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Bureau of Meteorology

Monthly Data Report

Australian Baseline Sea Level Monitoring Array

July 2025

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Release history

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Acknowledgements

The Monthly Data Report is prepared by the Bureau of Meteorology.

Further enquiries about the Monthly Data Report may be made to:

Bureau of Meteorology
700 Collins Street
Docklands, VIC, 3008
Email: tides@bom.gov.au
Website: http://www.bom.gov.au/oceanography/projects/ntc/ntc.shtml

Disclaimer

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1. Executive Summary

This summary, and the overview that follows, is intended to provide a synopsis of the recent month's observations in addition to longer-term variations over the life of the project to date.

July 2025

- The Australian Baseline Sea Level Monitoring Array (ABSLMA) continued to collect high-quality sea level and associated meteorological information to support long-term sea level monitoring around Australia.
- The overall rate of sea level data returned from the operating network during July 2025 was 89.8%.
- A Pacific-wide tsunami was generated by a magnitude Mww 8.6 earthquake off Kamchatka on 29 Jul 2025 and small tsunami signals were detected by the SEAFRAME stations at Spring Bay, Port Kembla, Rosslyn Bay and Cape Ferguson.
- A record-high sea level was observed at Thevenard when a storm surge of over 1 m coincided with the high tide on 9 July 2025.
- A record-high July sea level was observed at Thursday Island.
- Record-high monthly mean sea levels were observed at Esperance and Thevenard.
- When astronomical tides and a linear trend are taken into account positive sea level anomalies ranging from +5 cm to +13 cm were observed at Thevenard, Esperance, Portland, Lorne, Stony Point, Burnie, Spring Bay, Port Kembla and Darwin, but a negative sea level anomaly of -9 cm was observed at Cocos Island.
- Negative barometric pressure anomalies were observed at all stations but most notably below -4 hPa at Portland, Thevenard, Port Kembla and Burnie

2. Introduction

Welcome to the July 2025 Monthly Data Report for the Australian Baseline Sea Level Monitoring Array (ABSLMA). The report details the month-by-month operation of SEAFRAME sea level monitoring stations around Australia, including operational problems with the network and the occurrence of abnormal sea level events in the context of related astronomical tide, weather, and climate variations. A companion array of SEAFRAME sea level monitoring stations in Pacific Island Countries is supported under the Pacific Sea Level and Geodetic Monitoring Project.

The ABSLMA was originally developed and supported from grants under the Australian Climate Change Science Program through the Department of Climate Change and Energy Efficiency, with a primary goal to monitor long period sea level changes around Australia focussing particularly on the enhanced greenhouse effect. Operation of the array continues to be supported by the Bureau of Meteorology, underpinning the advanced technologies gathering global observations for climate change research as well as providing real-time information for tidal monitoring and tsunami detection.

The ABSLMA consists of 15 standard SEAFRAME stations operated by the Bureau of Meteorology at representative sites around Australia, as well as two customised, privately-owned stations at Lorne and Stony Point (Figure 1). The SEAFRAME at Port Stanvac was removed in November 2010 to allow Mobil Refining Australia to decommission the oil refinery.

The standard SEAFRAME stations not only measure sea level, but also observe several “ancillary” variables - air and water temperatures, wind speed, wind direction and barometric pressure. The privately-owned stations at Lorne and Stony Point do not measure the ancillary variables, although winds are measured at Stony Point.

The Bureau of Meteorology and Geosciences Australia, through their membership on the Intergovernmental Committee on Surveying and Mapping (ICSM) Tides and Sea Level Working Group (TSLWG), strive to sustain geodetic levelling programs implemented by various state surveying organisations in order to monitor shifts in the vertical of the sea level sensors due to local land movement.

Observations collected by the sea level monitoring network are routinely processed into a range of quality-controlled data products. The monthly data report is the primary source of up-to-date information relating to these data products.

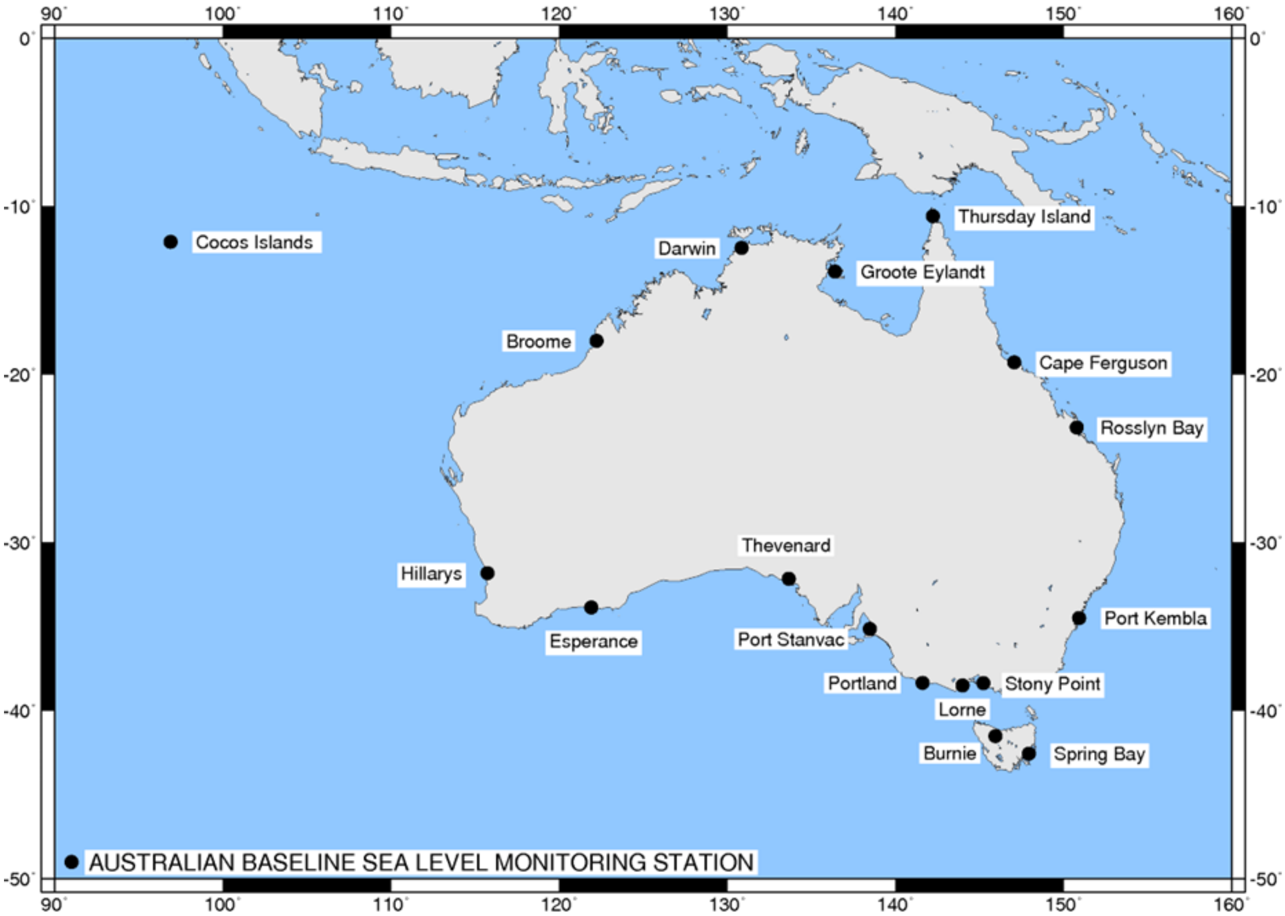

Figure 1: Network of Australian Baseline Sea Level Monitoring SEAFRAME stations.

3. Sea Level and Climate

Astronomical tides and weather conditions are largely responsible for daily perturbations in sea level, but over monthly, seasonal, and longer timescales sea levels around Australia are largely influenced by fluctuations in climate and ocean heat content.

Intra-annual or seasonal changes in sea level are closely linked to the annual solar radiation cycle and associated shifts in weather patterns and ocean current systems. Across southern Australia, sea levels tend to be at their highest during winter, while the opposite is true across northern Australia, where sea levels tend to be higher during the summer wet season. Further information relating to seasonal climate variations around Australia is provided by the Bureau of Meteorology at http://www.bom.gov.au/climate/.

Inter-annual sea level variations are largely influenced by the El Niño – Southern Oscillation climate cycle, particularly across the northern and western Australian coastlines. Sea levels are generally lower than normal around Australia during El Niño, in response to cooler than normal ocean temperatures and higher than normal barometric pressures that are brought about by weaker than normal easterly Trade Winds across the Pacific. Conversely, during La Niña sea levels around Australia are generally higher than normal, in association with warmer than normal ocean temperatures and lower than normal barometric pressures, due to stronger than normal easterly Trade Winds across the Pacific.

A summary of broader Southern Hemisphere monitoring by the Bureau of Meteorology, including the El Niño – Southern Oscillation, is available at http://www.bom.gov.au/climate/enso/.

4. July SEAFRAME Data

4.1. Monthly Sea Level and Environmental Data

The observed sea levels (Figure 3) are dominated by the daily oscillations of the tide. In most cases, the tide rises and falls twice per day (semi-diurnal), but at Groote Eylandt and Hillarys the tide tends to have a single high and low per day (diurnal). Where the tides follow a semi-diurnal pattern, the greatest tidal variations are called spring tides, which tend to occur around the time of the new and full moons. A full moon fell on 10 July 2025 (UTC) and a new moon fell on 24 July 2025 (UTC).

Gaps in the data are the result of instrumental errors or data retrieval problems and are discussed under Instrument Performance.

The residuals (Figure 4) are the differences between the observed sea levels and the astronomical tidal predictions. They highlight non-tidal sea level fluctuations, such as those due to the effects of weather or tsunamis.

A Pacific-wide tsunami was generated by a magnitude 8.6 (Mww) earthquake that struck off the east coast of Kamchatka at 23:25 UTC on 29 Jul 2025. Small tsunami signals can be seen in the residuals at Spring Bay, Port Kembla, Rosslyn Bay and Cape Ferguson on 30 July 2025.

Low pressure systems can produce storm surges where the combination of low barometric pressure and strong winds raise sea levels well above the predicted astronomical tides for a period of a day or more, such as at Thevenard on 9 July 2025 when residual sea levels exceeded 1 m.

The non-tidal sea level fluctuations can be amplified or sustained by the shape of the bay or harbour in which the gauge is located. Some of the SEAFRAME stations are located in harbours that exhibit ‘sloshing’ under certain conditions (a phenomenon referred to as a seiche).

The sea level residuals at all stations from time to time and to some degree exhibit semi-diurnal or diurnal fluctuations which last a few days or weeks and then disappear. If these fluctuations were to persist, they would form part of the astronomical tide prediction and thus not appear as residuals.

The barometrically corrected residuals (Figure 5) have had a major part of the effect of atmospheric pressure fluctuations removed from the sea level residuals of Figure 4. The rule of thumb for the ‘inverse barometer effect’ is that a 1-hPa fall in the barometer, if sustained over a day or more, produces a 1-cm rise in the local sea level (within the area beneath the low-pressure system).

The winds, temperatures and barometric pressures are plotted in Figure 6 to Figure 11. The incident winds in Figure 8 follow the meteorological convention, that is, they point in the direction the wind is coming from. For example, the winds at Cocos Island prevailed from the southeast for most of July.

Air and water temperatures (Figure 9 and Figure 10) are plotted using the same vertical scale for the purpose of comparison. The air temperatures are seen to fluctuate over a much wider range than the water temperatures.

Barometric pressures (Figure 11) tend to fluctuate by around 3 hPa twice daily at all stations as a result of atmospheric tides, which are largest in the tropical regions and reduce to near zero toward the poles. The longer-term barometric pressure fluctuations that occur over periods of days to weeks are due to passing weather systems. These fluctuations tend to be larger at sites farther away from the equator, particularly those along the southern Australian coastline.

The monthly data extremes are put into perspective by Figure 12. In this figure, if an open circle falls above (below) a solid dot, a new maximum (minimum) for the particular month has been set. The data sets only include the ABSLMA data, which have been collected since May 1990 when the first station was installed at Darwin. The SEAFAME station at Thursday Island has only been collecting data since April 2015, and the monthly data extremes do not include data from an earlier tide gauge. The short data records for Thursday Island means that extreme levels are exceeded on a regular basis.

In July 2025, the following noteworthy extremes were observed:

- An all-time record-high sea level at Thevenard (3.368 m) when a storm surge coincided with a high tide on 9 July 2025.
- A record-high July sea level at Thursday Island (3.697 m)
- A record-low July barometric pressure at Thursday Island (994.0 hPa)

Figure 12 also shows the monthly mean values for the latest month in comparison to those derived for the same time of year over the long term. The mean sea levels for July 2025 were higher than the long-term July mean sea levels at all operational stations.

Further sea level and meteorological statistical information is available at http://www.bom.gov.au/oceanography/projects/abslmp/data/monthly.shtml

4.2. Monthly Means and Anomalies

Figure 13 through Figure 16 show the monthly means, or simple arithmetic averages, for sea level, barometric pressure, water temperature and air temperature. The monthly means demonstrate the seasonal variations of the recorded parameters. Groote Eylandt, for example, normally experiences an annual sea level cycle of about 0.6 m that peaks around March of each year.

Record-high monthly mean sea levels were observed at Esperance and Thevenard in July 2025, eclipsing the previous records set in July 2021 at both stations by 1.5 cm.

Figure 17 through Figure 20 show the monthly mean sea level, barometric pressure, air temperature and water temperature anomalies. The sea level anomalies are the residuals after tides, annual and semi-annual seasonal cycles and linear slope have been removed by way of harmonic tidal analysis of the complete record. The annual sea level cycle at Groote Eylandt (which has the largest consistent annual cycle) is quite notable in Figure 13 but less apparent in Figure 17. By removing the seasonal cycles, the anomalies help to bring out irregular features, such as lower than normal sea levels around much of Australia during the 1997/98 El Niño.

Noteworthy monthly anomalies observed during July 2025 include:

- Positive sea level anomalies at Thevenard (+13 cm), Esperance (+10 cm), Portland (+9 cm), Lorne (+8cm), Stony Point (+7 cm), Burnie (+7 cm), Spring Bay (+6 cm), Port Kembla (+6 cm) and Darwin (+5 cm), but a negative sea level anomaly at Cocos Island (-9 cm).
- Negative barometric pressure anomalies at all stations, particularly at Portland (-5.5 hPa), Thevenard (-5.1 hPa), Port Kembla (-4.6 hPa) and Burnie (-4.4 hPa).
- A positive water temperature anomaly of +1.0 °C at Spring Bay.
- Negative air temperature anomalies of -1.0 °C at Broome and Hillarys.

5. Overall Rate of Movement in Sea Level

Table 1 shows the overall rate of movement in sea level at individual Australian Baseline stations based on the data so far collected at those sites. For most sites, the underlying data sets now exceed thirty years in length, Port Stanvac and Thursday Island being the exception.

The overall rates of movement are updated every month by calculating the linear slope during the tidal analysis of all the data available at individual stations. The rates are relative to the SEAFRAME sensor benchmark, whose movement relative to inland benchmarks is monitored by Geosciences Australia.

Please exercise caution in interpreting the overall rates of movement of sea level – the records are too short to be inferring long-term trends and have not been corrected for land movement or other parameters that may influence the reported rates.

Table 1: Updated overall rates of sea level movement based on SEAFRAME data from installation through July 2025

Location	Latitude	Longitude	Date of first data	Rate[1] (mm/yr)	Change in rate from previous month (mm/yr)
Cocos Island	12°07'07.1"S	96°53'30.9"E	Sep 1992	6.5	0.0
Groote Eylandt	13°51'36.2"S	136°24'56.1"E	Sep 1993	5.2	0.0
Darwin	12°28'18.4"S	130°50'45.1"E	May 1990	5.9	0.0
Broome	18°00'03.0"S	122°13'07.1"E	Nov 1991	5.8	0.0
Hillarys	31°49'32.0"S	115°44'18.9"E	Nov 1991	6.7	0.0
Esperance	33°52'15.2"S	121°53'43.3"E	Mar 1992	4.3	0.0
Thevenard	32°08'56.2"S	133°38'28.8"E	Mar 1992	3.9	0.1
Port Stanvac[2]	35°06'31.0"S	138°28'1.3"E	Jun 1992	4.7	0.0
Portland	38°20'36.4"S	141°36'47.4"E	Jul 1991	3.1	0.0
Lorne	38°32'49.4"S	143°59'19.8"E	Jan 1993	2.5	0.0
Stony Point	38°22'19.7"S	145°13'28.9"E	Jan 1993	2.6	0.0
Burnie	41°03'0.3"S	145°54'54.0"E	Sep 1992	3.3	0.0
Spring Bay	42°32'45.1"S	147°55'57.8"E	May 1991	3.5	0.0
Port Kembla	34°28'25.5"S	150°54'42.7"E	Jul 1991	4.0	0.0
Rosslyn Bay	23°09'39.7"S	150°47'24.6"E	Jun 1992	5.1	0.0
Cape Ferguson	19°16'38.4"S	147°03'30.4"E	Sep 1991	5.4	0.0
Thursday Island	10°35'11.4"S	142°13'18.8"E	Apr 2015	13.1	+0.2

[1]Relative to SSBM (SEAFRAME Sensor Bench Mark)

[2]Port Stanvac decommissioned November 2010

6. Instrument Performance

In Figure 21, which shows sea level data return, the columns represent the percentage of quality-controlled data returned from the gauge each month. Sea level data return from the network was 89.8% during July 2025 and 97.8% overall since the start of the project (Table 2).

Noteworthy problems relating to the instrumentation include:

- The station at Groote Eylandt remained out of service having been destroyed during Severe Tropical Cyclone Megan on 16 March 2024.
- Intermittent station power outages continued to be experienced at Cape Ferguson during July 2025, while the station at Spring Bay experienced a power outage on 27 July 2025.
- The station at Cocos Island failed to collect data from 1-8 July 2025 due to a fault in the CPU card which needed to be replaced.
- The water temperature sensors at Portland, Port Kembla, Rosslyn Bay and Cape Ferguson remained faulty throughout the entire month. The water temperature sensor at Broome was removed in January 2025 due to relocation and changes to the station infrastructure.
- The air temperature sensors at Darwin and Cape Ferguson remained faulty for the entire month.
- The anemometers at Stony Point and Thursday Island remained faulty through July, while at Portland the anemometer has been unable to record winds above 13 m/s and was subsequently switched off on 21 July 2025.
- The anemometers at Darwin, Esperance and Spring Bay remain absent having been previously removed to accommodate changes to the wharf infrastructure.

Table 2: Rates of sea level data return

Location	Installation Date	Data Return Since Installation (%)	Data Return in July 2025 (%)
Cocos Islands	Sep 1992	98.4	72.0
Groote Eylandt	Sep 1993	94.1	0.0
Darwin	May 1990	99.8	99.4
Broome	Nov 1991	97.6	100.0
Hillarys	Nov 1991	97.4	99.8
Esperance	Mar 1992	98.0	100.0
Thevenard	Mar 1992	95.0	100.0
Port Stanvac[1]	Jun 1992	n/a	n/a
Portland	Jul 1991	99.4	100.0
Lorne	Jan 1993	95.7	99.8
Stony Point	Jan 1993	96.7	100.0
Burnie	Sep 1992	99.0	100.0
Spring Bay	May 1991	99.5	96.0
Port Kembla	Jul 1991	99.7	100.0
Rosslyn Bay	Jun 1992	99.4	100.0
Cape Ferguson	Sep 1991	97.2	70.4
Thursday Island	Apr 2015	98.6	100.0
Network Average		**97.8**	**89.8**

[1]Port Stanvac decommissioned November 2010

7. SEAFRAME Stations Layout

Standard SEAFRAME stations now employ a TELMET (previously SUTRON) programmable data logger, water level gauges and other sensors. The data logger and associated electronics are normally housed in fibreglass huts. A sketch of a typical SEAFRAME station is shown in Figure 2. Water level sensors include:

- Primary water level using an acoustic or radar sensor mounted above the water,
- Secondary water level (or backup) using a vented pressure transducer mounted close to the seabed, and
- Tertiary water level using a radar sensor mounted above the water.

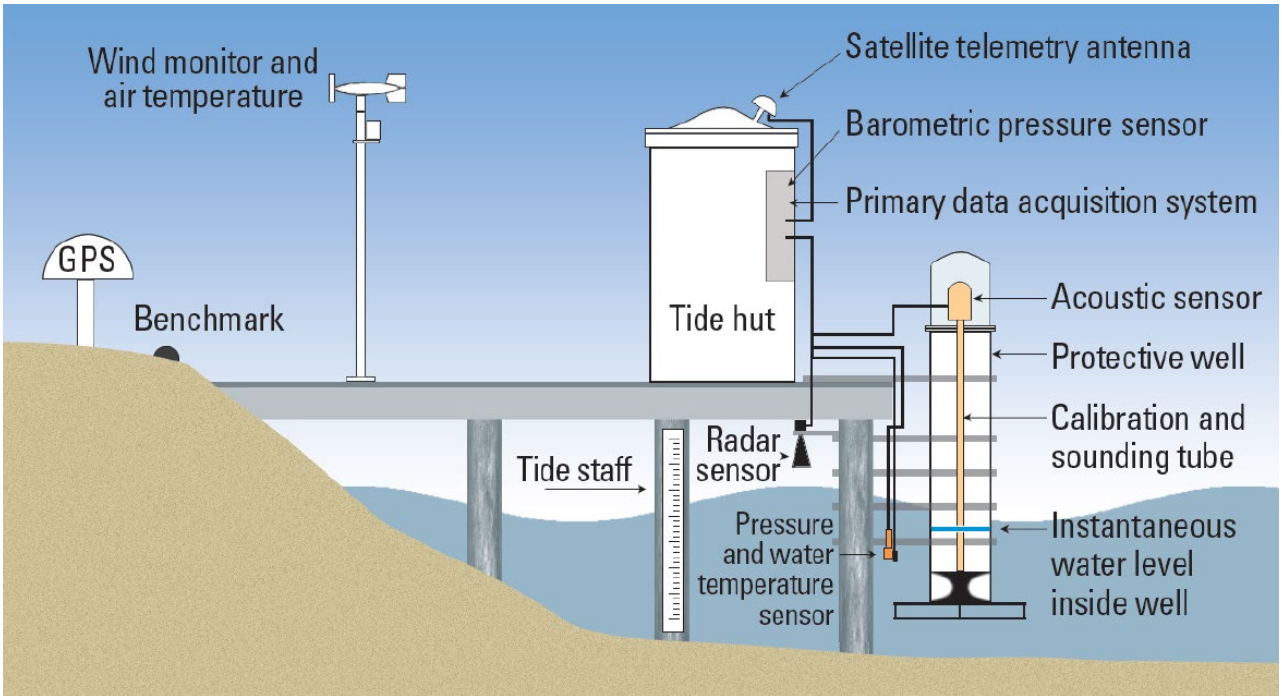

Figure 2: Schematic of a SEAFRAME sea level monitoring station.

8. Further Information

ABSLMA Web site: http://www.bom.gov.au/oceanography/projects/abslmp/abslmp.shtml

ABSLMA Levelling Survey (Geosciences Australia): https://www.ga.gov.au/scientific-topics/positioning-navigation/geodesy/gnss-networks/levelling-connections-between-gnss-sites-and-tide-gauges

Ocean Forecasts: http://www.bom.gov.au/oceanography/forecasts

ENSO Wrap-Up - El Niño / La Niña information: http://www.bom.gov.au/climate/enso/

Sea Level Rise (CSIRO): https://research.csiro.au/slrwavescoast/sea-level/

9. Appendix: SEAFRAME Data Figures

Please note: The privately-owned stations at Stony Point and Lorne do not record air temperature, water temperature and barometric pressure data and are not present in Figures 5, 9, 10, 11 and 12. The tide gauge at Lorne does not record wind data and is not present in Figures 6, 7 and 8.

The anemometers at Esperance and Spring Bay have been removed.

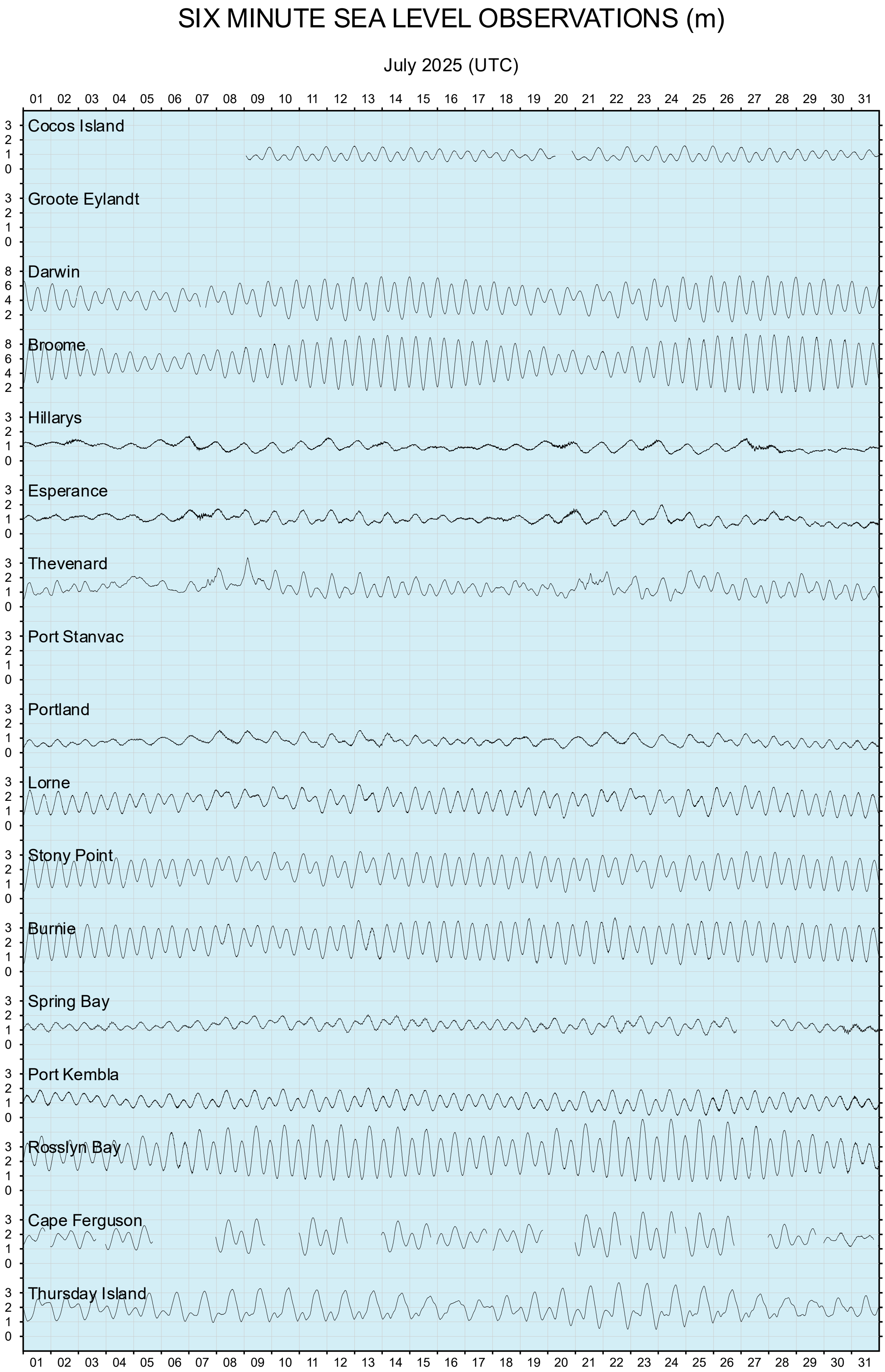

Figure 3. Sea level observations during July 2025.

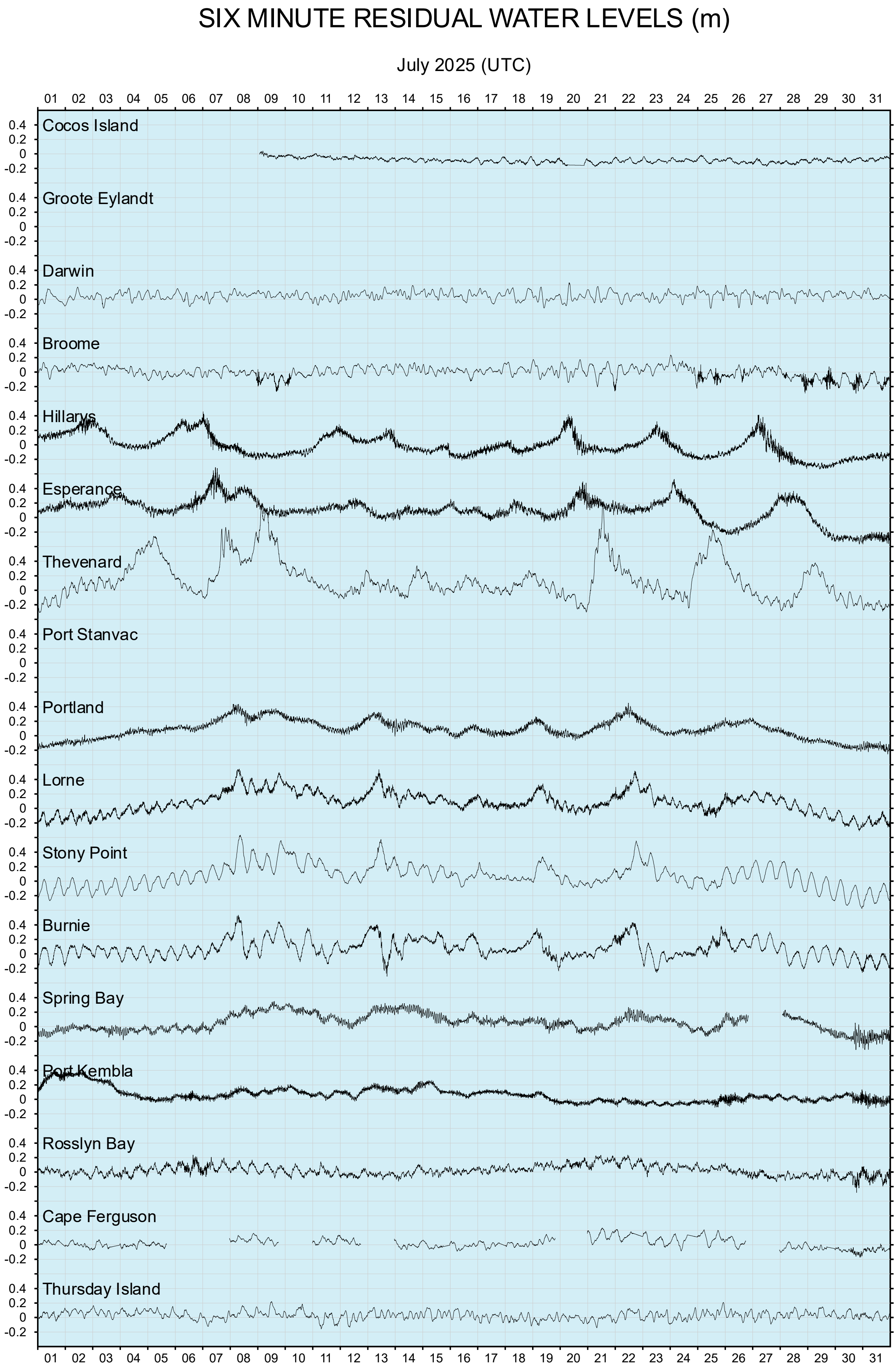

Figure 4. Residual sea levels during July 2025.

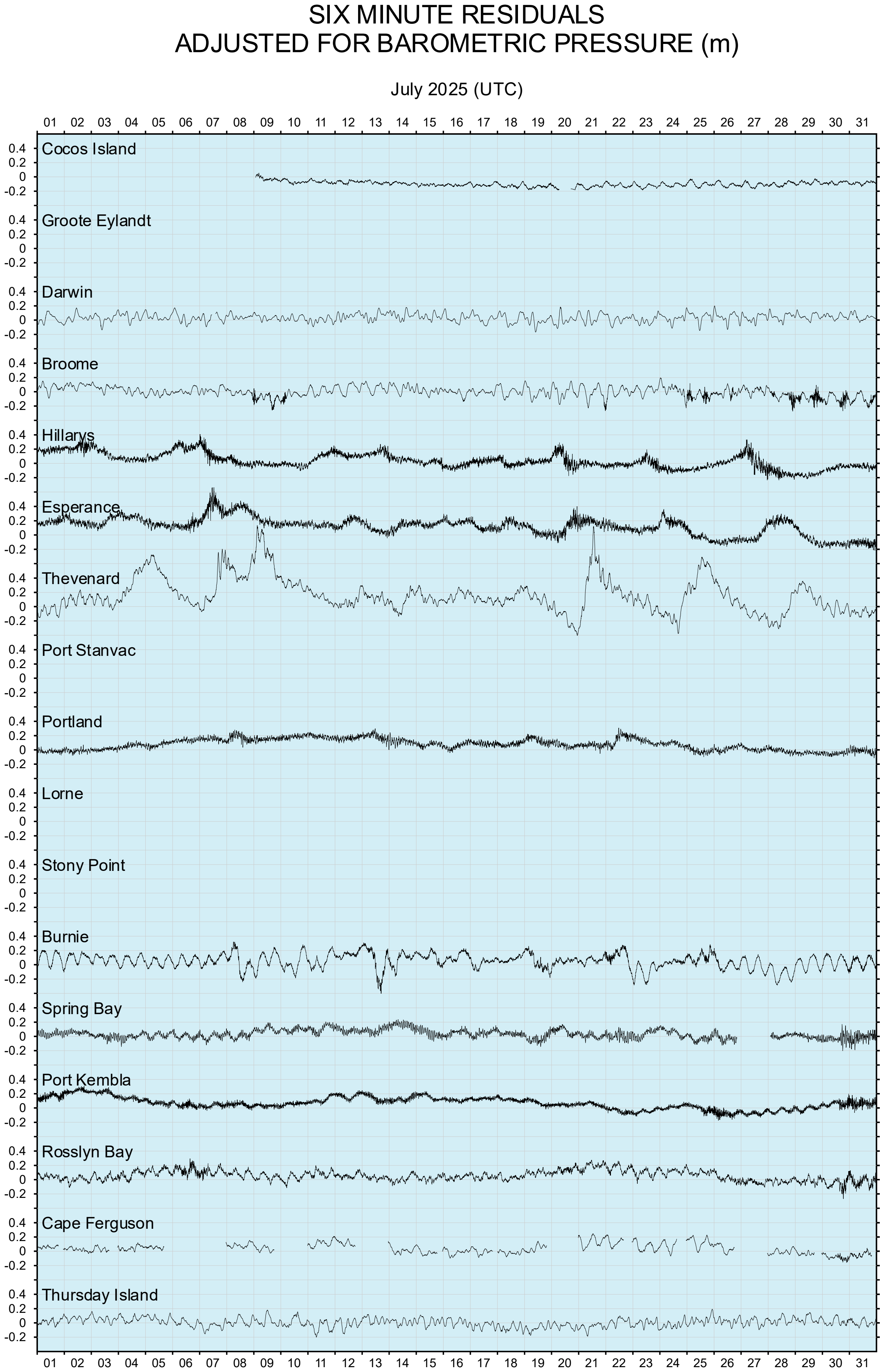

Figure 5. Residual sea levels adjusted for barometric pressure during July 2025.

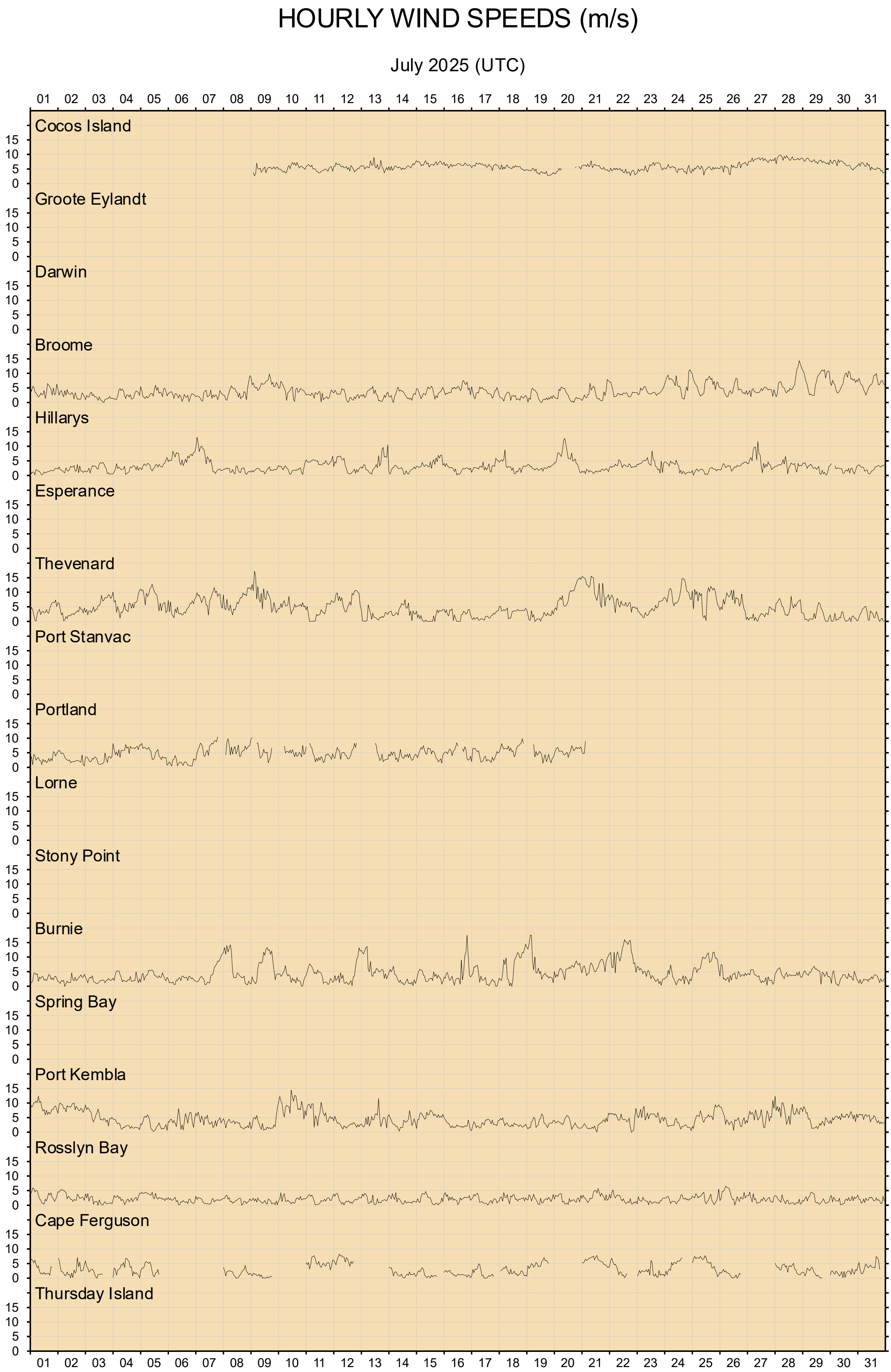

Figure 6. Wind speeds during July 2025.

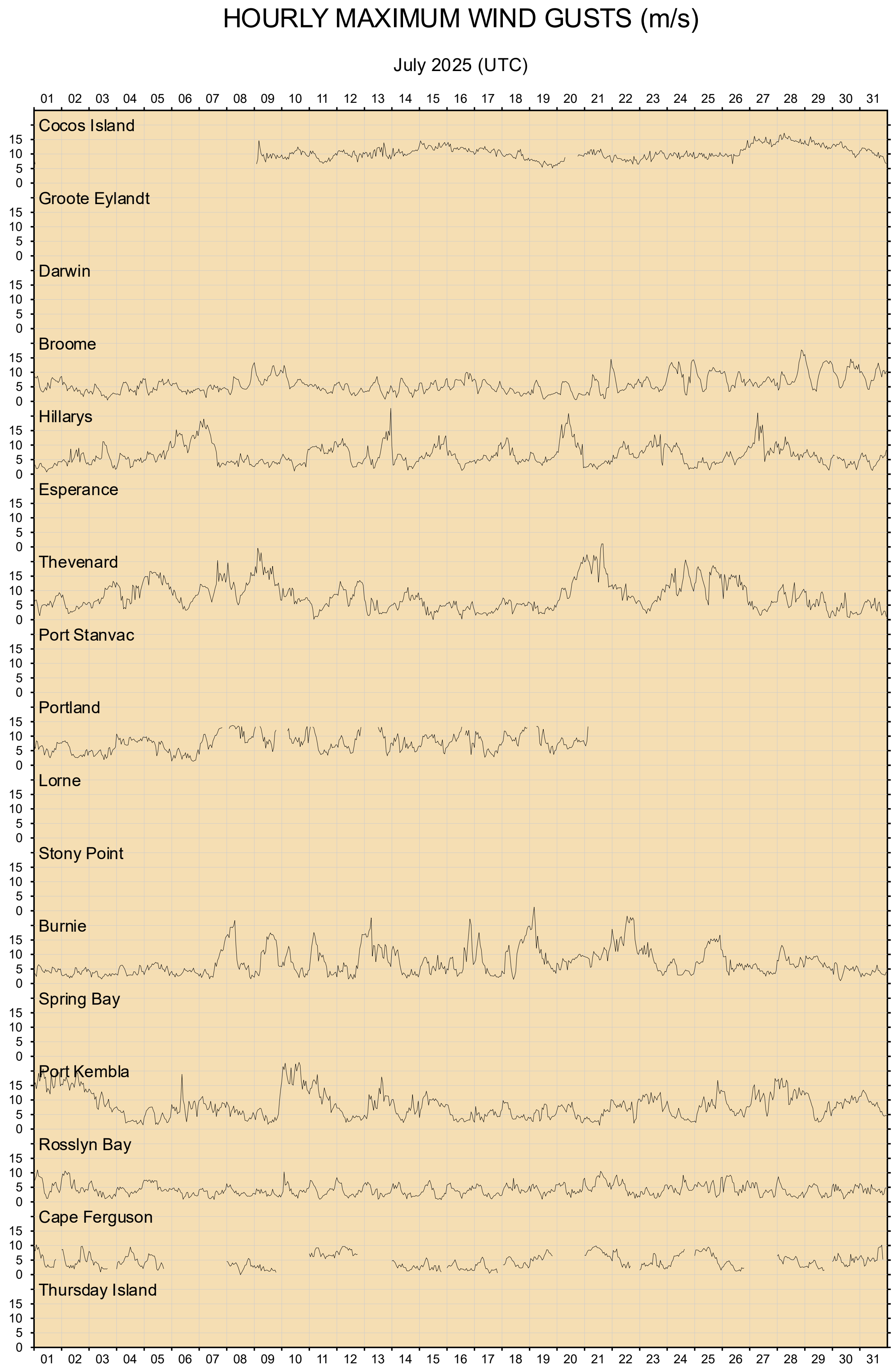

Figure 7. Wind gusts during July 2025.

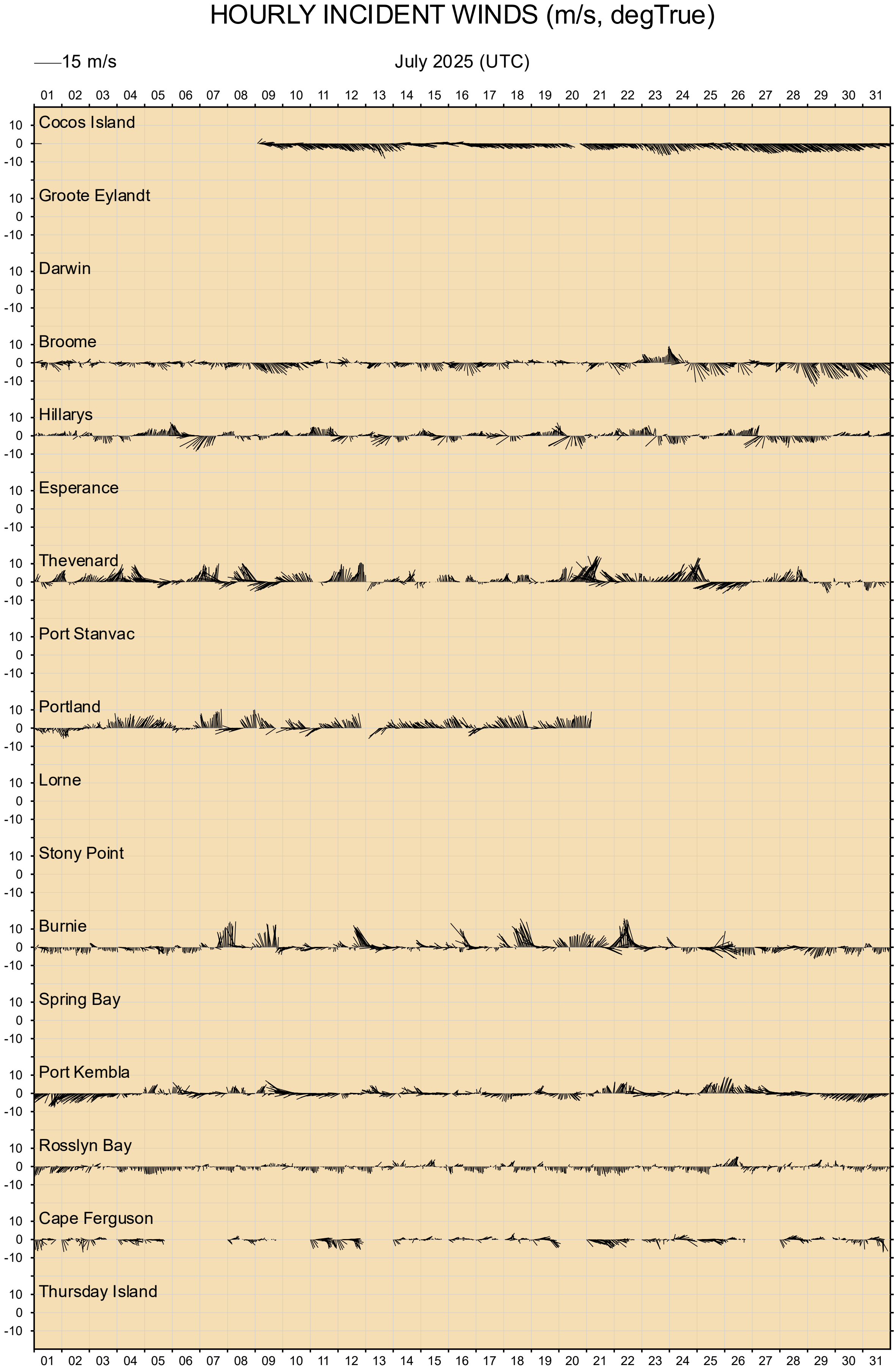

Figure 8. Incident winds during July 2025

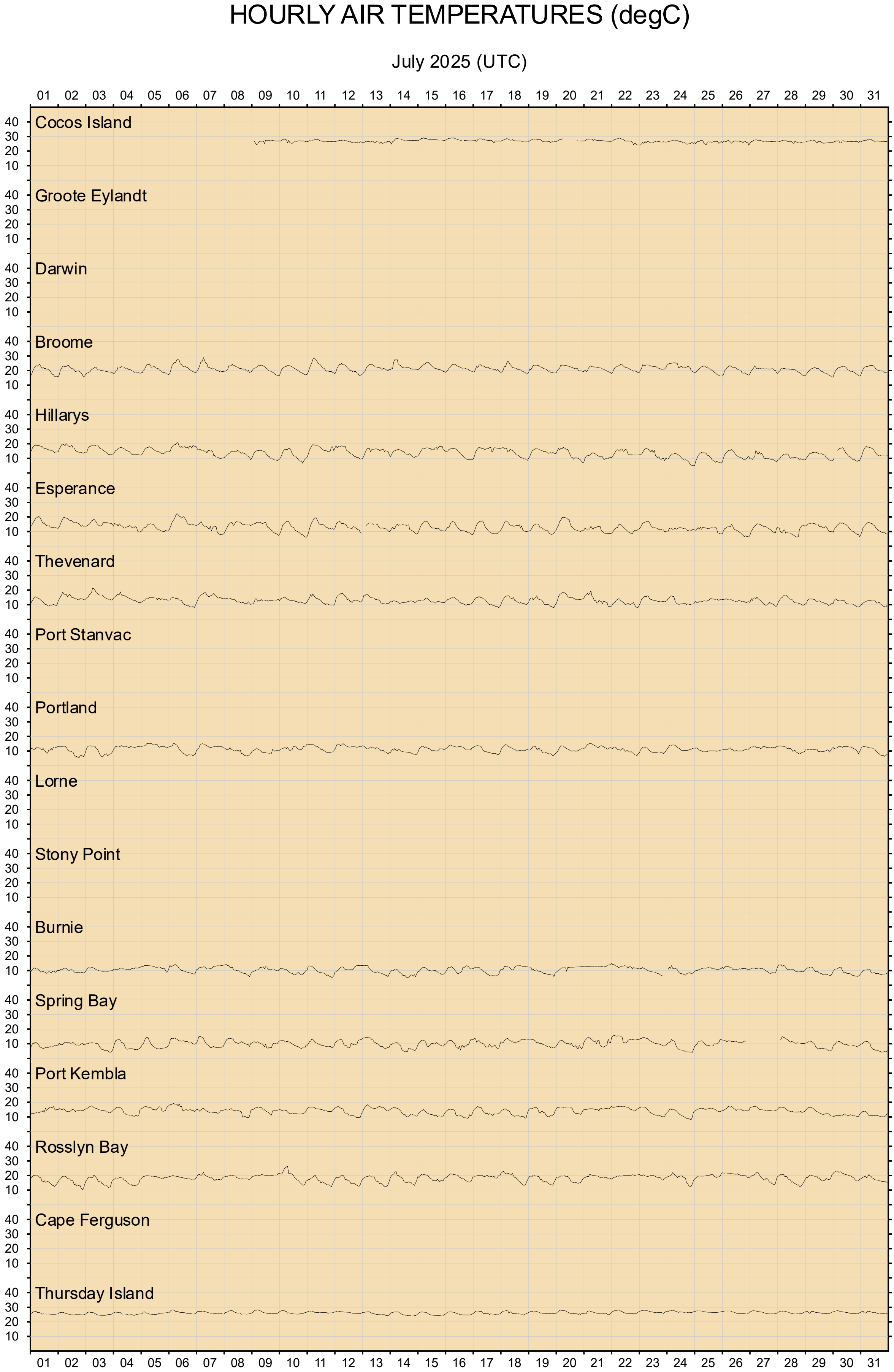

Figure 9. Air temperatures during July 2025.

Figure 10. Water temperatures during July 2025.

HOURLY BAROMETRIC PRESSURE (hPa)

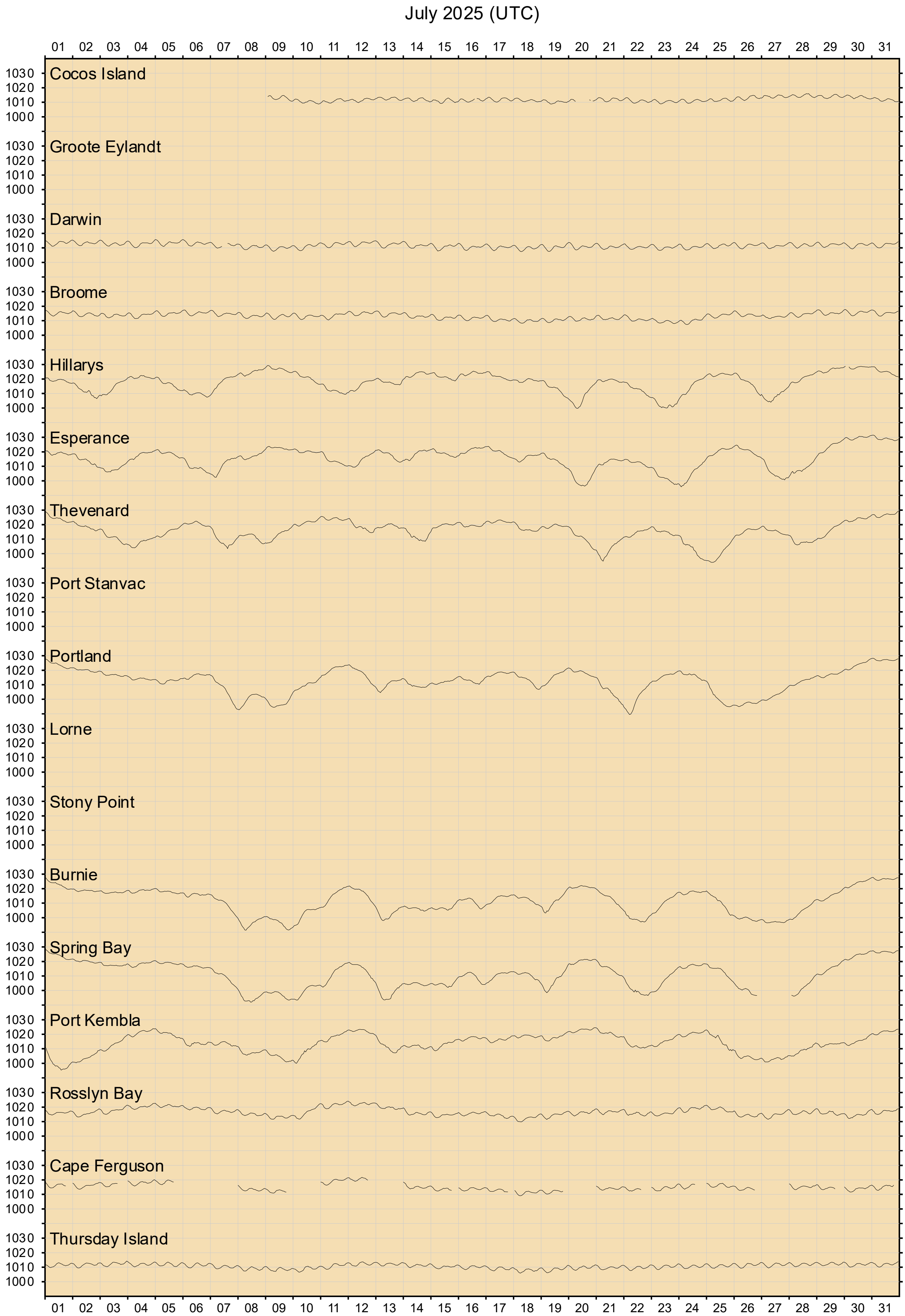

Figure 11. Barometric pressures during July 2025.

COMPARISON OF JULY 2025 MAX,MIN AND MEAN WITH LONG-TERM JULY VALUES

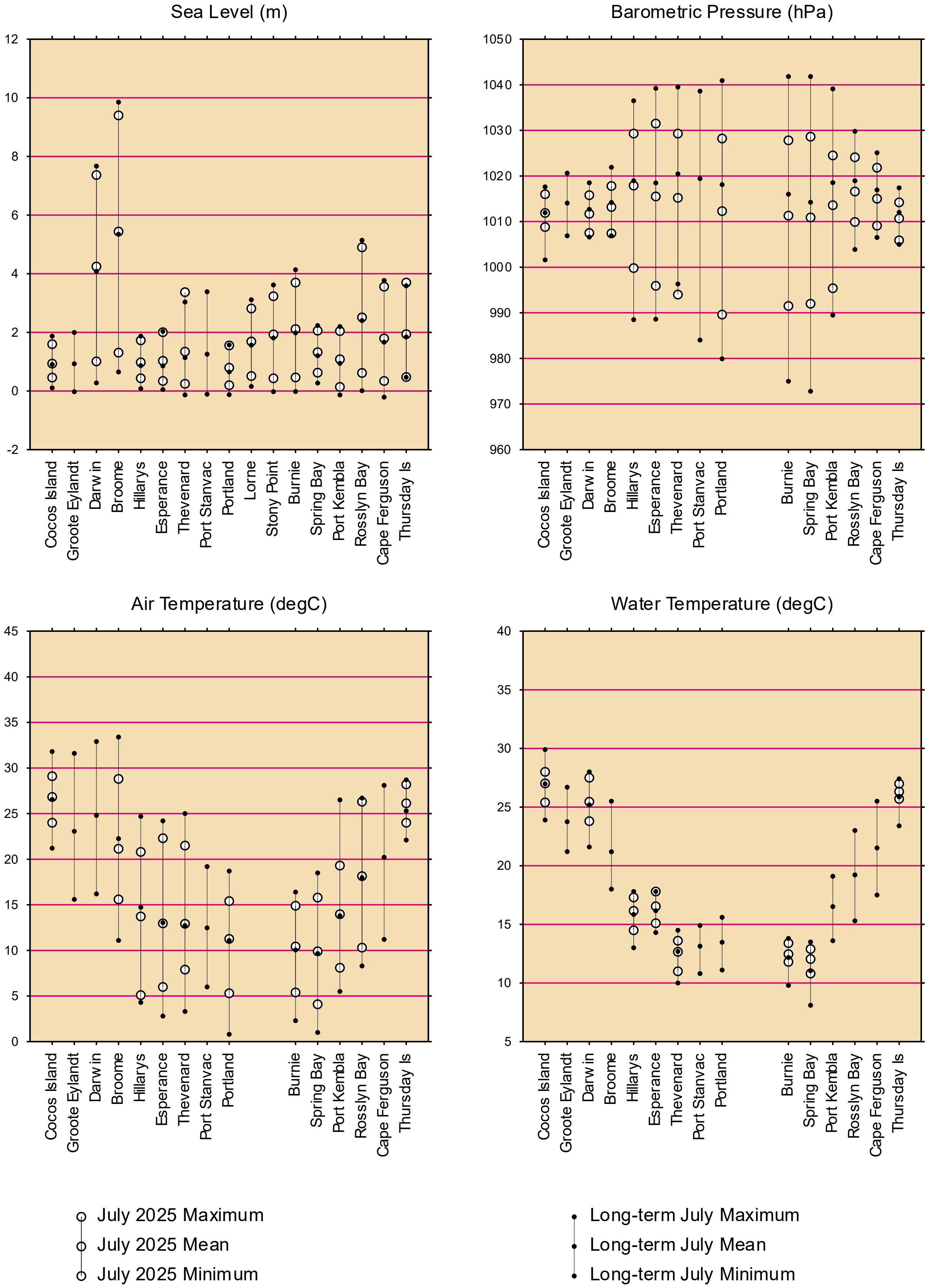

Figure 12. Comparison of July 2025 data with long term July values.

MONTHLY MEAN SEA LEVELS THROUGH JULY 2025 (m)
(The zero line represents mean sea level)

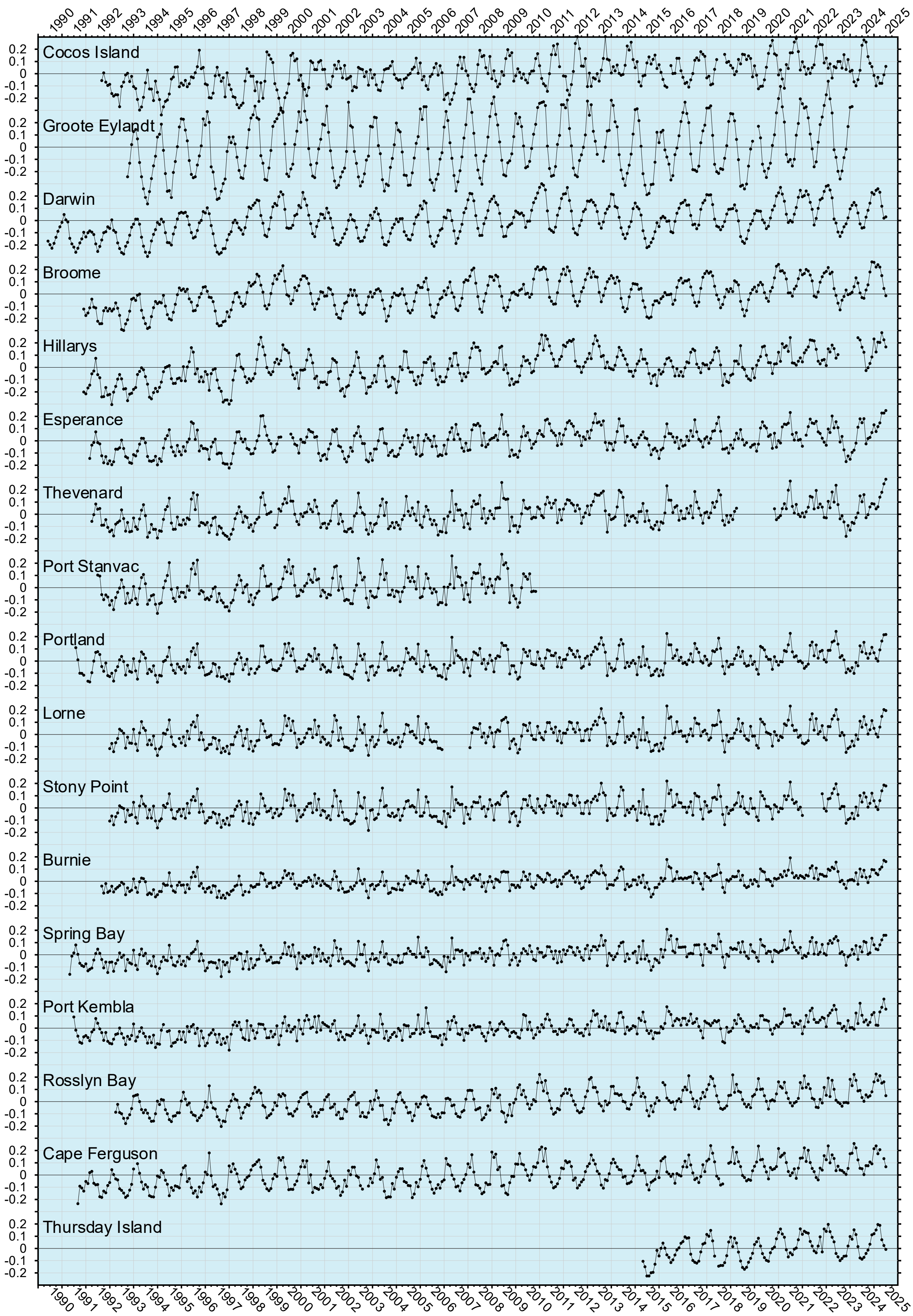

Figure 13. Monthly mean sea levels to July 2025.

MONTHLY MEAN BAROMETRIC PRESSURES
THROUGH JULY 2025 (hPa)

Figure 14. Monthly mean barometric pressures to July 2025.

MONTHLY MEAN WATER TEMPERATURES
THROUGH JULY 2025 (degC)

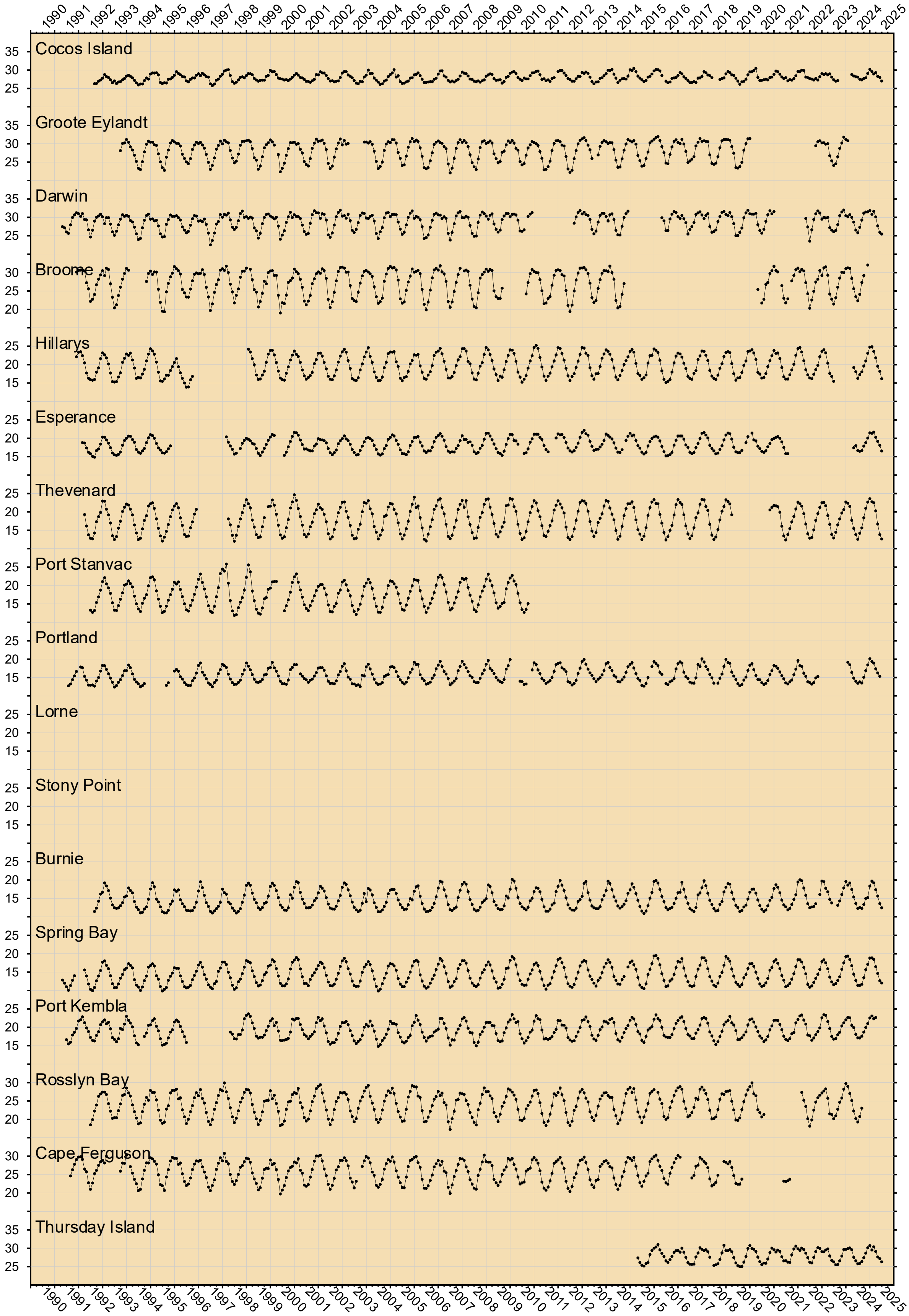

Figure 15. Monthly mean water temperatures to July 2025.

MONTHLY MEAN AIR TEMPERATURES
THROUGH JULY 2025 (degC)

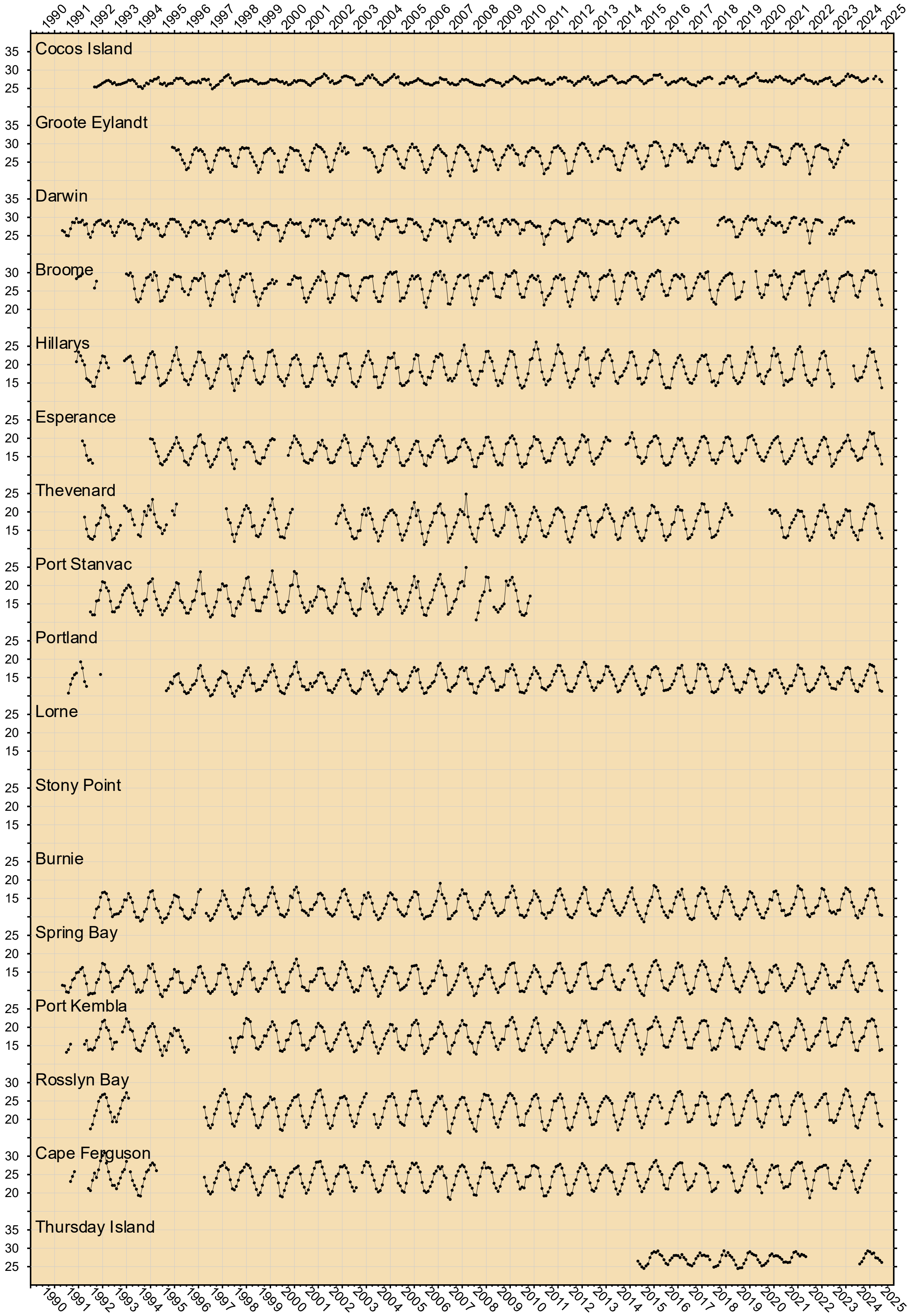

Figure 16. Monthly mean air temperatures to July 2025

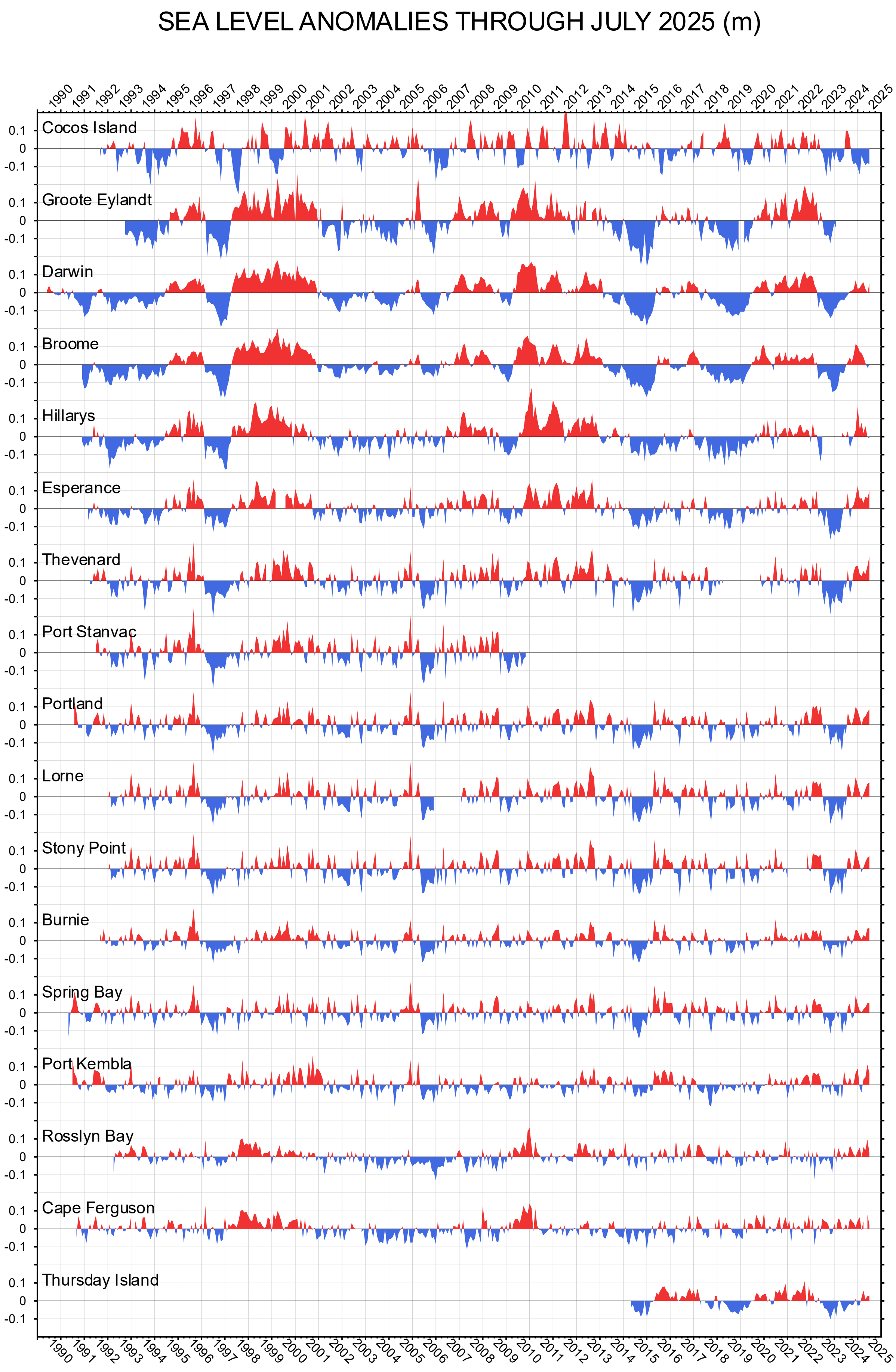

Figure 17. Monthly sea level anomalies to July 2025.

BAROMETRIC PRESSURE ANOMALIES
THROUGH JULY 2025 (hPa)

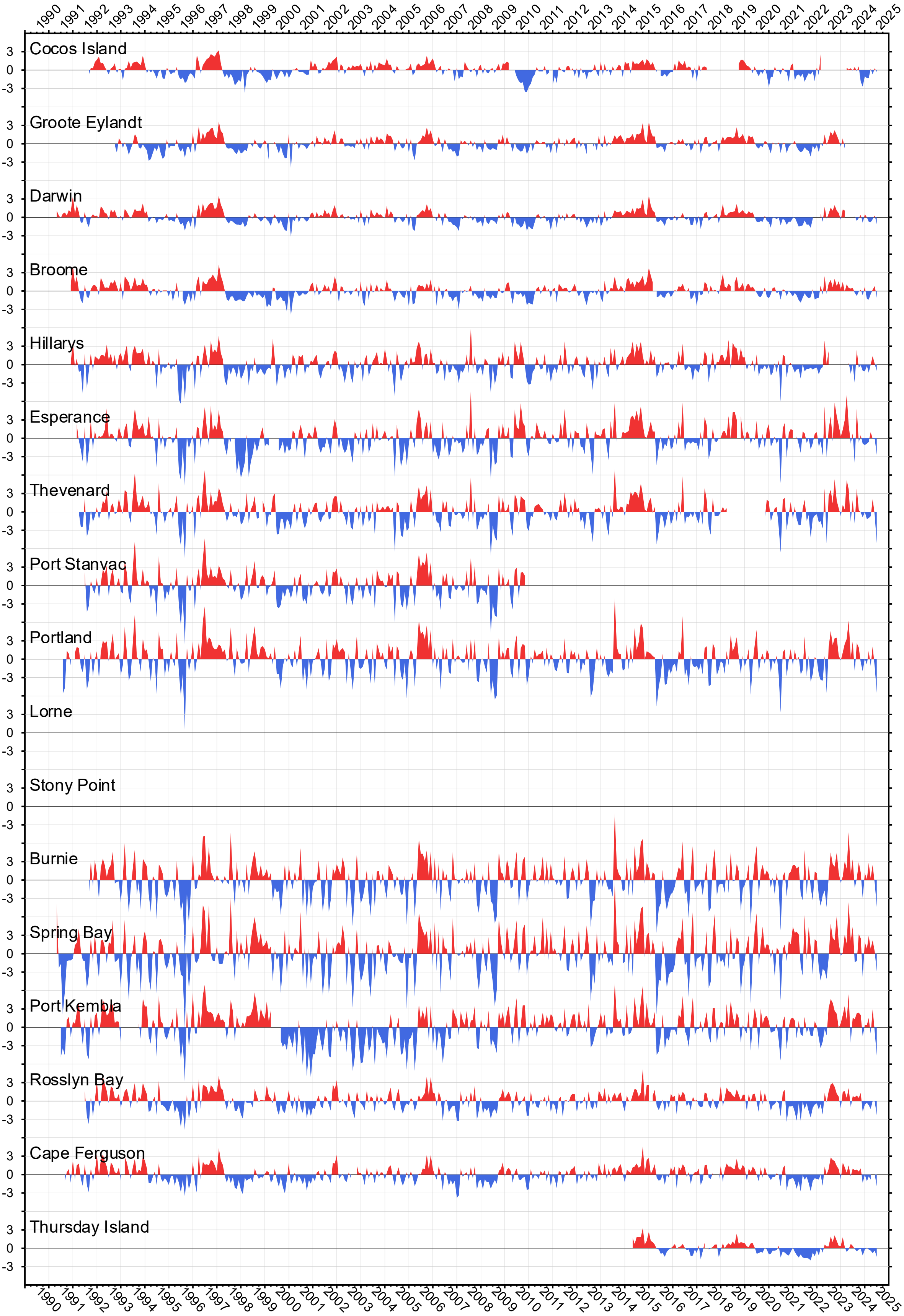

Figure 18. Monthly barometric pressure anomalies to July 2025.

WATER TEMPERATURE ANOMALIES
THROUGH JULY 2025 (degC)

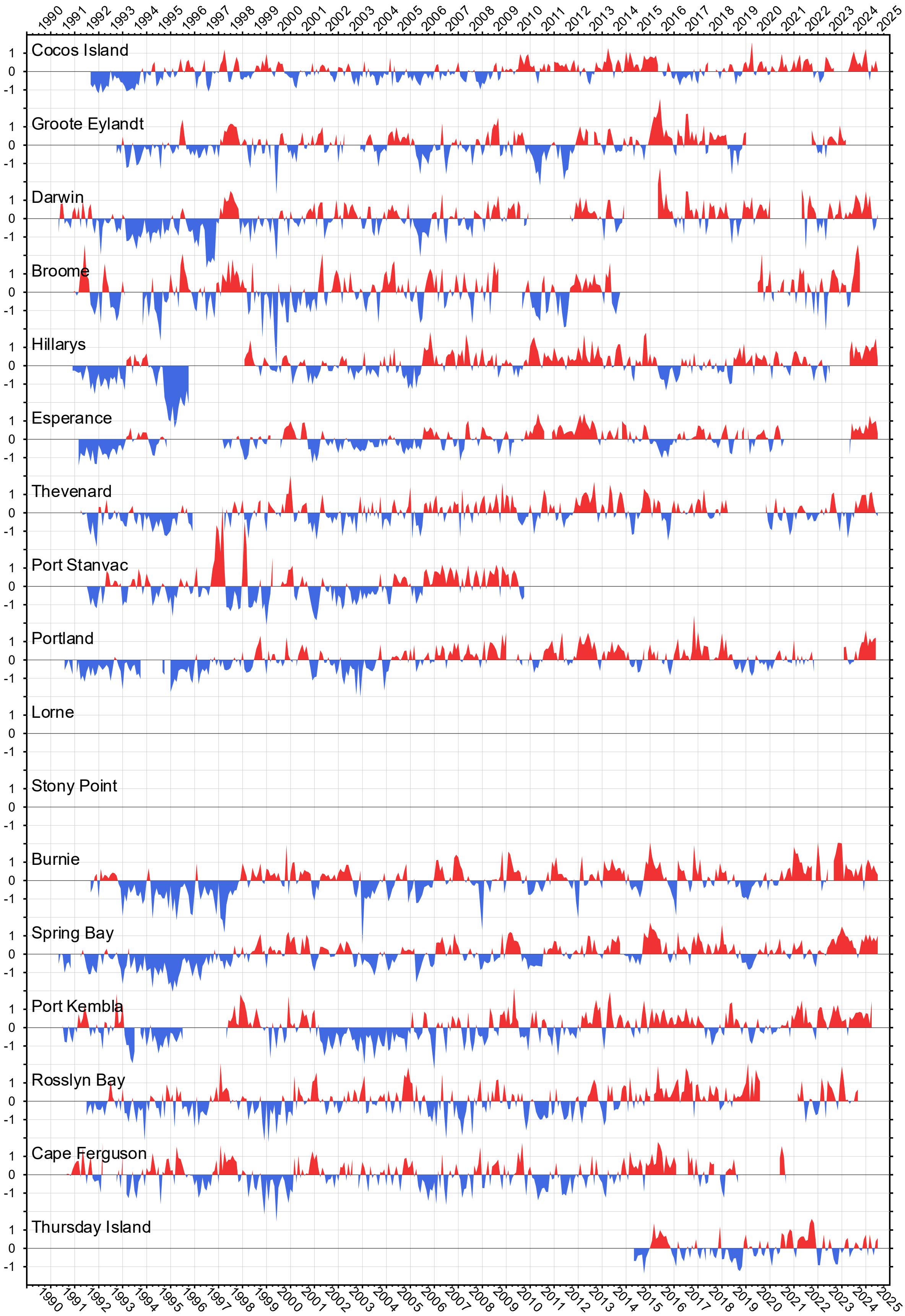

Figure 19. Monthly water temperature anomalies to July 2025.

AIR TEMPERATURE ANOMALIES
THROUGH JULY 2025 (degC)

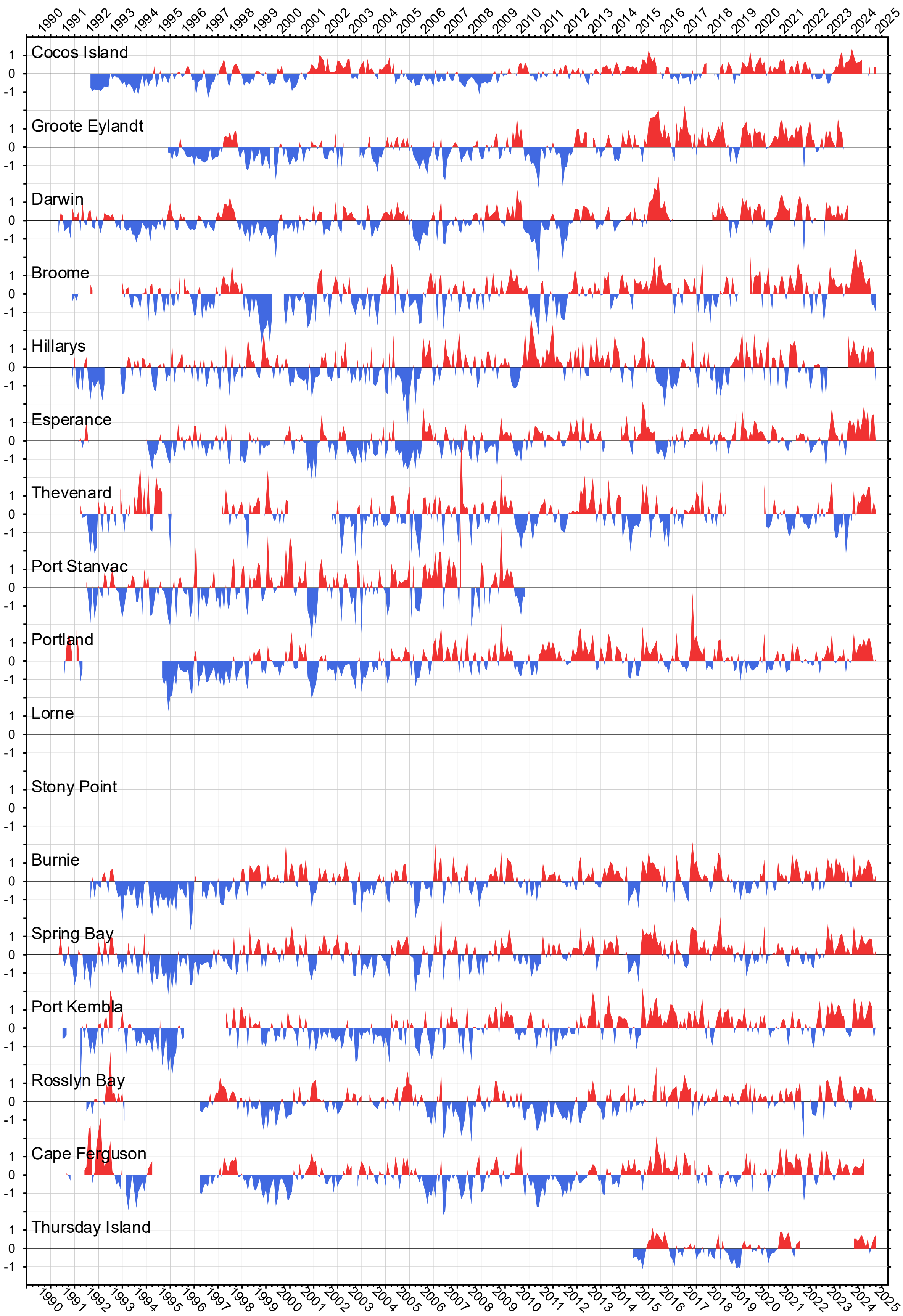

Figure 20. Monthly air temperature anomalies to July 2025.

MONTHLY SEA LEVEL DATA RETURN THROUGH JULY 2025 (%)

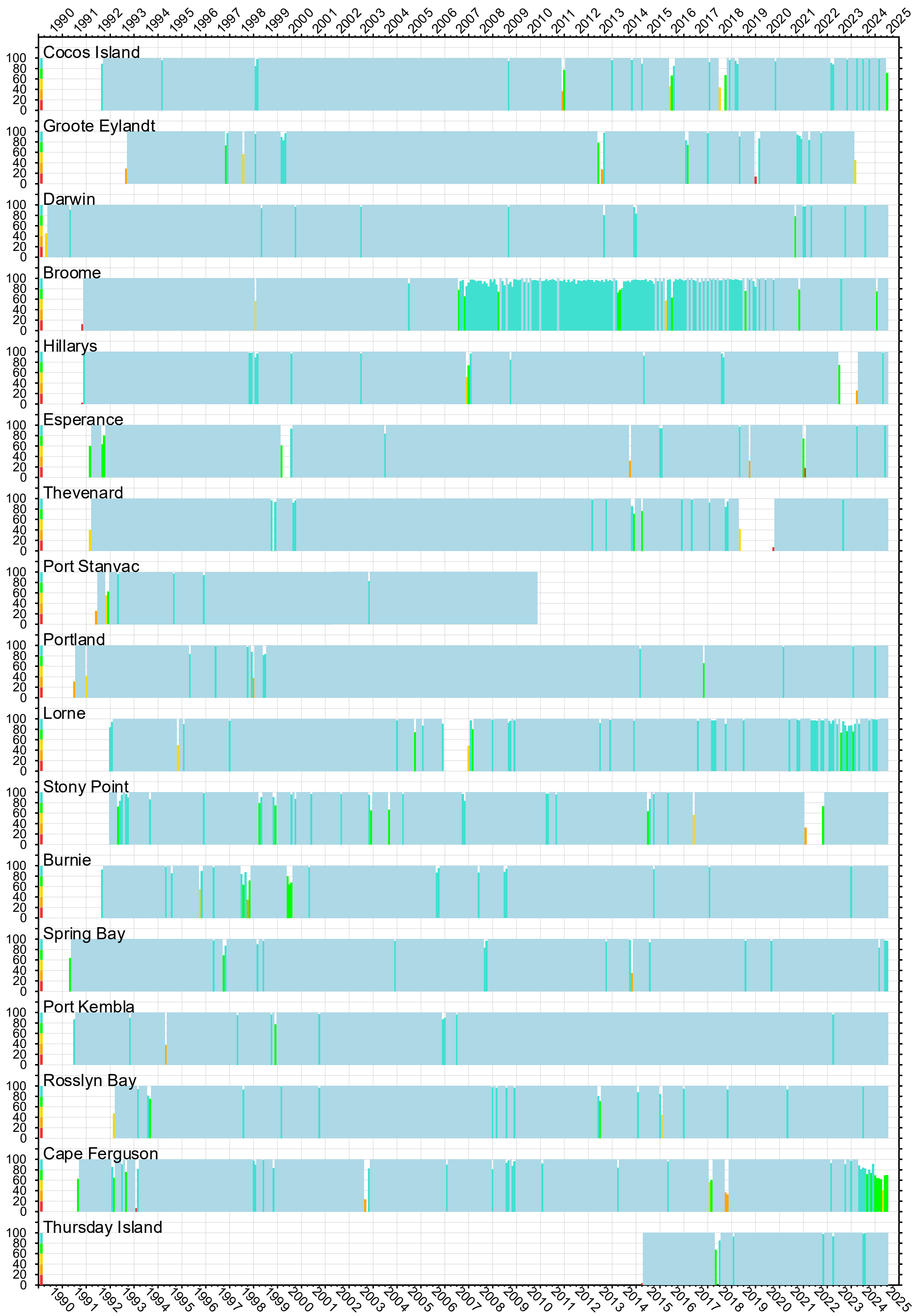

Figure 21. Sea level data return.