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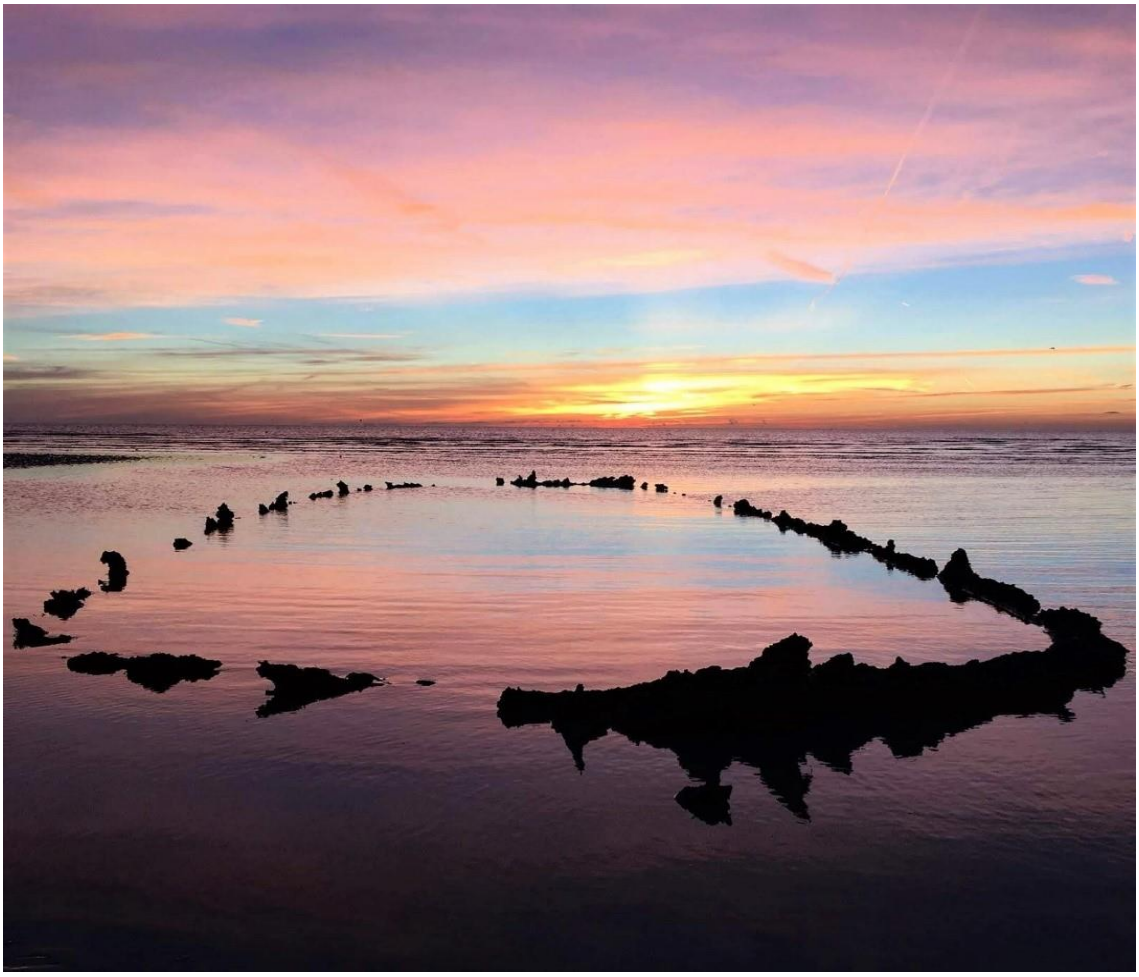
Wrecks in Coastal and Marine Ecosystems: The Goodwin Sands and Kent Coast

Sally Evans and Matt Davison

Discovery, Innovation and Science in the Historic Environment



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Wreck Sites
The Goodwin Sands and Kent Coast

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SUMMARY
The bulk of this report is concerned with the development of a methodology for applying natural capital and ecosystems services assessments to heritage assets. The report also contains a case study in which this method is applied. The case study investigates ecosystems services arising from wreck sites on the Goodwin Sands and Kent coast.

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SUMMARY

The environment we have inherited today is the result of a combination of human activities and natural processes, some of which have occurred over millennia. Archaeological sites and landscapes form both physical manifestations of this ongoing human-environment relationship, and arenas in which this relationship will be played out today and in the future. Recognising the important role of past human activity in shaping our environment, the influence that environment has had on our past, and its current relationship with physical remains of that past, is critical to future approaches to management.

The environment plays an important role in human wellbeing, and both cultural and natural heritage give rise to social and economic values, through the goods and services they provide. Natural capital assets are those features of the environment from which Ecosystems Services flow. Identification of these services and their associated economic and social values is the aim of Ecosystems Services (ES) and Natural Capital assessments. These highly influential management frameworks have arisen from the need for the natural environment to be better represented in policy and decision-making. The aim of the current project has been to develop a methodology to allow for the historic environment to be better included in these assessments, and to provide a pilot study to show how this would work in a marine and coastal context. This project sought specifically to bring together the natural and cultural elements of marine archaeological assets (wreck sites) to consider the Ecosystems Services they provide.

The wrecks within our study area, the Kent Coast and Goodwin Sands, were found to contribute to the provision of food (fish), cultural heritage, recreation and tourism, aesthetic value, inspiration, social relations and habitats for species. While the value of heritage to tourism and recreation for example is well known, the ecosystems services framework represents a useful means of identifying beneficiaries whose use of the sites may relate to factors other than their heritage value. For example, use of a wreck site by anglers.

There is a vast array of literature concerned with ecosystems assessments, methods of valuations and outcomes, and no general consensus on the best methodologies. This is particularly true for those services which relate to culture. Our methodology has stakeholder engagement and site-specific research at its heart, and involved a series of different steps:

1. Defining the study area and purpose of the project;
2. Desk-based research into heritage and ecology;
3. Questionnaire and general discussions with stakeholders (note this occurred throughout the lifespan of the project and information gathered from these sources was relevant for all following steps, in addition to the development of the methodology itself);
4. Site specific survey;
5. Consideration of the relationship between natural and cultural heritage;
6. Identification of ecosystems services;
7. Identification of sites which give rise to different ecosystems services;
8. Assessment of value

An outcome of the workshops associated with this project was the need for different methods for different assessment types (e.g. those to underpin policy, those undertaken when impacts may arise etc), and this project has focused on the development of a methodology for sites on which impacts may arise. Defining the purpose of the study and the study area represents the first step in our methodology.

The desk-based phase which followed sought to identify the baseline heritage and ecology in the study area. During this phase it became clear that there is a scale difference between heritage datasets, which tend to focus on sites, and ecological datasets, which tend to cover broader areas. As such it was necessary to collect information to bridge the gap between these datasets. Information which allowed us to bridge this gap was the result of a literature review, in which we looked into published evidence for the relationship between wrecks and ecology, site surveys which allowed us to collect direct evidence of this relationship, and stakeholder engagement.

This project trailed a number of methods for engaging with stakeholders, from direct participation in training and survey events, to photo competitions, questionnaires and ad-hoc discussions. The combination of site-surveys with stakeholder participation, and requirement for participants to fill in a questionnaire proved to be the most successful method for gathering quantifiable data on ecosystems services arising from wreck sites. However, ad hoc discussions also worked well with members of the fishing community. We found that the techniques with the best success rate were those tailored to fit within the comfort zone of a particular group.

Lasting connections can be an important outcome of ecosystems services assessments. We found that, possibly due to the level of engagement with local communities, many of the participants of the project have kept in touch with the project team. This has led to desirable outcomes such as the involvement of volunteers on repeat surveys of the Sandwich Flats intertidal sites which have been conducted by MSDS Marine and the Nautical Archaeological Society, and ongoing relationships with the fishing community. In particular, following discussions which began as part of this project, MSDS Marine have been approached by members of the fishing community to advise on the specific locations, dimensions and orientation of wreck sites in the area. This has allowed these individuals to ensure their gear does not snag on wreck sites, which is advantageous both to the ongoing preservation of wreck sites and the safety of members of the fishing community and their gear.

It is important to note here that while stakeholder participation is crucial for identifying important ecosystems services where the flow of services is readily understandable (e.g. wreck sites have historical connections, from which flow cultural ecosystems services; or, wreck sites form artificial reefs which the fishing community use) stakeholders may not always be aware of the role's wrecks play in ecosystems. Site surveys are imperative for identifying these services.

This project highlights the importance of site-specific research and surveys for understanding ecosystems services arising from wreck sites. Too little is currently known about the relationship between heritage and ecology for generalisations to be made which adequately characterise this relationship. Predictive methods for identifying which sites give rise to which ecosystems services suffer from a lack of data. Classification of the benthic habitat of wreck sites, using the EUNIS classification system, may allow for

predictive assessment of benthic communities based on characteristics including biological zone and hydrodynamic considerations, as has been done for certain steel wrecks in certain environments (Connor et al. 2004). If further information such as this were available, predicting potential sites at which ecosystems services arise may be possible, but, for local scale studies, this would always require verification in the form of site surveys and input from stakeholders.

As a demonstration of the new information on the relationship between wrecks and ecology which has yet to be understood, our study found that in addition to their role as artificial reefs, and the provision of hard substrate, wrecks also appear to affect their surrounding environments altering habitat and possibly species in a zone of influence around the sites. This project identified communities of worms represented by dense concentrations of worm casts surrounding the wreck sites on Sandwich Flats which differed in size and density to those the rest of the beach. The reasons for the presence of these worms is not known, but it appears likely that their occurrence relates to the presence of wreck sites.

The site surveys proved to be the most effective means by which the differing scales of the heritage and ecological desk-based data could be bridged. It also demonstrated that not all wreck sites are the same, and differences between the ecology of the metal B17 wreck site were observed when compared with the wooden wreck sites on Sandwich Flats.

Our project identified a series of different services arising from wreck sites, including those within the provisioning category, as well as cultural services and supporting and habitat services. However, this work also demonstrated that ecosystems services arise at different scales. Some services arise at site, or even sub-site level, while others only arise from groups of sites or landscapes. These issues also affect valuations. As such it is necessary to consider the possibility that while some services and values may be tied to individual sites, the same sites may also form part of a wider network which give rise to other services and values.

This project also identified a variety of parameters which alter the social and economic value of a site to different beneficiaries, including tourists, archaeologists, divers and the fishing community. This research was undertaken in order to identify areas and sites which may be particularly sensitive to change, either positive or negative. The number of variables affecting the value of a site, and the unpredictability of some of those variables, means that the use of characteristics to serve as proxies for value can only serve to indicate the potential services and value associated with a site. Site-scale research and stakeholder engagement must be conducted to determine whether these values are truly present.

Valuation is a complex issue. The instrumental value of sites, as defined in Conservation Principles (Historic England 2008), allows for social and economic value to be brought in to existing frameworks for assessing heritage significance. However, methods for assessing instrumental value are not defined in Conservation Principles and this framework only allows for consideration of those benefits which arise from the heritage value of the site. This excludes consideration of those values arising from the role of the site in the ecosystem. However, valuation methods associated with ecosystems services assessments may be well placed to flesh-out this aspect of the Conservation Principles

methodology. While some potential data sources are identified by this project, economic valuation is a specialist area and it is recommended that Historic England seek advice from economists in order to develop this part of the methodology.

Overall, the wrecks within the area provide a variety of different Ecosystems Services and are multi-valued. Areas where value can be increased have been identified, and the results of this assessment will feed into the work of the Ramsgate Heritage Action Zone which seeks to achieve economic growth using the historic environment as a catalyst.

Figure 1: Intertidal survey on an unidentified wooden wreck, Sandwich Flats, Kent.

INTRODUCTION

The environment we have inherited today is the result of a combination of human activities and natural processes, some of which have occurred over millennia. Archaeological sites and landscapes form both physical manifestations of this ongoing human-environment relationship, and arenas in which this relationship will be played out today and in the future. Recognising the important role of past human activity in shaping our environment, the influence that environment has had on our past, and its current relationship with physical remains of that past, is critical to future approaches to management.

Definitions, Origins and Direction

Definitions for Natural Capital and Ecosystems Services (ES) focus around the concept that:

Natural Capital is considered to be the world's stocks of natural assets including geology, soil, air, water and biodiversity. It is from this natural capital that ecosystems services, and related human well-being, are derived. These services are therefore valuable to humans, both socially and economically.

Ecosystems Services and Natural Capital assessments arose from the natural science disciplines. The origins of ecosystems services as a form of assessment is connected with the recognition that the contribution of nature, ecosystems and their components to human well-being was underrepresented in policy decisions and management, resulting in harm to ecosystems and thus human wellbeing. The ecosystems services approach evolved as a way to assess and represent the vital human-nature relationship in management decisions. The concept arose in the 1970s as 'environmental services', later re-defined as 'ecosystems services', and developed to include 'natural capital'. Typically, assessments within this framework aim to identify, assess, prioritise and value benefits to society arising from ecosystems, and many assessments include consideration of the effects of changes to ecosystems in terms of the impact on these values, which can be social or economic, though the focus is often on the latter.

The rise of this form of assessment has been punctuated by major studies such as the Millennium Ecosystems Assessment (MA 2005) and The Economics of Ecosystems and Biodiversity (TEEB; Sukhdev 2008). These studies, and many others, group ecosystems services into four categories:

1. Provisioning Services
2. Regulating Services
3. Supporting and Habitat Services
4. Cultural Services

While some organisations such as Natural England envisage heritage as contributing to ecosystems, the historic environment is, in general, absent from ecosystems services and natural capital assessments. As a result of this Historic England have commissioned a series of pilot studies to investigate how the historic environment might better engage with Ecosystems Services and Natural Capital Assessments.

There are many different levels of connection between cultural heritage and ecosystems. Our environment, and places, are a palimpsest of all past and present interactions between ecosystems, humans and nature. Humans exist as part of ecosystems, and our responses and decisions shape those ecosystems today as in the past. Understanding past relationships and the effects of those relationships on the environment can help us better understand today's ecosystems. Our ongoing relationship with the environment can also be deeply connected with concepts of cultural identity, spirituality and sense of place ('Cultural Services').

There are also archaeological sites and landscapes themselves, and the direct benefits they bring to human well-being, as sources of identity, through tourism and through other roles these sites may play within ecosystems, such as habitat formation. Archaeological sites often form physical representations of the past or ongoing relationships with ecosystems. These sites and archaeological landscapes demonstrate that not all capital is natural, and heritage assets must therefore be added to the definitions and recognised as sources from which human well-being is derived.

This report details the work of one of the pilot studies commissioned by Historic England to understand how heritage may be better included within Ecosystems Services methodologies and Natural Capital assessments. A key conclusion of the workshops which have been undertaken as part of these projects has been the identification of a series of levels at which Ecosystems Assessments for heritage can be conducted. These include national-level assessments, connected with policy and high-level decision level; regional assessments; and local assessments or assessments where there is to be an impact. This project is concerned principally with the latter.

This project enables us to understand how heritage may be better included within Ecosystems Services methodologies and Natural Capital assessments. Our pilot study has defined a series of steps, sources and tools for undertaking such assessments, in cases where there may be an impact to heritage (see overview in Section 10).

AIMS

Historic England is pursuing a number of initiatives which aim to support the heritage sector in engaging with natural capital and ecosystem services methodologies in order to protect the historic environment within future environmental policy.

These initiatives will look at:

- What need is there for advice – what does the sector (natural environment and heritage sector) want?
- How is the historic environment included at the moment?
- How might the historic environment be better included – what might this look like?
- Developing guidance/handbook on best practice and how to do this.
- The pilot studies commissioned as a result of this call are primarily addressing aim 3 above but will also inform the development of the guidance for the heritage sector on how to engage with natural capital and ecosystem services approaches (aim 4 above). Although these studies will inform this guidance the development of the guidance itself will be the subject of a separate project.

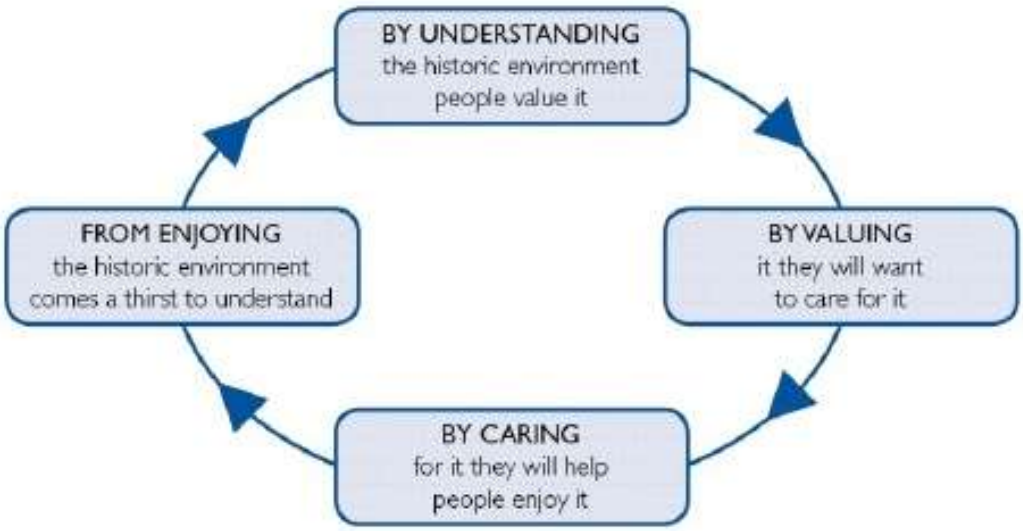
By looking in detail at the heritage associated with particular environmental contexts the aim of the pilot studies is to:

- Identify the heritage alongside the natural capital associated with these environments. To what extent do the two coincide? What is the relationship between the two?
- Set out in the language of ecosystem services what public and environmental goods and services the heritage assets provide (including 'provisioning', 'supporting', 'regulatory' and 'cultural services')
- Identify other values that fall outside the ecosystem services framework that can be ascribed to the heritage assets.
- In doing the above develop a methodology that can be used to ensure that heritage can be reflected in a way that is compatible with natural capital and ecosystem services approaches.
- Provide the heritage and natural environment sectors with case study examples of how this might work for different environmental contexts.

Additional aims not identified within the Historic England brief:

- To create a mapped resource which identifies heritage value within the framework of ecosystems services, in order that the data gathered as part of the pilot study can be used in historic environment management decisions (including for research and development-based situations).
- To engage and enthuse the public, even at this early stage, about their heritage and ecological resources. It is our experience that even a basic introduction to the

subjects can make a lasting impression and promote enjoyment and understanding, key components of the heritage cycle.



Additionally, information set out in this report can contribute to the aims of the Ramsgate Heritage Action Zone which seeks to achieve economic growth using the historic environment as a catalyst. While also contributing to related high-level objectives of Historic England as set out in the Marine and Coastal Network Vision Statement and Priorities, in particular Priority 2:

Demonstrating the economic contribution of marine and coastal heritage assets.

Our work, and in particular the intertidal surveys, questionnaires and other forms of engagement have also addressed priority 1 of the Vision Statement:

Raising the profile of England's marine archaeological resource with Government, developers and the wider public;

METHODOLOGY

Define the purpose of the assessment

Natural Capital and Ecosystems Services assessments come in a wide variety of forms. One of the key factors in determining the methodology is an understanding of the purpose of the assessment, as this will dictate the form the assessment takes. Different styles, with different foci, may be required depending on the end goals. For example:

- Natural Capital and Ecosystem Services assessments at a national or international level, to underpin policy creation;
- Natural Capital and Ecosystems services on a regional level;
- Natural Capital and Ecosystems Service assessments where there is to be an impact to ecosystems and services (positive or negative), for example associated with development or schemes aiming to regenerate areas[1];

From the outset clarity in the goals of the assessment and its scope are key. The aims of the assessment need to be set out clearly. This will dictate not only the study area, but also the scope, stakeholders and overall methodology.

The focus here is on creation of a methodology for use when there is to be an impact to ecosystems, either positive or negative. Our pilot study has therefore focused principally on a local scale, though national issues are present. The goals were to understand the natural capital and ecosystems services provided by maritime heritage in the Goodwin Sands and Kent coast area, to define its associated values, and to connect with the work of Ramsgate Heritage Action Zone (HAZ). The focus here is also on archaeological sites, though the historical context and the development of human-environment relationships are referred to and researched where they help underpin understanding of the ecosystems services and values associated with the sites. However, it is noted that this information may also underpin wider-ranging ecosystems services assessments and these factors in particular can help to understand cultural identity, spiritualty and other issues in which time-depth, memory and history are key influencing factors.

Although site-scale assessments were the focus, all stages were used to build up a picture of the general historical development in the area with particular efforts to understanding the development of human-environment relationships and ecosystems services in the area. This has a dual purpose. Firstly, to ensure the archaeological sites can be understood in context, and secondly to provide a background for understanding Cultural Ecosystems Services generally, which include complex issues such as social relations etc., which typically have some element of time-depth (e.g. Tengberg et al. 2012). Local knowledge is key to this. Assessments of ecosystems services without consideration of social issues such as this has led to problems in the past, and the loss of associated heritage values and services (e.g. Wu and Petriello, 2011). Tengbery (et al. 2012) advocate the need for an historical perspective to fully understand cultural ecosystems services, and thus the historic environment has much to offer in support of ecosystems assessments generally, as well as those specifically aimed at assessing values associated with heritage sites. These issues become particularly important when assessing value –

1Recent studies have indicated that Ecosystems Services Assessments should be incorporated into the Environmental Impact Assessment process. E.g. Tardieu et al. 2015.

where economic means of valuation typically lead to undervaluing or omission of the value society attaches to intangible aspects of culture, such as identity. However, they need to be considered at an early stage to ensure the assessment is framed and conducted in the most appropriate manner.

This pilot study identified a series of stages to be used for undertaking ecosystems services assessments in relation to heritage. A key part of each stage is its ability to contribute to most other stages going forward. This is primarily due to the strong focus on flexibility and stakeholder engagement throughout the process. Appendix 2 contains a summary of the method set out in this report, and an overview of the stages is shown below.

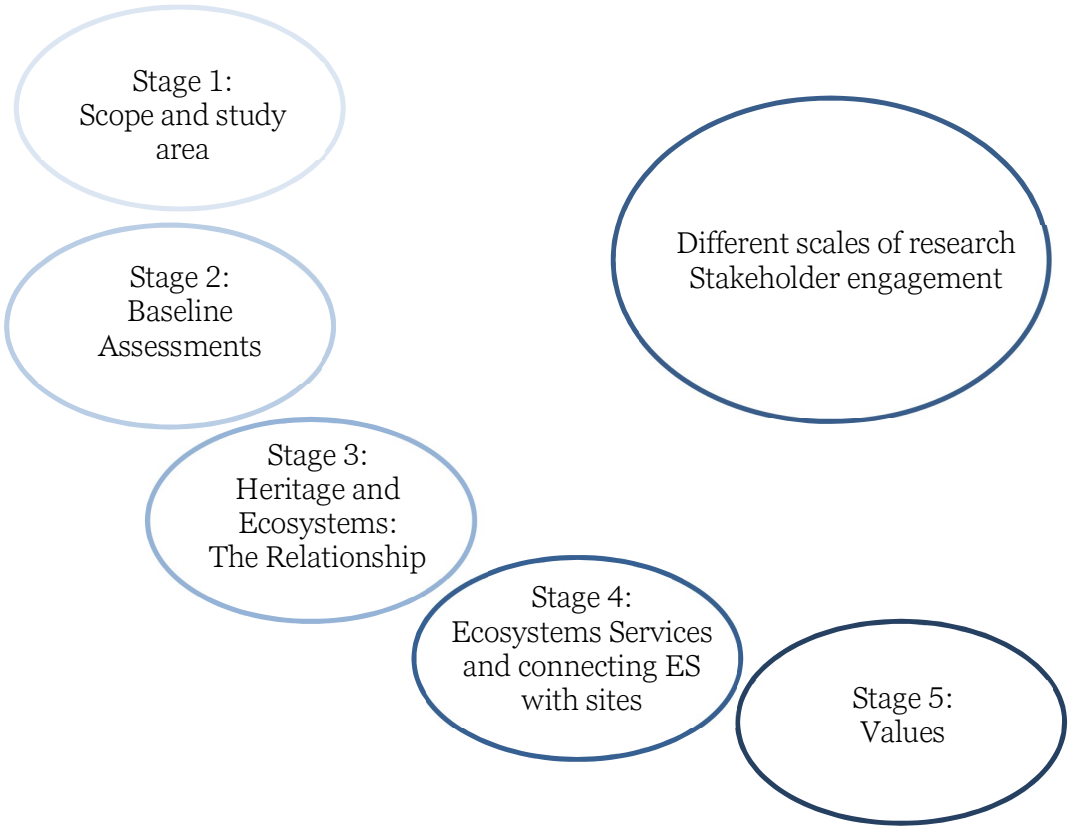


Figure 2: Overview of the methodology set out within this report

However, some of the steps and work set out here have only been necessary to develop the methodology and will not normally be needed in the application of this methodology. This includes primary research undertaken here to define, for example, the characteristics of wreck sites which relate to the value of the sites. While understanding of this may be added to in the future, it is not the intention that ecosystems assessments undertaken to the following methodology will need to undertake this work themselves. They can rather use the results set out here. Description of these stages is therefore excluded from the summary of the methodology given in Appendix 2.

Stakeholder Involvement

At the core of ecosystems services is the concept that sustainability and continuing public benefits is key. Paramount to this pilot study has been development of a methodology which draws assessment based firstly on public benefits and stakeholder involvement into heritage management.

Stakeholders have been consulted throughout the process of this project, and much of the feedback is relevant at different stages of the work. Therefore, the engagement activities have been reported on here in the sections to which they have most relevance. However, much of the stakeholder feedback has guided this methodology, so there have been many feedback loops during the formulation of this methodology in order to incorporate information from stakeholders.

STAGE 1: DEFINING THE STUDY AREA AND SCOPING THE ASSESSMENT

Developing the methodology

Developing the study area is a key part of the process, and the work set out here has been led by a number of previous studies, and in particular Everard and Waters (2013).

The extent of the study area will relate to the purpose of the assessment. For example, development-led or, as in this case-study, research-based. The study areas for development-led projects should cover, at a minimum, the area of impacts. When developing the study area take advice from those with local knowledge, to ensure the area is expansive enough to understand the natural capital and ecosystems services. For heritage this should include, at a minimum, the local authority archaeologists.

A key point to consider is, while it may be possible to define the boundaries of heritage assets quite clearly (in particular individual sites), that may not be the case for the ecosystems which have a relationship with this heritage. Thus, although the study area should guide research when considering heritage in terms of its natural capital and ecosystems services, it may not be useful to treat the study area in a restrictive way. For example, services may be produced within the study area, but beneficiaries may be located beyond it (Everard and Waters 2013). In our pilot study we found that individuals travelled to the local area from a variety of distances in order to 'access' heritage sites, and are therefore direct beneficiaries (e.g. those who travelled to attend an open day associated with the excavation of a historic wreck site within the study area). Thus, data from beyond the area, if it bears a relationship to heritage within the study area, should not be excluded.

Summary of the methodology

- Identify the study area with consideration of the type of project being undertaken (e.g. area associated with development impacts; an ecosystem; an historic landscape component/unit; a research area etc).
- Consult with key stakeholders including local authorities to ensure the study area is sufficient to identify natural capital and ecosystems services associated with heritage in the area.
- Treat the study area as the focus for investigations, but be prepared to consider information from outside of that area to identify beneficiaries for example.
    - The key outputs from this stage will be:
        - Identification of the study area
        - Contact with some of the key stakeholders

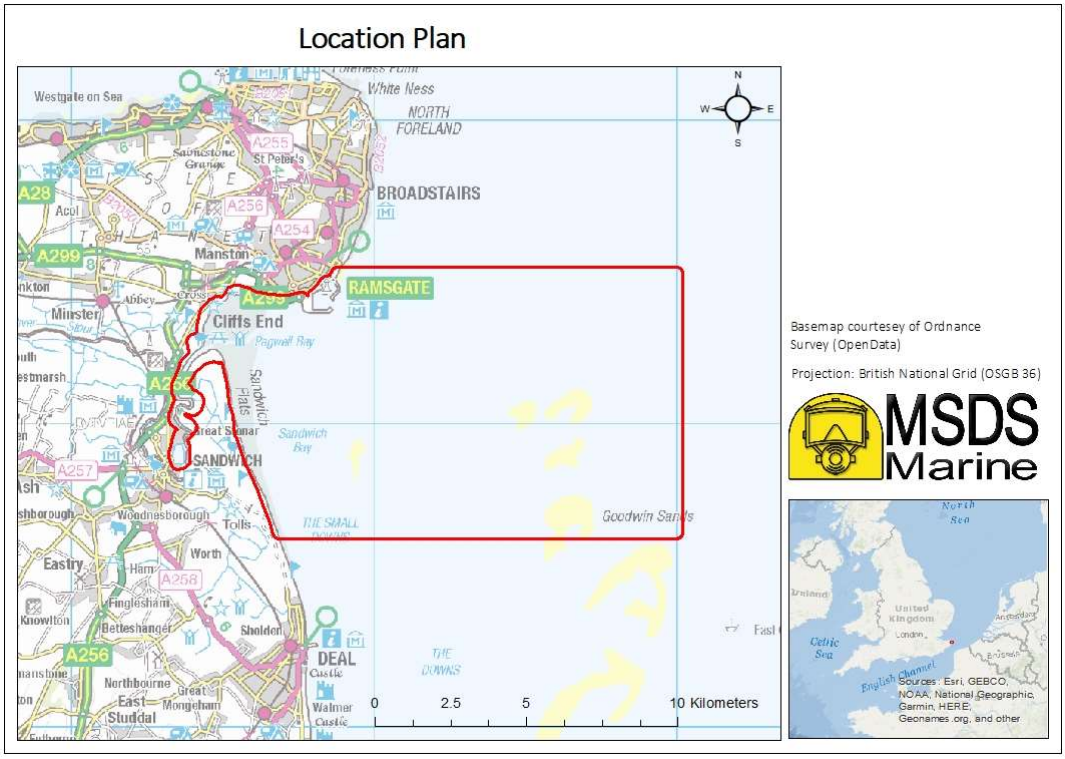


Figure 3 Study Area

Case Study: Wrecks of the Kent Coast and Goodwin Sands

The study area was agreed in consultation with Historic England and Kent County Council. It incorporates the Goodwin Sands and Kent coast. The study area originally incorporated the whole area of the Goodwin Sands. However, this was reduced during the early stages of the project following receipt of the data for the area. It was considered that enough information could be obtained from a study area containing a section of the Goodwin Sands and Kent coast to characterise this area more generally, while also reducing processing time.

The 'study area' for our pilot study was also further honed as we went through the assessment process, to focus specifically on wreck sites.

STAGE 2: BASELINE ASSESSMENTS

The primary aim of this stage is to:

- Identify the heritage alongside the natural capital within the study area. To what extent do the two coincide? What is the relationship between the two?

An understanding of the baseline heritage and natural capital, and the relationship between, forms the basis for later consideration of ecosystems services and values.

Developing the methodology

The first step in our study was to collect data relating to cultural heritage and ecology from within the study area. This data formed the focus for identifying the heritage alongside the natural capital, and for considering the relationships between the two. Rapid desk-based assessments were conducted for both disciplines, with a particular focus on the collation and creation of GIS data, in order to consider the spatial relationships between heritage and ecology within the study area (see later steps). Following collection and assessment of this data we were able to draw a number of conclusions which determine the direction taken by this pilot study.

Initially we had planned to identify key heritage asset types (e.g. wrecks; prehistoric landscapes; aircraft crash sites; harbours; parks and gardens etc), based on physical differences. This approach was proposed on the basis of the assumption that different ecosystems services can be related to sites with different physical differences.

Additionally, we also planned to use historic seascapes data to characterise values. The rapid assessment allowed for the identification of the heritage assets and asset types within the study area. This gave us an insight into possible beneficiaries, with whom we had ad hoc discussions during the development of our methodology. In particular, discussions with the fishing community show that not all wrecks have the same productivity from a commercial perspective and different characteristics, such as substrate, are thought to affect the productivity of different wrecks in terms of fish stocks. Thus, although we had originally considered that classification of site type (i.e. 'wreck') could be sufficient to characterise its values, this is not likely to be the case, and site-specific data must be taken into account. This is discussed further below (see Section 6). Our second point of consideration was the difficulty in relating the heritage datasets which, with the exception of HLC/HSC data, tend to be site-specific, to the ecological datasets, which tend to be broader in their coverage and inherently less detailed in relation to specific locations. This difference in scales makes it difficult, on the basis of these datasets alone, to identify the relationships between the heritage and ecology. This is discussed in more detail in the later stages of this report.

Taking into account these difficulties, our aim became to conduct in-depth research into a small number of sites, while also collecting data from beneficiaries, in order to identify the ecosystems services of those sites. We also aimed to identify those characteristics of a site which (in reality or perception), affect its ecosystems services and values. One of the aims became to have certain values 'flagged' or identified according to which characteristics are present. This would allow the methodology to predict value based on characteristics (see Section 8 and 9).

At this time, it was also decided that, while the application of the assessment methodology would focus on the Goodwin Sands and adjacent coastal areas, information to support the development of the assessment could be gained from outside this area. Thus, the literature review and photo competition bring data from further afield into the development of the methodology.

With this in mind, the focus became the collection of site-specific data. We undertook work in a number of areas to:

- Record the heritage and ecology of specific sites
- Understand the relationship between heritage and ecology
- Identify site specific characteristics which may relate to ecosystems services and values.

Summary of the methodology

Detailed methodologies for the baseline assessments are included in Appendix 4 and 5. A summary is included here:

- Obtain data from existing sources in order to undertake a rapid desk-based assessment of the area (note that this stage may be the first step in a landscape-scale assessment, but, if a site of interest is already identified [e.g. a particular site which may be lost as a result of development, or a site which is being considered for designation for example], this step may be skipped. During the course of this pilot study this step was used to identify the specific sites for more detailed investigation – see steps ii onward).
- Collect heritage data relating to the site of interest (desk-based). Include key datasets including:
    - HER data;
    - Historic England data (designation and AIME);
    - UKHO data;
    - Historic seascapes/ landscapes data[2]; and
    - other key studies for the specific area in question.
- Analyse this data to identify sites and draw out key themes and narratives. The aim is to use these datasets together to rapidly identify sites and characterise the general historic development of the area, allowing the sites to be understood in context, and provide a backdrop for understanding the development of human-environment relationships and ecosystems services in the area.
- Collect and analyse ecological data relating to the site of interest and the surrounding ecosystems (desk-based). Include key datasets including:
    - EMODnet Seabed Habitats (Seabed habitats and biotope classifications for European seabed habitats (MESH) data & EUNIS classifications.)
    - Cefas / Ellis *et al*, (2012) / Coull *et al*, (1998) (Fisheries sensitivity maps (UK spawning and nursery areas))

2 In view of the decision to focus principally on sites, we found that the HSC data does not provide enough detail so cannot be used as a reliable indicator of areas of potential value associated with wreck sites. i.e. the identification of the site as a wreck is not sufficient to understand what ecosystems services that wreck provides. However, consideration of the HSC data does, at a broad scale, indicate some of the potential beneficiaries.

    - Scottish Government / Marine Management Organisation (MMO) (Fishing effort and landings data by ICES rectangle (geographic area).)
    - Joint Nature Conservation Committee (JNCC) (Conservation designations for UK taxa.)
    - MAGIC (Conservation designations for UK areas.)
    - National Biological Network (NBN) Gateway (Wildlife records for the UK.)
    - OBIS Seamap (Sighting and recordings network for marine mammal, sea turtle and other megafauna e.g. basking shark.)
    - British Trust for Ornithology (Sightings and recordings research and datasets)

- Undertake a literature review, in particular to establish the connection between heritage and the ecosystem (our focus was ecology and shipwreck sites);
- Undertake survey work to further record the heritage and ecology of the site, in particular to consider the relationship between ecosystems and heritage, and note users/beneficiaries as survey progresses. Attempt to involve key stakeholders in the survey as they will have relevant local knowledge (our survey involved individuals from the local community, IFCA, TCE, the MMO and KWT).[3]

3 Note, a photo competition was run as part of this pilot study. This was undertaken in order to develop the methodology and baseline information for that methodology, rather than for the purposes of the ecosystems assessment itself. However, photo competitions may represent one of a series of tools for gathering information from stakeholders.

Case Study: Baseline Assessment of heritage: desk-based phase

The study area and surrounding landscape have undergone considerable changes throughout history, changes which are reflected within the historic landscape and seascape. Thanet, once an island separated from the mainland UK by the Wantsum channel which ran from Reculver in the north, to Sandwich, in the south-east, is now joined to the mainland due to silting and the recession of the sea leaving some of Kent's former major coastal ports far inland. Further offshore the movement of the Goodwin Sands has been the cause of thousands of shipwrecks.

The earliest remains recorded in the area date from the prehistoric period, and are generally characterised by find spots of prehistoric material. Caesar is thought to have made landfall within this area during the Roman invasion of Britain, due in part to its proximity to mainland Europe. Roman remains within the study area demonstrate settlement and funerary activity, alongside isolated findspots some of which may represent the presence of Roman shipwrecks. Local reports also refer to a Roman wreck off Sandwich Flats. The origin of Sandwich itself may date to the Roman period, and the nearby fort at Richborough was also constructed at this time.

The name, 'Sandwich'; 'sand-wic' indicates the presence of a coastal trading settlement during the early medieval period (Kent Past 2010). By the medieval period Sandwich was a major port, along with nearby settlements of Deal and Ramsgate, the latter starting life as a fishing and farming hamlet. The inhabitants of Sandwich also took part in fishing activities, including collection of an annual tribute of 40,000 herrings. Sandwich formed one of five 'Cinque Ports', which provided ships and men for Edward the Confessor in the 11th century to help defend Britain from attackers crossing the Channel. However, over the course of the medieval period the importance of Sandwich as a major port diminished as the River Stour silted up, following land reclamation from the Wantsum Channel and the gradual accretion of sediment along this stretch of coastline (Rose 2013).

By the post-medieval period Ramsgate was the most significant port in the area, with almost twice the number of registered ships compared with Sandwich (Palmer 2008). Construction of the harbour, the only Royal Harbour in the UK, began in 1750. There are many documented losses of shipwrecks from this and later periods, and known wreck remains within the study area principally date from the 18th century and later. These include four which are designated under the Protection of Wrecks Act, 1973. Navigation is a key problem, principally due to the rapidly shifting sand banks, which have been the cause of many wrecks in the area. The inhabitants of the area from the post medieval period were chiefly employed in farming, fishing and seafaring, though tourists also made up a portion of the population by the 19th century (Hasted, 1800). Many of the wrecks and documented losses represent cargo, passenger and fishing vessels, and warships, reflecting the general activities of the area. Due to its proximity to mainland Europe, the area has formed a chief point of embarkation in times of war, including during the Napoleonic wars and WWII (in particular relating to the Dunkirk evacuation in 1940) (Ramsgate Town Council 2018). Wartime remains include the wreck of a B17 bomber, designated under the Protection of Military Remains Act, 1986. The number of losses in the area has led to the inclusion of the Goodwin Sands within historical literature. The Goodwins and their shipwrecks are, for example, mentioned by both Shakespeare and Melville.

A number of key themes characterise the cultural heritage of the area, many of which relate to the relationship between the study area and its ecosystems and environment:

- Trade
- Fishing
- Navigation
- Recreation
- Defence
- Connections with Europe
- Coastal change

Sculpture in Deal dedicated to the fishing heritage of the area.

Case Study: Baseline Assessment of ecology: desk-based phase

Predominant seabed habitats within the study area and surrounding regions consist of infralittoral /circalittoral fine sand, infralittoral/circalittoral high energy rock and circalittoral coarse sediment environments. These are productive habitats supporting a diverse range of benthic fauna. Fine sand environments are mainly associated with the Goodwin Sands, which is a recommended MCZ. Key Annex I habitats contained within the Goodwin Sands include permanently wetted sandbanks, which are home to a high abundance of specialist sand dwelling species such as amphipods, polychaete worms and hermit crabs. The sandbanks also provide essential nursery and foraging habitats to a variety of ecologically and commercially important fish species such as Dover sole, plaice and cod. Biogenic reefs formed from blue mussels and ross worm are also a feature of the Goodwin Sands. These form highly productive ecosystems by providing increased complexity and hard structure in an otherwise homogenous soft sediment environment.

The study area is utilised by both cetaceans and pinnipeds throughout the year. The most commonly occurring cetaceans include the harbour porpoise and white beaked dolphin with Minke whale being considered as a frequent visitor to the region. Bottlenose dolphins are also shown to occur within the eastern English Channel and Thames Estuary. Infrequent visitors include larger species such as the fin and sperm whales. Coastal areas are of importance to both the grey and harbour seal with the south and south-eastern region of England inhabited by approximately 1,000 seals (Balanced Seas, 2011). There are rare recordings of other megafauna within the region of the study area for the giant leatherback turtle. All cetaceans, pinnipeds and turtle species listed in this document are protected under some form of legislative conservation e.g. the Wildlife and Countryside Act.

Fish and shellfish species within the study area are considered typical to those of the region. Few species will be truly resident, and the majority are likely to move between the inshore and offshore regions of the study area over the course of the year. Critical spawning and nursery areas were identified for several species, some of which are regarded as 'high intensity' usage areas. However, it should be recognised that these habitats are not restricted to the study area; rather they form a small part of a much larger regional and often national spawning / nursery area. Ecologically important species are shown to inhabit the study area, particularly sandeel which is a key food item within marine food webs. A diverse assemblage of commercial finfish and shellfish species have been identified from landing records. Shellfish were predominantly represented by cockles and whelks but also include scallops, crab and lobster. Commercial finfish were predominantly represented by demersal species such as Dover sole, cod and whiting with large quantities of herring, a pelagic species, also being recorded. Migratory species utilising rivers on the south east coast of England include salmon and sea trout. These species are likely to traverse the study area on a regular basis to reach their foraging / spawning grounds.

The coastal and offshore regions of the study area are host to a variety of seabirds which use the area for foraging and overwintering. Turnstone's are of particular importance as they are a feature of the Thanet Coast and Sandwich Bay SPA and Ramsar sites. Species known to use the study area also include kittiwakes and cormorants which feed on a variety of small fish and invertebrates. Fulmar and gannet utilise the region incorporating the study area on a seasonal basis.

Juvenile fish species within the study area

Case Study: Literature review phase

The literature review is focused on the ecology of wreck sites, the relationship between the natural and cultural heritage and the value of wreck sites. Key studies of relevance for this pilot study include:

- Wessex Archaeology 2008. *Wrecks Ecology*. ASLF.
- Offshore Aggregates and Species Inhabiting Shipwrecks (OASIS) project, which focused on a number of wrecks around the Isle of Wight
- Lengkeek, W. et al. 2013 Ecological Relevance of Shipwrecks in the North Sea. *Nederlandse Faunistische Mededelingen,* 41.
- Studies of wreck sites which have been considered as Marine Protected Areas (e.g. Irving, 1996);
- Studies of artificial reefs particularly in UK waters such as Loch Linnhe reef and HMS Scylla. The latter was deliberately sunk and is used by divers and has been studied by marine biologists (Hiscock et al. 2010; Elliot and Mazik 2011). Studies also include socio-economic assessments of the impact of sinking the vessel (South West Economy Centre, 2003).
- NAS, 2013. *The local economic value of a protected wreck.*
- Fjordr, 2015. *The social and economic benefits of marine and maritime cultural heritage*. Honor Frost Foundation.

Studies considered the relationship between wreck sites and their environment are not new (e.g. Muckleroy 1977), however, in recent years there has been an increase in the number of researchers looking into this area and in particular the relationship between ecology and wreck sites. Many have provided case studies of the ecology of individual wreck sites (e.g. Lengkeek et al. 2013; Wessex Archaeology 2008). Some have also considered methodologies for gathering data on the ecology of wreck sites, while also considering the differences between habitat on wreck sites and the surrounding areas in different types of seabed (Wessex Archaeology 2008). Key issues explored by the literature also include the differences between ecological communities of wreck sites or artificial reefs compared with natural reefs, for example comparing historic wrecks and metal wrecks to reefs (e.g Connor et al 2004; Hiscock et al. 2010). One study compared coral reef communities with those on a 119 year old wreck finding that the communities are only the same when the wreck possesses similar structural features to the reef (Perkol Finkel et al. 2006.). Identification of the characteristics of reefs and wrecks which affect ecology is also a theme running through many works (e.g. Granneman and Steele 2015). In particular characteristics including structural complexity have been shown to influence the density of species present and the assemblage (Granneman and Steele 2015). The rate and patterns of colonisation have also been studied (Hiscock et al. 2010). As in all benthic habitat classification substrate, biological zone (e.g. infralittoral, circalittoral etc) hydrodynamic energy, salinity also all affect species present.

Studies which consider other artificial reef structures are also of relevance (Løkkeberg et al. 2002; Soldal et al., 2002). There are more than 56 artificial reefs which have been constructed within the north-east Atlantic (OSPAR maritime area), mainly to provide socio-economic benefits. The majority are related to fisheries management, although some have been constructed for research purposes and to attract recreational divers (OSPAR 2009). Studies associated with the creation of artificial reefs show that careful consideration of the placement of the reef can be undertaken, in order to target the ecological preferences of the species targeted by the reef. The correlation between benthic habitats and benthic demersal species for example makes this possible (Sayer and Wilding, 2002; Sell and Krönke 2013). These studies are of importance for understanding the different factors which may influence the importance of a wreck ecologically.

Some of the above studies have also included estimations of value, based on recreational uses of wreck sites, or fishing activities. Others have also valued sites on the basis of their heritage tourism, such as the NAS' study of the economic value of the *Coronation* Protected Wreck to the local economy (NAS 2013). The issue of value is considered in broader terms in a recent study on *the social and economic benefits of marine and maritime cultural heritage* (Fjordr 2015).

Case Study: Baseline Assessment of heritage and ecology: Fieldwork phase

Intertidal surveys were carried out on Sandwich Flats in order to record the natural and cultural heritage of the area, and study the relationship. The surveys included volunteers who were given training in archaeological and ecological survey techniques, including offset surveying, photogrammetric recording, wreck recording, phase 1 habitat surveys, seine netting and strand line surveys. A key reason for including volunteers was to invite discussion on the development of the methodology for heritage and natural capital, and to gain insights into how people value wrecks.

A number of wreck sites were recorded in the area prior to these surveys. During the surveys an additional four wreck sites, not previously recorded on heritage databases, were identified. Local knowledge was key to this, and all of the wrecks were known to the local community. Thus inclusion of local volunteers in this element of data gathering was important for understanding the baseline heritage. One of the wrecks, a B17 bomber, has an identity. The remainder, which represent a range of wooden vessels, have not been assigned identities. They appear to represent a range of vessel types including a barge and possible fishing vessel. Further research would be required to determine their dates and significance (in heritage terms).

The majority of the wrecks are oriented with the bow facing the land. This suggests that the vessels may have been deliberately beached in this way, either for offloading or for deliberate abandonment. As a whole the group may represent a ship's graveyard, however, given the proximity to the medieval port town of Sandwich (and the problems with silting experienced by that settlement) it is possible that Sandwich Flats were used as a landing site. Thus, the wrecks may reflect responses to the changing environment of the area and connect with key themes identified by the desk-based assessment.

While undertaking the surveys locals (either involved in the surveys as volunteers, or bypassers walking the beach) told us local stories about the wrecks. One, known as the Portugese, is thought to be the wreck of a Portugese vessel, and other snippets of information such as removal of elements of some of the wreck sites were within local memory.

The ecological surveys focused on the wreck of the aircraft and one of the wooden wrecks. Species recorded on the metal wreck site included: Green sea lettuce *Ulva lactuca*, red macroalgae *Plocamium cartilagineum,* Purple laver *Porphyra umbilicalis,* brown toothed wrack *Fucus serratus,* barnacles Cirripedia (*Semibalanus balanoides* and *Elminius modestus*) and Dahlia anemones *Urticina feline.* Species recorded on the wooden wreck site included: Green sea lettuce *Ulva lactuca,* Red macroalgae *Plocamium cartilagineum,* Piddock (Pholadidae) bivalve (burrower), ross worm *Sabellaria spinulosa* , Peackock worm *Sabella pavonina,* Tubeworms Serpulidae, Sea squirt (Ascidian) and barnacles. Other wreck sites in the area were also rapidly assessed and the presence of invasive Pacific Oysters *Crassostrea gigas* was noted on the wooden wreck sites, along with blue mussels *Mytilus edulis*. Away from the wreck sites the sands of Sandwich Flats did not typically hold these species.

The wrecks form areas of hard substrate in an otherwise sandy bay. Beyond the immediate wreck sites, the wrecks were also found to be associated with areas of soft sediment, which tended to be landward of each wreck. This is likely caused by a slowing down of the flow of water by the wreck, and the subsequent deposition of fine-grained sediments which would otherwise remain suspended in faster flowing water. During the August surveys these areas were found to be associated with dense concentrations of small worm casts, thought to be juvenile blow lugworm *Arenicola marina*. Adult lugworm were present across Sandwich Bay, and the possibility exist that the wrecks create environments for the juveniles of the species.

The surveys also included seine netting, conducted in order to ascertain what species inhabit the area when submerged. The seine netting resulted in the identification of a range of juvenile fish including herring *Clupea harengus*, sea bass *Dicentrarchus labrax*, sandeel Ammodytidae, plaice *Pleuronectes platessa* and dover sole *Solea solea*. The presence of these juveniles suggests the area is likely to be important as a nursery, and large number of mysiid shrimps recorded are likely to be prey. A stand line survey also undertaken revealed evidence of a multitude of species. Among them were egg cases from the common whelk *Buccinum undatum*. These egg cases require hard substrate on which to attach, and thus the whelks may use the wrecks for this purpose (although this was not directly observed).

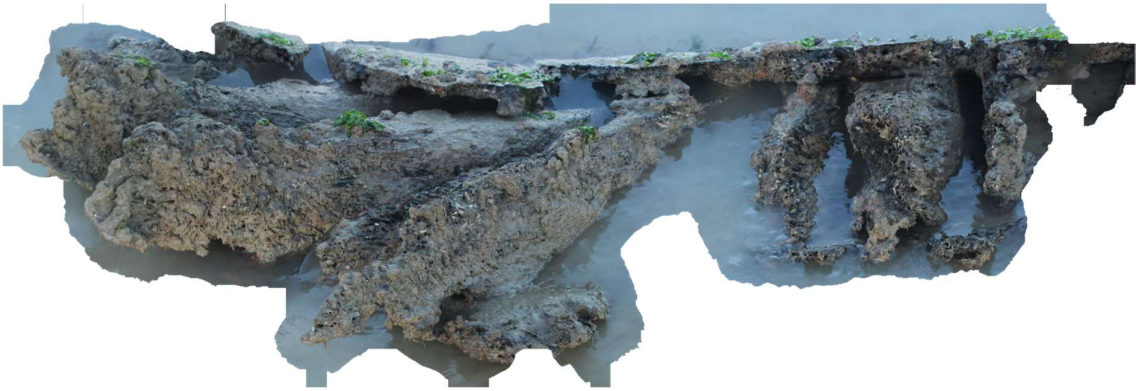


Figure 4 Image of a photogrammetric model of part of one of the wooden wrecks

The intertidal surveys provided evidence for the connections between wreck sites and the environment, while also providing an opportunity for detailed stakeholder engagement. The relationships between ecology and heritage identified reflected the broad themes identified in the desk-based assessment and literature review, and also provided new data on potentially unrecorded relationships between wreck sites, soft sediment and worm species.

Figure 5 Drone footage of the intertidal wreck survey at dawn

The fieldwork phase showed that the heritage and natural capital have a great deal of overlap. A large part of the biodiversity for the intertidal area was focused on the wrecks. While juvenile fish are found in the area likely due to Sandwich Bay's qualities (shallow, sandy bay) as a nursery area, they too may use the wrecks for shelter and foraging though this was not directly observed.

The specific relationship between heritage and ecology appears to depend, in part, on the physical characteristics of the wreck site, such as the material, elevation above the seabed, and intactness or complexity of the wreck site, some of which may relate to the age and preservation of the wreck. The introduction of unoccupied hard vertical surfaces, as presented by a new wreck, are also likely to be of importance. The fieldwork component included recording biodiversity of the different wreck sites. Higher species diversity was observed on the wooden wreck than the metal aircraft site. This was thought to be a reflection of the softer structure of the wood compared with the metal, allowing boring bivalves (piddocks) to burrow and therefore overtime increasing habitat complexity. Conversely, fish species may be more likely to inhabit more intact wrecks (which tend to be metal), offshore and thus fishermen (anglers in particular) target these wrecks for fishing activities. Structural complexity is also important in this context, alongside elevation above seabed and the nature of the surrounding habitat. For example, if the wreck is located within soft sand it will likely represent the only hard structure. This will therefore provide new opportunities for colonisation by species that would not otherwise be able to inhabit the area. Other studies have shown that biotopes for wreck sites can be characterised according to the EUNIS system of classification, with different studies concurring that the 'Circalittoral fouling faunal communities' biotope 'Alcyonium digitatum and Metridium senile on moderately wave-exposed circalittoral steel wrecks' (Connor et al., 2004) is associated with the same dominant and characteristic species, applicable to many different steel wreck sites in comparable environments (Hiscock et al 2010). This suggests that characterisation of floral and faunal communities of wreck sites are ecologically meaningful and can occur when studies of substrate, biological zone (e.g. infralittoral, circalittoral etc) hydrodynamic energy and salinity are undertaken (Parry 2015).

During the site survey invasive species of live Pacific oyster were noted on the wreck sites. These species require hard substrate, and as such in areas of soft/sandy seabed the presence of wreck sites may assist the progression of invasive species.

Moving beyond the immediate confines of the wreck sites themselves, during the intertidal survey areas of soft sediment were observed on the landward side of each of the wrecks. It is likely that this soft sediment was the result of changes to flow velocity which is likely to have affected sediment deposition in the area, with the result that finer sediment is deposited landward of the wrecks. The area of finer/softer sediment is present in a rough crescent-shape. Within this area high concentrations of small worm casts were identified, thought to be juvenile lugworm (on the basis of cast morphology). Studies indicate that juvenile species of worm (including lugworm) display preferences for medium grained sediment, and sheltered locations (Hardege et al. 1998). It is possible that the area landward of the wrecks provide just such a location, and are thus used by juveniles of this species.

Figure 7 Expanse of soft sediment disturbed by worm casts in relation to the wreck sites.

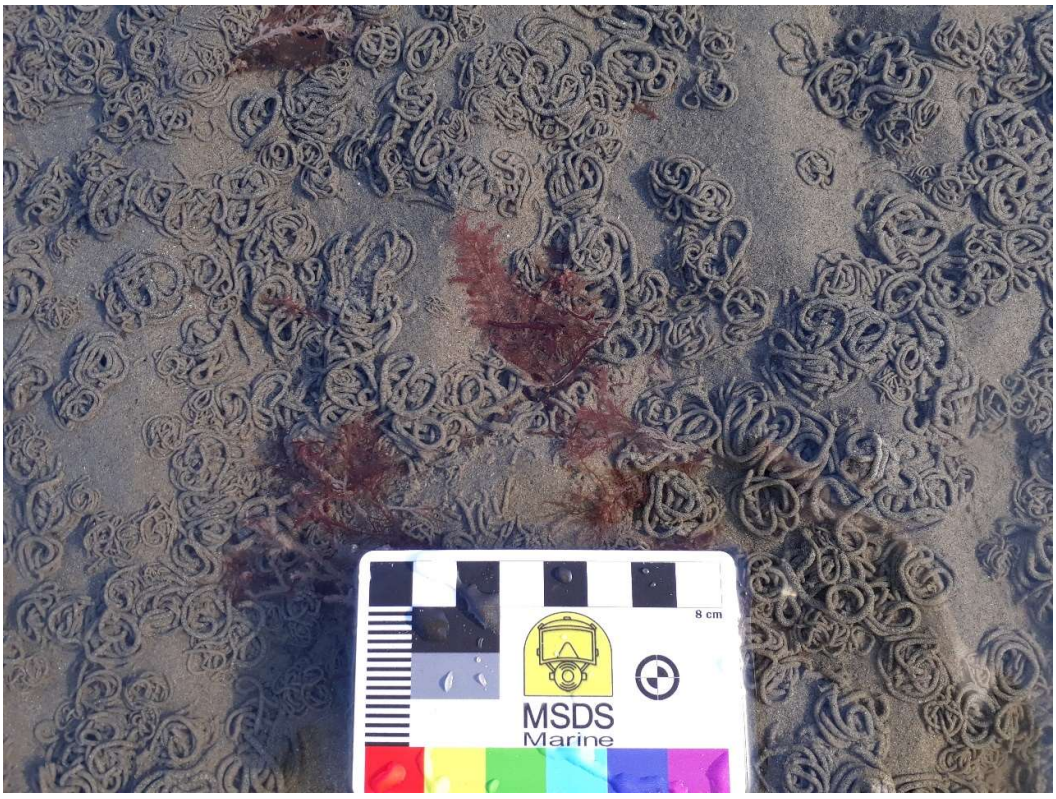


Figure 6 Small worm casts observed in soft sediment in the area landward of the majority of wreck sites

Evidence of organisms exploiting soft sediment surrounding wreck sites has also been observed on a number of Australian sites (e.g. the SS Yongala; Stieglitz 2013). Studies of these sites have recorded halos of holes with biogenic origin around the wreck sites, extending to hundreds of metres around the wrecks in soft sediment. The relationship between the wreck and the construction of these holes is thought to have been made by nesting, feeding or other activity associated with marine creatures, which either live in or navigate by the wreck sites. This further indicates the effect wreck sites can have on their surrounding environment.

Ecosystems services are reported on below. However, it is important to note here that while stakeholder participation is crucial for identifying important ecosystems services where the flow of services is readily understandable (e.g. wreck sites have historical connections, from which flow cultural ecosystems services; or, wreck sites form artificial reefs which the fishing community use) stakeholders may not always be aware of the role's wrecks play in ecosystems. Site surveys are imperative for identifying these services. The possible identification of juvenile lugworm may be of importance as a source of bait, and also as a food source to overwintering birds, through which the area has gained many of its nature designations. Without the intertidal survey these potential relationships would not have been identified. Further survey work would also be necessary to better understand this relationship, including confirming the exact species and age class of the worms present, as this is yet to be confirmed.

Figure 8 Bait diggers on Sandwich Flats

Case Study: Baseline Assessment of heritage and ecology: Photo competition

The photo competition run as part of this project aimed to:

- Gather images of wreck sites and identify species present
- Obtain information about the wreck site to understand their environment
- Obtain information about the wreck site to understand their potential histories
- Gather information on how and why people value different wreck sites

Information was extracted from images by noting the presence/ absence of species. Entrants also sent in information about the ecology and wreck sites depicted in their images. These are illuminating with regard to ecosystems services provided to these beneficiaries of wreck sites.

Entries (examples):

Torrey Canyon, on Seven Stones Reef, Cornwall.
'It's an amazing wreck site which stretches over ⅓ kilometre. She is very broken up in relatively shallow water and in places most divers don't even know they are diving on a wreck such is the coverage of marine life. It is an exposed site some 20 odd miles off the coast of Land's End and at high tide you could easily miss the Seven Stones rocks where she hit on 18th March 1967. It was and still is one of the all-time worst environmental disasters sending around 120,000 tons of crude oil into the Celtic sea. Even today some 50 years later you can still find clumps of oil on the rocky shoreline of Southwest Cornwall's coast. But despite this nature has an amazing way of enveloping the steel remains and making it home to a tremendous variety of marine life. Jewel anemones appear to love the Torrey Canyon and in places you would think you are diving a tropical reef. You can also see that most of the wreckage is topped with kelp further disguising its identity. If you haven't dived her you must - it's probably the best example of how marine thrives despite one of the worst pollution incidents on record.' Photos thought to be '*taken around the bridge section, the wheel is probably from one of the anchor winches.'*

Valentine Tank, near Studland Beach, Dorset.
School of Bib making a Home on a Sunken Valentine Tank near Studland Beach, Dorset. The entrant noted a fascination with the history of the tanks. The diver also noted the aesthetic qualities of dive sites, noting that *'On a good day with good light the UK waters rival anything in the world for colour and beauty'*

H.M.T Corientes, off Malin Head, Ireland.
*'H.M.T Corientes (Dived 04/08/2018). Originally built in 1910 by Cook, Welton & Gemmell of Beverly, Hull, (yard no. 201) she was owned by T.W. Bascomb, Grimsby, registration no. GY 552. She was drafted into the Navy in February 1915 as a minesweeper (Admiralty No. 1149) and fitted with a single 6 pounder gun only to hit a mine while patrolling off Malin Head. She now lies, extensively broken up in 32m. I first dived this wreck in 1990 and as far as I'm aware was the first to do so. I undertook some research, and with the help of the Grimbsy Trawler Museum I was able to identify the wreck, that had previously just been a "snag" and is now known locally as 'Mickey Willie's Wreck'. The image shows a juvenile European spiny lobster (*Palinurus elephas*) – also known as crayfish or crawfish (one of several seen on the dive) and a UK priority species sheltering on the wreck surrounded by Dead man's fingers (Alcyonium digitatum). It has been over 20 years since I've seen crayfish on wrecks in the area and seeing juveniles is an encouraging sign! Shame the lobsters, congers, wrasse, pollock, topknots etc weren't in shot too! The lighting contrasts the vibrant life on the wreck and the bleaker lost gear.'*

Outcomes:

The photo competition was advertised via social media channels and word of mouth in the local (study) area and a £50 Go-Dive voucher offered as the prize. A small number of entries were received, perhaps indicating that open calls for information/photos are not as fruitful as other methods of data gathering. Despite this, we gained valuable insights into the ecology of wreck sites and achieved the aims of the competition:

- The entries included images and descriptions of the species present on the wrecks;
- The entries included information about the environments of the wrecks in some cases, and in others this can be inferred from the photographs;
- The entries included information about the wreck sites, including their identities and in some cases history of the wrecks;
- The entrants also demonstrated a range of ways in which they value the sites, including as heritage assets, ecological sites, and for their aesthetic qualities.

The wrecks depicted in the photographs principally date to the last century, including wrecks associated with both world wars and a later vessel. One entrant included images of an earlier wrecks emerging from shifting sands, and wreckage washed up after storms, demonstrating the relationship between environment, weather and wrecks. The wrecks shown include an ice barque, valentine tank, trawler/minesweeper and supertanker. Historical interest therefore appears to encompass wreck sites from a variety of periods and of a variety of types.

The species recorded in the photographs and information from the divers largely supports the findings of the desk-based work, literature review and fieldwork. Anemones, shellfish (crayfish), cuttlefish, pouting, kelp, dead man's fingers, lobsters, conger eels, wrasse, pollock, blennies and topknots were all recorded on the wreck sites.

The information and images also demonstrate the importance of seabed type when considering the ecological role of wrecks. In particular the Valentine Tank wreck is visibly covered by marine growth, in contrast to the sandy/shell seabed on which it sits, while the kelp-covered Torrey Canyon, is situated on a reef which, as a hard substrate, can also provide an environment for kelp and other species.

The entries are shown in the figure below.

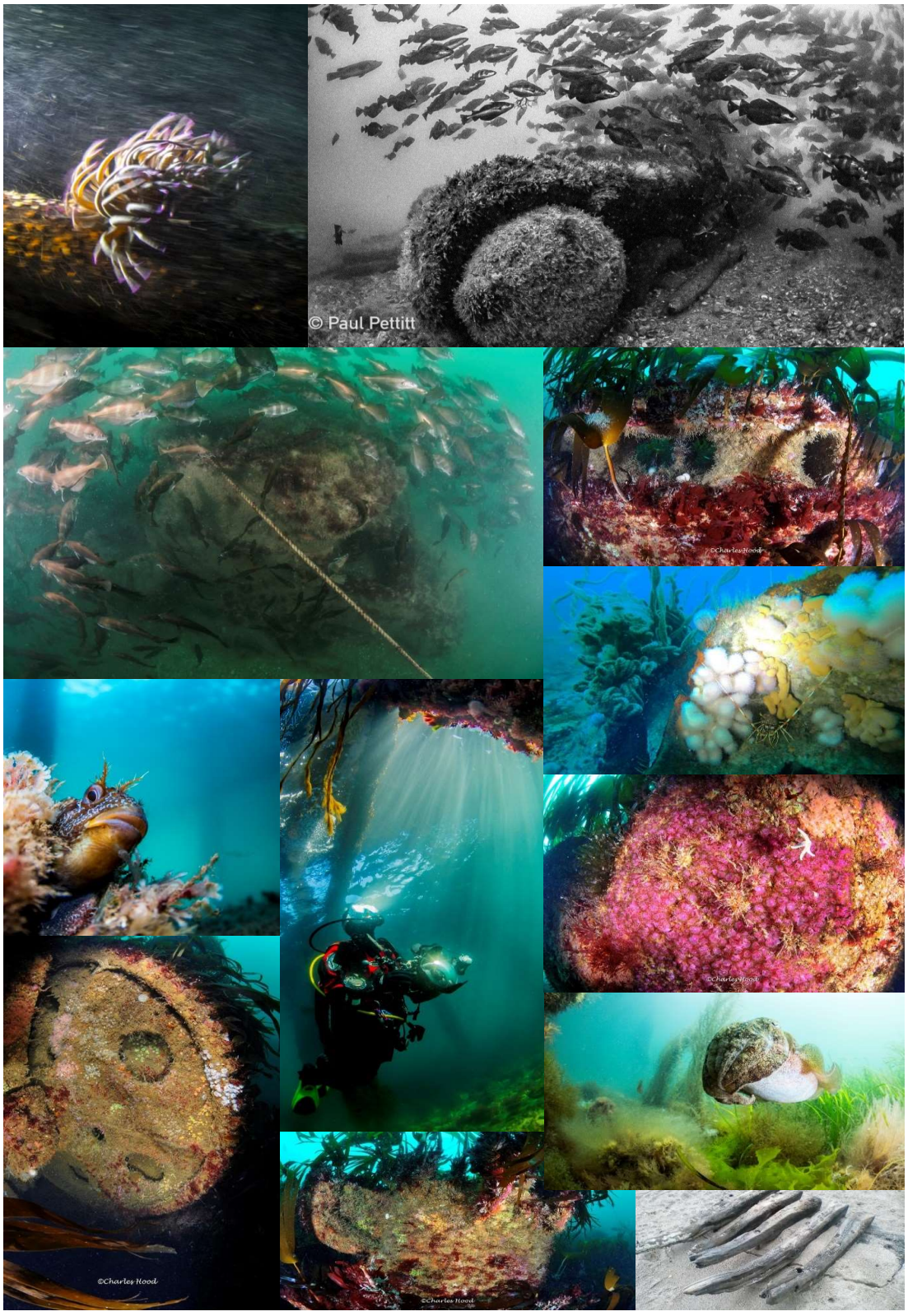


Figure 9 Photo competition entries, courtesy of Charles Hood, Lianne Havell, Paul Pettitt, Tim Mackie. Copyright retained by the photographers.

STAGE 3: OVERVIEW OF THE RELATIONSHIP BETWEEN WRECK HERITAGE AND ECOLOGY

Based on the results of the desk-based study, existing research (e.g. Wessex Archaeology 2008), fieldwork, photo competition and stakeholder consultation, the relationship between heritage and ecosystems was considered. As is well acknowledged in existing literature, wrecks form artificial reefs and provide habitat for a variety species. As with biogenic reefs (which are present within the Goodwin Sands and associated with high biodiversity), wrecks and artificial reefs can provide habitat which is very different from the surrounding seabed or beach. This leads the areas to be foci for species using the wrecks as shelter, and other species which inhabit solid structure. Wrecks may provide particularly important habitat in areas of sandy/ soft seabed, where the wreck forms the only hard structure. This was found to be the case in the intertidal zone of Sandwich Flats, where homogeneous sands predominate and thus the wrecks provided areas of increased habitat complexity compared with the surrounding sands. Additionally, other studies have found that wreck sites do not tend to be inhabited by the same species as nearby hard substrate, suggesting they may increase biodiversity even in areas of rocky seabed.

In summary, features of importance in the relationship between wrecks and ecosystems, from an ecological perspective, include:

- The role of wrecks as artificial reefs;
- Importance of the wreck as an artificial reef is likely to be, in part, related to the substrate on which it lies (wrecks on sandy/ soft substrates may provide areas of increased habitat complexity and thus may be of greater importance than those on hard substrate or reefs (Langeek et al. 2013; Wessex Archaeology 2008; this study)) though even those on hard substrate may host different species and thus increase biodiversity. However, there also concerns caused by artificial reefs. When situated in a soft sediment environment they represent a change in localised community structure and as such introduce species that otherwise would not be there. This can have consequences to the endemic soft sediment populations i.e. increased predation. Additionally, there is a concern that artificial reefs can form 'stepping stones' for Invasive Non-Native Species (INNS), which colonise hard strata. This can facilitate to the geographic spread of these species. This was noted within the study area by the presence of the Pacific Oyster on the wreck sites on Sandwich Flats.
- The wooden wrecks surveyed had higher levels of biodiversity, possibly due to the fact that wood boring species cannot penetrate the metal sites in the same way as on the wooden sites. The burrows noted on the wooden wreck sites were relict, and any evidence of the species which created the burrows appears to have been eroded away. However, the soft chalk in the surrounding environment is likely to form habitat for both piddock worms and *Lyrodus* sp. Thus the burrows may have been created by a combination of both species. This burrowing creates higher levels of habitat complexity allowing greater opportunity for colonising species to take hold. This may

also be related to the age of the wreck. Thus, complexity of structure may relate to the biodiversity of a wreck. Other studies have also noted a correlation between structural complexity and the presence and density of different benthic, demersal and in some cases pelagic fish species (e.g. Granneman and Steele, 2015). This may affect the use of a wreck.

- Wreck sites also appear to have a 'zone of influence' which may include localised alterations to the natural hydrological, sedimentary and biological parameters. Wrecks within the study area appear to affect patterns of sedimentation in their local surrounding environment which in turn appears to affect species presence/density/diversity.
- Wreck sites may present new habitats for species during different stages of their development or migratory phase. For example, juvenile flatfish such as plaice use shallow sandy bays as nursery areas and may therefore use the wreck sites for refuge and foraging opportunities. Additionally, the wreck sites may provide additional anchorage opportunities for egg laying species such as rays, small spotted catshark and common whelk.
- Wreck sites are likely to be of importance for benthic and demersal species (distributions of pelagic species are not thought to relate directly to benthic habitat, unless the species use the seabed for spawning, as with herring);
- Review of all available data shows species present on wreck sites vary from site to site, across individual sites, and on a temporal basis. Conditions on wreck sites can include extremely localised areas of different habitats, and benthic species tend to prefer niches with specific chemical, biological and physical conditions, thus while it may be possible to predict the potential for some species to occur on wreck sites (as has been done for steel wrecks in certain environments (Connor et al., 2004)) on the basis of broad parameters, further site research is necessary to build up more data relating to the benthic habitats of wreck sites generally. Even where this is generated, individual wrecks are still likely to be varied in terms of the species present. Variables affecting this may include structural complexity, seabed sediment type; seabed topography; turbidity; temperature; salinity; anthropogenic factors; availability of prey; season; time of day, etc.[4]

The role of wreck sites situated in a probable nursery area may be important and would warrant further research. It has been suggested that North Sea cod may use wreck sites as nursery areas, along with other species (Lengeek et al. 2013). Within the Sandwich Flats area our surveys recorded the presence of juvenile herrings, sea bass, sandeel, plaice and Dover sole. Habitats with increased structural complexity have been demonstrated to produce higher densities of juvenile fish compared with surrounding habitats (Lengeek et al. 2013). Thus, the possibility that the wrecks, as more structurally complex areas of habitat, provide shelter in nursery areas could warrant further research.

Features of importance in the relationship between wreck sites, ecosystems and environment, from an archaeological perspective, include:

- Effects of the biotic and abiotic factors on the survival of wreck sites;

4 Information on variables gathered primarily from ecological studies and the fishing community

- potential damage caused to wreck sites by species including wood borers (such as ship's worm) species causing biofouling and bioturbation, or species which can affect the environment such that other organisms can inhabit that environment and cause damage (e.g. mussel byssus threads can trap organic matter encouraging bacterial growth and accelerating corrosion on wreck sites (Watzin et al 2001; Wessex Archaeology 2008);
- potential protection of wreck sites by organisms (e.g. barnacles may protect metal wreck structures when securely attached to the surface (Arbuzova 1961));
- the effects of physical and chemical processes on survival (including substrate, hydrodynamics, geodynamics, depth, temperature, salinity etc. Wessex Archaeology 2008: 32-33)
- Damage caused by human exploitation of wreck sites and surrounding environments, relating to their ecological role, e.g. by trawling;
- The wreck within its setting (Historic England 2017). Consideration of the environment of the wreck site provides information on elements of its setting which can contribute to the significance of the wreck site. For example, the loss of many of the wrecks within the offshore part of the study area relates to the presence of the highly mobile and dangerous Goodwin Sands, thus the location and environment of wrecks on the sands forms an important part of their setting. The intertidal part of the study area may have a high number of wrecks due to deliberate beachings either as part of a ships graveyard or use of the area as a landing/offloading point. The latter is connected with coastal change, a theme which characterises much of the historic environment in this area. In terms of the methodology, this stage involves using all baseline data to develop an understanding of the relationship between heritage and ecology.

Figure 10 Sandwich flats. One of the wrecks can be seen in the distance, along with other intertidal features such as fish traps or wartime defences (linear features)

STAGE 4: ECOSYSTEM SERVICES

This section is concerned with identifying the Ecosystems Services associated with the wreck heritage of the study area, in order to address the following project aim:

- Set out in the language of ecosystem services what public and environmental goods and services the heritage assets provide (including 'provisioning', 'supporting', 'regulatory' and 'cultural services')

This stage involved using data which can flow in from a number of different areas:

- Desk-based research
- Fieldwork
- Stakeholder input (via general discussion and questionnaires, reported on below)
- Photo competition

There are many different methods for identifying ecosystems services. In general, these are classified under the following headings: provisioning, regulating, habitat or supporting and cultural services. The table below demonstrates the main ecosystems services have found to be associated with wrecks within the study area, along with the main beneficiaries (note: Appendix 1 gives a breakdown of all possible Ecosystem Service categories. Those included in the table below are relevant to wreck sites). This table reflects an amalgamation of the ecosystem services presented by all of the wrecks within the study area. Thus, not every wreck provides these services, and some services may arise from the presence of multiple wrecks. This is discussed further in the next section of the report. Likewise, wrecks in other areas may provide additional services. For example, no connection between the wrecks and regulatory services was identified by this pilot study. However, it would be possible for a wreck to provide, for example, erosion protection. This further demonstrates the importance of site-specific research for the identification of ecosystems services.

During the course of this research heritage was observed being used in other ways, which are not well represented by the below table. This included use of an exposed wreck for shelter by work/ patrol vessels (this example was observed along the Kent coast, but outside of the main study area). The example relates to the use of a Phoenix Unit (Mulberry Harbour) for shelter by patrol vessels on rough days. In this sense the use is comparable to the use of shipwrecks for shelter by other species, and thus this example may be situated within the 'habitats for species' heading, although the main focus of that heading is on habitat for non-human species.

Ecosystem Services	Wreck Sites	Key Beneficiaries
Provisioning Services		
Food	Habitat for fish (inc. demersal fish, shellfish); lobsters, crabs (brown, spider), whelks, squid and cuttlefish (all need hard substrate to lay eggs), pouting, bream, bass, conger eels, cod, pollack, ling, wrasse, mackerel, scad, sandeel, turbot, plaice, dabs, coafish, brill, squid, spurdogs, tope, smoothounds, blonde rays. Note some of these species are thought to inhabit wreck sites while others may be present on wreck sites while feeding.	• Commercial fishing community • Angling / recreational fishing community • Ecologists • Divers with an ecological interest
Cultural Services		
Cultural heritage	Wrecks are heritage assets.	• Archaeologists • Members of the public interested in heritage
Recreation and tourism	The wreck sites form foci for recreational activities, through direct visits to wreck sites, open days, museums and online visits to virtual trails etc.	• Divers • visitors to intertidal wrecks • visitors to local museums
Aesthetic value	The aesthetic value of wreck sites has been identified.	• Photographers and walkers visiting wreck sites
Inspiration of art etc.	Inspiration for plays, paintings, films. Inspiration and the focus for stories in the local area. The Goodwin Sands and their shipwrecks are referred to in the Merchant of Venice, and by Melville.	• Members of the public
Social relations	Facebook groups have been created in relation to the wrecks within the study area. Licensees for individual Protected Wrecks form part of an England-wide licensee community represented by the Association of Protected Wreck Licensees (APWL)	• Members of the public (online)
Educational values	The wrecks provided foci for teaching activities as part of this project, demonstrating the educational values of these assets.	• Members of the public
Sense of place	The wreck sites represent the maritime cultural heritage of the area, and also represent the ongoing relationship with the environment in terms of coastal	• Members of the public

	change, fishing activities, and navigation problems, thus contributing to the sense of place in this area.	
Supporting and Habitat Services		
Habitats for species	Wrecks provide habitats for a wide variety of species. When submerged wrecks have a role as artificial reefs and fish aggregation devices. Submerged: Habitat for fish (inc. demersal fish, shellfish); lobsters, crabs (brown, spider), whelks, squid and cuttlefish (all need hard substrate to lay eggs), pouting, bream, bass, conger eels, cod, pollack, ling, wrasse, mackerel, scad, sandeel, turbot, plaice, dabs, coafish, brill, squid, spurdogs, tope, smoothounds, blonde rays. Note some of these species are thought to inhabit wreck sites while others may be present on wreck sites while feeding. Habitat for other species including anemones, kelp. Intertidal: Seaweed including: Green sea lettuce, *Ulva lactuca,* red *Plocamium cartilagineum,* Purple laver *Porphyra umbilicalis,* brown toothed wrack *Fucus serratus* barnacles Cirripedia (*Semibalanus balanoides; Elminius modestus*), Dahlia anemones *Urticina feline,* Piddock (Pholadidae) bivalve (burrower), ross worm *Sabellaria spinulosa,* Peackock worm, *Sabella pavonina,* Tubeworms, Serpulidae, Sea squirt (Ascidian), crabs. Effect on surrounding environment: Wrecks appear to affect the sedimentation patterns in their surrounding environment, which appeared to have a knock-on effect on species. Possible juvenile lugworm identified in soft sediment around wrecks.	• Commercial fishing community • Angling fishing community • Ecologists • Divers with an ecological interest • Bait diggers
Maintenance of genetic diversity	Relationship between biodiversity and different wreck sites noted. Also much higher biodiversity on wreck sites than surrounding area (e.g. sandy substrate).	• Human wellbeing

CONNECTING ECOSYSTEMS SERVICES WITH ARCHAEOLOGICAL SITES

Key ecosystems services arising from wreck sites within the study area are:

- Provision of food
- Cultural services; and
- Supporting (habitat) services

When applying ecosystems services assessments to heritage the question of scale is a key consideration. Different ecosystems services are derived at different scales. Some are derived from the presence of assets across a wide area, while others are derived from specific sites. Identification of these distinctions is important for understanding values, and defining areas or sites which may be particularly sensitive to change, be that positive or negative. A large part of our study therefore has focused on connecting ecosystems services with archaeological sites and landscapes, and investigating methods for identifying sites which give rise to which services. This too can then be related to the value of sites. It must be noted that there may be different ways to envisage this relationship. For example, the view taken here is that some wrecks give rise to provisioning services, while some give rise to cultural services (there is often overlap). However, an alternate view may be that wreck sites in general give rise to these ecosystems services, and the difference can be reflected by the value. So, for some sites the value of provisioning services would be higher, and for others the value of cultural services may be higher. However, which ever perspective is taken, different sites are associated with different services and values, and thus consideration is given here to the methods of distinguishing between these sites.

This section first investigates whether it may be possible to predict which sites give rise to which ecosystems services on the basis of certain characteristics, and attempts to define these characteristics. This is followed by an identification of the use of different sites based on observed and reported information as a means of identifying important sites.

Ecosystems Services at a seascape scale

The Goodwins and their shipwreck heritage as a whole give rise to ecosystems services. While some of these services arise from specific wrecks, others are associated with the wreck resource in general. These include services associated with the role the Goodwins and shipwrecks have played as an inspiration to literature (mentioned by Shakespeare and Melville), and their contribution to sense of place. These associations would also be considered to contribute to the historical value of the Goodwins and their shipwreck heritage.

The ecosystems services connected with inspiration are cited in direct opposition to proposed dredging activities on the Goodwins, and are summed up by a comment posted on the Goodwin Sands SOS Facebook page:

'Written about by Melville and Shakespeare, painted by Turner and threatened by Dover Harbour Board....' (posted by F. Punter, 29.10.18).

While there are certain ecosystems services which can derive from the presence of these wrecks together, others are associated with distinct sites. For the latter, different methods for investigating how to identify which sites provide which services have been studied here. These include observed and reported preferences for certain sites, and investigation into predictive mapping using proxy indicators.

Identifying factors which affect the Ecosystems Services associated with wrecks

Not all sites provide the same ecosystems services and thus not all sites are valuable. Identifying which ones are is necessary to prioritise resources and manage sites in the most effective and productive way. The relationship with economic value is dependant upon these parameters. Not all wreck sites fish the same, not all wreck sites have the same heritage value (in Conservation Principles terms), or level of interest from the public/ fishing communities etc. and so not all would form the focus for activities and economic output associated with these groups.

As part of this study research was undertaken to ascertain whether characteristics of wreck sites could be used as proxies for understanding provision of ecosystems services and value. This involved consultation with different groups of stakeholders in the form of open discussions and questionnaires, focusing on those who were identified as key beneficiaries of the ecosystems services produced by wreck sites, i.e. visitors/tourists, archaeologists, divers and the fishing community. Key studies also gave further information on the stakeholders such as DEFRA, 2018. Goodwin Sands: Recommended Marine Conservation Zone. These groups value the sites in different ways, and different datasets are available for assessing the values to each group. The discussion below focuses on wreck characteristics of importance according to the general public and the fishing community.

Characteristics of Importance to the General Public: Questionnaire

The use of questionnaires in participatory approaches to data gathering is a well-established technique. The questionnaire distributed as part of this project (included as Appendix 3) was split into sections. The first part aimed to build up an understanding of the awareness and use of wreck sites in the study area. The next section of the questionnaire was aimed at identifying whether any specific characteristics of wreck sites could be used as proxy indicators for the presence of certain values. The final section aimed to gather demographic and economic information, in particular travel costs relating to visits to wreck sites in the area.

Many of the questions involved free text in order to avoid restricting participants. Where this is the case answers (detailed below) have been classified according to themes.

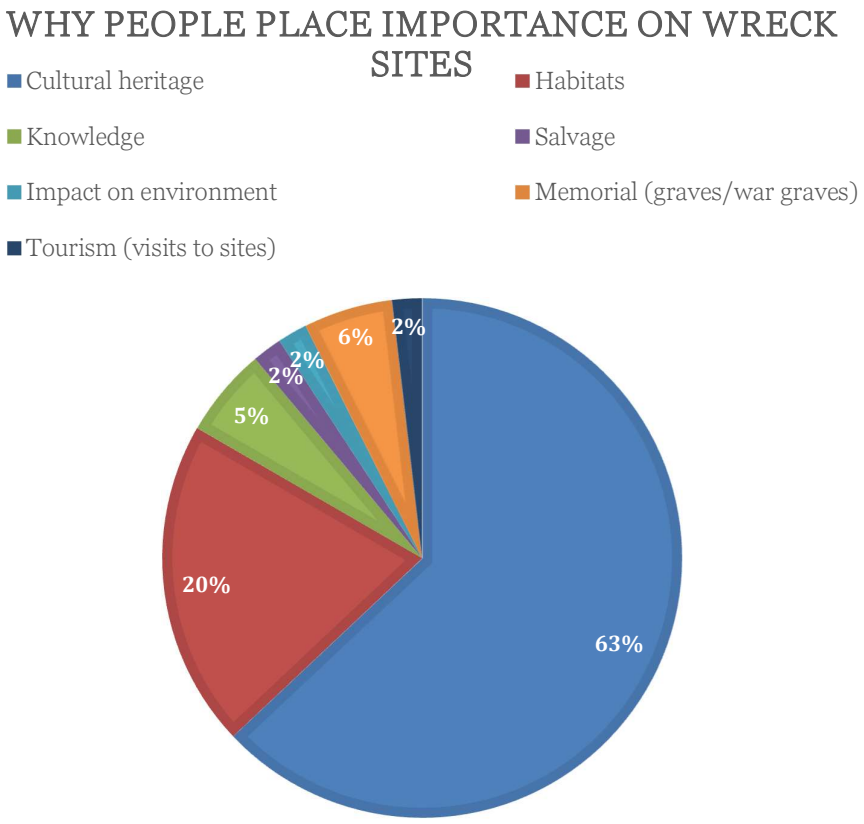
The questionnaire was distributed at the open day for the *Rooswijk* Protected Wreck Excavation, during the intertidal fieldwork undertaken as part of this project and online via e.Surv.org. In total, 34 hard copies and 7 online surveys were filled in.

The participants included visitors and tourists with professions including managers, directors, music teachers, counsellors, students, rail workers, archaeologists, ecologists, financial controllers, students and retirees and those with hobbies including diving and fishing.

Participants were asked 'are the shipwrecks important to you or do you value them in any way? Please explain'. Followed by the question 'Do you use or visit any of the wreck sites in the Goodwin Sands'. Although all of the participants noted either that shipwrecks are important to them or they can see values in shipwreck sites, only one third used or visited any of the wrecks on the Goodwin Sands. A small number said the wrecks were not personally important to them, but they still valued the sites for their historical associations etc. This suggests that the wrecks may have considerable non-use value (existence value – defined as value 'derived from the existence of an ecosystem resource, even though an individual has no actual or planned use of it' (DEFRA 2007: 31)).

The answers received can be grouped into a series of categories which relate to the importance of wreck sites as cultural heritage, habitats, to provide knowledge, as salvage sites, for their impact on the environment, as memorials, and for tourism.

The majority also suggested other opportunities for exploring the history of the Goodwin Sands wrecks, suggesting an appetite for interaction which is not currently met. This may suggest a potentially untapped area of value.



The questionnaire also sought to determine what about a wreck site is important to the participants, and what factors would determine whether participants would use a wreck site. This section was intended to help develop the methodology rather than finding out about values solely within the study area. The categories included were based on the Toolkit for Ecosystem Service Site-based Assessment (TESSA) questionnaire (Peh et al. 2013), the Angling Project Questionnaire, Conservation Principles (English Heritage 2008) and also discussions with local fishing and diving communities as to what characteristics are important.

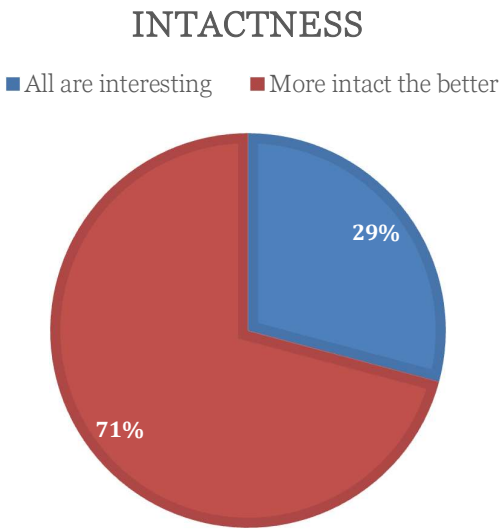
What determines whether a wreck is important to you, or would determine whether you would visit or use a wreck site (tick all which apply):	Yes (%)	No (%)
Historical associations of the wreck	82.50	17.50
Intactness of the wreck or amount of the wreck still present	78.05	21.95
Ecology/ species which inhabit the wreck	73.68	26.32
Whether the wreck forms a memorial or reminder	72.97	27.03
Age of the wreck	66.67	33.33
Material of the wreck	63.16	36.84
Type of the wreck	61.54	38.46
Source of inspiration	52.78	47.22
Aesthetics	51.35	48.65
Physical environment of the wreck	38.78	61.22
Previous or ongoing personal connections with the wreck	35.00	65.00
Your own memories	21.05	78.95

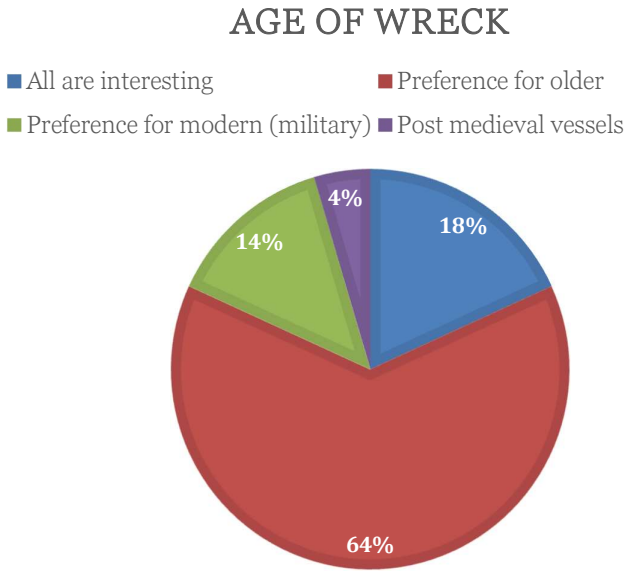
The most frequent response suggests that understanding the history of a wreck is the most important factor in determining whether a wreck site is important to the participants or not, followed by the intactness of the wreck. All of the categories deemed to be most important relate to the physical characteristics and history of the wreck sites. This is likely due to the fact that the main audiences for this questionnaire were in attendance at either an open day associated with an historic wreck, or the surveys run as part of this project. Thus, these participants are likely to have an interest in heritage. Less important were personal connections/memories etc associated with wreck sites. The physical environment of the wreck was also considered of lower importance by participants. Participants included a small number who partake in fishing activities. It is thought that greater importance would be placed on this parameter by the fishing community.

A breakdown of some of these values is possible. Explanations accompanying the list of parameters for what determines whether a wreck site is important gave insights into the most important categories for considering whether a wreck has values. Note, not all participants answered these questions. Figures given relate to the percentage of people who did answer this question and the breakdowns show reasons behind why individuals stated that the parameters were of importance for determining whether they would use or visit a wreck site.

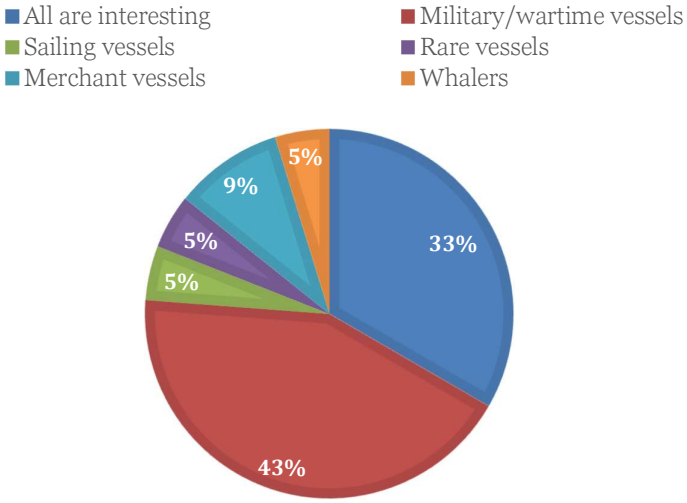
For intactness, the majority believed the more intact the wreck was the better, though a number of participants were interested in wrecks in all states of decay due

to interests in conservation, or noted that every piece of wreck is evidence which can be fitted into a bigger picture. However, on the whole participants preferred more intact wrecks.





TYPE OF WRECK



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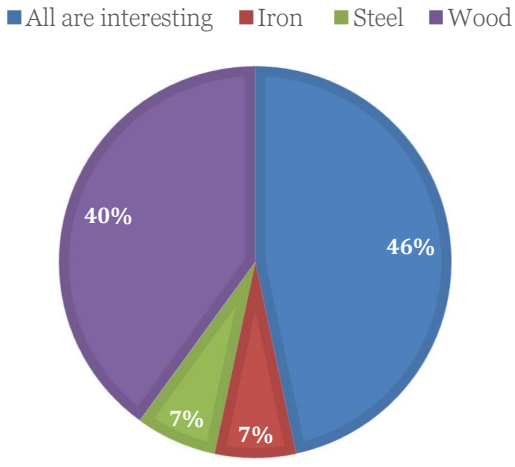


Those characteristics in which the greatest numbers of participants expressed interest are:

- Preference for intact wrecks (17 participants) (71% of those who answered this question/ expressed a preference, and 40% of all participants expressed this preference for intact wrecks)
- Preference for older wrecks (14 participants)
- Preference for military wrecks (9 participants) though interest in all wreck types was noted by a similar number (7 participants)
- The majority (7) expressed no preference in material type, although 6 participants preferred wooden wrecks while iron and steel were only preferred by 1 participant each.

Overall, the latter three categories are of lower importance to the participants than the first category (degree of intactness). Accessibility was also noted as being of importance to participants, both to divers and those accessing intertidal wrecks.

Use of questionnaires provided quantifiable and detailed information into wreck use within the study area, and allowed us to develop an understanding of the factors affecting wreck use by different participants. While the latter was useful for the development of this methodology, allowing us to see whether it is possible to predictively identify wrecks from which different ecosystems services arise, questions relating to this would not be necessary when conducting ecosystems services assessments in general. Removal of questions relating to this would allow for a much shorter and simpler questionnaire, which would be beneficial in attracting participants.

Characteristics of importance according to the media

A high level of media interest in the archaeological excavation of the *Rooswijk* wreck site also provides some insight into media preferences for communicating heritage sites to the public. During 2017 the project was reported on by over 25 regional papers and radio stations, and was also features in the BBC3 Digging for Britain series, as well as a National Geographic documentary (James and Evans 2017). Notable themes were present in the information communicated to the public by the media, these focused around:

- 'Treasure' (media reports tend to focus heavily on the silver recovered from the wreck)
- Tragedy (media reports also report on the tragedy and loss of life associated with the wrecking of the *Rooswijk*)[5].

Review of media outputs provided a valuable source and allowed us to identify these themes.

5 Example: https://www.theguardian.com/science/2017/aug/18/treasure-and-intrigue-scientists-unravel-story-of-1740-kent-shipwreck

Characteristics of importance according to the Fishing Community

Information was gathered from the local fishing communities (working within the study area and the wider Kent coast). The primary means of investigating what factors affect wreck value for the fishing community were general discussions. Questionnaires were also distributed in the Ramsgate area, and a small number of recreational fishers provided data in this manner.

General discussions with the fishing community (including charter vessel owners and commercial fishermen), provided insights into the species caught on wreck sites, and information about the possible characteristics of wreck sites which may affect species, abundance, and (critically) use. The nature of the marine environment is complex and fluctuating. The ways in which the fishing community use wreck sites depend on a wide variety of factors including:

- Structural complexity of the wreck
- Depth of the wreck
- Intactness of the wreck
- Underlying and nearby geology
- Tidal state
- Time of day
- Season
- Species targeted
- Location of the wreck in relation to topographic features (inc. headlands, submarine channels etc which may affect patterns of flow and speed, and fish availability)
- Regulations applying to fish stocks
- Status of the fish stocks
- Beliefs and perceptions of wrecks

The latter is of particular note. Scientific research has the potential to provide much information on the former variables, however, the wisdom of the fishing community with regards to species distributions and habitats is invaluable. In ecosystems assessment terms the latter point, the beliefs of the fishing community, directly affect the use of different wreck sites. This may include beliefs based on experience, research and evidence, or opinion. Examples of this were encountered during the course of this study, where, for example, the fishing community were found to target particular wrecks when trying to find new fishing marks, based on the type of vessel the wreck was thought to represent and a believed association between this wreck type and a particular species. Research into this particular example showed that the vessel targeted was not of the type believed by the fishing community. This highlights the role beliefs and opinions play in the use of wreck sites by the fishing community.

Regulations applying to fish stocks, and the fish stocks themselves, are intimately connected. Decreases or increases in population levels have a knock-on effect in terms of exploitation by the fishing community. Regulations seeking to protect fish stocks also affect this. Along the Kent coast for example, changes to bass regulations have altered the use of wrecks by the fishing community. Likewise, low occurrences

of cod, which are also exploited on wreck sites at certain times of the year, have led to a reduced use of wreck sites by some of the commercial fishing community. Changes in stock levels and regulations therefore affect the value of wreck sites. This further demonstrates the fluctuating nature of some values.

'Alternate state' questions were asked to the fishing community, in particular 'would it matter to you if all the wrecks within your area were removed?'. This was very important to recreational fishermen / charter skippers working with recreational anglers, and less important to the commercial fishermen who were asked. The latter focused on species of flatfish for their catch, which do not rely on wreck sites for habitat. They did however note that if they were involved in lobster or crab fisheries, this loss would be much more important.

General discussions with members of the fishing community allowed us to gain a detailed understanding of wreck use and factors affecting this use along the Kent coast.

Characteristics of importance according to the Heritage Community

Currently there are a number of different frameworks for expressing cultural heritage value amongst the heritage community. In England these include the framework set out within Historic England's (2008) *Conservation Principles: Policies and guidance for the sustainable management of the historic environment,* which advocates the use of a series of categories for understanding heritage value. These are: evidential value, historical value, aesthetic value and communal value. These values take into account the physical and historic qualities of heritage and aspects of their values to people, including associations and meanings. Evidential value is the potential for a place to hold information about past human activity; historical value is the ways in which a place can provide links to people, events and past lifeways; aesthetic value is the sensory and intellectual responses people have to a place (this includes architectural value); and communal value is the meanings of a place to individuals and communities.

Designation also denotes value. Sites are designated when they demonstrate facets of significance connected with a list of criteria which are considered for designation under both the Ancient Monuments and Archaeological Areas Act (1979) and the Protection of Wrecks Act (1973). For wreck sites, these criteria comprise:

- Period: Vessels from all periods are important in reflecting technological advances in construction and materials, and provide evidence of trade networks, industry, and transport. Those vessels which best illustrate or epitomise this development have a strong claim to national importance.
- Rarity: The rarity of vessels' remains for periods before 1700 is such that any firmly dated vessels from this period are likely to be of national importance and may merit statutory protection. For vessels of later date, particularly those types for which examples survive today, statutory protection will always be under exceptional circumstances only.
- Documentation/ finds: Our understanding of shipbuilding, transport, trade and industry can be greatly enhanced by the survival of historical documentation relating to particular vessels and their service. Where

interpretive documentation can provide evidence for especially strong historical claims, for example confirming a ship to be the last of its type, this may be a key factor in establishing its importance. Similarly, significance can be enhanced by the existence of artefacts such as those held in museums.

- Group value: In some instances, a vessel's importance may be strengthened by an association with other vessels of a similar type, for example the group of gunpowder boats at Waltham Abbey (Essex), which allow for comparative study. Association within a wider context which reflects their use can also be a consideration. In the case of hulks (vessels that have been stripped and abandoned), as well as having intrinsic interest, they can contribute to the story of a landscape, and its long-term evolution and management.
- Survival/ condition: Given the range of materials used in boat-building, survival of vessels can be highly varied, from the survival of the sand-imprint of the ship at Sutton Hoo or fragment of the log boat at Shardlow (Derbyshire) to the concrete boats of Second World War date at Purton (Gloucestershire). Given the rarity of surviving vessels of pre-1700 date, even fragmentary survivals are likely to be of national importance although a judgment must be reached as to the degree of survival and intactness. For vessels of later date, increasingly complete survival, allied to strong archaeological and historical importance, will be expected before statutory protection would be considered.
- Fragility/ vulnerability: Highly important archaeological evidence from some wrecks can be destroyed by the selective or uncontrolled removal of material by unsympathetic treatment by works or development or by natural processes. Some vessel types are likely to be more fragile than others and the presence of commercially valuable objects within a wreck may make it particularly vulnerable. Vulnerable sites of this type would particularly benefit from protective designation.
- Diversity: The policy statement cited above notes that assets may be selected for designation because they possess a diverse combination of high quality features, others because of a single important attribute. The importance of wrecked vessels can reflect the interest in their architectural design, decoration and craftsmanship, or their technological innovation or virtuosity, as well as their representativeness. Consideration should be given both to the diversity of forms in which a particular vessel type may survive and to the diversity of surviving features. Some vessels types may be represented in the surviving record by a wide variety of building types and techniques which may be chronologically, regionally, or culturally conditioned. The sample of protected sites should reflect this wide variety of forms. In addition, some wrecks may be identified as being of importance because they possess a combination of high quality surviving features or, occasionally, because they preserve a single important attribute.
- Potential: England's maritime past is one of its most defining characteristics throughout all periods. Evidence for the construction and use of vessels gives us great insight into not only the exploitation of our immediate marine environment, but also into the development of wider trade and transport networks. This is especially true of earlier periods which are lacking in the rich literature and documentation of later times. Surviving vessels may also

> provide evidence of their use and construction, reflecting technological developments which in some instances may be all but lost. For the prehistoric period, in particular, the remains of vessels may be some of the largest artefacts discovered which demonstrate the technology of woodworking and management of woodland resources. Similarly, where vessels are found in situ, associated deposits may be rich in palaeo-environmental remains. The potential which a vessel has for answering questions about our maritime past will be a consideration in establishing its importance. If remains of a cargo survive it is likely to add very considerably to the vessel's significance, for its evidence of trade and material culture at a particular point in time' (Historic England 2017).

Each of these categories denotes an area of significance. There is some overlap between these categories and the parameters by which the public appear to place value on wreck sites. However, the majority have no overlap.

Summary

The study has shown that a range of factors affect the importance of wreck sites to different groups. These factors affect whether the sites are used, and thus affects the ecosystems services provided by different sites. For example, some wrecks may provide better habitat for fish and are therefore provisioning sites, while others may form foci for recreation, and others may be culturally significant.

Ecosystems services also arise at different scales. Some are site specific, while others relate to landscapes or groups of sites (e.g. the inspiration value arising wreck sites on the Goodwin Sands and their role in historically significant literature including by Shakespeare and Melville). These factors can include physical characteristics, temporal characteristics and unpredictable characteristics. The physical characteristics include the age of a wreck and its intactness and historical associations (relating to value as an historic asset) and structural complexity (relating to value in ecological terms). Temporal characteristics also affect ecosystems services, i.e. different wreck sites are used by fishermen depending on the state of the tide or time of year. Unpredictable characteristics include personal preferences and beliefs. For example, individuals within the fishing community expressed preferences for different wrecks. While different parameters can be identified and used to predict value (for example by identifying which sites have the highest levels of intactness, age, structural complexity etc.) the unpredictable characteristics which affect value can only ever be understood through stakeholder engagement.

These characteristics will change through time. Although all heritage assets face degradation, those in the marine environment are subject to more extreme environmental conditions and as such degradation generally takes place at a much faster rate than on terrestrial sites. This permanently alters the physical characteristics of a site. Sites which are today relatively intact will become increasingly less so in the future. Likewise, as time moves on certain emotive values may change. Loss of members of the local community on a fishing vessel may be felt extremely strongly by the community to which they may have ties of family or

friendship, however, with the passing of time the strength of this feeling may alter. Thus the value of sites will alter through time, as their meanings, associations and physical characteristics change. This further demonstrates the importance of stakeholder engagement – to capture values at the time of the assessment.

Use of questionnaires and general discussions with beneficiaries has provided detailed information of use to this study, and their inclusion within Ecosystems Services and Natural Capital assessments in general would be beneficial.

Predictive Mapping of Ecosystems Services

It was the intention to use the above to map potentially valuable sites according to the characteristics which different groups felt was valuable. However, there were a number of problems. The principle problem was lack of information relating to the proxies connected with value. For most sites existing heritage databases (such as HER data, or HE data) do not systematically contain, for example, information on intactness. This is particularly true of sites on which there have been no detailed surveys. UKHO data include this information in descriptive form for some wrecks, but additional work would be needed to make this information comparable across different wreck sites. However, information is available in existing databases for some characteristics, including:

- Age
- Military associations
- Designation

For other characteristics, such as intactness, it may be possible to use geophysical survey data. The figure below shows a comparison of the differences in intactness between a modern metal wreck and an historic wreck (the sites shown are the probable remains of a 20th century Norwegian cargo vessel, the *Salina*, and the 18th century remains of the *Rooswijk,* a Dutch East Indiaman and one of the Protected Wreck sites within the study area), as demonstrated by multibeam data (Figure 11). However, detailed multibeam bathymetry is not available for the majority of the study area. If this data were to exist it may be possible to classify sites according to a scale of intactness (for example, high: very little change to the vessel's original structure; medium: some degree of degradation but the overall form of the vessel still discernible; low: site highly dispersed or broken). The UKHO data may be useful for cherry-picking intact wrecks, however, notes on intactness are not included for all wrecks and where the data is included it is descriptive and thus not easily comparable from site to site. Thus, any assessment based on this data may lead to an incomplete understanding of the intactness of different wrecks.

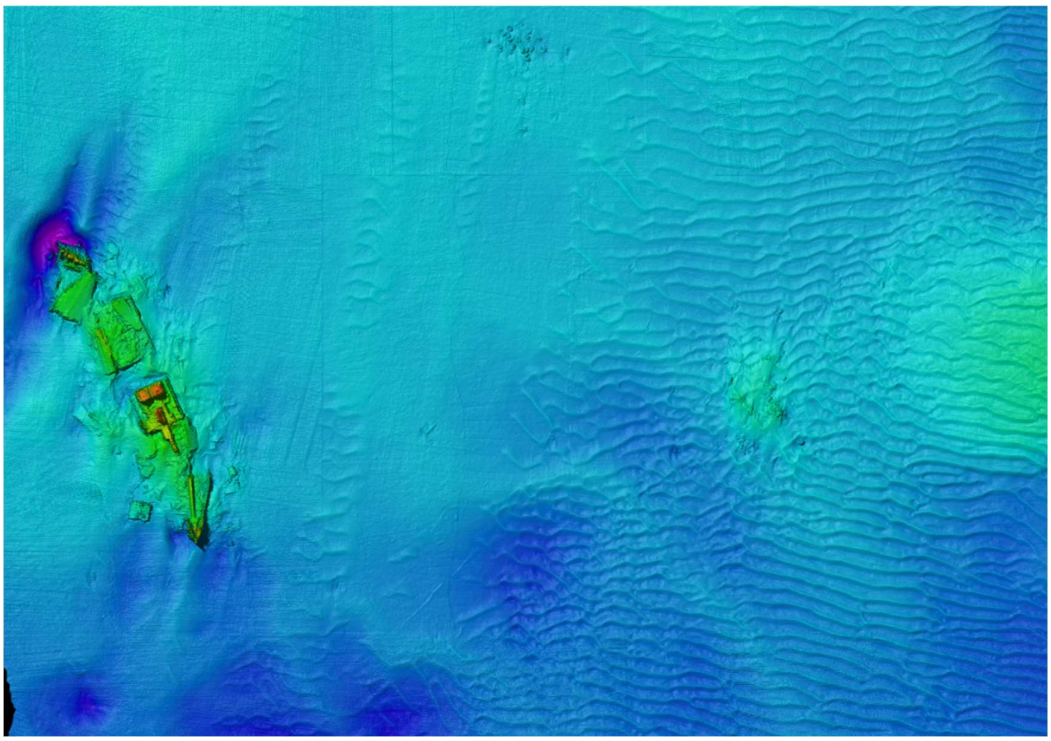


Figure 11 Comparison showing the potential for multibeam bathymetry data to be used in the classification of structural complexity. Intact wreck to the left of the frame and dispersed wreck to the right (the *Rooswijk*).

Age: The questionnaire indicated that in general participants valued older wrecks and age is also of importance for cultural heritage significance. The figure below shows the distribution of wrecks within the study area according to their age, where known. Undated wrecks are not shown on this figure. This data can be used to identify earlier wrecks, which is of importance for tourism/recreation and cultural heritage ecosystems services. The figure shows that most of the earlier wrecks are located within the south-eastern part of the study area.

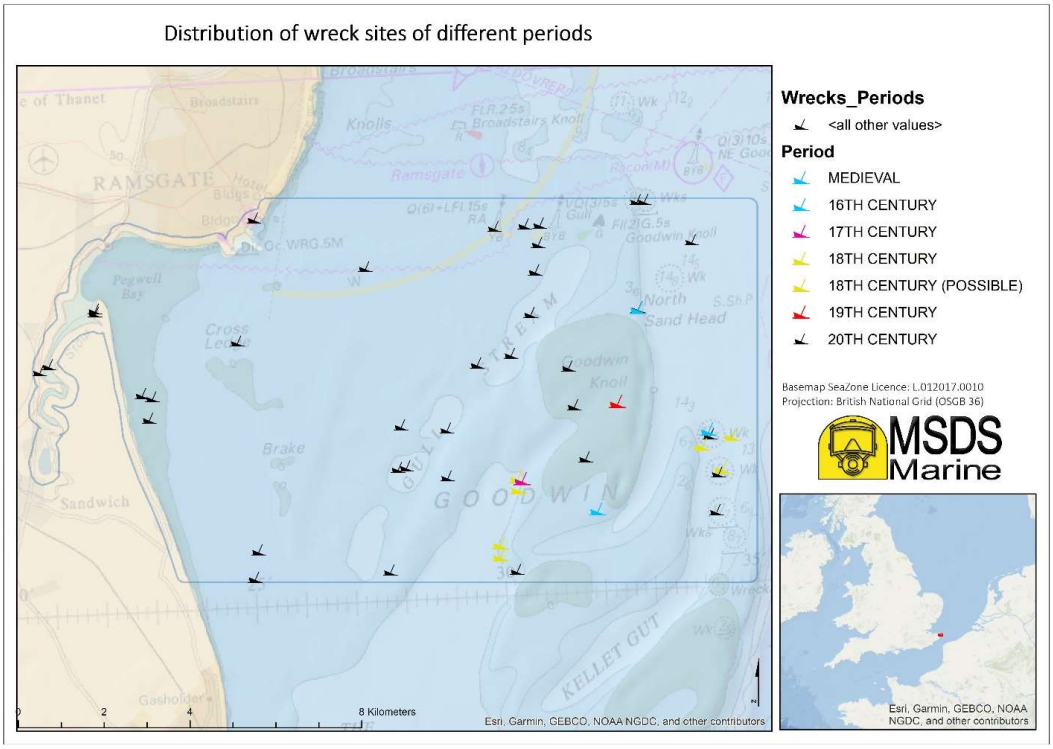


Figure 12 Distribution of wreck sites of different periods

Wartime associations: Figure 13 shows all wrecks within the area with wartime associations. The wrecks include the B17 bomber on Sandwich Flats, in addition to the remains of requisitioned trawlers, blockships, etc. As with the figure showing the different ages of the wrecks, this data demonstrates that the current datasets can be used to identify where different ecosystems services may arise (in this case, those associated with recreation or tourism).

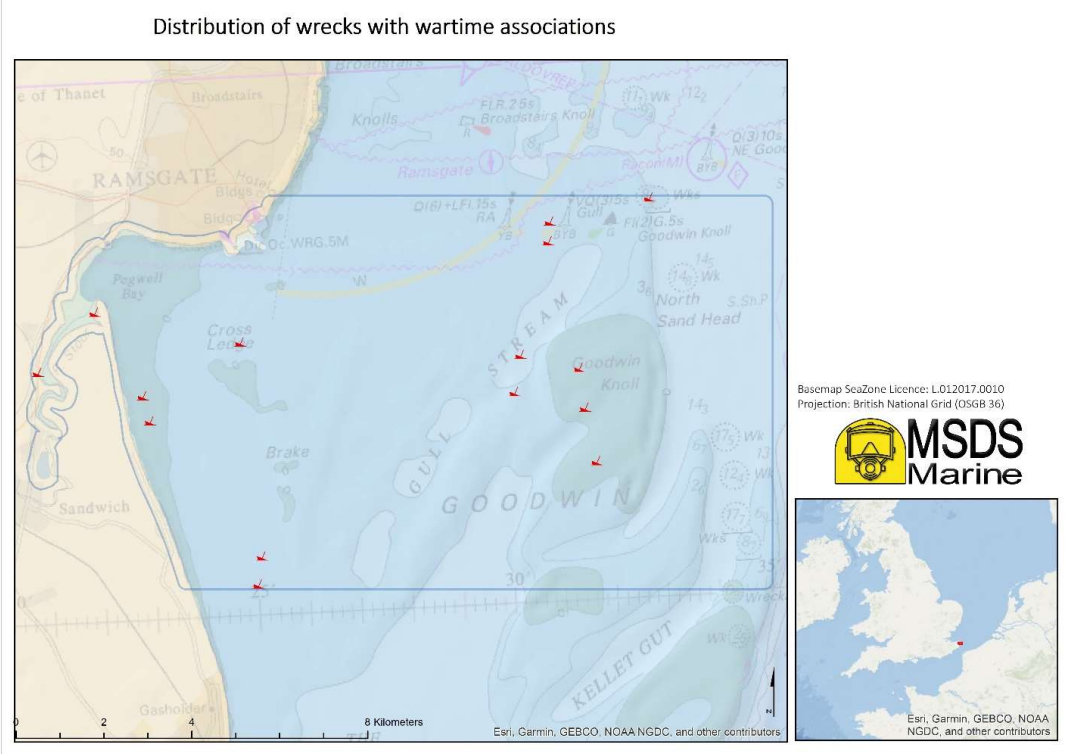


Figure 13 Distribution of wrecks with wartime associations

Designated sites: There is some overlap between the designated sites and the sites identified as valuable on the basis of preferred characteristics following the results of the questionnaire. The designated sites include the wreck of a B17 bomber, designated under the PoMRA 1986, which has military and wartime associations (characteristics identified as valuable by 43% of participants who expressed a preference for vessel type); and a series of 18th-century vessels designated under the PWA 1973 (with the age of the vessel noted as being a key factor of importance to 64% of participants who expressed a preference for the age of the vessel).

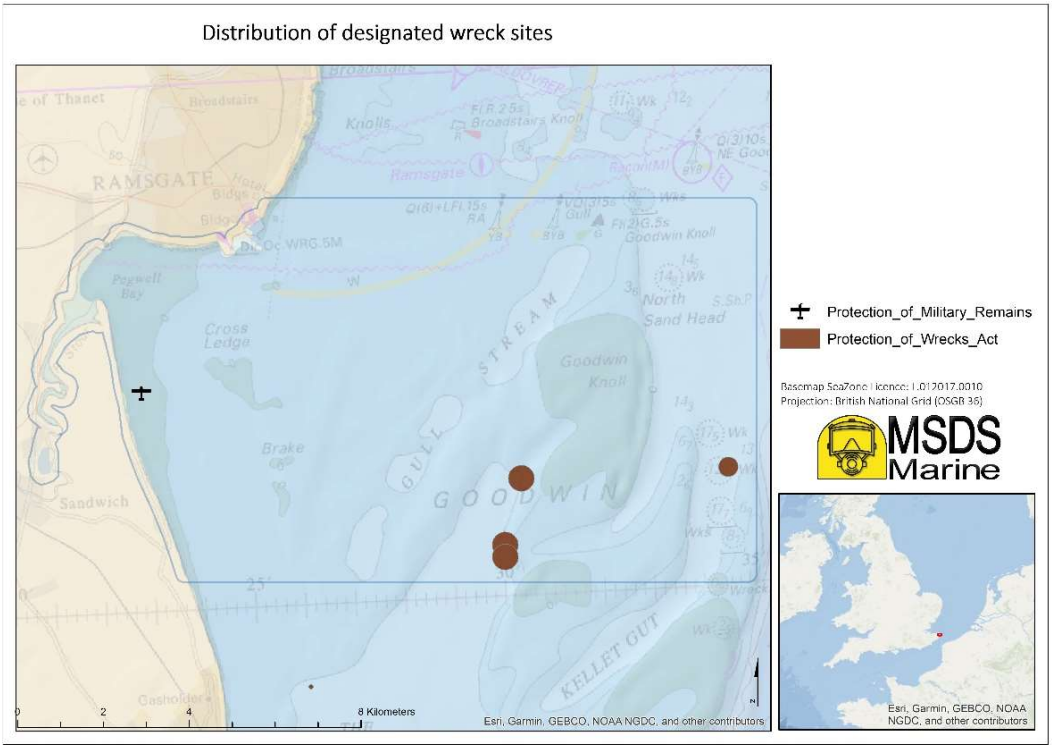


Figure 14 Distribution of designated wrecks

Characteristics of importance for the ecological role of sites (relating to both habitat and provisioning services) include position relative to broad classifications of benthic habitat. It is not currently possible to characterise the wrecks within the study area according to other important parameters such as their structural complexity, however, further studies may make this possible. In particular it may be possible to use multibeam bathymetry data to identify areas with higher complexity (e.g. Zeiger et al. 2009), while basic comparisons of the former can be made on the basis of the same data. Additionally, it may be possible to classify the benthic habitat of wreck sites. Classification in this manner, using the EUNIS classification system, may allow for predictive assessment of benthic communities based on characteristics including biological zone and hydrodynamic considerations, as has been done for certain steel wrecks in certain environments (Connor et al. 2004).

However, while this information could highlight some potentially valuable sites, other valuable sites may not be possible to identify using these characteristics as proxy indicators, due to the variability of use, in particular from the fishing community. This particularly relates to unpredictable and, to a lesser extent, temporal characteristics.

Benthic habitat: The physical relationship between natural and cultural heritage in terms of benthic habitat was compared using mapped data. A3.1, A3.2, A4.1 and A4.2 relate to areas of hard substrate including circalittoral and infralittoral rock and biogenic reef of moderate to high energy (grey in the figure below); A5.13 and A5.14 relate to circalittoral and infralittoral coarse sediment; and A5.23/24, A5.25/26 and A5.27 relate to circalittoral and infralittoral and offshore circalittoral

sand (yellow and orange respectively). The distribution of wreck sites clearly corresponds with areas of sandy deposits, which can provide a good preservation environment. These wrecks may form important areas of artificial reef on otherwise homogenous sandy substrate.

Wrecks appear to be largely absent from the areas of rock and biogenic reef. This may be due to the poorer preservation environment of exposed rock, particularly in high energy areas. However, wrecks could form the catalyst for the creation of biogenic reef, which could then mask the presence of the wreck sites themselves. Thus, their apparent absence from these areas may, in part, reflect problems of detection.

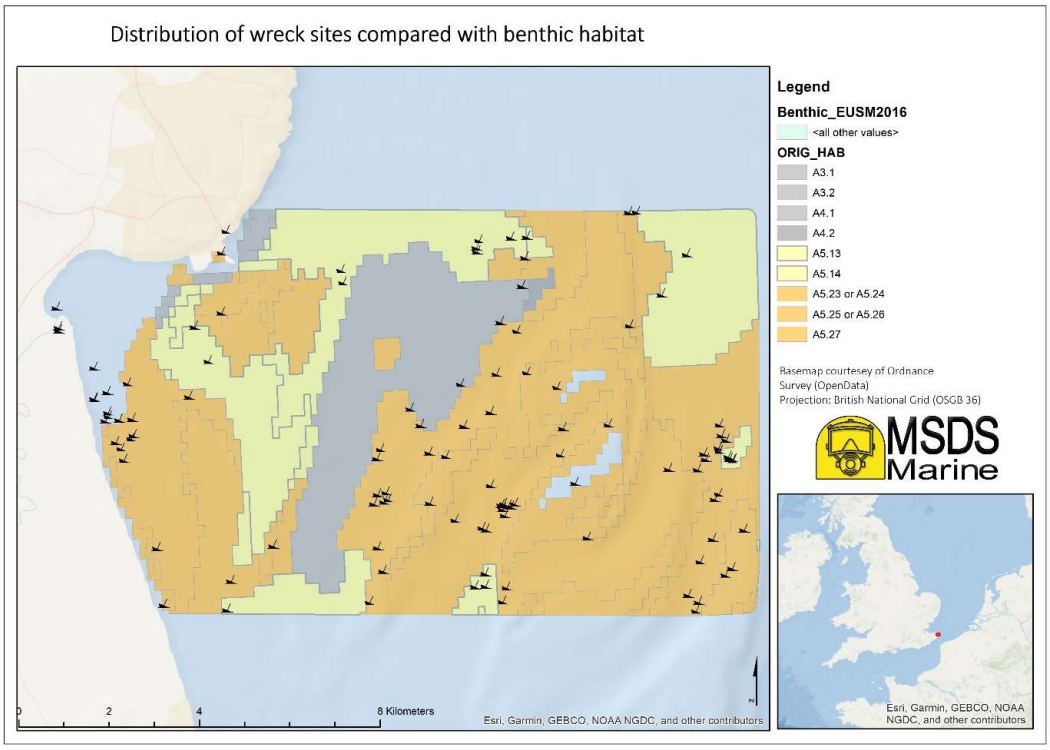


Figure 15 Distribution of wrecks compared with benthic habitat

Observed and Reported Assessments of Ecosystems Services

This section reports on trials in mapping observed and reported evidence of provision of ecosystems services from wreck sites within the study area. A number of different sources of information were trialled in order to understand which specific sites give rise to certain ecosystems services. This technique sits alongside the use of predictive data for the identification of sites which give rise to different ecosystem services.

AIS data

In May 2014 the use of Automatic Identification Systems (AIS) on all fishing vessels over 15m became compulsory. AIS datasets have been used to map fishing efforts in

a number of studies (e.g. Natale et al. 2015), demonstrating the potential for the use of AIS in establishing which wreck sites are of highest importance to the fishing community and dive charter industry. However, currently there are some limitations to this dataset. Foremost amongst these is the exemption of craft under 300GT or fishing vessels <15m in length from carrying AIS. While these vessels may carry AIS if they wish, they are not required to by law. As such many fishing vessels are not fitted with AIS, and those which are can turn the system off if they wish. Thus, any wrecks visited by these vessels cannot be identified in this manner.

AIS data for the study area was monitored via the marine traffic website[6] over the course of a month. The Port of Ramsgate has at least eight angling charter boats, of these only one appeared to use AIS, and this was switched off intermittently. The locations of good fishing grounds (including individual wreck sites) are notoriously well-guarded secrets and so the choice by the charter community to avoid using AIS is not surprising. However, a small number of wrecks in use by the angling community were identified in this manner.

Commercial vessels were also monitored. Of the small number who kept their AIS on, these were found to exploit grounds to the north-east of the study area. Thus this data cannot be used to understand patterns of use within the study area.

Published Sources and Fishing Websites

There are a large number of angling books and websites specifically targeted at providing advice to anglers. These can provide invaluable information about wreck fishing in an area, to aid with the identification of important wrecks. Identification of these sources can be made rapidly by an online review. Within the study area, relevant sources include:

- Stoker, H. 1973. Sea fishing in Kent.
- Cavenfish, M. 1977. Fisherman's handbook.
- Kent Coast Sea Fishing Compendium, 2010-2018. Online at: http://www.hagstone.net/ramsgate.html

These sources shed light on which wrecks are used by the recreational fishing community. 'Not a great deal of wreck fishing is carried on at Ramsgate, owing to the fast tides. Also, locating the wrecks is not always easy, as few of them are buoyed. However, when tides permit the local wreck fishing potential is undoubtedly good, and the following is a list of the better-known wrecks: *Surrenden Court, Dunbar Castle, HMS Blanch, Japanese Cargo Vessel, Harkalor, Yvonne, Briore, Napier, Collier, The Flanders* and *Lorent* (Stoker, 1973). Of these, *Napier* lies within the study area. Cavendish (1977) also indicates that those within the north-eastern part of the study area may have been good for cod and conger fishing.

While these represent potentially invaluable sources, those available for the study area are likely to be out of date. Dicsussions with memebers of the fishing

6 https://www.marinetraffic.com/

community suggest that, for example, while cod was once abundant in these waters, it is now much rarer. Thus, the wrecks on which cod used to be fished may no longer provide this ecosystem service to the same extent. This supports the importance of surveys (such as questionnaires) which seek to identify the current importance of different sites for providing different ecosystems services.

Summary

As has been demonstrated, it is possible to identify some potential sites from which Ecosystems Services arise. For example, information on the age of different wrecks enables us to identify the locations of the older wrecks, which is an important characteristic both in terms of recreation/tourism and cultural heritage. However, for many characteristics this is not possible because the data either does not exist within current datasets, or, unpredictable factors for preference come into play. With further work it would be possible to gather further information about these characteristics. For example, marine geophysical survey over a study area would provide visual data on intactness, a charaterstic of importance to the provision of all ecosystems services arising from wreck sites (i.e. recreation, provisioning and cultural heritage).

Even with incomplete data, the different characteritics on which we do have information provide insights into where ecosystems services may arise. However, predictive assessments will only ever show locations which have the potential for ecosystems services to arise. In order to get a true picture, stakeholder engagement should remain key. While beyond the scope of the current pilot study, it may be possible to use the maps of predicted ecosystems services sites as engagement materials, to facilitate and guide discussions on which sites do, in reality, provide which services. Thus, our proposed method for identification of sites which give rise to different ecosystems services is:

i. Gather data on which sites are used by people, and how. This could be gathered via the use of questionnaires and general discussions, as in this study, or other methods (such as photo competitions);
ii. Use existing data including the information from above and information from existing datasets to predict sites from which ecosystems services may potentially arise and create a map;
iii. Use the mapped data as a means by which to engage stakeholders to discuss where different ecosystems services arise.

STAGE 5: UNDERSTANDING VALUE

Conservation Principles (Historic England, 2008), recognises that places with heritage value can also 'generate wider social and economic ('instrumental') benefits, for example as a learning or recreational resource, or as a generator of tourism or inward economic investment, although their potential to do so is affected by external factors such as ease of access'. These instrumental values are often cited in Conservation Management Plans for wreck sites, along other heritage values. Social value is dealt with in relation to communal heritage values, and while some key considerations are signposted, no specific methods are set out for recording evidence of social value. Likewise, Conservation Principles does not give a method for assessing the economic value of sites. Thus, although the framework set out within Conservation Principles allows for consideration of social and economic value, methods for assessing these instrumental benefits are not defined. From this perspective ecosystems services assessments and valuation studies may be of use for fleshing-out the methods for assessing instrumental value in Conservation Principles terms. Additionally, Conservation Principles only allows for the social and economic benefits arising from archaeological sites as heritage assets, and does not include consideration of the values which arise from the role archaeological sites can play in ecosystems. Thus, also consideration of social and economic values could be slotted in to this framework the definition of instrumental benefits would require revision, to recognise that places can have heritage value as well as other environmental values, which can individually and in combination give rise to social and economic benefits.

Value is a complex issue in the context of ecosystems services, and particularly so for cultural ecosystems services (Hølleland et al 2017). It is measured in a variety of ways, including in monetary and non-monetary terms to demonstrate the contribution of ecosystem services to economic and social well-being and health (Peh et al 2017). Different methods are better suited to representing the values of different ecosystems services (DEFRA 2007), however, quantification for cultural ecosystems services is particularly difficult (Hølleland et al 2017). Many approaches of calculating economic value, such as market prices, are not applicable to the majority of heritage assets.

Although collecting economic information was not the focus of this pilot study we have considered potential sources for understanding the value of wreck sites. Our questionnaire attempted to gather costs relating to travel (Travel Cost Method). This method can be used 'as a proxy for the recreational value of that site' (DEFRA 2007). Connected to this are visitor numbers (Peh et al 2017), both in physical terms and visitor numbers to online resources such as Virtual Trails for Protected Wreck sites (James 2018). The Outdoor Recreational Value (ORVal)[7] tool also provides information on visitor numbers and associated value. These statistics are an important source of information for understanding the value of archaeological sites, and limited data has been collected for this pilot study in relation to specific wrecks within the study area. Our study has also looked into the use of social media as a tool for understanding and quantifying value as has been used elsewhere for

7 https://www.leep.exeter.ac.uk/orval/

valuing cultural ecosystems services (e.g. Figueroa-Alfaro & Zhenghong Tang, 2015; Sinclair et al. 2018), principally by using the numbers of followers and likes associated with pages which relate to the wreck sites within the area, while also using the content of posts to understand ecosystems services and values associated with these sites.

A previous study by the project team is also included as an example of the economic benefits to the local community of an underwater archaeological excavation conducted within the study area (James and Evans 2017), demonstrating the inward economic investments for designated wreck sites.

Examples of 'willingness to pay' also became apparent during the course of the project, and as such these too are included. Additionally, discussions of potential means of connecting economic data associated with fisheries and archaeological sites has also been considered. However, economic evaluation is a specialist area and thus we would recommend that an economist would be required to create a methodology for valuing sites economically. As such, no specific methodology has been set out here. Rather, we report on a series of potential sources of data and their potential usefulness to assessing value.

Valuing biodiversity is also a key consideration. 'Biodiversity and ecosystems are closely related concepts. There is significant evidence on the linkages between changes in biodiversity and the way ecosystems function. Biodiversity underpins all ecosystem services, but it can also be a service in itself (e.g. the existence value of a species under cultural services). Biodiversity is also considered to have insurance value by providing resilience in the face of current or future shocks to ecosystems and the services they provide.' (DEFRA 2007). Studies have highlighted the frequency with which loss in biodiversity or loss of habitat has been connected with loss of ecosystems services (IEEP 2006).

Case studies for valuing specific sites within the study area are set out below.

Valuing Wrecks As Heritage Assets: Case Study: The Local Value of the *Rooswijk*

Heritage Value: The *Rooswijk* is a Protected Wreck site. The wreck represents the remains of a Dutch East Indiaman, lost with all hands in 1740 on the Goodwin Sands. The vessel was on its way to Jakarta, and was carrying a cargo including items for trade, silver ingots and coinage. The designation of the wreck reflects the high level of heritage significance afforded by the site.

Economic Value: Ongoing archaeological investigations on the site of the *Rooswijk*, has highlighted some of the economic values given rise to by wreck sites. This Protected Wreck has been the focus for a large-scale archaeological excavation, and associated post-excavation and conservation activities. In total the project has funding to the value of over €2 million from the Dutch Government, while Historic England have contributed staff resources, conservation facilities, storage and additional funding.

During 2017 this project was responsible for contributing at least £46,000 to the local economy (James and Evans 2017), in the form of:

- Harbour fees
- Boat charter
- Fuel
- Shore-side conservation facility in Ramsgate
- Materials, supplies and equipment purchased from local shops used during the project
- Local hotels used by the project and visitors to the project
- Food and drink
- Recreation/ local attractions visited by the team on the days off

This total is associated with contributions to the economy made by the project team and directly associated visitors. The total does not include contributions made by visitors attending open days associated with the project (see below for visitor numbers).

The Protected Wreck of the Coronation has also been studied for the economic impact associated with a dive trail on that site. The NAS found that the site brought over £42,000 to the local economy in one year (2012), with an average of £60.00 per visit (NAS 2013). These examples serve to demonstrate both the value of a single Protected Wreck site within the study area (one of four), and other economic values which have been reported in association with Protected Wreck sites across a wider area.

Other valuation methods: Turning to visitor numbers as a means of understanding value, in 2017 and 2018, the *Rooswijk* project hosted 4 open days which have been attended by over 950 people, and an additional 50 visitors attended an open day specifically for home-schooled children in the area. Additionally, the project also brought a large number of others to the local area including 76 students, 21 SCUBA divers and 24 surface-supplied divers, 2 interns, 1 conservator, 1 onshore project manager, 1 support boat skipper, 9 individuals associated with a ministerial visit, and over 20 journalists.

Online, the *Rooswijk1740* project Facebook page is followed by 439 people, and the virtual trail of the site (commissioned by Historic England), is currently in preparation and online in a partial form. The number of current visitors, which is relatively low, reflects the fact that the virtual trail has not yet been heavily promoted. The promotion of the trail will follow updates which will depict the work of the recent project and include 3D models and animations, and is due to take place in January 2019. Looking slightly further afield, virtual trails for other Protected Wreck sites show the potential number of online visitors following promotion. The virtual trail for the U8 (also situated in Kent waters), for example has attracted over 6000 visitors to the site, in over 7,300 separate virtual dives. Overall, the dive trails produced for Protected Wreck sites in English waters have had over 10,000 new users and have facilitated 15,000 virtual dives (James, 2018).

This case study serves to demonstrate the social and economic impact of an archaeological project focused around a protected wreck, in addition to elements of the social value represented by visitor numbers (again connected with the project), and online interest generated by this and other Protected Wrecks.

Designation, value and Access

Heritage value (in Conservation Principles terms) and designation also bear a relationship with the economic value of heritage assets. This relationship is not necessarily always a positive one, and is defined by the legislation used for protection. For example, scheduling does not prohibit access to a site, but can mean that the site is suitable as a heritage visitor attraction, which gains the site economic value. However, designation under the Protection of Wrecks Act 1973 prohibits unlicensed access to sites, and in practice also prohibits fishing activities. Thus, this restricts economic value derived from potential visitors and the fishing industry. It is interesting to note that not all forms of protection for wreck sites prohibit access. For example, wreck sites can be Scheduled, and in Scotland the Marine (Scotland) Act 2010 provides protection to Historic Marine Protected Areas including wreck sites, and advocates a look but don't touch policy. Thus, wreck sites protected by these means would retain potential economic values associated with unlicensed visitors.

Additionally, although designation under the PWA 1973 prohibits unlicensed access, wrecks designated under this legislation can form foci for funding. Within the study area the Protected Wrecks have seen a number of archaeological projects, including the recent *Rooswijk* wreck excavation, and funding for the creation of a virtual trail which has the potential to allow large numbers of online visitors to access the site. Designation also creates the need for licensees, volunteers who monitor the sites on behalf of Historic England, who themselves represent a community with social value. Thus, designation of a site alters its potential social and economic values.

Case Study: Value of Intertidal Wrecks

Heritage value: The intertidal wrecks include a series of wooden vessels, about which little is currently known, and the wreck of a B17 bomber, designated under the Protection of Military Remains Act.

Currently little is known of these wrecks historically. The remains appear to relate to a range of vessel types; some are small, others large, with features such as sacrificial planking and wooden treenails. Lead has also been observed on one of the sites, however, at present their dates are unknown. Consideration of their distribution, with bows mostly facing landward, suggests they could form part of a ship's graveyard (Cant, pers. comm. 2018), or may suggest that the area was used as a landing site possibly in connection with the port of Sandwich. Therefore, although we do not have specific historical information on these vessels, they may be understood in the contexts of general themes which have characterises the historical development of the study area (see Text Box 2) including the changing fates of local port towns and volume of maritime traffic in the area over the course of the past few

hundred years. Thus, while the wrecks have not been assigned identities, they do have some historical context and connections. The wrecks also clearly exhibit vessel forms, (though sediment levels may obscure some at different times of the year), and as a group they are of interest.

In contrast, the history of the B17 is relatively well known. The aircraft was a flying fortress, a type of heavy bomber developed during the 1930s by the USA. The aircraft was lost on the 1st December 1943, during WWII, and all crew survived the crash (Imperial War Museum 2018).

Economic value: The B17 can be associated with some identifiable economic values. Wreckage from the bomber, collected by local members of the public, is on display at the RAF Manston History Museum, which has an entry price of £2 for adults and 50p for children. However, while some portion of this charge relates to the B17, it cannot wholly be attributed to the bomber.

The proxies for value also indicate areas of potential value. For example, the number of participants who noted the importance of crashed military aircraft in the questionnaire suggest value in this resource including any future findings of previously unknown aircraft crash sites. During the duration of the study this has been demonstrated by the identification of wartime aircraft on the Goodwin Sands within the study area of proposed dredging activities. There has been public outcry at the potential for this aircraft to be disturbed or impacted upon. The public have also demonstrated a clear 'Willingness to Pay', by the creation of a crowd funding cause 'Help us protect the Goodwin Sands from destruction by dredging'. This cause was galvanised by the recent discovery of the aircraft, though the cause also refers to other historic and natural assets on the Goodwin Sands, and within the course of a month (October 2018) there was over £8000 pledged to this cause, and rising (currently the figure stands at over £10,000 on 21/12/2018). The aim is to raise a further £30,000 to cover legal fees to challenge the decision to allow dredging on the Goodwin Sands, in the High Court[8].

8 https://www.crowdjustice.com/case/help-us-save-the-goodwin-sands/?fbclid=IwAR2RbHnyS1g89fprMa6mG25s8Y_A6mo1kr0rzmwwFGGsxZYsiQMevHONpDo

Figure 16 Wreck of the B17 (drone footage captured on a survey conducted by MSDS Marine and the NAS, drone footage by Chris Ohlsson).

Although the discovery of an aircraft galvanised this crowd funding cause, demonstrating willingness to pay, the cause relates to both natural and cultural heritage of the Goodwin Sands, and the focus of the discussion in the public arena is largely on the potential destruction of heritage and the role of the Goodwin Sands as a whole, as a graveyard. Thus this cannot be tied specifically to one site but rather applies to a group of sites (i.e. the wrecks of the Goodwin Sands) and natural heritage.

Economic valuation of the other wrecks within the intertidal zone is also problematic. Access to these wrecks is not mediated or associated with a fee relating to the wrecks themselves, there are no local car park charges. The only fees incurred when accessing the sites is the £7.00 road toll through Sandwich Bay. During this study our questionnaire gathered data on travel costs and other associated spending by individuals while on heritage related visits, both to the intertidal surveys, and to the *Rooswijk* open day. Only 14 participants entered any data for this question. However, amongst those average spend (excluding travel costs) ranged from £7 to c. £230. This includes money spent in local restaurants, pubs, shops, accommodation and car parks. Those who travelled furthest spent the most (this was primarily connected with the use of local accommodation). The average spend was £91.80. In total, participants who answered this question spent £1285.00 in the local area. While this data does not indicate any ongoing values associated with the wrecks, it does show that where heritage assets allow for outreach and engagement events this can raise the economic value of the sites drastically. However, with the exception of the toll charge (which relates to the whole area of Sandwich Bay, not just access to the wrecks), and specific planned outreach activities, the wrecks have no direct economic value associated with their role as heritage assets. Thus these wrecks may be unrepresented by economic forms of evaluation.

An additional source of information may come from the ORVal tool. This tool suggests that the area in which the wrecks lie may receive 16, 136 visitors per year, associated with an economic value of £72,822. However, this value appears to be connected with the role of the area as a nature designation site (with a local nature reserve, national nature reserve, Natura2000, Ramsar and SSSI designations). While undoubtedly some visitors appreciate the wrecks, it is unclear what portion of the visitors and value can be connected to them directly. While this tool may be of some use for terrestrial and intertidal sites, it provides no information on marine sites.

Other values: Visitor numbers associated with the surveys which formed part of this project demonstrate the interest in the wrecks generally. Surveys were undertaken on two consecutive days in the intertidal zone in association with this project. Additionally, a separate project, of which the current project team formed part, was also undertaken on the same wrecks in the intertidal zone in October 2018. Together these surveys attracted over 60 individuals to participate. However, these visitors were attending planned survey days and thus without these events, visitors with an interest in the wrecks as heritage assets would not have been 'visible' in valuations.

Social media may provide an additional source of information which, in a comparable way to visitor numbers, can reflect the value heritage assets. Social media groups and associated followers are not dependent upon planned archaeological outreach activities, and may be a better representation of the numbers interested in heritage sites. Social media groups exist for the wrecks in the intertidal zone. Related groups and numbers of followers include:

- Thanet and Sandwich Coastal Finds Group: 3119 Members
- Sandwich Bay B17 Group: 273 members
- Sandwich and Pegwell Bay Shipwreck Group: 282 members

The groups reflect the interest in these remains, with general interest in the shipwreck heritage of the area and specific interest in the B17 bomber. The latter accords with the interest in military and wartime wreck sites recorded by the questionnaire.

Taking a more holistic approach to understanding the value of these sites, the above figures represent the way people feel about heritage and how they value it. Qualitative information gathered from the groups can shed some light on the underlying beliefs, feelings and knowledge which give rise to the social and economic value of the sites.

Turning to the B17 as an example, information on the social value of this site can be gleaned from questionnaire responses in which participants were asked to explain certain views, as well as from the dedicated Facebook page, set up by members of the local community.

The Facebook page contains a wide variety of posts, including:

- Posts relating to remembrance and related historical events
- Posts relating to individuals with a family connection to wartime aviation
- Posts relating to the physical remains of the B17
- Posts relating to the physical remains of other wartime aircraft
- Posts relating to stories of B17's in action

These posts elucidate the value placed on some of the ecosystems services provided by the B17. In particular, they demonstrate that individuals visit the site and use it as a focus for recreation; they demonstrate that people value the site and remains as a heritage asset; they show that site is entwined with remembrance and ties individuals with the past. The fact that the group exists also served to indicate that the B17 is the focus for an element of social cohesion.

The Sandwich and Pegwell Shipwreck Group included posts on the following areas:

- Posts relating to the physical remains of the wrecks and disarticulated remains from wreck sites washed up in the bay
- Posts relating to historical accounts of losses in the bay
- Posts relating to other wrecks
- Posts relating to remembrance
- Posts relating to the archaeological surveys run as part of this project and other initiatives such as the Guardians of the Deep project
- Posts and comments relating to fascination with local history

Above all, the posts demonstrate the local interest in the shipwreck heritage of this area. Attempts to tie the wrecks up with historical accounts probably also reflect the interest in the history of wreck sites, demonstrated by the questionnaire. As with the B17, the presence of the posts and the obvious time spent by individuals on the shipwreck sites demonstrates their role as foci for recreation.

The existence of the social media groups, the number of followers, and the posts on the groups demonstrate the potential usefulness of social media as a valuation tool for heritage assets or groups of assets.

Biodiversity and habitat value: In addition to social and economic values, the wrecks within the intertidal zone also have biodiversity value. These wrecks were found to have much higher levels of biodiversity than the surrounding sands. Additionally, wooden wrecks were found to be more structurally complex, and so more biodiverse than the metal wrecks. The wrecks were also observed to have a zone of influence which in many cases included an area of soft sediment associated with possible juvenile lugworm casts, indicating the wrecks may create habitat for these species. Specific valuations of biodiversity for the sites are beyond the scope of this study, however, this remains an important consideration for Ecosystems Services and Natural Capital Assessments.

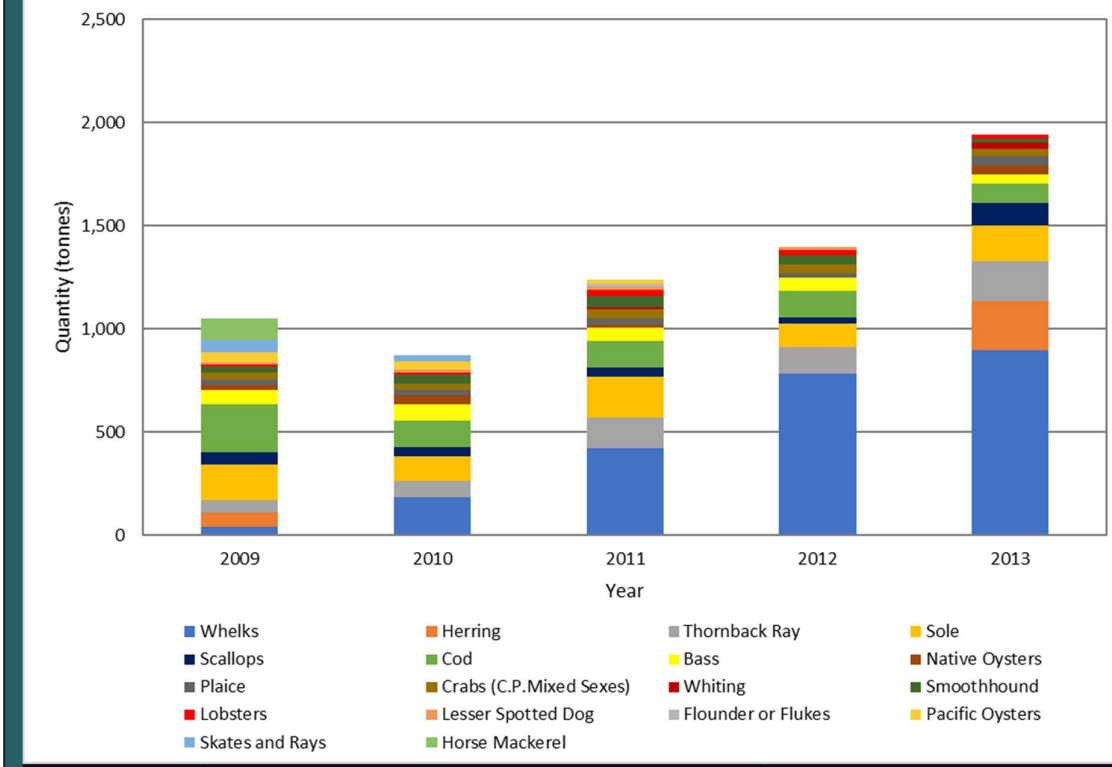
Valuing Wrecks as Ecological Assets: Commercial Landings Data

We now turn to the value of wrecks as ecological sites. As with the valuation of wrecks as heritage assets, there are some hurdles to understanding the value of wrecks as ecological sites.

The differing scales of the datasets presents a potential issue when considering the relationship between cultural and natural heritage. However, there are some potential ways to bridge this gap. We considered use of commercial landings data, in addition to other sources of information on landings (e.g. DEFRA 2018; IFCA pers comm.) coupled with known habitat preferences of different species to consider the potential contribution of wrecks to the economic value of catches.

Many of the species reported in commercial landings data can be caught around wreck sites, and wrecks form a focus for fishing activity. However, there are a number of species for which wrecks are specifically targeted. These include cod (during summer months), bass, crabs and lobsters (Figure 17). The wrecks are likely to be important for these species, and thus the wrecks make some contribution to the economic value associated with the species.

There are, however, difficulties with this data. These species may inhabit wreck sites for part or all of their lives. As such it is difficult to separate what role the wreck sites play in their economic value. Loss of the wreck sites may mean diminished stocks in certain areas (particularly areas where the substrate consists of homogenous sand), particularly for species known to inhabit the wreck sites. For example, whelks inhabit areas of muddy sand, gravel and rock. Their egg cases require hard surfaces for attachment, which can include rocks, stones, shells, or, as areas of hard structure, such as wreck sites. In expanses of sand, wreck sites may be of particular importance for this purpose.



Species	Relationship with wreck sites	Species	Relationship with wreck sites
Whelk	Yes- wrecks probably used for spawning (IFCA pers. comm 2018)	Crabs	Yes – can be found around wreck sites
Herring	No known relationship	Whiting	Yes – can be found around wreck sites
Thornback ray	Yes – can be found around wreck sites	Smoothound	Yes – can be found around wreck sites
Sole	No known relationship	Lobsters	Yes – can be found on wreck sites. Wreck sites important for this fishery.
Scallops	Uncertain	Lesser spotted dog	Yes – can be found around wreck sites
Cod	Yes – can be found around wreck sites. Wrecks form important summer habitat	Flounders or flukes	No known relationship
Bass	Yes – can be found around wreck sites. Wreck sites form an important part of exploited habitat	Pacific Oysters	Yes – can be found on wreck sites. Observed on intertidal wrecks.
Native Oysters	Yes – can be found on wreck sites	Skates and Rays	Yes – can be found around wreck sites
Plaice	Yes – can be found around wreck sites	Horse Mackerel	Yes – can be found around wreck sites

Figure 17 Commercial landings data for the study area and habitat information

However, spawning represents only one part of the lifecycle of the whelk and while wrecks may contribute to this aspect of the whelk's life, they are less likely to contribute to other aspects. Thus only a portion of the economic value associated with the whelk fishery may be connected with the presence of wrecks.

Therefore, while we are able to say wreck sites form part of the habitat of certain species, which have a market value, the exact contribution of individual wrecks to this value is not known.

Interfaces with other studies

An additional source of information for identifying values are other projects. The Big Angling Project has collected information on the amount being spent on the sport, and what species are being caught. This project also collects location information. It was not possible to access this data during the duration of this project, however, discussions were held with Substance, the company responsible for undertaking this work on behalf of the Centre for Environment, Fisheries and Aquaculture Science (Cefas). This presents a potentially invaluable source of information about the value of different wreck sites and data sharing would be desirable however, this may necessitate specific agreements regarding data handling and confidentiality.

Conflicting values

Conflicting values were also considered by this project. During the course of this study informal discussions were held with individuals interested in salvage and artefact retrieval from wreck sites. These activities represent a conflict in values with other activities such as heritage visitors/tourism; biodiversity values; provisioning values etc as these activities will lead to the eventual loss of the wreck sites. The salvors were represented within the questionnaire participants and small-scale recovery of remains was observed in progress during the intertidal survey by one individual (the team explained the laws governing this activity and the individual ceased the removal of wreck remains).

Salvage relies on the market value of shipwreck goods. An expedition to the *Rooswijk* in 2005 led to the recovery of many coins, some of which were sold by the team. The total market value achieved by the 2005 work is unknown. However, coins are still available from the *Rooswijk* today on sites such as EBay, for prices ranging from £200 - £750 per coin. This type of value leads to the removal of heritage, thus impacting on other values.

Assessment of the valuation of wreck sites

This assessment has considered means of understanding the absolute value arising from the current ecosystems services associated with wreck sites within the study area, and some potential sources of information regarding value.

There is direct connection between heritage value and economic value (Firth 2016), although this may be difficult to calculate for specific sites. Additionally, the

economic value arising from the contribution heritage sites make to the ecosystem is also hard to calculate in some cases. Where this creates a focus for recreational activities, this can be measured in a site-specific way (engagement with other projects such as the Big Angling Project may in the future be able to provide economic data in relation to this), however, where wrecks form one part of the habitat of different species which is exploited it is difficult to estimate the economic importance of the wreck in that case. This is due to the uncertainties and division of value associated with these services.

Economic valuation is a key component in many Ecosystems Services assessments. It creates clear figures which demonstrate the relative importance of different services, however, its usefulness in expressing overall value is variable. A series of problems were encountered when undertaking research into the economic value of wreck sites. These included:

- Problems obtaining data. Many participants answered the project questionnaire fully with the exception of the monetary section.
- Problems separating out the contribution of specific heritage sites to, for example, provisioning services or recreation services.
- Many wrecks are not associated with a direct value, thus economic valuations alone would lead to an undervaluing/underrepresentation of heritage assets such as this within datasets.

However, the economic data did highlight the increase in value which can be associated with work and outreach activities on a wreck site, suggesting that value, to some extent, is what we make of it.

Visitor and Volunteer Numbers

Visitor numbers can be used as a measure of value (Peh et al 2017). Within the area there are a number of potential sources, including visitors:

- To museums
- To surveys (volunteers) or open days associated with archaeological projects
- To virtual trails (these tend to be associated with Protected Wreck sites- funding is necessary for their creation and maintenance which tends to be generated by high priority heritage sites, such as PWA sites)

It was not possible to obtain museum visitor numbers during the scope of this study, although this does represent a potentially valuable source of information. However, data on visitor numbers associated with surveys and open days (i.e. planned archaeological outreach events associated with wreck sites) was obtained, as were online visitor numbers for Protected Wreck virtual trails. The latter will typically only be available for the higher profile, or designated sites. Thus, as with economic data, while online access to virtual trails provides eye-catching statistics demonstrating the potential value of marine heritage, visitors will not be able to access the majority of sites online, as it tends to be designated sites which can

generate the funding required to create virtual trails. Thus, these statistics cannot be gathered systematically for other sites.

Social media

Social media was used for rapid quantification of the numbers of followers and likes relating to pages associated with the wreck sites within the study area. This supplemented data on visitor numbers. This data represents a readily available and easily comparable way of valuing sites. Not all sites will have a social media presence. This, however, may not be a failing. Instead, the representation of a site on social media in itself implies some form of value, while the number of likes and followers support and further demonstrate that value.

Social media has another major advantage, in that it includes posts in which people demonstrate how they value sites. Our study showed that they can be relatively rapidly categorised, revealing patterns about the value of sites. This provides a reflection of the intangible values of heritage. Social media has also been used by other studies to assess, for example, aesthetic value placed on different areas by mapping geo-tagged photographs from social media data on Panoramio and Flickr (Figueroa-Alfaro & Zhenghong Tang, 2015), and recreational values associated with defined ecosystems (Sinclair et al. 2018).

However, while archaeological sites are easily defined and bounded entities, the same is not true of some landscapes and landscape units, from which Ecosystems Services are derived. Thus while we may be able to represent the value of heritage using information from social media, this may not be immediately and directly comparable with the data gathered in association with other Ecosystems Services assessments.

Difficulties with the comparability of valuation methods thus exist, with some being better suited to demonstrating the value of some services and less so for others (DEFRA 2007).

Ecosystems Services and Natural Capital of the Goodwin Sands and Kent Coastal Wrecks

Differing scales of data and ecosystems interactions make assessment complex. Many Ecosystems Services and values from wrecks arise on a site-basis, while others arise from landscapes or collections of sites. Attempting to separate the contribution of a single site to a value which is derived from multiple sites would be a difficult process, and may not form a true representation of the value of that site. Thus, taking into account the information, sources of data and difficulties encountered during this study we propose that assessment and valuations should include multiple scales e.g. sub-site, site, landscape. This approach has a resonance with ecosystems themselves, which function through relationships on many different scales. The approach allows the heritage value of a single site, or part of a site, to be represented along with a group of sites which may form, for example, part of the habitat for migratory fish stocks.

The figure below gives an example of how this might look, for the study area. The figure shows the age of wrecks, connected with provision of cultural services, alongside groups of sites which give rise to 'inspiration' as a service (yellow). The Sandwich Flats wrecks, which form the focus for individual social media groups, represent a group which gives rise to recreational services (shown in green). All sites also form heritage assets and therefore represent provision of cultural heritage services, and designated sites indicate the locations of those with the highest levels of heritage value within the study area. The distribution of the sites relative to benthic habitat is also shown, to provide an indication of where the wrecks may contribute most in terms of provisioning services. As stated above, further research could refine our understanding of where different services and values are derived. Specific ecosystems services are noted alongside the figure for particular sites or groups of sites.

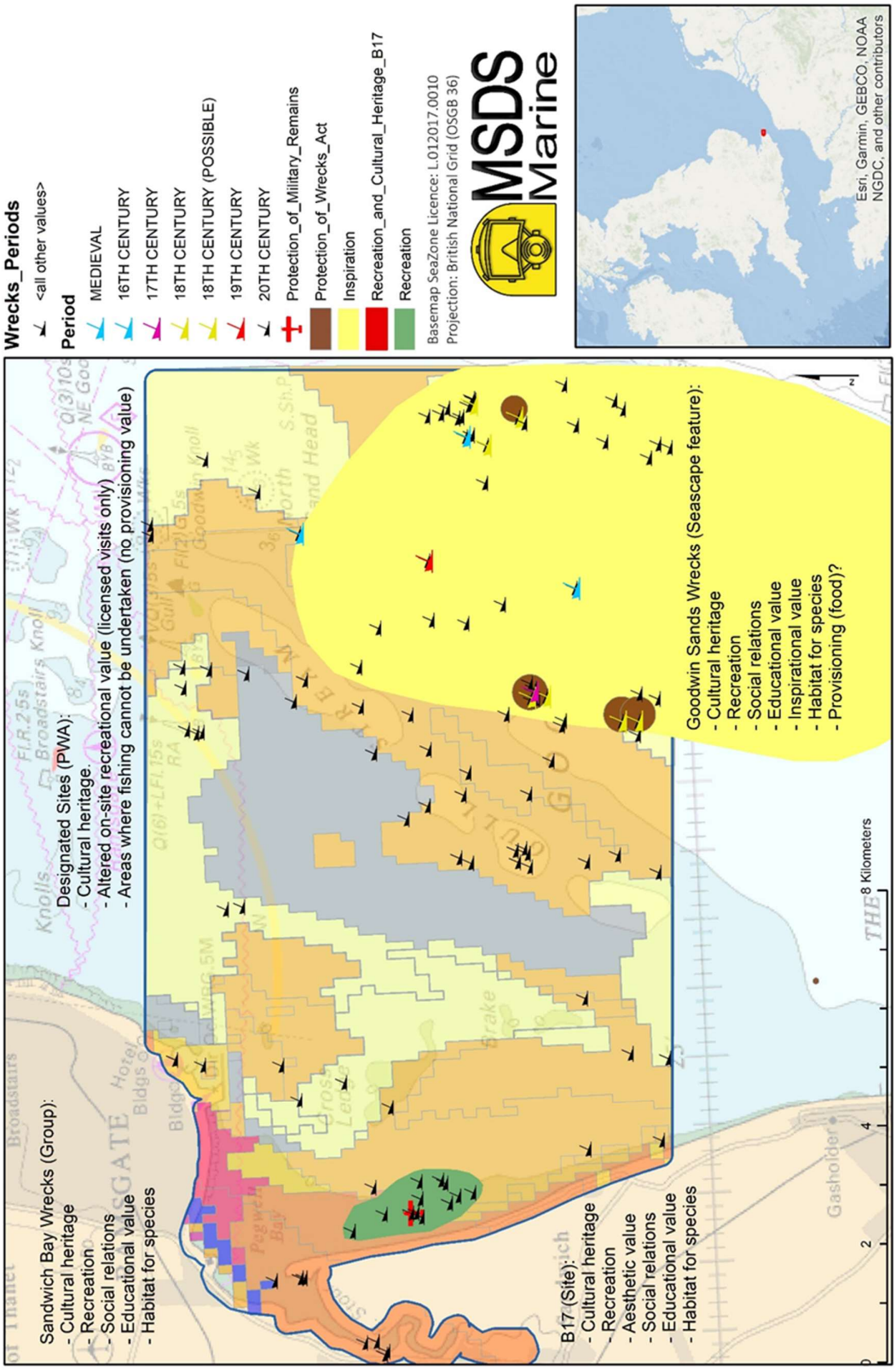


Figure 18 Ecosystems Services and Values associated with wreck sites in the study area

RECOMMENDATIONS AND CONCLUSIONS

This project has achieved the aims set out in Section 2. In particular it has developed a methodology which demonstrates how the historic environment might be better included in natural capital and ecosystems services assessments, and sets out the results of a case study where this methodology was trialled.

Our project has taken a staged approach to incorporating heritage within the natural capital and ecosystems services assessment framework. This begins with identification of the purpose of the assessment and study area. Identification of the purpose of the assessment is vital for choosing the methodology and a key outcome of the workshops associated with this project was the need for different methods for different assessment types (e.g. those to underpin policy, those undertaken when impacts may arise etc). This project has focused on the development of a methodology for use in site specific studies and in areas where impacts may arise.

Desk-based assessment formed the first step in our method, and we sought to identify the heritage and ecological baseline for the study area. These datasets formed the focus for further study. However, there is a scale difference between heritage datasets, which tend to focus on sites, and ecological datasets, which tend to cover broader areas. As such it was necessary to collect information to bridge the gap between these datasets. Information which allowed us to bridge this gap was the result of a literature review, which looked into published evidence for the relationship between wrecks and ecology, site surveys which allowed us to collect direct evidence of this relationship, and stakeholder engagement.

This project trailed a number of methods for engaging with stakeholders, from direct participation in training and survey events, to photo competitions, questionnaires and ad-hoc discussions. The combination of site surveys with stakeholder participation, and requirement for participants to fill in a questionnaire proved to be the most successful method for gathering quantifiable data on ecosystems services arising from wreck sites. However, ad hoc discussions also worked well with members of the fishing community. We found that the techniques with the best success rate were those tailored to fit within the comfort zone of a particular group.

Lasting connections can be an important outcome of ecosystems services assessments. We found that, possibly due to the level of engagement with local communities, many of the participants of the project have kept in touch with the project team. This has led to desirable outcomes such as the involvement of volunteers on repeat surveys of the Sandwich Flats intertidal sites which have been conducted by MSDS Marine and the Nautical Archaeological Society, and ongoing relationships with the fishing community. In particular, following discussions which began as part of this project, MSDS Marine have been approached by members of the fishing community to advise on the specific locations, dimensions and orientation of wreck sites in the area. This has allowed these individuals to ensure their gear does not snag on wreck sites, which is advantageous both to the ongoing preservation of wreck sites and the safety of members of the fishing community and their gear.

It is important to note here that while stakeholder participation is crucial for identifying important ecosystems services where the flow of services is readily understandable (e.g. wreck sites have historical connections, from which flow cultural ecosystems services; or, wreck sites form artificial reefs which the fishing community use), and social benefits, stakeholders may not always be aware of the role's wrecks play in ecosystems. Thus, our methodology couples stakeholder engagement with site specific surveys.

This project highlights the importance of site-specific research and surveys for understanding ecosystems services arising from wreck sites. Too little is currently known about the relationship between heritage and ecology for generalisations to be made which adequately characterise this relationship. Predictive methods for identifying which sites give rise to which ecosystems services suffer from a lack of data. Classification of the benthic habitat of wreck sites, using the EUNIS classification system, may allow for predictive assessment of benthic communities based on characteristics including biological zone and hydrodynamic considerations, as has been done for certain steel wrecks in certain environments (Connor et al. 2004). If further information such as this were available, predicting potential sites at which ecosystems services arise may be possible, but, for local scale studies, this would always require verification and input from stakeholders.

As a demonstration of the new information on the relationship between wrecks and ecology which has yet to be understood, our study found that in addition to their role as artificial reefs, and the provision of hard substrate, wrecks also appear to affect their surrounding environments altering habitat and possibly species in a zone of influence around the sites. This project identified communities of worms represented by dense concentrations of worm casts surrounding the wreck sites on Sandwich Flats which differed in size and density to those the rest of the beach. The reasons for the presence of these worms is not known, but it appears likely that their occurrence relates to the locations of wreck sites.

The site surveys proved to be the most effective means by which the differing scales of the heritage and ecological desk-based data could be bridged. It also demonstrated that not all wreck sites are the same, and differences between the ecology of the metal B17 wreck site were observed when compared with the wooden wreck sites on Sandwich Flats.

Our research identified a variety of parameters which alter the social and economic value of a site to different beneficiaries, including tourists, archaeologists, divers and the fishing community. This research was undertaken in order to identify areas and sites which may be particularly sensitive to change, either positive or negative. The number of variables affecting the value of a site, and the unpredictability of some of those variables, means that the use of characteristics to serve as proxies for value can only serve to indicate the potential services and value associated with a site. Site-scale research and stakeholder engagement must be conducted to determine whether these values are truly present.

This project also recognised that ecosystems services arise at different scales. Some services arise at site, or even sub-site level, while others only arise from groups of sites or landscapes. These issues also affect valuations. As such it is necessary to consider the possibility that while some services and values may be tied to individual sites, the same sites may also form part of a wider network which give rise to other services and values. Services arising from the wreck sites under study by this project included those within the provisioning category, as well as cultural services and supporting and habitat services, including:

- Provisioning (food)
- Cultural heritage
- Recreation and tourism
- Social relations
- Educational value
- Aesthetic value
- Inspirational value
- Sense of place
- Habitat for species

Valuation is a complex issue. The instrumental value of sites, as defined in Conservation Principles (Historic England 2008), allows for social and economic value to be brought in to existing frameworks for assessing heritage significance. However, methods for assessing instrumental value are not defined in Conservation Principles and this framework only allows for consideration of those benefits which arise from the heritage value of the site. This excludes consideration of those values arising from the role of the site in the ecosystem. However, valuation methods associated with ecosystems services assessments may be well placed to flesh-out this aspect of the Conservation Principles methodology. While some potential data sources are cited here (see below for summary), and social media may represent an important tool for understanding value, economic valuation is a specialist area and it is recommended that Historic England seek advice from economists in order to develop this part of the methodology.

In summary, undertaking Ecosystems Services and Natural Capital Assessments is a complex process, reflecting the complexity of ecosystems themselves and our relationship with them. One of the strengths of ecosystems services assessments is that they encourage consideration of all the potential connections between a site and its environment, and all potential beneficiaries. Currently, the focus for wreck sites is on their role as heritage assets. Designation reflects that. However, the importance of wreck sites to the fishing community for example does not tend to be represented when sites are threatened, for example by development activities. A key strength of the Ecosystems Services and Natural Capital Assessment process is to bring these unrepresented benefits into consideration. This is of particular importance if sites are threatened.

Taking into account these findings, our project has defined a series of steps, sources and tools for undertaking assessments in these circumstances where site-specific

ecosystems services assessments are required, or in areas where there is to be an impact:

Stage 1: Defining the study area and scoping the assessment

The key purpose of this stage is to define the aims of the study and the study area.

i. Identify the study area with consideration of the type of project being undertaken (e.g. area associated with development impacts; an ecosystem; an historic landscape component/unit; a research area etc);
ii. Consult with key stakeholders including local authorities to ensure the study area is sufficient to identify ecosystems services and natural capital associated with heritage in the area;
iii. Treat the study area as the focus for investigations, but be prepared to consider information from outside of that area to identify beneficiaries for example.

Stage 2: Baseline assessments.

The key purpose of this stage it to identify the baseline heritage and natural capital within the study area, and to gather data which will allow an understanding of the relationship between the heritage asset(s) and ecosystem (see Stage 3).

iv. Obtain data from existing sources in order to undertake a rapid desk-based assessment of the area (note that this stage may be the first step in a landscape-scale assessment, but, if a site of interest is already identified [e.g. a particular site which may be lost as a result of development, or a site which is being considered for designation for example], this step may be skipped. During the course of this pilot study this step was used to identify the specific sites for more detailed investigation – see steps v onward);
v. Collect heritage data relating to the site of interest (desk-based). Key datasets include:
   - HER data;
   - Historic England data (designation and AIME);
   - UKHO data;
   - Historic seascapes/ landscapes data[9]; and

9 In view of the decision to focus principally on sites, we found that the HSC data does not provide enough detail so cannot be used as a reliable indicator of areas of potential value associated with wreck sites. i.e. the identification of the site as a wreck is not sufficient to understand what ecosystems services that wreck provides. However, consideration of the HSC data does, at a broad scale, indicate some of the potential beneficiaries.

- Other key studies for the specific area in question (e.g. grey literature reports, published accounts etc).

vi. Analyse this data to identify sites and draw out key themes and narratives. The aim is to use these datasets together to rapidly identify sites and characterise the general historic development of the area, allowing the sites to be understood in context, and provide a backdrop for understanding the development of human-environment relationships, natural capital and ecosystems services in the area.

vii. Collect and analyse ecological data relating to the site of interest and the surrounding ecosystems (desk-based). Key datasets include:
   - EMODnet Seabed Habitats (Seabed habitats and biotope classifications for European seabed habitats (MESH) data & EUNIS classifications);
   - Cefas / Ellis *et al*, (2012) / Coull *et al*, (1998) (Fisheries sensitivity maps (UK spawning and nursery areas));
   - Scottish Government / Marine Management Organisation (MMO) (Fishing effort and landings data by ICES rectangle (geographic area));
   - Joint Nature Conservation Committee (JNCC) (Conservation designations for UK taxa);
   - MAGIC (Conservation designations for UK areas);
   - National Biological Network (NBN) Gateway (Wildlife records for the UK); and
   - OBIS Seamap (Sighting and recordings network for marine mammal, sea turtle and other megafauna e.g. basking shark)

viii. Undertake a literature review, in particular to establish the connection between heritage and the ecosystem (our focus was ecology and shipwreck sites);

ix. Undertake site survey work to record the heritage and ecology of the site, and in particular to consider the relationship between ecosystems and heritage, and note users/beneficiaries as survey progresses. Attempt to involve key stakeholders in the survey as they will have relevant local knowledge and this forms an important opportunity to gather information on ecosystems services arising from the sites (our survey involved individuals from the local community, IFCA, TCE, the MMO and KWT).

Stage 3: Identify the relationship between heritage and ecology

The key purpose of this stage is to define the connection between heritage and ecosystems.

x. Using the information gathered from the desk-based and survey work identify the relationship between heritage and ecosystems.

Stage 4: Identify ecosystem services and identifying sites/ landscapes which give rise to each ecosystem services

xi. Using the information gathered from the desk-based and survey work, and an understanding of the relationship between heritage and ecology, identify the ecosystem services produced across the study area and arising from different sites. Use established methods and tables to set out provisioning services, cultural services, regulating services and habitat or supporting services;

xii. Gather data on which sites are used by people, and how. This could be gathered via the use of questionnaires and general discussions, as in this study, or other methods (such as photo competitions or use of social media);

xiii. Use existing data, including the information from above and information from existing datasets to identify sites from which ecosystems services may potentially arise and create a map;

xiv. Use the mapped data as a means by which to engage stakeholders to discuss where different ecosystems services arise. Recognise that different services can arise at different scales, some may be site-specific while others may arise in relation to groups of sites.

Stage 5: Value

The instrumental value of sites, as defined in Conservation Principles, allows for social and economic value to be brought in to existing frameworks for assessing heritage significance. Methods for assessing instrumental value are not defined in Conservation Principles, and valuation methods associated with ecosystems services assessments may be well placed to flesh-out this aspect of the Conservation Principles methodology. However, although some potential data sources which are of relevance for understanding the value of wreck sites have been cited here, economic valuation is a specialist area and Historic England should seek advice from economists in order to develop this part of the methodology.

Sources which may be of use for assessing the value of wreck sites include:

- Visitor numbers for archaeological events and sites, recorded by:
    - Project-related events during which specific visitor numbers can be recorded. These often represent one-off events and so this information will not be available for most sites, typically unless they have been the focus of an archaeological project.

    - The Outdoor Recreational Value (ORVal)[10]. While this tool gives indications of the number of annual visitors to an area it does not separate out the reasons for the visits, and as such the specific values of different archaeological sites is difficult to judge using this tool.
    - Online visitor numbers to heritage sites such as virtual dive trails of Protected Wreck Sites;
    - Social media statistics, for example from groups which relate to specific sites, or in relation to posts about sites. Social media groups and associated followers are not dependent upon planned archaeological outreach activities, and may be a better representation of the numbers interested in heritage sites. Qualitative information gathered from posts can also illuminate the underlying beliefs, feelings and knowledge which give rise to the social and economic value of the sites.
- Economic valuation methods:
    - The ORVal tool cited above also provides economic valuations;
    - Use of questionnaires to gather data relating to travel costs for example (note this pilot study had little success using this method, due to an apparent unwillingness on the behalf of participants to answer this question);
    - Account of the economic impact of archaeological investigations centred around specific sites and archaeological activities (e.g. travel costs incurred by visitors to archaeological events and money spent in association with the running of archaeological projects);
    - Economic values associated with wreck material which is for sale following removal from archaeological sites by salvors;
    - Unique or site-specific indicators of value. Indicators of value may also change from site to site, with some sites having clear indications of value associated with specific circumstances. The overall contribution made by such sources to understanding value overall may be limited as the results are not likely to be directly comparable with other site, so indications of relative value of different sites would be difficult to obtain.
- Biodiversity value. Biodiversity value is a key component of many ecosystems services assessments and there is extensive literature on this issue, however, quantification of this value is beyond the scope of the current project.

10 https://www.leep.exeter.ac.uk/orval/

- Economic value associated with the ecological value of wreck sites
    - Commercial landings data. This provides economic values for catches for an area, however, while knowledge of the habitats of different species can be used to infer which species may be caught on wreck sites, separating out the values of individual sites presents difficulties.
    - The Big Angling project may provide a valuable source of information, but current data-sharing restrictions have not made this a viable source for use during this project.

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APPENDIX 1: DEFINITIONS OF ECOSYSTEMS SERVICES

Extract from the Millennium Ecosystems Assessment (2005), and expanded to include habitat services as defined by Ecosystems Service and Biodiversity (ESB) (Food and Agricultural Organisation of the United Nations, 2018).

Provisioning Services

These are the products obtained from ecosystems, including:

- Food. This includes the vast range of food products derived from plants, animals, and microbes.
- Fiber. Materials included here are wood, jute, cotton, hemp, silk, and wool.
- Fuel. Wood, dung, and other biological materials serve as sources of energy.
- Genetic resources. This includes the genes and genetic information used for animal and plant breeding and biotechnology.
- Biochemicals, natural medicines, and pharmaceuticals. Many medicines, biocides, food additives such as alginates, and biological materials are derived from ecosystems.
- Ornamental resources. Animal and plant products, such as skins, shells, and flowers, are used as ornaments, and whole plants are used for landscaping and ornaments.

- Fresh water. People obtain fresh water from ecosystems and thus the supply of fresh water can be considered a provisioning service. Fresh water in rivers is also a source of energy. Because water is required for other life to exist, however, it could also be considered a supporting service.

Regulating Services

These are the benefits obtained from the regulation of ecosystem processes, including:

- Air quality regulation. Ecosystems both contribute chemicals to and extract chemicals from the atmosphere, influencing many aspects of air quality.
- Climate regulation. Ecosystems influence climate both locally and globally. At a local scale, for example, changes in land cover can affect both temperature and precipitation. At the global scale, ecosystems play an important role in climate by either sequestering or emitting greenhouse gases.
- Water regulation. The timing and magnitude of runoff, flooding, and aquifer recharge can be strongly influenced by changes in land cover, including, in particular, alterations that change the water storage potential of the system, such as the conversion of wetlands or the replacement of forests with croplands or croplands with urban areas.
- Erosion regulation. Vegetative cover plays an important role in soil retention and the prevention of landslides.
- Water purification and waste treatment. Ecosystems can be a source of impurities (for instance, in fresh water) but also can help filter out and

decompose organic wastes introduced into inland waters and coastal and marine ecosystems and can assimilate and detoxify compounds through soil and subsoil processes.
- Disease regulation. Changes in ecosystems can directly change the abundance of human pathogens, such as cholera, and can alter the abundance of disease vectors, such as mosquitoes.
- Pest regulation. Ecosystem changes affect the prevalence of crop and livestock pests and diseases.
- Pollination. Ecosystem changes affect the distribution, abundance, and effectiveness of pollinators.
- Natural hazard regulation. The presence of coastal ecosystems such as mangroves and coral reefs can reduce the damage caused by hurricanes or large waves.

Cultural Services

These are the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences, including:

- Cultural heritage values. Many societies place high value on the maintenance of either historically important landscapes ("cultural landscapes") or culturally significant species. Note this is taken to also include important sites.
- Cultural diversity. The diversity of ecosystems is one factor influencing the diversity of cultures.
- Spiritual and religious values. Many religions attach spiritual and religious values to ecosystems or their components.
- Knowledge systems (traditional and formal). Ecosystems influence the types of knowledge systems developed by different cultures.
- Educational values. Ecosystems and their components and processes provide the basis for both formal and informal education in many societies.
- Inspiration. Ecosystems provide a rich source of inspiration for art, folklore, national symbols, architecture, and advertising.
- Aesthetic values. Many people find beauty or aesthetic value in various aspects of ecosystems, as reflected in the support for parks, scenic drives, and the selection of housing locations.
- Social relations. Ecosystems influence the types of social relations that are established in particular cultures. Fishing societies, for example, differ in many respects in their social relations from nomadic herding or agricultural societies.
- Sense of place. Many people value the "sense of place" that is associated with recognized features of their environment, including aspects of the ecosystem.
- Recreation and ecotourism. People often choose where to spend their leisure time based in part on the characteristics of the natural or cultivated landscapes in a particular area.

Supporting and Habitat Services

Supporting services are those that are necessary for the production of all other ecosystem services. They differ from provisioning, regulating, and cultural services in that their impacts on people are often indirect or occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people. (Some services, like erosion regulation, can be categorized as both a supporting and a regulating service, depending on the time scale and immediacy of their impact on people.) These services include:

- Soil Formation. Because many provisioning services depend on soil fertility, the rate of soil formation influences human well-being in many ways.
- Photosynthesis. Photosynthesis produces oxygen necessary for most living organisms. Primary production. The assimilation or accumulation of energy and nutrients by organisms.
- Nutrient cycling. Approximately 20 nutrients essential for life, including nitrogen and phosphorus, cycle through ecosystems and are maintained at different concentrations in different parts of ecosystems.
- Water cycling. Water cycles through ecosystems and is essential for living organisms.
- Habitat for species: Ecosystems provide living spaces for plants and animals; they also maintain a diversity of complex processes that underpin the other ecosystem services.. Some habitats have an exceptionally high number of species which makes them more genetically diverse than others; these are known as 'biodiversity hotspots
- Maintenance of genetic diversity: Genetic diversity (the variety of genes between, and within, species populations) distinguishes different breeds or races from each other, providing the basis for locally well-adapted cultivars and a gene pool for developing commercial crops and livestock

APPENDIX 2: SUMMARY OF METHOD

Stage 1: Defining the study area and scoping the assessment

- Identify the study area with consideration of the type of project being undertaken (e.g. area associated with development impacts; an ecosystem; an historic landscape component/unit; a research area etc).
- Consult with key stakeholders including local authorities to ensure the study area is sufficient to identify ecosystems services and natural capital associated with heritage in the area.
- Treat the study area as the focus for investigations, but be prepared to consider information from outside of that area to identify beneficiaries for example.

Stage 2: Baseline assessments

- Obtain data from existing sources in order to undertake a rapid desk-based assessment of the area (note that this stage may be the first step in a landscape-scale assessment, but, if a site of interest is already identified [e.g. a particular site which may be lost as a result of development, or a site which is being considered for designation for example], this step may be skipped. During the course of this pilot study this step was used to identify the specific sites for more detailed investigation – see steps v onward).
- Collect heritage data relating to the site of interest (desk-based). Include key datasets including:
    - HER data;
    - Historic England data (designation and AIME);
    - UKHO data;
    - Historic seascapes/ landscapes data[11]; and
    - other key studies for the specific area in question.
- Analyse this data to identify sites and draw out key themes and narratives. The aim is to use these datasets together to rapidly identify sites and characterise the general historic development of the area, allowing the sites to be understood in context, and provide a backdrop for understanding the development of human-environment relationships and ecosystems services in the area.
- Collect and analyse ecological data relating to the site of interest and the surrounding ecosystems (desk-based). Include key datasets including:

11 In view of the decision to focus principally on sites, we found that the HSC data does not provide enough detail so cannot be used as a reliable indicator of areas of potential value associated with wreck sites. i.e. the identification of the site as a wreck is not sufficient to understand what ecosystems services that wreck provides. However, consideration of the HSC data does, at a broad scale, indicate some of the potential beneficiaries.

    - EMODnet Seabed Habitats (Seabed habitats and biotope classifications for European seabed habitats (MESH) data & EUNIS classifications.)
    - Cefas / Ellis *et al*, (2012) / Coull *et al*, (1998) (Fisheries sensitivity maps (UK spawning and nursery areas))
    - Scottish Government / Marine Management Organisation (MMO) (Fishing effort and landings data by ICES rectangle (geographic area).)
    - Joint Nature Conservation Committee (JNCC) (Conservation designations for UK taxa.)
    - MAGIC (Conservation designations for UK areas.)
    - National Biological Network (NBN) Gateway (Wildlife records for the UK.)
    - OBIS Seamap (Sighting and recordings network for marine mammal, sea turtle and other megafauna e.g. basking shark.)
- Undertake a literature review, in particular to establish the connection between heritage and the ecosystem (our focus was ecology and shipwreck sites);
- Undertake survey work to further record the heritage and ecology of the site, in particular to consider the relationship between ecosystems and heritage, and note users/beneficiaries as survey progresses. Attempt to involve key stakeholders in the survey as they will have relevant local knowledge (our survey involved individuals from the local community, IFCA, TCE, the MMO and KWT).

Stage 3: Identify the relationship between heritage and ecology

- Using the information gathered from the desk-based and survey work identify the relationship between heritage and ecology.

Stage 4: Identify ecosystem services and identifying sites/ landscapes which give rise to each ecosystem services

- Using the information gathered from the desk-based and survey work, and an understanding of the relationship between heritage and ecology, identify the ecosystem services produced across the study area;
- Gather data on which sites are used by people, and how. This could be gathered via the use of questionnaires and general discussions, as in this study, or other methods (such as photo competitions);
- Use existing data including the information from above and information from existing datasets to predict sites from which ecosystems services may potentially arise and create a map;
- Use the mapped data as a means by which to engage stakeholders to discuss where different ecosystems services arise.

Stage 5: Value

Economic valuation is a specialist area and as such no method is proposed here. It is recommended that Historic England take the advice of specialists on this matter. This report does however set out some potential sources of information on valuation, and notes that social media may be a useful tool for valuing maritime heritage.

APPENDIX 3: QUESTIONNAIRE

MSDS Marine and Carcinus are working on a project for Historic England, to identify the social and economic values of wreck sites. Currently it is mainly archaeologists who decide if a wreck is significant or not. We would like to gather information to change this, to make sure that the many different groups of people who use and value wreck sites in different ways are also represented when decisions are made. To do this we need your help!

Please help us to understand how and why you value shipwreck sites	
1. Do you visit any heritage, memorial, archaeological or cultural sites in Ramsgate, if so which?	
2. Are you aware of the shipwrecks on the Goodwin Sands? …… yes/no	
3. Are the shipwrecks important to you or do you value them in any way? Please explain.	
4. Do you use or visit any of the wreck sites in the Goodwin Sands area …… yes/no	
5. If yes, for what purpose (tick all which apply):	
a. Fishing (see question 5) b. Diving, to visit archaeological sites (see question 6) c. Diving, to visit ecological sites (see question 6) d. Photography/ art	e. Other, recreation (please specify) f. Other, work (please specify if your job includes visiting/using wreck sites) g. Other (please specify)
6. Which wreck sites do you target for fishing and why? (please provide a position if possible)	
7. Which wreck sites do you dive and why? (please provide a position if possible)	
8. What other opportunities would you want to explore the history of the Goodwin Sands Wrecks and Ramsgate's Harbour of Refuge either on land or at sea?	

9. If activities within the Goodwin Sands were to impact upon, or lead to the loss of shipwrecks, would this be important to you and why?

10. What determines whether a wreck is important to you, or would determine whether you would visit or use a wreck site (please provide details of why this is important for you):

What is important to you?	Important?	Please give details of how and why is this important/ not important to you?
Intactness of the wreck or amount of the wreck still present	Yes/No	
Age of the wreck	Yes/No	
Type of the wreck (e.g. sailing vessel, wartime wreck etc. please specify which types of wreck you would be most/least important to you and why)	Yes/No	
Material of the wreck (e.g. metal wreck/ wooden wreck please specify which materials would be most/least important to you and why)	Yes/No	
Historical associations of the wreck (e.g. if the wreck is associated with a key historical event such as WWI/ WWII, or notable historic person).	Yes/No	
Whether the wreck forms a memorial or reminder (such as for the war)	Yes/No	
Aesthetics (i.e. whether the wreck has any aesthetic qualities which you value)	Yes/No	
Source of inspiration	Yes/No	
Previous or ongoing personal connections with the wreck (s)	Yes/No	
Your own memories (do you have memories of any of the wrecks in the area, could you share them with us?)	Yes/No	
Physical environment of the wreck (e.g. the seabed on which it lies, bottom type, depths, strength of currents in the area etc)	Yes/No	Seabed bottom type: Depth: Strength of currents: Others:

Ecology/ species which inhabit the wreck (please specify the species)			Yes/No					
Other (please specify) (e.g. proximity to shore etc.)			Yes/No					
Tell us a bit about yourself...								
Gender	Female			Male		Prefer not to say		
Age	<18	18-35	36-50	50-67	>67	Occupation		
How often do you visit/see wreck sites in the area	Daily		Weekly	Monthly		Few times a year	Once a year or less	
How far do you travel to access the wreck sites? (approximate mileage)								
				Tick all which apply		Average spend per visit		
Do you use any of the local amenities when visiting the wreck sites	Local restaurants					£		
	Local pubs					£		
	Local shops					£		
	Local accommodation					£		
	Local car parks					£		
	Other					£		

Please provide any further information you would like to share. We understand that the ways in which a wreck might be important to you might not easily fit in the boxes above – so, feel free to use this space to describe or draw anything else relating to how you value wreck sites which you feel is important.

Thank you for taking the time to complete our questionnaire. The information provided by you in this questionnaire will be used for research purposes. It will not be used in a manner which would allow identification of your individual responses. Anonymised research data will be archived with Historic England in order to make them available to other researchers in line with current data sharing practices. For any questions, or to find out more about the project and getting involved, please contact Sally Evans at sally@msdsmarine.co.uk. 07791217114

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