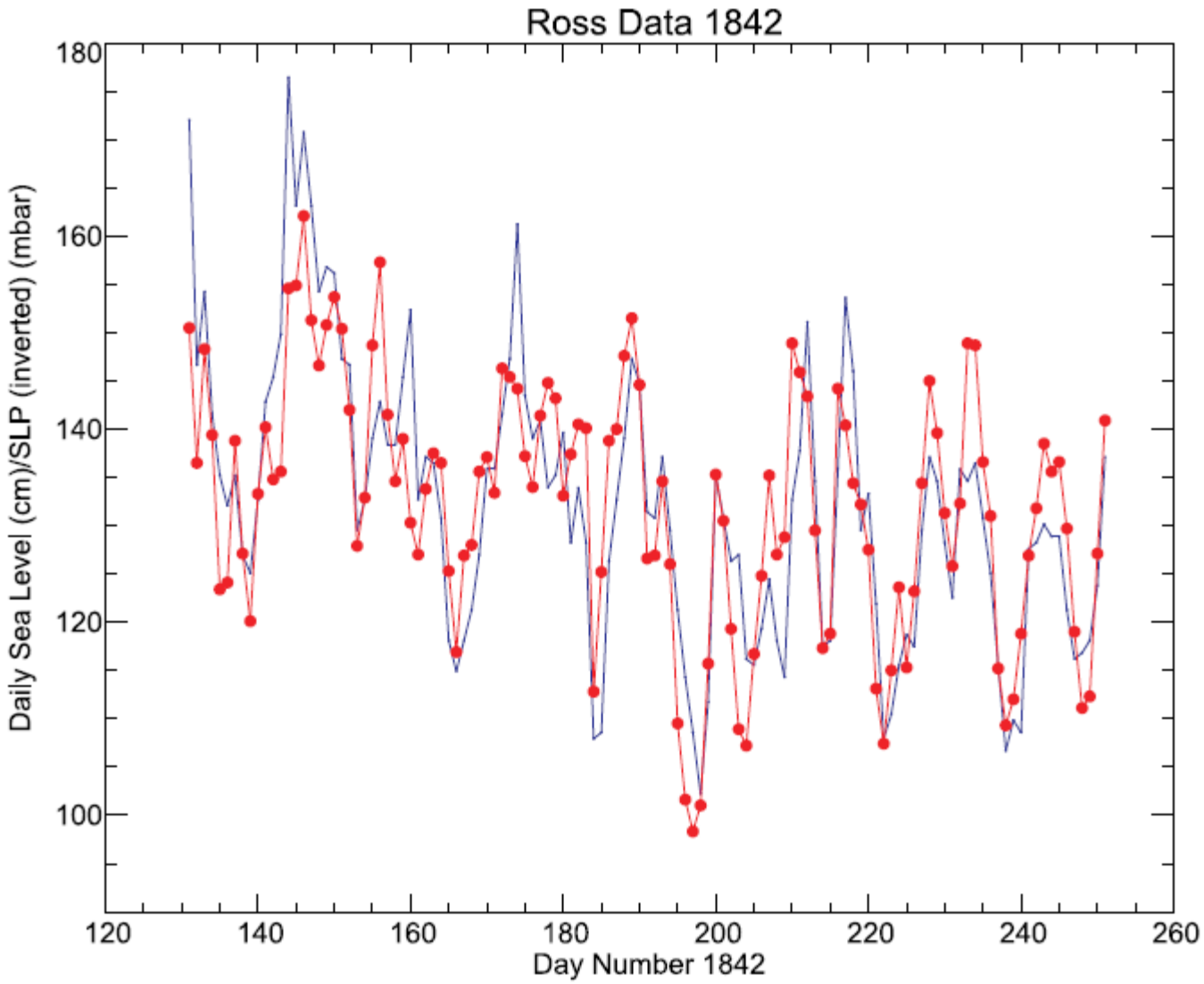
- **A similar exercise by BODC in 2001 resulted in > 1400 station-years of data being identified**
- **This exercise > 4000 station-years (*)**
- **Exercise should be repeated in a couple of years with questionnaires in multiple languages**

* Caldwell, P.C. 2013. Tide gauge data rescue. pp. 134-149 in, Proceedings of the UNESCO Conference on The Memory of the World in the Digital Age: Digitization and Preservation (eds.L. Duranti and E. Shaffer), 26-28 September 2012, Vancouver, British Columbia, Canada. Available from www.unesco.org.

Historical Met Data

We need to interact with the historical met data community for several reasons:

- **To understand sea level variability you need air pressures and winds (as a minimum)**
- **Air pressure in particular can provide an essential cross-validation of the sea level data**
- **Met people are good at getting funded**



Sea level (blue) and air pressure (red) measured by James Clark Ross at Port Louis, Falkland Islands in 1842

ACRE Historical Met Data

We should take a lead from ACRE:

http://www.met-acre.org

- **Recovery of historical instrumental surface terrestrial and marine global weather observations**
- **To underpin 4D weather reconstructions (reanalyses) over the last 200-250 years**
- **To serve studies of climate and impacts needing worldwide historical met (air pressure) data**
- **Taking data from conventional met sources and also unconventional ones**
- **e.g. ships' logs back to 1750**

- **A highly visible, successfully funded project**
- **See also www.oldweather.org , www.iedro.org and a range of Citizen Science projects**

Conclusions

- How much old sea level data is out there?
- Decide how much is scientifically useful and determine priorities
- Design techniques to computerise it
- Find funding for this important (and urgent) work

- Object of the exercise is to construct better and longer data sets with which we can all do better Sea-Level Science