Sussex Sediment Monitoring and Adaptive Response Workshop Report

18th May 2023

Terrace Room, Bramber House, University of Sussex

CHASM
Crustaceans Habitat and Sediment Movement

BLUE MARINE FOUNDATION

Sussex Kelp Recovery Project

THE REWILDING NETWORK
Supported by Rewilding Britain

Contents

Introduction

Sediment in Sussex is a complex issue which in some forms may impact fisheries and limit kelp recovery. Despite activities undertaken by Blue Marine Foundation and the CHASM (Crustaceans, Habitat And Sediment Movement) project since 2021 involving a broad range of stakeholders, not all the sources or impacts of sediment are yet fully understood. There is however, an urgent need to move towards action.

The focus of the workshop therefore looked to identify what steps *can* be taken forward to help address potential negative impacts of sediment in Sussex, including which of 50 pre-defined CHASM work packages and tasks have the most support from workshop attendees, and to draw out any potential options for funding/collaboration.

- The **Sussex Sediment Monitoring and Adaptive Response Workshop** funded by Rewilding Britain and hosted by Blue Marine Foundation and CHASM, brought together 41 stakeholders from over 27 cross-sector organisations on 18th May 2023.

- 10 speakers - representatives from government agencies, NGOs, universities, local authorities and research consultancies – shared their learnings and views in presentations and panel Q&As. The slides from all presentations can be viewed here: https://drive.google.com/file/d/16aCwXlpcHvvzrlOqihwvXpZqYCWGThON/view?usp=sharing

- Attendees working in smaller groups answered the following questions in relation to four topics: 'Sediment Transport Source to Sink', 'Dredging and Disturbance', 'Contaminants' and 'Crustaceans, Fishing and Fishing effort'.
    - What are your key priorities relating to this topic?
    - What are your key research questions relating to this topic?
    - What are you already doing to address some of these issues, or planning on doing?
    - What do you think are the evidence or activity gaps for these?

- Attendees then prioritised the CHASM work packages and tasks based on whether they would have the most impact or filled a research gap. Opportunities for collaboration relating to the work packages and any potential funding sources were also discussed.

Executive Summary

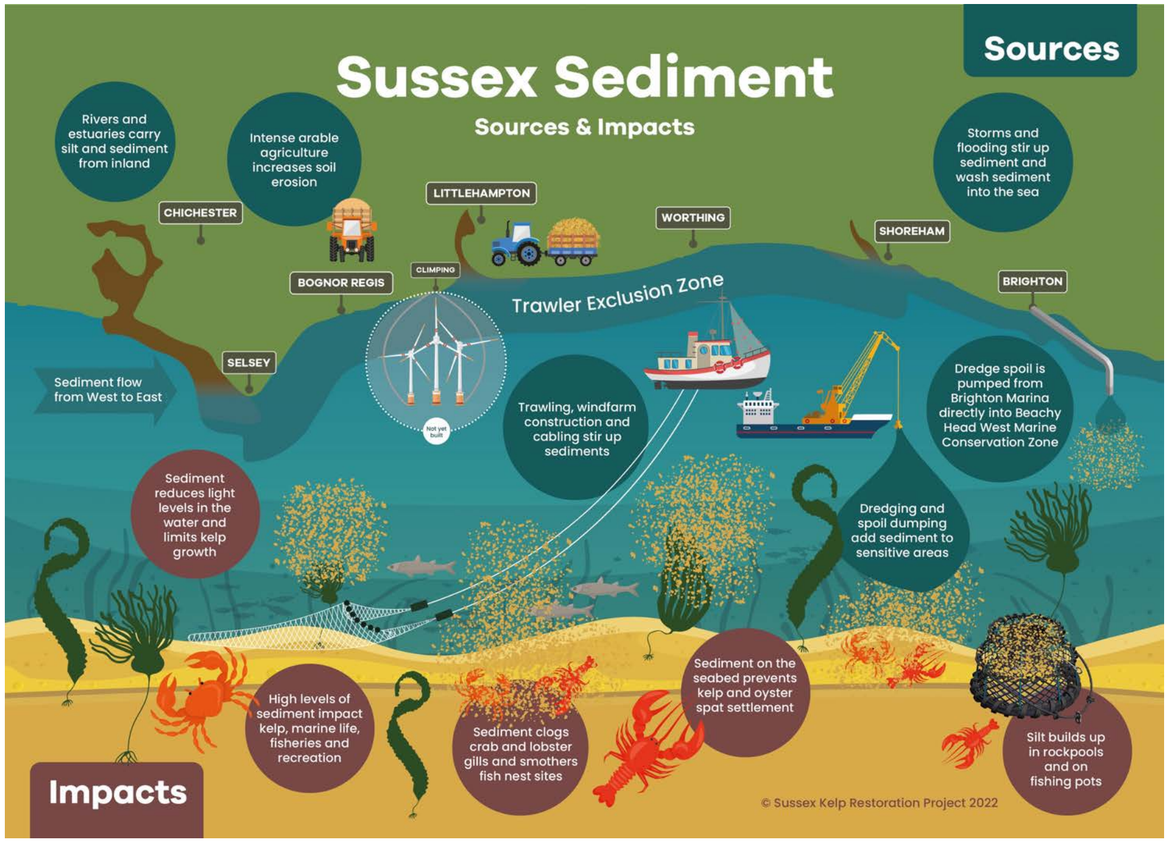
Historically, vast kelp beds stretched along more than 40 kilometres of the Sussex coast, teeming with life and providing vital habitat, nursery and feeding ground for a great diversity of species from seahorses and cuttlefish to lobster, sea bream and bass. However, since 1987, over 96 per cent of the area once covered by Sussex kelp has disappeared. Increased storm intensity, years of trawling and other human pressures had taken their toll on the underwater forest.

To help reverse this decline, the Sussex Inshore Fisheries and Conservation Authority (IFCA) introduced the Sussex Nearshore Trawling Byelaw in 2021, prohibiting trawling from over 300 square kilometres of seabed to allow the kelp to recover and protect essential fish habitats.

There are early reports of kelp returning, but also growing concern that changes in sediment dynamics and associated contaminants could hinder the full natural recovery of historic Sussex kelp beds and be directly impacting local shellfisheries.

From previous work (Appendix A), it is clear there are multiple sediment sources, both natural and anthropogenic, affecting Sussex coastal waters.

These sources and the pathways from source to sea are also highly dynamic, affected by climate change (rainfall patterns; sea level rise; wave climate; temperature change); impacts of population growth (sewage discharge; air quality; water extraction); land use change (urbanization; road run off; farming practices; river basin management); and maritime activities (port and marina operations; dredging and fishing practices; leisure/tourism activities).



Sediment sources and impacts. © Sussex Kelp Recovery Project 2022

Executive Summary – key themes

Identifying and monitoring these sources and pathways and their relative importance is a complex and challenging issue, and their dynamic nature requires our management response to take an adaptive approach.

The Sussex Sediment Monitoring and Adaptive Response Workshop on 18 May 2023, hosted by Blue Marine Foundation and the Crab and Habitat Sediment Movement (CHASM) project partners, brought together over 40 representatives from 27 organisations including government and fisheries agencies, local authorities, researchers, NGOs and local sea users.

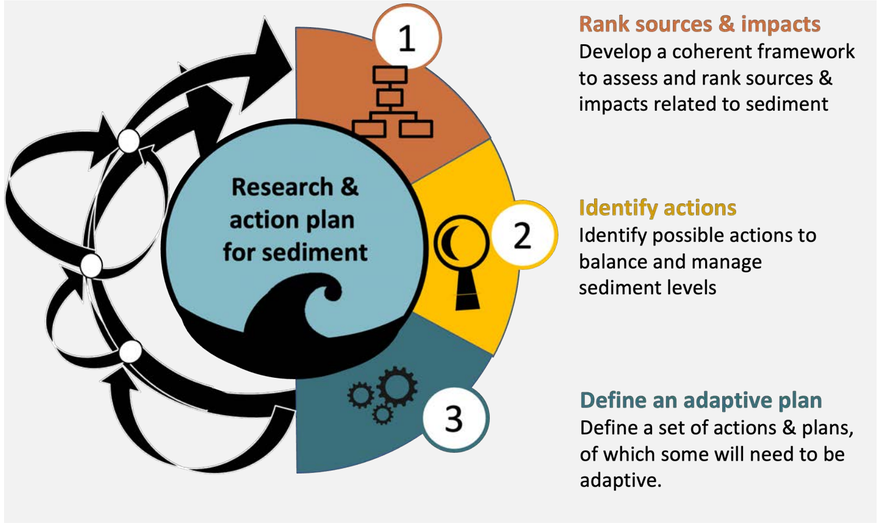
Ten presentations summarised current knowledge about sediment sources and impacts, monitoring and research initiatives. Breakout groups then reviewed and prioritised a package of 50 potential monitoring, research and management actions, identifying those of most concern to attendees.

The actions identified were grouped by CHASM into five areas of concern:

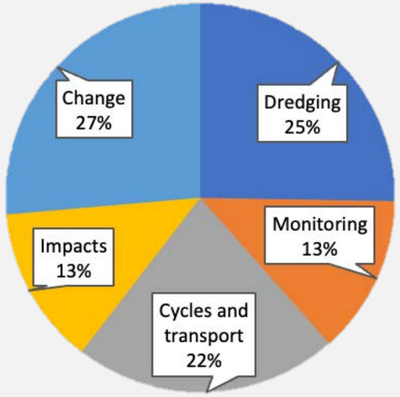
- **Assessment of changes over time –** including assessments of physical environmental change, and changes in species composition, fishing effort and fishing practices.
- **Dredging –** research on the impact of dredging and disposal (capital, maintenance and scallop dredging) on sediment levels and collation of existing data from, for example, Cefas and MMO licences.
- **Transport pathways and cycles –** understanding the sources of suspended sediment, in particular, where it goes and how sediment is recycled naturally within the ecosystem.
- **Impacts and Monitoring** - tasks linked to these two areas of concern were less of a priority to attendees.

The overall picture was that the lack of our fundamental understanding of, and trends in, the nearshore system must be prioritised before causal links to impacts can become the focus of ongoing work.

Developing an adaptive framework



Percentage of prioritised tasks falling within five areas of concern



Executive Summary – outcomes

Participants engaged in wide-ranging discussions (Appendix C) and, together with the work prioritisation exercises and the post-workshop survey results (Appendix B), the outcomes from the day can be summarised as follows:

- **Prioritisation** - 50 potential work streams identified by the CHASM project were prioritised collectively by a wide range of stakeholders, helping to identify the most important tasks for future research, monitoring and management intervention.
- **Assessment of the issue** – There are fundamental knowledge gaps about the sources, pathways and impacts of sediment and interactions between habitats and species, which need to be better understood before an effective response plan can be created.
- **Adaptive response** - An adaptive framework is necessary to address changes in sediment to take into account and respond to changes in climate, land use, fishing practices. The approach needs to consider multiple avenues and identify which have the greatest potential positive impact and return on investment.
- **Funding** – Lack of funding is a challenge due to the scale and complexity of the sources and potential impacts, which requires significant resourcing to assess, with access to major grants proving a challenge.
- **Awareness** – Policy makers, decision-makers and industry stakeholders need to be made more aware of the issues and level of concern regarding sediment to channel funding and integrated policies towards addressing them.
- **Action** – While there are knowledge gaps to fill, there is a strong case for action to be taken now and to learn lessons from other parts of the UK.
- **Connectivity** - Sediment is an issue that connects different areas, habitats and sectors, and to respond effectively and efficiently, a collective and cohesive approach is needed to draw together the various stakeholders and initiatives.

Executive Summary – conclusions and next steps

Sam Fanshawe (Blue Marine Foundation) concluded the day, summing up what had been achieved, the opportunities identified and the challenges to be addressed to collectively take action.

Prioritisation of CHASM work packages is a great first step

- Together, we have reviewed and ranked 50 work packages. That we have done so collectively gives us leverage and will help when it comes to funding.

Today we've collectively identified new collaborations and made new connections

- How do we keep these going? Is there value in keeping this network together? Please let us know if you think so.

There is a huge amount of activity in Sussex, but it is missing a way that brings it all together

- Sediment is an issue that connects different areas, habitats and sectors. Likewise, in Sussex, we need to show that all the projects underway are connected and part of a cohesive approach. There are some emerging initiatives that are already thinking about this, which we need to explore and potentially get behind.

An adaptive framework is necessary to address changes in sediment

- There is no single, linear route to tackle changes in sediment, and there will likely be many cul-de-sacs and digressions along the way. So our approach needs to consider multiple avenues to identify which ones have the biggest impact and work at the fastest speed – and then we need to work collectively to achieve them.

Funding is the next challenge

- There is no funding secured to support this work beyond today, and we've not had the opportunity to really explore it in this workshop. What do we need to move this conversation forward? How do we escalate this upstream to policymakers, decision-makers and those who hold the purse strings?

We need action – and visibility of the issue at all levels is key to this

- We can monitor and capture trends moving forward, but we've got to take some action now. We need to make it more visible to those who can take action. Government agencies have a key role to play. Raising the concerns expressed today about sediment internally at a high level is necessary to help prioritise resources and policy change.

In a follow up survey, participants were asked if they would be interested in joining a Sussex Sediment Working Group, with 70% of those responding confirming positively. To build on the consensus and sense of urgency reflected through the workshop, Blue Marine and CHASM will explore a number of steps to take forward, for which funding will be required:

- **Establish a Sussex Sediment Working Group.**
- **Produce a short briefing note to raise awareness within government bodies and amongst local policy and industry stakeholders.**
- **Explore potential funding sources such as Fisheries Industry Science Partnership to fill the priority knowledge gaps.**

Executive Summary – survey comments

17 attendees responded to the post workshop survey, representing a good cross-section of stakeholder groups.

Feedback about the experience of the workshop was overwhelmingly positive with respondents agreeing or strongly agreeing that they:

- understood the workshop's scope and purpose;
- found the workshop constructive;
- found information provided beforehand useful;
- would attend another Blue Marine Foundation workshop.

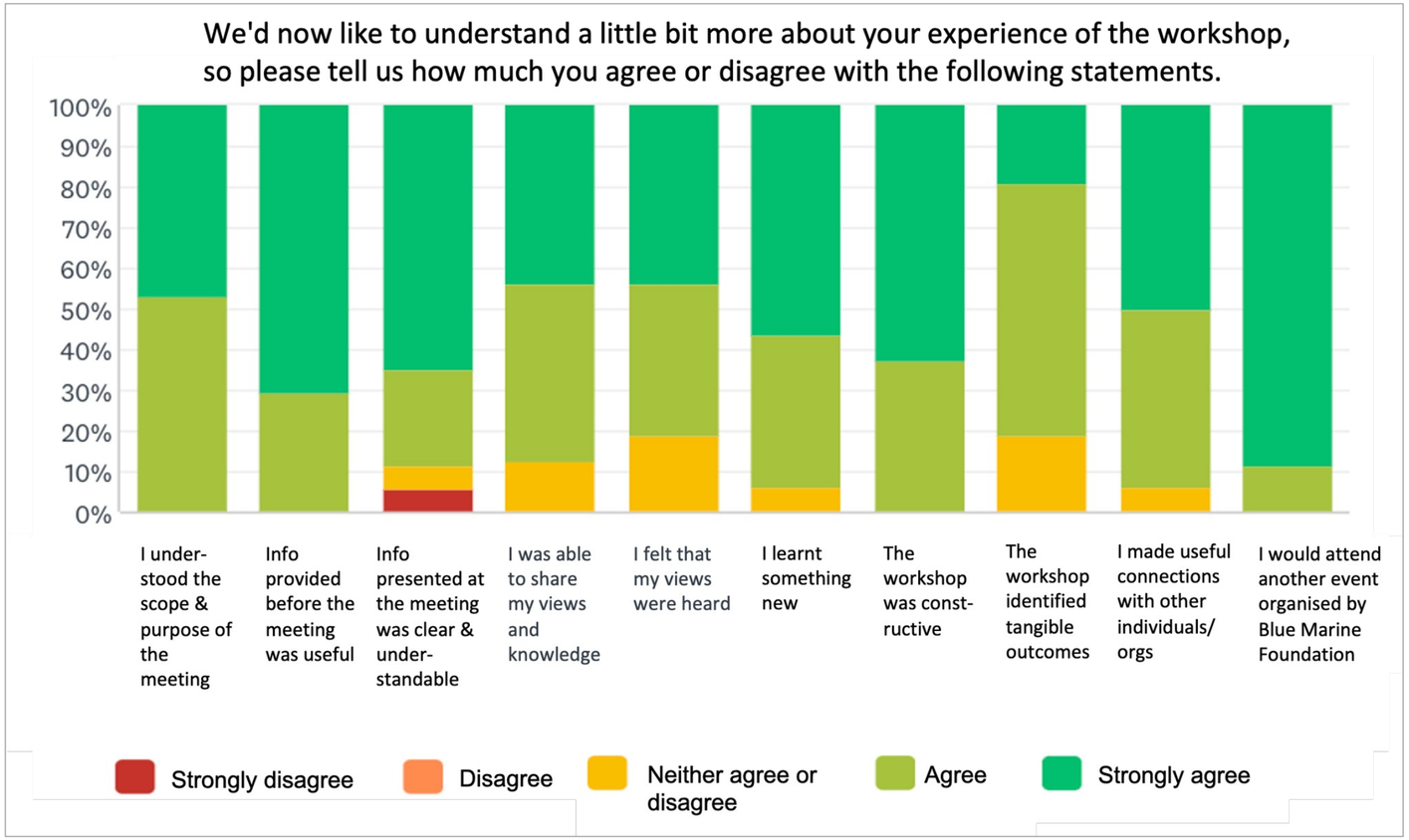
Aspects of the workshop where consensus was less than 100% positive included providing tangible outcomes, and the clarity of information presented on the day. In addition some attendees were not able to agree (or disagree) that they'd been able to share their views, or felt their views had been heard.

Future involvement

Responders expressed their interest in staying both informed and involved with the issue of sediment, and to be invited to future events:

- 70% (12) were interested in being part of a sediment working group
- 88% (15) wanted to be kept informed on sediment in Sussex
- 88% (15) wanted to be kept informed about future events from CHASM and Blue Marine Foundation.

The survey also gave attendees the opportunity to provide further feedback on some of the questions posed during the workshop.
Their responses are captured in Appendix D.



Workshop Overview

Workshop purpose and aims

Purpose

Develop a framework to target monitoring, future research and adaptive coastal management actions on priority areas that will achieve maximum effect to balance and manage sediment levels and optimize the conditions for natural kelp recovery and healthy habitats to support inshore shellfish populations.

Aims

- Bring together key stakeholders involved in research, monitoring and regulating inputs and impacts of sediment in Sussex coastal waters.
- Share current knowledge about trends in sediment inputs, pathways and impacts.
- Identify and prioritise future monitoring and research activities and actions, that will have maximum effect to balance and manage sediment levels and support future coastal management adaptation.

Attendees

Government agencies	Local Authorities	Research bodies/ Consultants	Industry representatives (non-fishing)	Fisheries representatives	Non-government bodies
• Crown Estate • Environment Agency • Marine Management Organisation • Natural England	• Adur & Worthing Councils • Arun District Council • Chichester District Council • Havant Borough Council • Sussex IFCA • Worthing Borough Council	• HR Wallingford • University of Brighton • University of Newcastle • University of Oxford • University of Portsmouth/ Seascape Restoration Research Network • University of Southampton • University of Sussex • Zoological Society of London	• Shoreham Port Authority* • Southern Water	• Bognor Fisherman's Association • Hastings Fisherman's Protection Society • Monteum Ltd • Seafish • Worthing Fisherman's Association	• Arun and Rothers Rivers Trust • Blue Marine Foundation • RSPB • Surfers Against Sewage • Sussex Underwater • Sussex Wildlife Trust • Weald to Waves

* Registered but didn't attend

Photos from the day

Workshop Presentation Abstracts

Assessing sources, impacts and solutions for sediment

Sam Fanshawe, Blue Marine Foundation

An overview of the Sussex Kelp Recovery Project (SKRP) partnership vision and mission to champion, study and facilitate the recovery of Sussex kelp and other essential fish habitats.

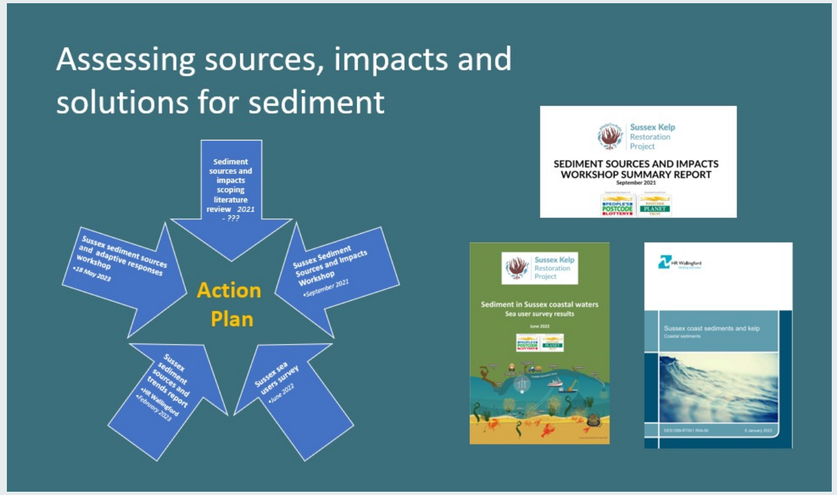
The SKRP has five core aims, one of which is to identify and minimise damaging impacts that could be a barrier to natural recovery of the kelp and other habitats. Following introduction of the Sussex IFCA Nearshore Trawling Byelaw, increased levels of sediment had been identified as a potential factor inhibiting kelp settlement and growth and impacting local crustacean fisheries.

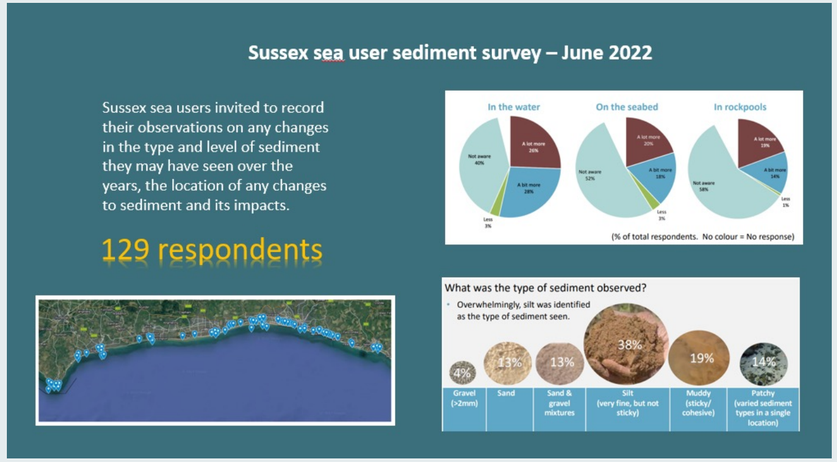
In response, Blue Marine Foundation on behalf of SKRP initiated a programme of work to gather and share the available knowledge and data on the sources, transport pathways, impacts and current management of sediment in Sussex waters to inform potential actions to reduce sediment inputs including:

- Sussex Kelp Recovery Project Sediment Sources and Impacts Workshop in September 2021, bringing together 40 stakeholders from over 25 organisations to share information and identify opportunities for further research, collaboration and management interventions.
- Sussex Sea Users Sediment Survey in June 2022 to gather observations of sediment type, location and potential sources from commercial and recreational sea users.
- Sussex Sediment Sources, Pathways and Trends Report commissioned from HR Wallingford by Blue Marine to collate available evidence on sediment budgets, transport, sources, sinks and trends in Sussex waters; and the current regulatory framework relating to management of sediment inputs.

These initiatives and the attendance at this workshop reflect a groundswell of interest and concern across many sectors about the levels and impacts of sediment in Sussex nearshore waters.

This workshop aims to bring together the many and varied stakeholders involved in monitoring and regulating sediment inputs, with local fishermen and sea users to collectively identify the priorities to achieve a balanced sediment system that minimises impacts on kelp, habitats and fisheries.





CHASM introduction

Jane Cunningham, Chichester District Council/CHASM

The fishing grounds near Selsey Bill, West Sussex, have traditionally been well managed and productive in common with many small inshore fisheries round the UK coast. Fishing in the area has been dated back to the Bronze Age, while individual fishing families can trace their roots back to the 1750s, 1600s and for one family, over 1000 years.

Huge changes in the fishing grounds have been seen in recent years. Local fishermen feel there has been more change in the last decade than in the previous 100 years.

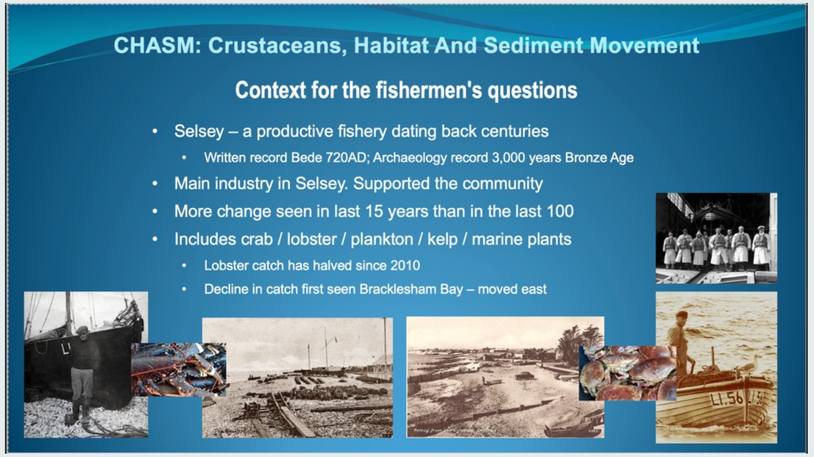
Something has affected the marine environment but it isn't clear what that is. However a number of factors are likely to be involved including human inputs and climate change. Should pollutants be identified as an issue there may be implications for water quality, the visitor economy and the wider community to consider.

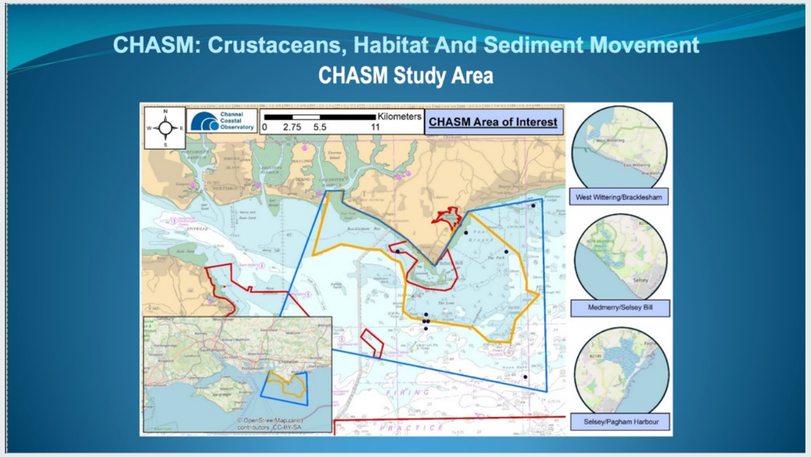
The Crustaceans, Habitat And Sediment Movement project was initiated in 2020 to explore the issues raised by two key questions from the Selsey fishermen

1. **Why are there so few crabs and lobsters now?**
2. **Why is there so much more sediment?**

The same questions are now being asked regionally and nationally. A good understanding of the nearshore area and associated water column is needed to understand what the changes are, why they happened, and whether mitigation measures are possible.

Partnerships between the fishing industry, academic institutions, local authorities, government agencies, special interest groups and NGOs are essential in order to explore the issues.





Sussex coast sediment regime

Dr Tom Benson and Mike Dearnaley, HR Wallingford

HR Wallingford was commissioned by Blue Marine Foundation to produce the Sussex Coast Sediments and Kelp report. Their presentation is a summary of the report's findings. The full report can be read here.

The kelp beds are located between Selsey Bill in the west and Beachy Head in the east (Top, right). The west of the region is characterised by low lying shingle beaches and coastal defences. East of Brighton, the coastline consists largely of undefended chalk cliffs.

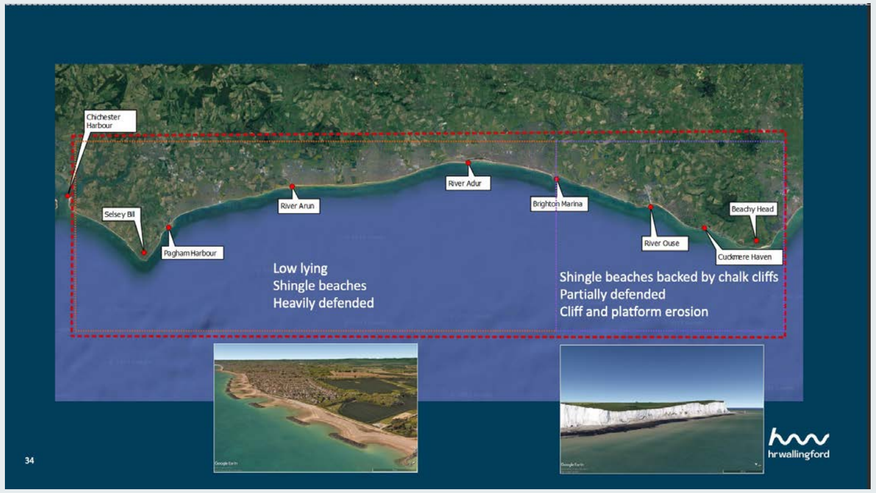
Eroded chalk and mud is much finer than sands and gravels and can be carried as suspended particulate matter (SPM) and contribute to turbidity. Higher turbidity results in less light available for photosynthesis by the kelp. SPM concentrations in the region are ~5-60 mg/l, higher inshore where waves interact with the seabed and, during storms, may be around ten times greater.

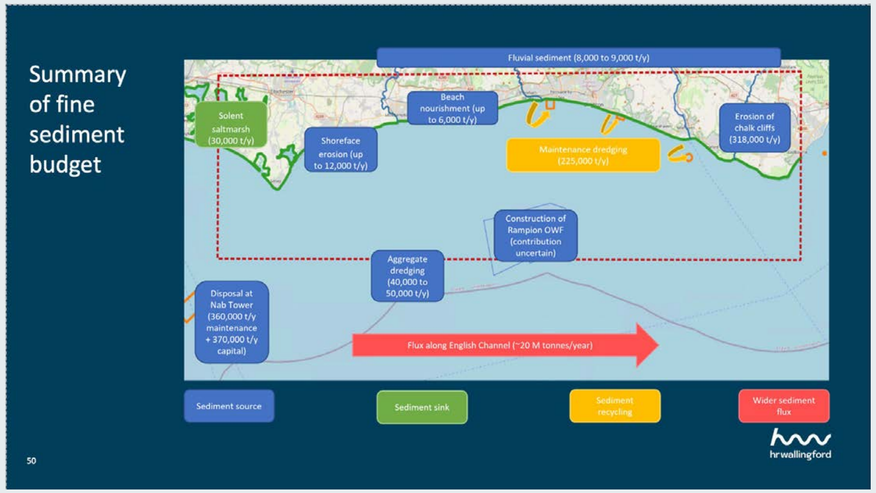
Modelled coastal currents indicate a complex residual flow pattern (in the absence of wind) with a westerly residual over the historic kelp bed area to the west of Brighton which turns southwards at Selsey Bill. Further offshore the residual currents are towards the east.

The main sediment sources and sinks of sediment along the Sussex coast were identified and quantified (Below, right). Some activities introduce new sediment (e.g. coastal erosion and beach nourishment), others recycle sediment already present or may increase resuspension by disturbing the seabed. The largest identified source is erosion of chalk cliffs, although the sediment volume transported through the English Channel is much larger than local sources.

Evidence of long-term trends in SPM is limited to a single study that used satellite derived SPM. This revealed a statistically significant increase in SPM only during the spring. Longer data records are needed. There is scope for future increases in SPM due to climate change (e.g. wave erosion due to higher sea level) and future changes to coastal management policies.

Further monitoring and modelling of fine sediment transport is recommended to better understand the potential sources, pathways and sinks of SPM.





Impact of suspended particulate matter on kelp recovery in Sussex Bay

Marianne Glascott, University of Sussex

To understand the impact of Suspended Particulate Matter (SPM) on kelp habitats, a PhD research study is underway at the University of Sussex. The study is comprised of three strands:

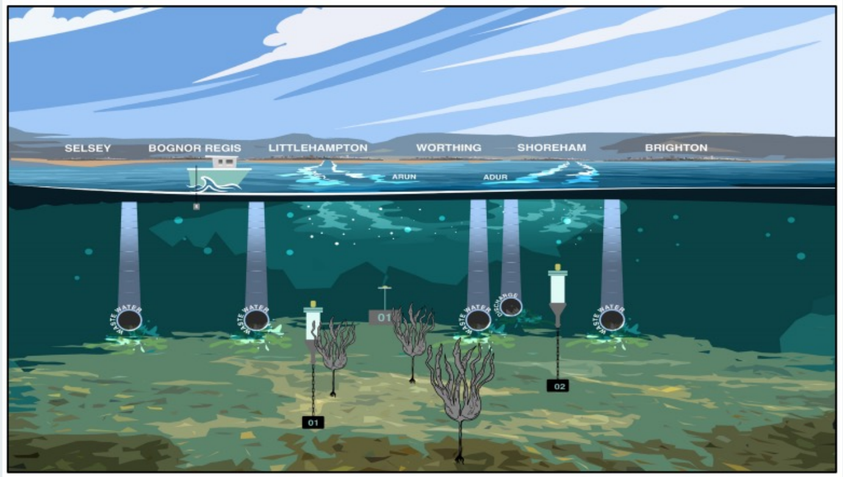
Strand one: understanding SPM composition and distribution in the Sussex Bay area. SPM includes all particles in the water column such as clay, sand, contaminants, pollutants, algae, phytoplankton, zooplankton, organic matter, bacteria, and viruses, both living and dead. Turbidity, Suspended Sediment Concentration (SSC) and light in the 1-2m above the sea floor are most relevant to kelp growth and development. Research will investigate nearshore coastal environments where the University of Sussex monitors kelp habitat and biodiversity recovery. Regular sea users will be sought to aid measurement and sample collection.

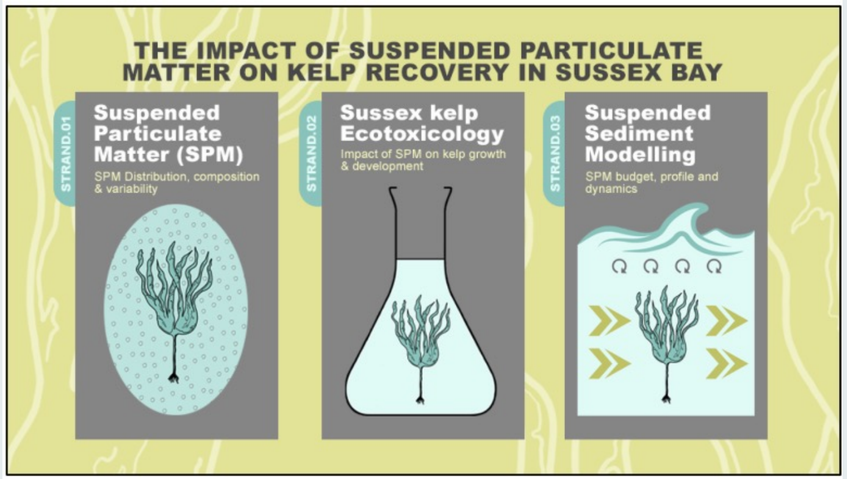
Strand two: understanding the impact of local SPM on Sussex kelp growth using controlled experiments in aquaria. Through the development and implementation of ecotoxicology testing, this lab-based assessment will enable an evaluation of the risks to the three most important species of kelp for reforestation in the area: *Laminaria hyperborea* (Tangle or Cuvie), *Laminaria digitata* (Oar Weed) and *Saccharina latissima* (Sugar Kelp).

Strand three: providing a baseline understanding of the sediment budget, profile and dynamics within Sussex Bay through the lens of how this impacts kelp habitat. It will map the pattern of SPM within the kelp restoration area to underpin our understanding of changes to water clarity and the photic zone, and its implications for kelp ecosystem recovery.

Providing meaningful data to help inform environmental decision-making

Kelp have evolved to develop within a forest environment where pH, dissolved oxygen, nutrient balance, light and shade is determined by the kelp forest: it is a clean, clear, sheltered, shady and protected habitat.
In Sussex Bay however, kelp is sparse and so its micro life stages are vulnerable to environmental stresses they have not evolved to tolerate. A number of sensors in Sussex Bay close to shore and further out are focused on areas where the kelp is and where we can understand the impact of river and wastewater pipe outflows. Research on turbidity and light will be linked to work being undertaken on biodiversity and distribution to provide a more rounded picture of what is happening. It will consider both established toxins (e.g. herbicides) and emerging contaminants known to be toxic to kelp but which may or may not be present in sufficient concentration to do damage.





Monitoring in marine and estuarine environments

Rebecca Hartless and Kathleen O'Reilly, Environment Agency

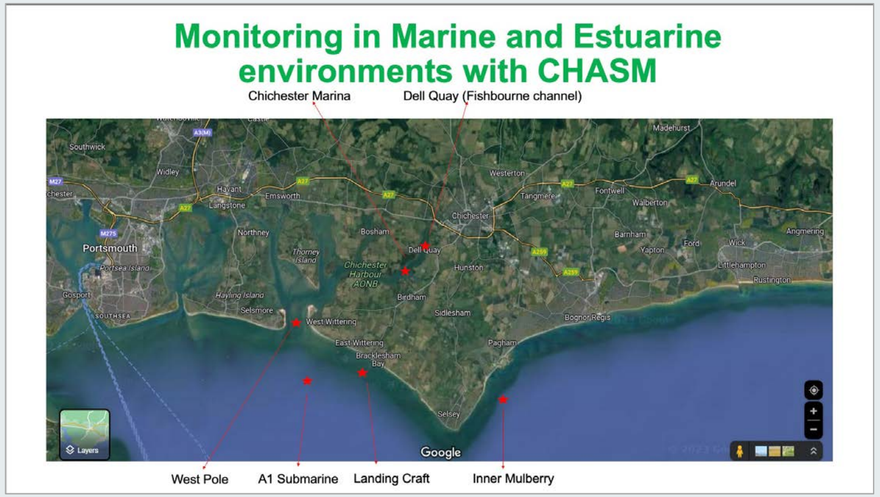
The National Water Quality Instrumentation Service is a small team within the Environment Agency who have a network of real-time, continuous water quality monitoring systems across England in freshwater, marine, estuarine and groundwater environments.

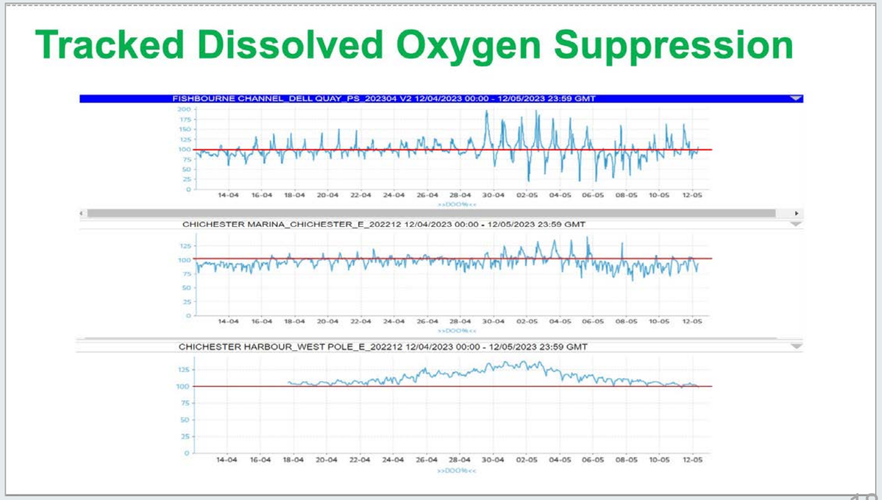
These include roughly 210 real time monitoring systems for their own investigations, 37 real time water quality stations for commercial customers (including CHASM) and 323 handhelds used by Environment Agency officers doing routine sampling and responding to pollutions.

For the work they are doing with CHASM, 6 monitoring systems have been deployed in the Chichester Harbour/Selsey area. The investigation has had four phases of activity to date. Results from the first phase of tests using Loggers showed that while turbidity levels were relatively low and not of concern, Dissolved Oxygen was below 100% SAT, suggesting the presence of Biological Oxygen Demand (BOD). This was also unusual as it was found in the ocean where you would expect dilution to play a large factor.

The second phase using a Logger and a Telemetry Unit found that water quality wasn't a concern as a whole, but there were significantly low levels of Dissolved Oxygen at Chichester Marina, almost reaching 0% SAT. The third phase using just Telemetry Units also picked up lower than expected Oxygen levels, as low as 60%. While causes of this remain unclear, pollution from upstream is one possibility. The final phase using a Telemetry Pumped System indicates significant biological oxygen demand (BOD). Chlorophyll data does not indicate an algal bloom, but could potentially indicate the input of another oxygen depleted water source into the water body (depleted by either algal activity elsewhere or pollution).

All the results are available to view at https://telemetry-data.com/open?profile=LIVELINKCHI





Rother basin sediments: sources, storage and transport

Professor John Boardman, University of Oxford

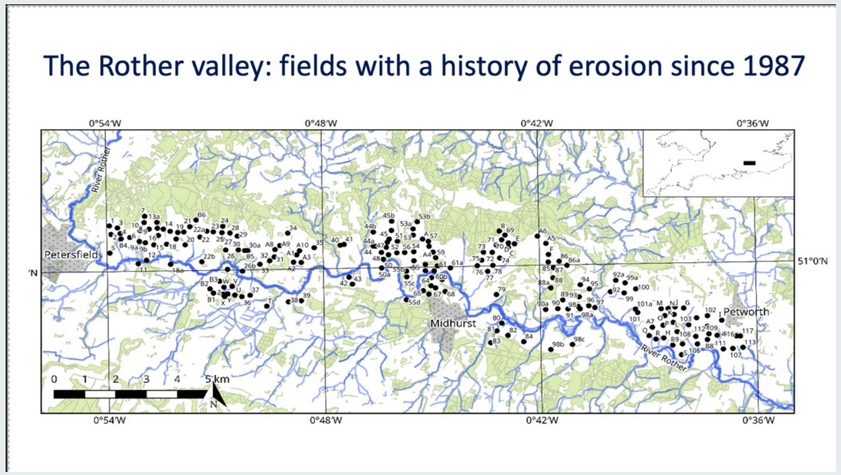
Serious erosion in the years 2000 and 2006 stimulated 20 years of research on this and associated pollution problems in the Rother basin. The Rother is the largest tributary of the Arun and runs for a total length of 52km, approximately 42km of which lies within West Sussex.

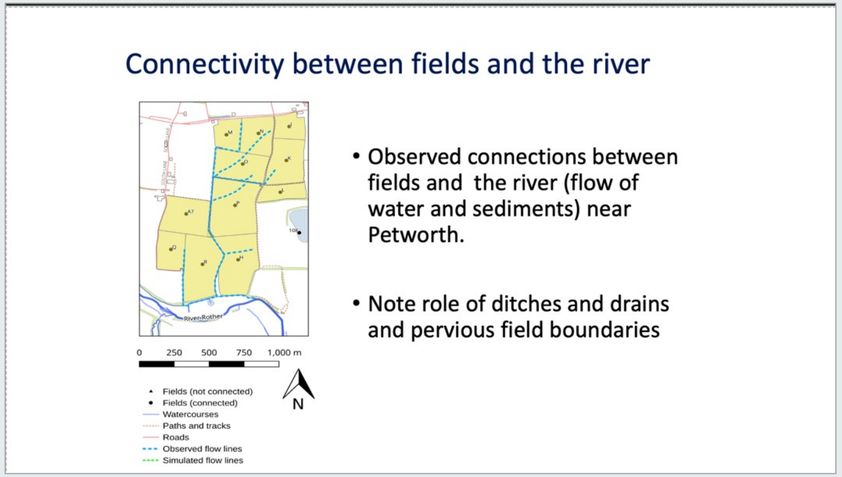
A combination of highly erodible Greensand soils and intensive farming gives rise to a long history of soil erosion affecting around 200 fields in a belt from Petersfield to Petworth. Most arable fields are close to the river and often well connected via ditches, tracks, drains and sunken lanes. Although the flood plain is generally grazed, ditches connect arable fields to the river.

Eighteen weirs on the Rother act as storage sites for considerable amounts of sand derived from erosion on fields and the river banks. A major tributary, the Lod, is an important contributor to the sediment load and reasons for this are being investigated; these include the role of Himalayan Balsam.

Sediment storage sites – the weirs, several Hammer Ponds and detention structures on farms, detain sand but most silt and clay travels onwards to the Arun and the sea. This contains contaminants including pesticides, nitrates and phosphorous. Contaminants in the water have serious cost implications for Southern Water at Hardham where water is extracted for human consumption.

Plans to remove weirs on the Rother should be considered carefully as the release of stored sediments will have ecological consequences particularly for fish spawning where gravels are coated with sand. The contribution of eroded sediment in the Rother basin to pollution on the Sussex coast is unknown but worthy of investigation.





Learnings from dredging and sediment management practices in the River Tees

Dr Gary Caldwell, University of Newcastle

Until recently the North East had a thriving crustacean fishery with a very strong sense of its own identity. But in the Autumn of 2021 that changed when along the coast from Teeside to Whitby, dead lobsters and crabs began washing up on the beach, at some points piling up to hip height.

An estimated 95% of crustaceans were lost in that event, and with it, the livelihoods of the local fishery. What caused this mass die off?

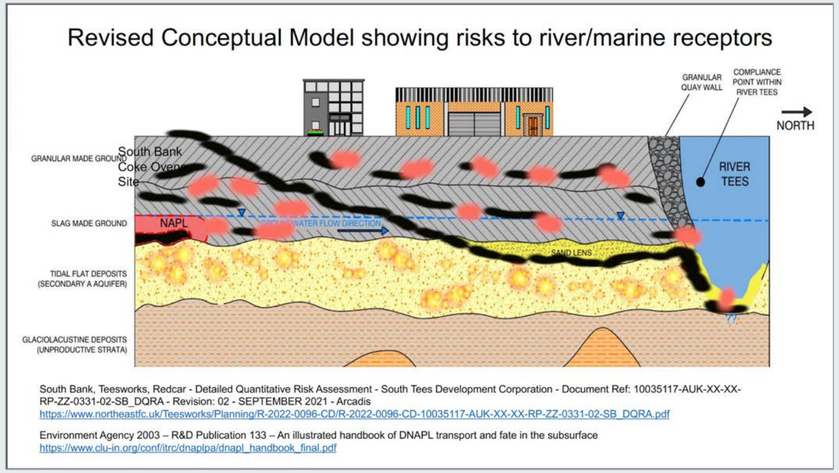
Academics from the Universities of Newcastle, Durham, York and Hull, working with the fishing community, have been investigating potential links to capital dredging and exceptional maintenance dredging in the River Tees, and the impact to marine life from contaminants in the dredged sediment such as pyridine.

Teeside is one of the most industrialised parts of the UK and was the site of a major steel works – consequently the land is extremely contaminated. Ambitious plans to transform the area into the new home of green energy have been subject to fundamental cuts to both budget and timings. The universities' research highlights where corners were cut (including environmental risk assessments), and where dredging events and sediment transport modelling correlate with evidence from fishers.

In addition, they point to critical failures in the way environmental risk assessments are currently carried out, as they look for chemicals on an individual basis rather than where they mix and interact.

The North East crustacean die off is an issue that's become increasingly political after an independent government report discounted dredging, instead citing a novel pathogen as the cause. This finding has been rejected by academics and fishers.

Learnings from the events in the North East include to hold agencies to account, to keep asking questions about dredging and to keep testing dredged material.



CHASM: the building blocks of a complex research question

Dr Charlie Thompson, CCO/CHASM, and Dr Heidi Burgess, University of Brighton/CHASM

Over the past 10 years the fisherfolk off Selsey Bill (West Sussex) have noticed a drastic decline in the stock of lobsters and crabs being landed.

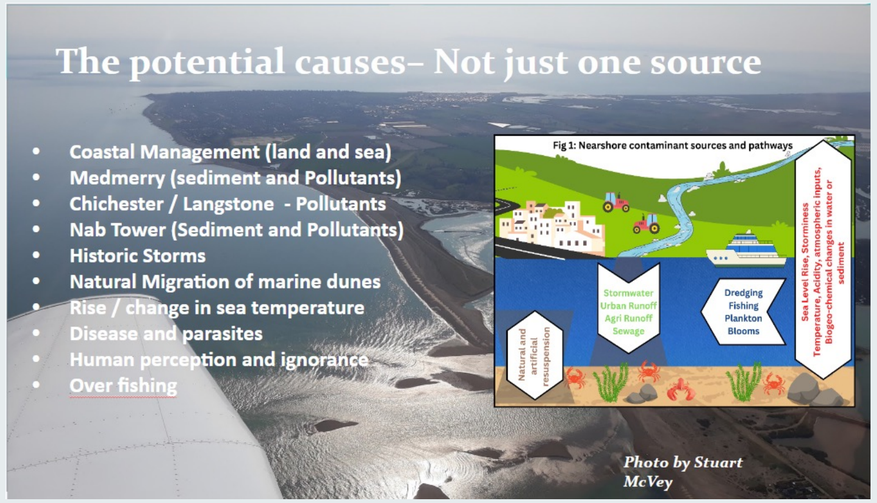
A high number of individuals landed are moribund (twitching-lethargic, dying shortly after catch). Reports of similar and sometimes more sudden events have been reported from other areas of the UK and globally.

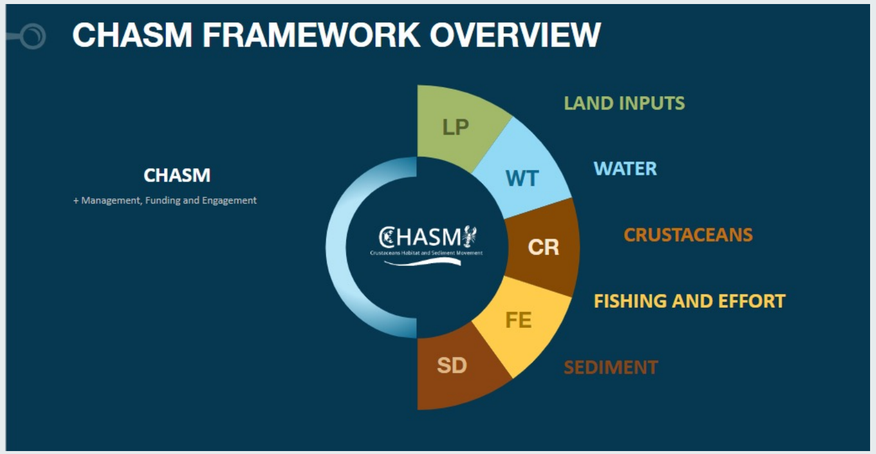
Multiple potential stressors and the complexities of their impacts on crustacea health and habitat mean there are no definitive mechanisms by which to identify the causes of moribund events.

In coastal areas, there are multiple sources of a wide range of potential stressors.
These include:

- climate change (sea level rise, temperature increase and acidification, phytoplankton blooms);
- maritime activities, including changing fishing practices;
- contamination from sewage and stormwater overflow;
- road and agricultural run-off;
- dredging and dredge disposal operations;
- and wider habitat change resulting from coastal management.

A framework of work packages identifying the research needed to assess the relative impacts of these stressors on these nearshore habitats aims to focus discussion on priority knowledge gaps and target future funding opportunities.





Panel Discussions Q&A

Panel discussions Q&A (some responses have been paraphrased)

- **Is coastal erosion the main factor contributing to sediment deposits in comparison to dredging and other inputs? If the kelp beds existed, would they be resilient to these deposits, or would it suppress their ability to recover?**
  - It is difficult to know how sediment concentrations have changed over time and the exact contribution of each sediment source to Sussex Bay. The fine sediment deposits (chalk sediment is often around 5 microns), from cliff erosion change every year so it is challenging to quantify. Only a 50 to 100-year time period can show significant changes. Sediment systems adjust to a new equilibrium relatively quickly.
  - Sediment impacts kelp in two ways: 1 - it has a direct impact on kelp beds. 2 - suspended sediment in the water column absorbs the sunlight and warms up the water quicker.

- **Do we know the level of sedimentation that damages kelp?**
  - This is variable depending on the species type, but multiple reports show sediment is linked to the decline of kelp around the world. Unfortunately, there is a lack of historical data on this issue. Evidence shows that a 65% reduction in light (from sediment) reduces photosynthesis by 95%.
  - Flora and fauna are are naturally adapted to certain levels of sediment, but changes to the equilibrium may change their response to this.

- **Maintenance dredging is described as recycling sediment that was already there, however dredged sediment from the harbour contains contaminants which are then being removed and deposited into areas such as Beachy Head MCZ, causing a potential net introduction of pollutants into the system. What effect might this be having?**
  - Materials that come into the harbour through natural cycling are the same as those being dredged. The rate of removal of sediment is different to natural cycling however (the latter being many 100s tonnes a day). The issue of contaminants in the harbour being taken offshore should be captured in routine sampling tests by the licencing process and consequently there *shouldn't* be a risk to marine life – this is the purpose of those tests. However not every deposit can be sampled.

- **Is there a risk to habitats and fisheries from offshore sediments coming from the Nab Tower and aggregate dredging west of Selsey peninsular?**
  - There needs to be more work and modelling to understand the impacts of dumping from the Nab Tower and aggregate dredging.

- **How long has aggregate dredging been going on for and how big a risk is it compared to maintenance/harbour dredging?**
  - The UK aggregate industry started in the 60s/70s. It is not in their interest to dredge for sediments with fine sediment because they are targeting sand and gravel . Therefore, unlike maintenance dredging, aggregate dredging normally consists of small amounts of fine material and hence fine sediment plumes are generally of very low concentration. For disposal of maintenance dredging, offshore disposal sites have been long established, following a detailed consenting process with regulators to determine where to deposit sediment on the seabed.

- **When does the monitoring and modelling of environmental impacts start for Rampion 2?**
  - It is not known by the panel what monitoring for Rampion has been agreed, but taking measurements is recommended. A potential data gap is monitoring of operational plumes – very little is known about the impact of these. Though the main activity will be further offshore than the kelp beds, trenching and cable laying will take place closer to the shoreline.

Panel discussions Q&A continued

- **In Bognor it is believed that kelp loss is associated with lace weed / Japanese weed species that have increased with climate change. Is this your understanding?**
  - This could be due to increased competition as kelp is sparse and no longer the dominant species.
  - Regarding climate change, there has been a belief that kelp won't be able to withstand marine heat waves. However new research shows that if the water is clear enough, kelp can survive and even thrive due to increased photosynthesis. Therefore, the issue may not be warming itself but the quality of the water kelp are in when it happens.
  - There is evidence of a build-up of *Sargassum muticum* which may out compete our native kelps.

- **With Environment Agency monitoring, are all the fixed monitors at bed level?**
  - The Chichester pole is almost on the seabed and the west pole is suspended at 2m depth.
  - Care needs to be taken when interpreting reduced oxygen levels at each location as it changes with the state of the tide. It would be good to have poles placed in areas where the water level is consistent.

- **Have the contaminants in the North of England impacted species other than crustaceans?**
  - Yes. It impacted larval dispersal and resulted in a regime shift as well as other benthic predators. There was a 'boom and bust' trend of sea hares, and then brittlestars, mussels and then starfish dying. Some of the larger fish are now starving. There is a need to be able to quantify this as we only have anecdotal evidence from marine users and fishermen reports. On this basis it seems like crustaceans are the canary in the coal mine.
  - Comment from the audience: it is difficult to unpick the cause of the die-offs. We should be looking at multiple factors in combination e.g. acidification issues, nutrients, nitrates, and particularly looking at how nutrients flow into the marine environment.
  - Comment from the audience: Capital dredging for aircraft carriers in Portsmouth harbour may be causing a similar issue with reports of dead crab and lobster from Selsey to Dungeness. Many boats in Sussex are now laid up as they can't earn good money from fishing.

- **The CHASM study area has a very local focus – can we expand this on a wider scale?**
  - National scale mapping is needed but this is hard with a lack of baseline data and resource. There is also the challenge of matching up different scales of data. You need a local focus first to collect the baseline data and then look at where the sources are at a national level to start joining up the dots.
  - There needs to be collaboration with national bodies and national leadership roles.

Breakout Sessions

Sediment topics discussions – key points

Sediment topics discussions

In the first of the afternoon's sessions, attendees formed smaller groups to discuss four topics:

Sediment Transport Source to Sink	Dredging and Disturbance	Contaminants	Crustaceans, Fishing and Fishing effort

For each topic they answered the same four questions.

1. What are your key priorities relating to this topic?
2. What are your key research questions relating to this topic?
3. What are you already doing to address some of these issues, or planning on doing?
4. What do you think are the evidence or activity gaps for these?

What follows on the next slides are the key points raised during these discussions.
Further detail can be found in Appendix C

Sediment Transport
Source to Sink

Sediment transport source to sink – key points

A holistic systems approach to sediments

- Need to look at the balance of sediments throughout the system and the impact of sediment at different stages. What are the impacts of sediment removal or changes to sediment pathways in certain areas? What is the impact of some of the larger scale or wider interventions?
- Terminology is important, as Source to Sink doesn't capture the cyclical nature of sediment transport.

Sediments as they relate to habitats

- Ensuring intertidal habitats have a source of sediment supply. Considering managed realignment habitats e.g. nearshore vegetation. Freshwater habitats.
- What is the potential of using sediment that's not in the right place to help maintain some of these habitats e.g. via BUDS?

Climate change and longer-term thinking

- Understanding the impact of climate change on sediment transport and on habitats.
- Ensure we're thinking long term, how do we join up various longer term initiatives that might be at different scales?

The balance of sediment: from terrestrial to marine and vice versa

- Need to track the sediment sources and transport pathways to understand what's going where and inform what potential interventions might do.

Legislation: impacts, changes and levers

- How does legislation impact sediment transport and the wider processes that are affecting sediment. What are the legislative drivers for doing things?
- As legislation changes over time, our evidence base needs to be flexible enough to meet changing needs while still providing a longer term outlook.

The need for cost benefit analyses

- Consider all the economic factors within the system and undertake cost benefit analysis of approaches and their potential impacts on other economies.

Data availability and data opportunity

- Leverage opportunities for data and monitoring e.g. utilising water company monitoring data and boats already in the marine area e.g. ferry box scheme.
- Explore the opportunities for citizen science. Take on learnings from EA and others to ensure schemes have sufficient investment to make them robust.
- Collaborate with/influence other nature recovery projects up and downstream to undertake sediment monitoring on our behalf.

Dredging and disturbance – key points

Licensing and regulatory mechanisms – are they fit for purpose?

- More accountability, transparency and scrutiny needed.
- Lack of transparency and public scrutiny in marine licensing. Local people have no input into the process which is controlled by one organisation. Closer alignment to land planning applications would mean they are subject to public consultation.
- 30 year license cycle is too long and should be reduced. Once a company has a licence there's very little/no incentive to change practices.
- Can we work with the MMO, look at some of their policies and try to influence changes to these policies?

Access to data

- Though a lot of data is being collected e.g. by government agencies and industry, it is difficult to find and access. Better signposting to this data and making it more available will increase usage.

Methods of dredging

- Are the standard dredging methods applicable in all situations? Should we review how they're being done as well as what's being done? What novel approaches to dredging are emerging?

Monitoring of dredge extraction and spoil

- Monitoring before, during and after extraction. Undertaking eco-surveys of where spoil will be dumped before, during and after this process.
- Overturning the assumption that if material is dumped, the seabed will return to what it was. Repeated dumping, particularly with a different material will change the nature of the seabed.

Testing for contaminants in sediments *[Explored further in the Contaminants group]*

- Current testing only covers specific materials so many emerging chemicals/materials will be missed.
- Suggested new approaches include broadening the suite of contaminants to be tested for, or adopting a more localised approach which uses historical understanding of the area and its uses to develop bespoke testing. This could be in addition to or instead of standard testing.

Contaminants – key points

Synergistic effects (the interplay between contaminants)
- How do we tackle and measure this? How do we develop effective ways of measuring and reporting on the impact of this?

One health diagnostic
- Rather than looking at specific problem areas and building up a complex picture of problems, we should look at the habitat's overall health and narrow it down to contributing factors. Within this, we should look at the vulnerability of particular components in that habitat and life stages.

Defining and sourcing contaminants
- The scope of contaminants is vast and difficult to get a handle on. But there are huge dangers in going too narrow. How do we handle this?
- There is a need to source contaminants through the biological and chemical pathways for impact, whether at the cellular level or macro.
- Considering those contaminants such as herbicides and insecticides that we know have been applied to the Sussex Bay coastline should be a priority.

Who pays?
- Who pays for testing, monitoring, research, and sharing information? Where does the money come from? Is it the polluter? If alternative ways for dealing with contaminants need to be developed, where does the money come from?

What's already happening
- Highlighting the impact of the Environment Act 2021, CHASM proposal and its scope if NERC funding is achieved. Southern Water buoys and monitoring systems – and the development of thinking towards qualitative rather than just quantitative monitoring systems. University of Sussex research.

Fit-for-purpose risk assessments
- The information systems that feed into decision-making aren't currently fit for purpose: MMO licenses, political decision making etc. Significant information gaps exist.

Public awareness
- Within communities there is insufficient awareness of some of the practices that are going on and the implications of these.

Political and organisational accountability
- There is a need for transparency and accountability around decisions that have been made.

Open access information sets
- E.g. Fisheries data. Need much more awareness of what's available and easy sourcing of that data to be able to interpret it.

Crustaceans, fishing and fishing effort – key points

Individual, combined and synergistic effects of sediment

- Not just where sediment is coming from but the issue of possible pollutants carried with them (in some cases a cocktail of these) and how they all interact.
- Suggested ways to address this include: harsher penalties for pollution offences, and the need for more standardised monitoring of ecotoxicology.
- Rather than a one-sized fits all approach to what is measured, a case by case which considers the main potential sources of pollutants in an area.

Assessing the economic impact of sediment

- We have data on biological impacts and anecdotal impacts on fishermen. What is needed is the economic impact to fishermen and other businesses in the area.

Trust and relationships

- There is a need to build trust between the fishing communities and government agencies, and also with the research sector.
- Better relationships can lead to leveraging of funding sources such as the Fisheries Industry Science Partnership (FISP). Access to these funds is challenging especially for smaller fishing groups.
- Consideration into how we engage the fishing community and other communities in research/citizen science; potential to employ fishers to collect data.

Impact of habitat variability on crab and lobster

- To understand what habitats are and how they've changed, requires surveys, mapping and monitoring to be carried out more often than 6 years (current cycle).

A holistic ecosystem based approach

- Need to look at food webs and how different species interact and their different life stages.
- Has the loss of kelp created a negative feedback loop, which now means there is more sediment?
- How do we tease apart all these different factors affecting fisheries – there's so much!

Plankton, the lack thereof, and the benefit of plankton surveys

- Plankton surveys are needed to research a decline in plankton. These may be a more cost effective way to get a good breadth of data than species-focused monitoring.

Sussex in relation to the rest of the coast

- Incidents in the North and elsewhere: who's got oversight of this? Are any trends and signals coming out? Are all incidents being broadcast? Need for an incident map.
- Are crustaceans the canary of the sea, or are other species better to focus on? The need to check whether we are measuring the right things for the right reasons.

Marine infrastructure - windfarms

- Rampion 2 cabling has been done and sediment disposal mounds have occurred - are these being monitored? What is the impact of this construction?

Breakout Sessions

Prioritisation of CHASM work packages and tasks

Prioritising CHASM work packages and tasks

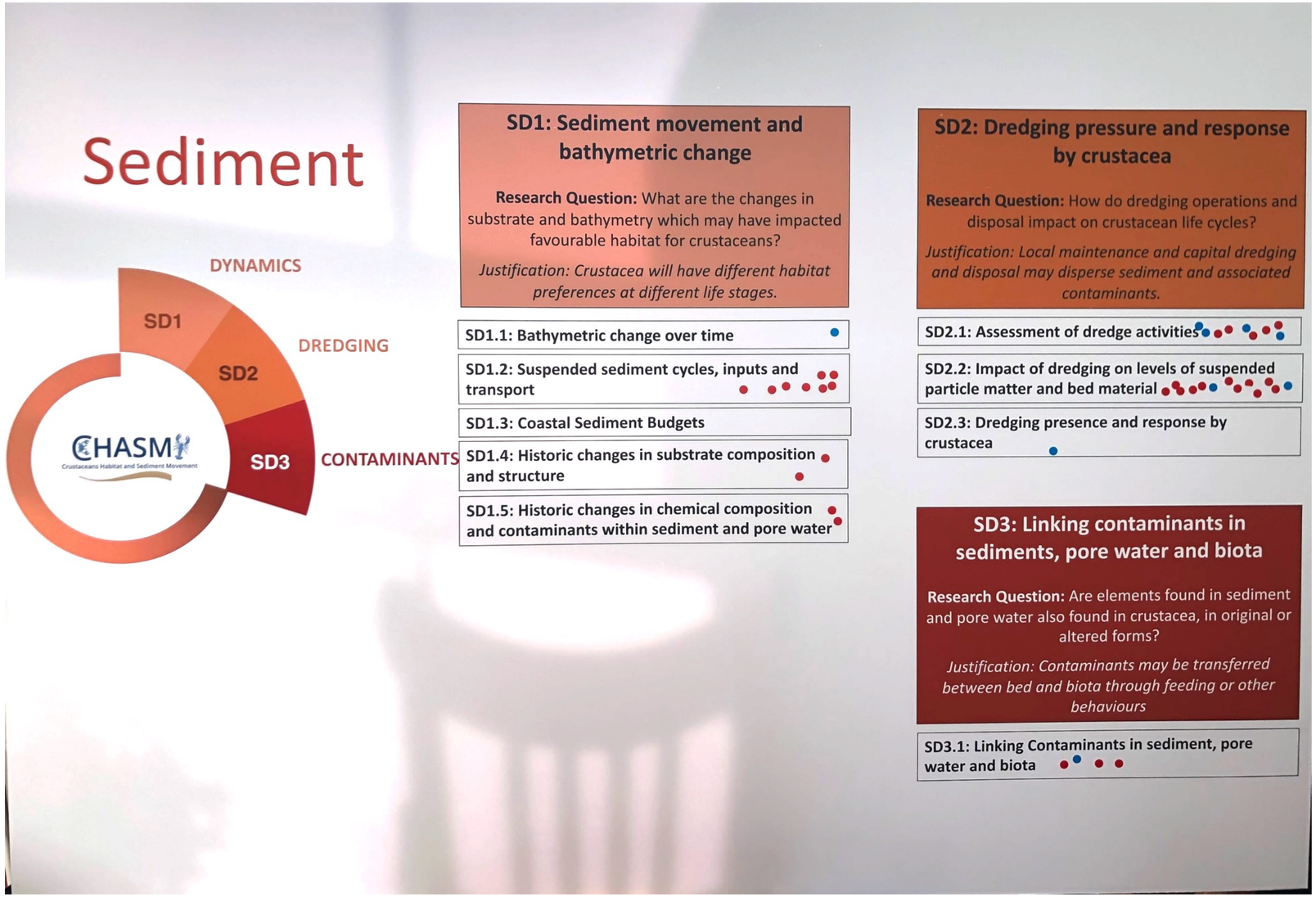
In the next exercise, attendees prioritised CHASM work packages and tasks by placing blue or red dots against those they felt would:

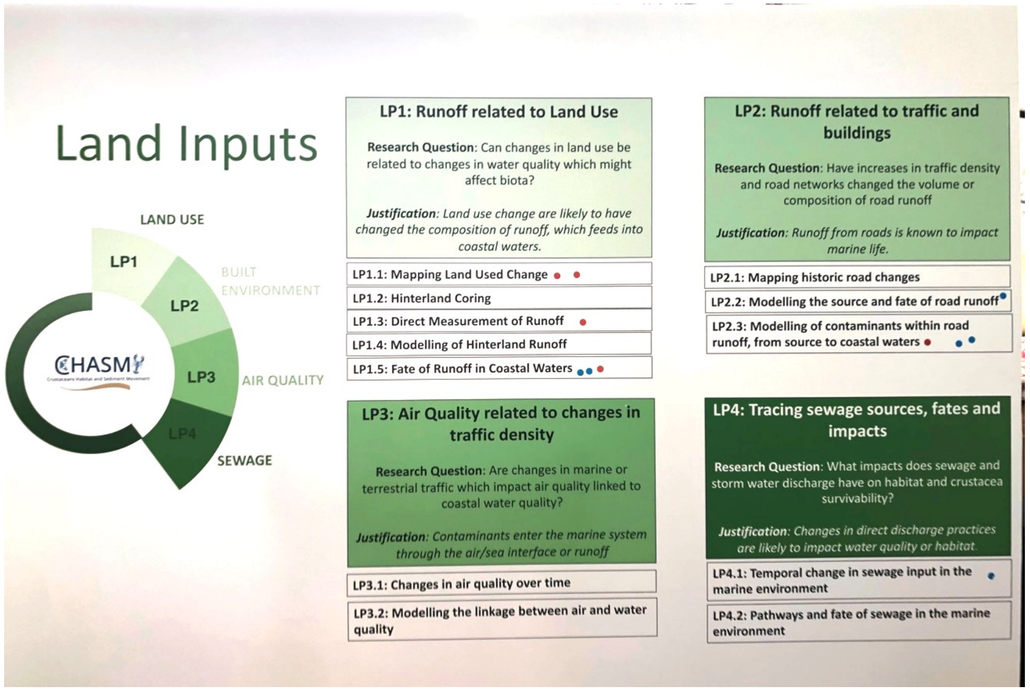
- have the biggest impact (red dot) – attendees could select two tasks based on this criteria.
- fill the biggest gap (blue dot) - attendees could select one task.

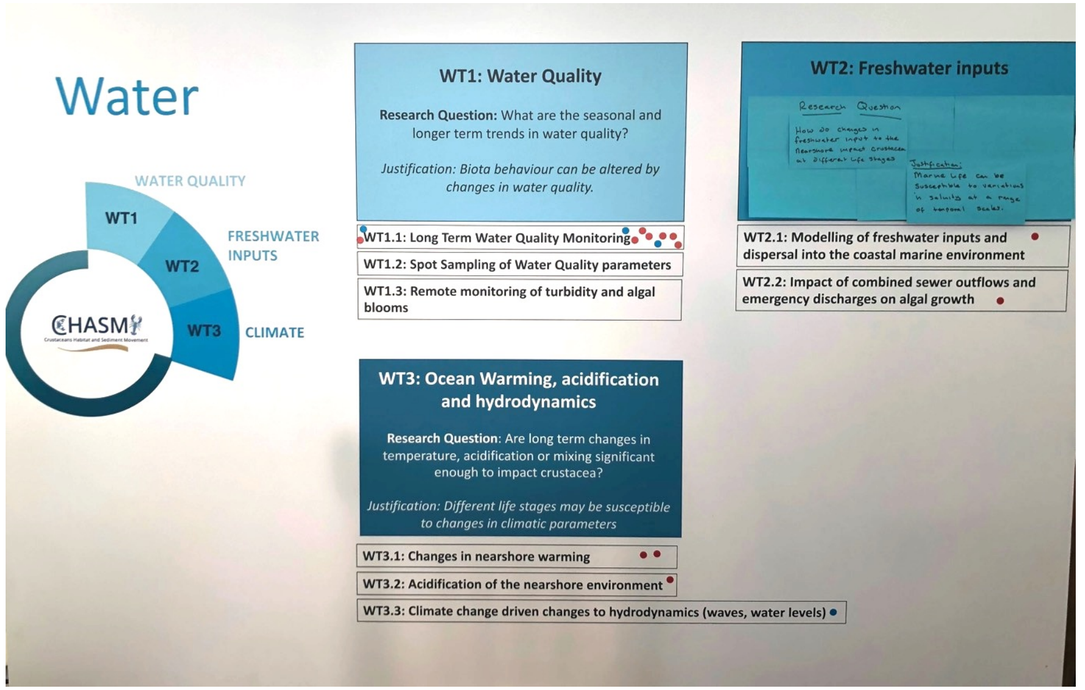
Five boards placed around the room aligned to CHASM themes:

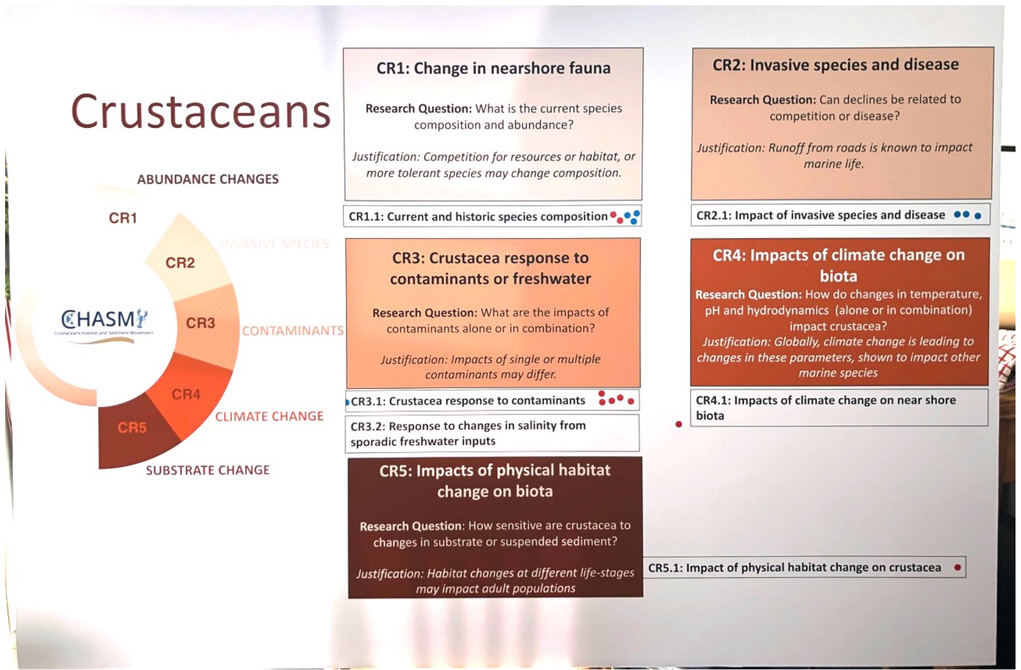
- Sediment
- Land Inputs
- Water
- Crustaceans
- Fishing and effort

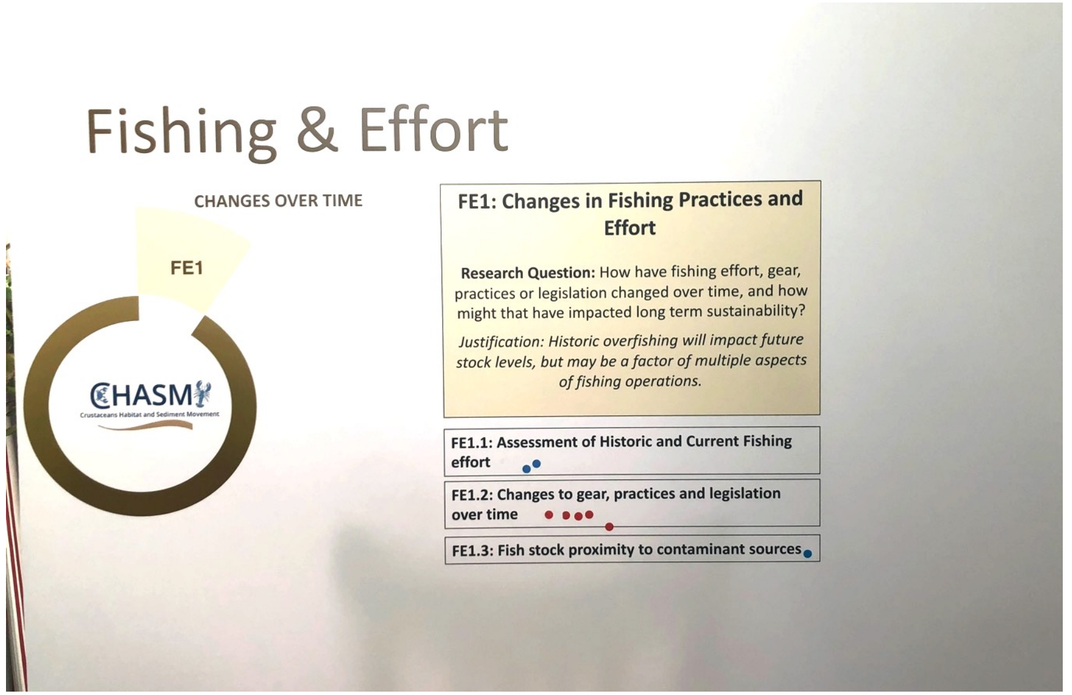
Overall 62 red dots and 29 blue dots were placed on the boards.




Land Inputs
LAND USE
LP1
LP2
LP3
LP4
BUILT ENVIRONMENT
AIR QUALITY
SEWAGE
CHASM
LP1: Runoff related to Land Use
Research Question: Can changes in land use be related to changes in water quality which might affect biota?
Justification: Land use change are likely to have changed the composition of runoff, which feeds into coastal waters.
LP1.1: Mapping Land Used Change
LP1.2: Hinterland Coring
LP1.3: Direct Measurement of Runoff
LP1.4: Modelling of Hinterland Runoff
LP1.5: Fate of Runoff in Coastal Waters
LP2: Runoff related to traffic and buildings
Research Question: Have increases in traffic density and road networks changed the volume or composition of road runoff
Justification: Runoff from roads is known to impact marine life.
LP2.1: Mapping historic road changes
LP2.2: Modelling the source and fate of road runoff
LP2.3: Modelling of contaminants within road runoff, from source to coastal waters
LP3: Air Quality related to changes in traffic density
Research Question: Are changes in marine or terrestrial traffic which impact air quality linked to coastal water quality?
Justification: Contaminants enter the marine system through the air/sea interface or runoff
LP3.1: Changes in air quality over time
LP3.2: Modelling the linkage between air and water quality
LP4: Tracing sewage sources, fates and impacts
Research Question: What impacts does sewage and storm water discharge have on habitat and crustacea survivability?
Justification: Changes in direct discharge practices are likely to impact water quality or habitat.
LP4.1: Temporal change in sewage input in the marine environment
LP4.2: Pathways and fate of sewage in the marine environment


Water
WATER QUALITY
WT1
WT2
WT3
FRESHWATER INPUTS
CLIMATE
CHASM
WT1: Water Quality
Research Question: What are the seasonal and longer term trends in water quality?
Justification: Biota behaviour can be altered by changes in water quality.
WT1.1: Long Term Water Quality Monitoring
WT1.2: Spot Sampling of Water Quality parameters
WT1.3: Remote monitoring of turbidity and algal blooms
WT2: Freshwater inputs
Research Question
How do changes in freshwater input to the nearshore impact crustacea at different life stages?
Justification:
Marine life can be subsequent to variations in salinity at a range of temporal scales.
WT2.1: Modelling of freshwater inputs and dispersal into the coastal marine environment
WT2.2: Impact of combined sewer outflows and emergency discharges on algal growth
WT3: Ocean Warming, acidification and hydrodynamics
Research Question: Are long term changes in temperature, acidification or mixing significant enough to impact crustacea?
Justification: Different life stages may be susceptible to changes in climatic parameters
WT3.1: Changes in nearshore warming
WT3.2: Acidification of the nearshore environment
WT3.3: Climate change driven changes to hydrodynamics (waves, water levels)


Crustaceans
ABUNDANCE CHANGES
CR1
CR2
CR3
CR4
CR5
INVASIVE SPECIES
CONTAMINANTS
CLIMATE CHANGE
SUBSTRATE CHANGE
CHASM
CR1: Change in nearshore fauna
Research Question: What is the current species composition and abundance?
Justification: Competition for resources or habitat, or more tolerant species may change composition.
CR1.1: Current and historic species composition
CR2: Invasive species and disease
Research Question: Can declines be related to competition or disease?
Justification: Runoff from roads is known to impact marine life.
CR2.1: Impact of invasive species and disease
CR3: Crustacea response to contaminants or freshwater
Research Question: What are the impacts of contaminants alone or in combination?
Justification: Impacts of single or multiple contaminants may differ.
CR3.1: Crustacea response to contaminants
CR3.2: Response to changes in salinity from sporadic freshwater inputs
CR4: Impacts of climate change on biota
Research Question: How do changes in temperature, pH and hydrodynamics (alone or in combination) impact crustacea?
Justification: Globally, climate change is leading to changes in these parameters, shown to impact other marine species
CR4.1: Impacts of climate change on near shore biota
CR5: Impacts of physical habitat change on biota
Research Question: How sensitive are crustacea to changes in substrate or suspended sediment?
Justification: Habitat changes at different life-stages may impact adult populations
CR5.1: Impact of physical habitat change on crustacea


Fishing & Effort
CHANGES OVER TIME
FE1
CHASM
FE1: Changes in Fishing Practices and Effort
Research Question: How have fishing effort, gear, practices or legislation changed over time, and how might that have impacted long term sustainability?
Justification: Historic overfishing will impact future stock levels, but may be a factor of multiple aspects of fishing operations.
FE1.1: Assessment of Historic and Current Fishing effort
FE1.2: Changes to gear, practices and legislation over time
FE1.3: Fish stock proximity to contaminant sources

How work packages and tasks scored (1/2)

Theme	Work packages and tasks	Most impact	Fills a gap	Total per task	Total per package
Land Use	LP1: Runoff related to Land Use				6
Land Use	LP1.1: Mapping Land Used Change	2		2	
Land Use	LP1.2: Hinterland Coring				
Land Use	LP1.3: Direct Measurement of Runoff	1		1	
Land Use	LP1.4: Modelling of Hinterland Runoff				
Land Use	LP1.5: Fate of Runoff in Coastal Waters	1	2	3	
Land Use	LP2: Runoff related to traffic and buildings				
Land Use	LP2.1: Mapping historic road changes				4
Land Use	LP2.2: Modelling the source and fate of road runoff		1	1	
Land Use	LP2.3: Modelling of contaminants within road runoff, from source to coastal waters	1	2	3	
Land Use	LP3: Air Quality related to changes in traffic density				0
Land Use	LP3.1: Changes in air quality over time				
Land Use	LP3.2: Modelling the linkage between air and water quality				
Land Use	LP4: Tracing sewage sources, fates and impacts				1
Land Use	LP4.1: Temporal change in sewage input in the marine environment		1	1	
Land Use	LP4.2: Pathways and fate of sewage in the marine environment				
Water	WT1: Water Quality				10
Water	WT3.1: Long term water quality monitoring	7	3	10	
Water	WT3.2: Acidification of the nearshore environment				
Water	WT3.3: Climate change driven changes to hydrodynamics (waves, water levels)				
Water	WT2: Freshwater inputs				2
Water	WT2.1: Modelling of freshwater inputs and dispersal into the coastal marine environ	1		1	
Water	WT2.2: Impact of combined sewer outflows and emergency discharges on algal grow	1		1	
Water	WT3: Ocean Warming, acidification and hydrodynamics				4
Water	WT3.1: Changes in nearshore warming	2		2	
Water	WT3.2: Acidification of the nearshore environment	1		1	
Water	WT3.3: Climate change driven changes to hydrodynamics (waves, water levels)		1	1	

How work packages and tasks scored (2/2)

Theme	Work packages and tasks	Most impact	Fills a gap	Total per task	Total per package
Crustaceans	CR1: Change in nearshore fauna				5
Crustaceans	CR1.1: Current and historic species composition	2	3	5	
Crustaceans	CR2: Invasive species and disease				3
Crustaceans	CR2.1: Impact of invasive species and disease		3	3	
Crustaceans	CR3: Crustacea response to contaminants or freshwater				6
Crustaceans	CR3.1: Crustacea response to contaminants	5	1	6	
Crustaceans	CR3.2: Response to changes in salinity from sporadic freshwater inputs				
Crustaceans	CR4: Impacts of climate change on biota				1
Crustaceans	CR4.1: Impacts of climate change on near shore biota	1		1	
Crustaceans	CR5: Impacts of physical habitat change on biota				1
Crustaceans	CR5.1: Impact of physical habitat change on crustacea	1		1	
Fishing	FE1: Changes in Fishing Practices and Effort				8
Fishing	FE1.1: Assessment of Historic and Current Fishing effort		2	2	
Fishing	FE1.2: Changes to gear, practices and legislation over time	5		5	
Fishing	FE1.3: Fish stock proximity to contaminant sources		1	1	
Sediment	SD1: Sediment movement and bathymetric change				13
Sediment	SD1.1: Bathymetric change over time		1	1	
Sediment	SD1.2: Suspended sediment cycles, inputs and transport	8		8	
Sediment	SD1.3: Coastal Sediment Budgets				
Sediment	SD1.4: Historic changes in substrate composition and structure	2		2	
Sediment	SD1.5: Historic changes in chemical composition and contaminants within sediment a	2		2	
Sediment	SD2: Dredging pressure and response by crustacea				23
Sediment	SD2.1: Assessment of dredge activities	5	4	9	
Sediment	SD2.2: Impact of dredging on levels of suspended particle matter and bed material	11	2	13	
Sediment	SD2.3: Dredging presence and response by crustacea		1	1	
Sediment	SD3: Linking contaminants in sediments, pore water and biota				4
Sediment	SD3.1: Linking Contaminants in sediment, pore water and biota	3	1	4	

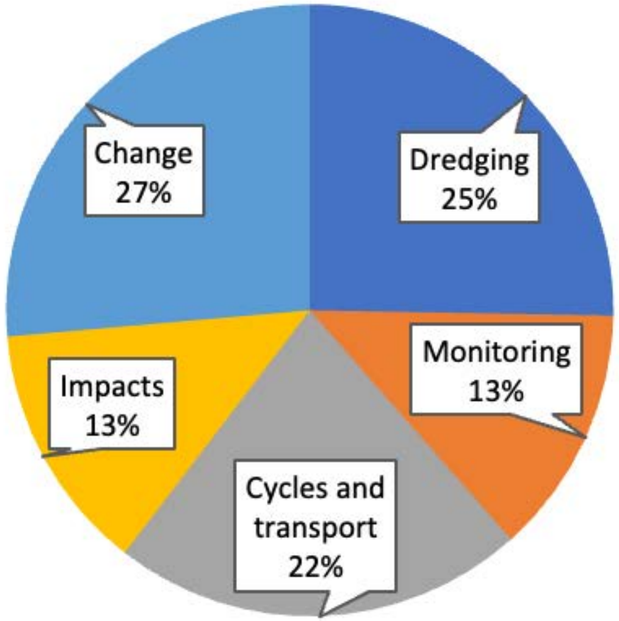
Final prioritisation of CHASM tasks

Theme	Work package tasks	Most impact	Fills a gap	Total per task
Sediment	SD2.2: Impact of dredging on levels of suspended particle matter and bed material	11	2	13
Water	WT3.1: Long term water quality monitoring	7	3	10
Sediment	SD2.1: Assessment of dredge activities	5	4	9
Sediment	SD1.2: Suspended sediment cycles, inputs and transport	8		8
Crustaceans	CR3.1: Crustacea response to contaminants	5	1	6
Crustaceans	CR1.1: Current and historic species composition	2	3	5
Fishing	FE1.2: Changes to gear, practices and legislation over time	5		5
Sediment	SD3.1: Linking Contaminants in sediment, pore water and biota	3	1	4
Land Use	LP1.5: Fate of Runoff in Coastal Waters	1	2	3
Land Use	LP2.3: Modelling of contaminants within road runoff, from source to coastal waters	1	2	3
Crustaceans	CR2.1: Impact of invasive species and disease		3	3
Land Use	LP1.1: Mapping Land Used Change	2		2
Water	WT3.1: Changes in nearshore warming	2		2
Fishing	FE1.1: Assessment of Historic and Current Fishing effort		2	2
Sediment	SD1.4: Historic changes in substrate composition and structure	2		2
Sediment	SD1.5: Historic changes in chemical composition and contaminants within sediment a	2		2
Land Use	LP1.3: Direct Measurement of Runoff	1		1
Land Use	LP2.2: Modelling the source and fate of road runoff		1	1
Land Use	LP4.1: Temporal change in sewage input in the marine environment		1	1
Water	WT2.1: Modelling of freshwater inputs and dispersal into the coastal marine environ	1		1
Water	WT2.2: Impact of combined sewer outflows and emergency discharges on algal grow	1		1
Water	WT3.2: Acidification of the nearshore environment	1		1
Water	WT3.3: Climate change driven changes to hydrodynamics (waves, water levels)		1	1
Crustaceans	CR4.1: Impacts of climate change on near shore biota	1		1
Crustaceans	CR5.1: Impact of physical habitat change on crustacea	1		1
Fishing	FE1.3: Fish stock proximity to contaminant sources		1	1
Sediment	SD1.1: Bathymetric change over time		1	1
Sediment	SD2.3: Dredging presence and response by crustacea		1	1
		62	29	91

CHASM prioritisation summary

Following the workshop prioritised tasks were regrouped by the CHASM team. Through this exercise five key areas of concern emerged: change over time; dredging; monitoring; cycles & transport; and impacts (see Appendix D for more details).

% of prioritised tasks falling within five areas of concern



Assessing sediment change over time was the clear front runner concern, comprising 27% of overall choices. These include assessments of physical environmental change, as well as species composition change (which existing projects and PhD research could feed into, for example both SKRP and CHASM are undertaking eDNA); fishing effort (which could be assessed at a national scale); changes to fishing gear (potential for IFCA and fisher collaboration to assess this locally).

Dredging was clearly a hot-topic, with 25% of prioritisation choices highlighting dredging as either important or needed to fill a knowledge gap.
In particular, the impact of dredging on sediment levels was the overall frontrunner choice, with 13% of dots on this work package alone. There is some data available on dredging, associated with licensing from the MMO and Cefas, but it needs to be collated. The topic of dredging could be broad, incorporating a range of different types of dredging (maintenance, capital, aggregate, fishing), dredge disposal, policy, licensing, and monitoring.

The next biggest concern was around cycles and transport (22%), including the pathways and fates of a range of inputs into the nearshore environment but with a clear focus on the cycles, inputs and transport of suspended sediments in particular (9%).

Work packages and tasks focussed on impacts and monitoring scored lower overall (13% each), which may indicate that the lack of fundamental understanding of, and trends in, the nearshore system must be prioritised before causal links to impacts can become the focus of ongoing work.

Closing Comments

Closing discussion points

Fishermen are desperate. Generations are leaving the industry. They want action now. How do we get there?

- A single organisation or even two on their own can't fix the issue for fishermen. Sediment needs a groundswell of organisations working together along with funding. Today is about showing there is a very broad church of interested parties who, along with the fishermen, are all worried about sediment.
- *Action: We need to work out how we collectively galvanise the expertise and passion in this room and take it up the chain to decision-makers.*

Fishermen are scrutinized for their impacts on ecosystems but the damage done to habitats and the fishing industry by polluting incidents seems to go unchecked. The balance is wrong. Are scientists telling the government the right things?

- We have a situation where both scientists and fishers are on the ground seeing the changes day in and day out, whereas policymakers operate at a distance and likely have to make decisions that balance many factors. However, government *doesn't always* act upon all the evidence shared by scientists related to sediment and may make decisions that some in this room won't agree with…
- A collective voice is necessary to ensure that fishing and environmental sectors aren't played off against each other (intentionally or not).
- *Action: Fisher and industry science partnerships are very powerful, so we need to unlock more of them to ensure we have a cohesive voice.*

[To Gary] How do you get action?

- Bringing the community with you is key. It gives you a stronger voice and the support and motivation to continue fighting the cause. On a personal level, its doing something your children are proud to tell their mates about.
- *Action: Find your community, support each other. Though it will be hard, the more hands you have at your back the better.*

What learnings can we take from other kelp restoration projects around the world?

- The direction of travel (from communities in California, Tasmania and Chile) is towards seascape restoration as this brings disparate groups together within an overall identity and direction. This enables progress because while individual organisations may undertake different activities, there is an overall forward motion that makes their actions cohesive and this can attract money, political support and draw people in.
- Sussex is the ideal place in the UK for us to achieve this together. And if we can do it here, we can export it anywhere.
- *Action: To gain traction, how do we collectively unite under the banner of seascape restoration?*

Sussex sewage incidents have been happening for a long time in an area we are trying to protect. How do we address this?

- It is shocking that sewage is still an issue many years after the European Bathing Water Directive was implemented. Sewage is just one part of the sediment issue, but unlike others, we know where it is coming from, and it is a point source that current campaigns such as those by Surfers Against Sewage are tackling.
- *Action: for more information on the activity of Surfers Against Sewage, please visit www,sas.org.uk*

Appendix A

Other work exploring sources and impacts of sediment in Sussex

Other work exploring the sources and impacts of Sediment in Sussex coastal waters

- **Crustacean Habitats and Sediment Movement (CHASM)** – website.
- **Sussex Kelp Recovery Project** - website
- **Sussex Kelp Recovery Project Sediment Sources and Impacts Workshop** (September 2021) **-** Forty stakeholders from over 25 organisations shared information and identified opportunities for further research, collaboration and management interventions.
- **Sussex Sea Users Sediment Survey** – a survey of commercial and recreational sea users to gather observations of sediment type and location and potential sources.
- **Sussex Sediment Sources and Pathways Report** (January 2023) - Blue Marine commissioned sediment modelling experts HR Wallingford to prepare a report on: previous studies on sediment transport, sources and sinks in Sussex waters; trends in sediment levels; potential future trends linked with climate change, coastal development and marine activities; and the regulatory and policy framework relating to management of sediment inputs.
- **Sussex Sediment Sources and Impacts Report** (in prep.) – incorporating a desk-based literature review; personal communications with academics, benthic habitat specialists and fishermen; and outcomes from the Sussex Sediment Surveys and Workshops.

Appendix B

Post workshop survey comments

What are your key priorities regarding sediment?

Knowledge of sediment impacts on inshore fisheries

Local Authority

Data. Engagement with MMO on licensing options

Local Authority

Establishing tangible actions that support marine ecosystem recovery

Non government bodies

Identify and quantify the sources of sediment along our coast. I appreciate the work done on the subject but the values given in the workshop are dated or estimates. Field data is essential: Sonar surveys, sediment transport and coastal hydrodynamics are three key parameters that need to be measured

Research body/consultant

Clearer data on movement and contamination of sediment

Research body/consultant

Use modelling and measurements to understanding the main factors and transport mechanisms that may lead to increases in sediment concentration over the kelp bed area, with a particular focus on turbidity/reduced light levels.

Research body/consultant

I am interested in the beneficial use of dredged sediment for habitat restoration

Non government bodies

Understanding sediment dynamics in the Rother catchment

Research body/consultant

What is in the sediment and what is the impact on the water quality

Government agency

Dredging has to be controlled and should be included as a local planning regulation

Local Authority/Fisheries Representative

Reduction and raising awareness of the issue within our partnership network

Non government bodies

Sediment contaminants

Government agency

Reducing sediment pollution from the Rother and Arun

Non government bodies

What are your key research questions relating to sediment?

WT3: Are long term changes in temperature, acidification or mixing significant enough to impact crustacea? CR1: What is the current species composition and abundance? CR5: How sensitive are crustacea to changes in substrate or suspended sediment? SD1: What are the changes in substrate and bathymetry which may have impacted favourable habitat for crustaceans?

Local Authority

Transport & fate of sediments

Local Authority

Research around port licences so we can understand what actions will improve

Non government bodies

Are sediment contaminants remobilising and impacting the marine ecosystem? (to include emerging contaminants and interaction with water quality) How is climate change impacting our sediment regimes?

Government agency

Is dredging also the cause of beach erosion along with the chronic underinvestment on wooden groyne replacement and repairs.

Local Authority/Fisheries Representative

Are the chalk cliffs eroding more quickly, and if so is it leading to higher concentrations of chalk that lead to high turbidity? How does cliff erosion effects on turbidity compare with other sediment inputs such as from dredge disposal at Nab Tower?

Research body/consultant

Can BUDS be used to upscale saltmarsh restoration in a meaningful way? Is it safe (from a toxicology point of view) to used dredged sediments for restoration? Have suspended sediments in the Solent changed over time?

Non government bodies

What are the sources? What are the sinks? What are the current and eventually future processes of transport?

Research body/consultant

What is in the sediment? Where is it coming from? What is the impact of sediment on WQ?

Government agency

What is the cocktail of pollutants present in the sediment and how do they impact the biota

Research body/consultant

Identifying particular areas within our project boundaries where action should be prioritised

Non government bodies

How much fine (< 2mm diameter) sediment is moving out of the Rother and Lod and has the amount increased over the last ~century? Where is the sediment coming from? What is driving high sediment yields and high erosion rates? How quickly are catchment stores (e.g. Reservoirs) filling with sediment? What impact does this have on sediment yields? What effective management tools could be used to produce a measurable reduction in the amount of fine sediment carried by the Rother?

Research body/consultant

What are you already doing to address some of the issues related to sediment, or planning on doing?

Investigating whether there are water quality risks linked to sediment disturbance (incl. bioaccumulation of contaminants)

Government agency

Work with SKRP to deliver lobbying or campaigning actions and share new knowledge

Non government bodies

Monitoring inshore shellfish populations. Managing fishing effort through enforcing Shellfish Permit Byelaw. Engaging in partnership groups such as CHASM, SKRP, 3 Harbours. Input to FMPs. Respond to dredge licence consultations

Local Authority

Providing advice to Sussex IFCA etc.

Local Authority

Supervise a PhD in Chichester Harbour, community science actions in CH

Research body/consultant

I was involved in writing the sediment report for Blue Marine Foundation

Research body/consultant

As part of SSP we are undertaking BUDS trials to restore saltmarsh. We will also be monitoring whether water clarity changes throughout the course of the project time line

Non government bodies

We have completed a major study on sediment sources and rates of sediment accumulation in small reservoirs and are currently trying to estimate sediment yields for the Rother and Lod. We are exploring the role of weirs in disrupting sediment connectivity and hope to monitor the impact of weir removal

Research body/consultant

Real time water quality monitoring including turbidity readings

Government agency

Trying to make the general public more aware of the issue

Local Authority/Fisheries Representative

Supervising research students who are investigating relevant issues

Research body/consultant

Raise awareness, research mitigation techniques and share these as part of nature recovery advice

Non government bodies

I am currently looking for funding and partnerships to develop research projects on the matter

Research body/consultant

What do you think are the key evidence or activity gaps that prevent action on sediment being taken?

Answers to the above questions are required to target remediation but a more fundamental question for the marine environment is whether the sediment affecting marine ecosystems is derived from river inputs or other sources (e.g. coastal erosion). Evaluating fingerprinting methods for the marine system should be a major priority to focus interventions appropriately

Research body/consultant

Options to be environmentally more friendly

Local Authority

In combination effects

Non government bodies

Clarity on what is driving impacts in this area - physical smothering? contaminants that relate to sediments? water quality?

Government agency

Data on sediment (dredged) contamination

Research body/consultant

Offshore measurements of dredge disposal plumes are needed but may be expensive. Fully coupled wind/wave/hydrodynamic/sediment modelling is required too, which is also fairly costly (although less than taking measurements). So basically, funding is needed via grant application

Research body/consultant

Lack of historical data on suspended sediment levels. Lack of evidence on sediment impacts

Non government bodies

Lack of any Government action on the problem

Local Authority/Fisheries Representative

Pre conceived ideas and agendas

Government agency

Money? Funding is key for research or response activities. The knowledge and willingness are available at the University but again without funding nothing will be done

Research body/consultant

Lack of wider public understanding of the issue. Difficulty in quantifying/proving/observing direct impacts

Non government bodies

Rank sources and impacts. Long-term direct measurements of SPM and/or turbidity in the vicinity of kelp beds. Risk assessment failings - EA. Review of UK dredging legislation - MMO failing

Local Authority

Are there any existing or potential collaborations that are already or could be working on aspects related to sediment?

CHASM, SKRP, 3 Harbours

Local Authority

Need to link university / NERC/ Defra / MMO / CEFAS opportunities for collaboration

Local Authority

Myself at the University of Brighton. I am expert in coastal sediment transport. However, my position at the university entirely relies on external funding which means that to keep my job I need to find funds

Research body/consultant

The Crown Estates promised to get more involved in sediment research

Research body/consultant

Possible links with National Trust to explore weir and levee removal in and around the Woolbeding estate. Further collaboration with EA to measure sediment transport rates in Lod and Rother. Collaboration with ARRT to understand role of Himalayan Balsam in destabilising channel banks

Research body/consultant

MMO ambition to match our collective ambition

Non government bodies

This is certainly something we'd like to discuss within the Weald to Waves Partnership

Non government bodies

https://sednet.org/

Government agency

Are you aware of the NERC funded LOIS project in the 1990s which looked at sediment movement from inland to the continental shelf? There may be lessons from this major research initiative across numerous Universities and Research Platforms

Research body/consultant

Are there any potential sources of funding for work related to sediment that you're aware of?

Crown Estates? Private land owners covering coastal areas

Research body/consultant

New legislation from Government post Brexit

Local Authority

If resources were available related to sediment, what would you like to see happen next?

Working group on Sussex Sediment established. Funding for robust surveys on Crustacean population health. Link science with policy and management needs

Local Authority

Contact me and we can work together to address the key points I identified earlier

Research body/consultant

Annual conference with speakers from Defra & MMO

Local Authority

Evaluating the use of tracers for identifying sediment sources causing the problem in marine ecosystems

Research body/consultant

Set up a research project (even localized) but investigating movement, contamination and impact

Research body/consultant

Carry out a long-term field survey and also a numerical modelling study

Research body/consultant

Sediment (if scientifically shown to provide benefits rather than cause harm) should be retained in marine systems such as harbours and estuaries, rather than being disposed of at sea in huge quantities.

Non government bodies

More funding spent on wooden groyne repairs

Local Authority/Fisheries Representative

Shareable resources and guidance

Non government bodies

There was a lot of really good work presented at the workshop and how this all comes together in to an overall prioritised strategy will be very interesting. Understanding and utilising all the evidence that is already available is essential to make effective steps forward

Government agency

Appendix C

Sediment topics discussions – further detail

Sediment transport source to sink (1/3)

Priorities	Details	Research questions	Evidence or activity gaps	Current activities
Over-arching			Grain size vs. mineralogy/composition	EA's Citizen science programmes (learnings about how investment and stewardship needed)
			Clear Terminology (i.e. what is a sink)	
			Agreed end point for action.	
			Levering of data opportunities: • from existing projects and vessels (e.g. ferry box); • employing monitoring buoys near dredge sources; • other projects nearby; • sampling by marine users (fishers)	
			Prioritisation of areas.	
			Regulatory Levers and optimisation. Assess legal framework and demonstrate if they are working or not. Citizen science approaches.	
			Better comms and engagement activities to help public understanding	
			Cost:benefit analysis - economic benefits	
			Context based assessment – do we need different mitigation and adaptation plans for West and East Sussex?	

Sediment transport source to sink (2/3)

Priorities	Details	Research questions	Evidence or activity gaps	Current activities
Habitats	Intertidal mudflats and saltmarsh	What are the feedback loops between lack of habitats and sediment movement?	Identification of locations suitable for habitat recreation/restoration;	Habitat Creation Programme (although concerns about it's suitability)
	Nearshore vegetation (inc. seagrass)		Affordability of land in light of private investor pressures (BNG)	Pevensey Defence Scheme will utilise artificial reefs.
	Freshwater habitats	What are the risks/benefits associated with management of riverine catchment sediment sources and pathways (e.g. catchment landscape scale nature based solutions)	Riverine sediment loads	Southern water is working with farmers to reduce sediment loads into rivers
			Enable LA to team up with stakeholders to ensure chalk streams/rivers improve enroute to the sea. Networking blue corridors.	Landscape recovery on the Adur, looking at flood plain restoration.
	Coastal Squeeze and Accommodation Space	How much room is available in estuaries for sediment?	Sources and sinks of sediment from Managed Realignment.	
Source Tracking* indirectly identified		What is the balance of offshore vs onshore sediment? How are these linked to riverine loads?	Riverine/marine sediment loads.	Water companies required to bring in new water monitoring up and downstream. National network of publicly available data.
		How much sediment comes from each source? What are their relative importance?	Current sediment pathways and Budget.	
		What are the organic sediment sources?	Holistic perspectives; Whole landscape approaches.	
		Can impacts on marine environments be directly linked to sediment sources?	Sediment fingerprinting - using chemical properties to trace location and contribution of sources.	
Climate Change Impacts		What are the likely impacts of climate change on sediment inputs such as increased rainfall or sea level rise?		
		How are land management practices linked to climate change impacts and sediment sources?		
		How might sediment sinks be changed?	Sources and sinks of sediment from Managed Realignment.	
		Will climate change result in more or different (finer) sediment offshore?	Are current measurements (i.e. residual currents) able to track change over time with climate change?	
		How might climate change impact the sustainability of current/planned projects?		
		What is the impact of seasonality on things such as pH?		

Sediment transport source to sink (3/3)

Priorities	Details	Research questions	Evidence or activity gaps	Current activities
Ecological Function				Nutrient neutrality scheme - what can be learned? Brighton Uni PhD - carbon from sediment cores
Coastal Management* indirectly identified		What is the impact of lack of maintenance on coastal defences/sediment transport?	Impact of large-scale land management projects and their potential to capture and store material	Integrated coastal zone management.
		What are the potential impacts on offshore development on sediment transport?		
		What mitigation interventions work to reduce sediment where not wanted, or adapt inputs or pathways?	Relationships between intervention an actions.	
		How much sediment can be removed from a system?		
		Saltmarshes need sediment, but much is removed to sea. How do we ensure the sediment ends up in the right places? Can dredge spoil be better used?	Monitor and model Nab Tower dispersal	CTE is funding environmental studies into dredging (dredging contributes to the economy, but must be sustainable)
				SCOPAC Research Planned for impact of dredging on coastline (focus on sand/gravel sizes)
			Current sediment pathways and Budget.	
			Potential locations for BUDS etc.	

Dredging and disturbance (1/2)

Priorities	Details	Research questions	Evidence or activity gaps	Current activities/actions
Sources of contaminants	Within harbours From rivers / streams / freshwater – and their impact on the coast Run off Landfill sites	Localised impacts – in situ monitoring at disposal sites	Are current dredging licences necessary / fit for purpose? (Polluted pays)	EA monitoring/ground-truthing re chemical monitoring and sediment entrainment info water column
Making dredging more sustainable (CTE)	Sustainability and ethical traceability of dredged / disposal material	Broad spectrum analysis – metals/organics/eco toxicology	Are cores tested from the harbours before dredging?	Dredge and disposal policy development within the MMO planning team
Improved public awareness of dredging activities and notifications		Landfill sites Impacts and data from them Sea level rise and landfill	Regulatory mechanisms	HR Wallingford undertakes Indi assessment, but no/few others
Signposting of existing data to answer research questions		Core sampling within harbours and on the open coast	How do we support regulatory bodies re licenses? Review needed	Novel methods and alternative uses Consider new dredging methods e.g. in Marinas Can sediment be used not dumped? Work with dredging companies to explore. What alternatives to dredging and disposal at sea?

Dredging and disturbance (2/2)

Priorities	Details	Research questions	Evidence or activity gaps	Current activities/actions
Working with stakeholders	To identify research gaps and investor and practitioner needs Developing a strategy to facilitate the integration of finance and biodiversity (via restoration)	Understanding historical recovery of/ from events causing disturbance	Remediation measures to be improved	Dredge disposal monitoring – to take place and be used
Traceability of dredged materials	Dredging allowed in MCZ / Brighton Marina dredging dumped into MCZ and surf zone 2 Shoreham Harbour chemical factory 1870-1956 now being dredged! Rampion trench was not backfilled and spoil rocks are dispersing MMO license for dredging covers a limited number of analyses of sediment contaminants. There is potential for a lot more contaminants to go unnoticed and moved around.	Understanding points of change Review baseline data Natural disturbance and its influence Monitoring how dredge spoil affects habitats Trench dredging in the Solent + 10 years having effect	Independent quality assessor needed re monitoring and testing More onus on Crown Estate to look at dredging and contaminants i.e. More onus on the landowner Is the sediment disposal from Rampion 2 being monitored under an MMO licence condition? Environmental impact assessment – monitoring robustness e.g. Brighton Marina Dredge disposal, blue mussel beds Beneficial use of dredging including on terrestrial sites Screening of maintenance dredge material Dredged material to be tested before/after dredging Are rivers dredged?	

Contaminants (1/2)

Priorities	Details	Research questions	Evidence or activity gaps	Current activities/actions
Scope	Definition of contaminants	Where are contaminants and how have they arisen. What are the 'minor' or under monitored contaminants with potentially unforeseen impacts.	Mapping contaminants*	Southern Water Marine Buoys
	One health diagnostics		Tracing contaminant sources**	WSCC/Jet/UoS Marine Buoy proposal UoS Marine Buoy Proposal
	How do we define safe levels for humans and wildlife		Development of 'healthy environment' status	
	How can we focus on 'healthy environments' rather than levels of specific contaminants		Challenging historic models of thinking about contaminants	Metaldehyde reduction in Cuckmere
Assessment	Contaminant mapping*	Understanding the mechanisms for contaminant transport through trophic systems	Contaminant mapping*	CHASM work (solid v dissolved phase; remobilisation: physical, chemical, biotic)
	Defining sources**		Identifying source 'hot spots' **	
	Effectiveness of buffers around known sources such as landfill sites		Climate Change influence of contaminant concentrations, remobilisation and impacts	
	Identifying emerging contaminants	What is the effect of contaminant remobilisation	Groundwater nitrate/phosphate eutrophication	neQis - real time monitorinn
	Contaminant dynamics with other risks	How do contaminants impact environments	Development of advanced analytics to interrogate accumulative effects	Environment Act 2021 requires water companies to monitor storm overflow and sewage disposal works. Will include measurement of DO, temp, pH, turbidity and Ammonia.
	Risk assessment	How do we assess the risks	How do different contaminants dissipate as they are transported	Fibreglass assessment in Chichester Harbour
			Identifying risk drivers in complex mixtures. How do contaminants interface with SPM	
Policy	Chemical regulation	How can we make use of existing policy frameworks to be effective in a dealing with dynamic issues such as contaminants	Local authorities working more effectively with agencies to track, trace and hold polluters to account	Requirements to use silt curtains
	How to achieve secure governance		Managed realignment of contaminated land	Licensing of current activity Monitoring of fish stocks
			Effective regulation of pollution incidents	
			Monitoring of indicator species	

Contaminants (2/2)

Priorities	Details	Research questions	Evidence or activity gaps	Current activities/actions
Disposal	Alternative solutions required	How can contaminants be effectively removed from the environment	Development of effective approaches to reduce contaminant loading	SW work with farmers to reduce agricultural run off
Financial	Who pays for the work to be done?	Leveraging financial mechanisms for effective management of contaminants	Review and refinement of existing financial mechanisms to improve contaminant prevention and management	
	Scope to include: remediation impacts; testing; long term datasets			
	Mechanism to enable the principle of 'the polluter pays'			
Communication	Lack of public awareness	Developing access and stewardship	How to bring data to action	Sediment reporting
			Bring historical data to light	
	Providing access to data for eNGOs		Opportunities for citizen science monitoring of contaminants.	

Crustaceans, fishing and fishing effort (1/2)

Priorities	Details	Research questions	Evidence or activity gaps	Current activities/actions
Sediment interactions with fisheries	How trawling impacts sediment – resuspension and carbon release.	Economic assessments e.g. Ecosystem services and how sediment impacts the industry	Standardised national monitoring of chemical bioaccumulation	Scientific paper: The impact of bottom trawling on sediment resuspension in the Bay of Biscay
	Scallop trawling beyond the Byelaw area.	Ecotoxicity – how chemicals are bioaccumulating in the environment and finding sources/causes of this	Local monitoring depending on the primary contaminants in the area	
	Bioaccumulation in key commercial species in Sussex e.g. flatfish	Test water for chemicals	Are mussels a good indicator of water quality?	Seabed monitoring using multi-beam and acoustic monitoring (IFCA?)
	Linking sediment with microplastics and toxic chemicals and their impacts	look at synergistic effects e.g. what happens when two chemicals combine	More rigorous monitoring to understand the wider picture including species 'boom & bust' (e.g. death of sea hares, brittlestars and starfish seen in Teeside after initial crab and lobster mortality event)	
	Restricting pumping of toxic chemicals into sewers	Research into bioaccumulation impacts on juveniles life stages for lobsters/crab	Ecotoxicity prevention measures:	
		Research into microplastics	Increased penalties for polluting offences	
			Publicise products that have damaging effects. Make public aware of their ability to report companies who pollute.	
			Fisher led research: • Grab sampling, seabed cores. • Jam-jar method for fishers to collect sediment and record locations. • System for fishers to report when pots come up with sediment; type/location/amount/photos	
			Can we identify sediment source from the collections taken by divers and fishermen? Eg using magnetic fingerprinting?	
			More engagement with fishers: particularly communicating face to face about research outputs	
			Access to Fisheries Industry Science Partnership is a challenge for small fishing groups	

Crustaceans, fishing and fishing effort (2/2)

Priorities	Details	Research questions	Evidence or activity gaps	Current activities/actions
Ecosystem function	Lack of plankton (anecdotally from fishermen), leading to shift in the base of food webs	Are shifts in plankton causing changes throughout the food web?	Natural Capital Ecosystem Assessment – what signals are being seen with changes to the plankton	Environmental DNA surveys are being undertaken as part of SKRP but more monitoring needed to understand all the species in the water column
		Are crustaceans indicators of ecosystem health - Should we view shellfish mortalities as the canary in the coal mine?	Research into food webs and how the impact on one species impacts the whole ecosystem.	Sussex Underwater videos identifying marine life
	Increased fishing of whelks and the impact of this in the wider ecosystem.	What impact does climate change/ temperature have on whelks?	Study of crab/lobster recruitment and other life stages – e.g. plankton surveys (needs ~ £10k per year)	Compare Sussex with what is happening along the South coast and what the signals are there
		What impact is the increase in spider crabs having on other crustaceans?	Elasmobranch (smooth hand, tope, catsharks) predation and the impacts on species and key local fisheries	
		Habitat variability – can species survive if kelp habitat is lost?	Habitat monitoring: • Broadscale/seascape-scale habitat monitoring – do MMO do this? • Updating habitat maps more regularly – plus ground truthing and good resolution of data	Transects used for research e.g. BRUV surveys – use these for comparable habitat research
Fishing status and challenges	Need to support long-term survival of local fisheries	Is the current environment likely to support hatchery reared juvenile lobsters?	Monitoring/quantifying black spot disease and identifying causes	Industry led stock assessments
			Support for lobster hatcheries - but challenging if evidence for low survival rates when released	long-term stock assessment – CEFAS local assessments
			Fish and vertebrates need to be better represented as designated (MPA) features	
			Windfarm footings could be better utilised as habitats and Nature based solution • Engage with Rampion for multi-use of space • Monitor the seabed and boulders deposited from Rampion	

Appendix D

Regrouping of prioritised CHASM tasks

Post workshop, prioritised tasks were regrouped by the CHASM team. In this exercise five shared concerns emerged: change over time; dredging; monitoring; cycles & transport; and impacts.

Concern	Theme	Work packages and tasks	Most Imp	Fills gap	Total per task	% Most imp	% Fills gap	% Total dots
Dredging	Sediment	SD2.2: impacts of dredging on levels of suspended particulate matter and bed material	11	2	13			
	Sediment	SD2.1: Assessment of dredging activities	5	4	9			
	Sediment	SD2.3: dredging presence and response by crustacea		1	1			
						26	24	25
Monitoring	Water	WT3.1: Long term water quality monitoring	7	3	10			
	Land Use	LP1.3: Direct measuremnt of runoff	1		1			
	Fishing	FE1.3: fish stock proxiity to contaminant sources		1	1			
						13	14	13
Cycles and transport	Sediment	SD1.2: Suspended sediment cycles, inputs and transport	8		8			
	Land Use	LP1.5: Fate of runoff in coastal waters	1	2	3			
	Land Use	LP2.3: Modelling of contaminants within road runoff, from source to coastal waters	1	2	3			
	Land Use	LP2.2: modelling the source and fate of road runoff		1	1			
	Water	wt2.1: modelling of freshwater inputs and dispersal into the coastal marine environment	1		1			
	Sediment	SD3.1: linking contaminants in sediment, pore water and biota	3	1	4			
						23	21	22
Impacts	Crustaceans	CR4.1: impacts of climate change on near shore biota	1		1			
	Crustaceans	CR5.1: Impat of physical habitat change on crustacea	1		1			
	Water	WT2.2: impact of combined sewer outflows and emergency discharges on algal growth	1		1			
	Crustaceans	CR3.1: Crustacea response to contaminants	5	1	6			
	Crustaceans	CR2.1: impact of invasive species and disease		3	3			
						13	14	13
Change	Sediment	SD1.4: Historic change in substrate composition and structure	2		2			
	Sediment	SD1.5: Histoic changes in chemical composition and contaminants within sediment	2		2			
	Water	WT3.1: Changes in nearshore warming	2		2			
	Sediment	SD1.1: Bathymetric change over time		1	1			
	Crustaceans	CR1.1: Current and historic species composition	2	3	5			
	Land Use	LP1.1: Mapping land use change	2		2			
	Fishing	FE1.1: Assesment of historic and current fishing effort		2	2			
	Water	WT3.2: Acidification of the nearshore environment	1		1			
	Water	WT3.3: Climate change driven changes to hydrodynamics (waves, water levels)		1	1			
	Land Use	LP4.1: temporal change in sewage input in the marine environment		1	1			
	Fishing	FE1.2: Changes to gear, practices and legislation over time	5		5			
						26	28	26

Thank you