Starting to think about the questions science may need to consider to understand the ecosystems of the North East Kent European marine sites

Diana Pound BSc, MSc, MIEEM
Dialogue Matters, Wye, Kent. TN25 5BU

Part 1

Our use of the natural environment will only be genuinely sustainable when we understand the functional limits of the ecosystems on which we depend and chose to live in. The focus of this paper is to start to think about the questions science may need to ask in order to understand the functional limits of one particular coastal and marine area, the North East Kent European marine site (NEKEMS) which stretches from Whitstable, on the Northern Coast round to Deal, on the Eastern Coast.

It has been suggested in a separate paper in this report that the NEKEMS is well placed to begin to press forward with adopting the Ecosystem Approach. The Ecosystem Approach is described in that paper and is the primary framework for achieving sustainable development under the Convention on Biodiversity (see page 7). For the Ecosystem Approach to deliver its aims, ecosystems must be managed within the limits of their function. This requires:

- an understanding of what an ecosystem is,
- agreement amongst scientists and managers about the ecosystem/s under discussion,
- developing understanding about the relationships and processes within these systems and the ecosystems structure and function,
- developing a clearer idea of what the systems functional limits might be.

Definitions of the word ‘ecosystem’ abound, including:

- a functioning unit of biological life and natural processes,
- a community of interdependent organisms together with the environment they inhabit and with which they interact (Dictionary of the Environment),
- a dynamic complex of plant, animal and micro-organism and their non-living environment interacting as a functional unit (Article 2 of the Convention on Biodiversity).

What is notable about these definitions is that none of them mention humans as part of the system. It is implicit that we are included within descriptive titles such as, ‘biological life’, ‘interdependent organisms’ or ‘animals’. However, we rarely use these titles to describe ourselves in these terms, and have tended to see ourselves as separate or outside ecosystems. When we do this, and ignore the need to maintain the functionality of the systems that provide our life support, we put both the system and ourselves at risk.

Before the structure and function of any given ecosystem can be understood, the spatial scale must be defined. Ecosystems can be defined at any spatial scale depending on the scale of the process – or the problem - under consideration. It is possible to talk about the ecosystem of a rock pool, a shore, a coastal cell, a regional sea or an ocean. Many ecosystems do not have readily definable boundaries because key processes eg water and nutrient supply originate 'beyond any habitat or structural limit and operate at a range of scales' (Laffoley and others, 2004). This is particularly the case with the sea where processes operate over large scales and distances.

In practice, defining a particular ecosystem(s) is best done at a scale which is most appropriate in respect to managing human activities that form part of that system and depend on it. The focus of this paper is to start to think about the systems that operate in and around the NE Kent European marine site. The current boundaries of the NEKEMS have been defined based on the location of features of European importance and do not consider the ecosystem/s of which they are a part. For the purposes of managing NEKEMS from an ecosystem perspective, it will be necessary to decide whether the area defined on the current designations map is considered an ecosystem, part of an ecosystem or many ecosystems.

Once the ecosystem(s) relevant to local decision-making have been defined, the next challenge is to begin to develop a sense of how resilient those systems are and what their functional limits might be. This concept accepts that ecosystems are dynamic. Traditionally, ecologists perceived all ecosystems as progressing along a continuum in a recognisable sequence with incremental changes occurring in a process of succession. Natural processes and feedback mechanisms would keep the system functioning within certain limits. It is now also accepted that if a system experiences sufficient natural or human induced disruption, these limits can be crossed, sudden changes occur, and a new state emerges. The model below aims to describe this concept visually. The circle represents the current state of the ecosystem as a ball that can role backwards and forwards between two points. With enough disruption the ball crosses the tipping point into a whole new state.

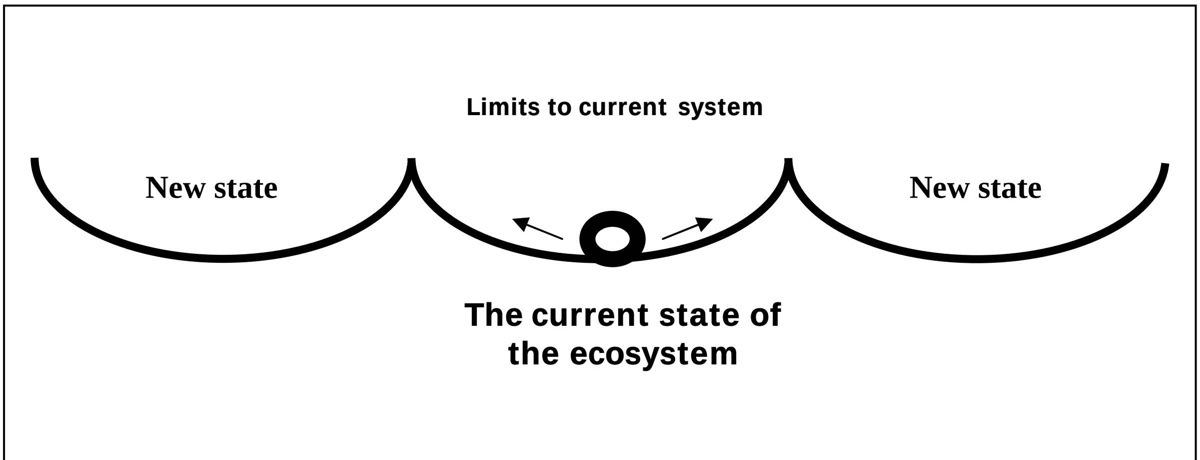


Diagram 1: Model showing the idea that there are limits beyond which the processes in an ecosystem collapse and a new state results

The implications of this are that scientists and managers need to start to work out what these limits might be, and what stresses or combination of stresses would take the system beyond the point of no return. Indicators can then be identified that provide early warning that the system is getting close to its functional limits. Indicators will include species that are sensitive to particular parameters - a concept that is already familiar, particularly in the monitoring of water quality and nutrient levels. Some indicators will also need to be non-biological, such as working out the sediment budget in a coastal cell and the indicators of whether or not this is sustainable or headed towards cell fragmentation.

Whilst the concept of indicators is not new, thinking about marine management from a holistic ecosystems approach is. There is an acknowledgement that we "need to shift the agenda from 'what is there' to 'what does it do'" (Laffoley and others, 2004). However, it is not necessary for marine scientists to start from scratch. The science of landscape ecology may offer some helpful insights and models as the following quote shows:

"Although applications in landscape ecology have traditionally been restricted to the study of terrestrial systems, the questions defining the science are equally relevant for marine systems. Indeed, knowledge of spatial pattern and the scales at which ecological processes take place is essential for effective management of marine environments. It is still unclear how the principles of landscape ecology can be translated into the marine environment, a three-dimensional milieu with physical and biological characteristics that often vary rapidly in space and time but it must start with bringing together researchers in the growing field of "seascape" ecology who are attempting to adapt the tools of landscape ecology to address ecological questions within marine and coastal systems", (US International Association of Landscape Ecologists 2004 Symposium).

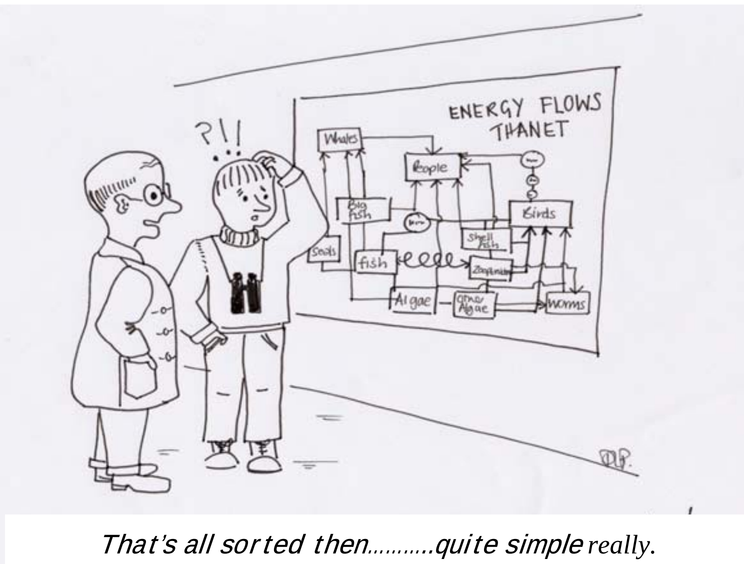
Part 2

The second part of this paper seeks to borrow from the science of landscape ecology by considering some of the basic concepts, and begin to explore how they might apply and help in taking an Ecosystem Approach to the NEKEMS.

Energy flows

A foundation of the science of ecology is the consideration of energy flows. Part of considering functional limits must be to consider what the main energy flows are, whether or not they are in equilibrium, or whether more is going into the system or being depleted from it.

At present the main flow of energy is from terrestrial ecosystems into marine systems in the form of nutrient runoff and wastewater. However, energy is also being depleted at higher trophic levels where over-fishing has led to the collapse of some fish stocks and as a consequence, fishing effort is now shifting down the food chain.



That's all sorted then..........quite simple really.

At a local level, work has yet to be done to understand the main energy flows in the ecosystem/s around north east Kent. Nutrient concentrations in the seawater are monitored and the Environment Agency is reviewing concentrations to see what effect they are having on the features of European importance (wintering turnstone and golden plover, chalk sea caves and reefs). However, the sensitivities and usefulness of these species and habitats as indicators for the health of the ecosystem as a whole is not known.

Hey guys….. I've just heard we're VIPs. We're KEYSTONE species!

Keystone species

The concept of keystone species is best explained with reference to the game of Jenga, a game in which wooden blocks are stacked on top of each other in a solid column. The game is to remove the blocks that are not essential to the stability of the column and the loser is the one who removes one of the crucial blocks so that the whole column collapses.

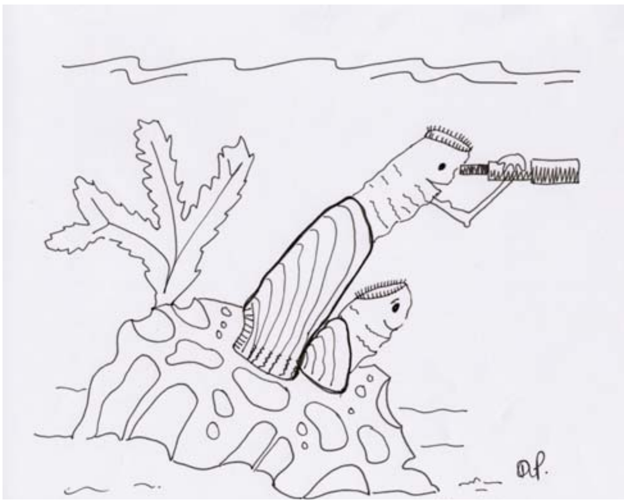
Keystone species are like those crucial Jenga blocks - they are vital for the functioning and resilience of the system, and have such a key role that their removal would lead to the collapse of the whole. Unlike Jenga, removing any components of the system unacceptably reduces its biodiversity. However, it is the keystone species that afford the system its stability.

If the keystone species of the European marine site can be identified, and their niche requirements and sensitivities understood, then a way of maintaining the resilience of the system will be to maintain a viable and healthy population of these species.

Metapopulations

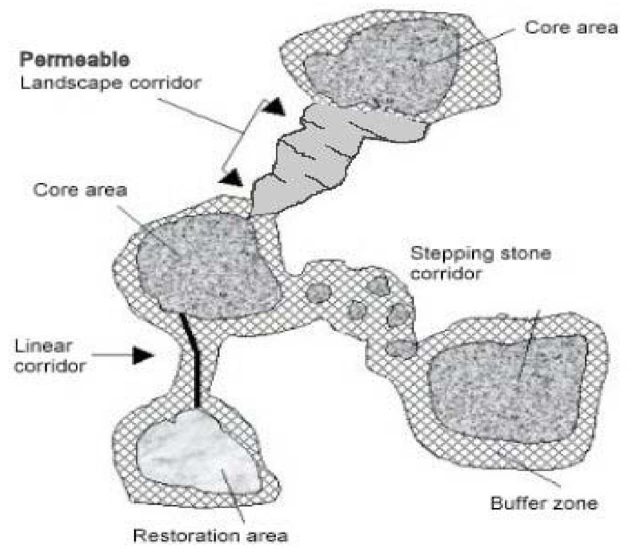
Metapopulations are the sum total of many local populations between which there is genetic mixing. Metapopulations provide resilience in a species gene pool and maximise the potential for adaptation to change. Isolated populations suffer the vulnerabilities of inbreeding with greater mutations, less resilience to disease or disaster, and loss of genetic diversity and adaptability.

Ensuring the viability of the European marine site's keystone species includes identifying whether or not they form part of a metapopulation and, if so, maintaining its range, size and connectivity.



*Say ……
just how many boring piddocks are there around here??*

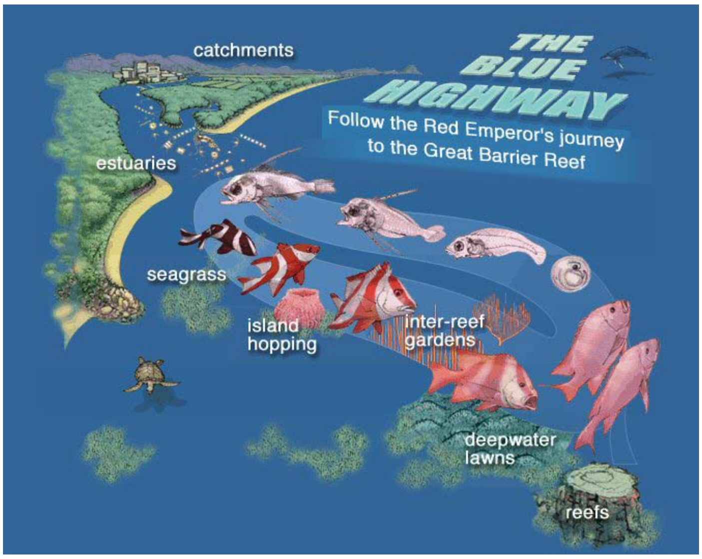
Connectivity



Schematic example of an ecological network adapted from ECNC 2000.

Connectivity is the word used to describe the links that allow genetic mixing and a fully functional metapopulation. From a landscape ecology perspective, connectivity is provided by linking corridors, stepping-stones and through *'permeable'* landscapes. Permeable landscapes are those that allow dispersal of species whilst not directly providing niche requirements. An example would be native grassland habitat that is permeable to more woodland birds, mammals and invertebrates than a freshly ploughed field or an urban area. It has been suggested that concern about connectivity is not relevant to the marine environment. This is because it appears to be seamless, with ecological process operating over large areas. However, although they may be subtle, natural boundaries do still exist, "defined by temperature, currents, depth, stratification and salinity" (Laffoley and others, 2004).

The extent to which human activities have created new boundaries to connectivity and dispersal in the sea has yet to be studied but it is certainly a possibility. It has been suggested that noise is a barrier to movement by species that travel in pods and communicate by sonar; dredging presents a barrier to movement by fish because the silt fines clog up their gills; near shore species may be prevented from long shore dispersal and breeding with adjacent populations by structures such as harbour walls that extend out to sea. All this is anecdotal but one clear example where the need to maintain connectivity has been demonstrated is the Red Emperor Fish of the Great Barrier Reef. At different life stages this species depends on different habitat types found at increasing distances from the shore. In areas



Great Barrier Reef Marine Park Authority where one of these habitats has been lost, the species can no longer complete its lifecycle. The poster *The Blue Highway* has been used to explain the concept and importance of connectivity to the public.

Drawing this back to consideration of the management of the (rather less exotic) north east Kent reefs would mean looking at the keystone species, finding out their lifecycle requirements and the mechanisms they use to disperse and mix at metapopulation scales. Once these mechanisms are known, consideration of whether they are viable for the long-term and whether or not they are susceptible to interruption by human activity, can be made.

Whilst the focus of this section is the connectivity within the sea, it is already known that the shores and sand flats of the north east Kent coast have a connectivity function, providing vital 'stepping-stones' for birds in passage between their northern breeding grounds and southern wintering grounds. Webb (2002) demonstrated that this link was at risk because levels of disturbance from human activity were compromising the ability of birds to feed and store sufficient body fat to survive the next leg of their journey.

Natural change

The Ecosystem Approach accepts that change is inevitable. There are processes of natural change in all ecosystems, some linear, some cyclical and others periodic. Teasing apart natural change from human induced change is a challenge and requires a greater understanding of the functioning of a given system and the web of natural and human feedback mechanisms that operate within it.

It also requires analysis of the long-term effects of humans on the system including:

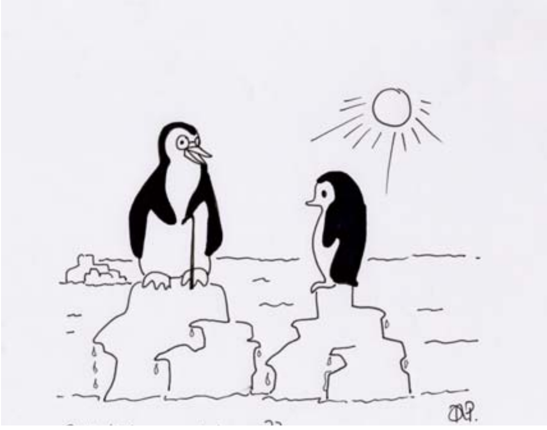
- adding nutrients and other chemicals,
- providing vectors for introduction of alien species,
- interrupting natural processes, eg by freezing the naturally eroding cliff line and interrupting coastal processes,
- extracting resources, eg fisheries, shellfish, dredged material.

How do we tell the kids that we're edible again?

Improvements in environmental quality will also have knock-on effects. For example, improved water quality may alter the composition and number of shore birds as a result of a change in the invertebrate community. Another example is an increase in harvesting of edible shellfish for human consumption as a result of cleaner coastal waters.

Locked in change

In considering ecosystem function it is important to take into account the changes that are already 'locked –in' to the environment as a result of past human activities. Global warming and sea level rise are two such changes that are going to affect the future management of the ecosystem(s) of the North East Kent European marine site.



Call this an iceberg??..... Now when I was a lad we really knew what an iceberg was!

In north east Kent, without naturalisation of the coastal process, sea level rise will squeeze the area of intertidal habitats against the current fixed sea walls. In time, as the shore continues to erode downwards and the sea level rises, the intertidal habitats will become subtidal. The only solution to this will be for the existing coastal protection to be removed and the cliffs to erode back inland naturally. In the short-term this will be politically unacceptable, with far reaching socio-economic consequences as cliffs erode and property falls into the sea. However, coastal squeeze and changes in coastal processes will also affect the beaches on which the tourist economy depends. Future generations will have some tough choices to make between keeping the coastal protection and losing the shore, or removing protection to maintain a shore and accepting the loss of property.

Climate space

Sea level rise is not the only consequence of global warming. Terrestrial ecologists have developed the concept of ‘climate space’. This is the climatic requirement of a particular species or habitat. They have theorised that with climate change the ‘climate space’ for a particular species will shift location. The species will be lost if it cannot disperse to the new location or the geological and other conditions there are not suitable for it.

As a result of global warming, sea surface temperatures are set to rise by up to 3° C in the UK’s shallowest seas by the 2080’s and more in semi-enclosed areas. “This will change the mixture, distribution and abundance of marine wildlife” (Laffoley and others 2004).

It is unclear what effect this will have locally. It seems likely that species that depend on the soft chalk substrate will be unable to shift location with their climate space. Species with less specific requirements will be able to migrate and colonise new areas whilst others that have not been recorded here before will arrive in north east Kent. Either way, the task of understanding the existing ecosystem is further complicated.

Summary

In summary, scientists and managers face a challenge as they seek to understand the ecosystems that comprise the sea and shore around the north east part of Kent. The extent to which borrowing concepts and models from landscape ecology helps in this challenge remains to be seen. What is certain is that short-term management and a narrow focus on the particular habitats and species that are specially protected will not allow a flexible, adaptive and holistic Ecosystem Approach.

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Eastern Channel Habitat Atlas for Marine Resource Management (CHARM Project)

C.S. Martin [1], A. Carpentier [2], F. Coppin [2], J.–C. Dauvin [3], N. Desroy [3], J.–M. Dewarumez [3], P.D. Eastwood [4], B. Ernande [2], S. Harrop [5], Z. Kemp [5], P. Koubbi [6], A. Lefèbvre [2], M. Lemoine [2], G.J. Meaden [1], S. Vaz [2], M. Walkey [5]

Addresses:
[1] Department of Geographical and Life Sciences, Canterbury Christ Church University College (CCCUC), Canterbury CT1 1QU, U.K., c.s.martin@canterbury.ac.uk
[2] Département Ressources Halieutiques (DRV/RH), Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER), 150 Quai Gambetta, BP 699, 62321 Boulogne-sur-mer, France, andre.carpentier@ifremer.fr
[3] Station Marine de Wimereux, Université des Sciences et Technologies de Lille (USTL), 28 Avenue Foch, B.P. 80, 62930 Wimereux, France
[4] The Centre for Environment, Fisheries & Aquaculture Science (CEFAS), Lowestoft Laboratory, Pakefield Road, Lowestoft, NR33 0HT, U.K.
[5] Department of Anthropology & Department of Computer Science, University of Kent (KENT), Canterbury, CT2 7NS, U.K.
[6] Université du Littoral Côte d'Opale (ULCO), Laboratoire d'Ichtyo-écologie Marine (LIMUL), Centre Universitaire Napoléon, Quai Masset, B.P. 120 62200 Boulogne-sur-mer, France

Introduction

The Dover Strait (Figure 1), which connects the English Channel to the North Sea, constitutes a significant economic resource for a wide range of human activities including the extraction of biotic (eg fisheries) and abiotic (eg aggregate) resources, ports, shipping. Exploitation of these natural and human resources currently lacks integration and applies pressure on the marine ecosystem, including fish stocks. CHARM (eastern Channel Habitat Atlas for marine Resource Management) is a Franco-British INTERREG IIIA project that intends to harmonize physical, biological and human use information in the Eastern English Channel through the development of a digital atlas. Included is a cross-border evaluation of the policy and legal frameworks for the assessment and monitoring of the marine ecosystem. The project intends to result in the development of an integrated system of marine management for the evaluation of living resources, important species and habitats in the Eastern English Channel. The main biological objectives of the project are to assess the status of key commercial fish species (15 species shown in Figure 2), to describe/model their habitats, and to develop a scientific prediction tool capable of accounting for the impact of various current and future anthropogenic impacts to marine habitats. Pressures might include planned and deliberate use of the area (eg aggregate extraction, wind farms, fisheries), unplanned events (eg accidental pollution, shipping accidents), but also long-term climatic change.

Potential users of the atlas include environment agencies, conservation bodies, fisheries managers, aggregate extraction companies, scientists, but also the general public since the project also aims to increase public awareness of the marine environment of the Eastern English Channel. Originally planned as a two phase project (of two years each), the project's phase I runs until June 2005, at which time a paper version of the digital atlas will be made available. Depending on further funding, phase II of the project will gather data for a larger area, will further develop habitat models, and then will use state of the art Web mapping technology to make the digital atlas available on-line and interactive on the project's Web site (http://charm.canterbury.ac.uk).

Study site

The physical characteristics of the seabed in the Dover Strait and adjacent waters are heavily influenced by the strong tidal dynamics encountered in the region. Much of the inshore waters are relatively shallow and generally do not exceed 10 m in depth, whereas offshore depths range up to 60-70 m. The slope of the seabed is relatively gentle throughout most of the region, but is more steeply-shelved in the immediate vicinity of the Dover Strait. A narrow deep (40 m) water channel runs through the centre of the Strait. The currents in the Dover Strait are dominated by tidal flows. Superimposed onto the tidal regime are wind-driven currents, and to a lesser extent, currents caused by density gradients from the mixing of fresh and saline coastal waters.

The seabed sediments in the region consist predominantly of sands and gravels. Sands are found along much of the French, Belgian and UK coasts, except in the immediate vicinity of the Dover Strait where gravely sediments dominate. A few localised areas of muddy sediments are found in the outer Thames estuary, along the southern UK coast, and along the Belgian coast to the east of the Dover Strait. The most prominent seabed feature within the region is the large number of sandbanks aligned roughly parallel to the coast in both nearshore and offshore waters.

A coastal-offshore temperature gradient exists throughout much of the year, particularly near to regions of freshwater influence (essentially the North coast of France): coastal waters tend to be warmer than the offshore waters in the summer, and colder in winter. The salinity of the water throughout the region is typical of oceanic water. The waters along the south-east coast of England are an exception, as they receive minimal freshwater inputs and so a higher salinity is maintained throughout the year. In contrast, the French coast of the Eastern English Channel is characterised by a region of freshwater known as the "fleuve côtier", or coastal flow (Brylinsky and others 1991). The flow, which can extend to 6 miles from the coast, is maintained by freshwater inputs from the numerous rivers discharging along the French coast.

The Dover Strait and adjacent waters represents a unique transitional zone between two contrasting environments: to the west lie the warmer, more saline waters of the Eastern English Channel, whilst to the north are the colder, less saline waters of the North Sea (Corten & van de Kamp 1996). This marine environment supports a number of important marine biological features, such as (1) a unique assemblage of demersal fish and benthic fauna that represents the biogeographical transition between the waters of the North Sea and of the English Channel, (2) important spawning and nursery habitats for key commercially-exploited fish (eg sole and whiting) and (3) an unique coastal and marine habitats of international importance (eg Thanet Coast and Parc Naturel Régional des Caps et Marais d'Opale, both Natura 2000 sites). The marine habitats and living resources of the region are environmentally valuable because they contribute toward the healthy functioning of this particular ecosystem.

Methods

Datasets

Work started by short-listing the physical, biological and human use parameters which best described the marine environment of the Eastern English Channel (Figure 1). Physical data types included eg bathymetry, seabed sediments, seabed stress, currents, nutrients, water temperature and salinity. Biological data types included eg chlorophyll a, plankton, benthos, fish abundance, fish larvae. Finally, human use data included eg fish landings, shipping traffic intensity, underwater cables, aggregate extraction, windfarm sites, and protected areas. Data sources are varied and numerous (eg oceanographic survey data provided by project partners; historical datasets; satellite imagery; published maps and models; administrative sources; conservation bodies; newly acquired data collected especially for the project; etc). It was usually necessary to standardise and validate data obtained from different sources in order to allow (1) displaying them at meaningful temporal and spatial scales within the atlas and (2) using some of these datasets for habitat suitability modelling. For all maps, a custom Transverse Mercator projection was chosen because it was applicable for the study area and preserved distance and area as best possible.

Metadata describing each of the atlas' datasets is being written and will be made available on the project's Web site in June 2005. Because of copyright issues, almost all the datasets gathered for CHARM have access restrictions, ie interested parties will have to contact data providers directly for accessing the raw data behind the maps.

From survey data points to continuous raster maps

When data were provided as data points (eg water temperature or fish abundance obtained from scientific surveys), kriging interpolation was used to create continuous raster maps. Geostatistics is a methodology for estimating the values of a parameter of interest in areas where the parameter has not been sampled directly. Kriging is the general term for geostatistical estimation, and is different from other interpolation techniques (eg inverse distance weighted) because it uses a model of the spatial variation within the dataset – the variogram (Webster & Oliver 2001).

In short, survey data points were interpolated by kriging into regular grids of chosen resolution (according to the spatial resolutions of the original survey dataset). These regular grids were then imported into ArcGIS version 8.2 (ESRI), plotted and projected to a custom Transverse Mercator projection. The grids' data points were then re-interpolated into raster maps using the default kriging parameters available in ArcGIS's Spatial Analyst tool. Care was taken to limit the spatial extent of the interpolated maps so as to avoid keeping data resulting from extrapolation (ie in areas where no sampling had taken place).

Habitat suitability modelling

A habitat suitability model describes the relationship between a species and its environment. It does not predict the abundance of a species but rather the environmental conditions that are more or less suitable for this species to live. Quantile regression (Eastwood and others 2001, Cade and Noon 2003) was used to model habitat suitability for fifteen commercial species of fish using five physical parameters (bathymetry plus mean sea level, water temperature and salinity, seabed sediment type, seabed stress). The software Blossom (Cade and Richards

1999) was used to automate the selection of physical factors by backward elimination. For each species of fish, the result was an equation where only the physical factors and interactions to which the fish was sensitive were kept. The ones to which the fish was not sensitive were dropped. ArcGIS' Raster Calculator was then used to apply the equation to the raster maps of the selected physical factors, hence creating a habitat suitability map for this species of fish.

Results to date & discussion

Although work is on-going, more than 400 geo-referenced maps have already been created for the project's atlas. Admittedly, the great majority of these maps show scientific survey data (temperature, salinity and fish abundance) from CEFAS and IFREMER, for the years 1988 to 2003, despite some years lacking data for certain parameters. Some examples of the atlas' maps are described below. This document is available on-line at http://charm.canterbury.ac.uk, with colour versions of the maps.

Seabed sediments

Among the GIS datasets available for seabed sediment in the study area, the paper map created by Larsonneur (1979) and digitised by IFREMER was found to provide the best spatial coverage. Although Larsonneur's classification comprises over 20 sediments types, a simpler five type classification (Figure 3A) was adopted: fine sand, coarse sand, gravel, pebbles, mud, since five sediment types were sufficient for habitat suitability modelling.

Water temperature

In-situ measurements of sea surface temperature were obtained from IFREMER (Channel Ground Fish Survey, CGFS, October months) and CEFAS (Beam Trawl Survey, BTS, August months). Temporal and spatial coverages were uneven, but relatively good datasets were available for 1997-2003 (CGFS) and for the years 1989, 1990, 1993, 1994, 1998-2002 (BTS, Figure 3B).

Fish abundance

Fish abundance data (as estimated from Catch Per Unit Effort, or CPUE) were also obtained from IFREMER's and CEFAS' scientific surveys (1988-2003). For each year and fish species, abundance maps were created. Figure 4A shows log transformed Flounder abundance for the years 1988 to 2003 for the month of October (IFREMER/CGSF).

Shipping traffic intensity

Anatec UK kindly provided shipping intensity data (in number of ship per year, Figure 5)

Habitat suitability models

Figure 4B shows a Habitat Suitability map for Flounder in October (based on IFREMER/CGFS data). The Habitat Suitability map is compatible with the mean abundance of Flounder for the month of October (Figure 4A) as obtained by kriging interpolation of survey data points.

Acknowledgments

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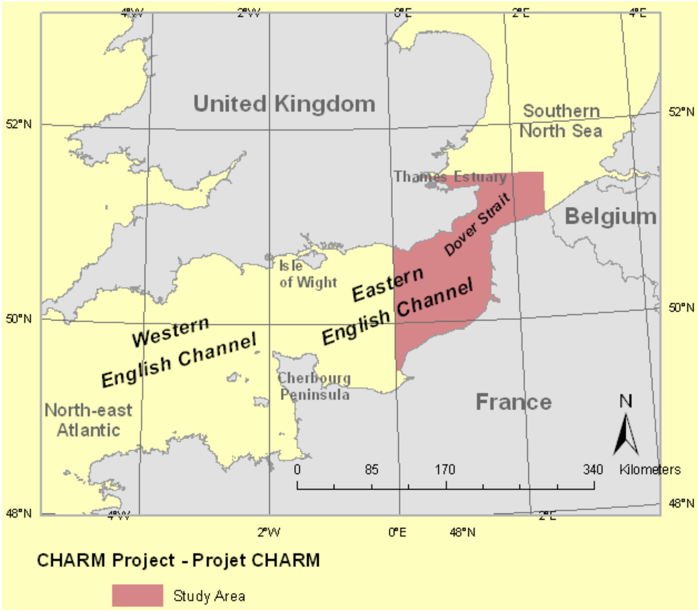

Figure 1. Map showing CHARM's study area.

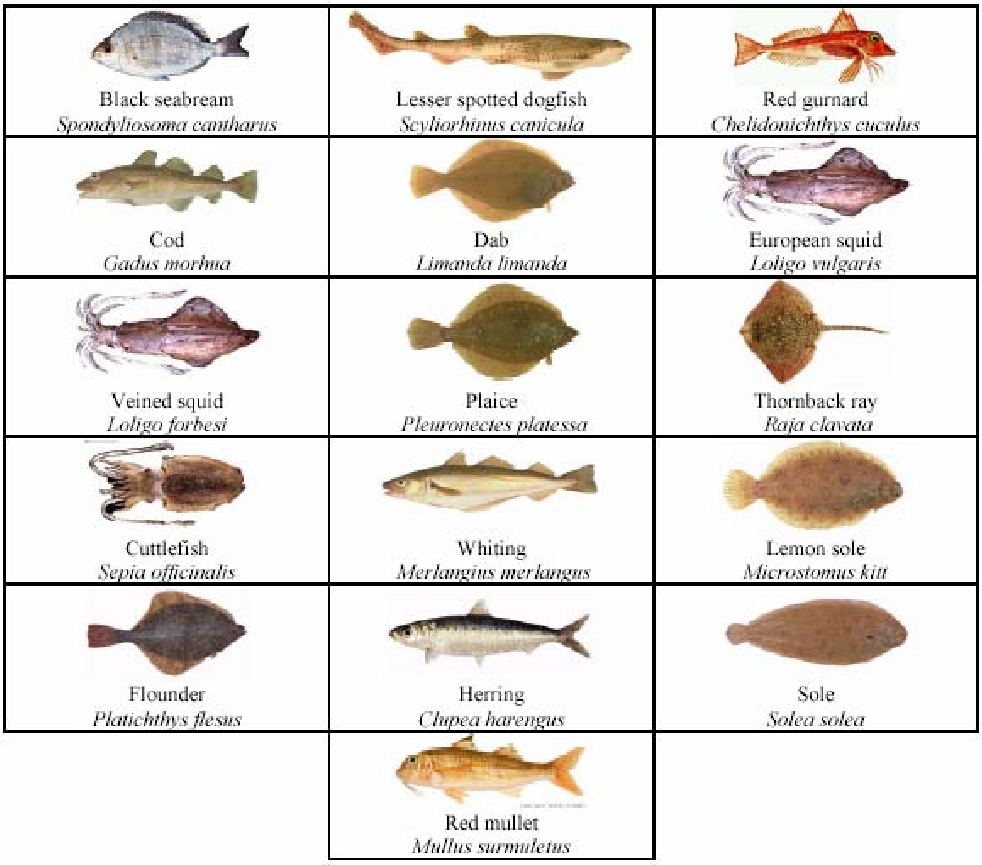

Figure 2. The 15 fish species selected for the CHARM Project.

A) B)

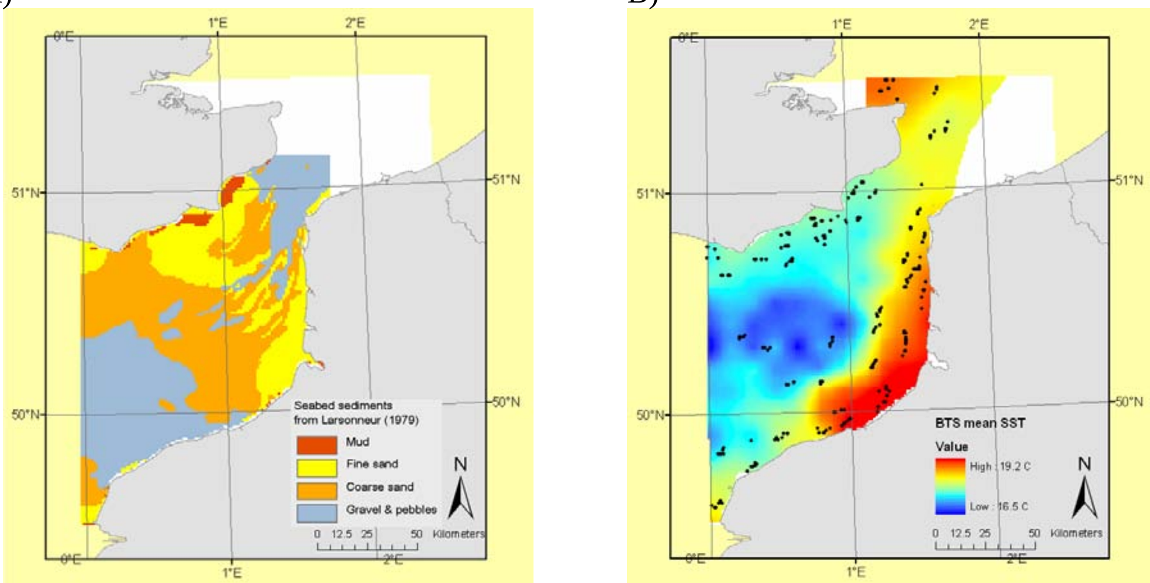

Figure 3. A) Seabed sediments according to Larsonneur (1979). **B**) Mean sea surface temperature over nine years of BTS surveys (CEFAS) in August (years 1989, 1990, 1993, 1994, 1998-2002). Survey sampling stations are shown in black. The map was created using kriging interpolation.

A) B)

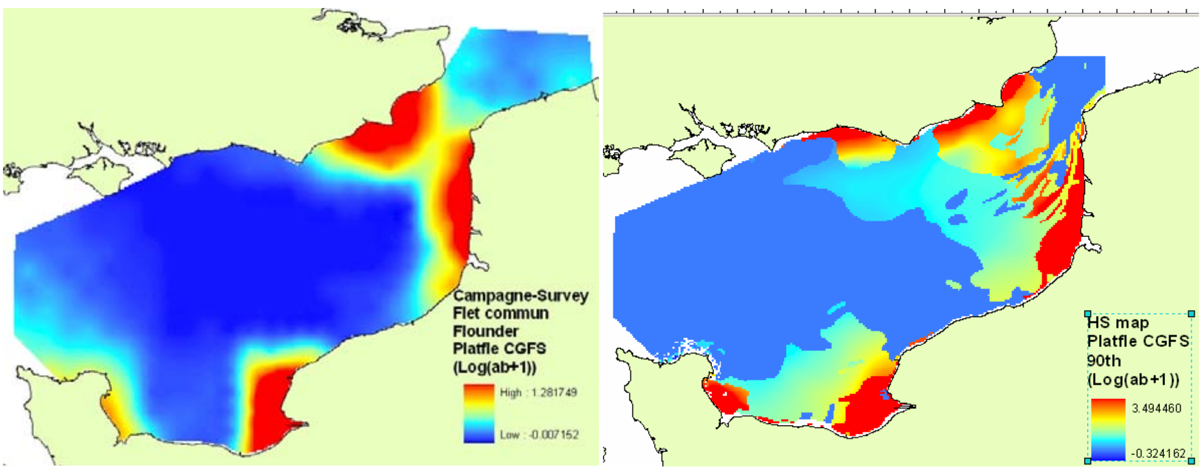

Figure 4. A) Log transformed Flounder abundance for the years 1988 to 2003 for the month of October (IFREMER/CGSF). This map was obtained using kriging interpolation. **B**) Habitat Suitability map for Flounder (high suitability in red and low suitability in blue) as obtained using quantile regression modelling.

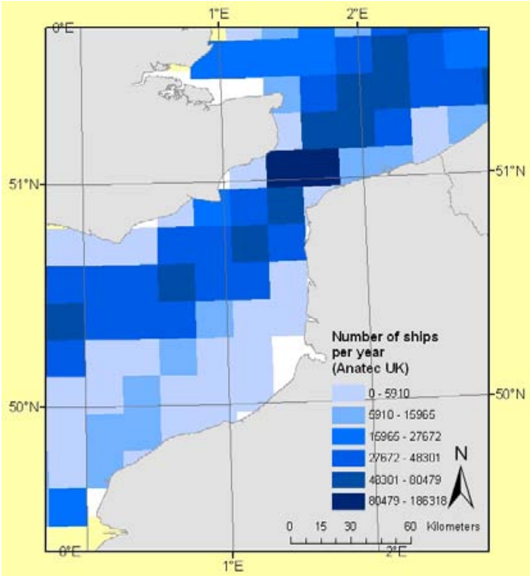

Figure 5. Shipping traffic Intensity (Anatec UK)

Pilot survey of seal haul-out sites off of the north Kent Coast

Jon Bramley
Bramley Associates, Forge House, London Road, Dunkirk, Kent ME13 9LL

Brett Lewis
Lewis Ecology, 41 Churchill Avenue, Beltinge, Herne Bay, Kent, CT6 6SG

Introduction

Seals belong to the group of mammals known as the 'pinnipeds' ('wing' footed animals) and world-wide there are some 33 species (Bonner 1989). Two of these species, namely the common or harbour seal *Phoca vitulina* and the grey seal *Halichoerus grypus*, have resident populations around the UK and a number of others, including walrus *Odobenus rosmarus*, harp-seal *Phoca groenlandica* and hooded seal *Cystophora cristata* are migrant visitors (Macdonald & Tattersall 2001).

Figure 1. This picture, taken during the pilot survey, shows common seals hauled out on the Goodwin Sands.

It is estimated that currently some 35,000 common and 120,000 grey seals occur around the coasts of Britain and this relates respectively to some 5%[*] and 45% of the world's population of these species (Jackson & McLeod 2000; English Nature 2004a). The importance of the UK populations is reflected in their conservation status and both species are listed under Appendix III of the Bern Convention and Annex II of the EU Habitats Directive, which requires 'appropriate measures' be carried out to ensure their protection.

[*] Four sub-species of common seal are commonly recognised. The eastern Atlantic common seal (*Phoca vitulina vitulina*) is the only sub-species that occurs in Europe and the UK holds some 40% of the population of this sub-species (Mitchell-Jones and others 1999).

The distribution of common and grey seals around the UK is related to the particular habitat preferences of both species, including the suitability of haul-out sites. Both species occur in many areas, though common seals tend to be found in more sheltered places with sandy coastlines and sandbanks, while grey seals are predominantly found on rocky shores.

In general, maps showing the distribution of common and grey seals around the UK do not show populations of either species as occurring in the SE corner of England (Bonner 1989; Anderson 1990) and no significant haul-out sites are identified south of Suffolk in two recent English Nature marine planning documents (English Nature 2004a & 2004b).

Seals are though known to occur in SE England, particularly around the coasts of Kent, and at a local level a number of organisations, including Kent Mammal Group, have been collecting records of reported observations of these species for a number of years. Most of these observations are of individuals or small numbers of seals seen feeding near to the shore or lying up in estuarine areas.

While there are some records of seals hauling up on one or two of the larger offshore sandbanks along the north Kent coast (M. Turner personal communication; C. Duck personal communication), the number and distribution of sandbanks used as haul-out sites in this area remained, until this survey, largely unknown.

Survey methods

For the collection of census data, it has become a standard practice in the UK to count hauled out seal populations on spring low tides in late July or August, a time of year when common seals are moulting (Anderson 1990). As not all seals in an area are likely to haul-out at any one time, it is estimated that this census technique collates some 60% of the seal population in any one area (Thompson and others 1997).

The aim of this pilot survey was to examine those offshore sandbanks (that had charted drying heights above 1 metre) lying within approximatley 12 nautical miles of the Kent coast, in the area between Whitstable around to Kingsdown, near Deal. Due to the number and dispersed distribution of these sandbanks (Figure 1), it was not possible to survey all banks in this area by boat during one spring tide. Therefore for the purposes of this survey, sandbanks were divided into three sub-groups according to their location.

One group referred to as ‘Off Herne Bay Banks’ included the sandbanks West Barrow, North Knob, Knock John, Shingles, Shingles Patch, Pan Sand and Ridge; a second group known as the ‘Margate Complex’ included Margate Sand, North East Last, Last and Margate Hook; the third group known as the ‘Goodwin Complex’, included North Sand (Goodwin Knoll), Kellet Gut Bank, Central Goodwin and South Calliper. A survey visit by rigid inflatable boat was made to all of the sandbanks within each sub-group during the first week of August 2004, with one sub-group being visited per spring tide.

On survey visits there was at least one dedicated surveyor and one cox/surveyor. Seal counts were taken of total numbers seen and included both adult and young animals.

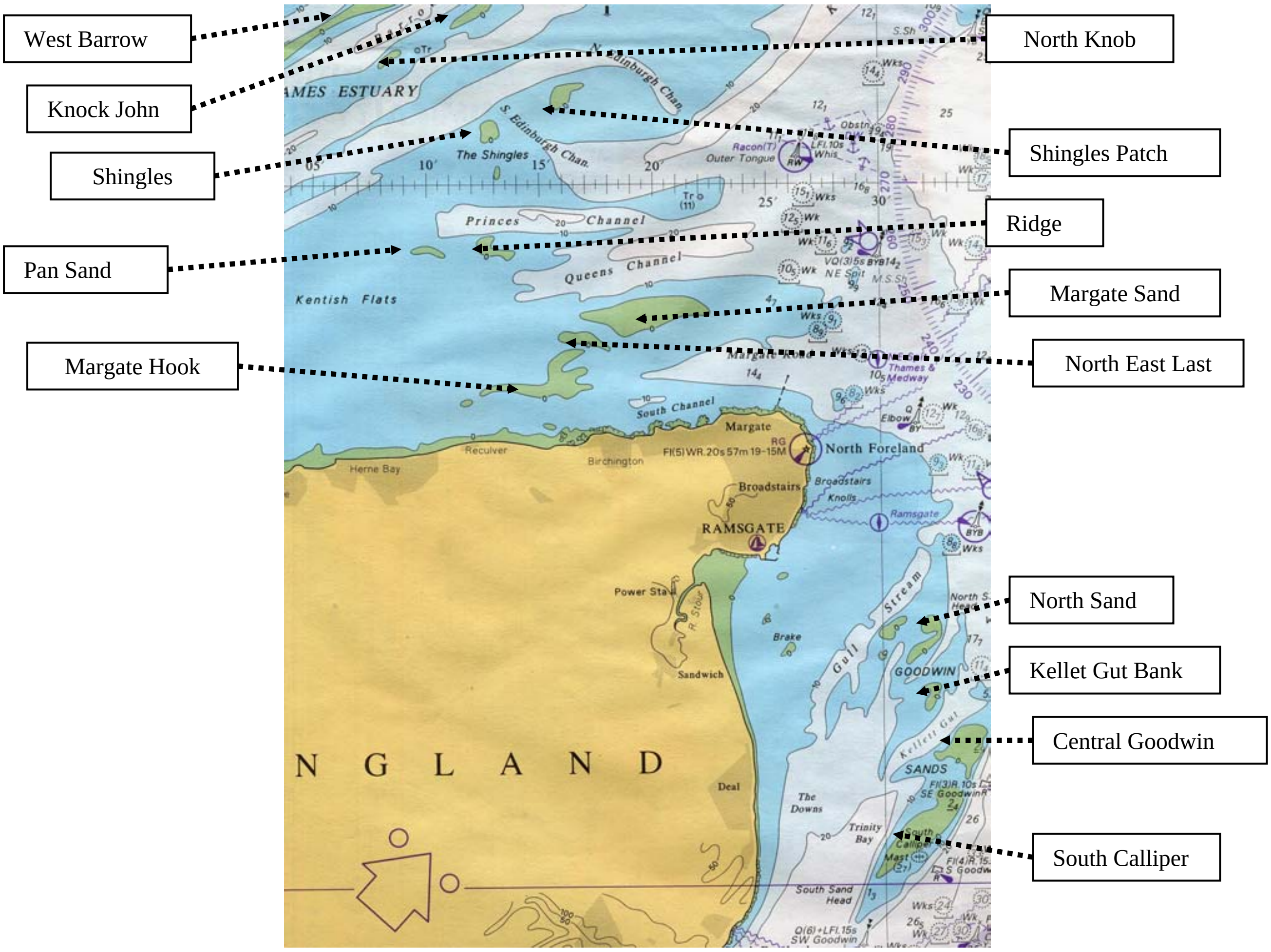

Figure 1. Shows the distribution of sandbanks lying off of the north Kent coast (out to about 12 nautical miles) surveyed in August 2004. The 'Last' sandbank lies between Margate Hook and North East Last. Reproduced from Admiralty chart 1406 by permission of the Controller of Her Majesty's Stationery Office, Port of London Authority and the UK Hydrographic Office.

Results

The total number of seals observed during the survey was 140; one hundred and twelve of these were common seals and twenty-eight were grey seals (Table 1).

Common seals were widely distributed across the whole survey area, from the West Barrow sandbank north of Herne Bay around to the Central Goodwin, lying just off of Deal.

Grey seals were also found on many sandbanks, but generally in smaller numbers and often in amongst larger groups of common seals. One group of 20 grey seals was recorded in the 'Goodwin Complex' on the North Sand sandbank.

Table 1. Displays the number and species of seals recorded on the sandbanks off of the north Kent coast in the August 2004 survey.

Sub-group	Sandbank	Number of common seals	Number of grey seals
Off Herne Bay Banks	West Barrow	21	3
	North Knob & Knock John	0	0
	Shingles & Shingles Patch	n/a	n/a
	Pan Sand & Ridge	12	4
Margate Complex	Margate Sand	10	0
	North East Last	9	0
	Last	0	0
	Margate Hook	0	0
Goodwin Complex	North Sand	25	20
	Kellet Gut Bank	1	1
	Central Goodwin	34	0
	South Calliper	n/a	n/a
	Totals	**112**	**28**

All records are of seals on or just in the water beside each bank, except those of the Kellet Gut bank. The two seals recorded at the Kellet Gut Bank were seen swimming above this bank, which was submerged at the time of survey. The Shingles and Shingles Patch banks did not show during the time of survey, although according to chart and tide information both banks should have been exposed. The South Calliper was the last sandbank of the 'Goodwin Complex' sub-group to be surveyed and was just covering as the survey team approached. No seals were seen in the water above the South Calliper, Shingles or Shingles Patch during survey periods.

To obtain accurate information on the identification and numbers of seals on sandbanks, great care was taken on approach to haul-out sites to minimise disturbance to hauled out groups. However, one large group on the North Sand in the 'Goodwin Complex', which may experience frequent disturbance from craft going in and out of Ramsgate harbour[*], did disperse to some extent on approach. Observations of this group, which are included in the overall count for this sandbank, are an estimation of species/number based on probable minimum numbers. Therefore, overall counts for this bank may have been slightly higher.

Conclusions

The total count of 140 seals observed on sandbanks during this survey equates to a possible population of around 250 seals in this area at this time (Thompson and others 1997). However, the actual overall figure of seals around north Kent in August 2004 though is likely to have been higher, as it is known that some seals also commonly haul-out on a few intertidal shore areas, particularly in Pegwell Bay and around Sheppey (personal observation). Although the haul-out numbers at intertidal shore areas is yet to be properly investigated, we estimate this to be at least 20 animals. Our overall estimate therefore is that at least 300 seals were resident in the north Kent area during August 2004. The vast majority of these (over 200) were likely to have been common seals.

[*] Deliberate disturbance of hauled out seals by boat users was observed on at least one occasion by the surveyors during the course of this survey.

The population of seals off on the north Kent coast is relative to the total UK population. However, it is probable that this population is an important and significant link between larger populations found in the Wash and those found across the Channel in northern Europe. The north Kent seals may also have given rise to populations known to occur along the south coast of England and in estuarine areas as far as Portsmouth.

This pilot survey has shown that common and grey seals use a number of sandbanks as haul-out sites on the north Kent coast and there is a case for including these important habitat areas within the Thanet cSAC.

A number of windfarm developments are envisaged for the north Kent coast/Thames estuary during the next decade. The possible impact of these developments on resident seal populations is unclear and further studies on these populations are required. For example, the seasonal use of sandbanks as haul-out sites and the fidelity of seals for individual haul-out areas is unknown. There is also uncertainty concerning the movement of seals between the sandbanks on the north Kent and between these sandbanks and elsewhere. On occasion over 140 seals have been recorded on the sandbanks of the 'Margate Complex' (personal observation) yet the count during this August 2004 survey was 19. So far the reasons for this disparity have not been established.

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Littorina littorea (Linnaeus, 1758) considered as an indicator of recovery from sewage pollution

Carol Torry, Ian Humpheryes and Georges Dussart
Canterbury Christ Church University College, Canterbury, Kent, England CT1 1QU
Email gbd1@canterbury.ac.uk

Introduction

After fifty years discharging untreated sewage, a short-sea outfall (SSO) at Foreness Point (FP) in the South East of England was replaced in 1989 by a 1900m long-sea outfall (LSO). In 1994, the chalk platform (about 0.25 ha) supporting the SSO had few algal macrophytes but had large numbers of *Littorina littorea*. By contrast, the adjacent Walpole Bay (WP) was covered by dense macroalgae but few *L. littorea*, Littorinids feed on diatoms and macrophytic algae such as *Enteromorpha*, although they avoid eating the tougher fucoids; on the upper shore, plant detritus becomes an important food (Watson and Norton 1985).

Since sewage pollution reduces algal diversity and encourages growth of green algae such as *Enteromorpha* (Borowitzka 1972), the outfall change might have affected the algal community. However, four years after the SSO stopped working, macrophyte cover on the shore had not significantly changed. On the mid/upper shore, algal cover was sparse and *L. littorea* population density remained high at approximately 161/m^2. By contrast, the lower middle shore had a higher percentage cover of algae than the upper middle/lower upper shore. However, these lower middle shore algae comprised mainly grazing-resistant taxa such as *Laurencia, Catenella and Corallina*. Here, where the settlement rate of sporelings was probably greater than in the higher shore zones, the littorinids could have been dependent on organic nutrients from other sources,

It was possible that before the change in outfall, the upper shore littorinids at FP had been partially sustained by the sewage nutriment, and loss of this resource might have ecologically stressed the population. Bilton (1974) observed that starved salmon could maintain body length yet lose body mass. The ratio of body mass to shell size ('body condition') of individuals in the littorinid population might have changed in a similar way.

Unfortunately, no detailed information was available on the *L. littorea* populations prior to the change in the outfall at FP, though Dayton (1971) notes that recovery time for mature rocky intertidal communities is typically greater than two years. The aim of the current investigation was therefore to use a *post hoc* study to investigate whether the *L. littorea* population had been stressed by the change in discharge. This would be achieved by, firstly, investigating the relationship between *L. littorea* and the algal community and secondly, comparing population structure and body condition of *L. littorea* populations at FP with populations unaffected nearby sites.

Method

The shore at each site comprises a Cretaceous chalk reef, exposed at low tide. All platforms have a gentle slope, and are backed by sea walls. For all parametric statistical analyses, data were confirmed to be normal.

The effect of removal of *L. littorea* on macrophyte cover at Forness Point (FP)

At FP, sixteen sites were randomly selected. Eight replicate sites of 1m^2 were situated in the upper shore intertidal band and eight in the mid shore. Four controls and four experimental sites within each band were randomly allocated and the experimental sites were each cleared completely of algae and littorinids on 29.6.1994. Numbers of *L. littorea* and macrophyte percentage cover were recorded at each site. The sites were observed regularly to 14.8.1994. Every day the transects were observed and littorinids counted in each square. Littorinids were cleared from the controls and within a buffer strip around each fixed quadrat. The quadrats were marked by painted nails hammered into the chalk at each corner such that a grid-divided quadrat could be laid exactly over each square. This method was used as it would cause less impact to the shore than alternatives such as the use of fixed exclusion cages.

Effect of the removal of *L. litto*rea on distribution of littorinids at experimental sites at Foreness Point (FP)

It was possible that littorinids were migrating into and out of the cleared areas on each tide so that unidentified animals would be responsible for the grazing being investigated in the previous experiment. Therefore, four experimental sites were randomly selected. Numbers of *L. littorea* /m^2 were recorded over several tides in four orthogonal directions for a distance of four metres using a metre quadrat. Data were investigated by analysis of variance.

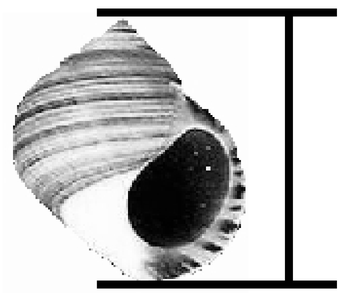

Figure 1. Dimension of shell length measurement

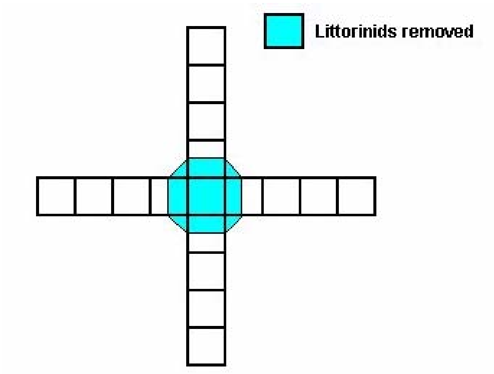

Figure 2. Design to test migration of *L. littorea* from adjacent positions after clearing of *L. littorea* from a m^2 quadrat.

Comparison of *L. littorea* number in relation to vegetation cover on three shores (FP, WB and BG)

In order to confirm results from the previous experiments, eight 1m^2 quadrats were randomly chosen on the mid-shore at each of three shores. Macrophyte percentage cover and density of *L. littorea* were recorded and compared between the shores

Population structure of *L. littorea* at Forness Point (FP) and Beresford Gap (BG)

L. littorea from two rocky shores were examined. The maximum shell length of all the *L. littorea* in a randomly selected quadrat on the lower and upper shore at FP was measured. The slope of the chalk platform at BG was so low that upper and lower shore could not be distinguished. Population structures were investigated by using an adaptation of the Cassie curve (Cassie 1954).

Body condition of *L. littorea* at Forness Point (FP), Beresford Gap (BG) and Ramsgate Undercliff) (RU)

Fifty specimens of *L. littorea*, ranging in size, were randomly selected from each shore. Maximum shell length was measured (Figure 1) and bodies were removed after 1m immersion in boiling water. The wet-weight of each body was recorded. Dry body weight was then obtained after drying at 60^0 C for 24 hours. Initially, body mass was plotted against shell length cubed. However, the regression fit was no improvement on a simple plot of shell length on dry mass and therefore, the latter was used as an index of body condition.

Results

Relationships between *L. littorea* and macrophyte cover

Before the experimental areas were cleared, the relationships between abundance of *L. littorea* and algae was investigated by multiple regression. This is not technically legal since each algal taxon is not independent of the others. However, the method serves as a pointer to relationships. Table 1 indicates a significant positive relationship between *L. littorea* density and abundance of both *Enteromorpha* and other green algae such as *Ulva*. (nb since this works was done, it has been suggested by Hayden and others (2003) that *Enteromorpha* and *Ulva* are, in fact, ecotypes of the same species). After removal of the *L. littorea* and algae, percentage coverage of *Enteromorpha* increased rapidly, reaching 100% cover by 6.7.1994. By contrast, the control sites showed fluctuating numbers of *L. littorea* and little algal presence except for *Catenella* sp. and the lichen, *Verrucaria maura*.

Table 1 Results of multiple regression analysis where number of *L. littorea* comprised the y variable and algal abundances comprised the x variables.

	Regression Coefficient	t	P
Miscellaneous green algae	-37.50	-1.98	0.050
Verrucaria sp.	-0.33	-1.85	0.066
Catenella sp.	0.24	0.42	0.674
Fucus sp.	16.38	3.62	0.000
Enteromopha sp.	-1.29	-9.13	0.000
Laurencia sp.	-5.63	-0.66	0.513
Porphya sp.	-0.99	-0.25	0.802

Effects of removal of *L. littorea* from experimental sites

A two-way analysis of variance was used to test whether harvesting from 4 separate quadrats caused significant depletion of littorinids from adjacent areas. The results (Table 2) indicated that aspect (North South East or West) had no effect on the distribution (F=0.1.56 d.f.=3 P=0.212). Harvesting caused significant depletion but only from quadrats in the adjacent position (F=4.56 d.f.=3 P=0.007). There was no significant interaction between aspect and position (P=0.96).

Comparison of *L. littorea* density in relation to vegetation cover on three shores

The algal community composition differed between the shores. With only 4.6 *L. littorea* /m^2, WP had the highest plant cover, mainly comprising Chlorophyta. BG with 270 *L .littorina* /m^2 supported fucoids and *Porphyra umbilicalis*, whereas at FP, *Catenella caespitosa* was most abundant .

FP and BG both had high densities of *L. littorea*, but differed in their algal communities. In order to investigate whether the littorinid population structures differed between these shores, the following analysis was carried out.

Population structure of *L. littorea* at Forness Point (FP) and Beresford Gap (BG)

The curve for BG (Figure 3) suggests there was a single cohort of large *L. littorea.* By contrast, the Foreness Lower Shore curve suggests there were two cohorts averaging approximately 9mm and 20mm in size. The curve for the Foreness Upper Shore population fell somewhere between the two.

Body Condition of *L. littorea* at Forness Point (FP), Beresford Gap (BG) and Ramsgate Undercliff) (RU)

The sites were visited in 1996, 1999 and 2000 in order to investigate possible changes in body condition which might reflect change in nutritional stress. Figure 4 compares the slope coefficients. At FP, body condition as indicated by the slope coefficient, stayed remarkably constant, whereas BG and RU showed significant fluctuations. Two-way anova indicated significant differences between the sites ($F_{2,841}$~65 P<0.0001), between the times ($F_{3,841}$~103 P<0.0001) and with significant interactions ($F_{6,841}$~33 P<0.0001).

A comparison of Summer and Winter data for 2000 (Figure 5) shows patterns similar to 1994 and 1999 but the mean slope coefficient at each site was lower in Winter. A two-way anova showed significant differences between seasons ($F_{1,300}$~14.7 P<0.0001) and sites ($F_{2,300}$~122 P<0.001).

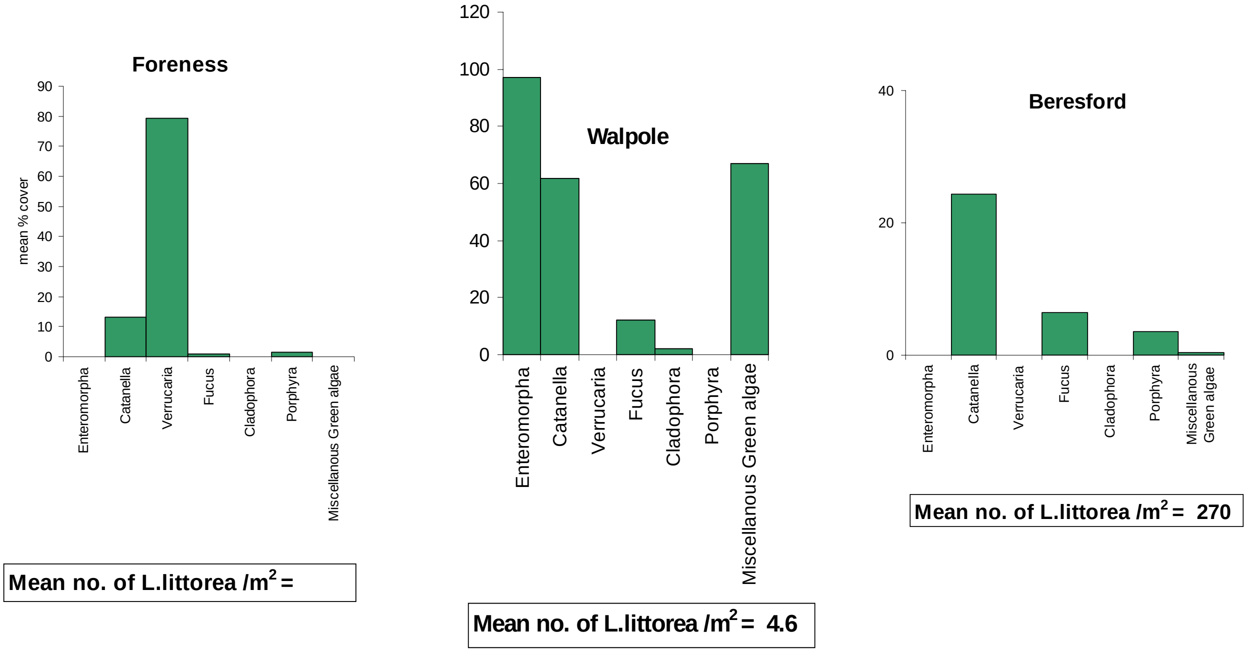

Figure 2 Mean percentage plant cover for eight replicate quadrats on each of three shores which differed in density of *L. littorea*.

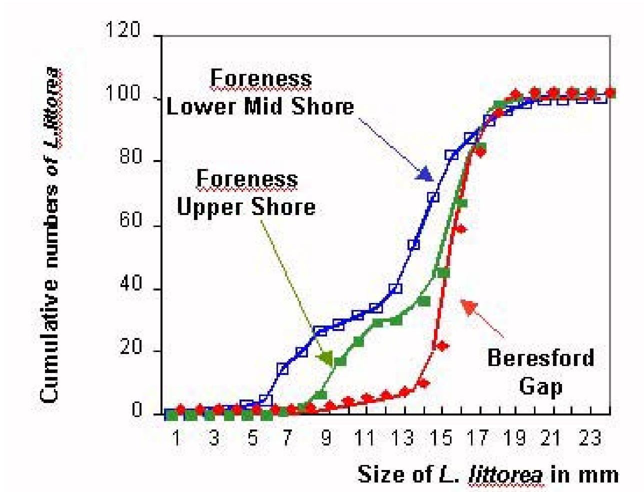

Figure 3. Comparison of the population structures of *L. littorea* populations at Foreness Point (FP) and Beresford Gap (BG)

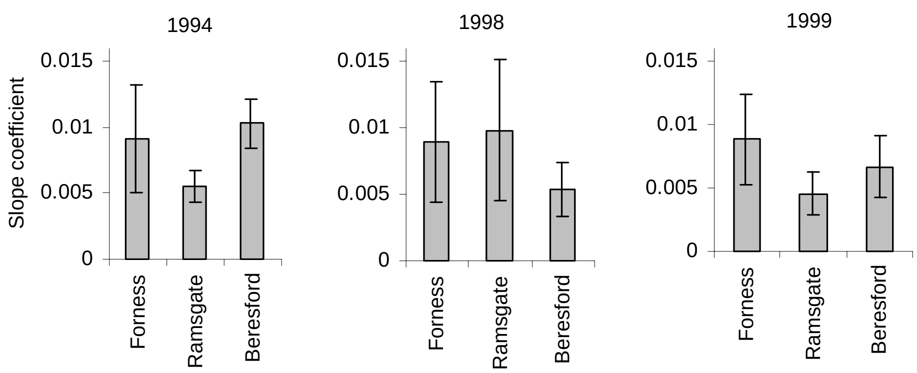

Figure 4. Comparison of regression slope coefficient (a measure of body condition) for dry weight of soft body, regressed on the maximum shell length.

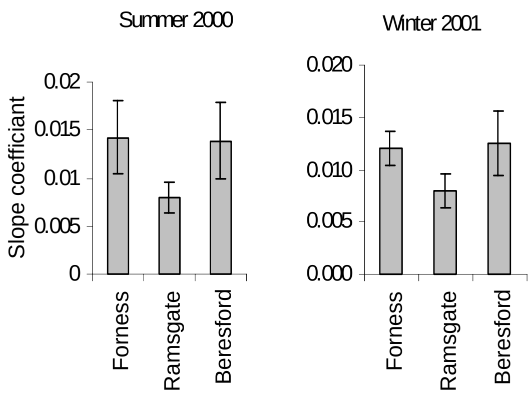

Figure 5. A comparison of Summer and Winter body condition of *L. littorea* at Forness Point (FP), Beresford Gap (BG) and Ramsgate Undercliff (RU) in 2000

Discussion

Relationships between *L. littorea* and macrophyte cover

As result of the experimental manipulation, there was an immediate increase in the abundance *E. intestinalis*. In some areas, vigorous colonisation by *E. intestinalis* led to the development of dense patches of this green alga. Invasion by *L. littorea* into these areas was then restricted. On other cleared areas, the results support the suggestions of Lodge (1948) , Southwood (1962) and Underwood (1980) that mollusc grazing is an important control on macroalgal establishment and production.

Effects of removal of *L. littorea* from experimental sites

The depletion experiment showed that although there was only a local effect of harvesting on the population density of adjacent areas. The results of the previous experiment were, therefore, unlikely to be due to littorinids migrating in and out of the harvested area on a single, or few tides.

Comparison of *L. littorea* density in relation to vegetation cover on three shores

Once *E. intestinalis* established itself in cleared areas, there was only a limited migration of *L. littorea* into the cleared experimental sites. Therefore, the investigation was extended to compare three sites with different macrophyte community composition and littorinid densities (FP, WB and BG).

L. littorea size of individuals within a population

During the experiment to look at grazing effects of littorinid on the vegetation, there appeared to be a different population structure between upper and mid shore at FP and a mixed population structure at BG. The sizes of the individual littorinids were examined at these three sites to investigate this observation. Size distribution analysis (Figure 3) of littorinids showed there were different size distributions at different shore heights. Contrary to anecdotal observation, the graphs showed that there were a larger number of smaller littorinids at the mid-shore, though there was a greater number of small littorinids on the mid-shore than on the upper shore area. The graphs also showed similarities between the upper shore at FP and the upper shore at BG. It is not possible to say from the Cassie curve analysis whether these size difference have any relationship to the age of the littorinids. Further research would need to be carried out on aspects such as shell formation to determine age differences. The Cassie curve did show distinct changes within the populations at all three sites. FP mid shore was different from the upper shores at FP and BG.

Population stress

The large numbers of *L. littorea* found at FP and the low amounts of vegetation in this area suggest that other forms of food must have been available to support the population. The original food supply may have come from the organic matter contained in the sewage which was discharged onto rocky chalk shore before the long sea outfall came into use. Since the removal of the sewage discharge, the amount of food available for the littorinid population has been reduced; therefore, there is constant competition for any macroalgae sporelings that may try to settle on the shore. Although the spores are continuously settling on the rocks, they are removed by the littorinids before the algae has a chance to establish. The results of body mass against shell size suggest that the younger members of the population are under stress and probably have difficulties finding sufficient food resources.

The larger members of the population are probably also under stress caused by competition for food but this is not so clearly seen when compared with populations supplied with organic matter. Littler and Murray (1978) found that *Littorina* sp. had larger gut volumes when taken from a control area, than those that were taken from an area polluted by domestic waste. They suggested that *Littorina* sp. may need to consume less food volume to meet their energetic requirements in an enriched environment. The finding of Littler and Murray may suggest a reason for the low body mass to shell size ratio at RU, while its population of littorinid are still receiving supplies of organic matter. The Western Undercliff population (RU) may be consuming less food but still gaining the same energy value, compared with other populations which might have to eat larger volumes of algae. Periwinkles feeding on the thin film of algal sporelings/ diatoms might also consume amounts of soft chalk, thereby adding to their body weight. This could also help to account for the large body mass to shell ratio found at FP among the larger littorinids. However, the younger members of the population at FP do not show this relatively greater body mass; one explanation for this could be that the larger littorinids are out competing the smaller littorinids and consuming greater amounts of the food available as well as chalk substratum.

The body mass to shell ratio at BG was greater than that found at RU. The disparity in the size of the littorinids at these two sites may be due to genetic differences. Curry and Hughes (1992) note that because *L. littorea* produce pelagic eggs, there is little difference between populations connected by tidal currents. On beaches which were separated by tidal currents not coming into contact with each other, populations were different. In this context, RU and BG are separated by tidal flows but BG and FP are not separated by tidal flow. The population structure on these two beaches are similar, thereby confirming the observations of Curry and Hughes (1982).

Conclusion

The main experiment showed that the intense grazing of littorinids was having an effect on the return of macroalgae to the mid and upper shore area of FP. It appears that A large population had been able to develop due to the sewage being discharged onto the beach. This sewage provided organic matter on which the littorinids could feed. The continuous supply of organic matter allowed the population to exceed the carrying capacity which might have been expected in more normal conditions. The removal of the organic matter supply has placed stress on the population at FP. This will probably lead to a reduction in the numbers of littorinids found in this area in years to come. The reduction in the numbers of littorinids may in turn allow the macroalgae (particularly fucoid species) to re-establish.

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The marine algal flora of Thanet - stability or change?

Ian Tittley
Department of Botany, Natural History Museum, London SW7 5BD

Introduction

The historical continuity of algal recording and research in Thanet has been referred to several times (Tittley and others 1999; Tittley 2004) and goes back 400 years. The earliest records for Thanet are species that today, and presumably in the past, are the characterising species of shores around Thanet although there is little past ecological information to support the assertion.

This paper will firstly review algal species records for Thanet and add new records from recent fieldwork, and secondly briefly describe local changes in community structure at Botany Bay that contradicts the notion of ecological stability.

The Thanet coast

Thanet coast and surrounding inshore waters have undergone change over the past 200 – 400 years. Coastal configuration has been altered through natural processes and more recently by man through the construction of sea-walls (cf Fowler & Tittley 1993), harbours, marinas, tidal swimming pools, and other structures. While natural habitat and some associated communities have been lost, artificial structures have increased habitat diversity and as a consequence enhanced species diversity. Nutrient enrichment in inshore waters may be responsible for encouraging blooms of certain algal species (cf Tittley and others 1998). Climate has undergone small oscillations over the past 400 years and North Atlantic sea temperatures have periodically risen and fallen (Lüning 1990; Hiscock and others 2004) with possible effects on algal species and communities and also animals (Southward 1967). Warmer periods may be linked to the temporary occurrence in Thanet of south-western species such as *Padina pavonica*. The effects of cold snaps on marine communities, such as the harsh winter of 1962-3 when inshore seas around Thanet froze, may have been profound but were not investigated.

The flora - species content

A large body of floristic (species) information has been built up over the past four centuries and contributes to our knowledge of algal diversity in Thanet. Time-series collation raises questions as to why species were recorded previously but not recently (and vice versa) with inferences for stability or change. Marine recording continues to identify new species records for Thanet or re-discover sometimes discounted older records. A full algal species list for Thanet is given below and is based on that of Tittley (2004) but with additions and amendments, comments on the validity of species records, and also some brief ecological information. In the list specimen records are indicated S and literature records L (other than the collations in Tittley & Price 1977; Tittley and others 1983; Tittley 2004); where indicated S^F specimens are with R.L. Fletcher (University of Portsmouth), and where S* specimens were examined but are not available. For full author citation see Hardy & Guiry (2003).

Chlorophyceae (green algae)

Acrochaete viridis: microscopic filaments; a single record from Westgate epiphytic on *Fucus*. Not found since the 1930s. (L)

Acrosiphonia arcta: recorded only sporadically. (LS)

Blidingia minima: widespread and common mainly on sea-walls, occasionally chalk cliffs; characterises a biotope at high tide level. (L S)

Bryopsis hypnoides: an imprecisely located early record. (L)

Bryopsis plumosa: long known, widespread and common. (LS)

Chaetomorpha linum: long known but rarely recorded. (S)

Chaetomorpha melagonium: long known, widespread and not uncommon. (S)

Cladophora albida: known only from two early records, one from Ramsgate. (S)

Cladophora fracta: recorded once at Westgate, possibly a misidentification. (L)

Cladophora hutchinsiae: an imprecisely located early record. (S)

Cladophora laetevirens: early records, not found recently. (S)

Cladophora lehmanniana: an early record, not found recently. (L)

Cladophora pellucida: until recently known only from an early imprecisely located specimen; discovered in 2004 growing abundantly on floating pontoons in Ramsgate inner harbour. (S)

Cladophora rupestris: long known, widespread and common. (LS)

Cladophora sericea: long known, widespread and common. (S)

Ectochaete wittrockii: a microscopic endophyte on larger algae growing on chalk cliffs; not found since the 1930s. (L)

Epicladia perforans: microscopic filamentous growths on chalk cliffs and on larger algae; occurs widely. (L)

Eugomontia sacculata: microscopic filamentous growths in shells; widespread and common. (S*)

Gomontia polyrhiza: microscopic filamentous growths in shells; widespread and common. (L)

Prasiola stipitata: Grows sporadically on breakwaters and sea-walls. (S)

Pringsheimiella scutata: microscopic discs epiphytic on larger algae; recorded sporadically.

Pseudendoclonium submarinum: microscopic clusters cells or filaments forming green gowths at high levels on walls and ceilings of caves. (S)

Pseudulvella applanata: microscopic discs or crusts; poorly recorded. (S*)

Rhizoclonium tortuosum (incl. Chaetomorpha ligustica, C. mediterranea): forms cotton wool like growths over *Corallina* in rock pools, or filamentous growths on chalk cliffs among *Ulva (Enteromorpha)* spp. (LS)

Ulothrix flacca: poorly recorded, known only on cliffs at Westgate. (L)

Ulothrix speciosa: poorly recorded, known only on cliffs at Westgate. (L)

Ulothrix subflaccida: poorly recorded, known only on cliffs at Westgate. (L)

Ulva (Enteromorpha) clathrata: long known but poorly recorded. (LS)

Ulva (Enteromorpha) compressa: long known, widespread and common. (LS)

Ulva (Enteromorpha) intestinalis: long known, widespread and common. (LS)

Ulva (Enteromorpha) linza: long known, widespread and common. (S)

Ulva lactuca: long known (since 1597), widespread and common. (LS)

Ulva (Enteromorpha) prolifera: widespread and common; common biotope forming species with other *Ulva (Enteromorpha)* spp and/or *Porphyra* spp. (LS)

Ulvaria obscura: poorly recorded, known only on cliffs at Westgate. (L)

Urospora penicilliformis: long known but poorly recorded. (S)

Urospora wormskioldii: common among green algae on cliffs; characterises a biotope with *Ulothrix* spp. on sea walls and occasionally chalk cliffs. (S)

Phaeophyceae (brown algae)

Acinetospora crinita: a small filamentous, often epiphytic, species, found in 1983 in Ramsgate inner harbour and in 2004 on *Laminaria* in Walpole rock tidal swimming pool. (S)

Arthrocladia villosa: not recently recorded, probably drift, absent from southeast England. (S)

Ascophyllum nodosum: does not grow on Thanet, common as drift. (LS)

Asperococcus fistulosus: an ephemeral species widespread in Britain, not recently recorded. (LS)

Chorda filum: not recently recorded, possibly drift. (LS)

Chordaria flagelliformis: not recently recorded, probably drift, absent from southeast England. (L)

Cladostephus spongiosus: long-recorded and common. (LS)

Compsonema saxicola: a minute crustose species on chalk overlooked and poorly recorded. (S^F)

Cutleria multifida: first recorded in the late nineteenth century and subsequently at Ramsgate, latterly only on pontoons in the inner harbour.

Cystoseira baccata: drift, southwestern species absent in southeast England. (S)

Cystoseira foeniculacea: as previously but not recorded since the early nineteenth century. (LS)

Desmarestia aculeata: long known as a drift species, absent from southeast England. (S)

Desmarestia ligulata: as previously. (S)

Desmarestia viridis: an isolated dense population on pontoons in Ramsgate inner harbour confirming a less precisely located nineteenth century record, otherwise absent from southeast England. (S)

Dictyota dichotoma: a long known and widely recorded species. (LS)

Ectocarpus fasciculatus: a long known but poorly recorded species. (S)

Ectocarpus siliculosus: as previously.

Elachista flaccida: an epiphyte on *Cystoseira baccata*, drift. (S)

Elachista fucicola: a long known, common epiphyte on *Fucus* spp. (L)

Feldmannia globifera: recently recorded only from pontoons in Ramsgate inner harbour. (S^F)

Feldmannia irregularis: a small filamentous species recorded in the 1930s from chalk cliff faces; not recently found and presumed locally extinct due to habitat loss. (L)

Fucus ceranoides: old misidentified records. (LS)

Fucus serratus: long known and common, characteristic species of a biotope on many Thanet shores. (LS)

Fucus spiralis: as previously. (LS)

Fucus vesiculosus: as previously. (LS)

Halidrys siliquosa: long known and common species of deep pools; characterising species of deep pool biotopes. (LS)

Himanthalia elongata: long known drift species, absent from southeast England. (LS)

Hincksia granulosa: small filamentous species, probably overlooked but known since the nineteenth century; common on offshore navigation buoys, and on pontoons in Ramsgate harbour. (S)

Hincksia ovata: known only from pontoons in Ramsgate inner harbour. (S^F)

Hincksia seunda: only once recorded in 1970 from Nayland Rock. (S)

Hincksia sandriana: known only from pontoons in Ramsgate inner harbour. (S^F)

Isthmoplea sphaeophora: although long known on Thanet, now occurs only on cliffs at Westgate. (LS)

Kuetzingiella holmesii: a small filamentous species recorded in the 1930s from chalk cliff faces; not recently found and presumed locally extinct due to habitat loss. (L)

Laminaria digitata: long known and common, characteristic species of the biotope at subtidal fringe and subtidal levels on many Thanet shores. (LS)

Laminaria saccharina: as previously; a non bullate form more common in the eastern southern North Sea was found in 2004 in Walpole Rock tidal swimming pool. (LS)

Leathesia difformis: a small globular epiphyte sporadically recorded in 1969 and 1970, not found since. (S^F)

Mikrosyphar polysiphoniae: a microscopic filamentous epiphyte not recorded since the 1930s. (L)

Mikrosyphar porphyrae: a microscopic filamentous epiphyte not found since 1970. (S^F)

Myriactula clandestina: a microscopic filamentous epiphyte on *Fucus*. (S^F)

Myrionema corunnae: a minute discoid epiphyte on *Laminaria* blades. (S^F)

Myrionema strangulans: a small discoid epiphyte on *Ulva* and *Laminaria* spp. (S)

Padina pavonica: known only from Margate and Foreness Point in the early and late nineteenth century; rarely recorded in southeastern England. (LS)

Pelvetia canaliculata: doubtful past records, does not grow on Thanet. (LS)

Petalonia fascia: widespread and common, seasonal (spring). (S)

Petalonia filiformis: widespread and not uncommon on chalk cliff faces only. (S^F)

Petroderma maculiforme: a small crustose species, infrequently recorded. (S^F)

Phycocelis foecunda: a minute epiphyte, sporadically recorded (Long Nose Spit, Ramsgate Harbour) and probably overlooked. (S)

Pilinia rimosa (=Waerniella lucifuga): grows only in caves at White Ness and Kingsgate. (S)

Pleurocladia lacustris: a minute filamentous species known only from chalk cliffs and Margate harbour wall; now presumed locally extinct. (LS)

Pseudolithoderma extensum: a poorly recorded crustose species. (S^F)

Punctaria latifolia: recorded only in 1970 epiphytic on *Chaetomorpha linum* and on concrete inner wall of a foreshore swimming pool at Ramsgate. (S^F)

Pylaiella littoralis: a widespread and common filamentous species. (LS)

Ralfsia verrucosa: a widespread and common crustose species. (LS)

Saccorhiza polyschides: an imprecisely located kelp record, drift; the species is absent in southeast England. (S)

Sargassum bacciferum: an imprecisely located record, drift; a tropical species. (S)

Sargassum muticum: a recent invasive species first recorded in 1987 and now common on the north coast of Thanet; has become a characterising species of a deep pool biotope. (S)

Scytosiphon lomentarius: a long known, widespread and common species. (LS)

Sphacelaria cirrosa: Small filamentous tufts found in 2004 in Walpole Rock tidal swimming pool epiphytic on larger algae; confirms an imprecisely located, older drift record, on *Chorda*. (S)

Sphacelaria nana: a small filamentous species that forms turfy patches; sporadically recorded in Thanet. (S)

Sphacelaria plumigera: known only as drift, but probably grows subtidally. (S)

Sphacelaria plumosa: older records, probably misidentified. (S)

Sphacelaria radicans: a small filamentous species that forms turfy patches; not uncommonly recorded. (S)

Spongonema tomentosum; a filamentous species usually epiphytic on *Fucus*; long known but only sporadically recorded. (LS)

Sporochnus pedunculatus: old probaly drift records; absent in southeastern England. (LS)

Stictyosiphon soriferus: known only from pontoons in Ramsgate inner harbour. (S^F)

Stragularia clavata: a widespread and common crustose species. (S)

Stypocaulon scoparium: first recorded in 1597, found once at Margate in 1960s, but abundantly on chalk and concrete walls in Walpole Rock tidal swimming pool in 2004. (LS)

Taonia atomaria: an ephemeral species recorded only in 1968 and 1972 at Botany Bay. (S)

Ulonema rhizophorum: a minute epiphyte on *Dumontia*, probably overlooked. (S^F)

Undaria pinnatifida: an invasive species recently found on floating pontoons in Ramsgate harbour. (S)

Rhodophyceae (red algae)

Acrochaetium daviesii: a minute filamentous epiphyte on *Palmaria*, poorly recorded, probably overlooked. (S)

Acrochaetium secundatum: a minute filamentous epiphyte on larger algae, poorly recorded, probably overlooked. (S)

Acrochaetium sparsum: a minute epiphyte, recorded only from Westgate in the 1930s, probably overlooked. (L)

Ahnfeltia plicata: a wiry plant long known and common but grows only on flint (not chalk). (LS)

Antithamnion cruciatum: a drift record only. (S)

Apoglossum ruscifolium: long known but only as drift. (S)

Bangia fuscopurpurea: a small filiform species, long known and widely recorded. (S)

Bostrychia scorpioides: a filamentous species imprecisely located early records; grows mainly in saltmarsh and currently not known in Thanet. (S)

Brongniartella byssoides: An old imprecisely located record. (S)

Calliblepharis ciliata: a mainly subtidal species, common as drift, long known and widespread. (LS)

Calliblepharis jubata: several early, presumed doubtful or drift records; discovered in 2004 growing abundantly on concrete wall of the tidal Walpole Rock swimming pool. (LS)

Callophyllis laciniata: several early, presumed doubtful or drift records. (Ls)

Catenella caespitosa: small creeping distended thalli, long known but sporadically recorded.

Ceramium cilatum: known only from an uncertain early record. (L)

Ceramium deslongchampsii: records confused with those of *C. diaphanum*; long known and widespread. (LS)

Ceramium echionotum: early records, correctly determined; the species has not been found since the nineteenth century. (LS)

Ceramium fastigiatum: old records only; not found since the 19th century. (LS)

Ceramium gaditanum: long known, common and widespread in Thanet. (LS)

Ceramium rubrum (= C. nodulosum): long known, abundant and widespread; with *Polysiphonia fucoides* forms a characteristic biotope/community at lower shore levels. (LS)

Ceramium shuttleworthianum: known only from two nineteenth century records. (S)

Chondria dasyphylla: long known from Margate but only rarely recently recorded. (LS)

Chondria tenuissima: very early records from Margate; possibly confused with *C. tenuissima*. (L)

Chondrus crispus: long known, widespread and common. (LS)

Coccotylus truncatus: two early possibly drift records. (S)

Corallina officinalis: widespread and common, records go back to 1597; characterises the shallow rock-pool biotope. (LS)

Cryptopleura ramosa: long-known and widespread; grows mainly at low shore and subtidal levels. (LS)

Cystoclonium purpureum: long known, widespread and common in Thanet. (S)

Delesseria sanguinea: although long known, recently rarely recorded only as drift. (LS)

Dilsea carnosa: known only from early, possibly drift records. (LS)

***Dumontia contorta*: long known, widespread and common; seasonal (winter-spring). (S)**

Erythropeltis discigera: an endophyte in the Bryozoa *Flustra foliacea,* rarely recorded; a taxonomically confused entity. (S)

Erythrotrichia carnea: a small filamentous epiphyte, not uncommon. (S)

Erythrotrichia ciliaris: two old records from Ramsgate, otherwise only recorded in 1971 on *Chaetomorpha linum* and base and sides of a tidal swimming pool at Ramsgate. (S)

Furcellaria lumbricalis: long known, widespread and common. (LS)

Gastroclonium ovatum: two old, imprecisely located records. (S)

Gelidium crinale/pusillum: long known, widespread and common; a taxonomically confused species group. (LS)

Gelidium spinosum (=G. latifolium): long known but sporadically recorded in Thanet; probably confused with the previous species. (LS)

Gracilaria gracilis: confused with *Gracilariopsis longissima* under the name "*Gracilaria verrucosa"*; recently found in Walpole Rock tidal swimming pool; probably widespread. (S)

Griffithsia corallinoides: grows only on floating pontoons in Ramsgate inner harbour. (S)

Gymnogongrus crenulatus: known only from old or drift records. (S)

Halopithys incurvus: known only from an old imprecisely located record; a southwestern species, probably drift. (S)

Halurus equisetifolius: known only from old or drift records. (LS)

Halurus flosculosus: long known, widespread and common. (LS)

Haraldiophyllum bonnemaisonii: known only from a drift record. (S)

Harveyella mirabilis: a minute parasite on *Rhodomela confervoides*, known only from a single drift record in Thanet. (S)

Heterosiphonia plumosa: long known but only once recorded in the twentieth century (Dumpton Gap 1967) as drift; a population discovered in 2004 growing on the inner wall of the Walpole Rock tidal swimming pool. (LS)

Hildenbrandia rubra: widespread and common, but grows on flint only. (LS)

Hypoglossum hypoglossoides: long known; occurs sporadically at low shore levels. (LS)

Jania rubens: a single imprecisely located early record; probably drift. (S)

Lomentaria articulata: long known but occurs only sporadically. (LS)

Lomentaria clavellosa: a single imprecisely located early record; probably drift. (S)

Lomentaria orcadensis: early records from Ramsgate not recorded since the nineteenth century; possibly drift. (LS)

Mastocarpus stellatus: long known, widespread but not common; grows only on

flint. (S)

Membranoptera alata: long known, widespread but not common; grows on rocks and in pools at low shore and subtidal levels. (LS)

Naccaria wiggii: known only from a single old record from Ramsgate. (S)

Nitophyllum punctatum: known only from a single drift specimen collected in 1966; probably grows at subtidal levels. (S)

Nitophyllum versicolor: a single imprecisely located early record; probably drift. (S)

Osmundea hybrida: grows widely and commonly. (S)

Osmundea pinnatifida: long known, widespread and common; characterises a turf biotope on wave washed shores. (LS)

Palmaria palmata: long known (since 1632), widespread and common; characterises a low shore biotope. (LS)

Phyllophora crispa: long known but only recorded as drift in the twentieth century. (LS)

Phyllophora pseudoceranoides: long known, widespread and not uncommon; grows only on flint. (LS)

Phymatolithon lenormandii: a crustose coralline alga; although poorly recorded, occurs widely and commonly. (LS)

Plocamium cartilagineum: long known, widespread and common in Thanet, grows at low shore and subtidal levels. (LS)

Plumaria plumosa: long known but only sporadically recorded; a characteristic species of shade biotopes. (S)

Polyides rotundus: long known, widespread and not uncommon. (LS)

Polyneura bonnemaisonii: long known but sporadically recorded; grows at lower shore and subtidal levels. (S)

Polysiphonia elongata: long known but sporadically recorded, found on several occasions in tidal swimming pools at Margate. (LS)

Polysiphonia elongella: rarely recorded in the Margate area. (S)

Polysiphonia fibrillosa: a single record from North Foreland. (L)

Polysiphonia foetidissima: a single record from cliffs at Westgate (L)

Polysiphonia fucoides: long known, widespread and common; characterises a species assemblage/biotope at low shore levels (see note to *Ceramium rubrum*). (LS)

Polysiphonia lanosa: drift records. (LS)

Polysiphonia nigra: long known, widespread but sporadic. (LS)

Polysiphonia stricta: occurs widely and commonly. (LS)

Porphyra leucosticta: Thanet material probably misidentified. (S)

Porphyra linearis: sporadically recorded on sea walls and chalk cliffs at high tide level. (S)

Porphyra purpurea: long known, widespread and common. (LS)

Porphyra umbilicalis: widespread and common. (LS)

Ptilothamnion pluma: a single imprecisely located early record; usually an epiphyte on *Laminaria hyperborea* stipes. (S)

Pterothamnion plumula: long known from Ramsgate; recently found only in the inner harbour on floating pontoons. (S)

Rhodochorton purpureum: a single imprecisely located early specimen, particularly in caves. (LS)

Rhodomela confervoides: long known and widely and commonly recorded. (LS)

Rhodophyllis divaricata: imprecisely located early records; probably drift. (S)

Rhodothamniella floridula: long known and widespread and common; forms cushions that characterise a biotope at lower shore levels. (LS)

Rhodymenia holmesii: widely not uncommonly recorded, often as drift; grows at low shore and subtidal levels. (S)

Rhodymenia pseudopalmata: known only from early or drift records. (S)

Scinaia furcellata: a single nineteenth century record from Ramsgate. (S)

Spermothamnion repens: long known but not recently recorded. (S)

Spyridia filamentosa: found for the first time in south and east England growing abundantly in the tidal Walpole Rock swimming pool. (S)

A small number of the species listed here are characterising species of the intertidal and shallow subtidal biotopes of Thanet. Others have been recorded consistently during the past two or more centuries and are faithful components of biotopes. Yet others are ephemeral components of the Thanet flora periodically appearing and disappearing sometimes with long, often irregular, time intervals between recorded occurrences. *Scinaia furcellata* is an example of an alga that remains for long and/or irregular periods as a microthallus. A macrothallus forms only when conditions are appropriate. The present data reflect the log-normal distribution curve for the abundance of successively ranked species where there is a small number of common species and a large number of rare species (Preston 1948; Wilkinson & Tittley 1979). Tittley (1999) showed that only a few species characterise the intertidal vegetation of the chalk shores of North Norfolk by contributing the major amount of biomass, as on Thanet. Qualitative data for Norfolk showed that species composition of the algal flora changed seemingly randomly from year to year. This situation seems to occur in Thanet too.

A recent feature in Thanet is the spread of non-native species. *Sargassum muticum*, first recorded in 1987, now occurs abundantly along the north coast although recent research (Vahid 2004) suggests that its local impact is minimal. *Undaria pinnatifida* currently remains restricted to Ramsgate harbour. Their dispersal has been facilitated by both anthropogenic and natural means. Man-made habitats around Thanet are currently the only known sites for a small but significant component of the local flora; some of those in Ramsgate harbour may have arrived via human vectors while dispersal from other habitats was presumably by natural means.

Several species that are common around Great Britain such as *Pelvetia canaliculata* and *Ascophyllum nodosum* do not grow in Thanet; reasons for their absence remain unclear. *A. nodosum* commonly occurs as drift and it is important to distinguish species records based on drift and attached so as not to inflate local species diversity and incorrectly define species distributions. The rich species lists and collections of the nineteenth century may reflect this lack of distinction and some of the early species records listed above are, as indicated, based on drift material. Species such as *Himanthalia elongata* and *Desmarestia aculeata* occur regularly and sometimes in quantity on Thanet shores as drift but are absent from southeast England.

Algal communities and biotopes

The intertidal plant and animal communities/biotopes were described and mapped by Tittley and others. (1998) although quantitative (Tittley & Price, unpub. MSS) and descriptive (Tittley & Price 1978) ecological studies that described the principal algal communities were undertaken between 1967 and 1969. Tittley and others. (1999) noted that the very early (1632) records of marine algae from Margate are those that today form the principal vegetational features on intertidal chalk reef and inferred long-term stability in the key features of the vegetation of Thanet. At Botany Bay, however, field observations in 1986 (Tittley and others 1986) and after revealed differences in intertidal community structure compared with the 1960s.

In May 1991 the Kent Marine Group (forerunner of *Shoresearch*) undertook a quantitative transect study at Botany Bay that re-visited the quadrats studied in 1968. The results of this study revealed for inshore parts of the wave-cut chalk platform the replacement of algae by animals. The common mussel *Mytilus edulis* formed an extensive cover where previously *Ulva* (including *Enteromorpha*) spp. and *Fucus serrratus* were the dominant and characterising features of inshore communities (Plate 1). Overall algal species diversity had decreased considerably, notably in deep pools and channels; *Halidrys siliqosa* present in large amounts in a deep mid shore pool in the 1960s was only present in 1991. On the outer parts of the foreshore *Mytilus edulis* was the dominant species on both occasions; the absence of *Ulva lactuca* in large amounts in 1991 may have been a seasonal feature. Still further seawards a species assemblage comprising the crustose coralline alga *Phymatolithon lenormandii* and the turf-forming *Osmundea pinnatifida* replaced an assemblage that in 1968 was characterised by *Palmaria palmata* and *U. lactuca*. At low shore levels differences were fewer and the filamentous red algae *Ceramium rubrum* and *Polysiphonia fucoides* were predominant in 1968 and 1991. The sublittoral fringe level vegetation in 1991 was characterised by *Laminaria digitata* and *P. palmata*, as in 1968. Table 1 is a quadrat recording made at 304 feet (approximately 100m) seawards of the cliffs that shows the differences in the characterising species in 1968 and 1991.

Table 1: Quadrat recordings made on the chalk reef at 304 feet seawards of the cliff.

Species	**April 1968**	**May 1991**
Mytilus edulis	+	**30%**
Lanice conchilega	*	+
Littorina littorea	0	+
Littorina saxatilis	0	+
Semibalanus balanoides	0	+
Patella vulgata	0	+
Nucella lapillus	0	+
Osmundea pinnatifida	**0**	**30%**
Phymatolithon lenormandii	+	**30%**
Dumontia contorta	0	+
Corallina officinalis	+	+
Osmundea hybrida	0	+
Arthropyrenia halodites	0	+
Fucus serratus	**65**	**0**
Cladophora rupestris	5	0
Gelidium pusillum	+	0
Ulva lactuca	+	0
Fucus vesiculosus	+	0
Palmaria palmata	+	0

Bold = dominant species; + = present in small amounts; * = possibly overlooked

Figures 1 and 2 are maps of the principal communities and biotopes respectively in 1968 (Tittley & Price, MS) and 1997 (from Tittley and others 1998); these figures also show the loss of the inshore *Fucus serratus* canopy and its replacement by a turf biotope of *Osmundea pinnatifida* and *Gelidium pusillum*, and by *Mytilus edulis* that had increased in extent. Low shore biotopes characterised by *Laminaria digitata* and *Palmaria palmata* in 1996 were as much as in 1968. The maps suggest there were changes to the inshore biotopes between 1968 and 1996.

Figure 3 is a DECORANA (De-trended correspondence analysis part of the VESPAN package, Malloch 1999) ordination of quadrat data collected in 1968 and 1991. The separation of paired quadrats in the plot (Figure 3 key) indicates change; had the quadrats remained similar in content they would have been positioned closer together. Most 1991 quadrats cluster together, suggesting their greater similarity; the 1968 quadrats are, in contrast, more widely spaced. Exceptions in 1991 are the lower shore quadrats 23 and 25. In quadrat 25, *Laminaria digitata* was more abundant in 1991 (50% cover) than in 1968 (5% cover) perhaps due to changes in chalk reef topography and an inshore spread of *L. digitata*.

More recently, Tittley and others. (2002) undertook in 2001 a monitoring survey of intertidal biotopes in the Thanet Coast cSAC and compared quantitative quadrat data with those gathered in 1997 (Tittley and others 1998). It revealed no decrease in extent and distribution of key biotopes and characterising species in the study areas in the short (4 year) time interval between surveys. Humpheryes (2004), however, demonstrated that change in periwinkle (*Littorina* spp.) dominance on the chalk reef at Foreness Point quickly changed an animal grazed area to an algal dominated community.

Conclusions

The historical record of algal occurrence on Thanet is exceptional and indicates a continuity of occurrence of species that characterise the principal intertidal and subtidal biotopes on many shores. Other species faithful to these biotopes but not present in large amounts also have a long history of records. Yet other species are ephemeral in occurrence appearing and disappearing at varying time intervals indicating natural change; reasons for this are unclear. Early recorders did not distinguish between drift and attached material and some Thanet records must therefore be discounted as part of the local flora. Although the principal communities/biotopes appear to be stable this is not true for the entire coast of Thanet, as at Botany Bay, there has been major change in community structure. Reasons for this are also unclear. Non-native invasive species are small in number although locally abundant and they do not appear to be deleterious to the local biota. Man-made structures create alternative habitats for algae and as a consequence species are present in Thanet that may otherwise have been absent. Overall algal diversity has been enhanced.

There is a continuing need for species recording to define accurately the marine algal flora of Thanet, its nature in relation to adjacent areas, and the impact of environmental change, man-made or natural, on the content and diversity of the flora. For similar reasons and especially those of sea-level rise, climate change, and water quality, there is also a continuing need to regularly monitor the nature, content and extent of species assemblages/biotopes.

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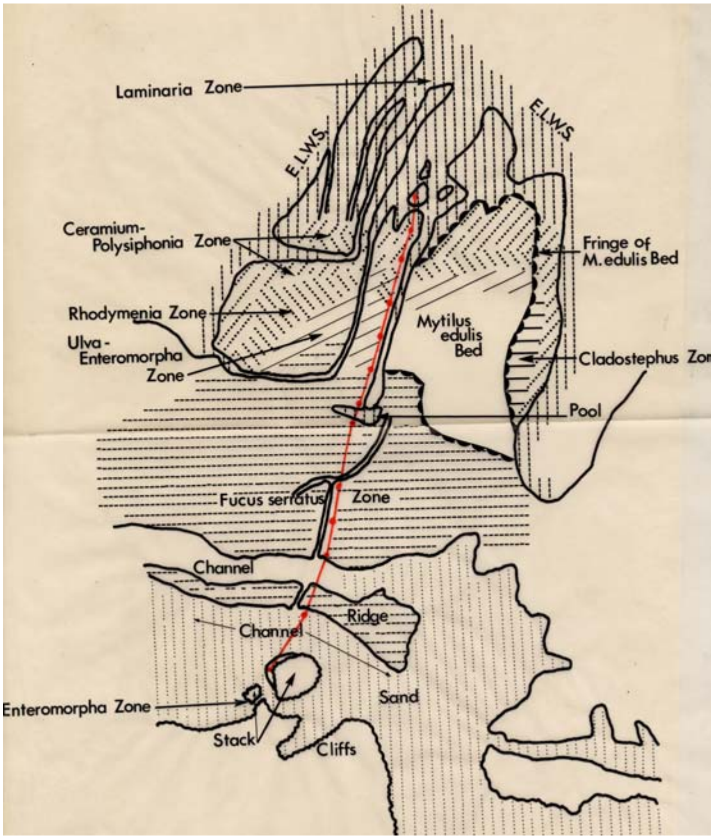

Figure 1. Botany Bay communities recorded in 1968 (red line indicates transect line).

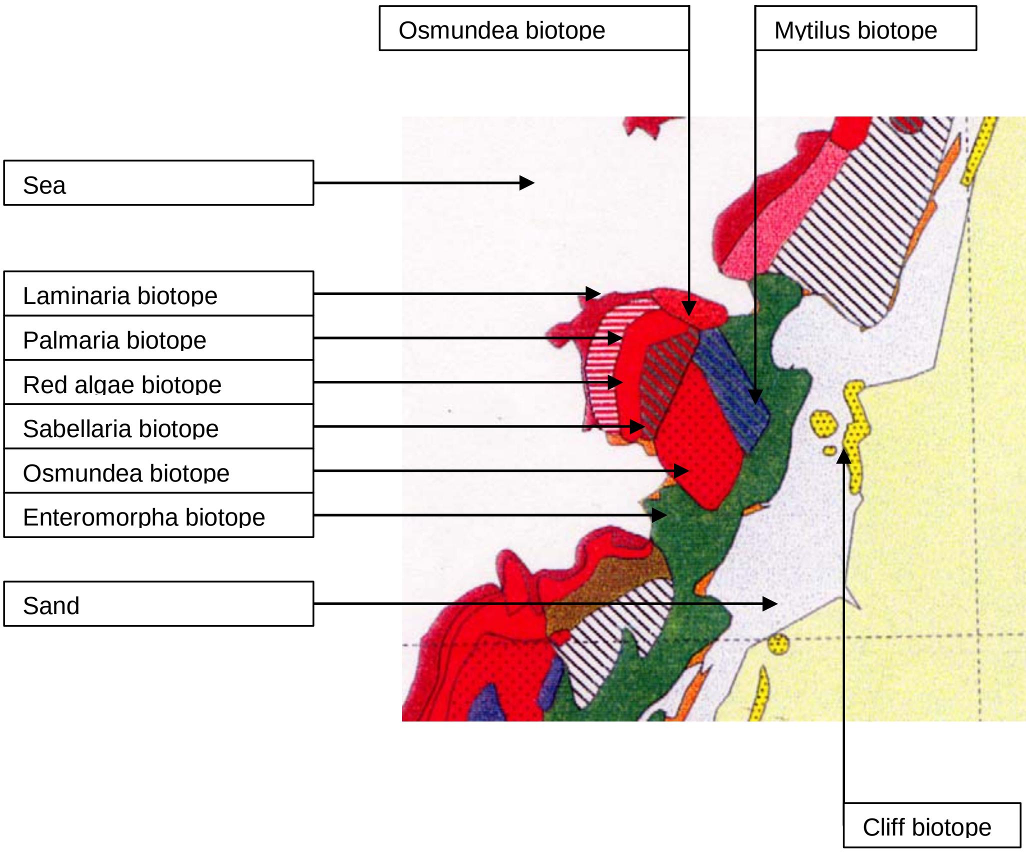

Figure 2. Botany Bay biotopes recorded in 1997 (Tittley and others 1998)

Key to numbers in plot.

April 1968	May 1991	Quadrat no.	Distance offshore (Feet)
Plot no.	Plot no.		
1	2	13	113
3	4	14	124
5	6	26	141
7	8	15	163
9	10	16	194
11	12	17	245
13	14	18	304
15	16	19	361
17	18	20	526
19	20	21	604
21	22	22	656
23	24	23	685.5
25	26	24	721.5
27	28	25	771.5

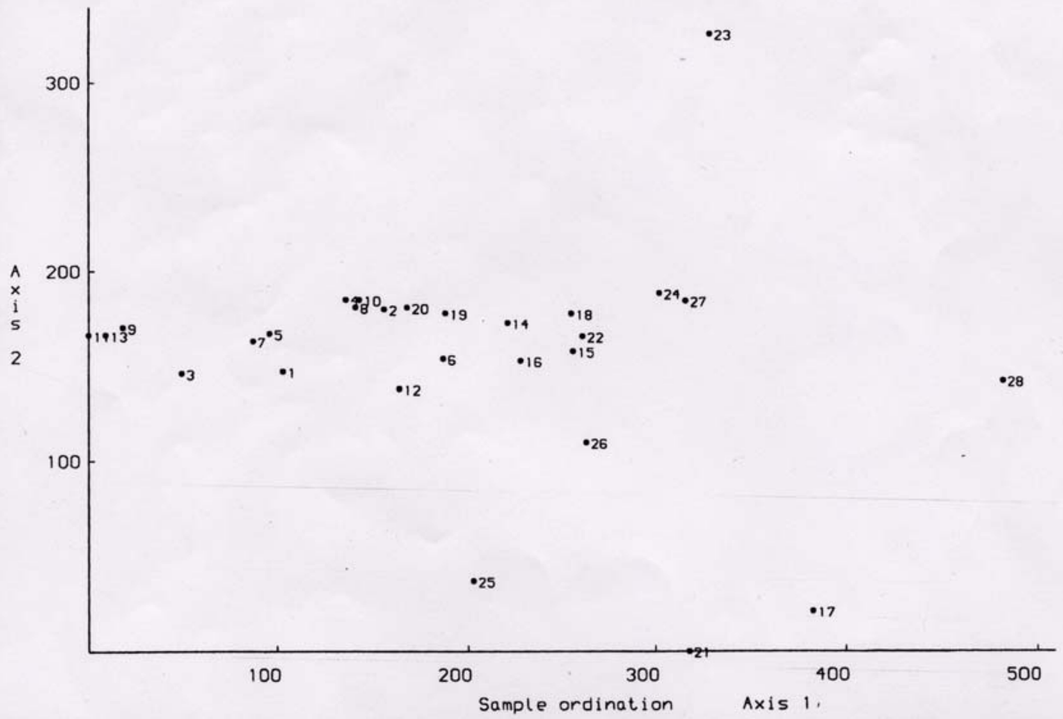

Figure 3. Ordination of Botany Bay quadrats 1968 and 1991

Plate 1. Botany Bay, inshore *Fucus* canopy in 1968

Appendix 1 Summary of workshops and whole group sessions

Verbatim report of discussion sessions

Question on arrival

What do we need to know about North East Kent's coastal and marine habitats and ecosystems to inform future integrated management?

Ray Lee

- We need to know what literature and other reports have been made.
- Present and future coastal construction projects.
- The 'positive' and 'negative' impact on Kentish Flats on bird, fish, seal, movements, habitat etc.

J Stroud

- Baseline study on existing ecosystems.
- The effects of the chalk reef being covered by sand.
- Study of fishing methods at present existing on site.

Chris Riddell

- Effect on the marine environment of pollutants entering the sea via the River Stour and its tributaries.
- Contribution to the East Kent economy of the leisure and business interests using the Great Stour Estuary and navigation.
- Keystone species – which are they?
- How are turnstones protected if dog walkers decide not to take into account their presence?
- Likely effects of silting Pegwell Bay and changes of sea level and global warming.
- All groups need to be singing from the same hymn sheet.
- Limits to ecosystem function.
- Understanding of variety and distribution of biotopes in wide area around NE Kent.
- Re: ecosystem approach.
  How are the priorities of national /international scientific / wildlife importance taken into account / weighted in and management system de-centralised to its lowest appropriate level?
- Ecosystem function
- Little terns in SPA – It only takes one group in the summer to land on Shellness Point when little terns are nesting with jet-skis, speedboats, outboard, for a BBQ, and with their dogs, and the species fails in nesting.

Questions and answers: before lunch

Do we talk to people where there are perceived problems?

- TC Coastal codes not always working – few people upset balance.
- Meeting proposed at Pegwell re kite surfing (and other activities) eg water skiing on Stour, dog walking.
- Thanet Water Users Group: barrier/membership scheme is effective.
- Jet Skiing: less controls in Dover DC area re. launching.
- New club at Beresford Gap, Thanet: self-regulation proposed – will this control disturbance to seals?
- Western Undercliff proposed – possible Pegwell conflicts?
- Approaching users – care with how they are tackled.
- Fishermen: Y.Ota's study found them approachable once detail of project explained, but. some shy. Importance of explaining nature-culture links.
- Bait Digging contact: PR found no hostility – respect for their knowledge is important.
- RL has found few difficult situations with bait diggers– not all co-operative.
- Feeling that interests threatened may make people cautious/hostile.
- Lack of info may make people cautious/hostile.
- ‘Amateurs’ perceive ‘professionals’ don't have single approach to kite surfing problem at Pegwell. English Nature are aware this is a significant problem:

  - need more facts and figures;
  - meeting with all interested parties to try to solve problem;
  - legal issues – require hard evidence;
  - Kite surfing "new" sport – mentioned in Management Scheme;
  - Principle agreed in Management Scheme: share problem and try to solve by consensus approach;
  - if this fails, legal action possible;
  - Kite surfers not involved in previous workshops so need a chance for discussion prior to further action.

Cockle harvesting banned in Holland – will this have a knock on effect and increased pressure at Thanet?

- Fishing in Thames governed by stocks.
- Private grounds are not so well managed.
- Maybe can learn from Dutch experience – about management issues and monitoring, legislation.
- Do we know if cockle stocks are declining?
- Cockles in Pegwell bay are not important to fishermen.
- Surveys by SFC in Essex – stocks there have remained stable over last 10 years 1994 onwards. Also some data goes back further than that.

- Morecambe Bay: Sea Fisheries Committee closed some of cockle areas – due to sustainability issues.
- Locally a change in season now.
- New machines – assumed cockily fisheries would decline but this is not what happened.
- Machines not damaging areas in the way people think.
- Sustainability model – take longer term view of fisheries. Historic changes in gear mean can fish new areas – so looks as if stocks are stable but need to look at bigger picture.
- Sustainable decisions need to take on cultural and historical heritage issues as well.

Questions and answers: after lunch

How important is seasonality?

- Very important: winter and summer give different info.
- Work on Carbon 14 on Stour Estuary and Saltmarsh – late June/July important for flowering plants.

Did Foreness work show periwinkle shell size increased independently of nutrients?

- No, but if animal stressed, amount of soft body to shell can vary greatly
- Implications of this for feeding birds

Issues covered today (and at NEKCAG meetings) from local to international level

- Most of us are practitioners – message that we need to **record change**: we can get out there and do it

Can we really operate on an ecosystem level?

How much of what we are monitoring is random?

- eg Mytilus at Whiteness: spat fall 2-3 years ago could be random/freak event. Shore very dynamic.
- IT: Norfolk work: core of continuity around which much "noise".
- 40 years data shows Whiteness and Fulsam have same spp composition now as they did then.
- Other areas have changed – randomness likely to be part of picture.
- Algae go ‘cryptic’ – static – until conditions right, then can suddenly change.
- Benthic data: much variability.
- Data collected in past can be used to inform now but need to co-ordinate future research with needs of sustainable decision- making.

NEKCAG ‘tension’ – pure science *vs* policy needs: how to bring together?

Are we missing info at local scale?

- Need to stand back and look at data to see change, but do need that local data.
- List of animal/plant communities only just starting to be monitored (eg seals) – important to look wider than just requirements of legislation / protected species.
- Ecosystem approach driver – lots of species-specific projects – fragmented approach – not enough resources and not a holistic view at present.
- Needs to be careful not to make wrong decisions eg for nature conservation, while trying to satisfy fundholders.
- Can we have a “Composite research team?” - importance of networking in science.
- How to do this practically – scientists to go out and do research together?

100 years from now what would the picture be?

- Stour Estuary: last 30-40 years changed from being “a dump”!
- Data on which to base today's management decisions is relatively recent – we are muddling along.
- Muddy boots to inform policy.
- Ensure we don't miss areas.
- Positive change here over last 10 years: info sharing and collaboration have increased.
- Pubic institutions: implications of Freedom of Information Act (Jan 2005) – info sharing.
- Duplication avoided by sharing info.
- English Nature Ecosystem Approach Report stresses scientific coherence: better aligned science, helping society to be more harmonious with natural environment.

Ecosystem approach workshop session: 3-4pm

The ecosystem approach has been raised at recent NE Kent Coastal Advisory Group meetings over the past year. The group has agreed that it seems sensible to consider our coastal and marine environment in a more holistic way and not purely in terms of conserving certain features of high nature conservation value. **However, we have not discussed what this means for us in practical terms as managers, researchers and users of the coastal and marine environment.**

Today we want to start that discussion process.

Below are some questions to help you consider what the ecosystem approach means for coastal and marine areas of NE Kent:

The review of the **NE Kent European marine sites Management Scheme** will start in April 2005 and a new scheme needs to be in place by April 2006. We want to consider to what extent we can bring the new scheme in line with the 12 principles of the ecosystem approach.

- What does the Ecosystem Approach mean for us?
- What does it mean for science?
- What does it mean for management?
- What does it mean for other plans, strategies and policies?
- What does it mean for the next draft of the Management Scheme?

Group 1. Ecosystem approach discussion session
(facilitator: Susannah Peckham, English Nature)

What does the ecosystem approach mean for us?

- It's a starting point for gathering of data and answering future questions
- Science can't always answer questions easily – it has limitations
- Approach will take time and needs to evolve gradually
- Will need to be validated
- Current Management Scheme already adheres to some EA principles – what are gaps?
- Detailed scientific data is needed but consider in broader context
- Local Authority view: need something to "hang" work on to justify funding
- Need to show it's part of the bigger picture
- This approach is credible in wider world of science so valid approach
- We can "pick and choose" what elements we use
- Allows human and business factors to be accounted for eg seal trips, other tourism efforts.
- Can monitor activities, put policy in place in holistic way
- Useful to many interests

What does it mean for management?

- "Hub" with all scientific disciplines linked to it
- Concern over definition of geographical area – in isolation from surroundings?
- Connectivity: influence of River Stour – how would this be considered?
- MW: scientific view: this is a scientific concept which has been "hijacked"
- We perceive boundaries of operation and management
- Social dimension needed to interpret science and implement
- It means integration of many disciplines, not just science
- Broadens environmental management into social and political dimensions
- The term may not have direct meaning for many people

- Feels like just another layer within a scheme that's already working
- Will it inform decision-making legislation?
- Danger of "intellectual bureaucracy" with this approach
- Setting boundaries – need to take calculated risk that you won't have the whole picture
- Gives opportunity for more holistic approach – framework
- But some sectors of society not involved
- If it means we can refer back to framework – network, multi-layer – can make more informed decisions.
- NEKEMS Management Scheme: we are already doing well on some of the principles of the ecosystem approach (eg principle 12 and some others)
- Importance of education and awareness raising: Thanet Coast Project doing this
- Principle 8: set objectives for long-term: need to do better but funding issues can dictate
- Difficult to define – need to pick indicator species etc
- Need to engage with users and managers so time meetings to be accessible to eg fishermen
- Marine knowledge limited – developed scientific methodologies on land and applying to sea. Foreshore is "meeting point" – we may get it wrong
- Lack of marine recording and issue
- Info from commercial fishermen, bait diggers etc – engage with them!

Key Points to feed back to whole group:

Holistic Framework

- Provides framework for holistic approach
- Less focus on "science" and more on humanities: "holistic"
- Overview must be holisitc
- Holistic
- Holistic approach will win a wider acceptance

Accountability

- There is a need for overall monitoring and accountability
- Key indicator species – 1st step
- System must provide a "measuring stick" for stakeholders

Engage others

- Make strenuous efforts to include others – eg fishermen, those who are often not included/ unable to attend
- Need to address ways of pulling others in – tailoring event times etc.
- Better engagement with core users (hold evenings in meetings)
- Engage others in meetings not just conservationists
- Holistic approach will win a wider acceptance

Long term • Emphasizes long(er) term objectives • Only achievable with long term funding
Limits / boundaries • Ecosystem boundaries. • It needs accepted limits to be workable
Focus on what we're not doing well • As so many points are already covered in management scheme, eco approach is obviously working. Can we concentrate on points not covered? • Ecosystems approach – probably following this approach in many ways already – formalise this plus find where it is not being followed • Current EMS Management plan already adheres to EA. Good start!

Group 2. Ecosystem approach discussion session **(facilitator: Tony Child, Thanet Coast Project)**
1. What does the ecosystem approach mean for us?
• Already aware of it – not a lot of difference to the way we will do things • More data collection - Essential scientific info as basis of decision-making • Needs more for comparison with elsewhere - Standard methodology and description of habitats • Collation of datasets - aware of all factors affecting the site/wildlife etc Connectivity is important – esp migrant birds Defining boundaries? • Do we know what is of interest to study / know? • Factors affecting populations eg jet-skis and birds - who/what takes priority? • Communicate with bodies outside our area of interest eg neighbours such as France Short term: needs to be long term plans -eg sea defences and erosion • Adding series of additional projects • Major factors affecting system need to be defined: recreational boat use – human activities • Climate changes occurring and global warming • Can be as detailed as we want? Can have all factors! Almost infinite. - could be broad-brushed to include factors eg nutrient input (sewage/organic inputs) • Need to consider broader consequences - but may need to consider other impacts eg energy flows seaweed removal on beaches impact on bird populations more research / assessments required Note: energy changes (sewage to land based disposal)

2. What does it mean for science?
• ID projects and get local sponsorship (Pfizer) and supervision • Standardising / streamlining wider data libraries and collection methods – monitoring data - student projects (SBBOT) • Would be better for informing scientists - overseeing: collating/standardising • Thames and other areas – multiple layers of systems • Ecosystem systems – recruitment of organisms • Better communicate policy to people - getting argument across
3. What does it mean for management?
• Management can adapt to change better - look at long term rather than short and take into account the science, community and integrate all aspects • Making resources available eg £/€ • Management more open here than elsewhere - decisions made around the community here • Simplifying it – to allow people to understand; - reporting to stakeholders • Monitoring? – NEKCAG • Management Group communication with other areas eg KCC networking newsletter shows many organisations that didn't know exist Links – shingle movements – EA/ English Nature/Local Authority -dredging – fluid injection is unlicensed!
4. What does it mean for other plans, strategies and policies?
• Make sure don't conflict • Loopholes • Communication awareness is important
5. What does it mean for the next draft of the Management Scheme?
• Big impact – more wording • More questions will have objectives/conditions to be addressed • Prioritising is important
Key points to feed back to whole group:
• Availability of data • Making funding resources available

Standard data collection • Standardising scientific methods • Educating locals and potential plans • Need to standardise data collection to make it comparable on a large scale • Need to make meta-data available to all (as a list of projects, studies) & abstract & contact details • Will influence research project by adding supplementary data • Invited new research project • Science guided / student guided data collection
Scope • Need to identify boundaries of ecosystem • Decide on what the scope of the ecosystem actually covers for NEKCSAG
Prioritise/Management • Prioritise nature conservation importance • This may mean using strict zonations • Long term approach by management • Need to consider indirect as well as direct effects on ecosystem • Level of detail to be established for initial phase at least • Need to consider broader consequences
Communication and information • Greater communication between groups and organisations – integration • Communication between different bodies • Standardisation of data formats • Share information with other areas and learn from each other – (helps avoid duplication and reduces waste of costs)

Group 3 ecosystem approach discussion session (facilitator: Diana Pound)
What does the ecosystem approach mean for us?
• Need to consider NEK in wider context, eg regional seas • Who are ecosystem managers? - BAP? - do manager need educating? • Is new legislation needed for the ecosystem approach? • It is a very ambitious thought • What is motivation/reasons/needs for ecosystem - everyone's ecosystem is different! • Are we trying to put straight jacket on things – fix at one point in time? • What is the objective for an ecosystem – is it an ideal or just reactionary? • What happens to concept of "flagship species" – protect this, protect everything?

• Species-specific management has been done for certain flagship species. These are usually high PR species. Tends to result in a focus on species – this skews management. • What about biotope conservation? This focuses on species or habitat, misses out socio-economic aspects. • Word "ecosystem" as a word seems biased towards nature conservation. • Sea change temp will result in loss of kelp forest – just 4°C. But can't stop this, hard to manage especially given uncertainty eg could have Gulf Stream switch off – so we end up like Newfoundland • How are we going to find an appropriate scale? • Fishermen don't think "ecosystem" includes them • Ecosystem approach may be mistaken as a political position – pro or anti-environment • Does change matter? – it's our attitude to environmental change that is an issue – our attitude is to "grab what you can"! • People's attitude is not ‘man against nature’ but “If I don't take this resource someone else will”, eg Kyoto and USA
What does the ecosystem approach mean for science?
• We need to be more holistic: share, exchange, collaborate; put the jigsaw together • £ affects research – so an Interreg bid to take an ecosystem approach locally? • Science tends to focus into detail • Will the ecosystem approach ring bells for Brussels and funding? • Trophic networks – need a work flow/mind map of connections • Cross-discipline approach will result in data problems • We need a knowledge map which would drive research • We need to know information gaps • Need to see links and where they are missing
What does it mean for the next draft of the management scheme?
• Encourage integration of activities • This group is biology dominated - what about social science, industrial science? • Knowledge map – action for a library, data/meta data resource • Standardise research ethics where possible eg use of data • It needs to look at all species and habitats in North East Kent area • Scheme needs to use language which makes it accessible • Take a wider view of area – and direction of change and trends • Take into account climate change • Self critical – look at what didn't work and move on

Key points to feed back to whole group:
Holistic approach/knowledge map • Integration of research activities and knowledge • Holistic approach to future research – knowledge map • Encourage integration of activities management • We need a knowledge map • Clarify "ecosystem" objectives • Knowledge map and practical applications • Knowledge map Sectoral Trophic networks
• Information gap – relates to points above
• Research ethics
• Recognise that ecosystem approach can be a political concept
• Social attitude to environment and nature – education?
• The dynamic environment:- change is maybe natural; - need to understand it
• Money
• NE Kent EMS Management Scheme • Look at all species and habitats in North East Kent Area • Consider NE Kent in wider context • Management scheme to take broader view of habitats and species • Who is the target of management scheme? Who will scheme persuade?
• Sandwich Bay as focus for data collection

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