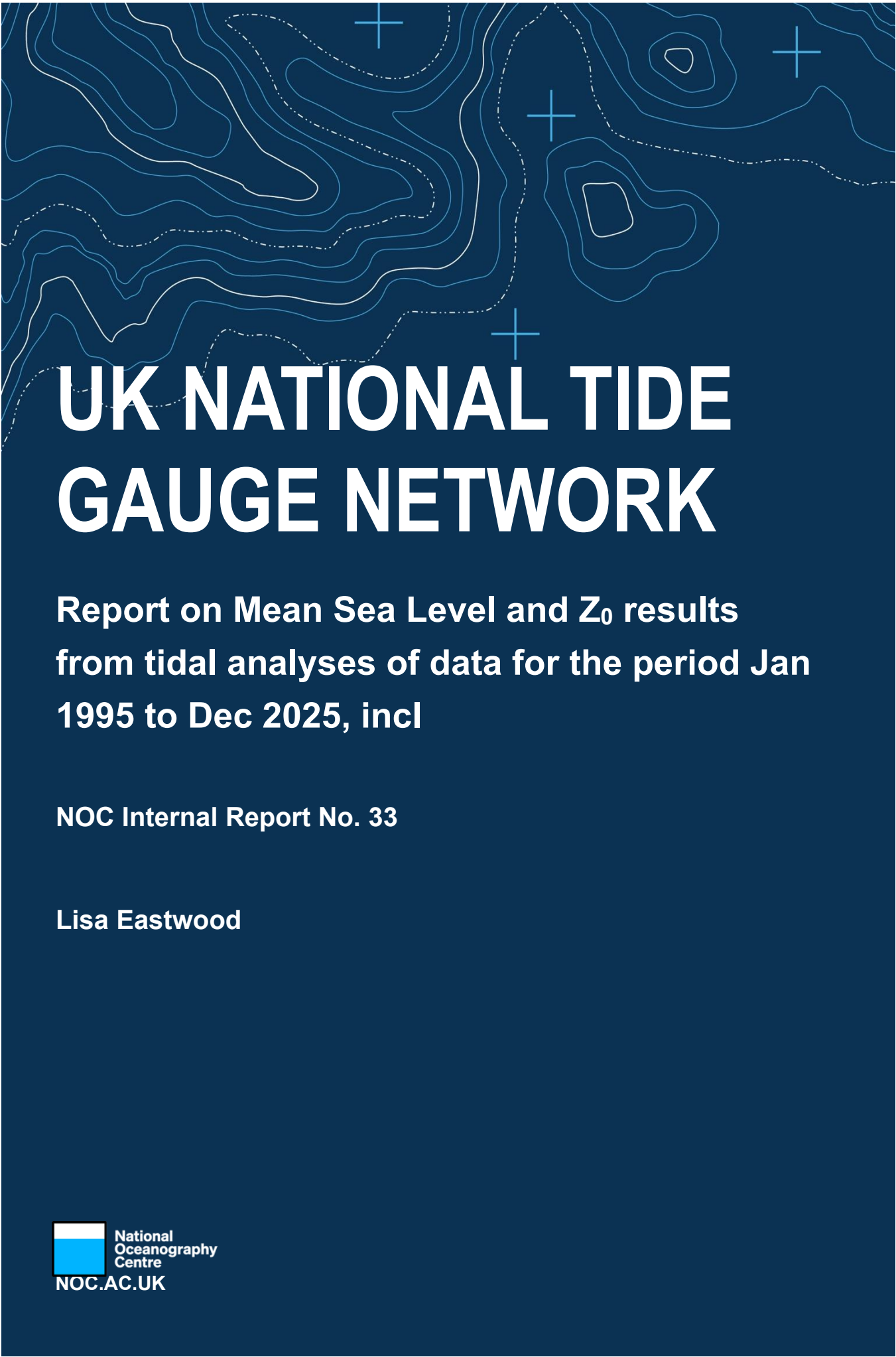




UK NATIONAL TIDE GAUGE NETWORK

**Report on Mean Sea Level and Z_0 results
from tidal analyses of data for the period Jan
1995 to Dec 2025, incl**

NOC Internal Report No. 33

Lisa Eastwood



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INTRODUCTION

The National Oceanography Centre (NOC) has provided national and international tidal prediction services for almost 100 years. Modern tidal prediction methods used around the world are based on the pioneering work of Dr Arthur Doodson, a former director of the institute. NOC has continued to develop and refine these analytical techniques and now makes them available through its software products. Poltips is NOC's commercially available tidal prediction software, designed to generate fully formatted tide tables.

Tides are the regular and predictable movements of water caused by astronomical forces, specifically the relative positions and motions of the Earth, Moon and Sun. These movements generate a series of known frequencies within the tide, each referred to as a tidal harmonic constituent.

Harmonic analysis is used to identify these constituents and determine their amplitude (size) and phase (timing). These pairs of values, known as harmonic constants, are unique to each location.

The harmonic constants define a series of sine waves centred around a zero reference level. Where observed tidal data is not centred on zero, a difference exists between the zero reference and the mean water level of the observations. This value is known as Z_0 and must be added to the predicted tide levels to align them with the observed data.

METHODOLOGY

The UK Tide Gauge Network forms part of the National Tidal & Sea Level Facility (NTSLF) which is hosted by the National Oceanography Centre (NOC). Quality-controlled NTSLF data series is available online at https://www.bodc.ac.uk/data/hosted_data_systems/sea_level/uk_tide_gauge_network/

Harmonic analyses have been carried out for ports on the UK Tide Gauge Network. The data in this study covered the period to the end of December 2025. In most cases, these analyses use data spanning 19 years to capture the full tidal nodal cycle of 18.6 years, while also reducing the influence of short-term meteorological effects on sea level. As a result, the Mean Sea Level (Z_0) value derived from the harmonic analysis represents an average over this entire period.

A mean sea level analysis using a rolling mean approach was then undertaken. The mean sea level was calculated daily using observation data from the preceding 369 days. The NOC adopted the 369-day averaging period used by the UK Hydrographic Office (UKHO) as this captures an equal number of spring and neap tidal cycles.

Where a significant trend in mean sea level was identified at a port, an additional harmonic analysis was carried out using the most recent five years of 'good' data, although the actual



analysis period involved may extend beyond 5 calendar years. The Z_0 value derived from this five-year analysis aligns more closely to present-day sea levels.

The resulting 5-year Z_0 value may then be incorporated into the Poltips database and used alongside the harmonic constituents from the 19 year analysis to better reflect current conditions while maintaining the accuracy of the underlying tidal analysis.

The rolling mean analysis was carried out for

- (a) ports showing a noticeable trend in Mean Sea Level (MSL) and for which the Z_0 value in the previous Poltips database had already been updated to the 5-year value
- (b) ports showing a difference of over 3cm between the newly derived Z_0 value and the Z_0 value in the previous Poltips database

The primary purpose of revising Z_0 was to provide a representative long-term average value for use in astronomical tidal predictions. In determining this value, greater emphasis was generally placed on more recent data, while reducing the influence of noisier observations.

Changes larger than 3cm have been included in Poltips and the new Z_0 incorporated into the prediction harmonics dataset.

The trends in Mean Sea Level can also be seen in plots of monthly data plots obtained from the Permanent Service for Mean Sea Level (PSMSL), 2026, "Monthly data plot", Retrieved July 2026 from <http://www.psmsl.org/data/obtaining/> these are added below for completeness.

The graphs on the following pages show the rolling 369 day mean water level for each national tide gauge location.

PLOT DESCRIPTION

The plots on the following pages show the rolling mean data together with various Z_0 values (from the full analysis, 5yr analysis, Poltips database, and a visual Z_0 value

The Z_0 from the full analysis (Table 1, column 2) is shown as the orange line on the graphs.

The Z_0 from the analysis of last 5 years of 'good data' (Table 1, column 3) is shown as the yellow line on the graphs

The Z_0 value currently in the Poltips data base (Table 1, column 5) is shown as the bright blue solid line, where this is on or near the grey line it is shown as a bright blue dashed line.

The grey line on the graphs was a revised Z_0 value and was derived from a visual assessment of the data available up to the end of 2019 and the professional judgement of the tidal analyst at the time. The assessment also considered that, at most locations, the quality of more recent data tends to be more variable and, in some cases, poorer than earlier



records. As a result, the revised Z_0 represents a balanced estimate rather than a purely statistical average. In most cases, this revised value was not adopted within Poltips and may therefore differ from the Z_0 value held in previous versions of the Poltips database.



RESULTS

Table 1. Z₀ values Column four shows differences between Poltips_2023 and Z₀ from new full analysis
Differences >4cm shown in **red**. >3cm shown in **amber**.

Ports showing a noticeable trend in Mean Sea Level (MSL) and for which the Z₀ value in the previous Poltips database had already been updated to the 5-year value shown in **green**

Tide Gauge	Z0 analysis	Z0 5y analysis	Difference Z0new-PT2023	PT_2023	Changed in 2026	Value adopted in POLTIPS_2026	Difference PT Z0 New-old
Aberdeen	2.60867	2.66377	0.03467	2.574	y	2.664	0.090
Bangor	2.10564	2.17771	0.04464	2.061	y	2.178	0.117
Barmouth*	2.75500		0.00000	2.755	n	2.755	na
Bournemouth*	1.58600		0.00000	1.586	n	1.586	na
Cromer	2.97813	3.02323	0.04913	2.929	y	3.023	0.094
Devonport	3.46285	3.52583	0.03885	3.424	y	3.526	0.102
Dover	3.83189	3.89643	0.04989	3.782	y	3.896	0.114
Fishguard	2.76468	2.78305	0.00068	2.764	n	2.764	na
Harwich	2.22845	2.28182	0.03545	2.193	y	2.282	0.089
Heysham	5.25103	5.30884	0.03703	5.214	y	5.309	0.095
Hinkley Point*	6.25149		0.00049	6.251	n	6.251	na
Holyhead	3.32821	3.36247	0.03421	3.294	y	3.362	0.068
Ilfracombe	5.03894	5.06718	0.03694	5.002	y	5.067	0.065
Immingham	4.23086		0.02086	4.210	n	4.231	na
Kinlochbervie	2.93863	2.98673	-0.00137	2.940	y	2.987	0.047
Leith	3.23070		0.02770	3.203	n	3.231	na
Lerwick	1.35642	1.39057	0.03542	1.321	y	1.391	0.070
Liverpool (Gladstone)	5.38560	5.41478	0.02160	5.364	y	5.415	0.051
Llandudno	4.11956		0.02856	4.091	n	4.120	na
Lowestoft	1.70774	1.75283	0.03774	1.670	y	1.753	0.083
Milford Haven	3.97505	4.0327	0.02705	3.948	y	4.033	0.085
Millport	2.06685	2.11723	0.04585	2.021	y	2.117	0.096
Mumbles*	5.24100		0.00000	5.241	n	5.241	na
Newhaven	3.70606		0.00606	3.700	n	3.706	na
Newlyn	3.27642	3.33105	0.04142	3.235	y	3.331	0.096
Newport	6.27460	6.31735	-0.01640	6.291	y	6.317	0.026
North Shields	2.99897		0.01997	2.979	n	2.999	na
Port Erin	2.95880	2.99688	0.00780	2.951	y	2.997	0.046
Portbury*	7.09800		0.00000	7.098	n	7.098	na
Portpatrick	2.24778	2.29832	0.04978	2.198	y	2.298	0.100
Portrush	1.30969		0.01969	1.290	n	1.310	na
Portsmouth	2.93446	2.98755	0.01246	2.922	y	2.988	0.066
Sheerness	3.11178	3.14868	0.04678	3.065	y	3.149	0.084
St. Helier	6.08098	6.14317	0.03798	6.043	y	6.143	0.100
St. Marys	3.18591		-0.00409	3.190	n	3.186	na
Stornoway*	2.96600	3.00272	0.00000	2.966	y	3.003	0.000
Tobermory	2.77321		0.02821	2.745	n	2.773	na
Ullapool*	3.12700		0.00000	3.127	n	3.127	na
Weymouth	1.17543		0.01743	1.158	n	1.175	na
Whitby	3.51957	3.53906	-0.01343	3.533	y	3.539	0.006
Wick	2.10463	2.15527	0.03063	2.074	y	2.155	0.081
Workington	4.54629		0.00429	4.542	n	4.546	na

* insufficient data available, no new analysis undertaken. Z₀ values taken from 2019 results.



Figure 1. Differences between Z_0 used in Poltips_2023 and those adopted for Poltips_2026

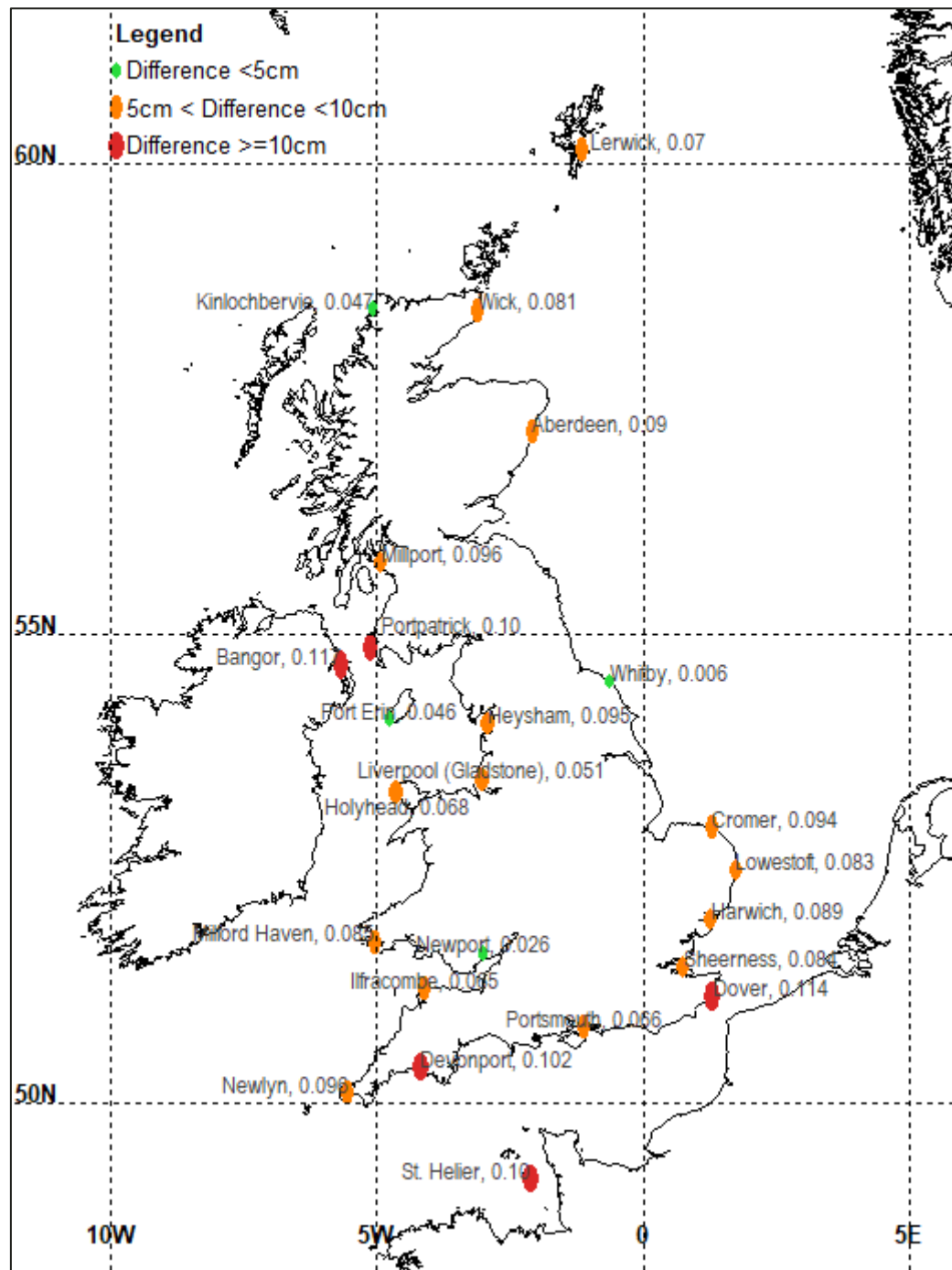




Table 2. 5Yr analysis information (data to end 2025)

[no. hours in 5y: 43848 / 43824, depending on no. leap years in 5 yr period]

- Ports showing a noticeable trend in Mean Sea Level (MSL) and for which the Z_0 value in the previous Poltips database had already been updated to the 5-year value shown in **green**
- Ports showing a difference of over 4cm between the newly derived Z_0 value and the Z_0 value in the previous Poltips database shown in **red**
- Ports showing a difference of over 3cm between the newly derived Z_0 value and the Z_0 value in the previous Poltips database shown in **amber**

Port	5 year start date record number	5 year Hours of data Target for 5y analysis = 43848 / 43824	Z0 from 5y analysis (2024 results)
Aberdeen	12/7/2020 (194) 895200	Hours of data: 47952.00 Hours of good data: 43850.00	2.66377
Bangor	27/12/2020 (362) 911300	Hours of data: 43927.00 Hours of good data: 43843.50	2.17771
Barmouth*	No new analysis	No new analysis	
Bournemouth	8/9/2016 725377	Hours of data: 48317.75 Hours of good data: 39401.00	1.51743
Cromer	23/9/2020 (267) 902200	Hours of data: 46202.00 Hours of good data: 43849.25	3.02323
Devonport	29/12/2020 (364) 911500	Hours of data: 43877.00 Hours of good data: 43861.50	3.52583
Dover	7/11/2018 (311) 836300	Hours of data: 62677.00 Hours of good data: 43840.25	3.89643
Fishguard	13/9/2017 (256) 796000	Hours of data: 72752.00 Hours of good data: 43931.75	2.78305
Harwich	7/10/2020 (281) 588000	Hours of data: 45864.00 Hours of good data: 43866.00	2.28182
Heysham	27/10/2020 (301) 905470	Hours of data: 45384.50 Hours of good data: 43848.25	5.30884
Hinkley Point*	No new analysis	No new analysis	
Holyhead	8/1/2020 (8) 864289	Hours of data: 52427.00 Hours of good data: 43857.50	3.36247
Ilfracombe	12/2/2020 (43) 880650	Hours of data: 51589.50 Hours of good data: 43847.75	5.06718
Immingham	1/7/2018 823873	Hours of data: 44215.50 Hours of good data: 44205.00	4.27902
Kinlochbervie	11/10/2019 (284) 868745	Hours of data: 54565.75 Hours of good data: 43874.25	2.98673
Leith	1/1/2020 876577	Hours of data: 42581.00 Hours of good data: 41598.25	3.25210
Lerwick	25/12/2020 (360) 911050	Hours of data: 43989.50 Hours of good data: 43849.25	1.39057
Liverpool (Gladstone)	24/7/2020 (206) 896300	Hours of data: 47677.00 Hours of good data: 43865.50	5.41478
Llandudno	1/1/2020 876577	Hours of data: 43500.75 Hours of good data: 41323.25	4.14617
Lowestoft	22/12/2020 (357) 910800	Hours of data: 44052.00 Hours of good data: 43857.00	1.75283



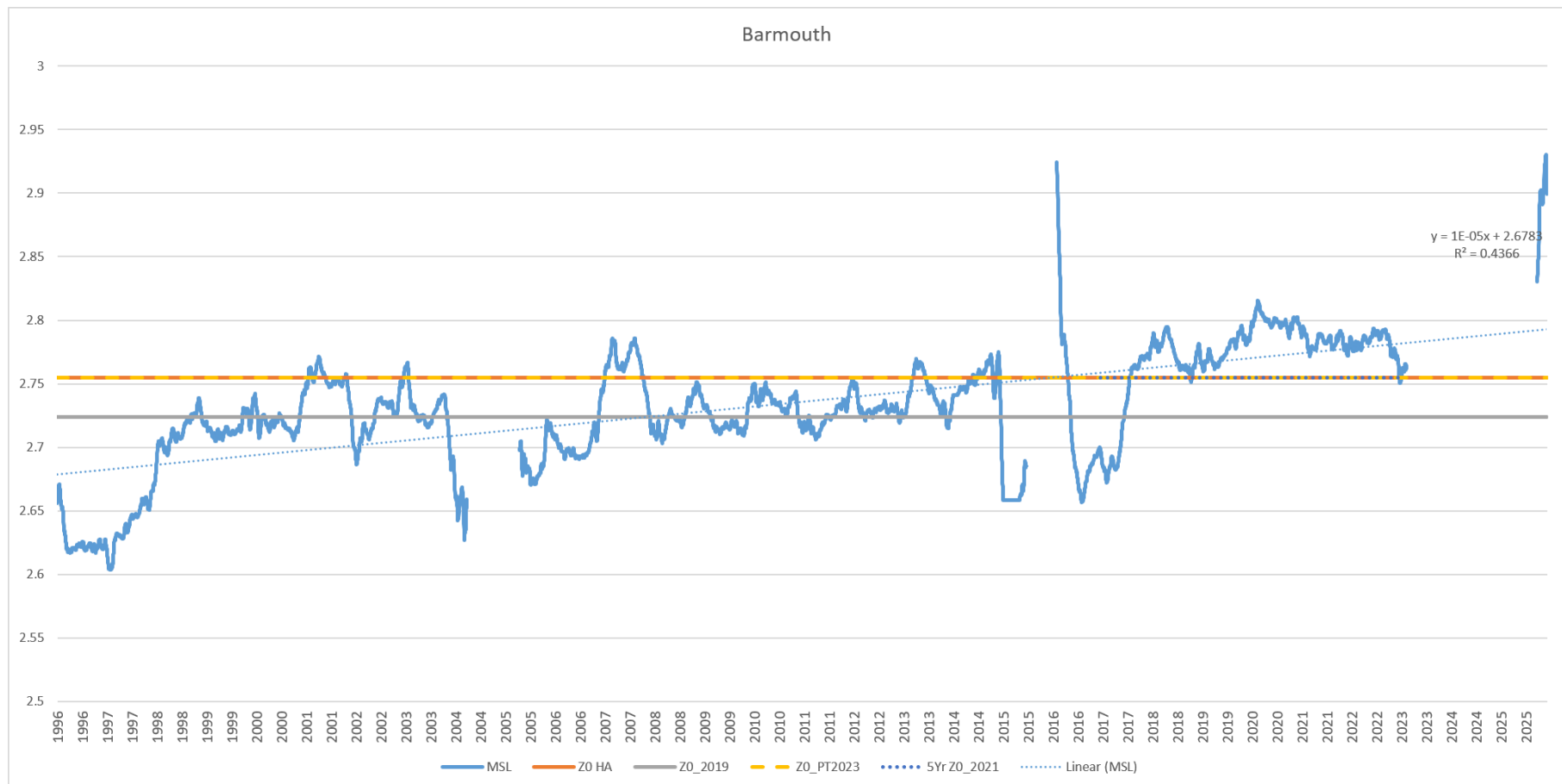
Port	5 year start date record number	5 year Hours of data Target for 5y analysis = 43848 / 43824	Z0 from 5y analysis (2024 results)
Milford Haven	14/11/2020 (319) 907200	Hours of data: 44952.00 Hours of good data: 43840.75	4.03270
Millport	21/12/2020 (356) 910750	Hours of data: 44064.50 Hours of good data: 43848.75	2.11723
Mumbles	1/1/2016 666145	Hours of data: 77870.75 Hours of good data: 44427.25	5.24157
Newhaven	1/1/2020 876577	Hours of data: 43847.75 Hours of good data: 40940.00	3.76237
Newlyn	9/7/2020 (191) 876193	Hours of data: 48027.00 Hours of good data: 43850.00	3.33105
Newport	31/10/2019 (304) 894900	Hours of data: 54077.00 Hours of good data: 43865.75	6.31735
North Shields	14/7/2018 825121	Hours of data: 56711.75 Hours of good data: 39910.25	3.02225
Port Erin	14/12/2020 (349) 910000	Hours of data: 44252.00 Hours of good data: 43902.25	2.99688
Portbury*	No new analysis	No new analysis	
Portpatrick	31/12/2020 (365) 911550	Hours of data: 43864.50 Hours of good data: 43848.50	2.29832
Portrush	1/1/2020 876577	Hours of data: 43847.75 Hours of good data: 41673.75	1.32226
Portsmouth	12/8/2019 (224) 863000	Hours of data: 56002.00 Hours of good data: 43834.25	2.98755
Sheerness	30/8/2020 (243) 899890	Hours of data: 46779.50 Hours of good data: 43848.50	3.14868
St. Helier	22/4/2020 (113) 887340	Hours of data: 49917.00 Hours of good data: 43847.50	6.14317
St. Marys	1/1/2020 876577	Hours of data: 43847.75 Hours of good data: 43834.50	3.16560
Stornoway	9/4/2020 (100) 886100	Hours of data: 44045.25 Hours of good data: 43853.75	3.00272
Tobermory	1/5/2019 853057	Hours of data: 44157.75 Hours of good data: 39188.25	2.80476
Ullapool*	No new analysis	No new analysis	
Weymouth	1/1/2020 876577	Hours of data: 43847.75 Hours of good data: 42701.00	1.22073
Whitby	26/12/2020 (361) 911200	Hours of data: 43952.00 Hours of good data: 43893.50	3.53906
Wick	4/12/2020 (339) 909100	Hours of data: 44477.00 Hours of good data: 43855.25	2.15527
Workington	1/1/2020 876577	Hours of data: 43847.75 Hours of good data: 43713.75	4.57907



Z₀ ROLLING MEAN PLOTS: PORTS USING 5YR Z₀ IN POLTIPS_2023 DATASET

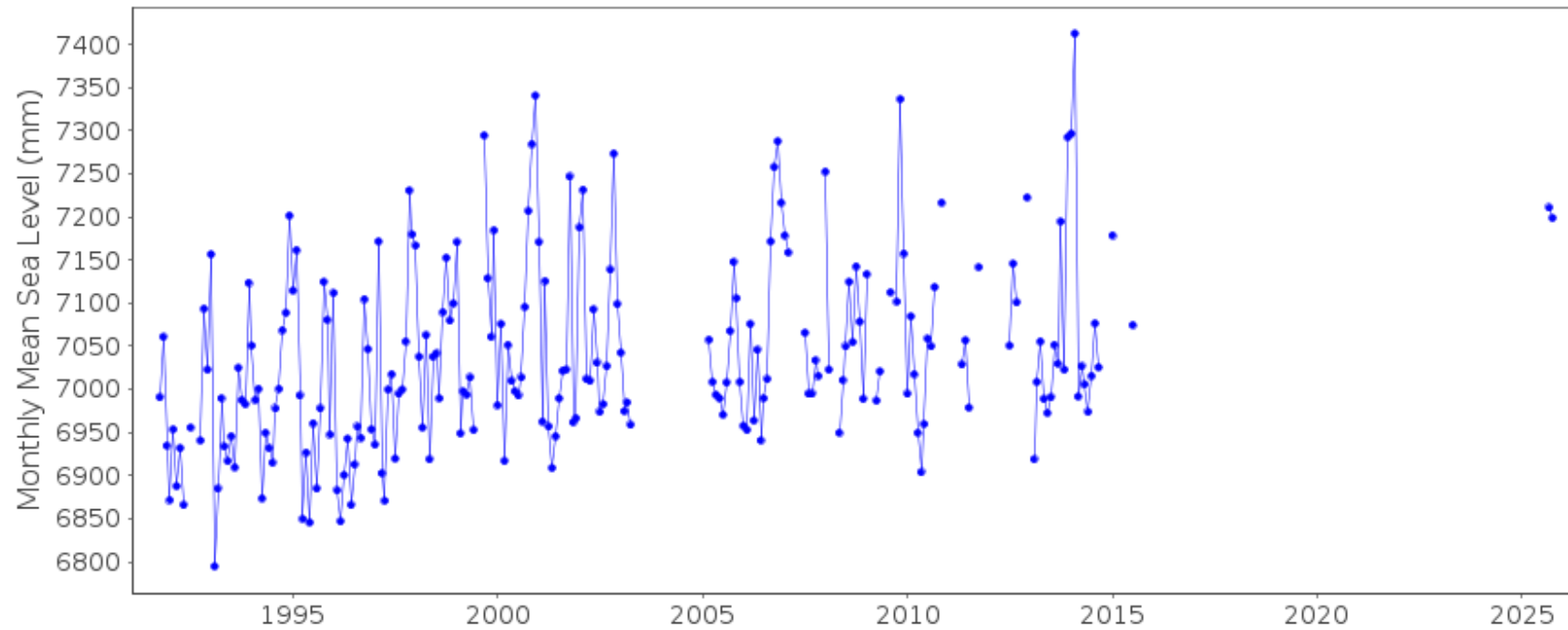
Barmouth

No new analysis but added for completeness



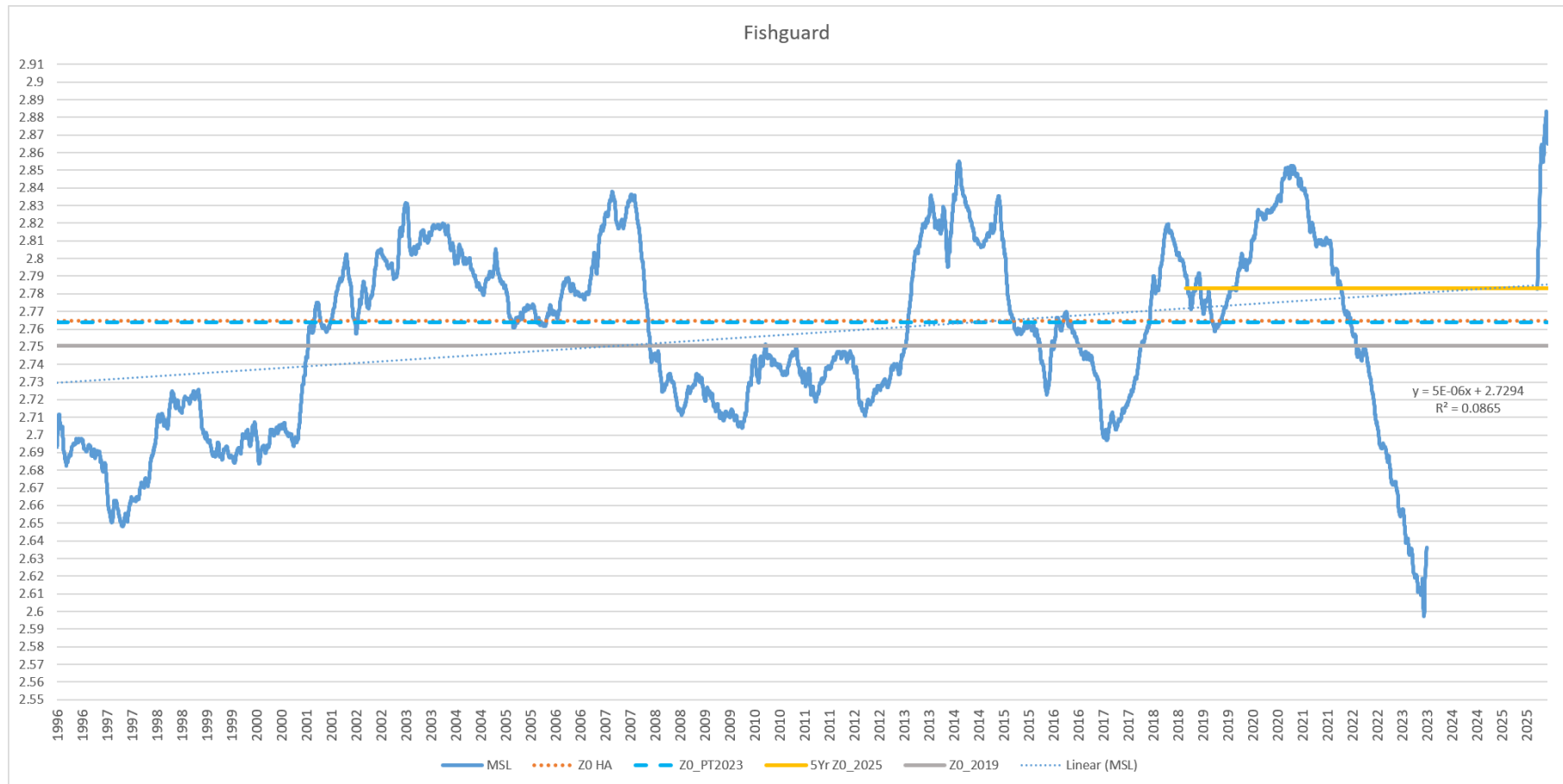


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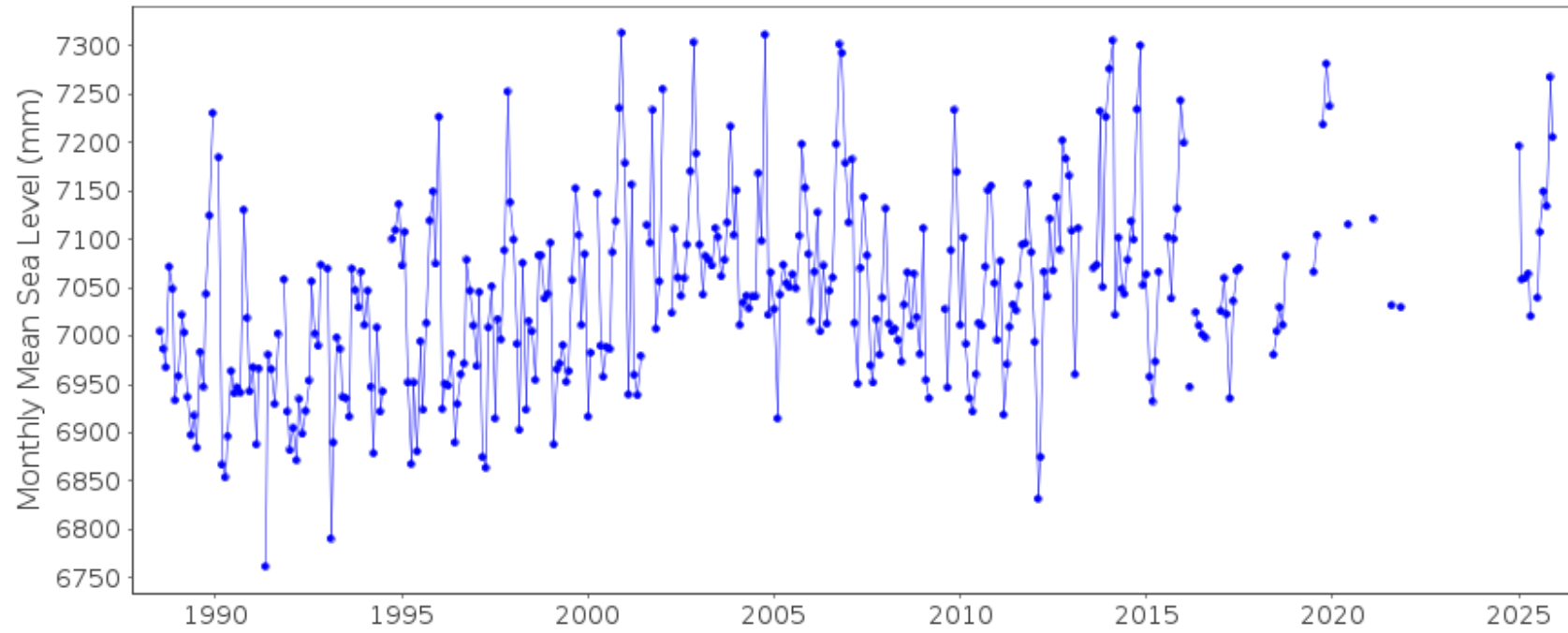


Fishguard



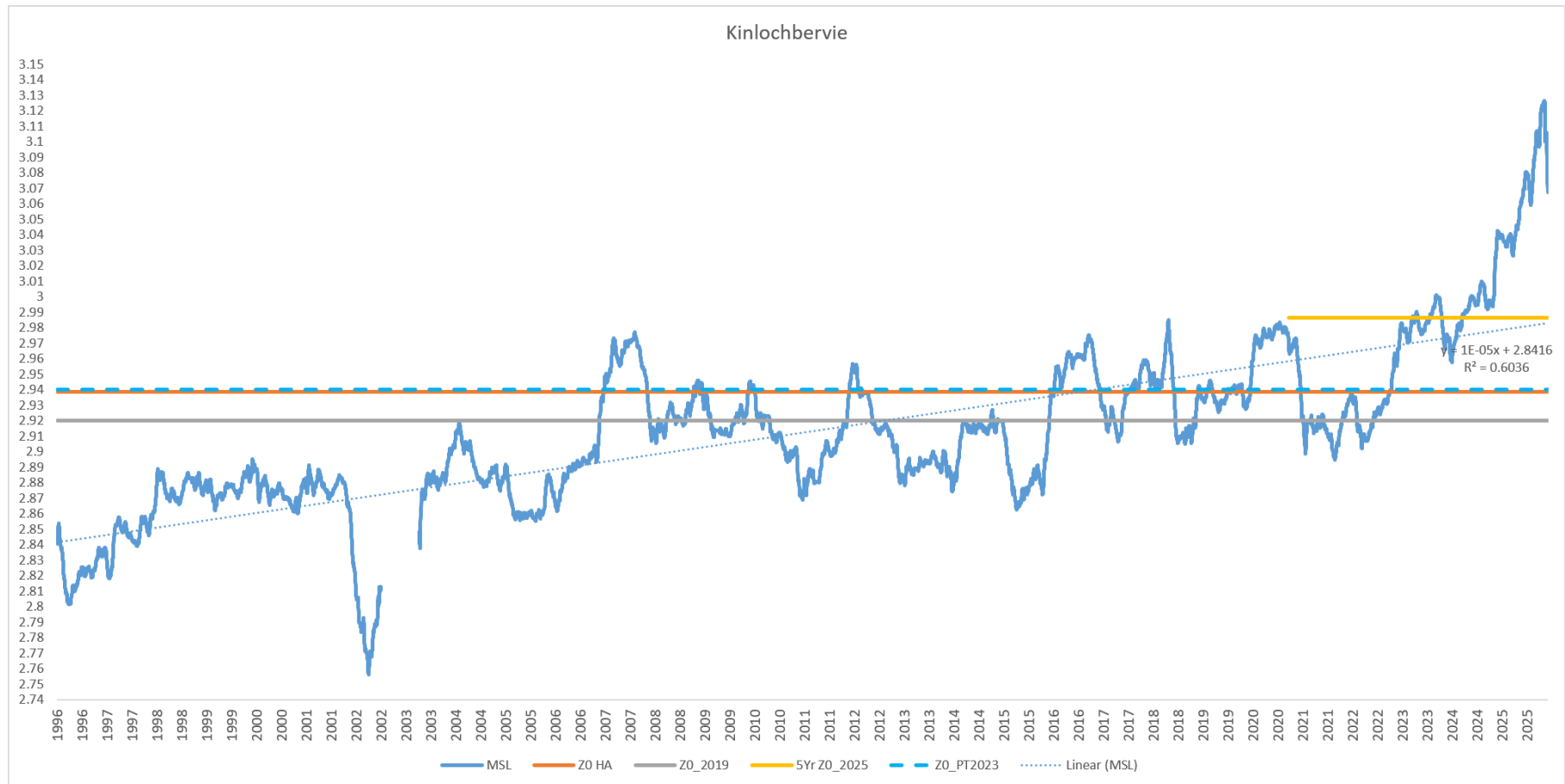


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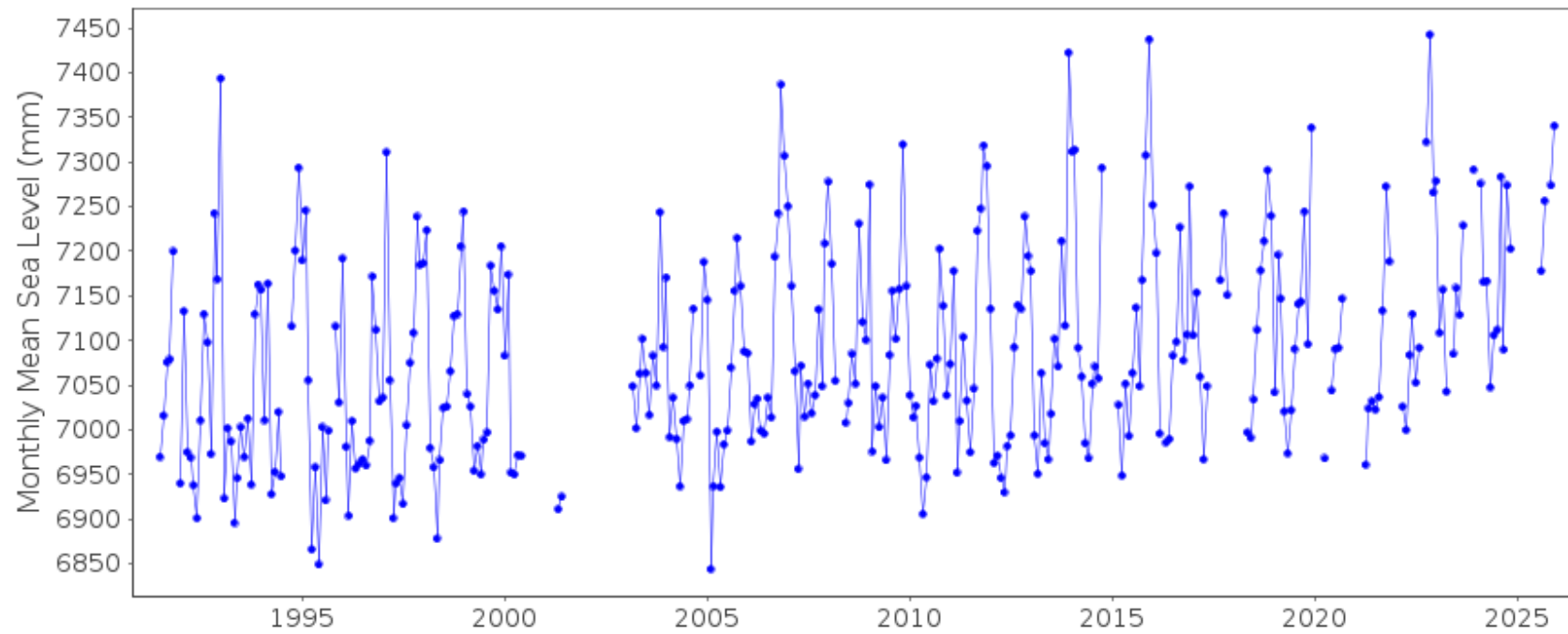


Kinlochbervie



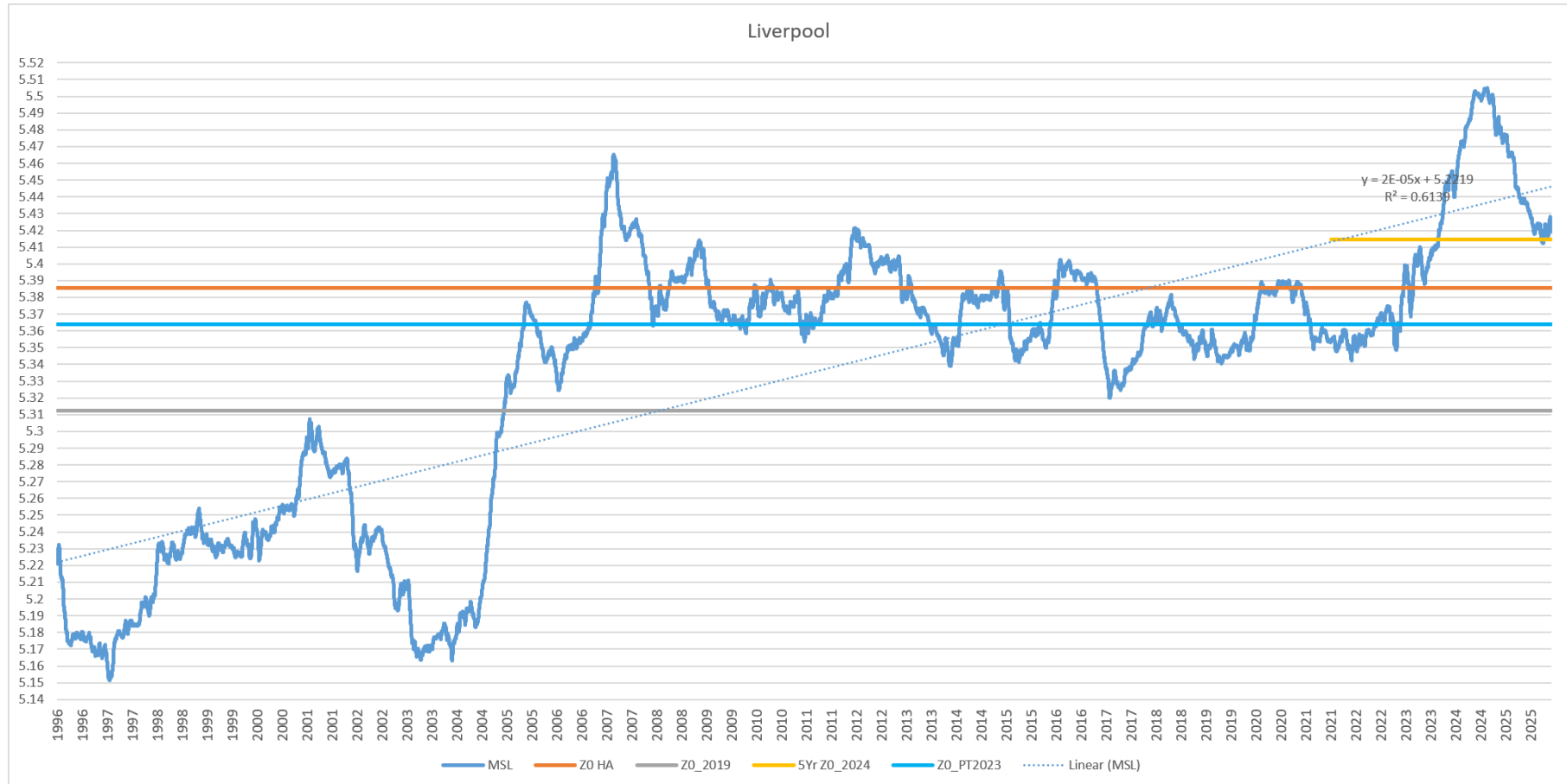


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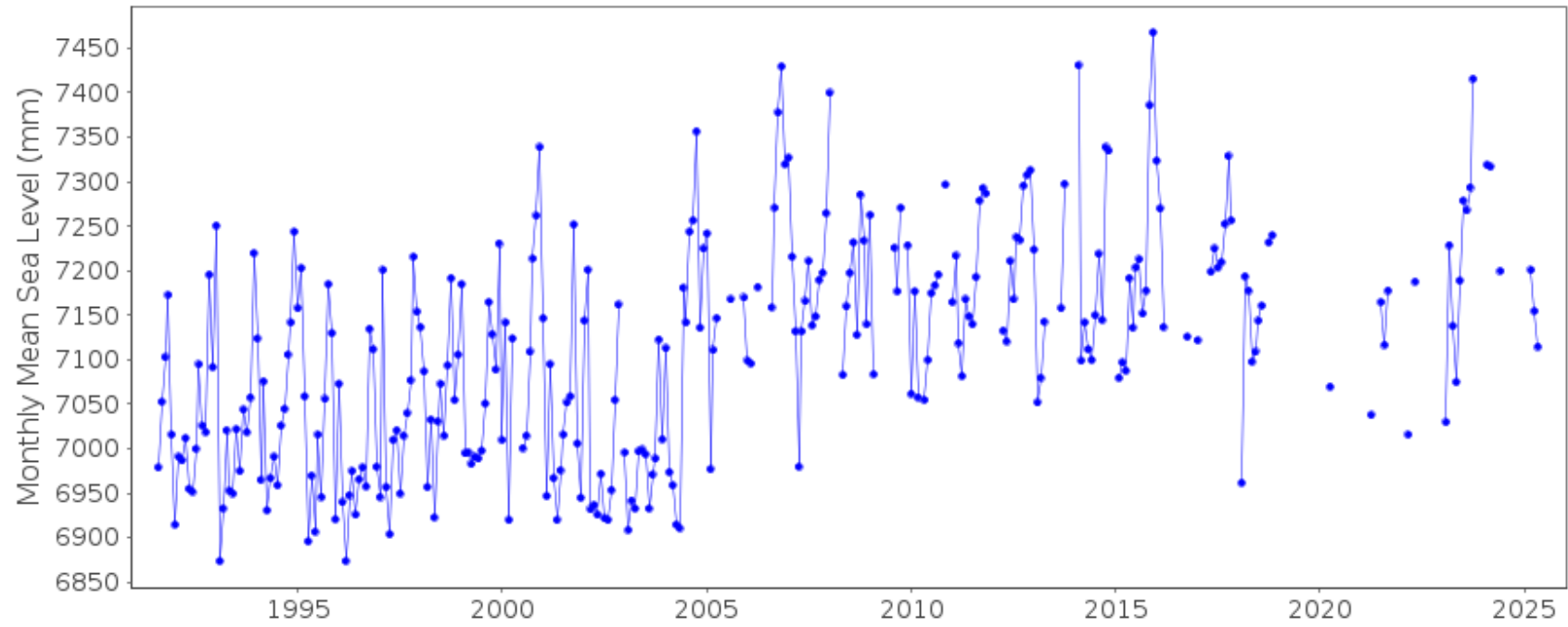


Liverpool (Gladstone)



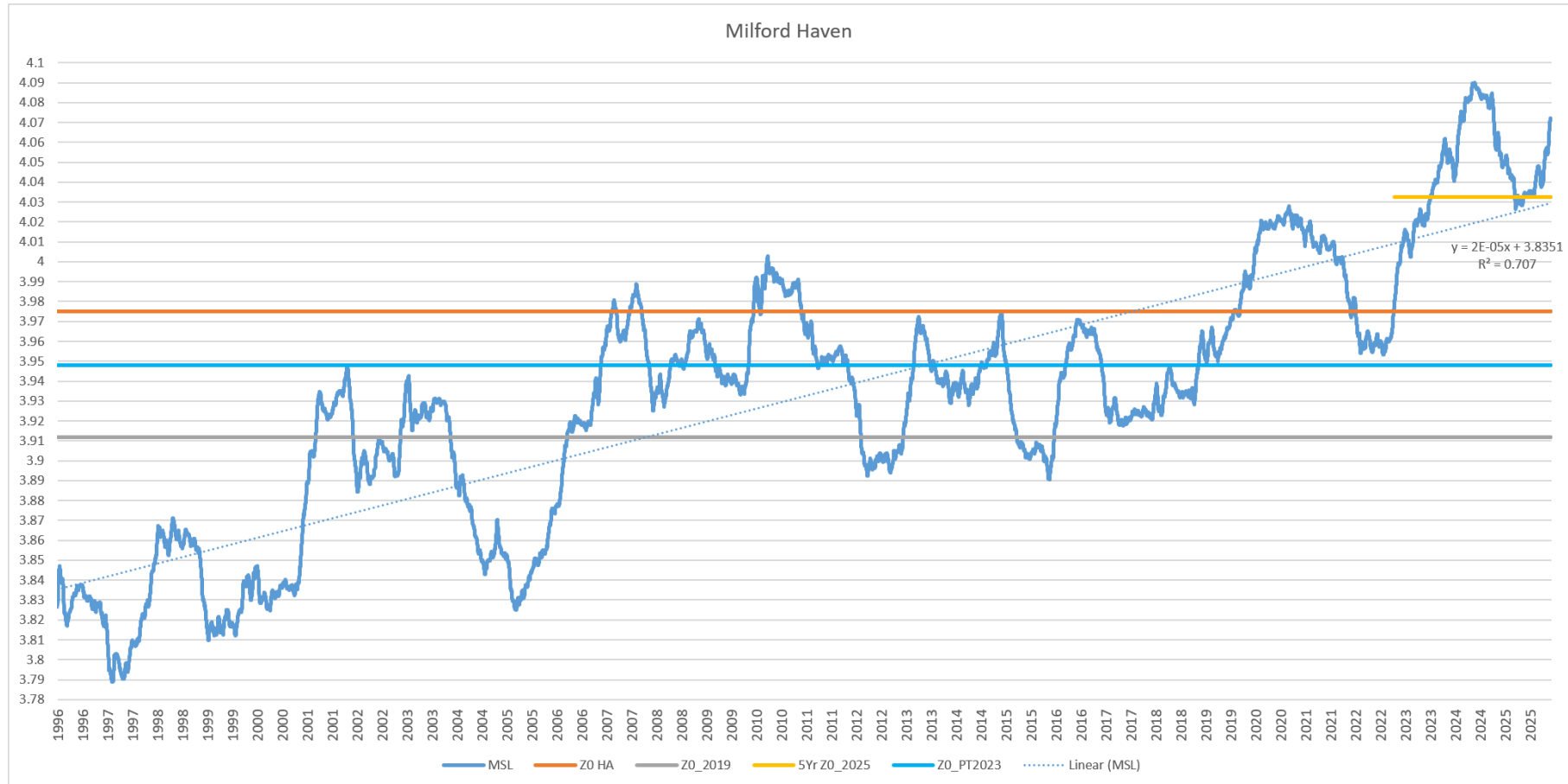


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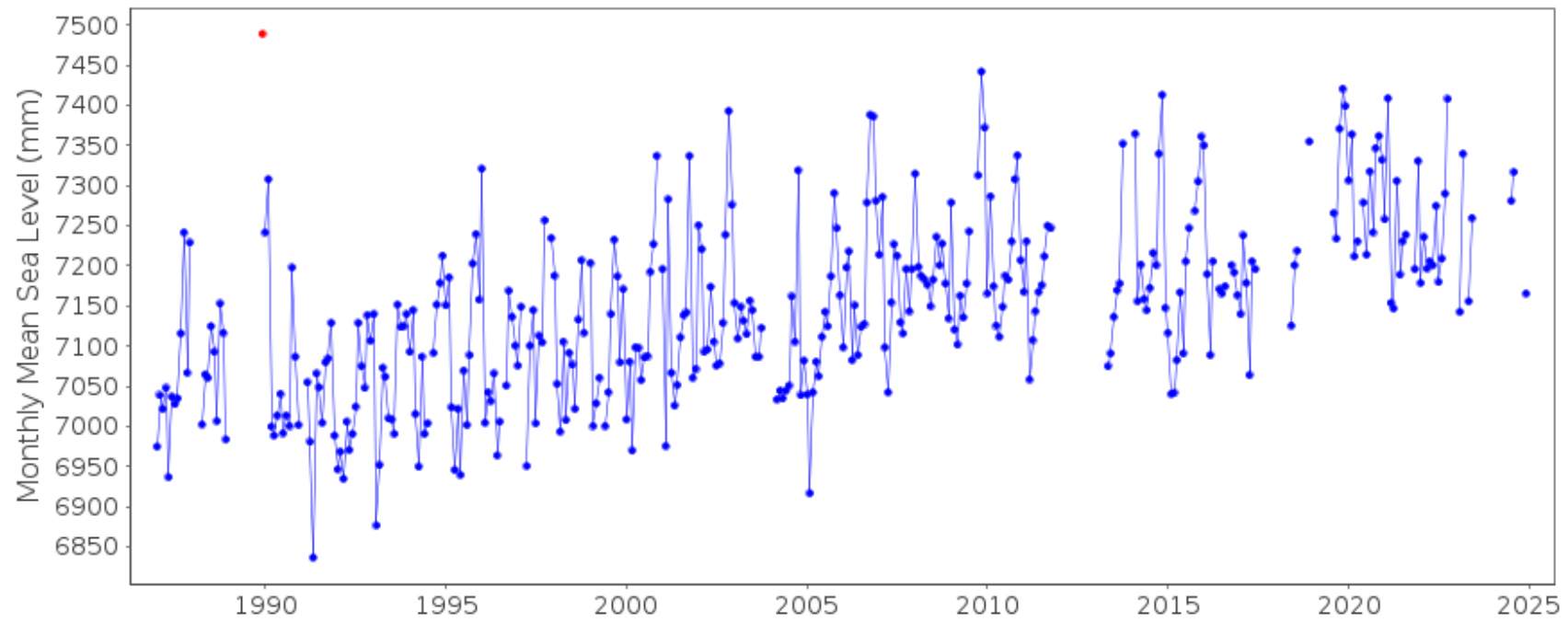


Milford Haven



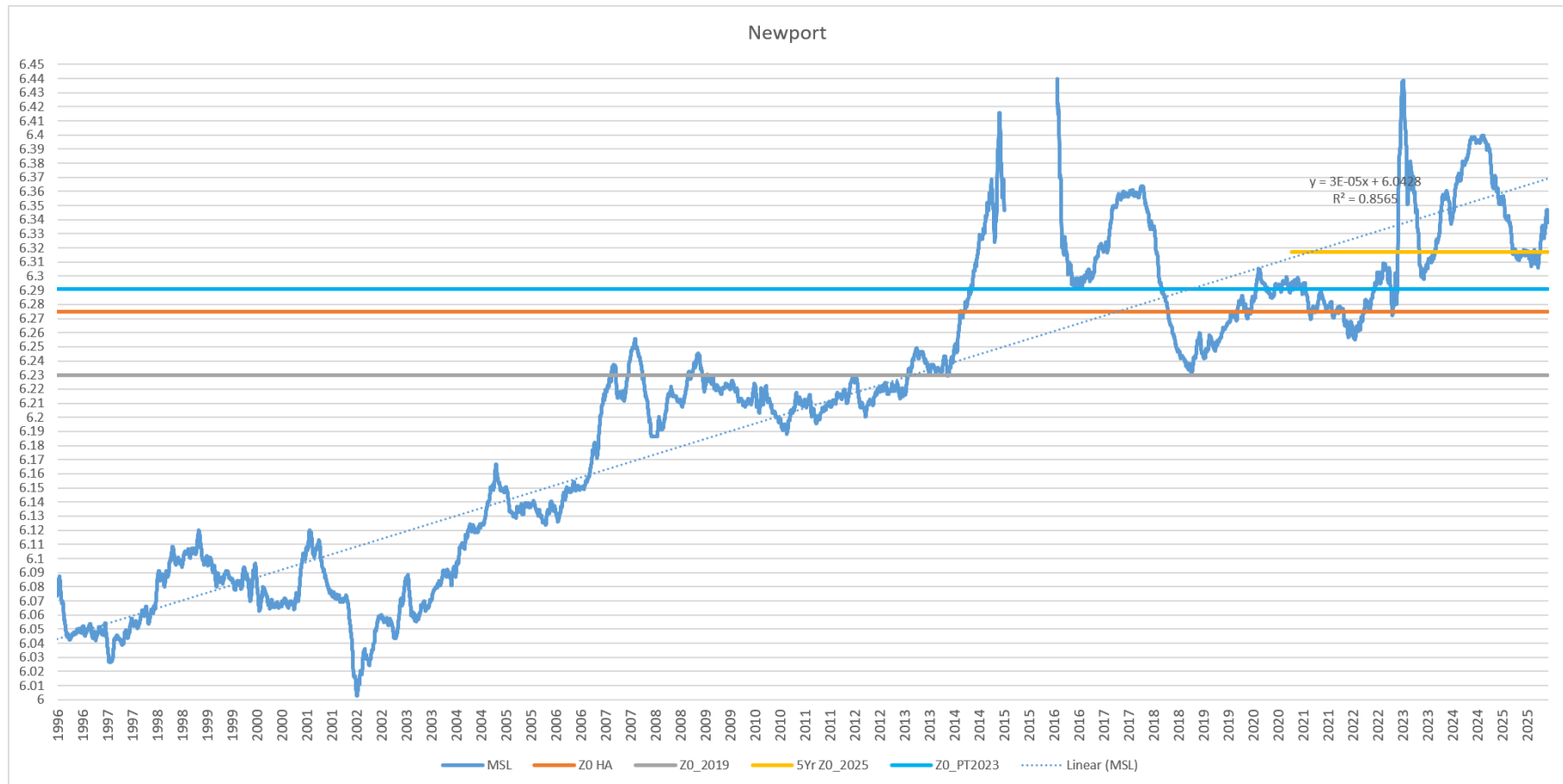


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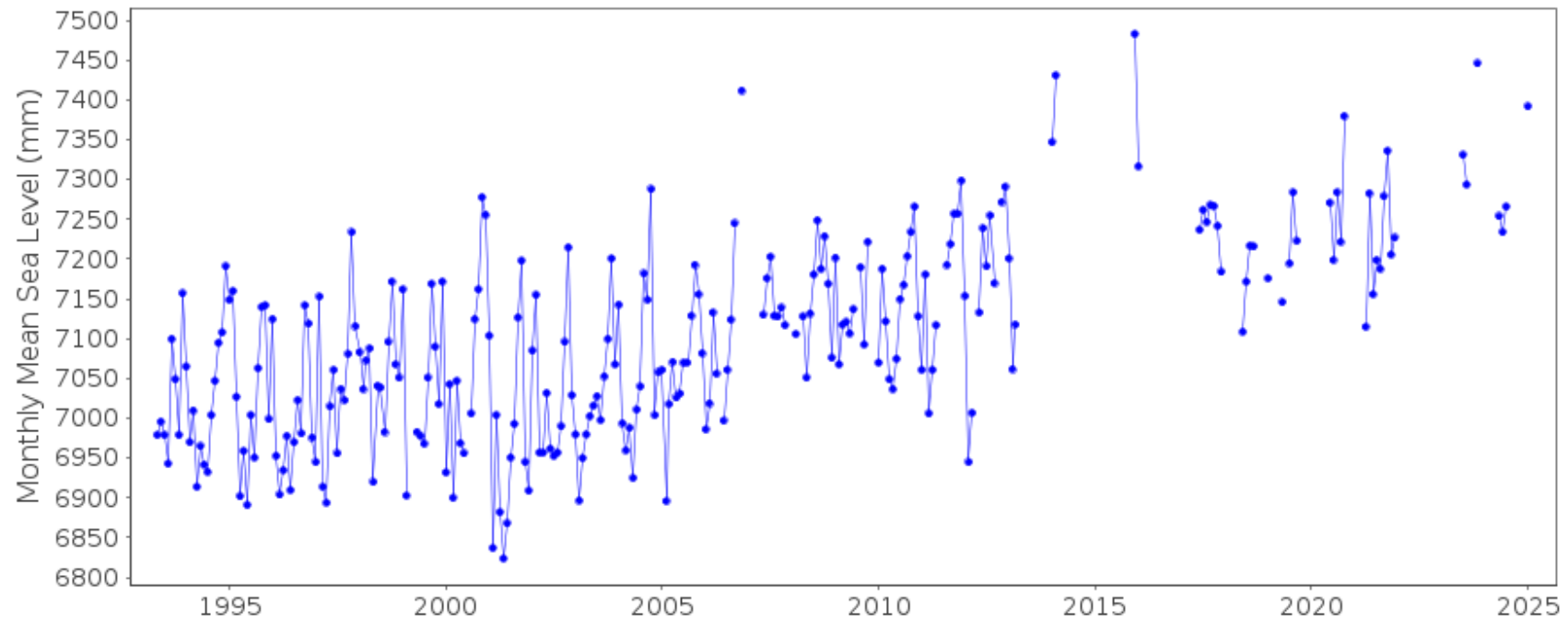


Newport



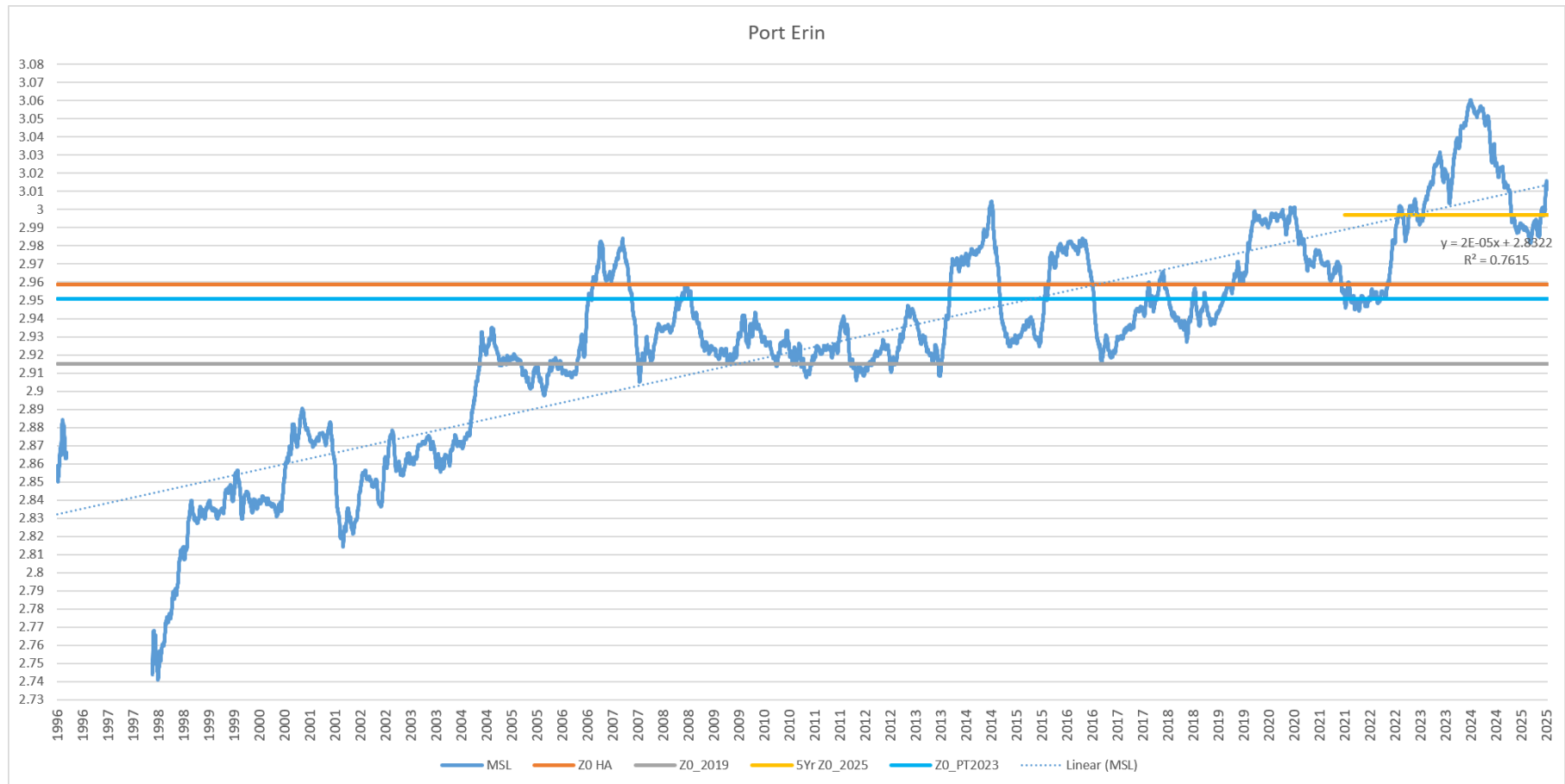


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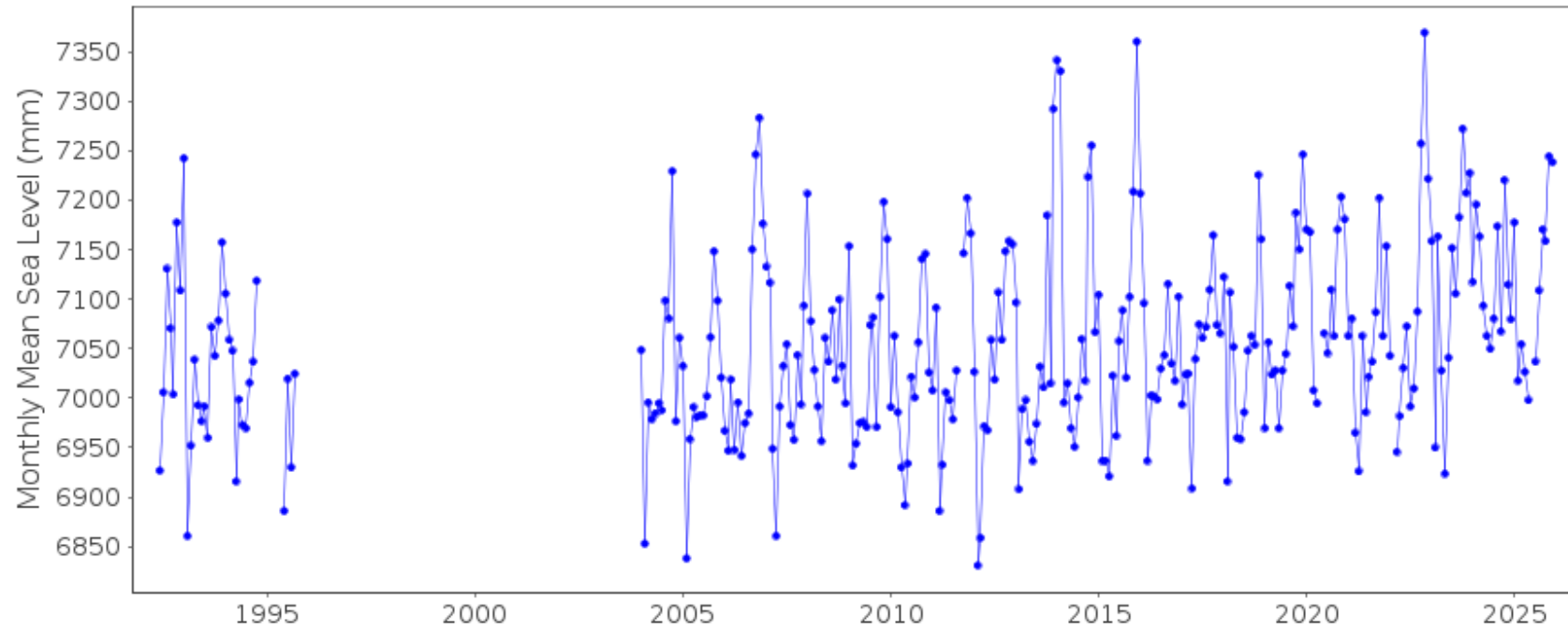


Port Erin, IOM



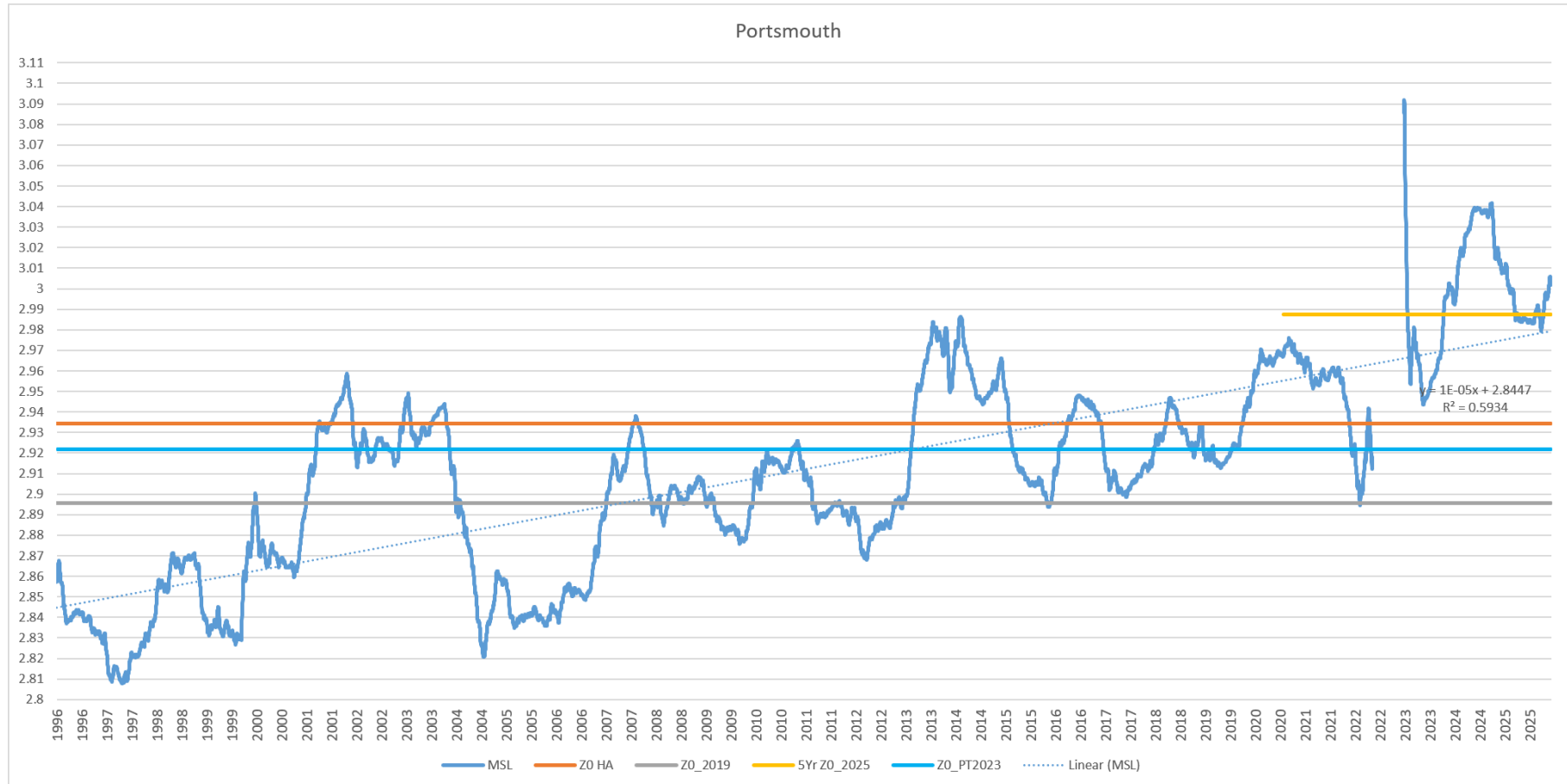


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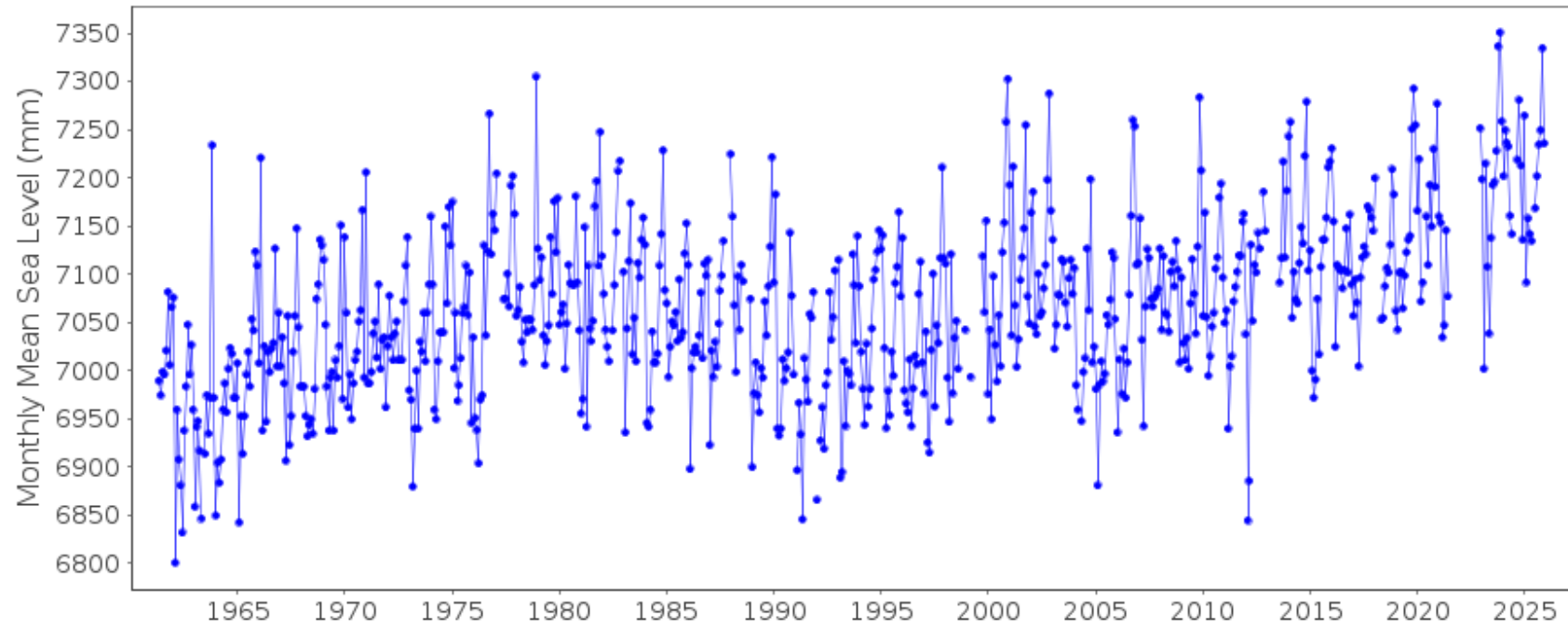


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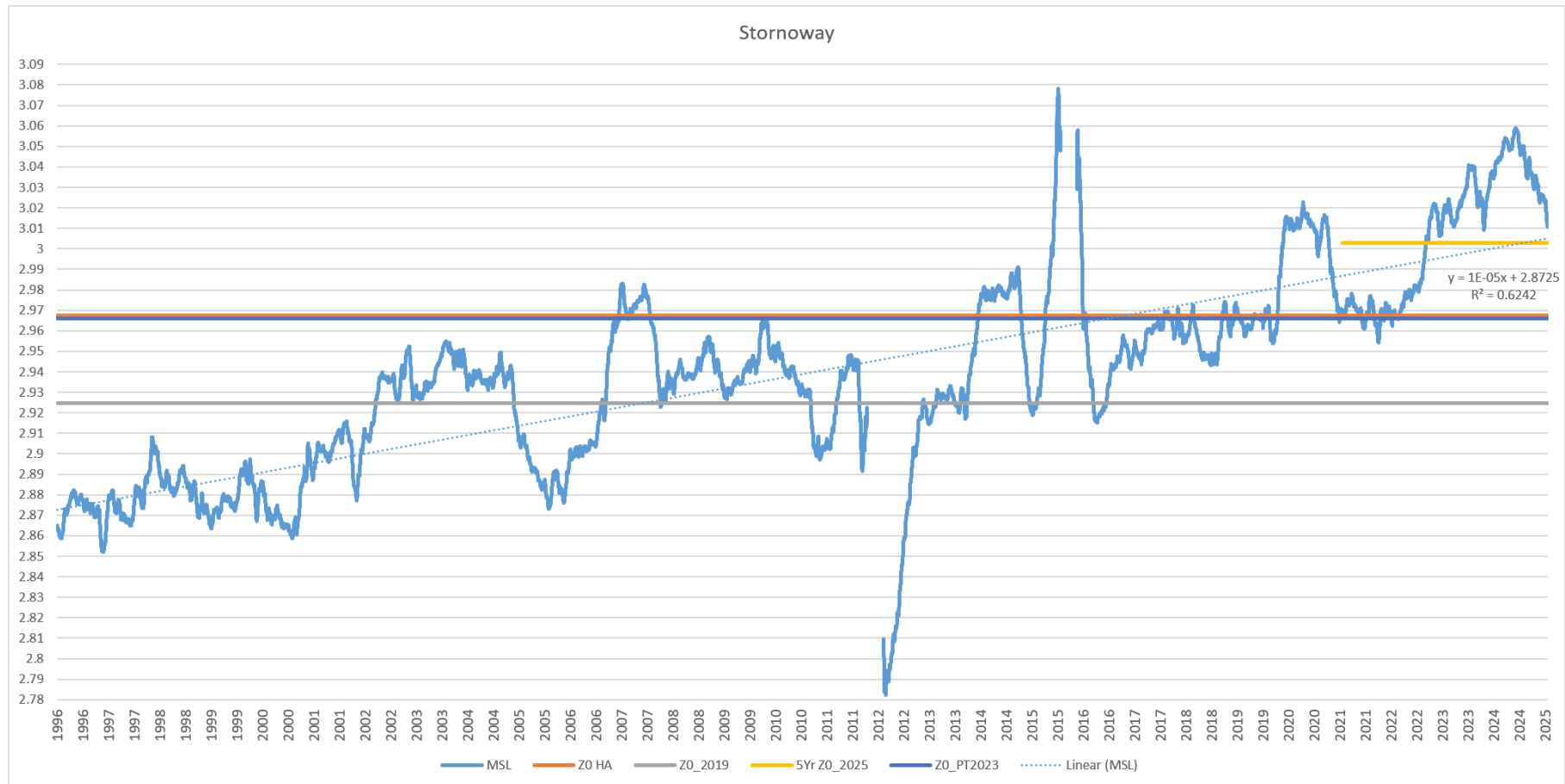


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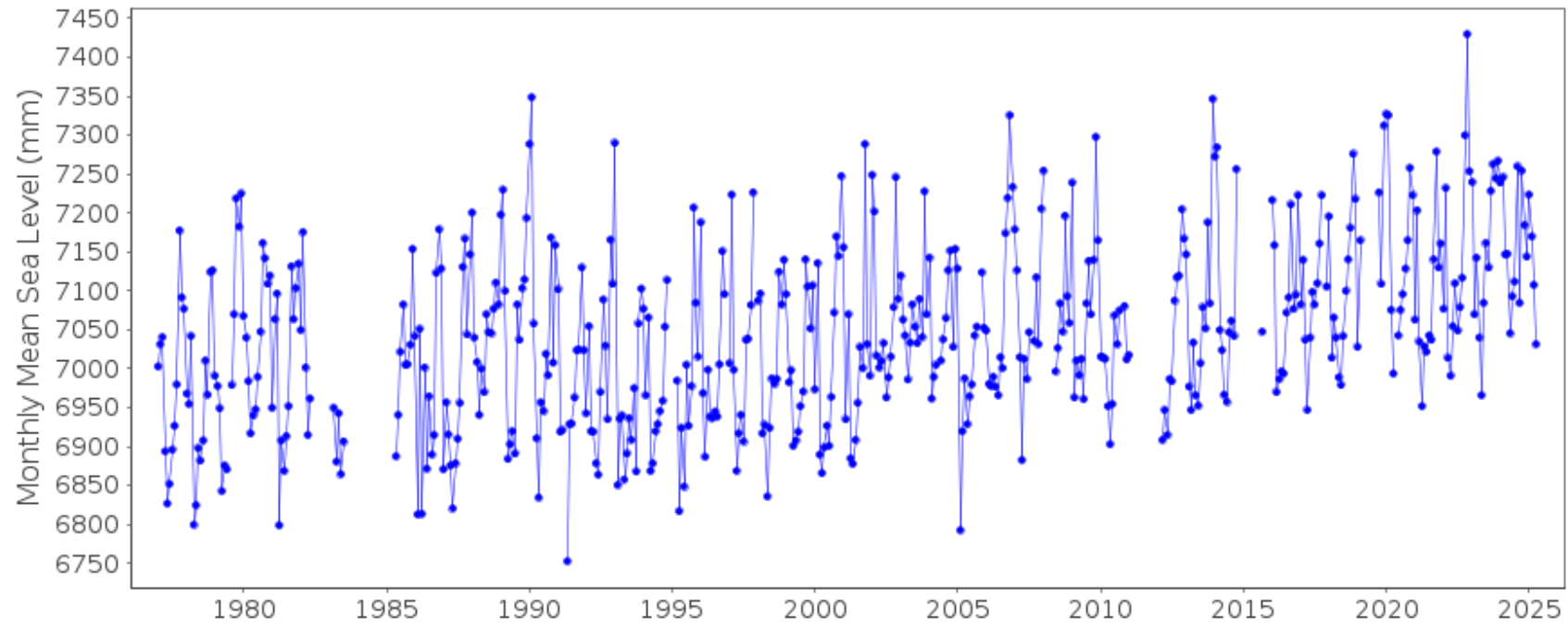


Stornoway



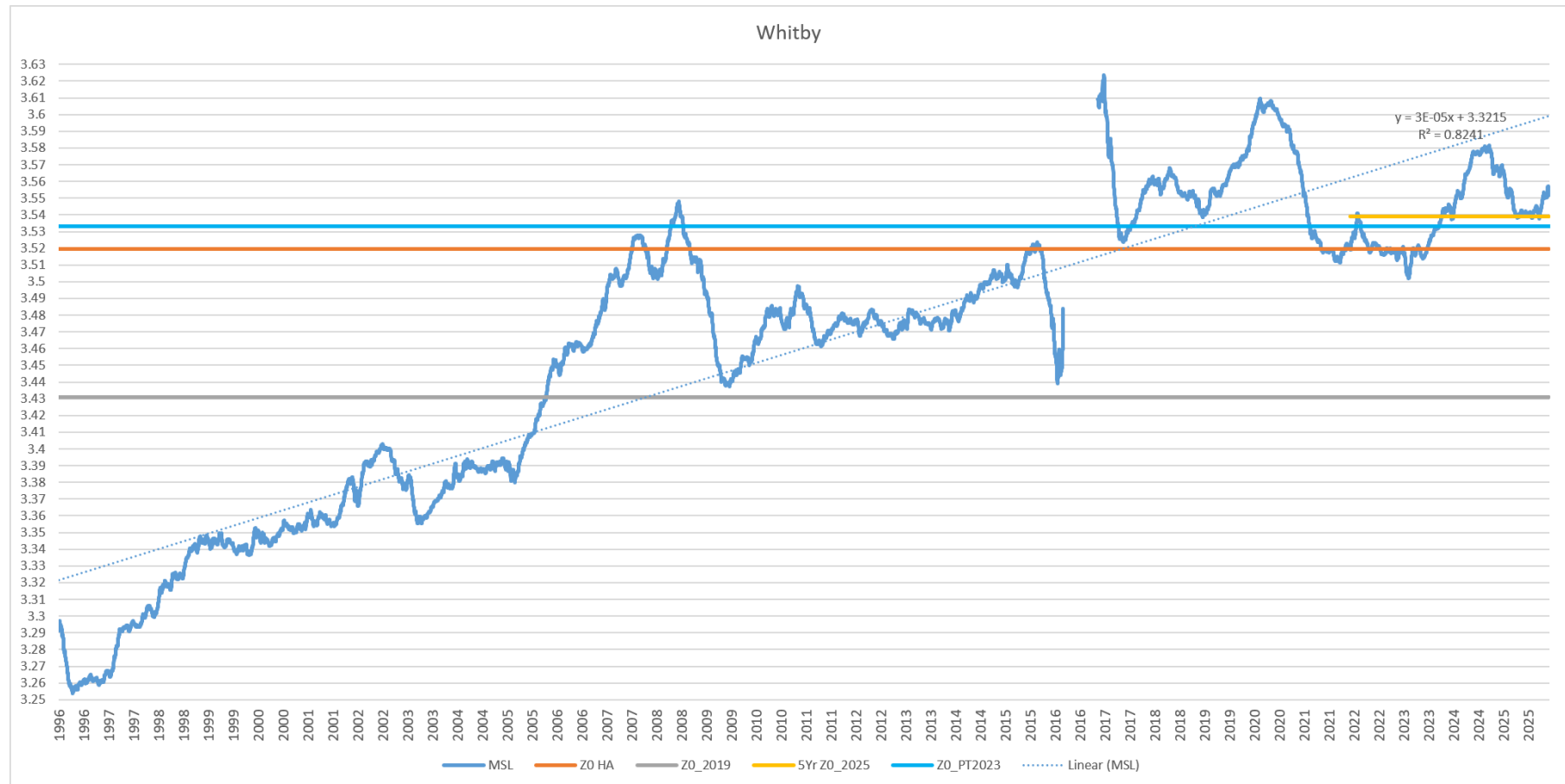


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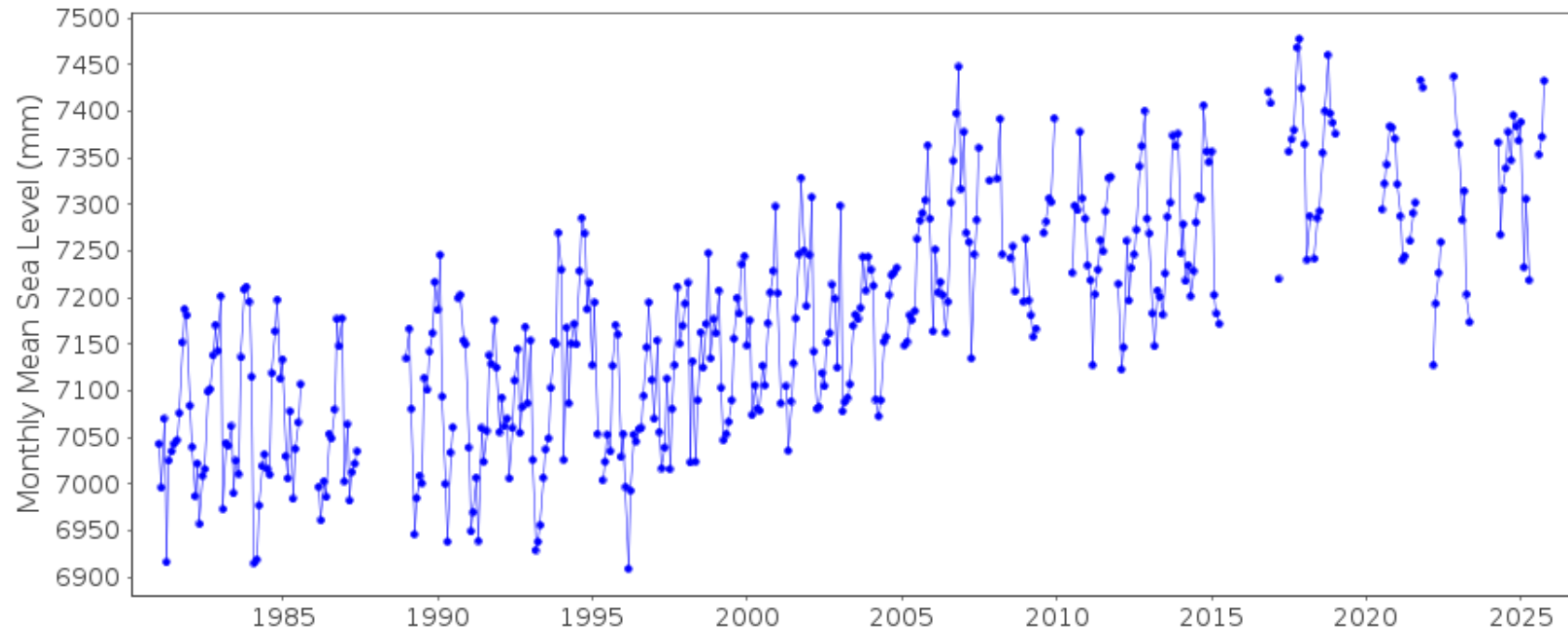


Whitby





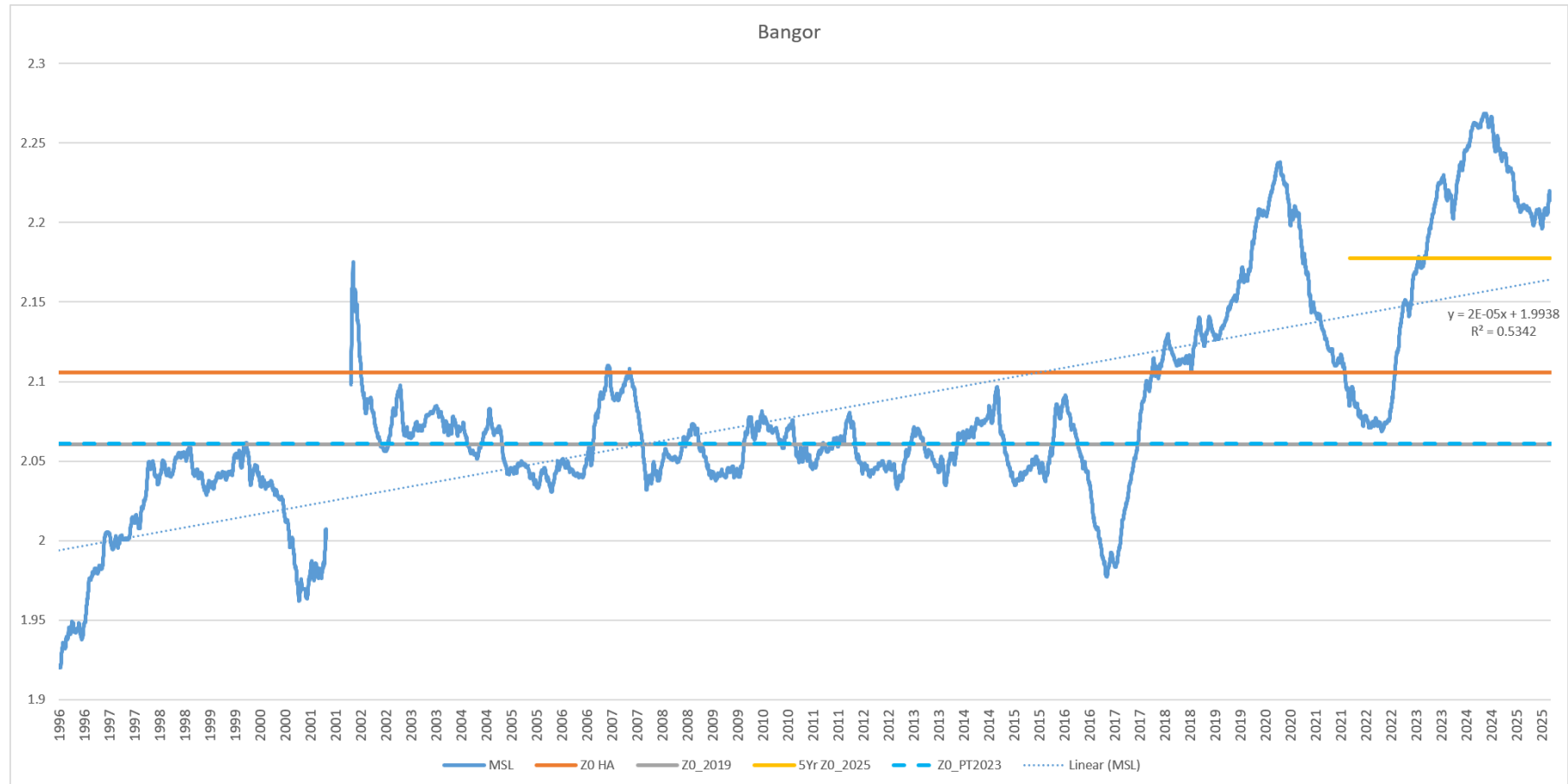
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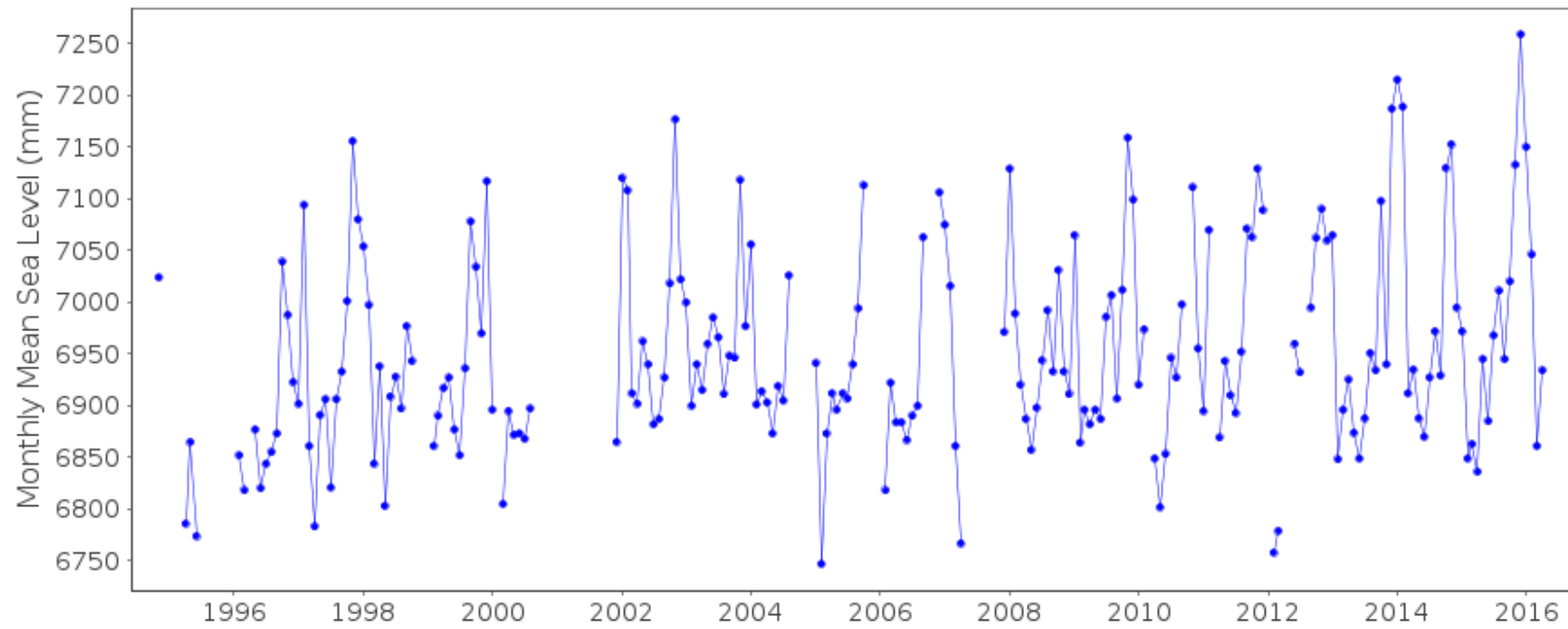
Z₀ ROLLING MEAN PLOTS: PORTS WITH ANALYSIS Z₀ >4CM DIFFERENCE BETWEEN POLTIPS_2023 DATASET

Bangor



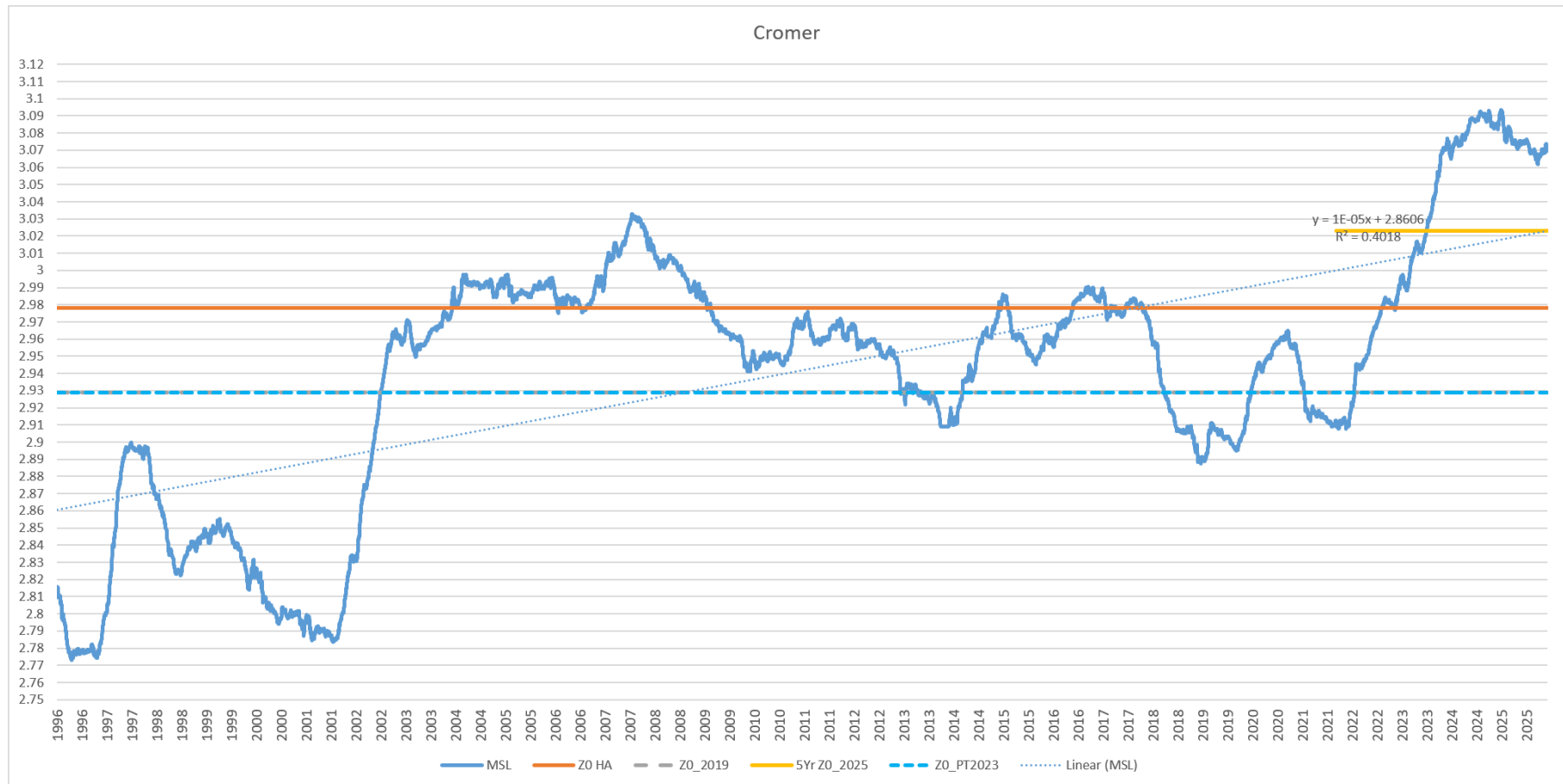


Bangor: <https://psmsl.org/data/obtaining/stations/1856.php>



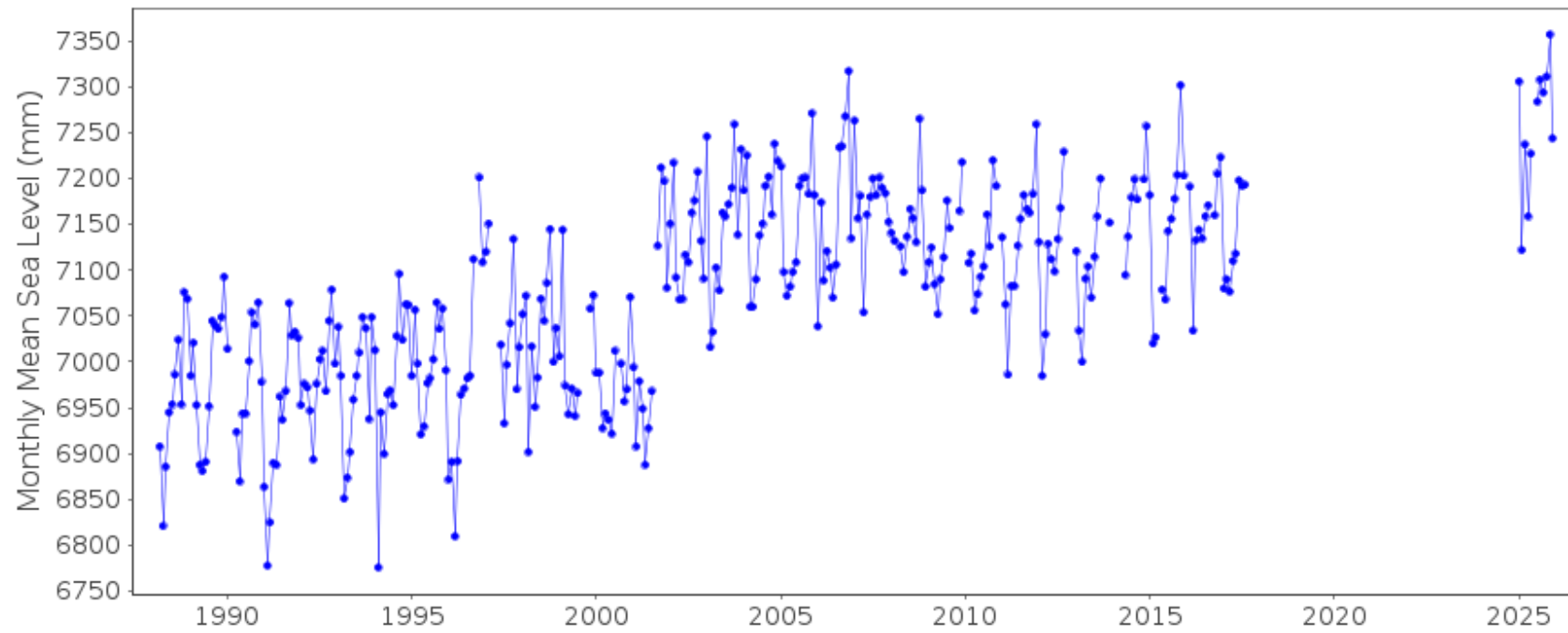


Cromer



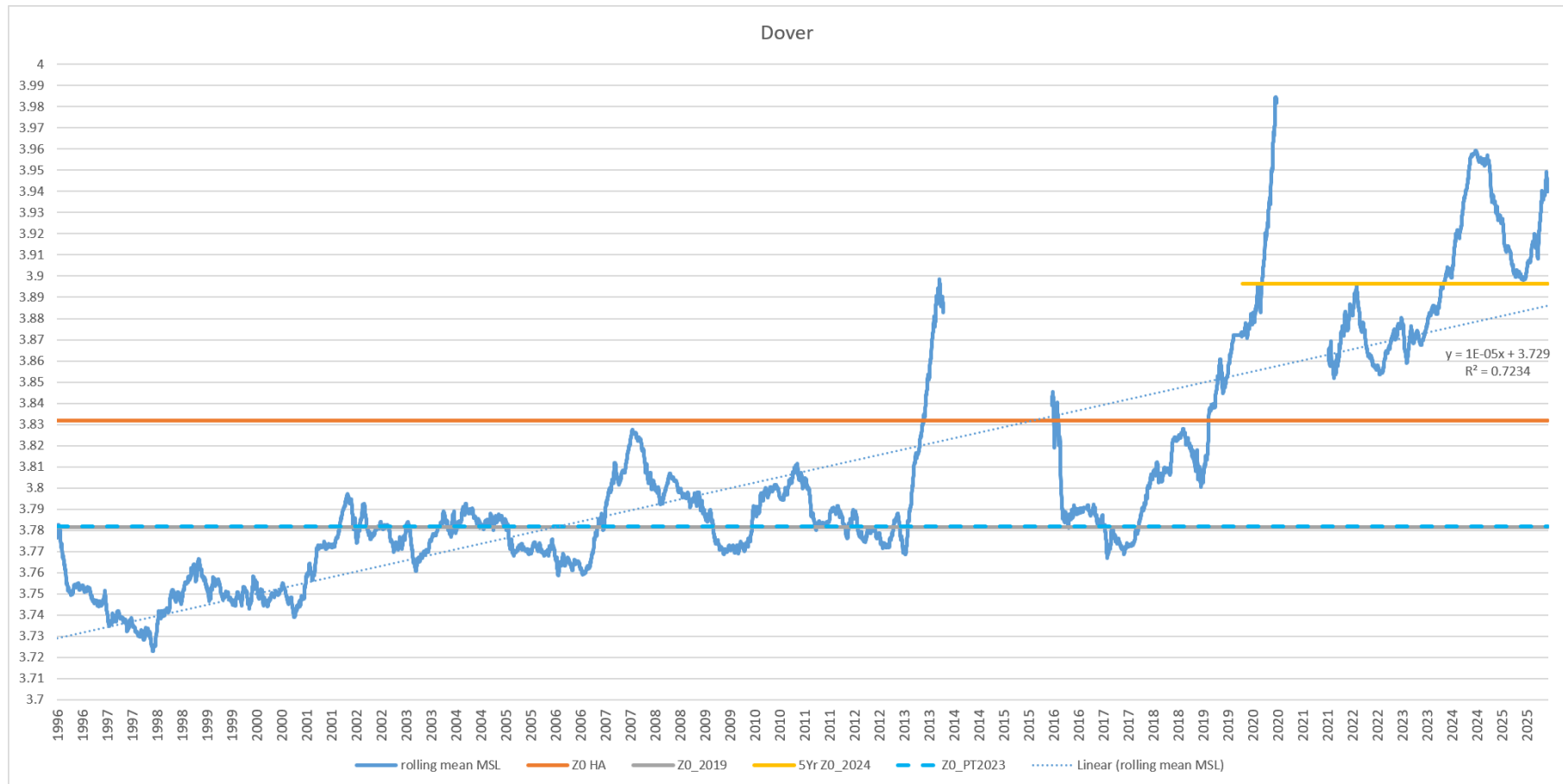


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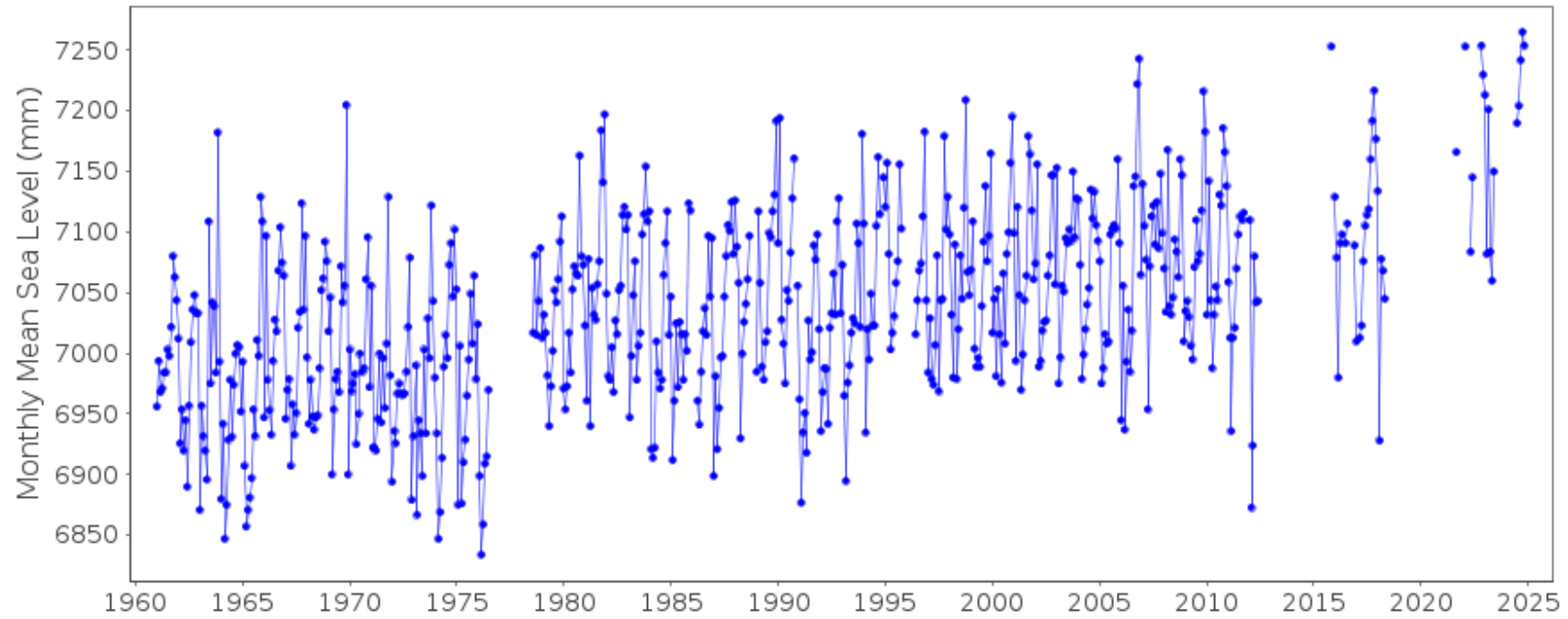


Dover



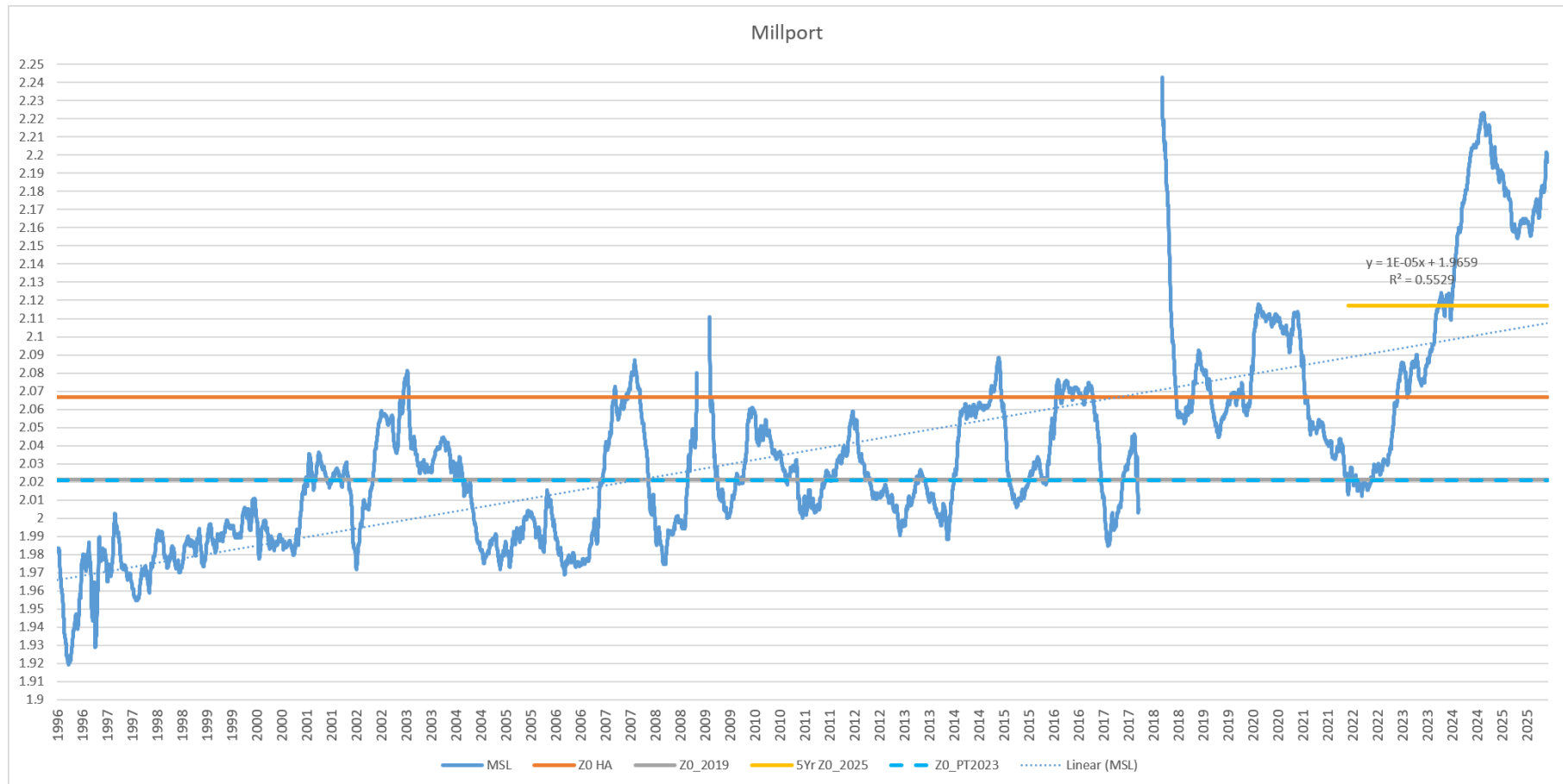


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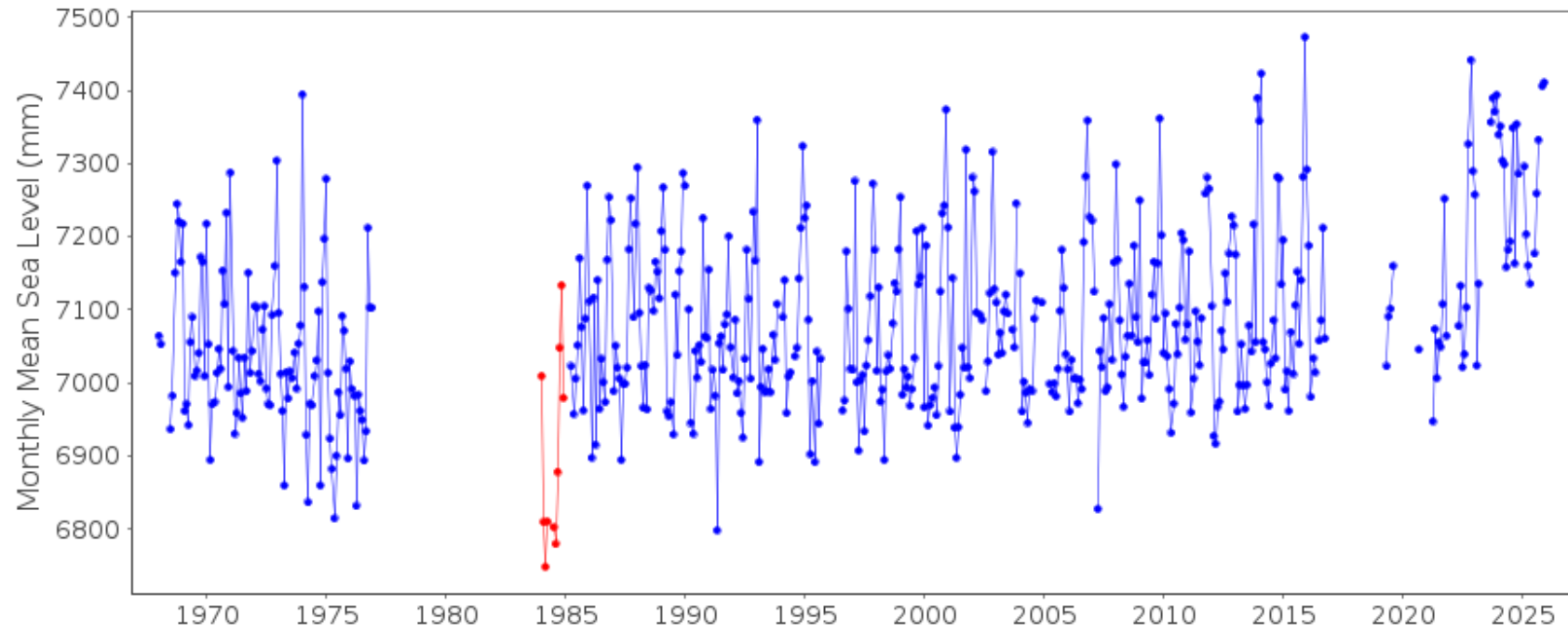


Millport



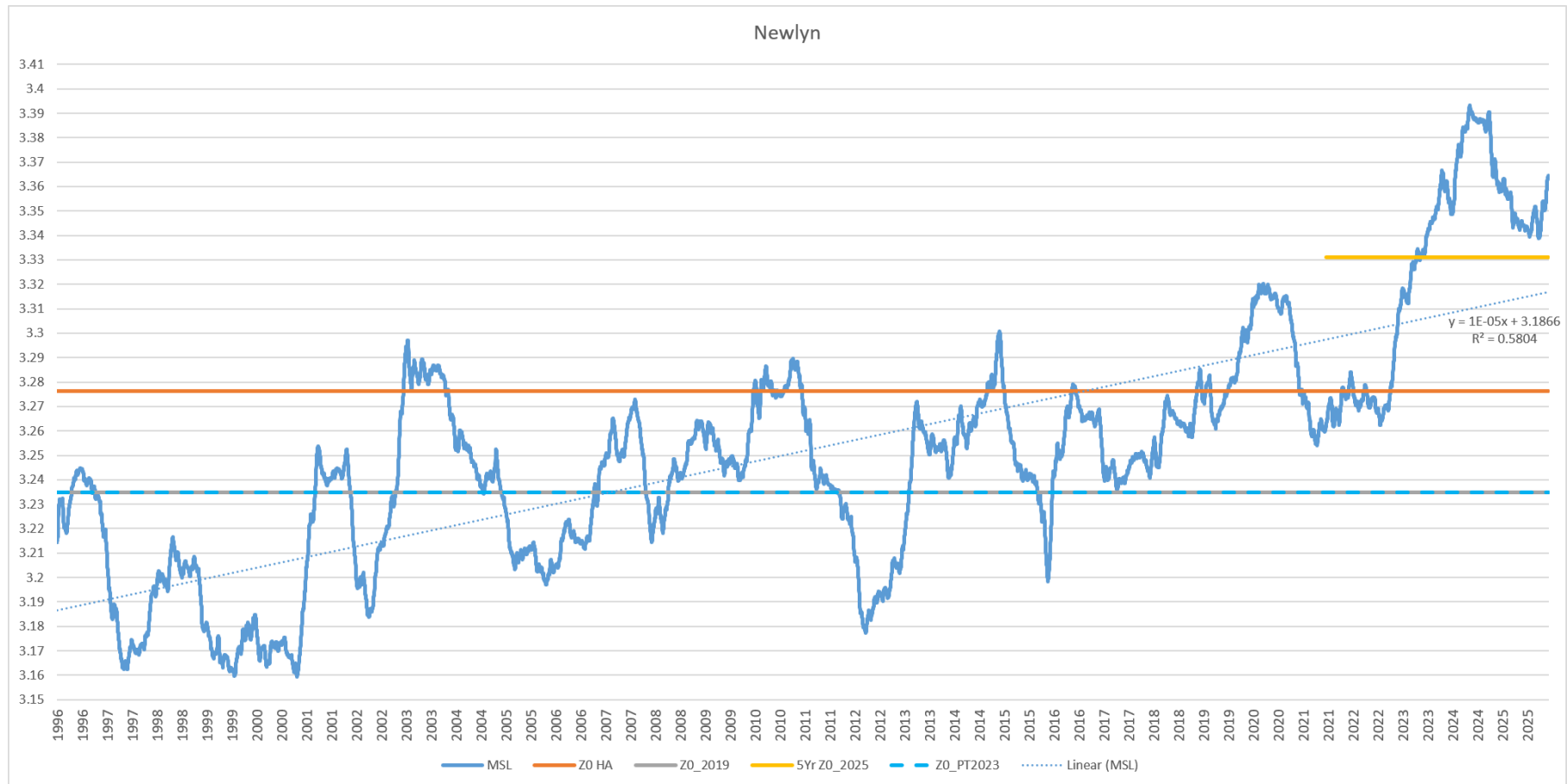


Millport: https://psmsl.org/data/obtaining/rlr.monthly.plots/755_high.png



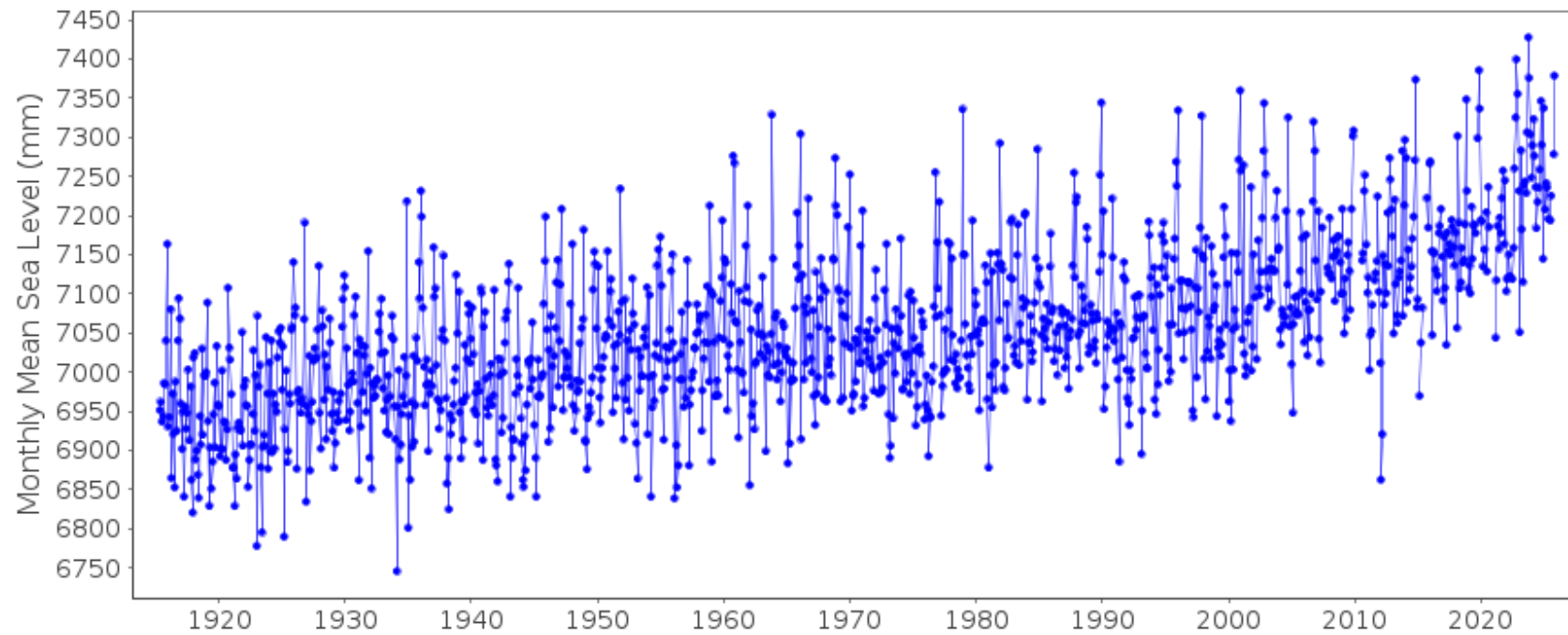


Newlyn



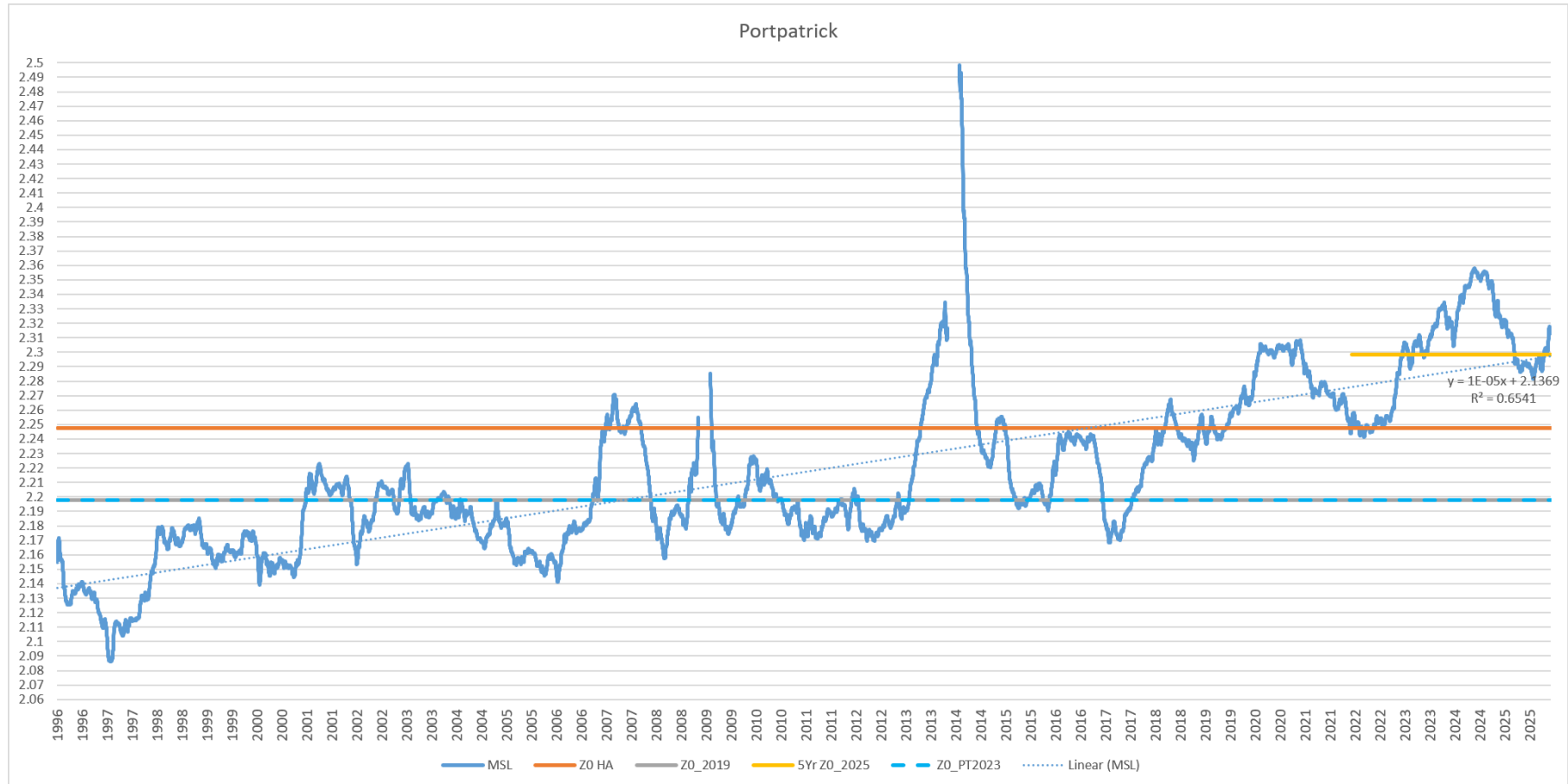


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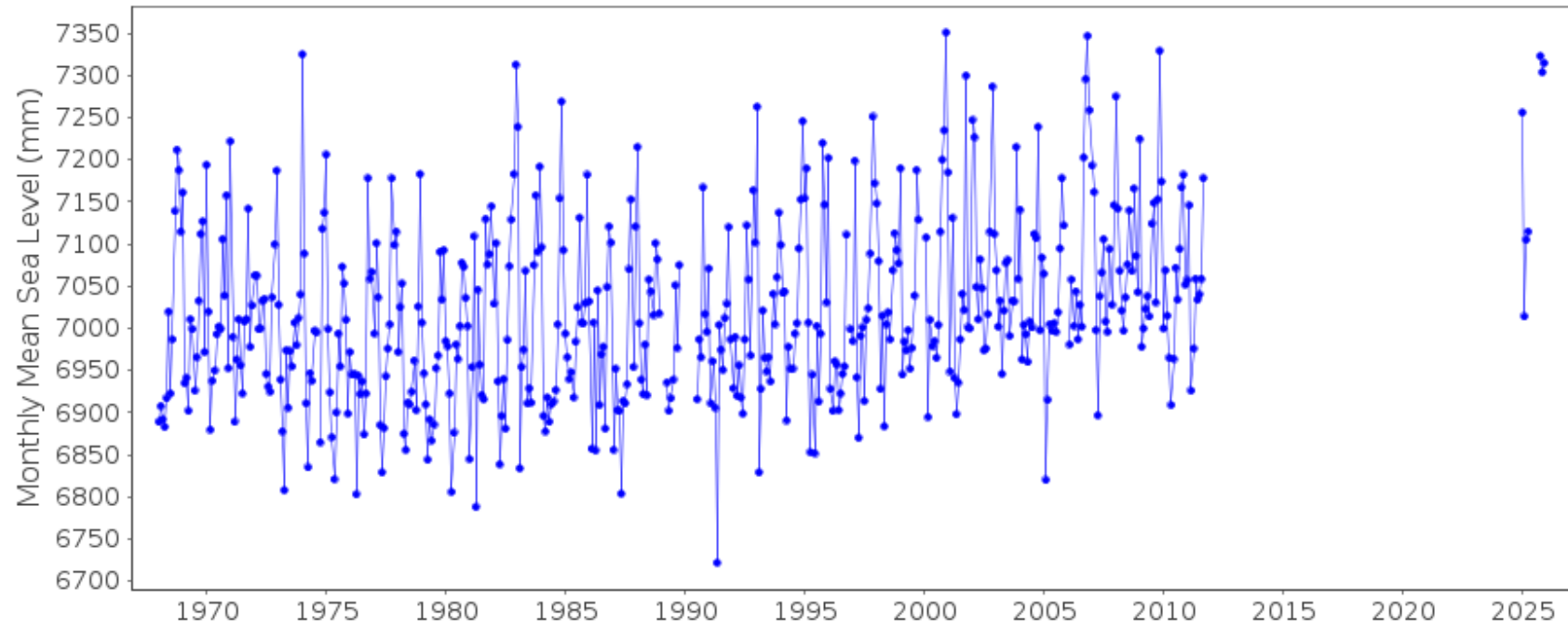


Portpatrick



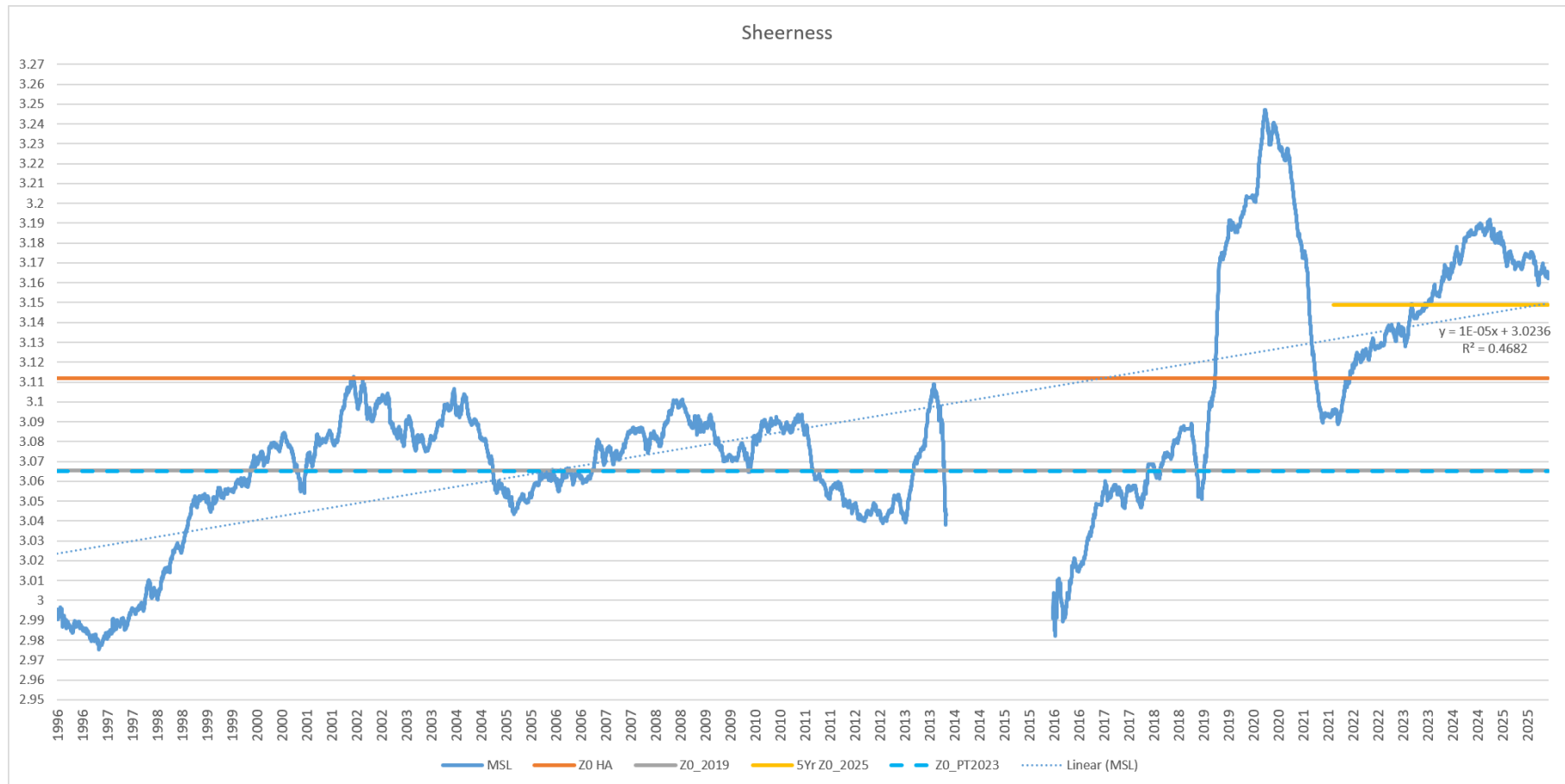


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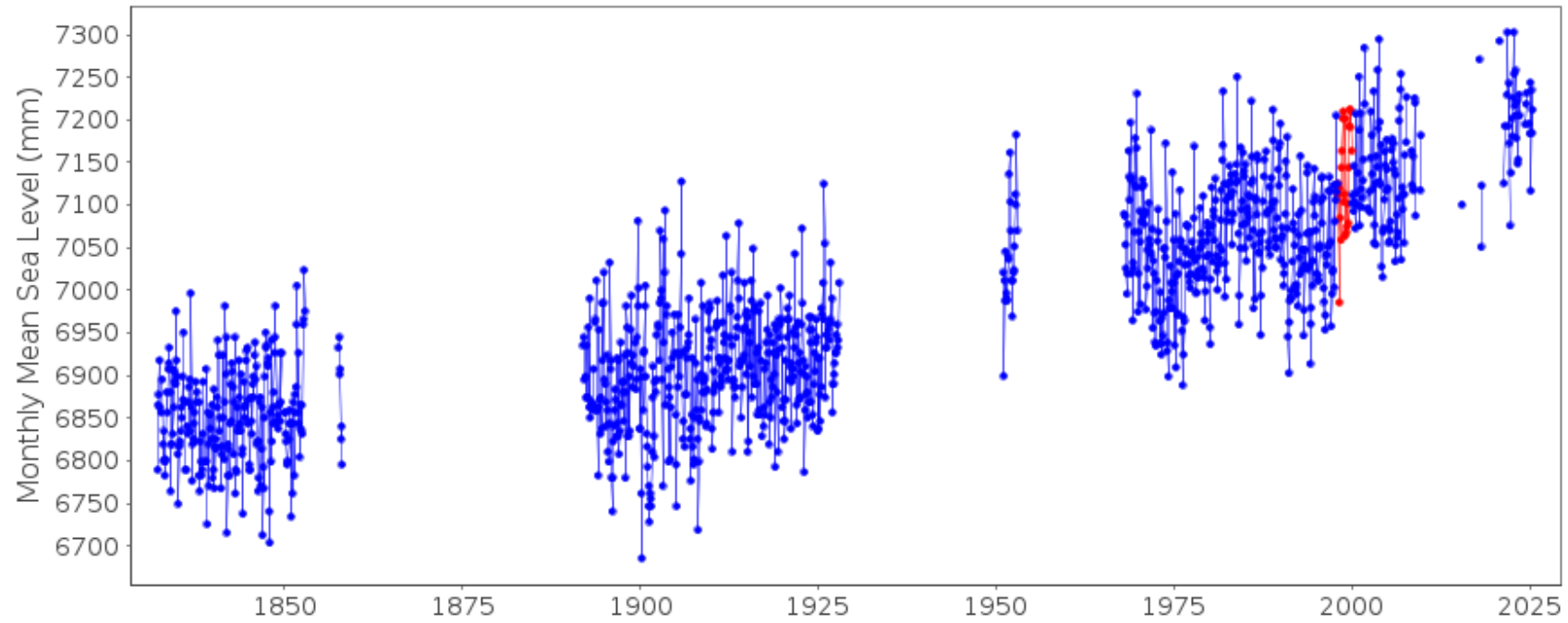


Sheerness





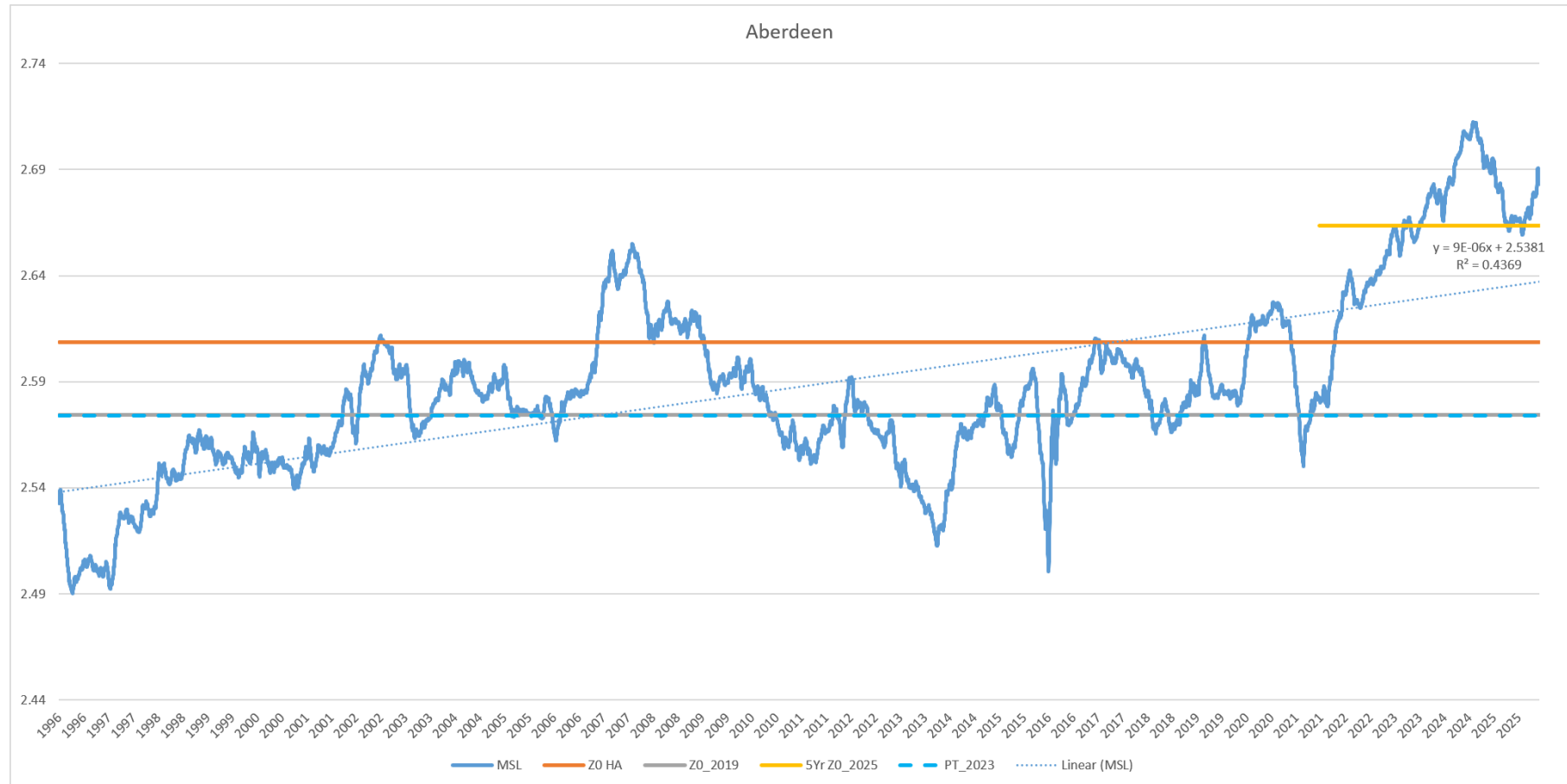
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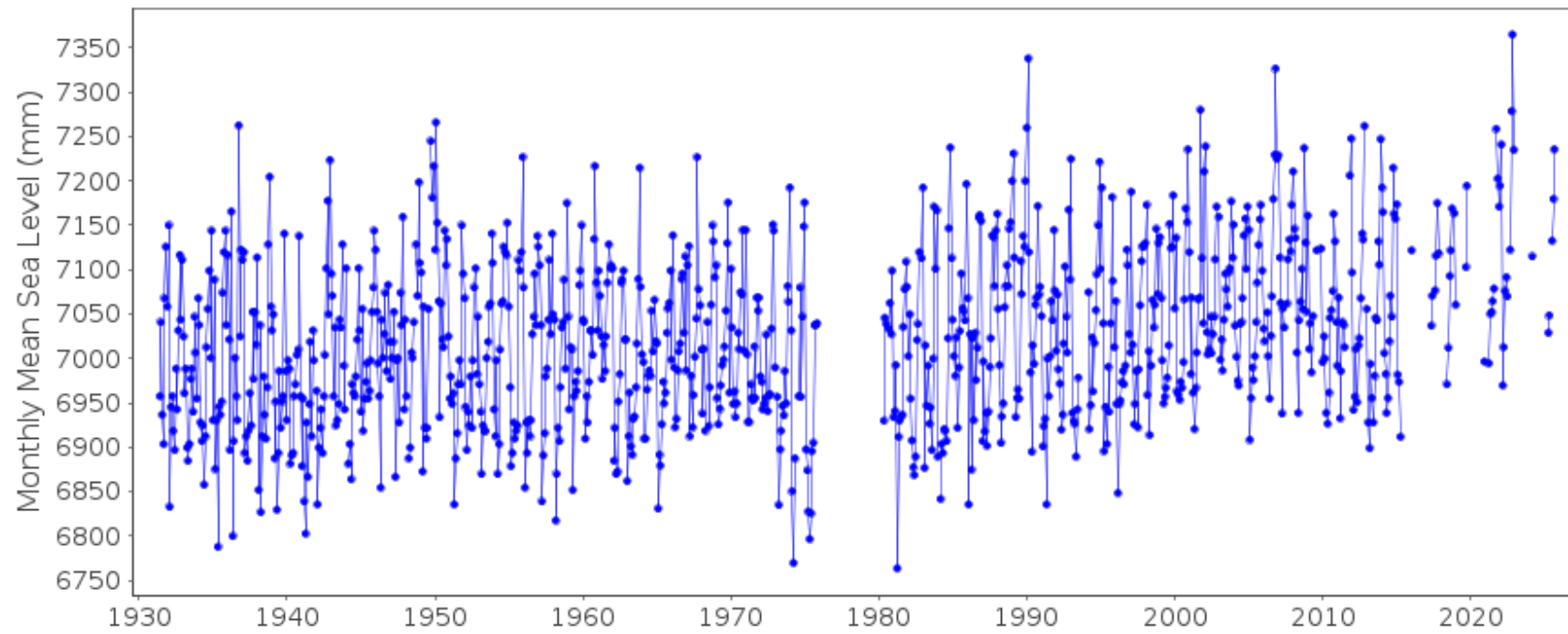
Z₀ ROLLING MEAN PLOTS: PORTS WITH ANALYSIS Z₀>3CM DIFFERENCE BETWEEN POLTIPS_2023 DATASET

Aberdeen



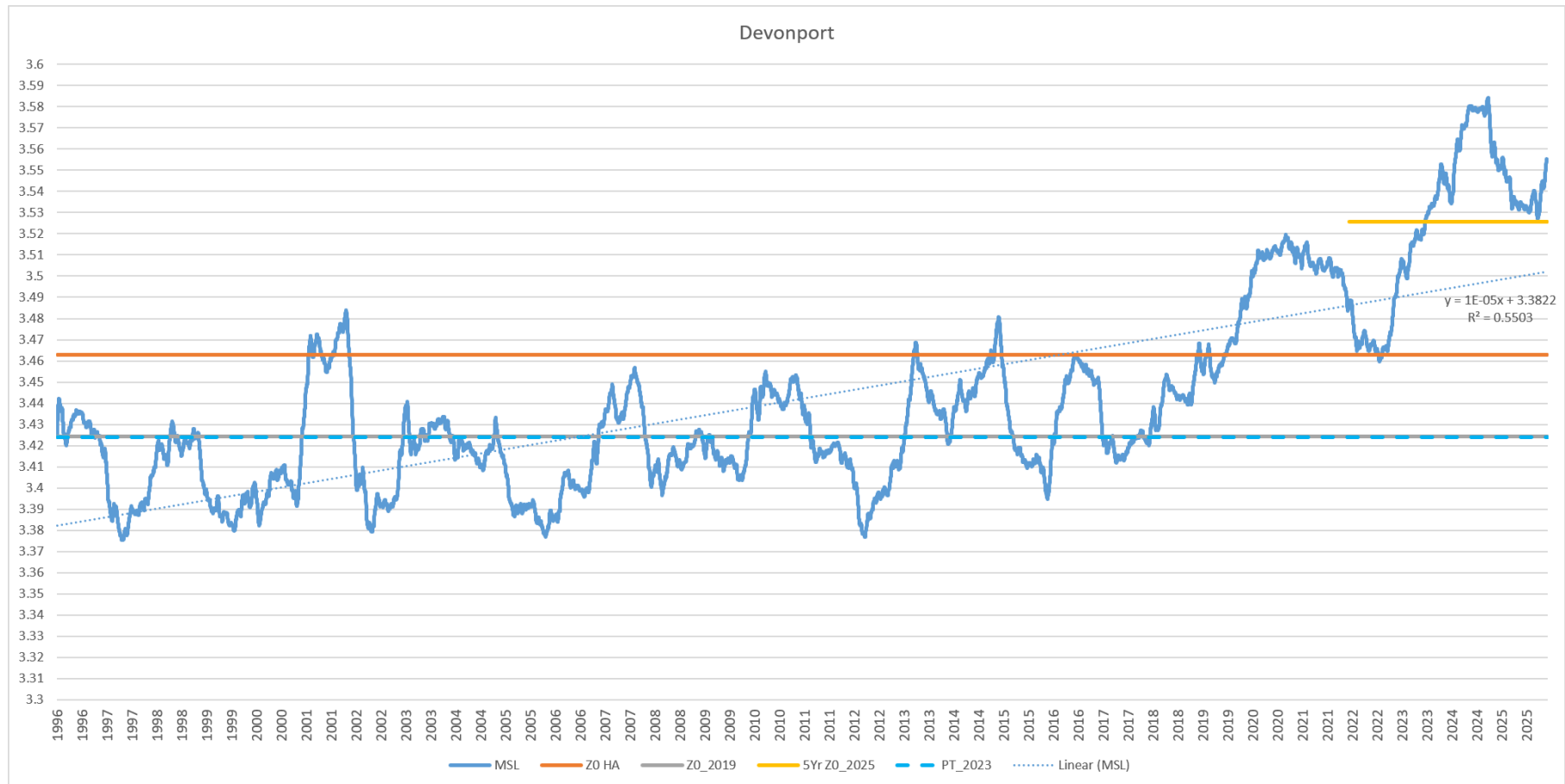


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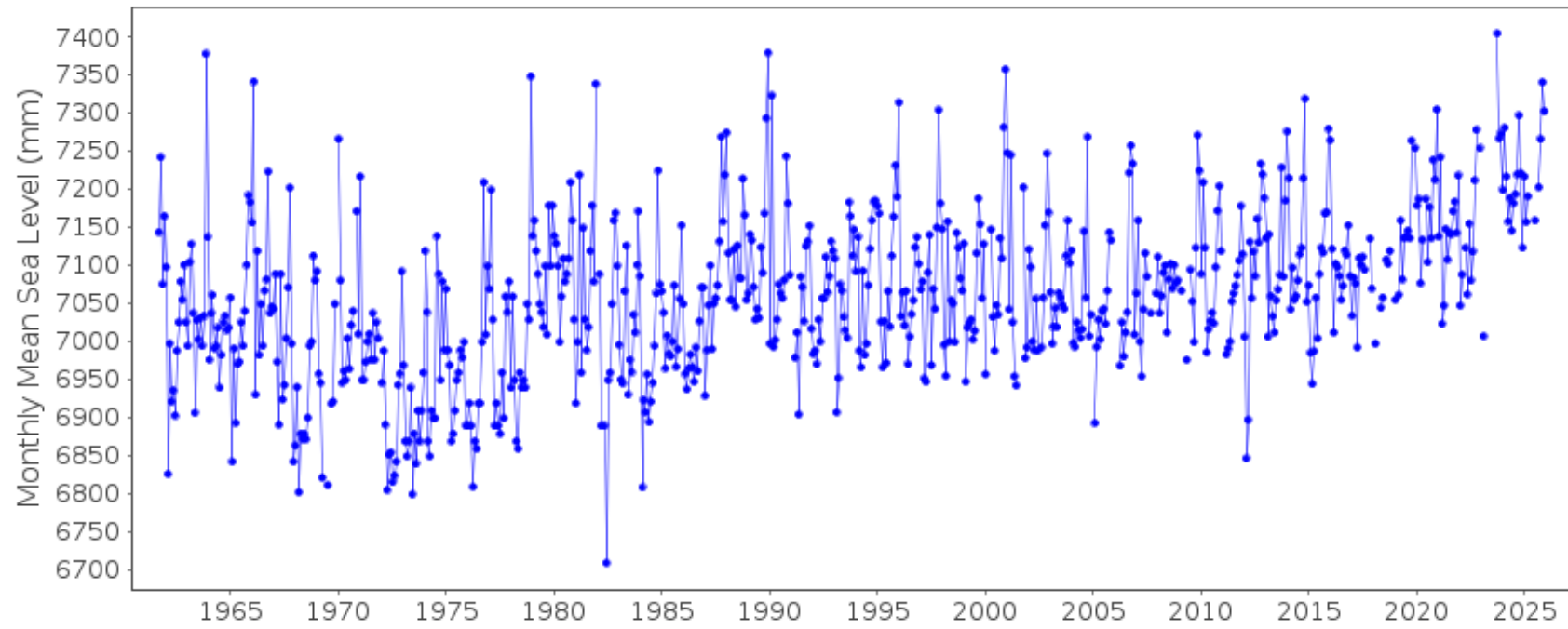


Devonport



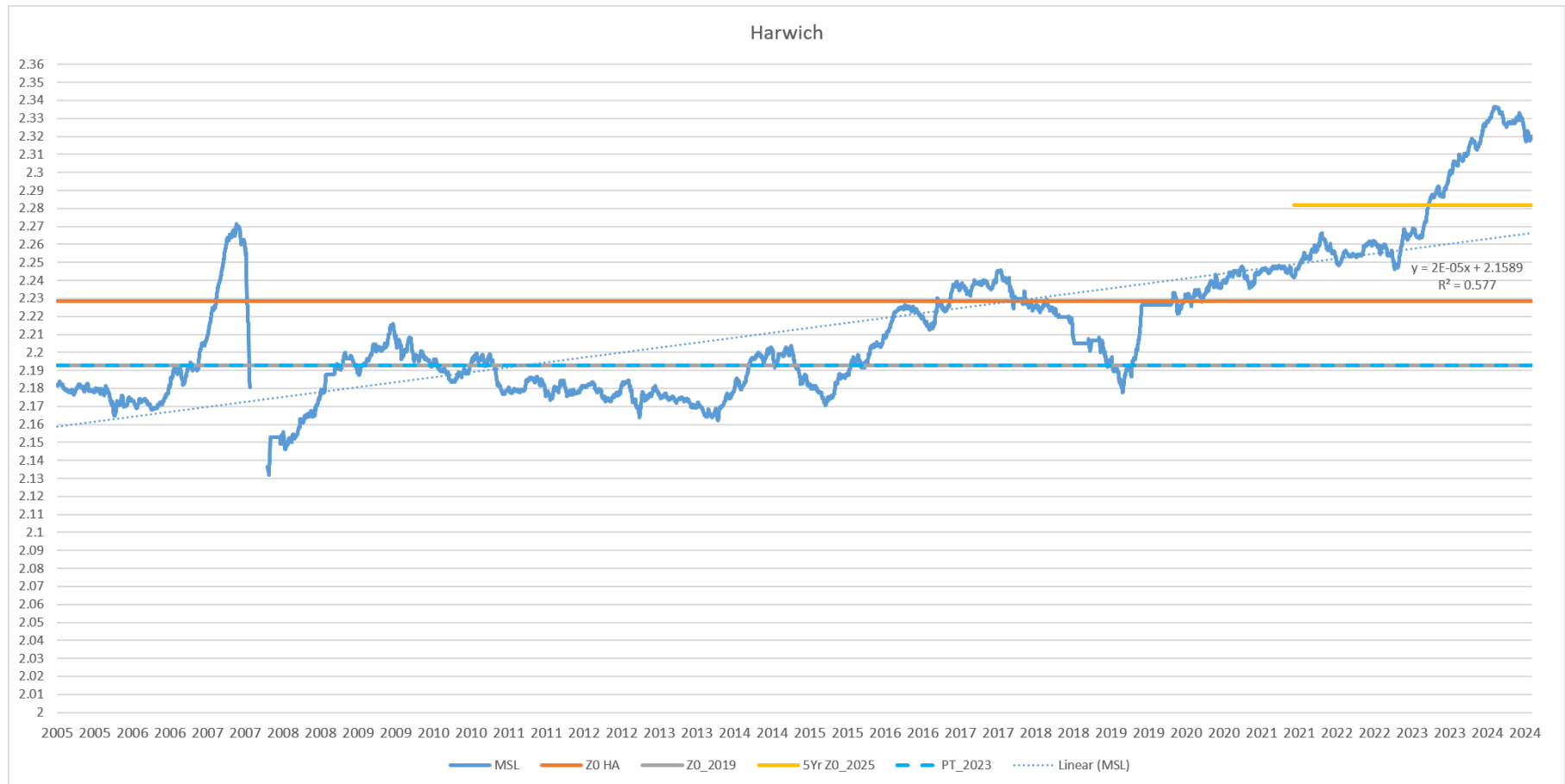


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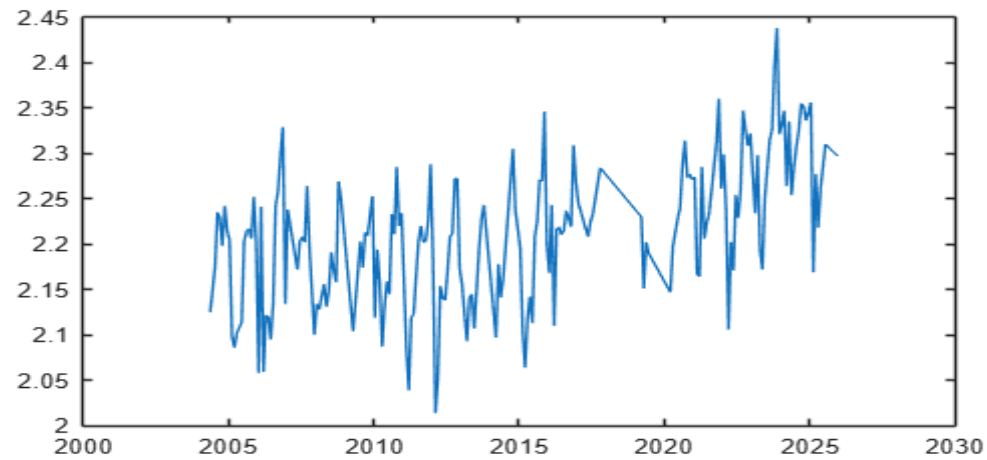
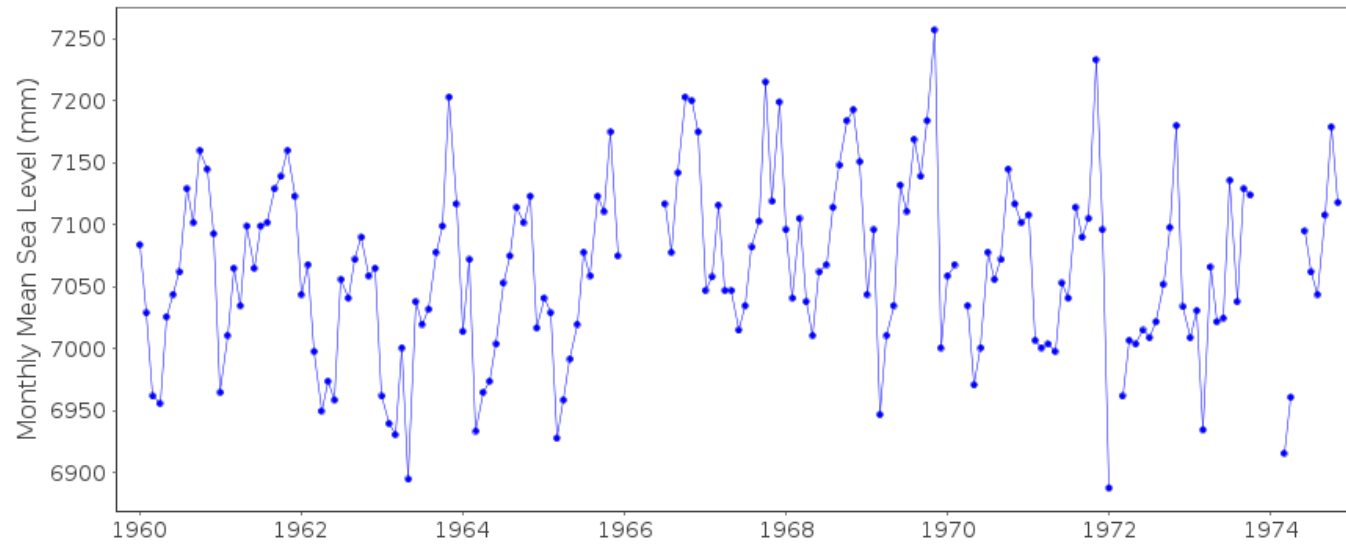


Harwich



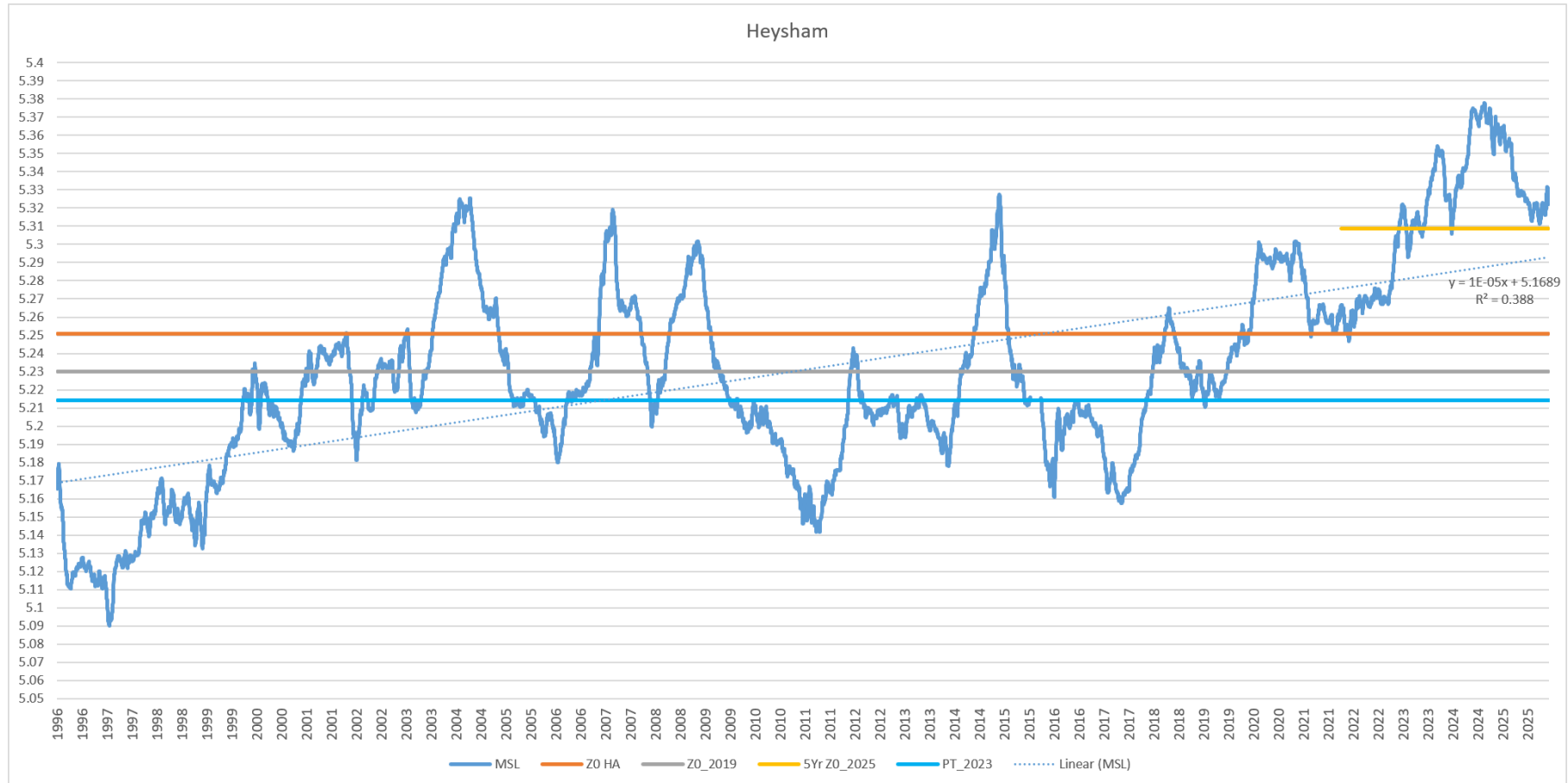


<https://psmsl.org/data/obtaining/stations/742.php> [together with additional draft version of the data from 2004 to 2026]



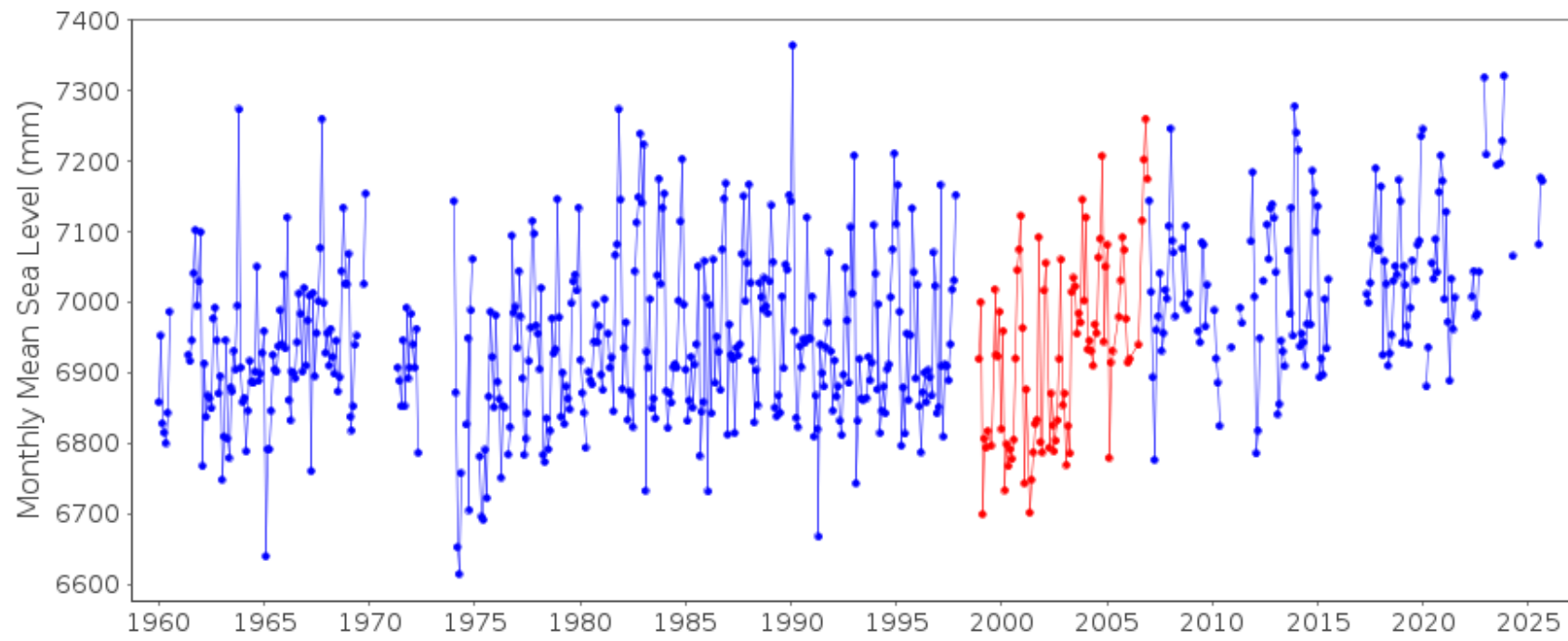


Heysham



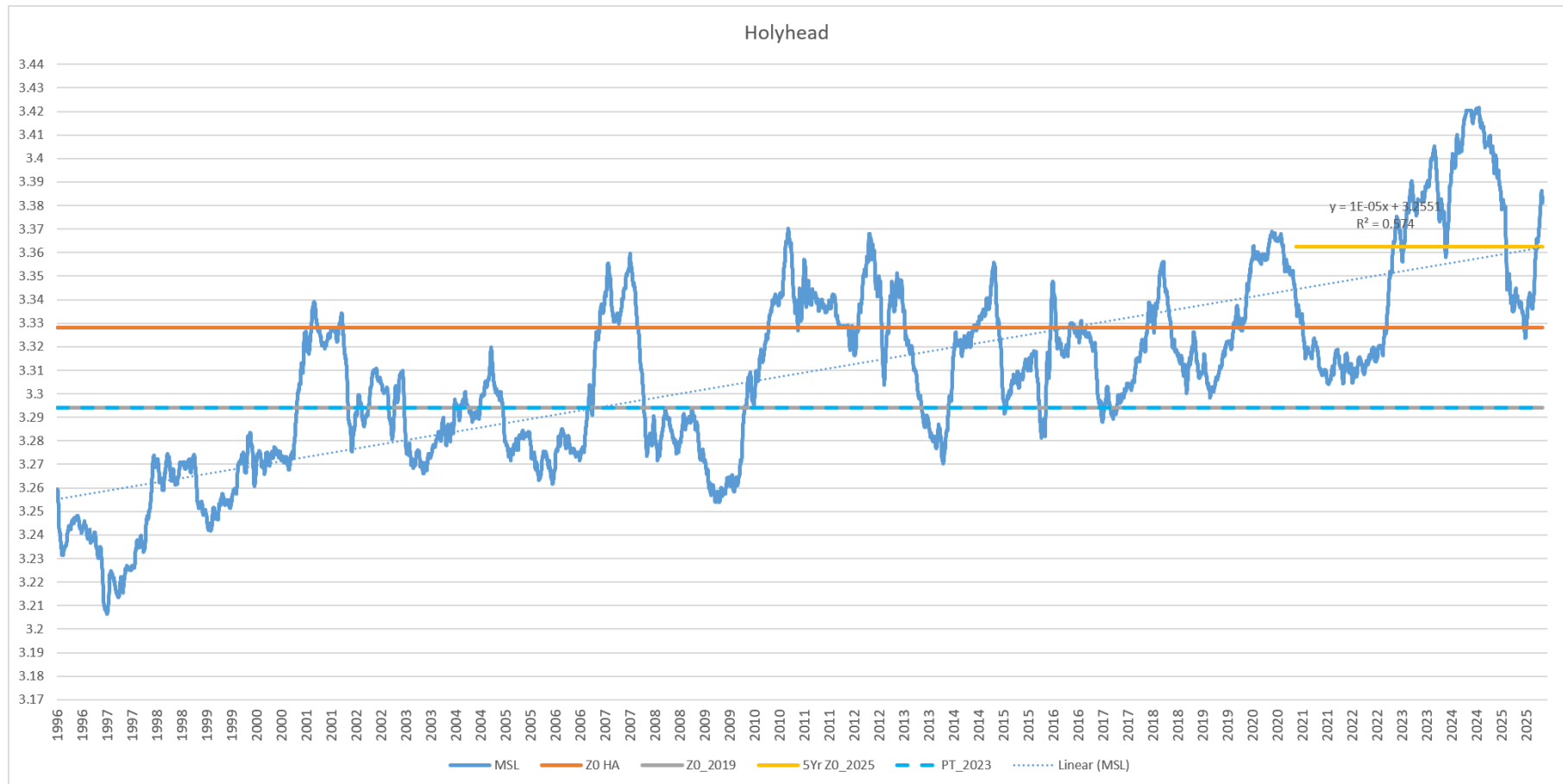


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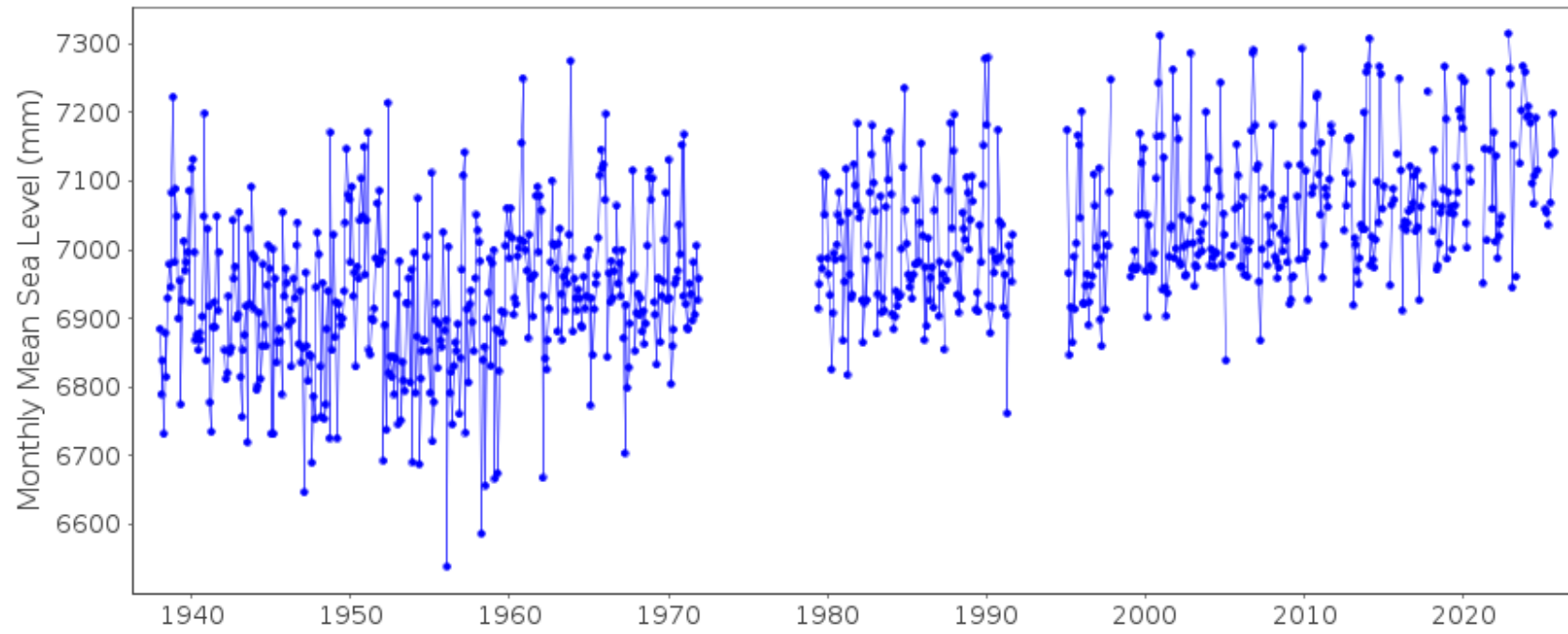


Holyhead



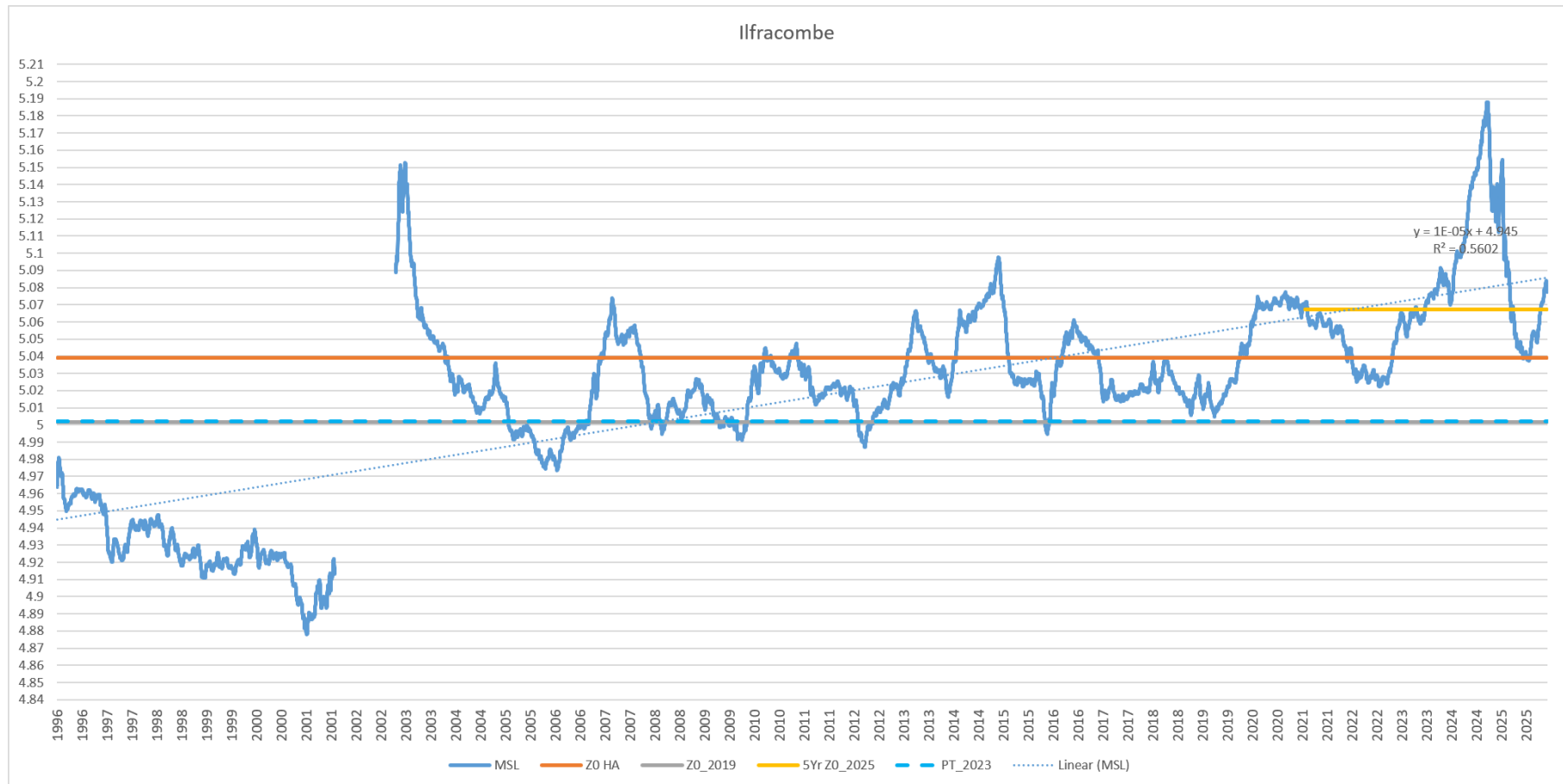


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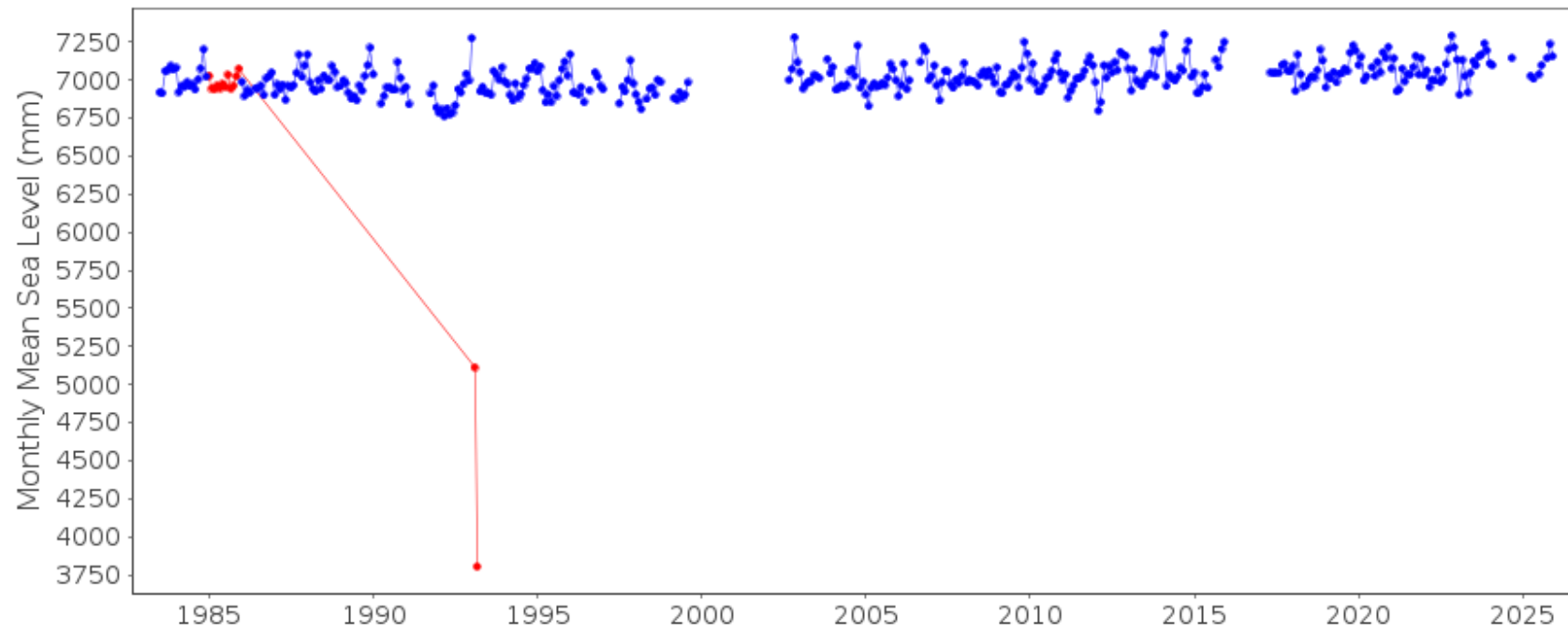


Ilfracombe



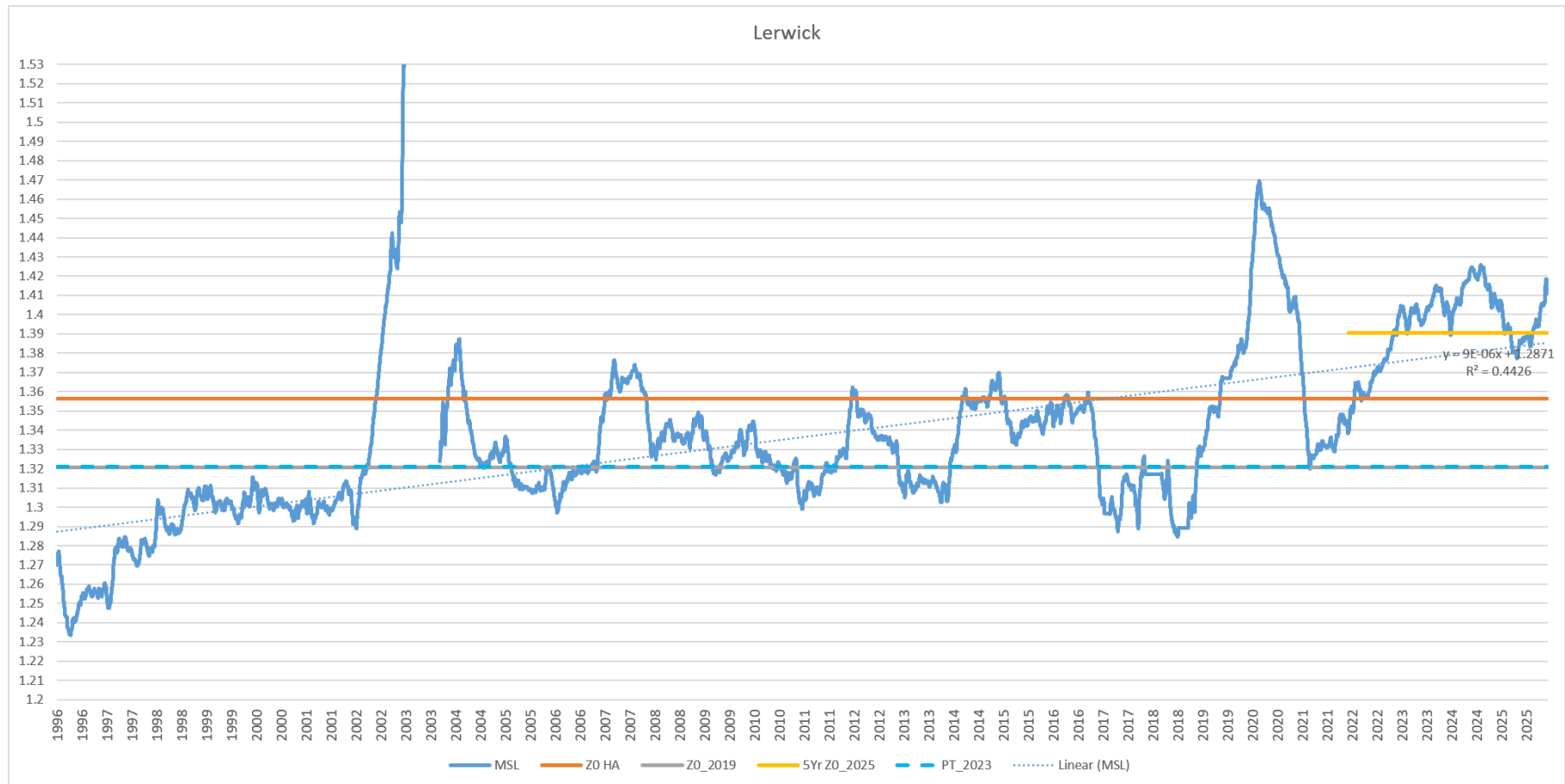


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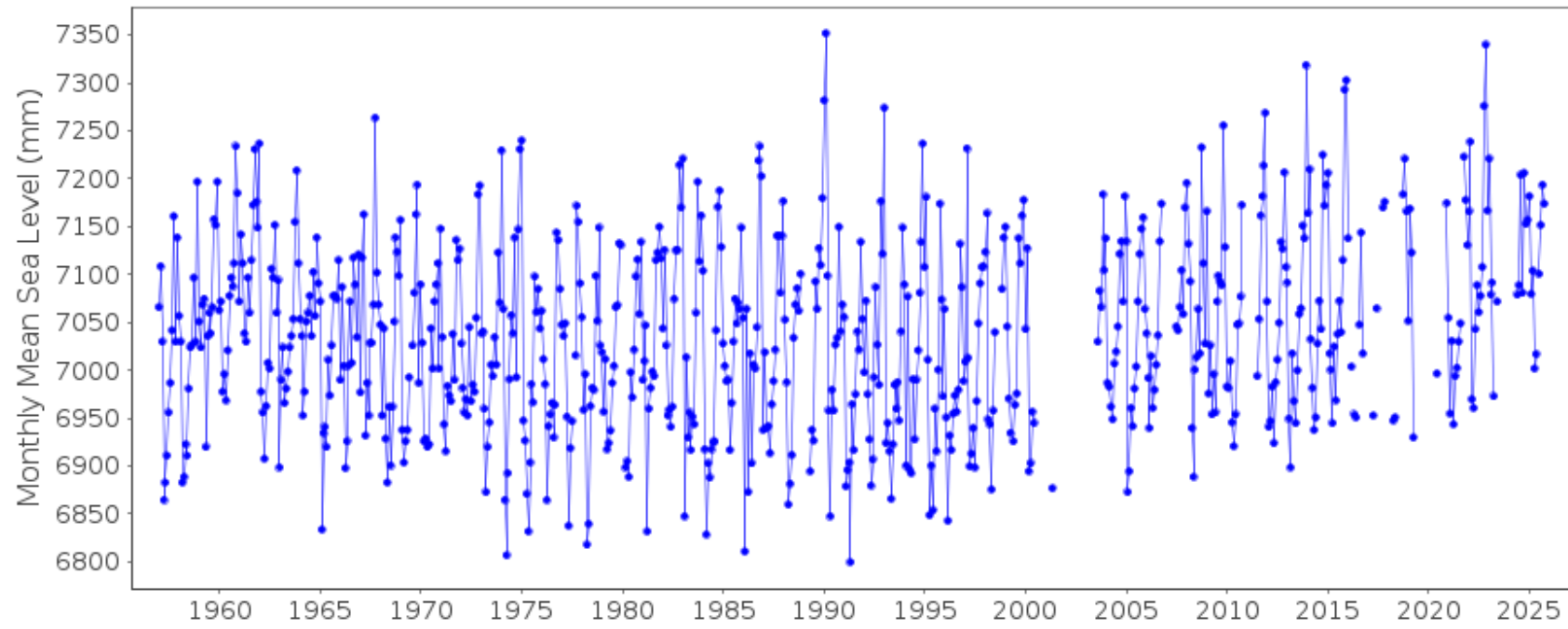


Lerwick



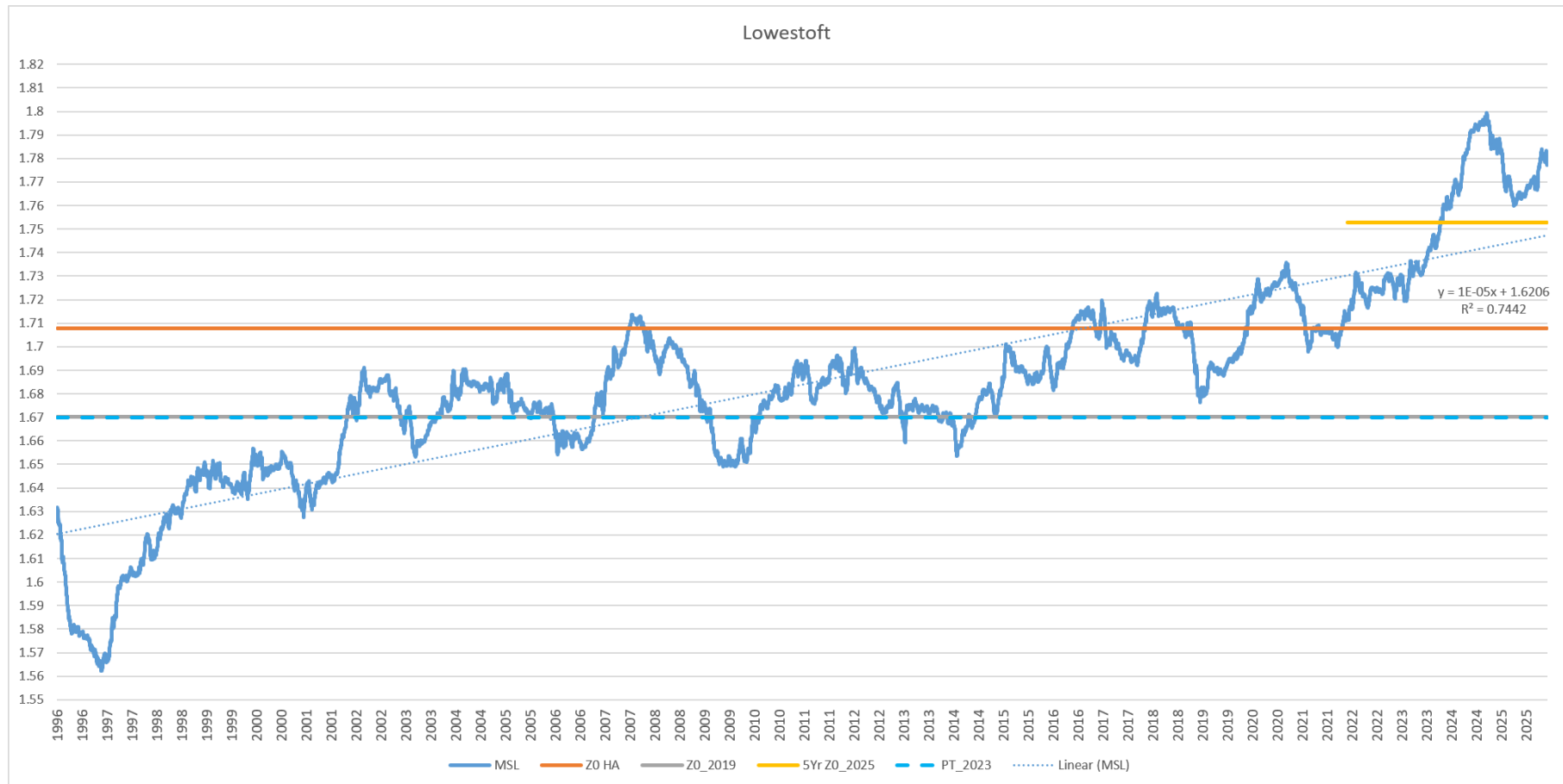


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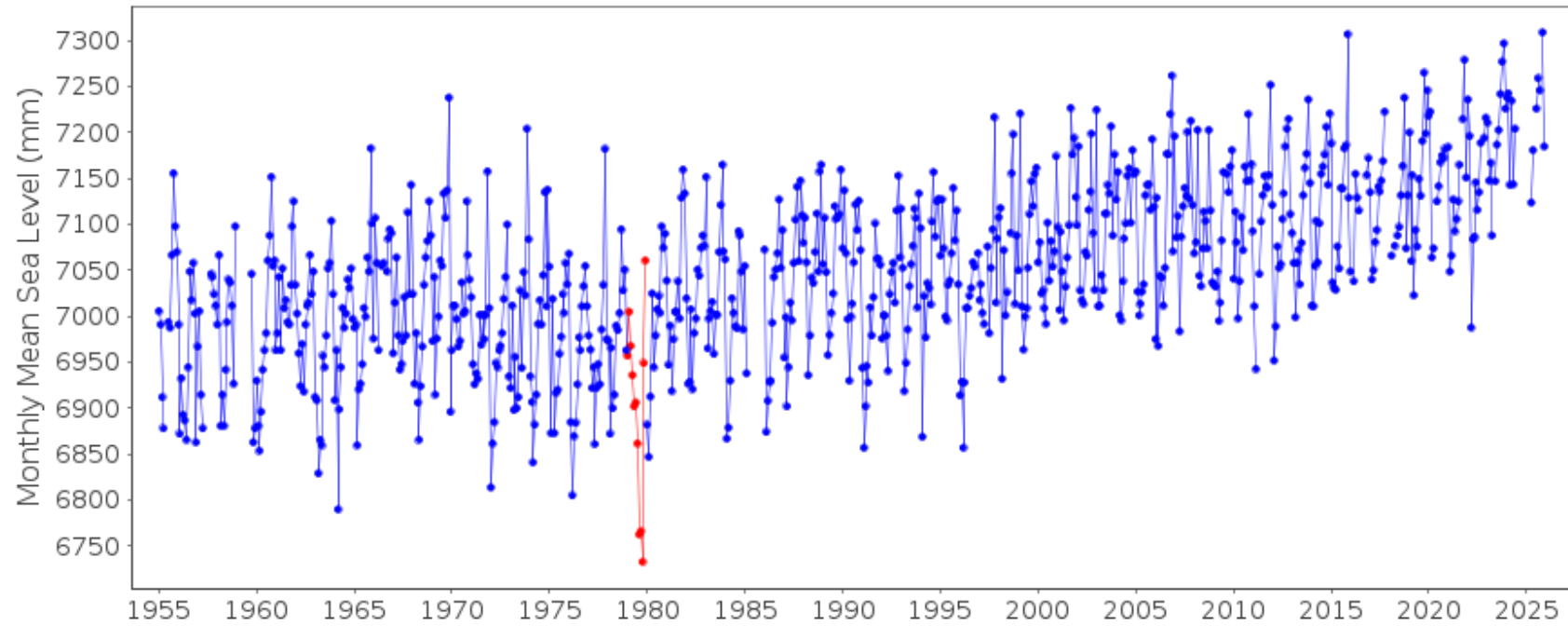


Lowestoft



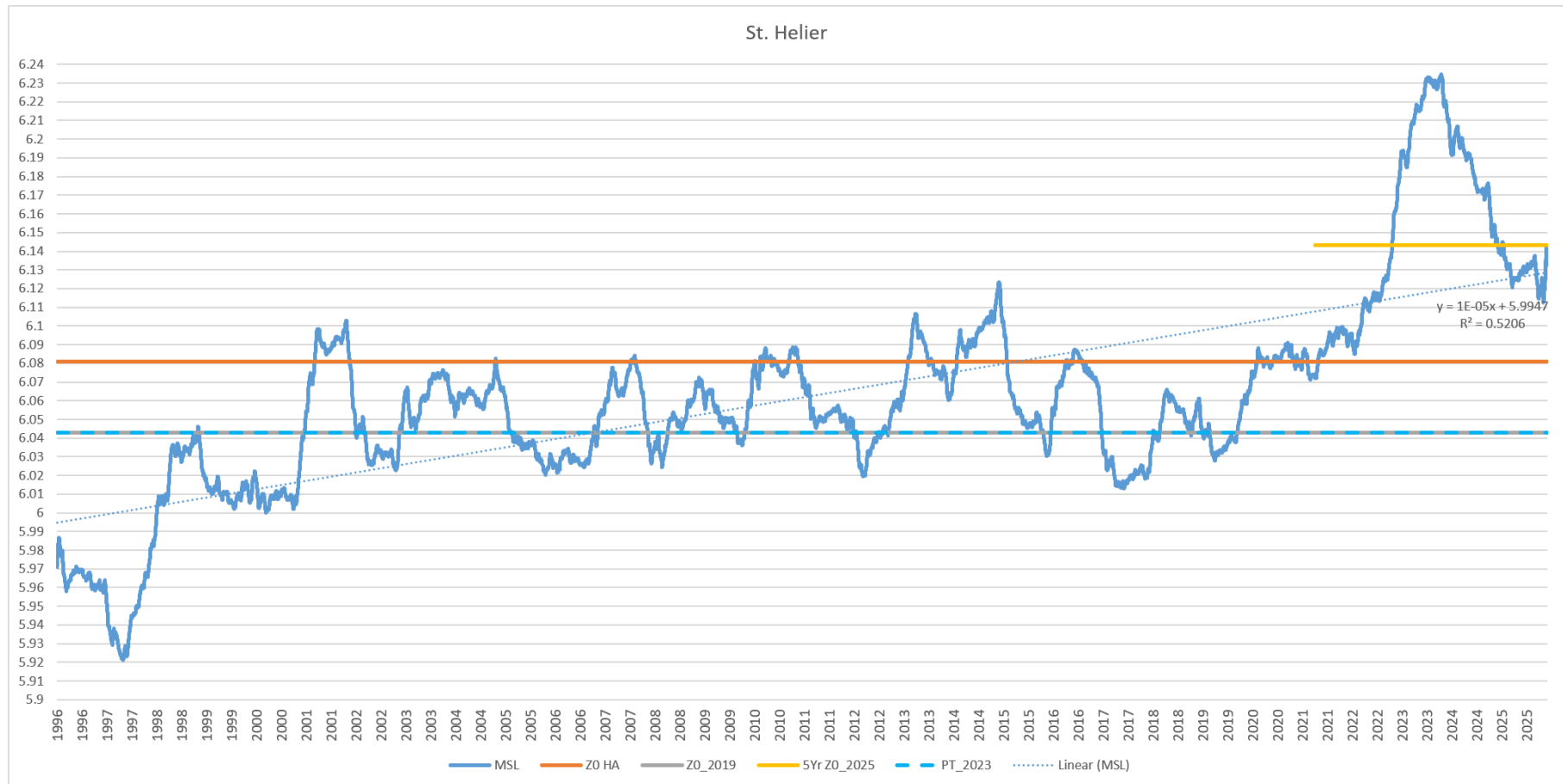


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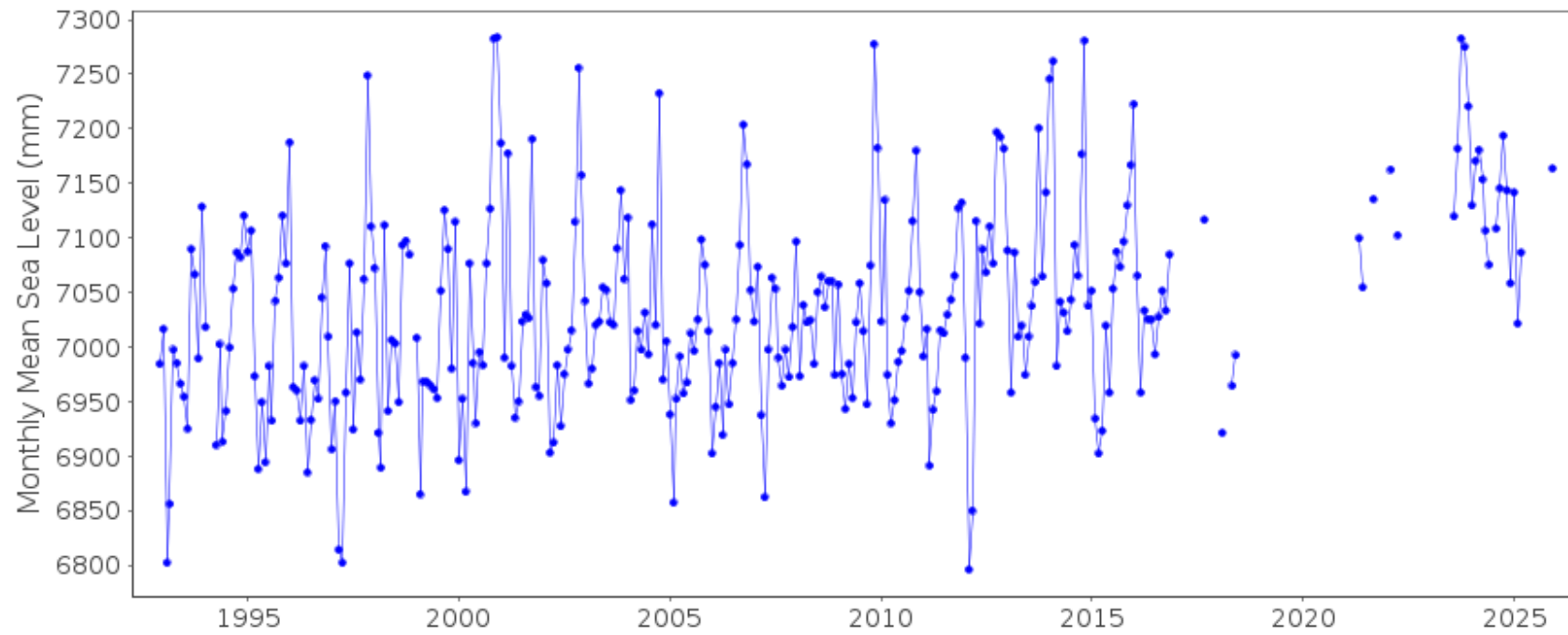


St Helier



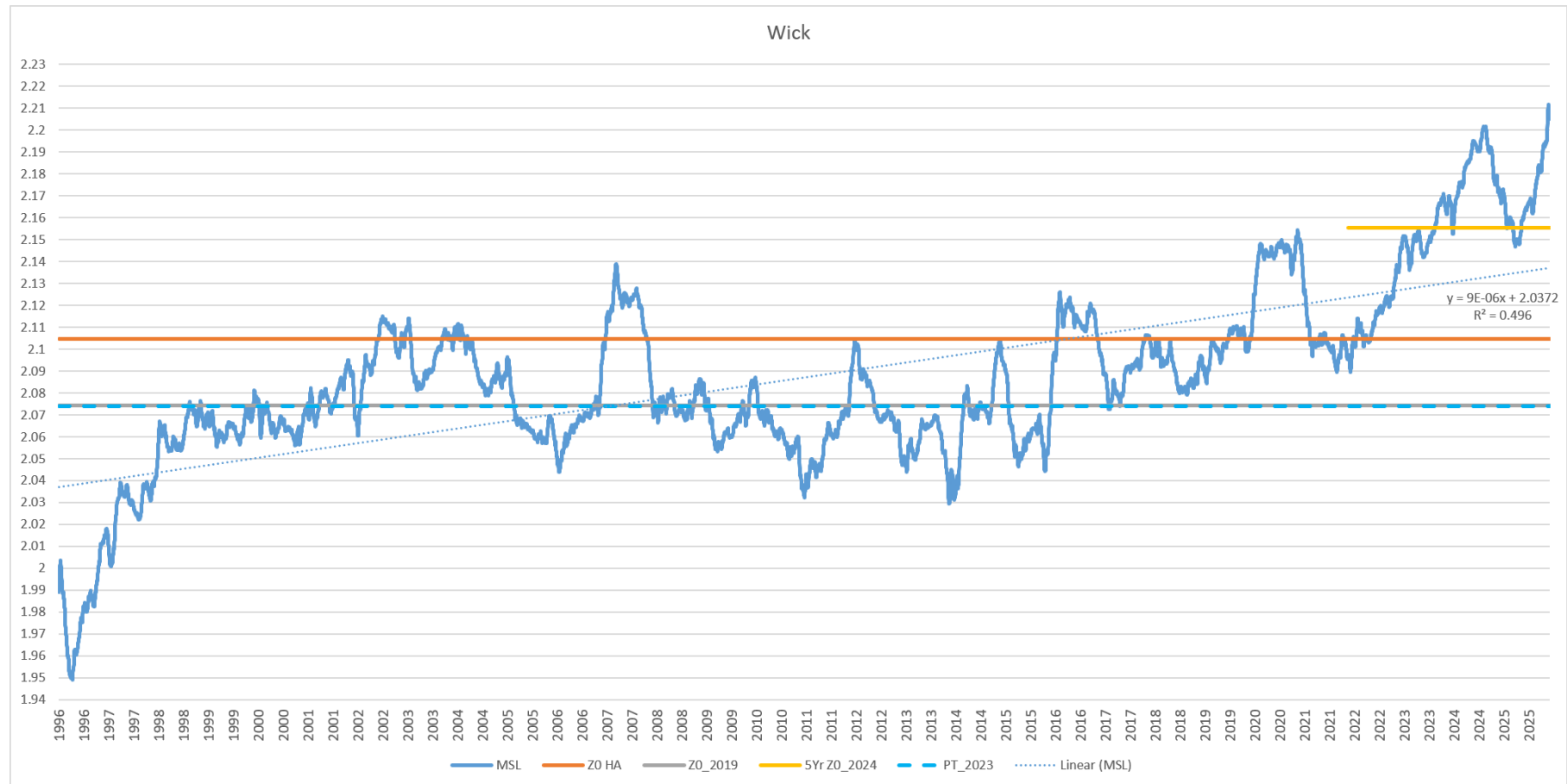


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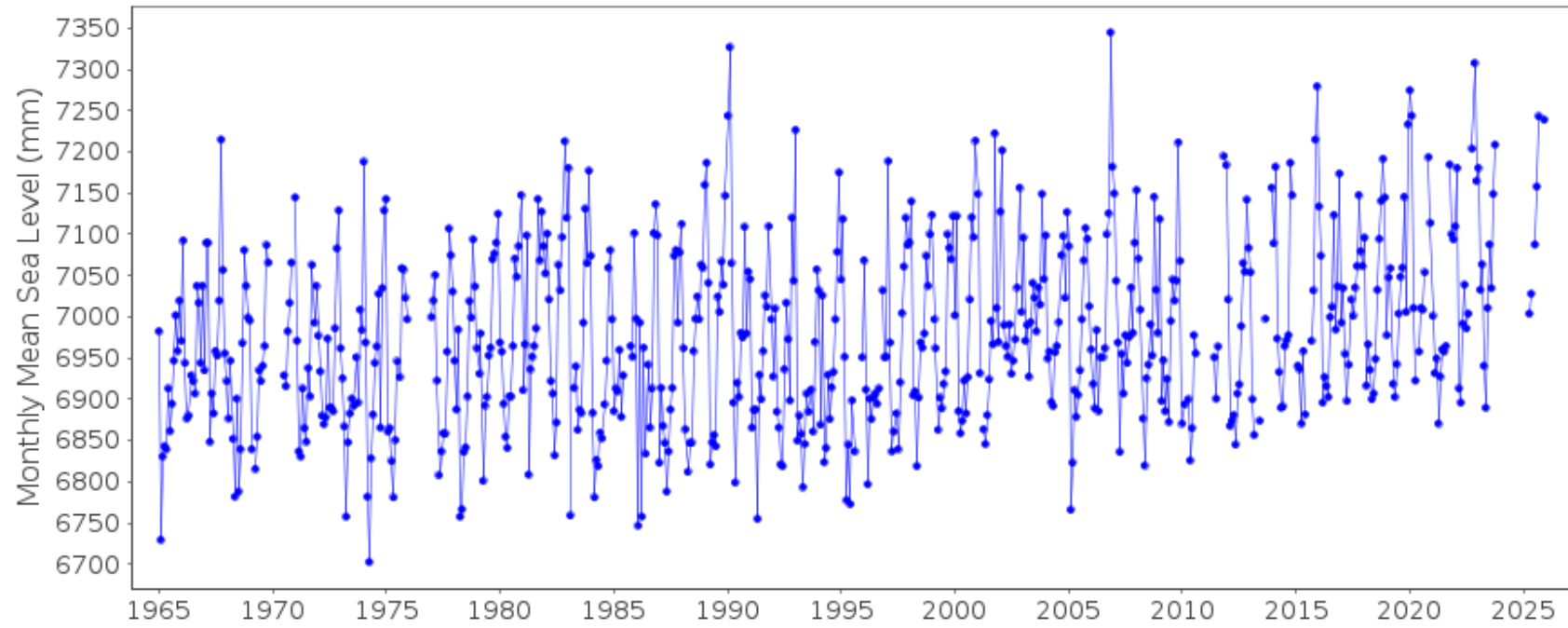


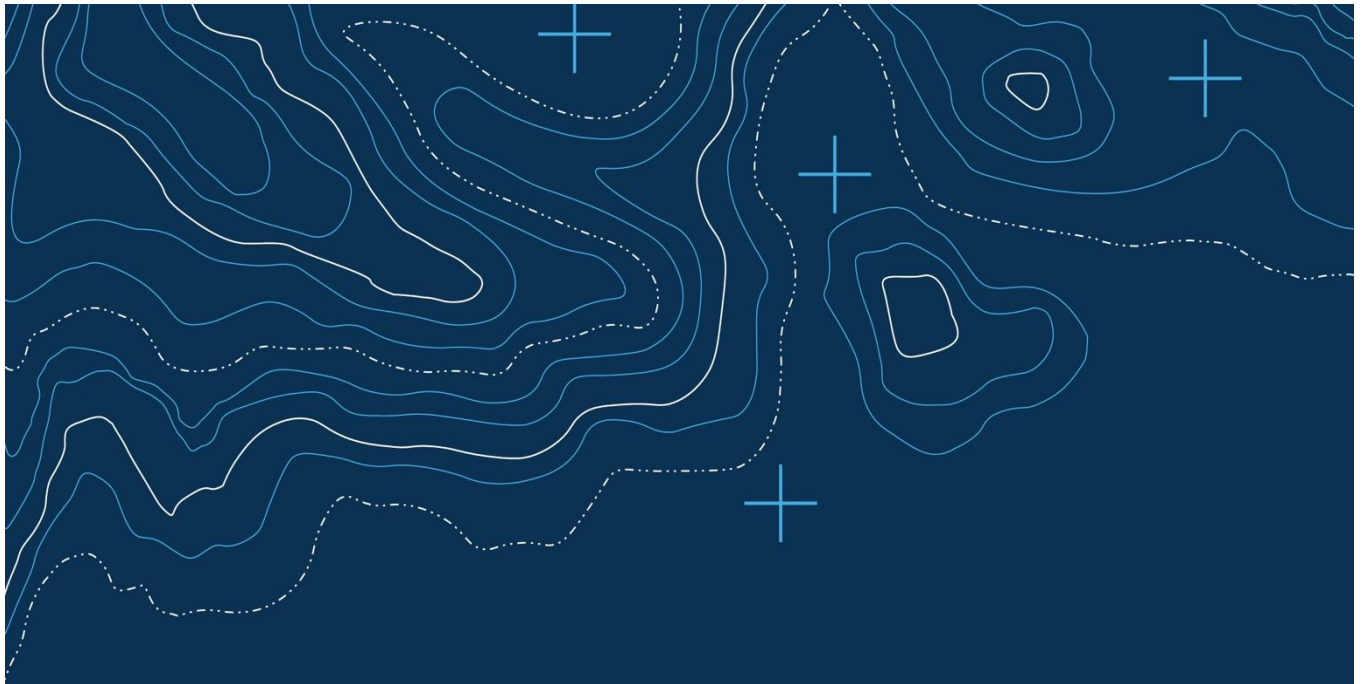
Wick





https://psmsl.org/data/obtaining/rlr.monthly.plots/1109_high.png





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