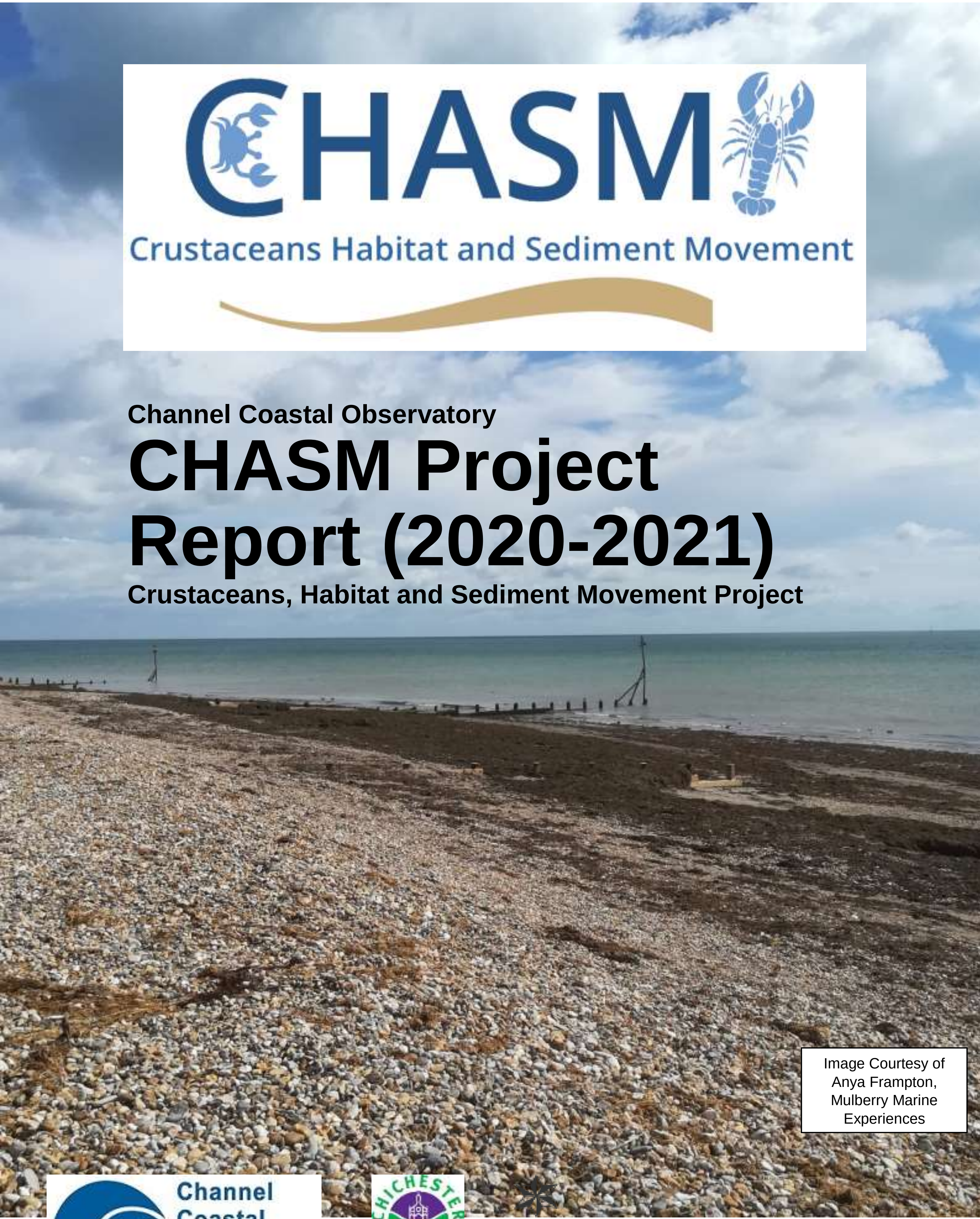
CHASM

Crustaceans Habitat and Sediment Movement

Channel Coastal Observatory

CHASM Project Report (2020-2021)

Crustaceans, Habitat and Sediment Movement Project



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Channel Coastal Observatory

Chichester District Council

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Document: CHASM Project Report (2020 – 2021)
Reference: TR114
Status: Final
Date: November 2021
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ACKNOWLEDGEMENTS

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- Sea Search
- Sussex Wildlife Trust
- Manhood Peninsula Partnership
- Selsey Town Council

CHASM will be working more closely with the Sussex Kelp Restoration Project thanks to Sarah Ward from Seasearch, who is the link between the two projects.

Table of Contents

1. Introduction

1.1. Introduction to the CHASM project

The fishing grounds near Selsey Bill have traditionally been well managed and productive, and fishing in Selsey has a long history going back several centuries. However noteworthy changes in the fishing ground have been seen in recent years. Something has affected the marine environment leading to significant reductions in crab and lobster catch, and a noticeable increase in fine sediment, but it is not clear what the causes are. A number of factors are likely to be involved including local human actions and climate change.

This report presents overview of change to the coast over the past 10-15 years, using existing coastal monitoring data. The report was not designed to answer wider questions regarding fisheries or water quality, but has highlighted several knowledge gaps. To better understand the issues, and work towards solutions, further work will need to be undertaken to better understand the lifecycle of the species affected, water quality changes, and wider-field effects such as dredging and dredge spoil disposal in the area. While initial work has concentrated on Selsey Bill, similar declines affect other marine animal and plant species along the Sussex and Hampshire coasts. It is intended that the monitoring and analysis to be undertaken during further phases of the CHASM project will create an environmental baseline of use to many other projects in temperate coastal regions.

The Selsey Bill and the Hounds Marine Conservation Zone (MCZ) is part of the CHASM project area. The features requiring MCZ protection include the High Energy Infra-littoral Rock forming the Hounds Reef and rocky outcrops near Selsey Bill, which have traditionally been an important part of the nearshore fishing grounds. A decline in crab and lobster catches indicates that not only are these species suffering, but questions may also be raised concerning the health of the marine environment within the MCZ itself.

Another consideration particularly relevant to sedimentation is the impact of licenced dredging and land runoff. It is unclear whether dredging and spoil disposal has impacted the CHASM project area or the MCZ, but future work will entail trying to identify sediment sources. The opening of Medmerry may have also increased terrestrial sediment inputs into the nearshore environment.

The aim of the Crustaceans, Habitat and Sediment Movement (CHASM) project is to better understand the factors affecting the decline of crab and lobster catch noted by the Selsey fishing industry along the coasts of Selsey and Bracklesham Bay. The Spatial extent of the area being investigated in this report is shown in **Figure 1** (blue box), with some key areas highlighted.

The CHASM project highlights the decline of the industry from a community and human perspective. The industry does not support as many fishermen as it did 50 years ago, and fishermen have been forced to work in areas that differ from the traditional nearshore fishing grounds. The need to understand the factors affecting the sustainability of the industry is higher than ever, in both an economic and community sense.

It is clear from a variety of fishermen's stories that there has been a perceived increase in changes in the Selsey fishing industry over the past 10 years; more so than there were in the prior 100 years. The past year has focussed on exploring recent environmental changes in the Selsey fishing area, where data already exists, to determine the extent to which they may have impacted the fishing industry.

This report is the first stage of the CHASM project, assessing the availability and utility of the existing evidence base and enabling identification of evidence gaps which will be targeted in future research. The questions posed by the Selsey fishery provide an initial framework, but the research necessary to provide solutions is likely to extend beyond this. The CHASM project began in January 2020, as an unfunded, voluntary project, with all time and data being donated by the relevant contributors and institutions.

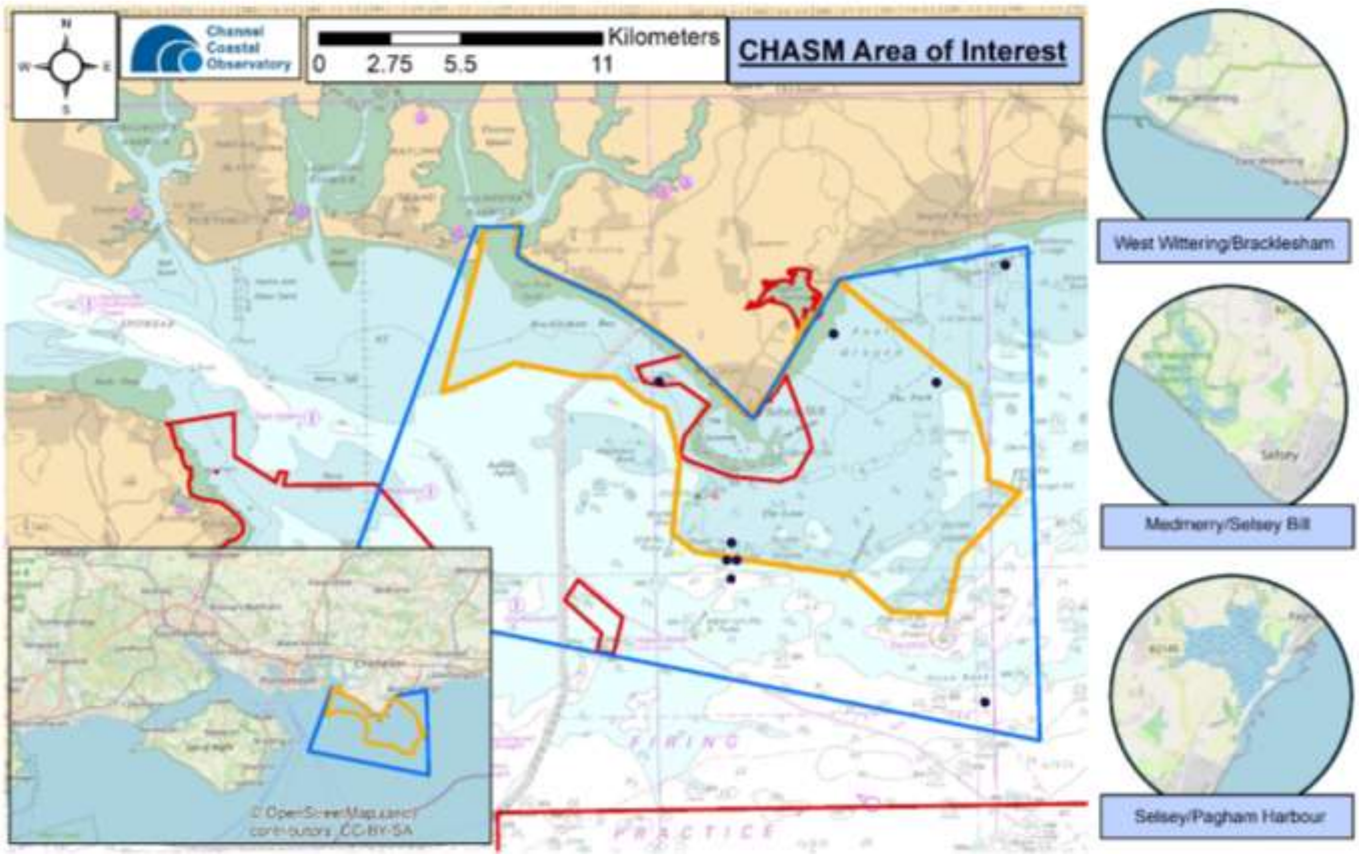

Figure 1** CHASM project area of interest, indicating the extent of the Selsey Fishing Grounds (yellow) and wider sediment sampling points (blue box, black points), and adjacent MCZs (red).* ***Adapted from Blue Marine Foundation. All rights reserved. Service Layer Credits: Esri, UKHO, GIS community

1.2 Key Aims of the project

The key long-term aims of the CHASM project are:

A1. To understand the environmental, physical and climatological changes that have taken place in the Selsey crab and lobster fishing grounds, particularly within the Selsey Bill & Hounds MCZ.

A2. To determine whether the marine environment and fishing grounds have been impacted by recent environmental inputs including: changes to sediment inputs from offshore and terrestrial sources; or changes to contaminants from freshwater inputs, land run-off and sewage discharge.

A3. To understand whether the negative effects on the Selsey fishing industry can be mitigated to ensure the sustainability of both the industry and the nearshore marine environment.

A4. To gain greater support and understanding of the marine environment from local communities, visitors and authorities by improving understanding of the benefits and challenges of the open coast through partnerships and education programmes onshore and underwater.

A5. Develop affiliations with other local initiatives including the Selsey Bill and the Hounds MCZ, the Sussex Kelp Restoration Project, CHaPRoN and Sussex Bay.

This report provides an interim summary of the work undertaken over the past year exploring the available evidence to address points A1 and A2 in the context of local and regional-scale coastal change over the past 10 – 15 years. This utilises existing coastal monitoring and research data, extending the record with supplemental evidence to cover changes in the past 50 years. By doing so, an evidence base for assessments of change is presented which can be used to help develop our understanding of how coastal change might impact the Selsey fishing grounds, along with some initial interpretation.

The following actions have been undertaken in the past year, with an indication of how they relate to the Aims of the main project:

- Determine a local change narrative based on key user groups and recorded events that may relate to coastal change (A1)
    - A timeline of key significant events has been constructed (Section 3.7, ***Figure 27*** *Timeline of significant events*)
- Establish the extent to which changes in sedimentation have been observed across the area of interest (A1, A2)
    - A baseline of sediment grain size, based on sediment samples from a range of sites (Section 3.4, **Figure 16**)
    - An assessment of turbidity associated with Medmerry and Pagham (Section 2.5)
- Assess regional trends of coastal change, from existing evidence-based datasets. (A1, A2)
    - Regional scale topographic and bathymetric change has been assessed using data collected as part of the Southeast Regional Coastal Monitoring Programme (SERCMP) (Sections 3.1, 3.2)
    - Hydrodynamic conditions are explored through time series analysis of data collected through the SERCMP. (Section 2.3)

2. Methods

2.1. Topographic Data

Regular topographic surveys are carried out by the Channel Coastal Observatory (CCO) as part of the Southeast Regional Coastal Monitoring Programme, with the area of interest split into five survey units: 5aSU01, 02, 03, 4dSU23 and 24 (**Figure 2**). Two surveys are carried out per year, combining interim profile surveys and baseline surveys. Full details of the methodologies used can be found at www.coastalmonitoring,com, including survey specifications[1], quality control procedures[2] and annual survey reports[3].

Real Time Kinematic Global Positioning Survey (RTK GPS) is the primary measurement tool, which is employed in a number of different ways[4]: (1) beach profiles, measured at intervals along a cross-shore transect; (2) walking surveys using backpack carried kits; (3) static terrestrial laser scanners; or (4) mobile terrestrial laser scanners mounted onto All Terrain Vehicles (ATV). Information on the accuracy and methods of topographic ground surveys are found in **Table 1**.

Table 1 *Topographic Surveys methods and accuracies*

Survey Type		**Equipment (Make, Model)**	**Accuracy**	**Data Collection Method**
Walked Survey	RTK GPS Survey Kit	Trimble GPS GNSS Recivers	+/- 0.030m	Beach profiles – measuring along contour profile lines and capturing slope intervals
Terrestrial Laser Scanning	Static	Leica Laser Scanner	+/- 0.030m	150 metre radius of data captured in 1 scan 360° rotation in a fixed position
	Mobile	Reinshaw MX2t Laser System	+/- 50mm, (RMS) up to +/- 20mm	150 metre radius of data captured in 1 scan

Topographic profile positions were established in 2004, in most cases extending to the mean low water springs contour (**Figure 2**). All data is freely available to the public through www.coastalmonitoring.org. A summary of the topographic change within the wider CHASM area of interest is included here, but for more details, please refer to the annual topographic surveys reports for each survey unit[3].

[1] https://coastalmonitoring.org/ccoresources/specificationsandbriefs/
[2] https://coastalmonitoring.org/ccoresources/dataqualitycontrol/
[3] https://coastalmonitoring.org/reports/#southeast
[4] https://coastalmonitoring.org/survey_techniques/

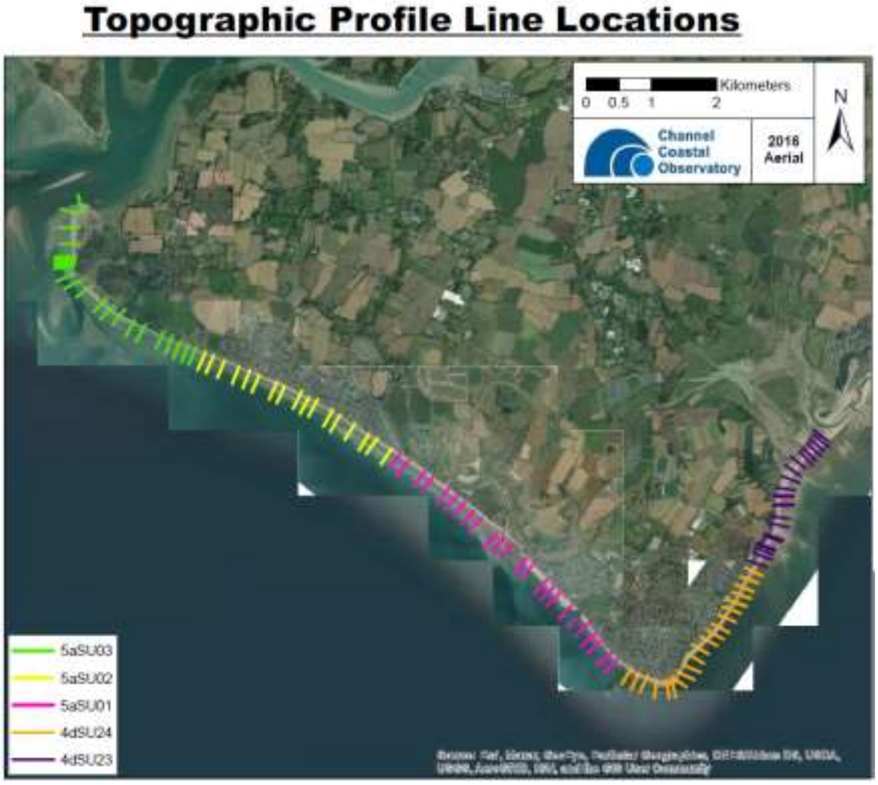

Figure 2 *Topographic profile positions within the 5 survey units which make up the CHASM project area of interest.*

The cross-sectional area (CSA) for each profile is calculated relative to a reference level of Mean Low Water Springs (MLWS).Changes in CSA are represented through a series of maps in **Section 3.1**.

The Medmerry Managed Realignment scheme was breached in August 2013 and this is used as a reference point for pivotal change, representing a significant cause of recent environmental change and coinciding with the most extreme storm season in the recorded data. Table 3 shows the time scales chosen to present CSA figures.

Table 3 *Topographic profile Cross-sectional area (CSA) change: annual and longer term changes*

	Survey Unit	Pre 2013	Post 2013	2014-15	2015-16	2016-17	2017-18
5a: Selsey Bill to West Witterings	5aSU03 West Witterings	Nov 2004 – Sep 13	Sep 2013 – Oct 18	Apr 2014 - 15	Apr 2015 -16	Apr 2016 – 17	Apr 2017 –18
	5aSU02 Bracklesham to West Witterings			May 2014 - 15	May 2015 -16	May 2016 -17	May 2017 -18
	5aSU01 Medmerry			Feb 2014 - Jan 15	May 2015 - 16	Jan 2016 – Mar 17	Jun 2017 – Jul 18
4d: Pagham Harbour to Selsey Bill	4dSU01 Selsey Bill	Sep 2007 – Sep 13	Feb 2014 – Aug 18	Feb 2014 – Jan 15	Jan 2015 -16	Jan 2016 – Mar 17	Mar 2017 -Feb 18
	4dSU02 Selsey to Pagham Harbour						

2.2. Bathymetric Data

Bathymetric surveys have been used to assess subtidal changes in depth for small inshore areas within the study area. Semi-regular single beam hydrographic surveys have been carried out as part of the Southeast Regional Coastal Monitoring Programme, measuring along transects between the mean low water contour and up to 1km offshore, at a line spacing of 25-50m. These are available for two areas within the main Area of Interest: Wittering (**Figure 3**, purple) and Medmerry (**Figure 3**, blue):

Table 2 Single Beam Bathymetry Data Available

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Wittering	■		■	■	■	■	■	■	■				■		■
Medmerry	■		■								■	■	■		■

In addition, swath multi-beam (MBES) surveys, which provide a 100% coverage of the seafloor, were carried out in June 2013 and June 2016 and combined to provide full baseline coverage of the Wittering area. There are no more recent MBES surveys.

Figure 3 *Bathymetric Survey Extents.*

2.3. Hydrodynamic & Water Quality Data

Three Datawell MkIII Directional Waverider buoys provide regional spatial coverage of nearshore wave parameters. The locations of the 3 wave buoys can be seen in ***Figure 4***. The Hayling Island and Rustington wave buoys were both deployed in July 2003, and the Bracklesham Bay buoy was deployed in 2008. All three sites are deployed in approximately 10 m CD (chart datum) water depth.

The wave buoys provide:

- Significant wave height (m)
- Mean wave period (Tz)
- Peak wave period (Tz)
- Wave Direction (Degrees)
- Sea Surface Temperature (°C)
- Storm Event Occurrence
- Bi-modality Occurrence

A storm threshold has been set for each buoy, based on the 0.25% return period (Dhoop & Thompson, 2018), of 2.80m for Hayling Island, 3.42m for Rustington and 3.23m for Bracklesham Bay. Annual data recovery rates can vary due to technical issues with the buoys, but the highest confidence is given to recovery rates above 95%.

Additional Sea Surface Temperature (SST) data for Pagham Harbour site is provided by Brighton University.

A tide gauge located at Arun Platform utilises a Valeport 730 with Druck Pressure Transucer to measure tidal elevations relative to Ordnance Datum, at an estimated vertical accuracy of 0.0005m (Dhoop, 2019). The tide gauge was deployed in 2008, and resurveyed in 2017 with no change in datum. Between September 2015 and May 2017 a low powered radar temporarily replaced the pressure transducer following damage. It should be noted that there have been significant periods of low data recovery because of restricted access to the platform due to health and safety considerations.

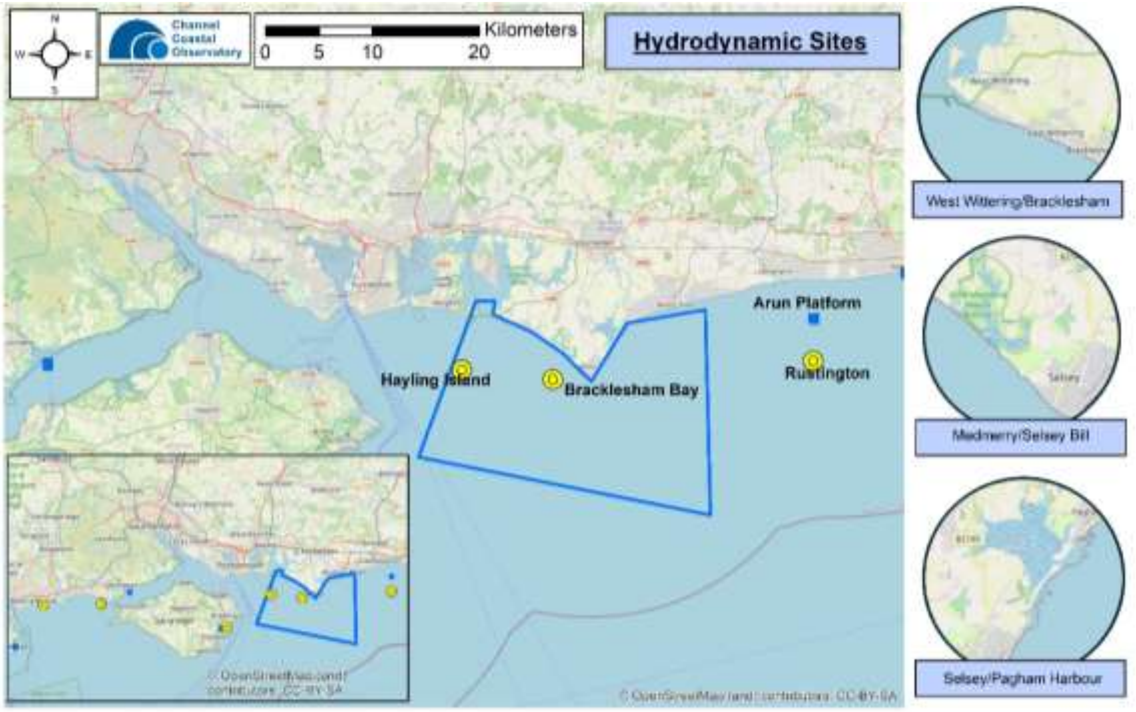

Figure 4 *Location of wave buoy (yellow circles) and tide gauge (blue squares) sites, in relation to the wider CHASM areas of interest. Inset shows wider wave and tide coverage.*

2.4. Sediment Sampling and Characterisation

Sediment samples were collected from the seabed surface either by hand, collected by divers, or by van Veen grab when sampling in deeper water. Target volumes of 100 grams were collected and stored in glass jars. Divers sampled the top 5 cm of the sediment surface, using a non-biased, randomised sampling strategy to collect representative samples from each site.

Sediment sampling locations were planned based on conversations with maritime users, informed by noticeable changes in species mortality and population or sediment composition. The locations of samples which have been collected and analysed are shown in **Figure 5**, along with the location of samples due to be collected in 2021 or that are awaiting analysis. As of November 2020, 16 offshore samples had been collected, between August and November 2020, before increased COVID restrictions prevented further sampling. These locations are shown in **Table 3**, along with the name of the organisation who collected the samples.

Thirteen of the samples were analysed in the Southampton University labs in the National Oceanography Centre, with the remaining samples stored frozen for analysis once COVID restrictions allow.

***Table 3** Samples that have been collected and who collected them*

	Sediment Sample Name	Collected By
1	A1 Starboard	Southsea SAC
2	A1 Stern	
3	A1 Bow	
4	A1 Port	
5	A1 Starboard + 30m distance	
6	A1 Bow + 30m distance	
7	A1 Stern + 30m distance	
8	A1 Port + 30m distance	
9	Mixon Rocks (a)	Mulberry Divers
10	Mixon Rocks (b)	
11	Far (Outer) Mulberry East (Bognor) End	
12	Medmerry Breach	
13	Landing Craft Bracklesham Bay	
14-16	Medmerry Bank (x3)	Sussex IFCA
17-19	Nab Tower (x3)	
20-22	Hooe Bank (x3)	

Each sample of 100 grams maximum was wet-sieved to remove salts and fine material, then dried at 60 (degrees Celsius) for at least 24 hours.

For grain sizes greater than 0.063mm, the samples were analysed using dry-sieving. The samples are vibrated for 10 minutes on a mechanical shaker, using a 17-tier sieve stack ranging from 0.063 mm to 8 mm at half phi (φ) intervals. The operation was undertaken in two stages due to equipment restrictions. For grain sizes smaller than 0.063 mm, the sample was dried and weighed to assess the proportion of fines in the sample. All grain size statistics were calculated using GRADISTAT (Blott & Pye, 2001).

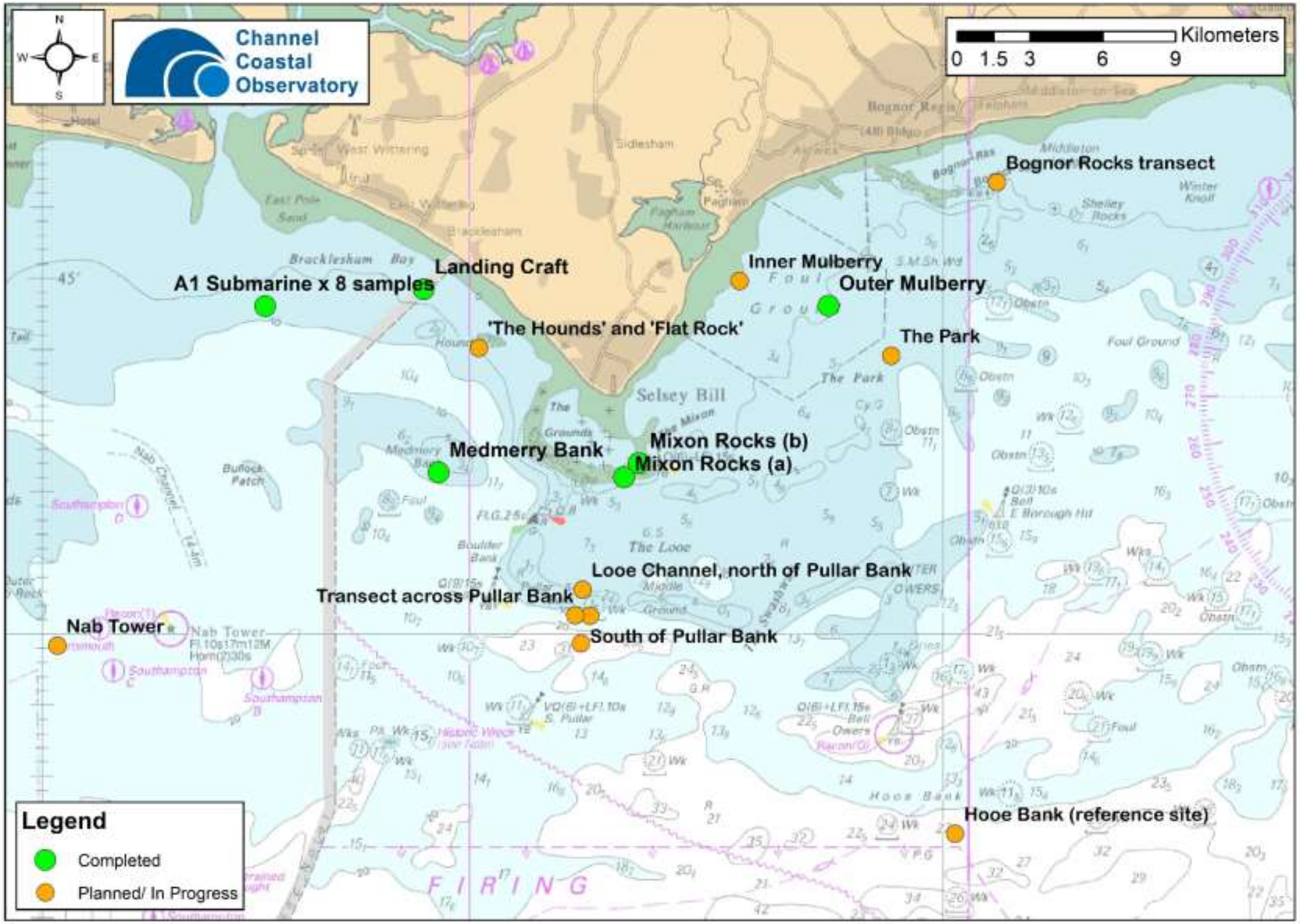

Figure 5 *Sediment sampling Locations, as of 22/09/2020.* ***Service Layer Credits: Esri, UKHO, GIS community***

2.5. In Situ Turbidity measurements, Medmerry and Pagham Harbours

An analysis of turbidity from within Medmerry Managed Realignment Site and Pagham Harbour was undertaken on data collected between 2014 to 2020. Data were collected using YSI EX02 Sondes, providing data on water depth (m), turbidity (FTU), temperature (°C) and salinity (PSU).

The aim of the analysis was to identify if there were any uncharacteristic increases in turbidity or changes in the magnitude of the normal turbidity rhythms (Dale, Burgess, & Cundy, 2017) (Mitchell, Burgess, & Pope, 2004). Any extra-ordinary events identified on the flood tide would be further investigated in order to ascertain whether or not they could be attributed to external marine activities or sediment sources (i.e. large disposal of dredging spoil). Wave and wind data were also available for these sites.

2.6. Additional Data Sources

A series of interview transcripts from seven Selsey fishermen, two coastal engineers and three other maritime users have been produced. Other less formal conversations with fishermen also took place. The interviews took place between May 2020 and January 2021. Observations and other anecdotal evidence have been extracted from the Seas the Day project's oral accounts of Selsey fishing industry (McMeekin, 2019). These oral accounts include times when the fishermen noticed changes in crab and lobster mortality, catching season and when fishing grounds could no longer be used. A timeline of key events has been compiled from these interviews. The timeline is a visual display of both measured and observed key events, including storm events, significant disposal sites and observed changes to sediment.

Other data sources, including reports from Sussex IFCA and details of dredging activity in the region of interest based on MMO licenses, are referenced in the bibliography at the end of the report.

A table to summarise changes that have been observed by maritime users and fishermen has also been compiled (**Figure 27**), to assist in assessing the significance of recent environmental change impacting the Selsey fishing industry.

3. Results

3.1. Topographic Data

Cross Sectional Change analysis for Selsey (4du24), Pagham (4du23), Medmerry (5asu01) and Wittering areas (5asu02 and 5asu03) are presented for a period of 13 years, 9 years before (2004-2013, **Figure 6**) and 5 years after (2013-2018, **Figure 7**) the breaching of the managed realignment scheme at Medmerry in November 2013.

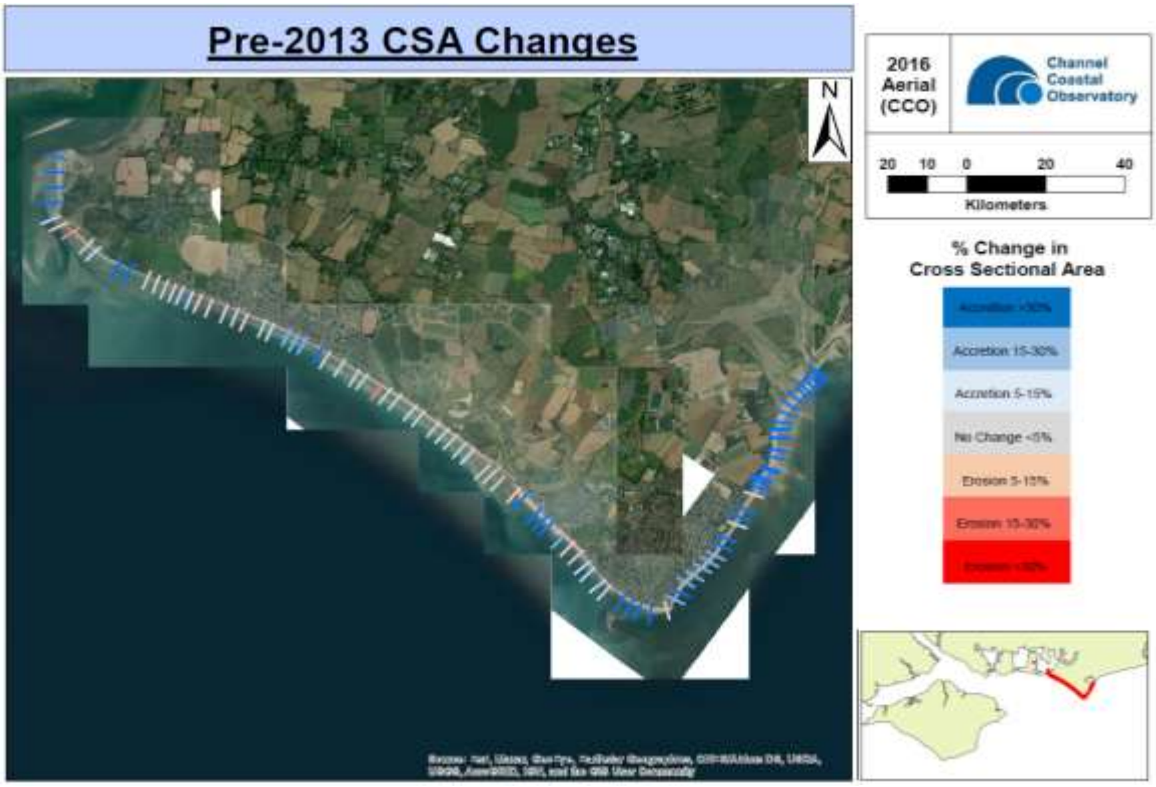

Figure 6 *CSA volume changes, pre 2013*

For the 9 years up to 2013, an increase in CSA of >30% is observed for many profiles between Pagham Harbour and Selsey Bill, and at East Head, indicating accretion. There are some isolated areas of erosion, and little change (CSA change <5%) identified between Medmerry and West Wittering.

In the period since 2014, there appears to have been a decrease in cross sectional area for most profiles between Pagham to Selsey Bill, with isolated areas of accretion still present. Medmerry Breach area sees significant erosion as would be expected, and there is associated accretion traveling North West along the coast. East head shows a reduction in CSA, indicating erosion, although the magnitude is lower. It should be noted that the lengths of the before and after periods differ, and so magnitudes of change should be treated with caution.

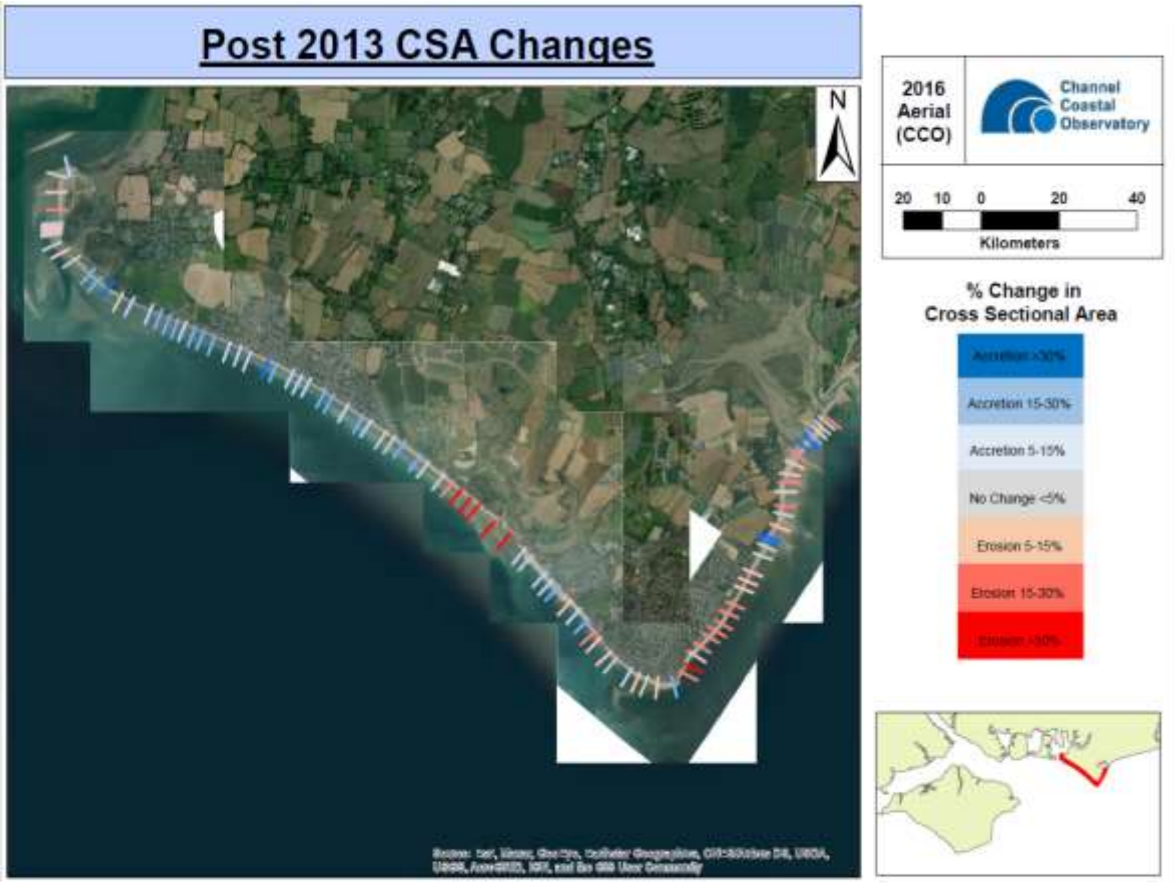

Figure 7 *Figure 7 CSA volume changes, pre 2013*

To explore the annual variability in CSA since 2013 in more detail, annual cross-sectional area changes are also presented.

The coastline between Pagham Harbour and Selsey, shows an annual alternating pattern of accretion and erosion (**Figure 8**), indicative of the dynamic nature of the coastline here. Further south towards Selsey Bill change is focussed on localised hot-spots at the Bill, and East Beach.

Following the coastline westwards towards Selsey Bill, annual variability was noted, however the magnitude of the changes are smaller, showing no clear trend (**Figure 9**). There are hot spots of erosion and accretion.

The Medmerry site (**Figure 10**) and West Wittering to Bracklesham coastline (***Figure 11***), also show annual variability. Hot spots of erosion are associated with the Medmerry breach. The West Wittering to Bracklesham coastline is mostly accreting.

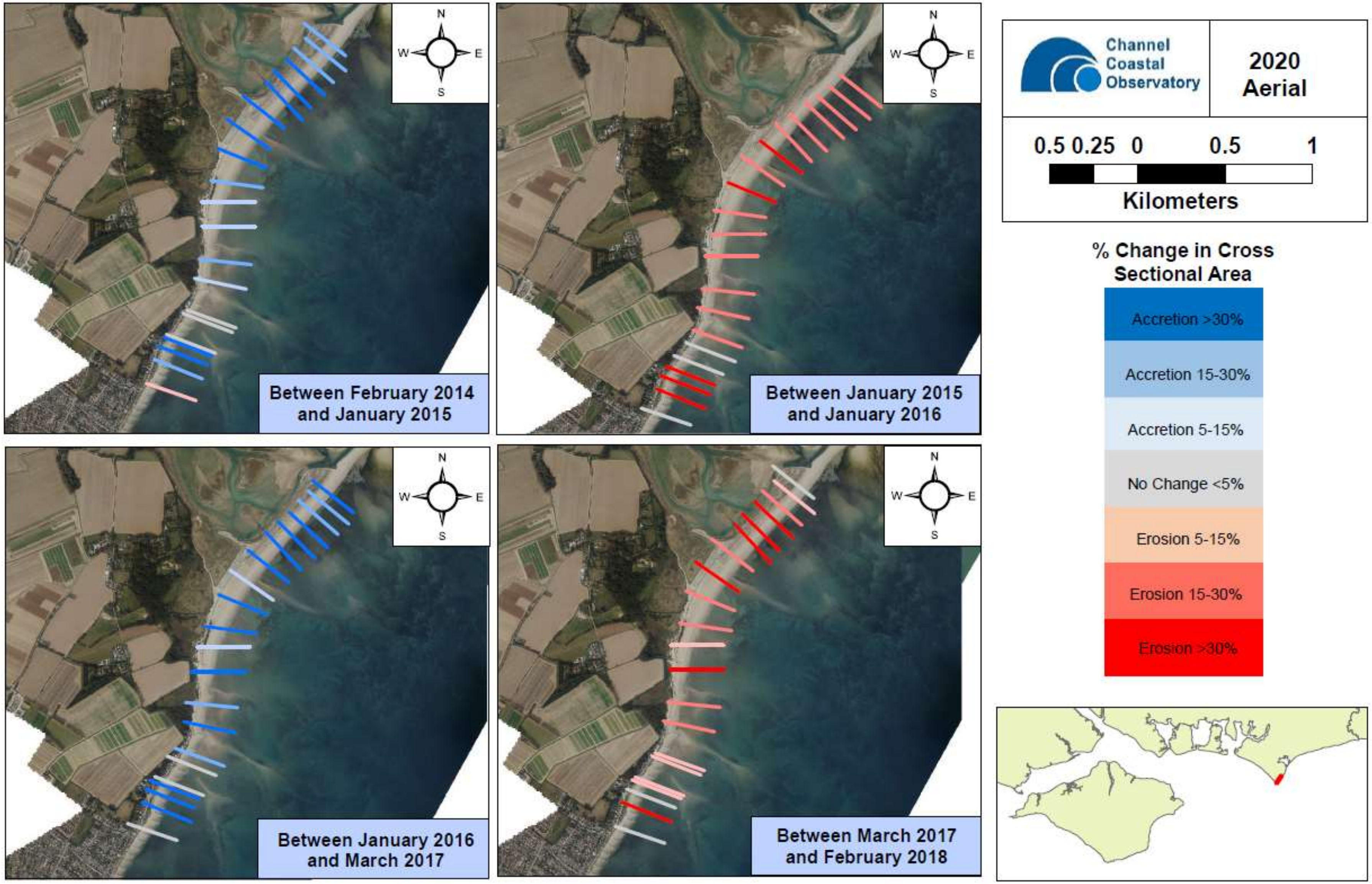

***Figure 8** CSA Change 2014-2018 from Selsey to Pagham Harbour*

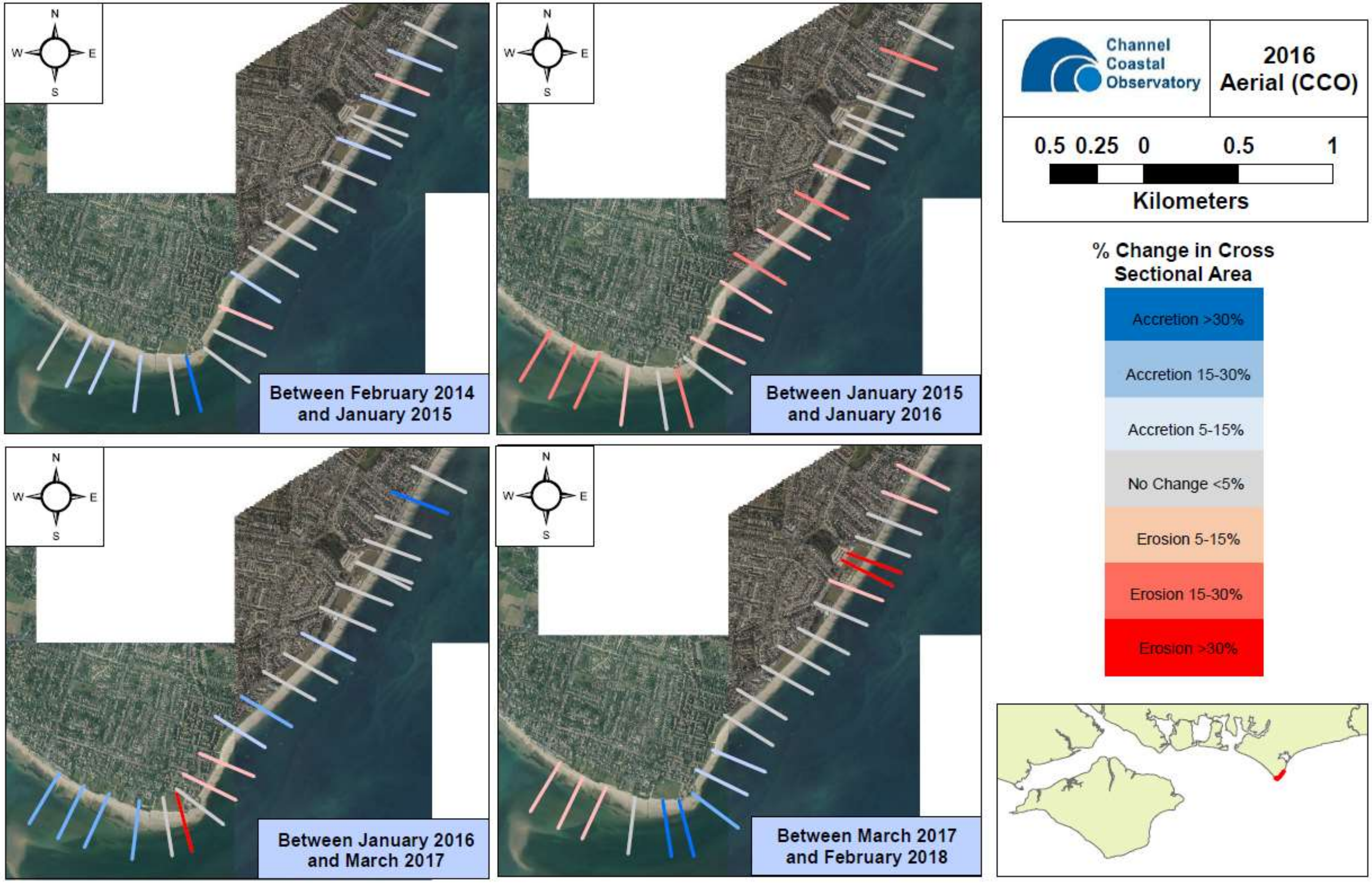

***Figure 9** CSA Change 2014-2018 from Selsey Bill to Selsey*

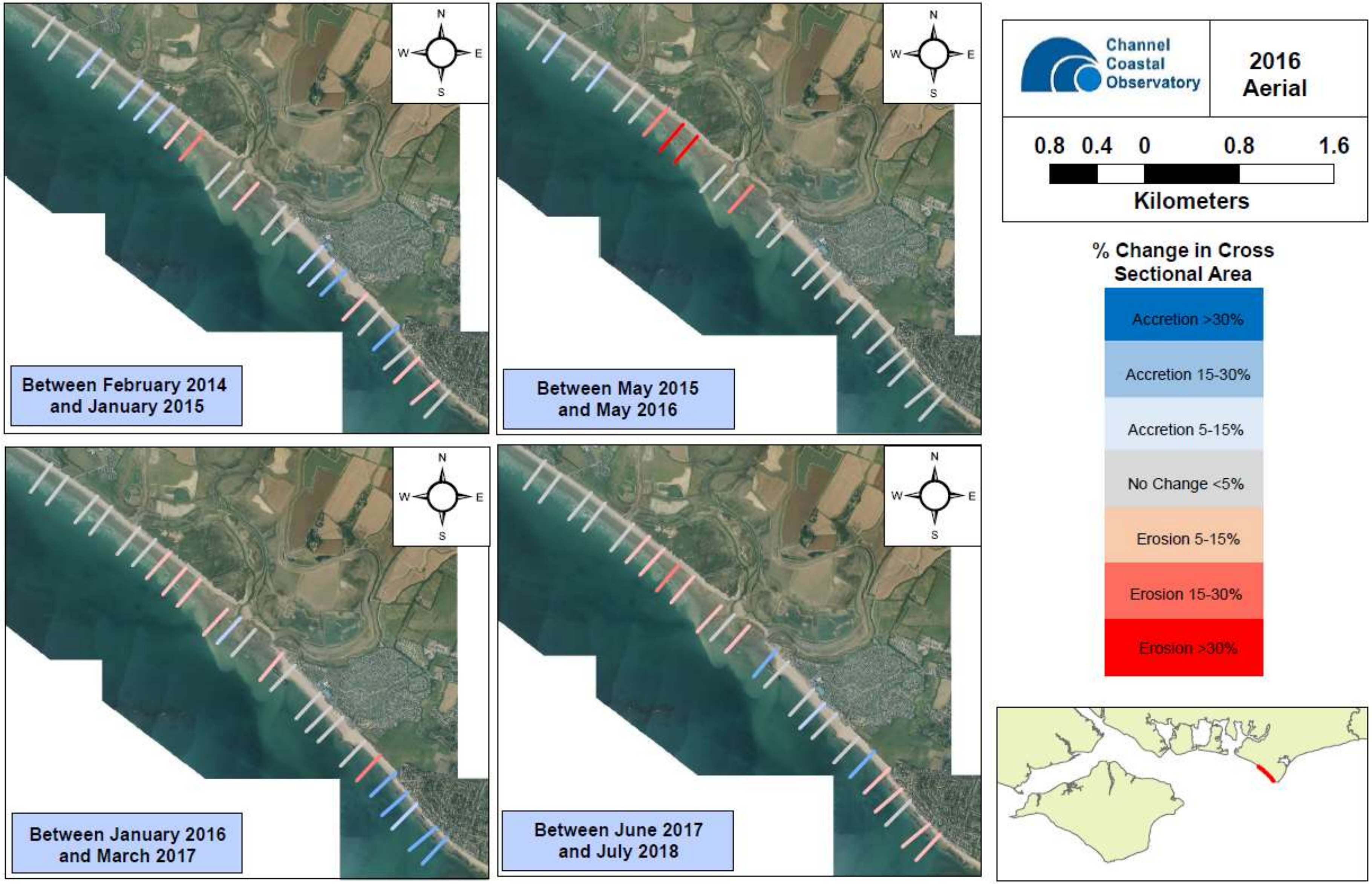

Figure 10 *CSA Change 2014-2018 at Medmerry*

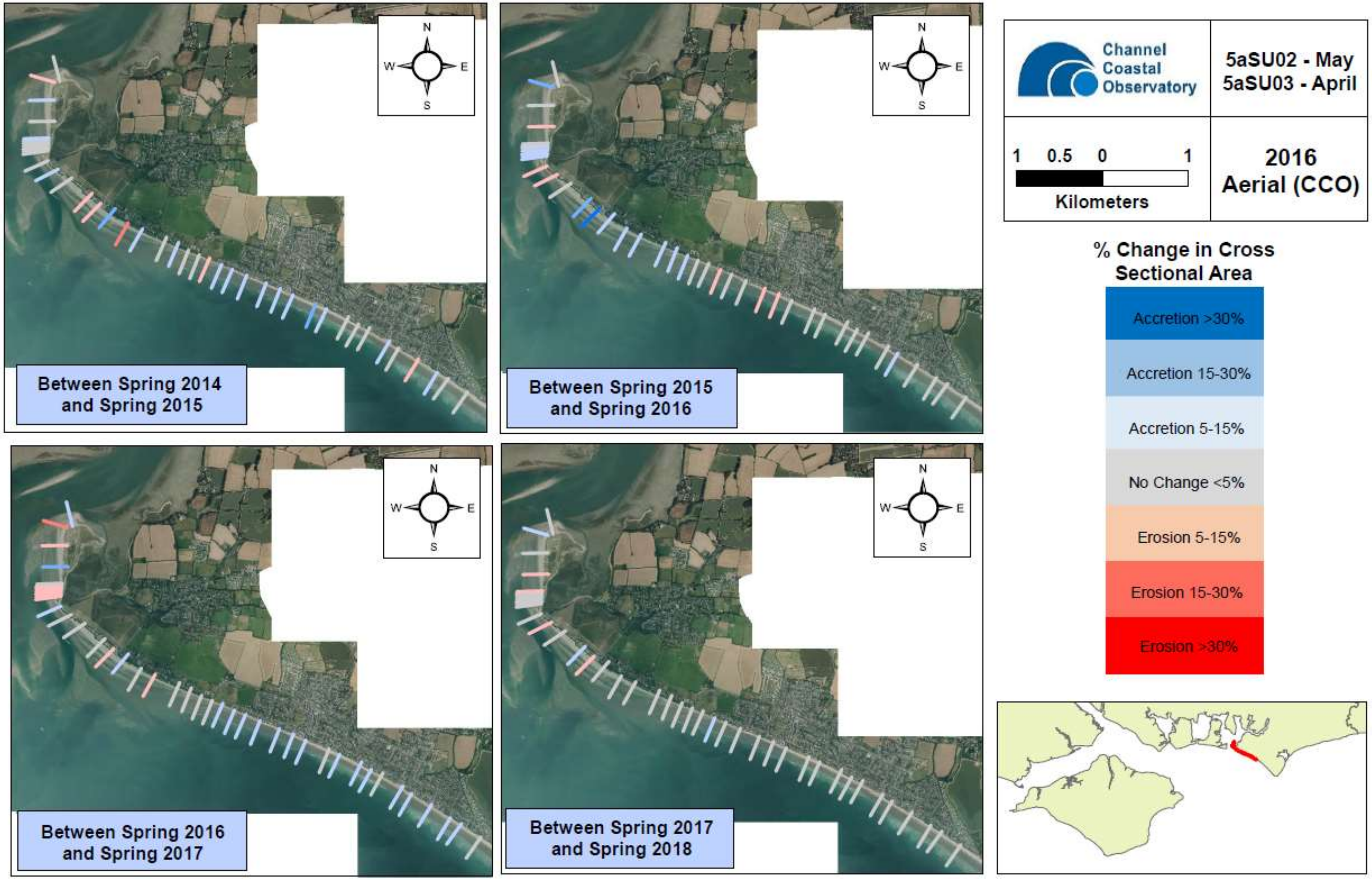

Figure 11 CSA Change 2014-2018 from West Wittering to Bracklesham

3.2. Bathymetric Data

3.2.1. Medmerry

Difference plots (**Figure 12**, **Figure 13**) illustrate the changes to the subtidal area up to 1km offshore from the Medmerry realignment site breach area. An increase of water depth between the 2004 and 2018 single-beam bathymetry surveys is in keeping with the overall loss of material seen at the site (Mylroie, 2018). Although over the wider area there has been accretion south of the breach.

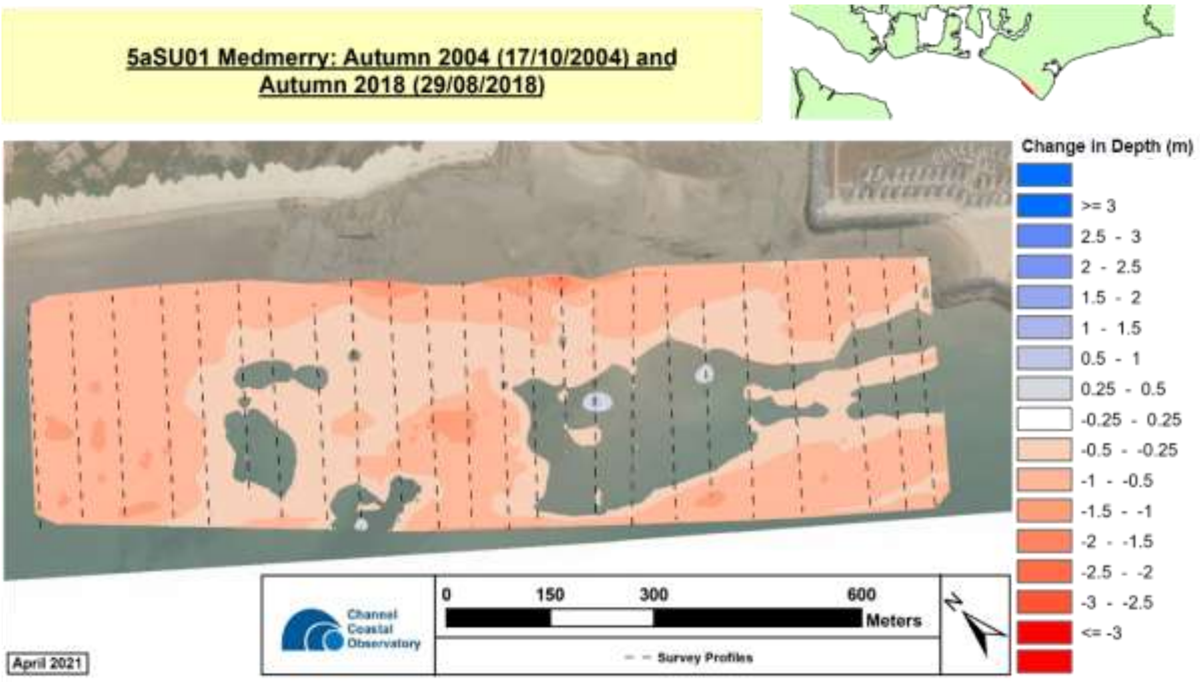

Figure 12 *2004 -2018 Depth Change outside the Medmerry Breach area*

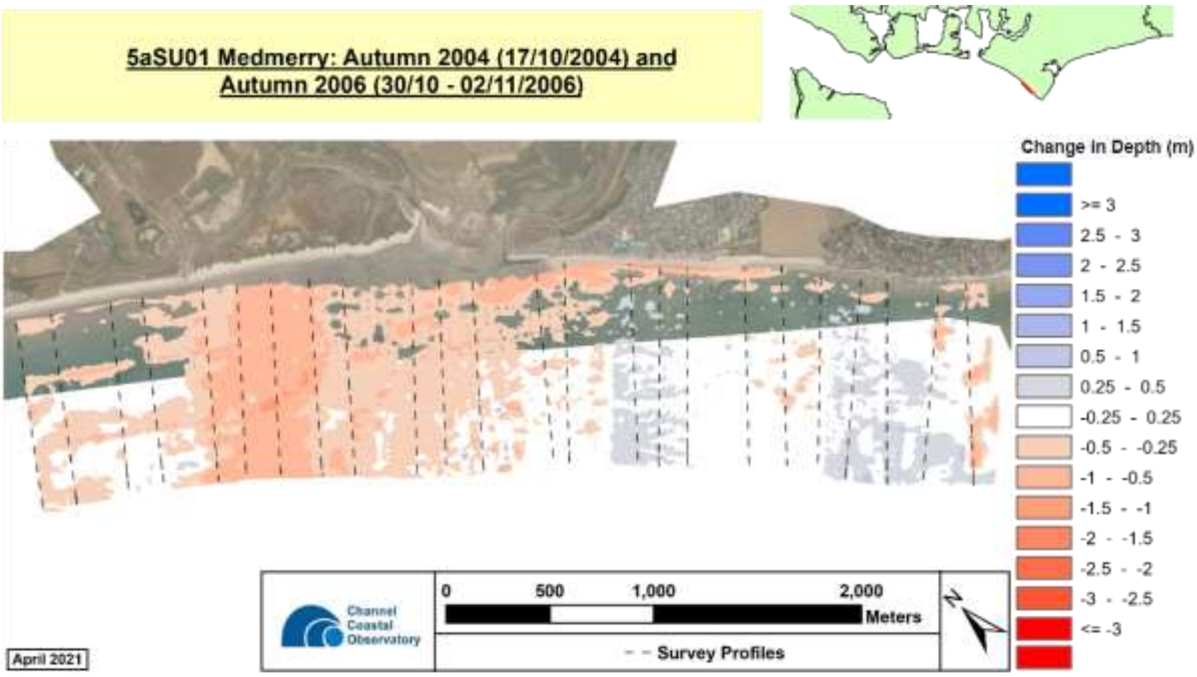

Figure 13 *2004 -2006 Depth Change in the wider area of the Medmerry Breach*

3.2.2 West Wittering

A difference plot of multi beam bathymetry shows both erosion and accretion occurring between 2013 and 2016, indicative of dynamic bed movement (**Figure 14**). A higher frequency analysis of the Wittering area from the single beam bathymetry surveys is shown in **Figure 15**, over a 9 year time scale from 2007 to 2018, shows variability associated with dynamic sand bars within the harbour entrance.

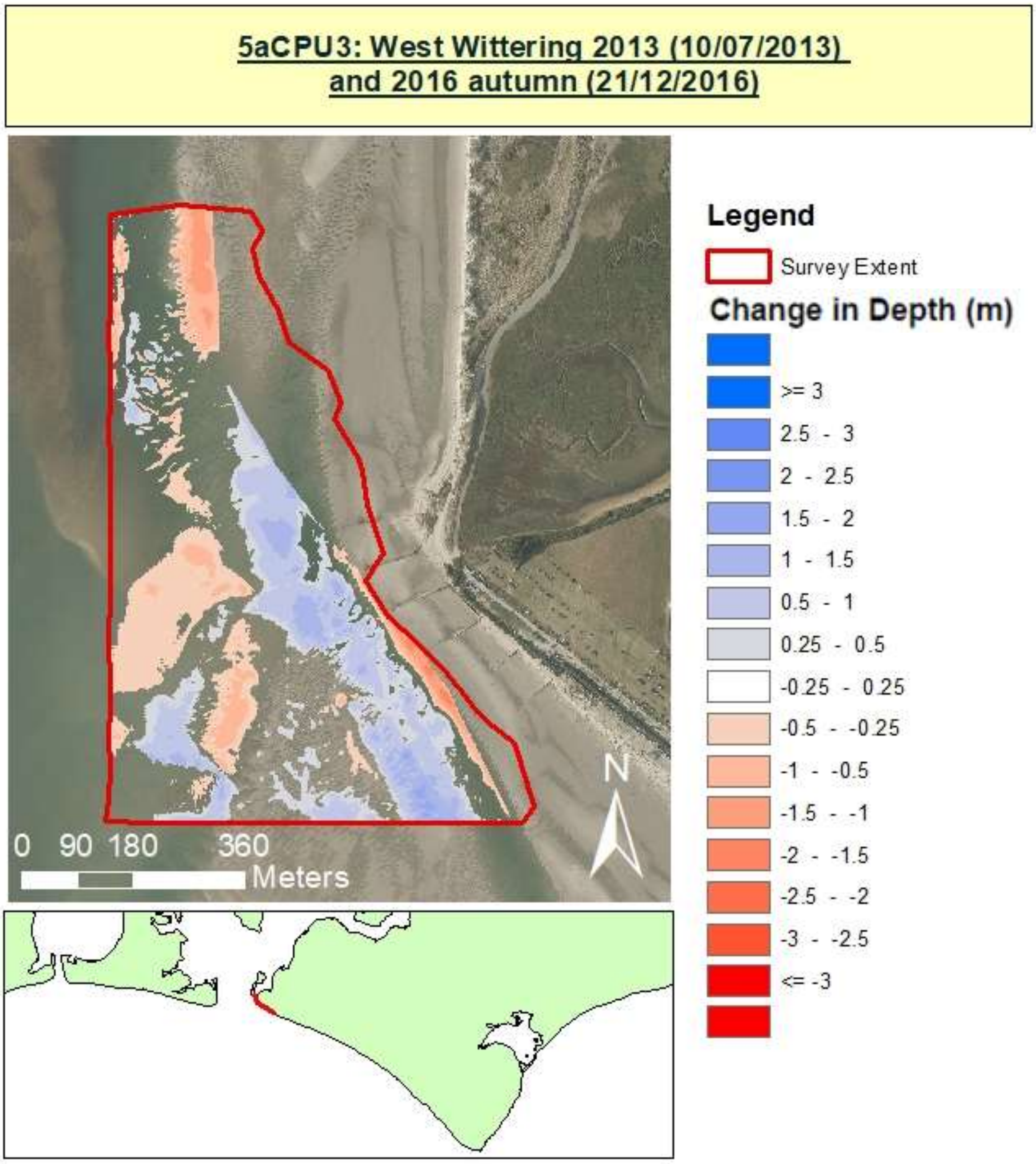

***Figure 14** West Wittering 2013 -2016 Changes to Depth (m)*

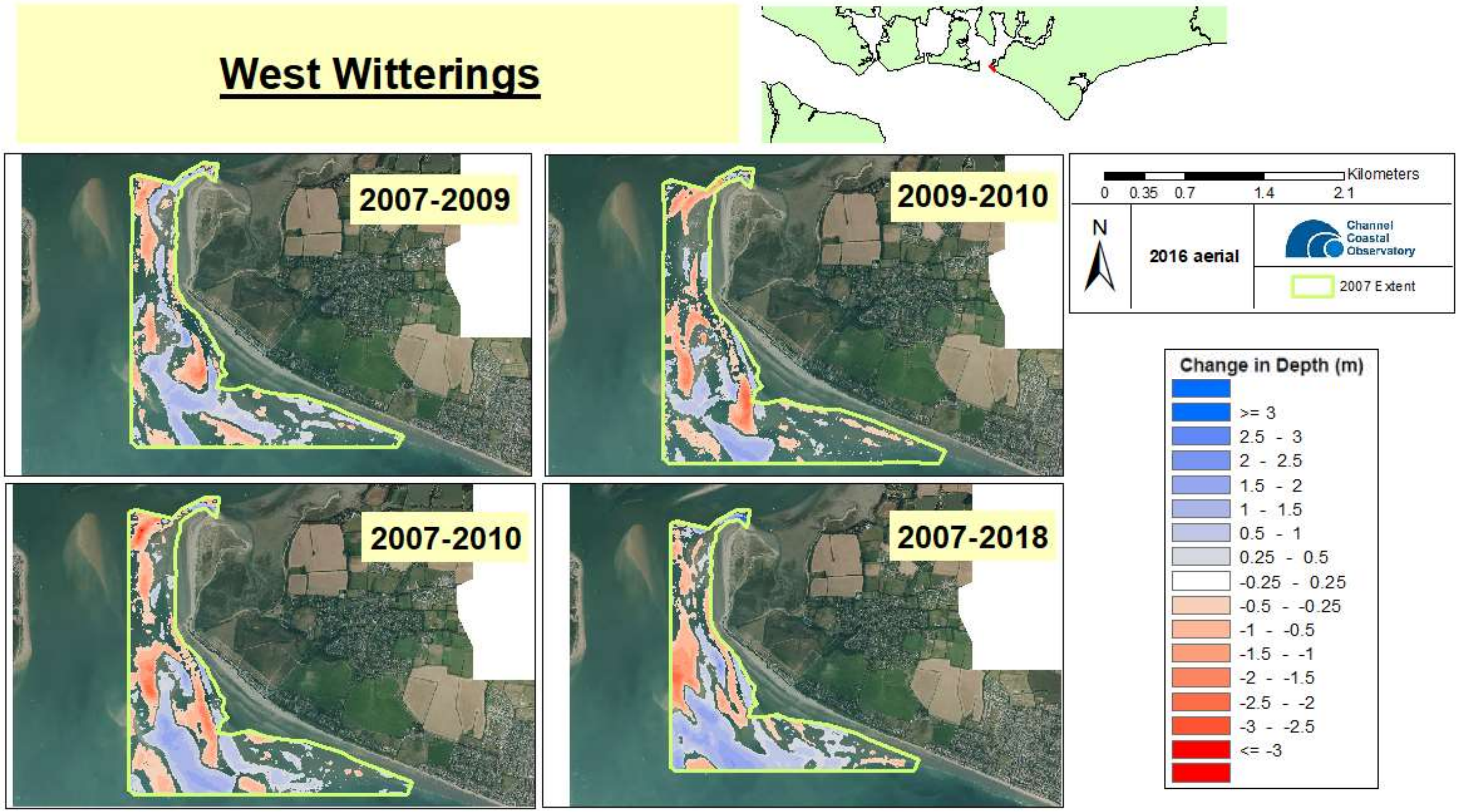

Figure 15 *Time Series Analysis of Depth Change from 2007 - 2018*

3.3. In site Medmerry & Pagham Turbidity Analysis

Initial analyses confirms similar diurnal and lunar hydraulic and turbidity patterns in Medmerry and Pagham. Figure 20 provides a visualisation of a data sample for one week in winter 2016. When individual high turbidity events were compared, initial findings indicate that extra-ordinary spikes (not following the usual rhythm) during the rising tide period, do not necessarily occur across both sites simultaneously.

As the Medmerry breach was still in an extreme stage of flux during the data collection period and exposed to the pre-dominant South-Westerly winds, then analyses is still ongoing to eliminate direct wind and locally formed wind wave impacts on turbidity levels.

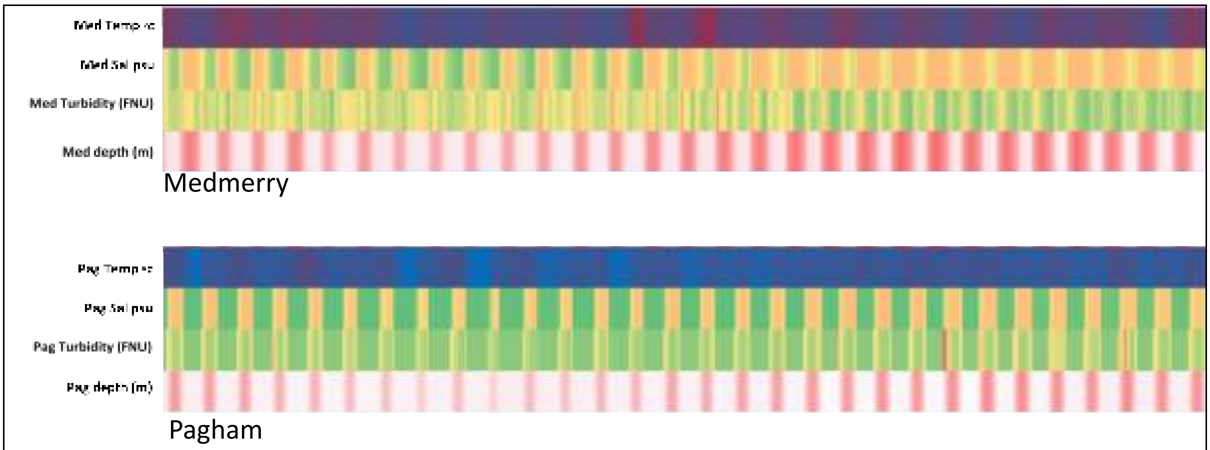

Figure 20: Sample visualisations of rhythms within Medmerry MR and Pagham Harbour for winter 2016 (note the two plots are not the same time period). The darker the colour the higher the value for the variable.

3.4. Sediment Particle Size Analysis

As of December 2020, a baseline dataset of particle size distribution is being collected. **Figure 16** provides an overview of the particle distribution results for the 13 sample sites analysed to date, with the data presented in **Table 4**.

Table 4 *Distribution of sand, mud and gravel in 13 samples processed in 2020*

	Mud (Silt & Clay) %	Sand %	Gravel %
A1 Starboard	1.1	84.7	14.2
A1 Stern	1.8	65.2	33.0
A1 Bow	10.6	86.2	3.2
A1 Port	4	44.4	51.6
A1 Starboard + 30m	6.6	16.9	76.5
A1 Bow + 30m	4.1	93.2	2.7
A1 Stern + 30m	4.9	13.1	82
A1 Port + 30m	10	42	47.9
Mixon Reef Top (a)	1.9	13.5	84.6
Mixon Reef Top (b)	2.1	29.1	68.8
Far (Outer) Mulberry East (Bognor) End	0.5	98.7	0.7
Medmerry Breach	0.4	99.3	0.3
Landing Craft Bracklesham Bay	6	80.7	13.3

The AI submarine wreck lies west of Bracklesham Bay, in approximately 12m of water. This was chosen as a sampling site as a known fixed point on the sea bed which is regularly dived, with historic sampling and where divers have documented changes in sedimentation patterns. The submarine is oriented with its bow facing North West. Two sets of sample were collected here, adjacent to and 30m from the wreck itself. On the starboard and stern of the wreck, a significant increase in the percentage of gravel, and decrease in sand are found with distance from the wreck. This coincides with a slight increase in the amount of fine, muddy material. To the bow and port of the wreck, there is little change with distance. This is one of the few sites for which there was existing data. Samples were also collected in 2009, and are summarised in **Table 5**. It appears there has been a coarsening of the bed sediments over the past decade.

For a more detailed analysis of all the samples taken to date, including particle distribution graphs and images of the location site and samples, please see TR113 sediment sampling analysis report (Searles, 2021).

Table 5 *Sediment definition, based on the Arithmetic Method of Moment Calculated findings of A1 samples (Sullivan, 2009)*

		A1 Bow	***A1 Starboard***	***A1 Port***
2009	***Textural Group***	Sandy Mud	Muddy Sand	Sandy Mud
	Sediment Name	Fine Sandy Fine Silt	Fine Silty Fine Sand	Fine Sandy Medium Silt
	Silt and Clay Percentage (<63 microns)	57%	47%	60%
	>63 microns Percentage	43%	53%	40%
2020	***Textural Group***	Slightly Gravelly Sand	Gravelly Sand	Sandy Gravel
	Sediment Name	Slightly Very Fine Gravelly Very Fine Sand	Fine Gravelly Very Fine Sand	Sandy Medium Gravel
	Silt and Clay Percentage (<63 microns)		20.69%	
	>63 microns Percentage			

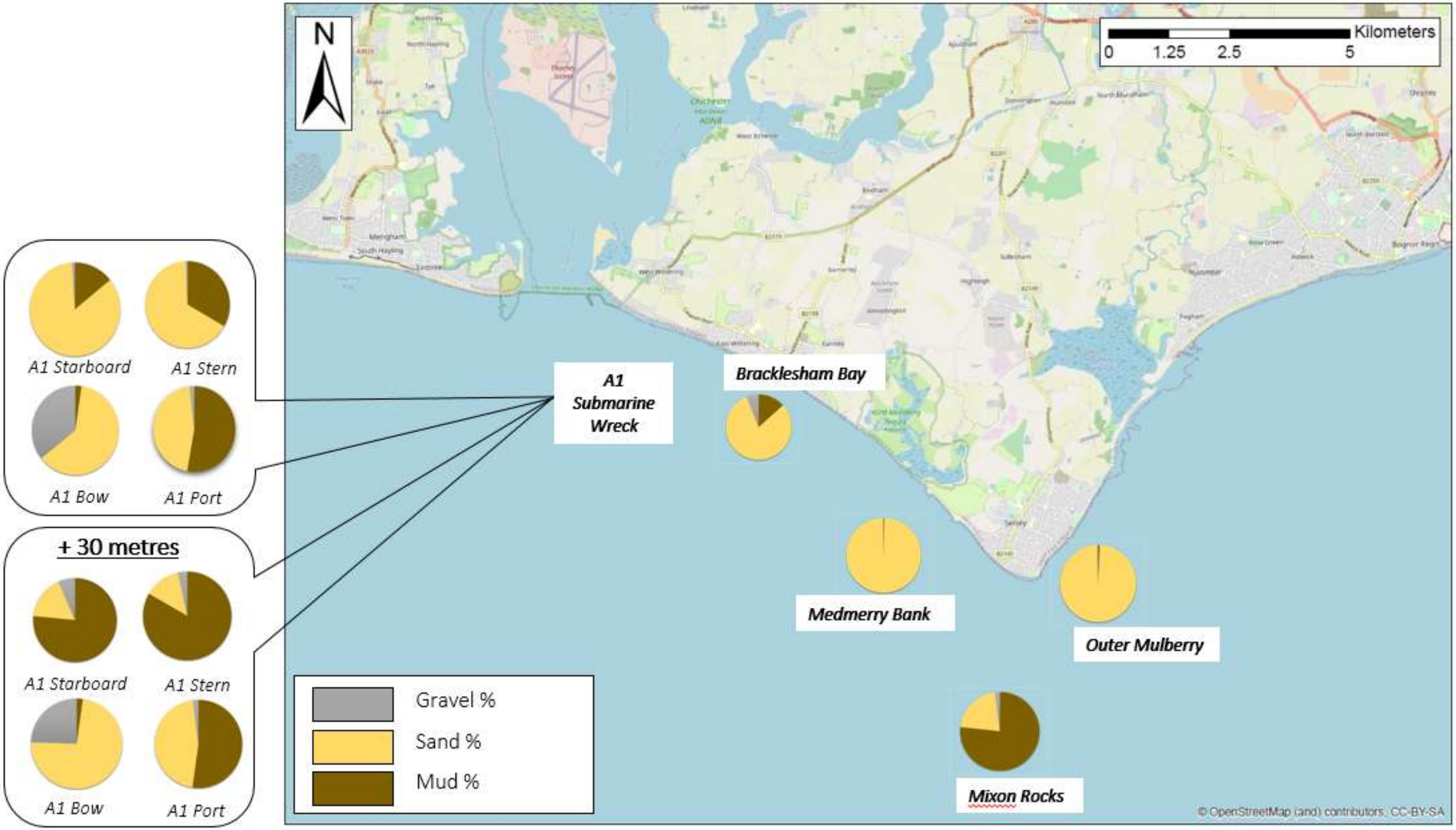

Figure 16 *Particle Size Distribution Charts for 13 Samples Processes and Analysed*

3.5. Hydrodynamic Data

3.5.1 Storms and wave conditions

Annual reports[5] for each of the wave buoy sites provide full details of the general wave conditions at the three locations. A recent study undertaken on behalf of SCOPAC[6] also summarises trends in the hydrodynamics within the area of interest.

All sites have an increasing trend in wave height, although not one that is statistically significant, i.e. the trends may be due to natural variability in wave parameters, and occur by chance. Increasing trends in wave period are also noted, although again these trends do not appear to be statistically significant. One issue is that the wave records are relatively short for determining longer term trends, given the natural variability in wave conditions. As wave records increase, it will become apparent whether these are actual trends or not. The wave power, an indication of the energy at the shoreline) and run up both also show upwards trends, although the statistical significance of these varies.

Table 6 shows the number of storm events (where the significant wave height exceeds the storm thresholds defined in Section 2.3). The 2013/14 storm season stands out in terms of numbers of events, but there have been other years that also experienced a high number of storms, in particular measured at the Hayling Island location. There have been approximately 34 named storm events (MetOffice, https://www.metoffice.gov.uk/weather/learn-about/past-uk-weather-events, 2020) over the period since 2015, however these do not always result in wave heights sufficient to define a storm at the buoy locations.

Table 6 Number of significant storm events per year at each buoy site

	2003	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Bracklesham Bay						2	6	2	3	4	8	8	6	6	4	5	4
Rustington	1	3	4	5	4	5	6	2	2	4	8	7	3	6	5	6	2
Hayling Island	1	3	3	4	6	8	9	3	1	3	2	8	3	7	4	7	4

Key:

1	2	3	4	5	6	7-9

Number of recorded storm events

[5] https://coastalmonitoring.org/reports/#southeast
[6] https://southerncoastalgroup-scopac.org.uk/scopac-research/scopac-storm-analysis-study/

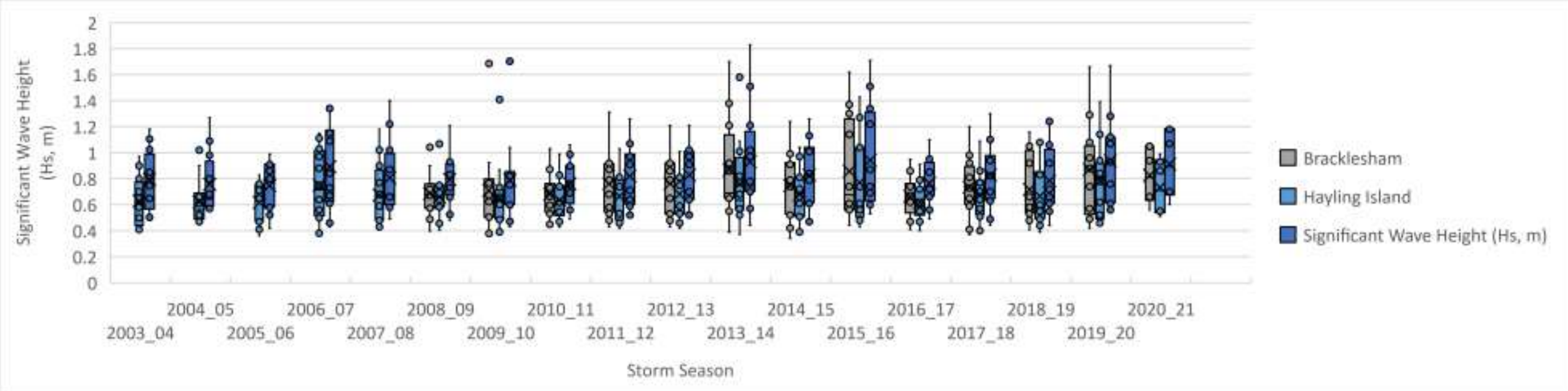

Figure 17 Mean monthly *Significant Wave Height, Hs (m) for the Bracklesham Bay, Hayling Island and Rustington Buoys*

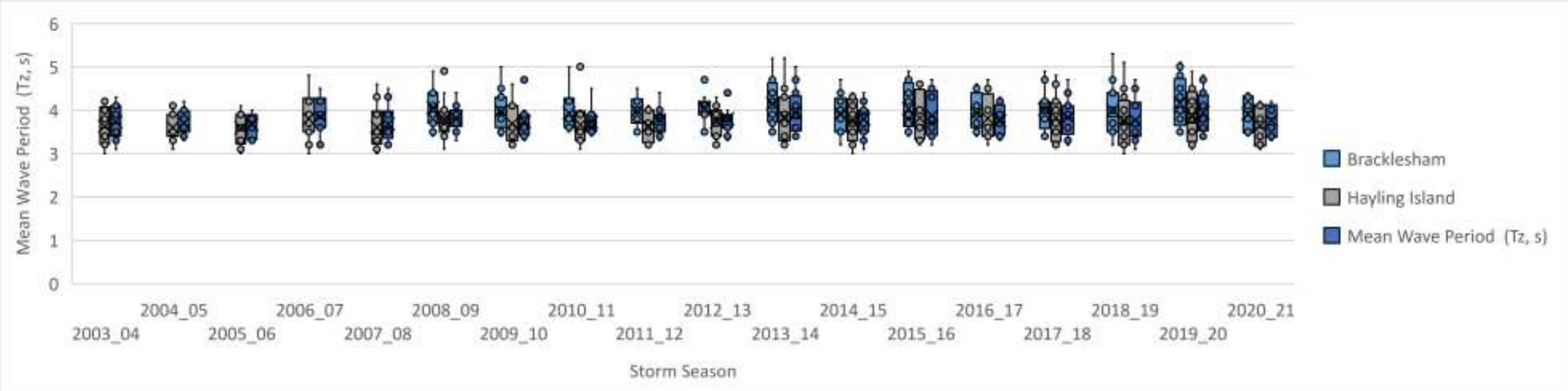

Figure 18 Mean monthly Mean Wave Period, Tz (s) for the Bracklesham Bay, Hayling Island and Rustington Buoys

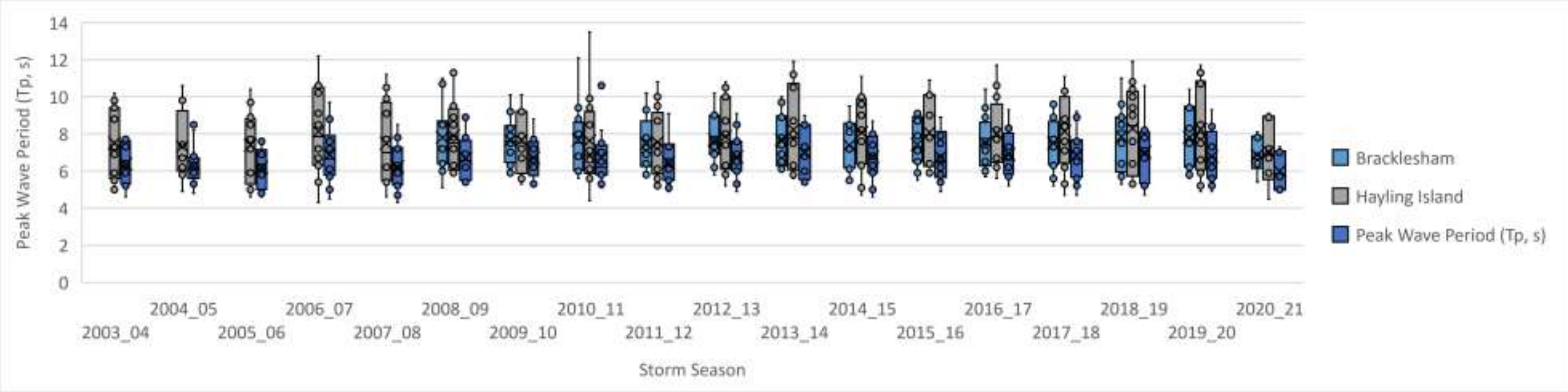

Figure 19 Monthly mean Peak Period (s) for the Bracklesham, Hayling Island and Rustington Buoys

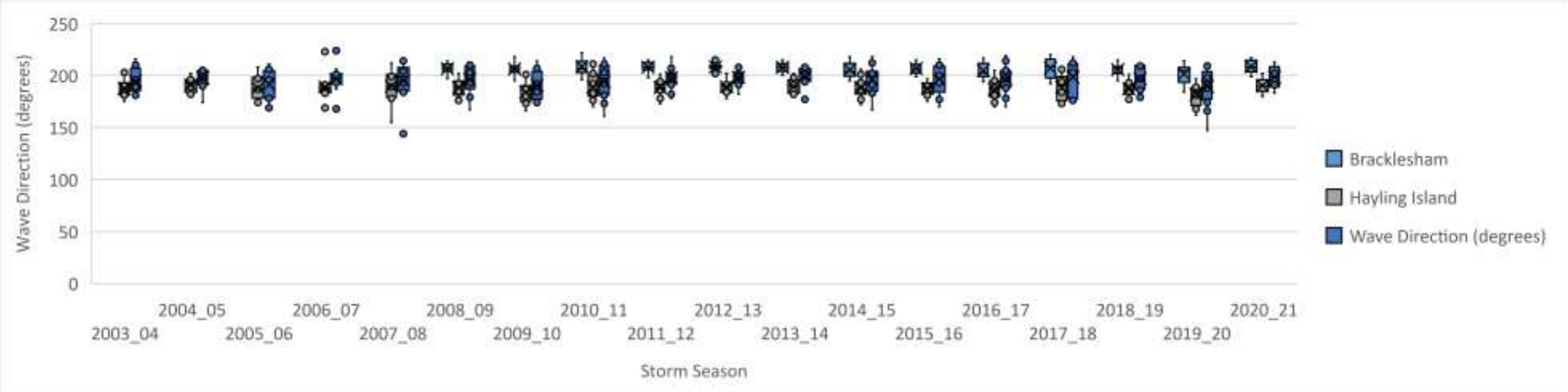

Figure 20 Monthly mean Wave Direction (°) for the Bracklesham, Hayling Island and Rustington Buoys

Figure 17 to ***Figure 20*** show box and whisker plots of mean monthly averages for Significant Wave Height, Mean Wave Period, Peak Period and Direction, separated into Storm Seasons (July – June). 2013-2014, 2015-2016 and 2019-2020 stand out in terms of maximum significant wave heights, but there are no clear trends. Mean wave period seems to show a consistently increased spread between the first and third quartiles appears to be higher since 2013-2014. However, it should again be noted that the time series is short for this type of analysis.

3.5.2. Bimodality

A bimodal sea state exists where high energy swell waves generated in the Atlantic Ocean occur alongside locally generated wind waves (shorter period but higher wave height). The result is a high energy environment that can do a lot of damage through increased overtopping of beaches and sea defenses[7].

CCO have calculated the percentage of bimodal seas monthly, as a percentage, for all wave sites. **Figure 22** shows these figures, illustrating that these conditions are most common over the winter periods, during November to February. ***Figure 21*** illustrates these in a box and whisker plot. 2006-07, 2015-16, 2018-19 and 2019-20 all exhibit higher bimodality, but the record is too short to determine trends. The highest values for both mean and maximum bimodality per storm season is 2015-16 for all the buoys.

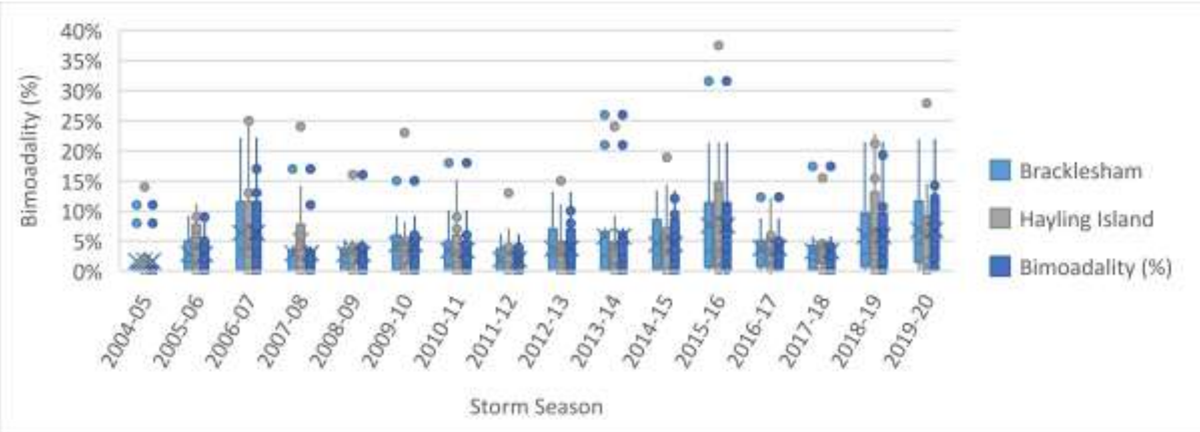

Figure 21 Percentage of conditions exhibiting bimodality, based on storm season

[7] https://coastalpartners.org.uk/bimodal-summary

Bracklesham Bay

	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	Monthly Average
July	3%	1%	1%	0%	0%	0%	1%	2%	0%	0%	1%	1%
August	0%	0%	0%	3%	0%	1%	1%	2%	1%	0%	2%	1%
September	0%	0%	5%	0%	0%	0%	1%	4%	2%	2%	8%	2%
October	5%	5%	4%	2%	8%	9%	4%	0%	5%	2%	11%	5%
November	19%	5%	12%	5%	3%	13%	9%	2%	2%	19%	14%	9%
December	9%	2%	10%	18%	25%	3%	32%	6%	6%	23%	20%	14%
January	7%	11%	8%	11%	25%	12%	24%	3%	15%	3%	19%	13%
February	6%	18%	1%	4%	31%	6%	12%	13%	2%	5%	30%	12%
March	3%	0%	3%	1%	3%	5%	5%	4%	4%	11%	10%	4%
April	2%	1%	3%	8%	3%	0%	3%	0%	4%	2%	1%	2%
May	0%	2%	0%	0%	1%	1%	0%	0%	1%	2%	3%	1%
June	0%	1%	3%	1%	0%	0%	0%	2%	0%	0%	1%	1%
Storm season average	5%	4%	4%	4%	8%	4%	8%	3%	4%	6%	10%	

Hayling Island

	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	Monthly Average
July	0%	1%	0%	3%	1%	2%	1%	1%	0%	0%	0%	2%	3%	0%	1%	0%	1%
August	1%	0%	0%	NaN	4%	1%	NaN	0%	3%	0%	1%	1%	2%	3%	0%	3%	1%
September	3%	2%	3%	1%	1%	1%	NaN	4%	0%	0%	0%	1%	2%	2%	2%	6%	2%
October	14%	7%	7%	0%	3%	4%	3%	2%	3%	9%	5%	4%	1%	5%	2%	8%	5%
November	0%	9%	7%	0%	4%	23%	7%	NaN	5%	5%	14%	14%	1%	2%	23%	NaN	8%
December	NaN	2%	25%	14%	4%	8%	2%	13%	15%	NaN	4%	38%	7%	4%	21%	NaN	12%
January	NaN	11%	25%	24%	16%	5%	9%	7%	11%	NaN	19%	21%	4%	16%	3%	14%	13%
February	2%	5%	13%	7%	5%	5%	15%	1%	4%	24%	7%	15%	12%	3%	6%	28%	10%
March	NaN	8%	5%	8%	2%	3%	0%	2%	2%	3%	7%	8%	6%	5%	15%	10%	6%
April	0%	1%	0%	3%	0%	2%	0%	4%	3%	2%	1%	2%	0%	3%	4%	2%	2%
May	1%	6%	3%	0%	3%	0%	1%	0%	NaN	4%	1%	0%	0%	1%	1%	1%	1%
June	0%	0%	1%	1%	0%	0%	2%	4%	NaN	0%	0%	0%	2%	0%	0%	0%	1%
Storm Season Average	2%	4%	7%	6%	4%	5%	4%	3%	5%	5%	5%	9%	3%	4%	7%	7%	

Rustington

	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	Monthly Average
July	0%	0%	0%	2%	NaN	3%	0%	1%	0%	0%	0%	2%	3%	1%	1%	1%	1%
August	1%	0%	0%	1%	3%	1%	0%	0%	3%	0%	1%	1%	4%	1%	0%	2%	1%
September	NaN	2%	4%	0%	0%	0%	1%	3%	0%	0%	0%	0%	5%	3%	3%	4%	2%
October	8%	9%	3%	0%	1%	6%	0%	4%	3%	7%	9%	4%	1%	4%	3%	9%	4%
November	0%	5%	7%	NaN	1%	15%	6%	NaN	4%	3%	13%	10%	1%	NaN	21%	10%	7%
December	NaN	1%	17%	11%	2%	6%	2%	NaN	13%	5%	3%	32%	9%	NaN	19%	14%	10%
January	11%	0%	13%	17%	16%	6%	10%	6%	10%	21%	12%	21%	3%	17%	1%	12%	11%
February	NaN	0%	22%	4%	5%	9%	18%	2%	NaN	26%	6%	12%	12%	3%	6%	22%	10%
March	NaN	2%	6%	NaN	2%	4%	0%	2%	2%	5%	6%	6%	5%	6%	11%	1%	4%
April	NaN	9%	0%	NaN	0%	3%	2%	1%	8%	NaN	1%	2%	1%	4%	3%	2%	3%
May	NaN	5%	3%	NaN	4%	0%	1%	0%	0%	2%	2%	0%	0%	1%	2%	5%	2%
June	0%	1%	1%	0%	0%	0%	1%	4%	2%	0%	0%	0%	3%	0%	0%	0%	1%
Storm Season Average	3%	3%	6%	4%	3%	4%	3%	2%	4%	6%	4%	8%	4%	4%	6%	7%	

0%	>0%	>2%	>5%	>10%	>15%	>20%	>25%	>30%	>35%

***Figure 22** Bi-modal occurrence (%) for the 3 wave buoy sites. See **Figure 4** for relative positions of the buoys.*

3.5.3. Tidal time series

A time series analysis of annual mean sea level at Arun Platform is presented in ***Figure 23***, with years with a 95% or better recovery rate indicated in black. Those years will low data recovery rates are provided in grey for reference.

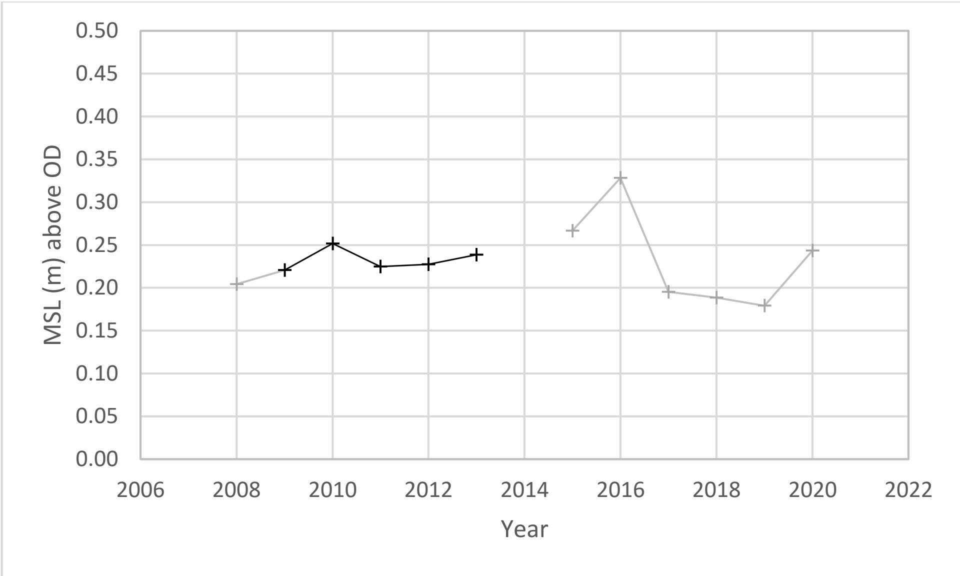

Figure 23 *Annual Mean Sea Level At the Arun Platform* Tide Gauge

Unfortunately, the record is too short to determine long-term trends. However, a study of 9 tide gauges across the English Channel shows with high confidence that mean sea level is rising, with the rate of rise accelerating in recent years (Wadey, 2020).

A table of the annual mean sea level values can be seen in **Table 7** Arun Platform Annual Mean Sea Level. The table shows Annual Mean Sea Level Elevation in units of 'metres, above Ordnance Datum'

Table 7 *Arun Platform Annual Mean Sea Level*

Year	Annual Mean Sea Level Elevation (m, aOD)	Data Recovery (%)
2008	0.20	99
2009	0.22	99
2010	0.25	98
2011	0.22	98
2012	0.23	100
2013	0.24	98
2014	-	0
2015	0.27	67
2016	0.33	27
2017	0.20	58
2018	0.19	71
2019	0.18	51
2020	0.24	29

3.6. Sea Surface Temperature

Monthly sea surface temperature (ºC) measured by the Bracklesham Bay wave buoy between 2011 and 2018 (**Figure 24**) shows a trend of increasing temperatures for all months except November, as illustrated in **Figure 25**. These increases are small, and the time series relatively short, however the relationships are statistically significant and may be an indication of coastal warming.

A time series analysis of the sea surface temperatures at Bracklesham Bay and Pagham Harbour site shows a steady increasing trend of surface temperature over the past 9-10 years at both sites (**Figure 26**).

	2011	2012	2013	2014	2015	2016	2017	2018	2019
Jan	5.73	8.05	7.09	3.04	7.34	8.50	7.17	7.59	7.66
Feb	6.24	5.76	5.88	5.72	N/A	7.76	7.01	6.23	7.16
Mar	7.06	8.29	5.35	8.18	6.83	7.54	8.63	5.80	8.76
Apr	10.31	10.33	6.93	10.88	10.08	9.65	11.23	9.47	10.72
May	13.22	12.66	10.83	13.28	12.34	13.07	13.50	13.60	13.40
Jun	14.63	14.83	13.87	16.51	14.94	16.05	15.65	16.73	16.17
Jul	16.06	16.58	17.99	18.73	17.37	17.79	19.01	20.75	19.34
Aug	17.50	18.09	19.07	18.04	17.65	18.68	18.66	20.00	19.38
Sep	16.49	16.57	17.58	N/A	16.27	18.43	16.11	17.74	16.21
Oct	15.14	13.66	15.16	N/A	13.92	13.65	14.72	14.86	15.08
Nov	12.80	10.86	11.09	N/A	12.34	11.39	12.05	11.55	11.05
Dec	9.26	8.14	8.47	4.87	10.98	9.07	8.20	9.54	8.87

***Figure 24** Monthly Sea Surface Temperature (ºC) as measured by the Bracklesham Bay wave buoy*

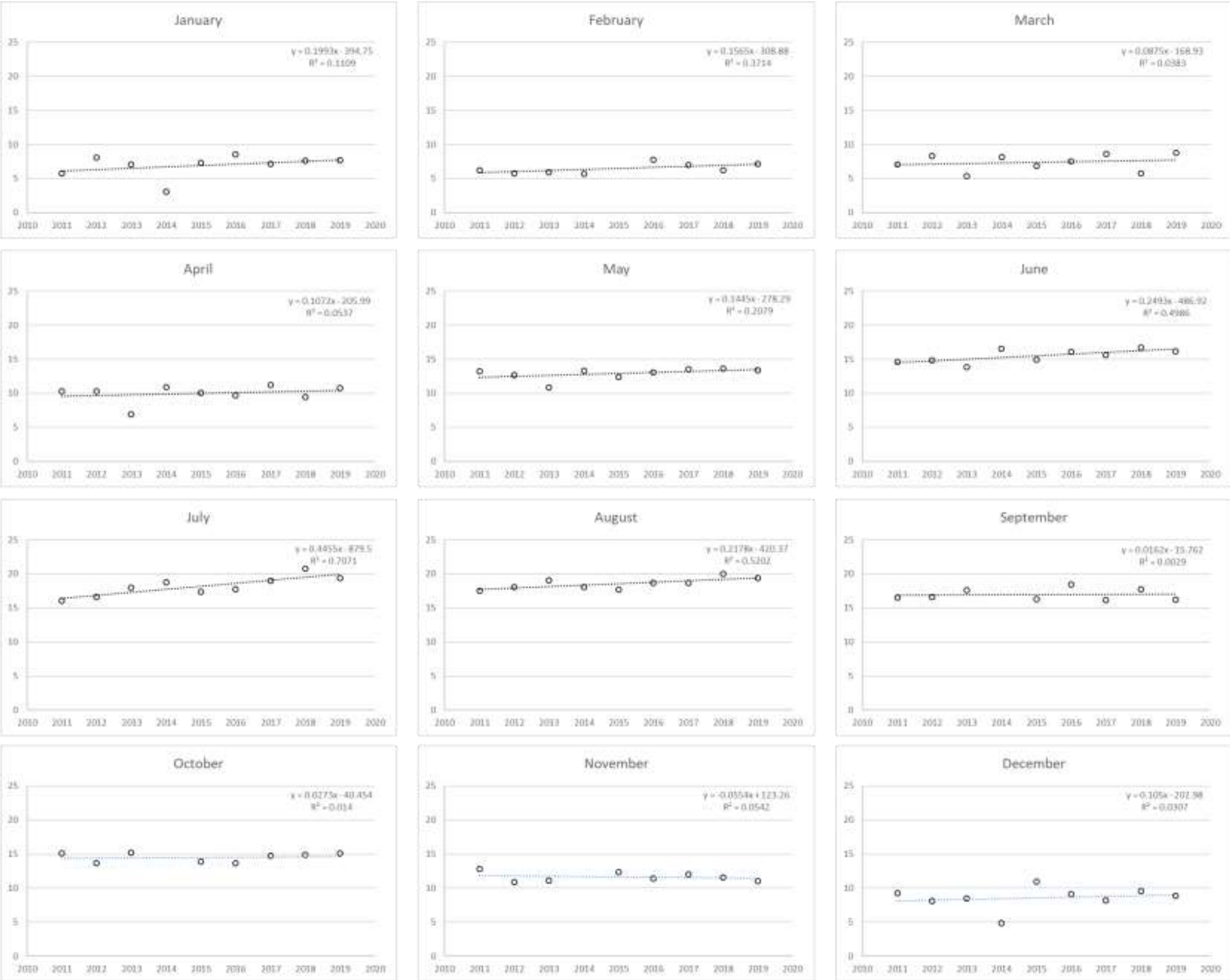

Figure 25 *Mean Sea Surface temperatures (ºC) measured by the Bracklesham, Bay wave buoy, presented by month.*

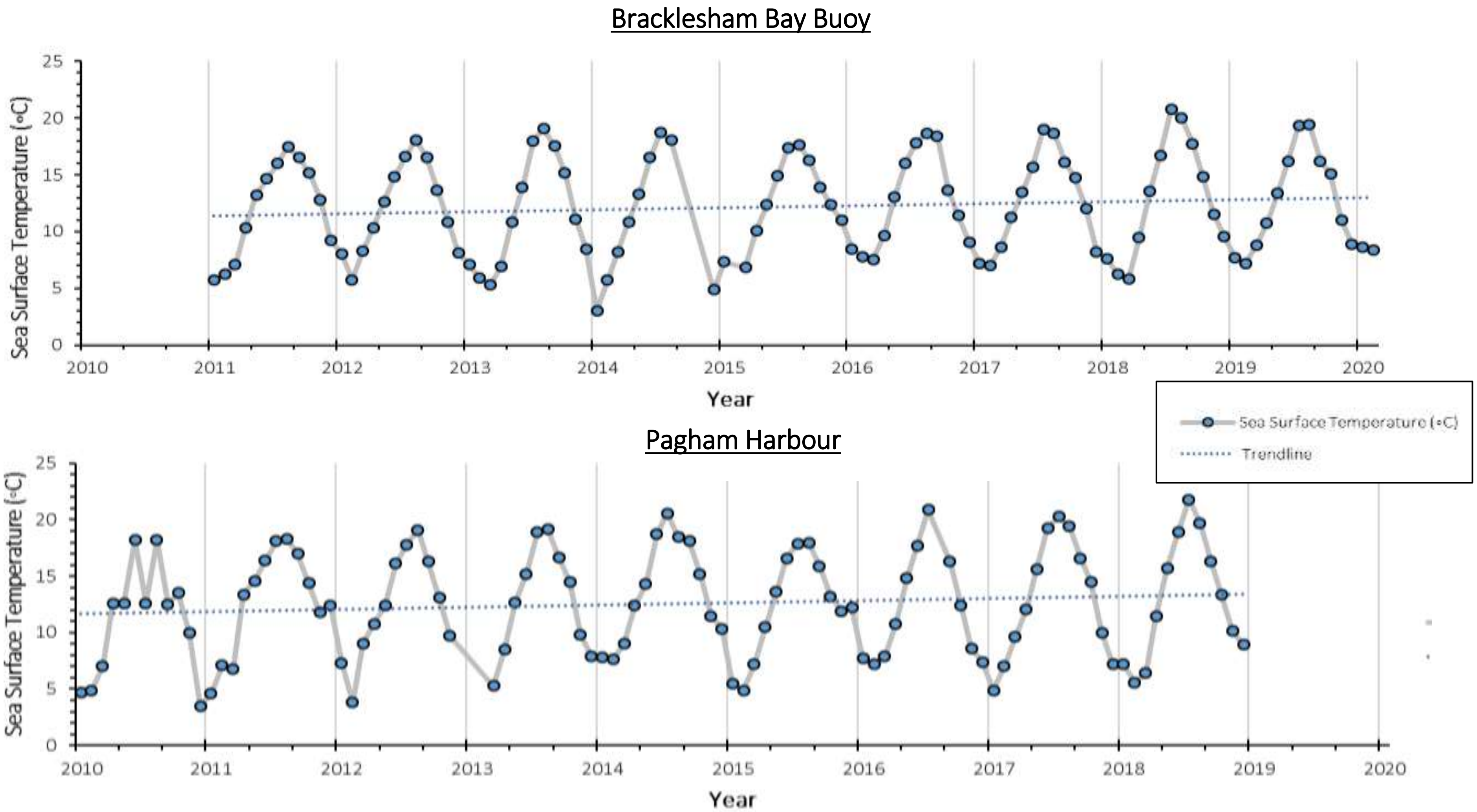

Figure 26 *Sea Surface Temperature Time Series comparison between the Bracklesham Bay wave buoy and measured within Pagham Harbour*

3.7. Secondary Data Results

A timeline of significant events has been produced; collated from a variety of sources, as presented in ***Figure 27*** with the key sources used presented in Table 8.

Table 8 *Key Sources Used for Timeline of Significant Events*

Timeline key	***Sources***
SFIV Interview (Sediment) SFIV Interview (Species)	Selsey fishermen and other marine users were asked for their observations on changes to the marine environment. Interviewees were asked when and where changes were noticed, particularly during the last 10 years. *Selsey Fishermen Interviews x 7* *Other* • Chichester District Council x 2 coastal officers • Mulberry ME x 2 marine education specialists • Southsea Sub Aqua Club
Material Disposal Sites	• CD: Capital Disposal ○ (CEFAS, 1997) • MD: Maintenance Disposal
Extreme Weather Events	• (MetOffice, https://www.metoffice.gov.uk/weather/learn-about/past-uk-weather-events, 2020) • (MetOffice, 2020)b
Anthropogenic – Sea Defences	• (Robinson & Williams, 1983) • (Duvivier, 1961) • (CCD, 2012) • (MMO, 2020) • (ADC, 2020)
BMP (Beach Management Plan) Strategies	• (Bone, 2018)
Natural Sediment Change	• (Williams, 2005)[i] • (West, 2018)

A summary of changes to the population of species across the Selsey fishing grounds area of interest has also been produced (**Table 9**). The table lists the observed changes over time to species, particularly the crab and lobster species. Anecdotal observations from the Selsey fishermen interviews have been used to produce this summary. A key of the locations and their acronyms is provided below***.***

Site Locations: **Key**

Mm: Medmerry
MR: Mixon
BR: Bognor Rocks
H: Hounds
P: Pullar
I: Inshore from Middle Grounds

S: Street
SY: Selsey
IO: The Inner Owers
EB: East Beach
G: The Grounds
SP: Shoal Point

Bb: Boulder Bank
B: Bracklesham bay area
PH: Pagham Harbour
MH: Mulberry area
Blank - location not specified

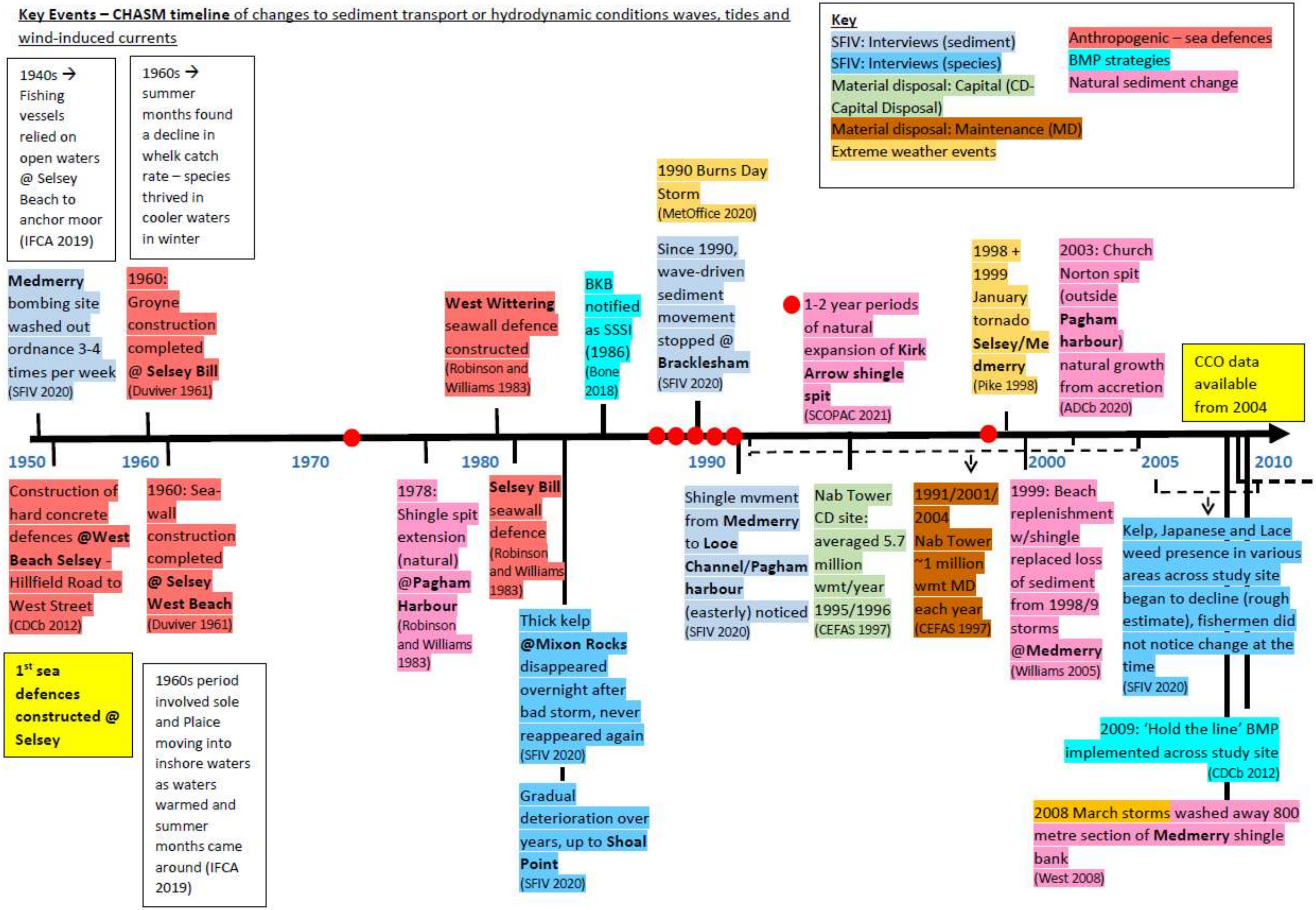

Figure 27 Timeline of significant events

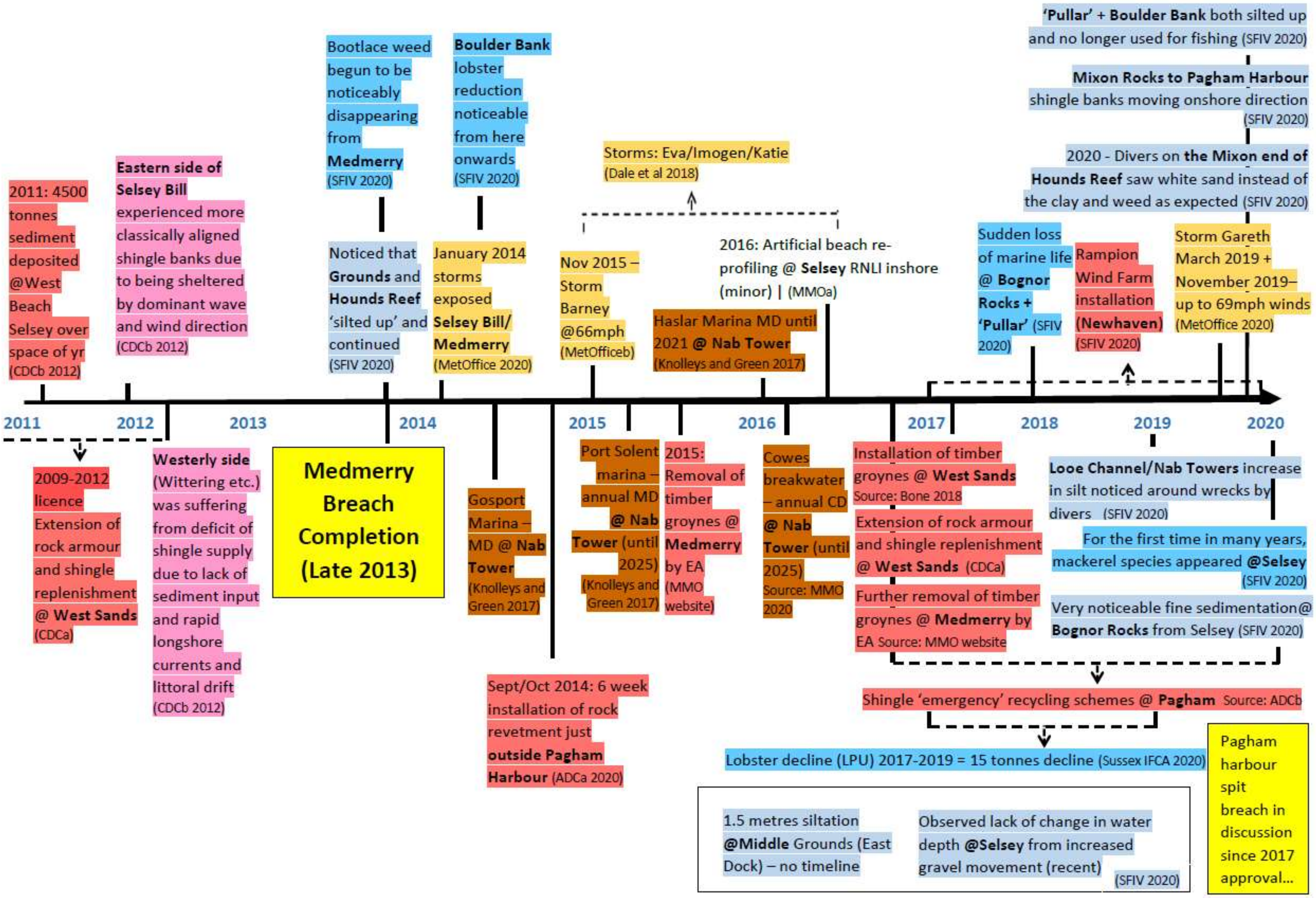
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2011: 4500 tonnes sediment deposited @West Beach Selsey over space of yr (CDCb 2012)
Eastern side of Selsey Bill experienced more classically aligned shingle banks due to being sheltered by dominant wave and wind direction (CDCb 2012)
Bootlace weed begun to be noticeably disappearing from Medmerry (SFIV 2020)
Boulder Bank lobster reduction noticeable from here onwards (SFIV 2020)
Noticed that Grounds and Hounds Reef 'silted up' and continued (SFIV 2020)
January 2014 storms exposed Selsey Bill/ Medmerry (MetOffice 2020)
Storms: Eva/Imogen/Katie (Dale et al 2018)
Nov 2015 – Storm Barney @66mph (MetOfficeb)
2016: Artificial beach re-profiling @ Selsey RNLI inshore (minor) | (MMOa)
Haslar Marina MD until 2021 @ Nab Tower (Knolleys and Green 2017)
Sudden loss of marine life @ Bognor Rocks + 'Pullar' (SFIV 2020)
Rampion Wind Farm installation (Newhaven) (SFIV 2020)
Storm Gareth March 2019 + November 2019– up to 69mph winds (MetOffice 2020)
'Pullar' + Boulder Bank both silted up and no longer used for fishing (SFIV 2020)
Mixon Rocks to Pagham Harbour shingle banks moving onshore direction (SFIV 2020)
2020 - Divers on the Mixon end of Hounds Reef saw white sand instead of the clay and weed as expected (SFIV 2020)
2009-2012 licence Extension of rock armour and shingle replenishment @ West Sands (CDCa)
Westerly side (Wittering etc.) was suffering from deficit of shingle supply due to lack of sediment input and rapid longshore currents and littoral drift (CDCb 2012)
Medmerry Breach Completion (Late 2013)
Gosport Marina – MD @ Nab Tower (Knolleys and Green 2017)
Sept/Oct 2014: 6 week installation of rock revetment just outside Pagham Harbour (ADCa 2020)
Port Solent marina – annual MD @ Nab Tower (until 2025) (Knolleys and Green 2017)
2015: Removal of timber groynes @ Medmerry by EA (MMO website)
Cowes breakwater – annual CD @ Nab Tower (until 2025) Source: MMO 2020
Installation of timber groynes @ West Sands Source: Bone 2018
Extension of rock armour and shingle replenishment @ West Sands (CDCa)
Further removal of timber groynes @ Medmerry by EA Source: MMO website
Looe Channel/Nab Towers increase in silt noticed around wrecks by divers (SFIV 2020)
For the first time in many years, mackerel species appeared @Selsey (SFIV 2020)
Very noticeable fine sedimentation@ Bognor Rocks from Selsey (SFIV 2020)
Shingle 'emergency' recycling schemes @ Pagham Source: ADCb
Lobster decline (LPU) 2017-2019 = 15 tonnes decline (Sussex IFCA 2020)
1.5 metres siltation @Middle Grounds (East Dock) – no timeline
Observed lack of change in water depth @Selsey from increased gravel movement (recent) (SFIV 2020)
Pagham harbour spit breach in discussion since 2017 approval...

Table 9 Table of Changes to Species Populations from Records of F*ishermen* Interviews in 2020

	Crustaceans			Sea Snails	
Species Name -->	**Crabs**	**Lobster**	**Spider Crab**	**Whelks**	**Winkles**
Year					
2020	Not as healthy	P			IO
2019		MR/BR/G/H/B			IO
2018		SP			
2017	Crabs not as affected by water quality, don't hide from storms. Source Unknown. Cadmium found in brown crabs				
2016		Bb			
2015					
2014					
2013					
2012		linked w/			
2011		increase in			
2010		smooth hounds			
2009					
2008					IO
2007					
2006					
2005					
2004					
2003					
2002					
2001					
2000					
1990-1999					
1980-1989		Bb/SY/P/MR			
1970-1979					
1960-1969					
1950-1959					
1940-1949					
1930-1939					
1900-1929					
1800s					
1700s					

Sea weed						
Kelp	**Weed**	**Lace Weed**	**Seaweed**	**Bootlace Weed**	**Black weed**	**Japanese Weed**
		SY/EB	SY/EB		P	BR/MR
					P	
				BR	P	
				BR		
H/S/P/MR						
PH/G/P						
		SY	SY			MR/BR
MR (storm)			SY			SY
Everywhere			SY			SY
		EB/IO				

	Sea Snails		Starfish and Sea Urchins	
Species Name -->	**Whelks**	**Winkles**	**Brittle Stars**	**5 fingered starfish**
Year				
2020		IO		
2019		IO		
2018				
2017		IO		
2016				
2015				
2014				
2013				
2012				
2011				
2010				
2009				
2008				
2007				
2006				
2005				
2004				
2003				
2002				
2001				
2000				
1990-1999				
1980-1989				
1970-1979				
1960-1969				
1950-1959				
1940-1949				
1930-1939				
1900-1929				
1800s				
1700s				

'Wipe out' mussel beds, brittle stars and whelks Correlate with spider crabs

Species Name -->	Cuttlefish	Herring	Skate	Cod	Whiting
Year					
2020					
2019	MH				
2018					
2017					
2016					
2015					
2014					
2013					
2012					
2011					
2010					
2009					
2008					
2007					
2006					
2005					
2004					
2003					
2002					
2001					
2000					
1990-1999					
1980-1989					
1970-1979					
1960-1969					
1950-1959					
1940-1949					
1930-1939					
1900-1929					
1800s					
1700s					

Species Name -->	**Plaice**	**Soles**	**Mackerel**	**Mullet**	**Smooth-hounds**
Year					
2020			SY	SY	
2019					
2018					
2017			SY		
2016					
2015					
2014					Mm
2013					
2012					
2011					
2010					
2009					
2008					
2007					
2006					
2005					
2004					
2003					
2002					
2001					
2000					
1990-1999					
1980-1989					
1970-1979					
1960-1969					
1950-1959					
1940-1949					
1930-1939					
1900-1929					
1800s					
1700s					

Feed on lobsters, crabs, small fish

Thrive in warm conditions Weed eaters - no weed, mullet die or migrate

4. Discussion

The coastline between East Head and Pagham, West Sussex is dynamic and has a history of management intervention dating back to at least the 1950s. Observations related to species populations in the area, based on interviews with local fishermen, indicate that many species of plants and marine animals have declined since the turn of the century. Recent observations show that the decrease has accelerated in the last few years. Strategic coastal monitoring of the area, which constitutes the data presented herein, only extends back to ~2003. Wider historic data from the area may yield additional insight, but was beyond the scope of initial investigations and funding.

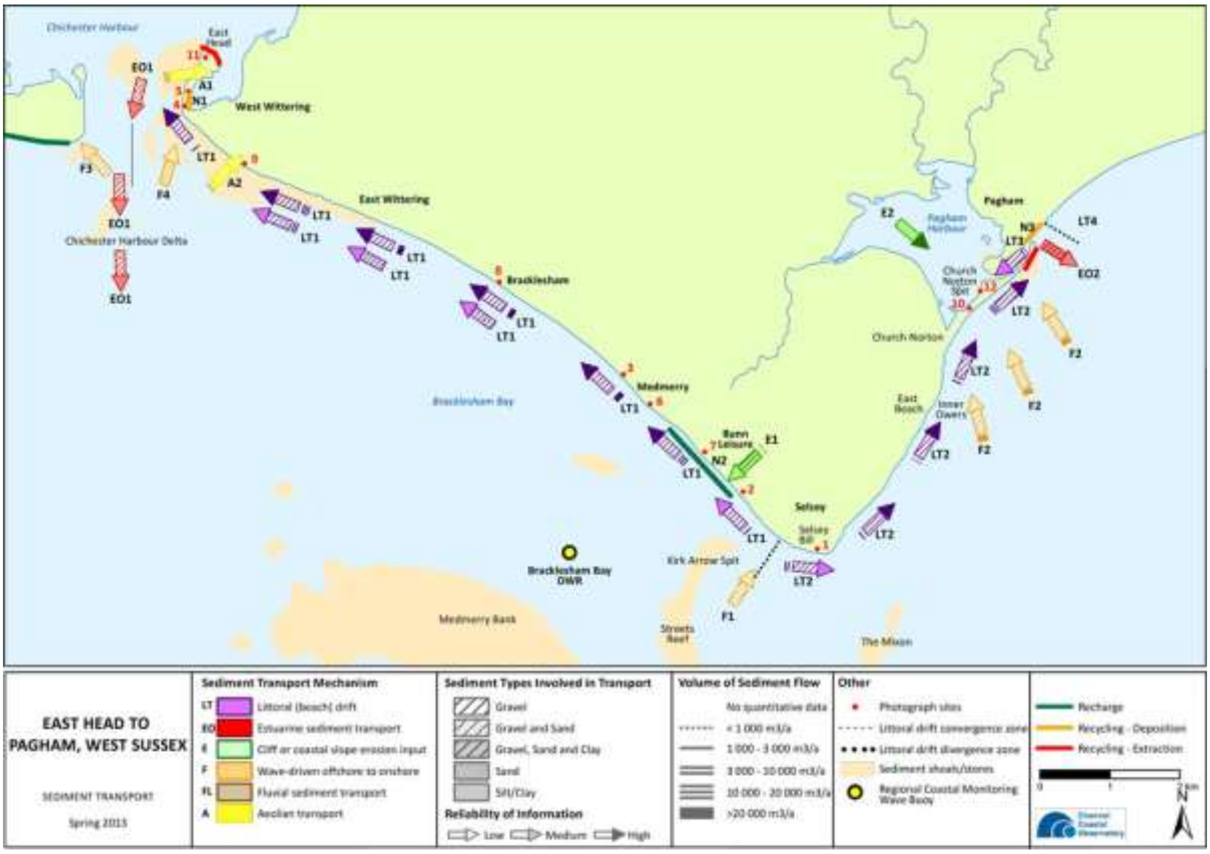

Figure 28 SCOPAC sediment Transport Study (2012), New Forest District Council

The SCOPAC Sediment Transport Study (2012) shows the predominant sediment transport mechanisms in the area, and identify a drift divergence located to the west of Selsey Bill. Transport to the East of the Bill is towards the North East, and to the West of the Bill is towards the North West. However, this does not incorporate the significant changes to sediment and hydro-dynamics associated with the breaching of the Medmerry Managed realignment site in 2013, and does not reflect the perpetual east/west current movement found in Bracklesham Bay.

The reanalysis of the topographic data before and after this intervention, which coincided with the extreme 2013/14 storm season, show a change from accretion to erosion for the coastline between Selsey Bill and Pagham Harbour. However, the area is dynamic showing annual variability rather than a chronic trend, which is likely responding the variability in wave conditions. For example, the recent observation, of a large deposit of shingle on a slipway along the Selsey Bill to Selsey coastline (figure 37), occurred after a series of events associated with long period swell in early 2021. On the West side of Selsey Bill, there is significant erosion associated with Medmerry, which is feeding the littoral drift northwards.

Subtidal bathymetry indicates steady erosion associated with Medmerry, as one might expect, and the dynamic movement of sand bars associated with East Head, fed by the longshore drift. However, it should be noted that bathymetric data was limited in spatial extend and frequency, and multiple observations have been made of increased sedimentation in the area such as in Looe Channel and Mixon Rocks. A dataset of sediment samples to compare to the baseline data may provide better understanding on how sediment distribution has changed in these areas. Initial comparisons suggest a coarsening of the sediment associated with the A1 submarine wreck.

Figure 29 *Selsey Slipway Beach Level Increase in* April 2021 (Martin Davies 2021)

Relating these shoreline changes to wave and tidal conditions is challenging, as the records are not long enough to statistically confirm trends, and topographic profiles are relatively low frequency. However, wave height, wave period and bi-modality do appear to show a non-significant trend of increase over the available time series. We can be more confident that sea level is increasing, and that this increase has been accelerating.

Relating both shoreline changes and hydrodynamic trends to the changes seen by the fisheries is even more complex, and would likely be the result in changes to water quality (suspended sediment), bed sediment, or other environmental factors yet to be explored. The period of 2017-2019 showed the largest decline in landing weight of lobsters on record, of 15 tonnes (Sussex IFCA, 2020). This correlates with anecdotal observations for the Bognor Rocks and Pullar regions. This period was not particularly stormy (when defined by Significant wave height), and while the 2018-2019 storm season did show some high bimodality, this was certainly not the highest values experienced in recent years which occurred in 2015-16. However, since the 2013-14 storms, the Bracklesham Buoy has recorded more storms on average per year (5 per year) than it did in the preceding period (3 per year). This difference is not as pronounced at the other two buoy locations, because they have been recording for a shorter period, and the storm threshold calculation is statistical.

However, other environmental changes may have an influence on fisheries success. Sea Surface Temperature (SST) does appear to be increasing across the region, which although small in magnitude for most months, equates to an approximately 4ºC change over a decade for the month of July. An in-depth study looking at longer-term temperature trends over a much wider area of interest, is being undertaken at the University of Southampton which might lead to additional insight.

While the coastal monitoring data presented provides an overview of change to the coast and hydrodynamics over the past 10-15 years, it was not designed to answer wider questions regarding fisheries or water quality, and has highlighted several knowledge gaps. To better understand the issues, and work towards solutions, further work needs to be undertaken to better understand the lifecycle of the species affected, water quality changes, and wider-field effects such as dredging and dredge spoil disposal in the area.

5. Conclusion

The past year of investigation has raised a number of interesting topics for further investigation:

- Sediment movement and bathymetric changes
- Impact of dredging
- Sewage inputs into Bracklesham Bay
- Water column monitoring
- Fishing effort
- Runoff from agricultural activities and roads
- Coastal ocean warming and acidification
- Invasive species / species change and disease
- Lobster response to contaminants and sporadic freshwater input
- Freshwater input into the nearshore due to a rising water table
- Changes in density of micro / macro fauna in the nearshore including the MCZ
- Public engagement, outreach and communications.
- Improved links with neighbouring projects

Whilst there is a better understanding of the region's recent environmental change, the lack of correlative evidence shows the need for further analysis into specific aspects of the marine landscape round Selsey. These include analysis of sediment, water quality, land runoff, pollution and other factors that may have contributed to the decline in crabs, lobsters and other species, and changes to plant species, notably kelp and cord grass, in the Selsey area. A summary of the key research areas that will be explored further is given in **Table 10**, with more specific research topics listed. There is considerable potential for overlap on all elements, however funding opportunities are being explored to progress some or all of these topics in the future.

Table 10 *Potential Research Focus areas for development as part of the CHASM project*

Project Management	Public Engagement and Outreach	Crustaceans	Water	Fishing and fishing effort	Land inputs	Sediment
Annual Project Seminar	Events – crab and Lobster	Invasive species/species changes and disease	Water Quality Monitoring of nearshore and harbours	Interviews with maritime users/fishermen	Runoff – changes in land use and nitrate neutrality	Sediment movement and bathymetric change
Cross analyses of data	RSPB Pagham visitor events	Change in density in micro or macro fauna in the nearshore (MCZ)	Freshwater input into the near coastal environment (rising water table)	Catch Data (IFCA)	Runoff – changes in traffic density and road building	Dredging and dredge disposal
Data storage and dissemination (CCO)	Coast Snap – Medmerry	Lobster response to contaminant and sporadic freshwater	Coastal ocean warming and acidification	Changes in fishing practices	Air Quality – changes in traffic density	Characterisation of sediment type
	Citizen Science projects	Seasearch – survey and observation data (historical and new)	Environmental DNA		Tracing sewage outputs into Bracklesham Bay	Heavy metal, organic and chemical analysis
	Publicity Film	Heavy metal, organic and chemical analysis			Change in population density over time	Seabed habitat mapping
	School and Adult education engagement	Presence of fibreglass				
	Social Media campaign and comms					
	Approaching potential sponsors and influences					
	GIS mapping for communicating results					

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