The Value of Monitoring Data to Sustainable Coastal Management in Northeast England

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Abstract
A National Coastal Monitoring Framework has existed since 2008 for the delivery of a suite of Regional Coastal Monitoring Programmes across England. There is widespread acceptance of an undeniable value in the coastal monitoring data that is being collected and, more importantly, in how the improved understanding of physical processes and coastal change is informing sustainable coastal management. With over ten years of data now available from this National Coastal Monitoring Framework, this paper provides specific examples from the Northeast England (Coastal Cell 1) Regional Coastal Monitoring Programme of how the data are now routinely used to inform various aspects of sustainable coastal management, including: (i) Long-term and strategic land use planning; (ii) Capital coastal defence schemes; (iii) Asset maintenance; (iv) Warning systems. It also describes the genesis of the Northeast England programme and how it has evolved over time to now incorporate mapping of marine sediment and seabed habitats and assessment of microplastics, as well as establishing approaches to 'valuing' the coastal monitoring data that is being collected.

Introduction
The coastline is dynamic; it perturbates daily with the tide, changes seasonally due to weather events, and varies over longer timescales as the coast persistently erodes or accretes, often in response to longer-term sea level changes. Coastal landforms are shaped and re-shaped by wind, waves, currents and sediment movement. These processes are the natural drivers of coastal evolution over different time scales (from seconds to millions of years) and over different geographical scales (from local to landscape).

The coast has to be considered over its entire width, with geological and sedimentological structure and governing physical processes reaching beyond the sea-land interface of the shore. The interaction between the hinterland, the shoreline and the nearshore processes needs to be considered.

Historically, mankind has attempted to resist this dynamic nature of the coastline through engineering works and coastal defences. In areas where lives, property and other important infrastructure are under threat from coastal erosion or sea flooding this remains a viable solution. However, in more recent decades, we have also identified the need to work with natural processes and in certain situations adapt to coastal change. Whichever coastal management decisions are made relating to coastal defences and other developments in the marine environment, they need to be based upon sound and up-to-date information relating to coastal change if they are to be technically effective, environmentally acceptable, economically viable and, ultimately, sustainable in the long term and not cause unwanted problems elsewhere.

Coastal monitoring is therefore important in providing understanding of where, by how much, and (through interpretation) why the coast is changing to help reach better-informed decisions regarding management of coastal risks such as erosion and sea flooding, and delivering enhancements and other opportunities, such as development and regeneration or creation (or re-creation) of coastal habitats (Cooper *et al.*, 2009, Bradbury, 2010; Environment Agency, 2010; Sutherland, 2010).

National Coastal Monitoring Framework in England

In 2008, a National Framework was established in England, funded by central government, to ensure that a co-ordinated approach was adopted to coastal monitoring. Prior to this, some areas of the coast received no monitoring, other areas had monitoring undertaken by individual local authorities covering only their own areas of jurisdiction, whilst some areas already had established regional (or sub-regional) programmes.

The purpose of the National Framework was not to dictate to each region of England specifically what monitoring should be undertaken and where or when; it was recognised quite categorically that the local operating officers working within each region were best placed to define the bespoke monitoring needs for their region in a risk-based manner, influenced strongly by an understanding of the geology, character and uses of their coast. Rather the National Framework was developed to ensure a consistency of approach to the specification, format, management, delivery and uses of coastal data derived from each region. Furthermore, by coordinating this approach through a National Framework, efficiencies were derived in many areas, including in the procurement of surveyors and in the analysis and interpretation of arising data.

The National Coastal Monitoring Framework in England has, in essence, developed an integrated network of regional coastal monitoring programmes that:

- use consistent, repeatable, risk-based and cost-effective methods for monitoring the coastal environment;
- optimise available funding to deliver both strategic and operational requirements;
- provide a sound evidence base for shoreline management plans, strategies and schemes to optimise coastal management investment decisions;
- provide integration of regional data sets to inform national initiatives; and
- develop collaboration between operating authorities and a sustainable skills base at local, regional and national scales.

Figure 1 shows the six regional coastal monitoring programmes that have existed in England as part of the National Coastal Monitoring Framework since 2008. Reference is also made in this figure to 'Cells'; these are macro-scale Sediment Cells that were defined on the basis of large scale movement of non-cohesive sediments in the littoral zone (Motyka & Brampton, 1993) and typically have boundaries at major headlands or major estuary mouths which provide a physical or hydraulic barrier to the transport of sands or gravels.

In some regions of England (e.g. Anglian and Southeast), the risks from sea flooding or coastal erosion are higher than others and, in those areas, there is typically a greater amount of monitoring undertaken and the regional programmes pre-date the National Framework. In some other regions, monitoring commenced with the establishment of the National Framework.

Within each region, the data collection typically involves beach profile/topography surveys, bathymetry surveys, aerial photography and airborne-LiDAR surveys. All data and reports arising from the National Framework are publicly-available from various web-based portals, all of which are accessible from the homepage of the Channel Coastal Observatory: https://www.channelcoast.org/.

Figure 1: National Network of Regional Coastal Monitoring Programmes (courtesy Channel Coastal Observatory)

Northeast England Coastline

The coastline of Northeast England is typically dominated by its geology and sedimentology, which has dictated the evolution of a series of headlands and bays.

In the north of the region, the geology is comprised of relatively hard rock such as Sandstones, Limestones and, with progression north, more resistant Whinstones which in places are mantled by a thin layer of glacial till and can have local weaknesses due to faulting in the rock structure or the presence of layers of more erodible Coal Measures. In the south of the region, the geology in zones above sea level is more typically characterised by glacial tills which form, in places, high coastal cliffs or slopes that are highly susceptible to landslips due to marine action, groundwater pressures and sub-aerial weathering.

There is generally plentiful sediment supply along the coast from the North Sea, leading to the establishment of wide sweeping sandy bays or generally healthy and, in places, accreting coastal dunes. The coastline is subject to a macro-scale tidal range (typically approximately 4 m) and whilst wave activity can be relatively high, it is not comparable to the west coast of England where Atlantic sea states dominate.

Land use across the Northeast region is mixed, with large swathes of rural land interspersed with discrete urbanised areas adjoining the major cities, suburbs and towns. Some nationally-important and regionally-important infrastructure is present close to the coast in the form of ports, harbours and marinas, road and rail transport networks and a power station. Many of the coastal areas are internationally, nationally, regionally or locally designated for their importance as sites of nature conservation (ecology), earth science conservation (geology and geomorphology) or cultural heritage significance.

At three locations along the coast, the legacy of coal mining remains dominant, many years after its cessation as the principal industry in the region. At two of these locations, namely Lynmouth Bay in County Northumberland and along the entire coastline of County Durham, historic colliery spoil tipping caused progradation and despoliation of the shore, with ongoing recession of the spoil beaches since cessation of tipping (now more than a decade ago). At the other location, Newbiggin Bay in County Northumberland, it has been alleged that exploitation of sub-sea coal seams caused subsidence of the shore and sea bed that has had adverse effects on coastal erosion risks.

The region's coastline is intercepted by a number of estuaries and coastal streams, some of which are major in size and have significant control structures at their mouths, such as the River Tweed, River Tyne, River Wear, River Tees and River Esk, whilst others are smaller and remain unconstrained, flowing to the sea via a natural channel through dunes or small incised valleys.

Northeast (Cell 1) Regional Coastal Monitoring Programme

Genesis of the Programme

When the Northeast Regional Coastal Monitoring Programme was established in 2008 as part of the National Coastal Monitoring Framework in England, it necessarily incorporated monitoring that had been undertaken on a sub-regional basis in the north since 2002, also incorporated existing *ad hoc* local monitoring programmes from some local authorities, and commenced monitoring in other areas. Its intent is to provide better understanding on the coastal processes and the locations, rates and mechanisms of shoreline change at key locations along the frontage to inform coastal management decision-making.

Recognising that 'one size does not fit all', rather than simply mirroring programmes from some other coastal regions of England, the Northeast programme was specifically designed to gain further insight into areas of risk and uncertainty that were identified in the Northumberland and North Tyneside *Shoreline Management Plan 2* (Royal Haskoning, 2009) and the River Tyne to Flamborough Head *Shoreline Management Plan 2* (Royal Haskoning, 2007). The design of the Northeast (Cell 1) Regional Coastal Monitoring Programme therefore reflects the nature and magnitude of the uncertainties in the coastal erosion and sea flooding risks in this region. The selection of appropriate monitoring techniques and suitable data collection frequencies took into consideration the following issues:

- anticipated extent and mechanisms of change in cliff top position, based on understanding of underlying solid geology and overlying drift geology;
- behaviour of dunes and beaches, based on seasonal and longer-term historic observations;
- magnitude and variation in coastal forcing conditions, such as waves, tides and surges;
- composition of shoreline and nearshore sediments and their dynamism;
- extent of development in areas of coastal change, recognising that much of the northeast coastline is rural but that there are some key urban and industrial areas;
- the anticipated behaviour of this coastal cell under projected future climate change; and
- the availability of complementary data from other public sources, so as to avoid duplication.

Based upon the above, the programme was originally designed to incorporate: (i) beach profile surveys, beach topographic surveys and cliff top surveys undertaken in autumn of each year, with repeat of the majority of these in spring of each year; (ii) bathymetric and sea bed characterisation surveys on a rolling programme; (iii) aerial photography and LiDAR surveys every 2 years; (iv) wave buoys deployed continuously at three locations and tide gauges at two locations (with access to data from pre-existing tide gauge networks deployed by other parties at a series of other standard ports); and, very importantly (v) analysis, interpretation and reporting of these data on an ongoing basis. In addition, walk-over surveys of coastal defences, cliffs, dunes and beaches are undertaken every 2 years to report on their condition and highlight any defects in need of repair.

The intention at the outset was that by collecting and analysing these coastal monitoring data our understanding of the way in which this coastal cell functions and the coastal defence assets (both man-made and natural) are performing would improve, leading to effective and sustainable coastal management decisions into the future.

Evolution of the Programme

Over the past decade, the Northeast Regional Coastal Monitoring Programme has been fine-tuned to meet local needs, including the addition of beach profile surveys, topographic surveys or cliff top monitoring surveys at a number of further locations where erosion concerns have increased or emerged.

In addition, the programme now also includes mapping of sea bed habitats from data captured during the bathymetric surveys. Indeed, this exemplifies one of the many benefits of the National Coastal Monitoring Framework since the inclusion of the sea bed habitat mapping in the Northeast has been enabled through use of a standard specification that was developed by the Southeast Regional Coastal Monitoring Programme but made available to partners elsewhere via the National Framework, thus enabling added value to be derived from the bathymetric surveys and a national consistency of approach to be applied in the mapping.

As technology has advanced since inception of the Northeast Regional Coastal Monitoring Programme over a decade ago, a number of terrestrial 3D-laserscan surveys have been undertaken and repeated at selected locations as trials of the ability of this technology to better understand the changes in cave formation at the base of cliffs, erosion at particular pinch-points of cliff lines or shores (Figure 2), and deterioration in condition (e.g. settlement or block-rotation) of coastal defence structures. These surveys provide very detailed datasets that, with the appropriate software, can be used to develop 3D models of sites or projects as part of the now routine Building Information Modelling (BIM) processes. Note that whilst unmanned aerial vehicles (UAVs, commonly known as 'drone') surveys have also been increasingly for coastal monitoring (Barlow *et al.*, 2017; Turner *et al.*, 2016) and have been used within the region to capture aerial imagery or LiDAR data for specific projects, this has not yet replaced aeroplane-based aerial photography and LiDAR surveys that form part of the Northeast Regional Coastal Monitoring Programme.

Figure 2 – 3D terrestrial laserscan survey of eroding colliery spoil at terminal end of rock revetment in Lynemouth Bay (courtesy Academy Geomatics)

Analysis of the data arising from the Northeast Regional Coastal Monitoring Programme has also recently evolved to address emerging issues in one particularly topical area, namely that of microplastic pollution in the marine environment. Ordinarily, the sea bed sediment grab samples arising from the bathymetric and sea bed characterisation surveys would have been subjected to standard laboratory testing for Particle Size Analysis (PSA) to determine the sediment grain size distribution and characteristic sorting, skewness and kurtosis of the samples. However, in 2019 the samples were also subjected to laboratory testing for microplastic content, with interesting results which are described later.

Use of Monitoring Data in Applied Coastal Management

More than a decade's worth of monitoring data now exists from the Northeast Regional Coastal Monitoring Programme (with more than this in the north of the region, where monitoring commenced in 2002). This provides a meaningful duration of data from which to draw some key findings and exemplify some applied uses in ongoing coastal management.

Understanding of Coastal Change

Beach levels throughout the northeast region have consistently been observed to be highly seasonal-dependent, mostly with little in the way of longer term trends apparent. In numerous locations upper beach berms and healthy beach levels are typically recorded during the autumn (i.e. post-summer and pre-winter) surveys, with often low levels and flatter profiles recorded along profiles in the spring (i.e. post-winter) surveys. This is classic seasonal response of beach profiles. Where dunes back the beaches, these seasonal variations often lead to erosion at the toe of dunes, and subsequent slumping of the dune face, during winter, with slow progressive recovery through sand build-up and vegetation growth over the spring and summer.

The effect of major storms can cause quite dramatic beach responses, with some record low beach levels being measured in surveys following significant events. Storms can also deflect the outflow routes of unconstrained river mouths, with these natural variations in channel alignment then in turn cause erosion (or accretion) along adjoining shores on either side, depending on whether the channel moves closer or further from a particular section.

The effects of the northeast coast's heavy industrial heritage is also obvious in the monitoring data, with examples shown from two locations in County Northumberland, one in Lynemouth Bay and the other in Newbiggin Bay.

Lynemouth Bay

There are extensive slag banks composed of colliery spoil and other industrial waste fronting the toe of natural dunes and cliffs throughout Lynemouth Bay. The beaches fronting these banks are also composed of colliery spoil. Spoil from a local colliery was tipped onto the beach and foreshore for many years, advancing and subsequently maintaining the position of the shoreline in the bay through this artificial 'beach feeding'. These activities finally ceased with closure of the colliery in 2005.

The data derived from the monitoring programme (which in this area extends from 2002 to the present date) is enabling the response of the shoreline to these changes to be quantified. Where the slag banks remain located above the limit of marine activity, such as towards the north of Lynemouth Bay, they are presently stable, but the fronting colliery spoil beach changes are quite rapid, causing lowering of levels and reductions in spoil beach width. If these processes continue, the presently stable slag banks will become subject to marine conditions in the mid term.

Further towards the centre of Lynemouth Bay, the slag banks front a former coal stocking yard. Here the spoil beach has mostly been eroded so that the banks are now subject to marine action and also are presently eroding. The implication of this is that much of the other industrial waste material buried within the colliery spoil is now being released into the marine environment. This is a matter now receiving attention regarding potential pollution effects.

Newbiggin Bay

The beach and nearshore sea bed within Newbiggin Bay have suffered badly from subsidence, alleged to be associated with historical coal mining activities that affected the nearshore area and headlands that control the bay, coupled with ongoing erosion due to marine processes. Over the

record of monitoring (which like in Lynemouth Bay extends from 2002 to the present date), this initially resulted in the toe of the sea wall that protects the town of Newbiggin-by-the-Sea becoming exposed and undermined. In response to this, a major capital coastal defence scheme was constructed in 2007, comprising foreshore sand recharge and the construction of an offshore breakwater. This restored the beach levels to very healthy volumes. Since scheme completion, the beaches have been adjusting to prevailing tidal and wave conditions and there appears to be measurable build-up of sand in the lee of the breakwater as a tombolo and redistribution of sand from adjacent areas to both the north and south of the bay. In the north this is causing problems associated with wind-blown sand on the promenade and car parks and making launching of vessels from the nearby boatyard and lifeguard station at times problematic. In the south, the risk of this sand re-distribution causing unwanted accretion, smothering the otherwise exposed rocky shore platform, used by overwintering birds for feeding, is being monitored through the surveys.

Long-term and strategic land use planning

Historic and contemporary rates of coastal change determined from data arising from the regional monitoring programme have been used to understand risks at particular sites from coastal erosion or sea flooding. In some cases, this has led to recommendations for capital schemes, whilst in other cases the need for adaptation to ongoing coastal change has been highlighted.

Given that the rationale for, and design of, the monitoring was triggered by recommendations from the Shoreline Management Plans (SMPs), it is unsurprising to note that the resulting data have been so beneficial to long-term and strategic planning. Indeed, some local authorities have used projections of future coastal evolution, developed from the monitoring data, to determine 'Coastal Change Management Areas' (CCMAs) in accordance with the National Planning Policy Framework. These CCMAs allow councils to ensure that new permanent development does not take place in areas that are at, or will become subjected to, risk of erosion and sea flooding whilst also inform plans to adapt or relocate existing 'at risk' properties, and the people who live in them.. Whilst 29 of England's 94 coastal planning authorities are currently using CCMAs, with a further 35 councils having some similar form of policy on coastal change, the remaining 30 – almost a third – have no policy on coastal change or do not use CCMAs (The National Trust, 2015). There is therefore a requirement to ensure that SMPs are implemented through local land use development plans, with more widespread use of Coastal Change Management Areas (CCMAs) around England; and SMPs require refreshing and, if necessary, revising in accordance with up-to-date understanding of coastal change based on results from the past decade's monitoring. An example of good practice can be seen in the Northumberland Local Plan (Publication Draft Plan) (Northumberland County Council, 2019) which has a defined policy on coastal erosion and coastal change management which states that areas vulnerable to coastal change will be managed in accordance with the principles and approach set out in the SMP while giving full weight to the level of importance of the coast's ecological and heritage value.

Capital coastal defence schemes

Data derived from the regional monitoring programme have been used to inform the appraisal of coastal management options, selection of preferred options and their subsequent outline and detailed design. This has included analysis of beach profile fluctuations to establish the basis of design of structural foundations (to avoid undermining) or crest levels (since low beach levels can increase wave overtopping risk). Additionally, data relating to physical processes have been used to inform the programming of works during construction to maximise working hours with respect to tidal windows, or better understand risks associated with working over winter months.

Asset maintenance

Once every 2 years, walkover inspections are undertaken of the entire coastline. Their purpose is to highlight areas where existing assets are in need of maintenance or repair, covering not only coastal defence structures but also including other coastal assets such as beaches, dunes and cliffs. These findings are often used to inform the biennial in-house maintenance regimes of local coast protection authorities partners. Outputs from the inspections, in terms of a rating of the condition, assessment of residual life and recommendations for further maintenance, repair or replacement, are documents within a Database, with accompanying photographs. This has proved particularly useful when attempting to justify financial investment in capital schemes, since the location and rate of deterioration in an asset can be demonstrated.

Warning systems
Monitoring of physical processes such as tidal levels and wave heights is used to inform operational sea flood forecasting systems, enabling competent authorities to issue preparedness warnings in advance of sea flooding events. Specifically at Whitby Harbour, for example, wave heights measured by the waverider buoy offshore of the harbour mouth are used to decide when access to the piers should be closed to the members of the public so as to reduce the risk of people being swept off the piers due to overtopping waves.

Microplastics
The issue of microplastic pollution has seen an increasing focus in recent years, both as a research and media topic. There is presently great concern about the presence of microplastics in the marine environment and their role in overall ecosystem condition. Due to this interest, a pilot study has been undertaken as part of the regional monitoring programme to analyse a selection of 24 sea bed sediment samples collected off the coast for the presence of microplastics. These are defined as plastic particles between 300 microns and 5 mm in size that enter marine waters from effluent (e.g. microbeads within cosmetic products or microfibres from wastewater treatment plants) or through degradation of larger plastic items over time (e.g. microfragments). Examples of each type of microplastic are shown in Figure 3.

The sediment samples were subjected to laboratory analyses in accordance with guidance methods published by the National Oceanic and Atmospheric Administration Marine Debris Program (NOAA, 2015) and results showed the presence of microplastics within all 24 samples. A large number of samples also contained coal particles (Figure 4) as a legacy of the industrial past and history of colliery spoil tipping. The number of microplastic particles found in a single sample ranged from 6 to 532 particles per kg (p/kg) of sediment. The average number of microplastic particles found was 80 p/kg. The most common microplastic type was microfibres, accounting for 54% of the microplastic particles found and all samples contained microfibres. Microfragments accounted for 41% of microplastics and were present in all but one sample. Microbeads were the least common microplastic type (accounting for the remaining 5%) and were present in only 10 of the 24 samples.

This pilot project, believed to be the first of an applied nature in the UK, now provides a baseline against which any future changes in extent or percentage content of microplastics in defined sea bed areas can be assessed, potentially informing environmental legislation and control.

Figure 3 – Microplastics (beads, fragments and fibres) in sea bed sediment samples (courtesy SOCOTEC)

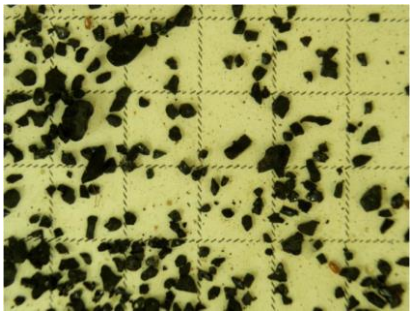

Figure 4 – Coal particles in sea bed sediment samples (courtesy SOCOTEC)

Marine habitat mapping
Existing swathe bathymetric surveys in the Northeast regional monitoring programme use Multi-Beam Echo Sounder (MBES) technology for purposes of surveying the morphology of the sea bed (Figure 5). Following advice, specification and technical support from partner organisations within the National Framework those surveys undertaken after 2015 are now being extended to incorporate processing, analysis and interpretation of accompanying acoustic backscatter information, along with ground-truthing grab sample surveys, to enable mapping of the habitats, substrate type and anthropogenic features on the sea bed. Marine habitats are mapped to Level 3 of the European Nature Information System (EUNIS) habitat classification.

Due to the costs associated with these surveys, and given that there are few features such as nearshore sandbanks, it is intended that the region's sea bed will be covered only once during every 5-year phase of the regional monitoring programme, but with surveys conducted on a rolling basis, with one sub-region covered each year. This means that repeat surveys, which can be used to detect changes rather than purely offering a one-off classification, will fall in future 5-year phases of the regional monitoring programme.

This substrate and habitat mapping, in addition to the conventional bathymetric surveying is useful to our understanding of the condition of the marine area, particularly in areas now protected by Marine Conservation Zones in UK waters. Figure 6 shows the EUNIS Level 3 habitat mapping for the sea bed off Filey Brigg (the same area corresponding to the bathymetry shown in Figure 5). The bathymetry shows a pronounced extension seaward of the rock ridge that forms Filey Brigg at the shore headland. Associated with this ridge are rocky habitats, contrasting to the generally sandy sea bed habitats elsewhere.

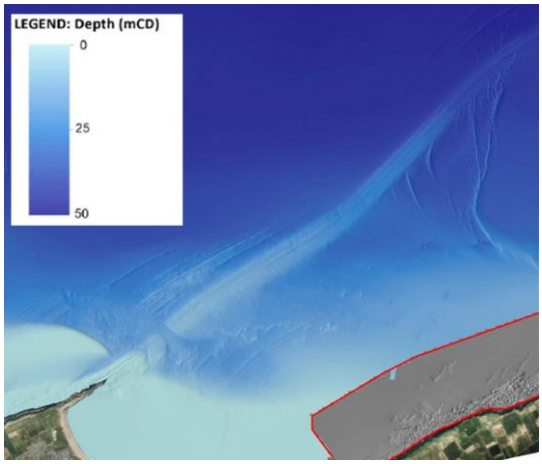

Figure 5 – Sea bed bathymetry

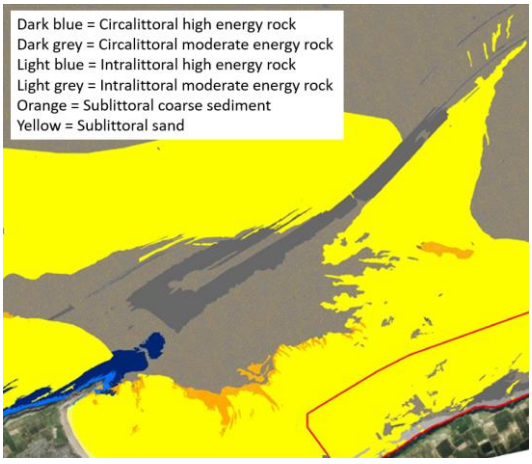

Figure 6 – EUNIS Level 3 habitats

(both figures courtesy Channel Coastal Observatory)

Value of Coastal Monitoring Data

Despite the numerous benefits of regional coastal monitoring data, as exemplified through the case study above of the Northeast Regional Coastal Monitoring Programme, the National Coastal Monitoring Framework in England is funded over only at present 5-yearly timescales, with new business case justification being required to ensure its uninterrupted continuity. There is presently no mechanism that is widely and unequivocally accepted for monetarising the value of the coastal monitoring data within the context of a conventional business case. Furthermore, there is no known international 'standard' or 'model' for this that can be drawn upon.

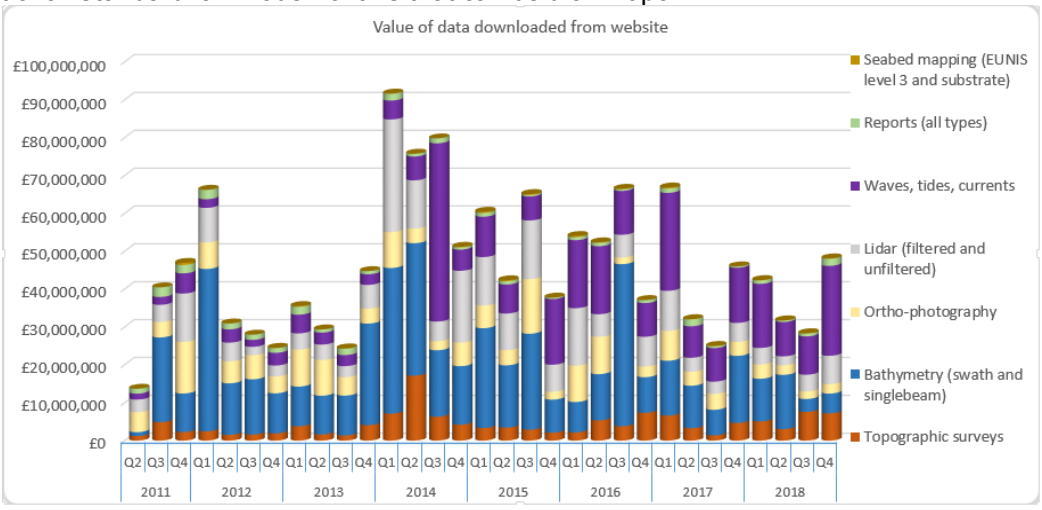

Figure 7 - Valued downloads from the National Framework's data repository

(courtesy Channel Coastal Observatory)

All collected data and analytical reports are made freely available under the open (UK) Government Licence on the national network of regional coastal monitoring programmes data repository website www.channelcoast.org/data_management/online_data_catalogue/. Data downloads are recorded with respect to which sectors are requesting the data and an attributed monitory value is given for the selected data based on the cost of its collection or analysis. To January 2019 the total value of data downloaded from the website since 2011 is £1,419,935,350 (see Figure 7). Since storing its data on the programme's central website in 2011 the Northeast programme has also recorded a significant monetary value of downloads as part of this overall total, with £39,471,350 being recorded over these 8 years.

To January 2019, the central website repository has received 408,910,233 hits since 2013 which demonstrates a large volume of traffic using the website. Statistics have also been captured demonstrating the different sectors downloading the data. For the Northeast region these comprise universities, consultants; local government or governmental quangos; conservation organisations; schools. This shows the applied and practical value of the data derived from the programme as well as its academic research and educational benefits.

Data from the Northeast programme have been used widely for coastal management projects by local authorities. This includes many studies, strategies and schemes addressing coastal erosion or sea flooding risk, as well as informing land use development plans and port or harbour developments. Over the past five years alone, it is estimated that the value of the data used for these specific purposes by far exceeds its cost of capture. In addition, other organisations have recorded beneficial uses of the data over this period. This includes Natural England who use bathymetric data to help understand and manage the recently designated marine conservation zones off the Northeast coast and habitat mapping data to update their marine evidence geodatabase. The aerial photography and LiDAR data are used by the Estuary and Coastal Monitoring Assessment Service (ECMAS) of the Environment Agency to undertake saltmarsh monitoring for purposes of Water Framework Directive (WFD) compliance. At a more local level Northumbrian Water Limited have used beach level data to examine potential impacts on some of their sea outfalls and local Development Trusts have used beach topographic data to help assess the feasibility of a new developments, such as marinas.

Those organisations that utilise data from the Northeast programme do so because free and simple access to the data saves them time and money in commissioning their own surveys, and the track record of change over (at least) a decade provides considerably greater understanding and context than can be gained by a single new survey alone. The data from the programme is quality controlled and collected to strict specifications with common required standards around the six regional programmes that form part of the National Framework. Some users of the programme's data feed benefit back into the programme through collaboration. For example, the Northeast programme has worked jointly with the United Kingdom Hydrographic Office (UKHO) during bathymetric surveys in recent years, whereby the ongoing UKHO 'offshore' seabed surveys (undertaken for navigational and marine conservation zone management purposes) were extended into the 'nearshore' zone by the Northeast programme (under commission), enabling the offshore data to be offered 'in kind' to the programme and generating a high resolution representation of the entire sea bed off sections of the northeast coast. In effect, some £130k of data collection has been freely provided to the Northeast programme through this arrangement. Also, in a *quid pro quo* arrangement, the Northeast programme has freely provided the inshore data to the UKHO, whilst the UKHO has undertaken processing and quality assurance for free to ensure that it meets their required high standards.

Looking ahead, the existing SMPs in England are likely to be subject to 'refresh reviews' in the imminent future. Data from the National Monitoring Framework since it was established in 2008 will provide an excellent source of where and how the coast around England has changed since the first SMPs were developed, mostly around a decade ago. Given that many of the regional programmes were designed to specifically address issues and uncertainties about coastal change that were identified by the SMPs, many of these aspects will be better understood by the presence of a decade's worth of relevant monitoring data. This, in many areas, will help confirm existing shoreline management policies with greater confidence, but in some areas it may help inform the need for changes in management policies to provide more sustainable solutions given the rates and locations of change observed.

Conclusions

There is undeniable value in the coastal monitoring data that has been collected in England since 2008, via six regional coastal monitoring programmes, as part of a coordinated National Coastal Monitoring Framework. A key to this success has been in allowing a risk-based approach to be applied within each region to develop a programme bespoke that that region's specific coastal character, risks and needs, rather than dictating a uniform 'standardised' approach that must be applied nationally.

As demonstrated by means of the Northeast Regional Coastal Monitoring Programme, these data fulfil a practical function in enabling sustainable coastal management decisions to be made at a regional level, whilst also providing data in a manner that enables national-level assessments when required due to the consistency of its specification, format and storage. Conference delegates are invited to offer their experiences in the presentation session from other countries where regional or national monitoring programmes have (or have not) been developed and the relative advantages or disadvantages they see over the approach currently applied in England. This is intended so that lessons can be learned and international good practice identified before the current 5-year phase of the National Framework in England, which is due to expire in 2021, is further refined for its future phases.

With over a decade's worth of data now available from the National Framework in England (and considerably more than this in some regions or sub-regions) understanding of coastal behaviour has advanced considerably. However, it remains necessary to justify continuation of funding for the programme on 5-yearly cycles. With no mechanism pre-agreed with the central government funding body for monetarising the value of the coastal monitoring data, the only quantifiable means of doing this is through records of data downloads from the public web-based repository. This shows an exceptionally high number of data downloads for educational, research and, importantly, applied coastal management uses. This can be monetarised in terms of the actual cost of the data downloaded, with the benefits of the National Programme being that these data were collected only once, in a coordinated manner rather, than on multiple occasions by disparate bodies. Again, conference delegates are invited to offer their own experiences of the challenge of monetarising the value of coastal monitoring data, again with the intent of sharing international best practice.

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