Report Number
570

Proceedings of the North East Kent Coastal Research Workshop

22 October 2002

English Nature Research Reports

working today
for nature tomorrow

English Nature Research Reports

Number 570

Proceedings of the North East Kent Coastal Research Workshop, 22 October 2002, Sandwich Bay Bird Observatory

Ian Tittley
Natural History Museum, Cromwell Road, South Kensington,
London SW7 5BD

and

Susannah Peckham, English Nature Kent Team

ISSN 0967-876X

Contents

Introduction

The North East Kent coast encompasses the area between Whitstable and Deal, stretching all the way around the Thanet Coast. The area is important for a range of coastal habitats including a 26km stretch of chalk cliffs and reefs, plus shingle, sand dunes, mudflats, saltmarsh and soft cliffs. It is also important for some of its wintering bird species. The area has a number of national and international nature conservation and geological designations including a Special Protection Area (SPA) for turnstone and golden plover; two candidate Special Areas of Conservation (cSACs) for chalk reefs and caves and sand dunes; a Ramsar Site for its bird and invertebrate interest; and two Sites of Special Scientific Interest (SSSI) for various geological and nature conservation features. Collectively, those parts of all the designated sites which are covered some or all of the time by seawater are known as the North East Kent European marine sites.

The North East Kent Coastal Research Workshop held in October 2002 at Sandwich Bay Bird Observatory provided the first opportunity for scientists engaged in a wide range of coastal environmental research in the area to come together to share information.

The need for an event of this kind was identified when the North East Kent European marine sites Management Scheme was produced in 2001. The Management Scheme was written using a technique known as 'stakeholder dialogue' where local people affected by a decision or course of events are involved in making the decisions themselves. Scientists were among the stakeholders and they decided that this event would help with sharing knowledge and planning future research. Some of the more detailed questions addressed by participants in workshop sessions at this event also came out of the Management Scheme process.

The day consisted of a series of presentations on a range of coastal research topics, followed by whole group discussion sessions and small group workshops. Feedback was very positive and many people made new contacts or reinforced existing links. There were a number of suggestions for further action and events.

Since then, a new North East Kent Coastal Advisory Group has been formed, with sub-groups looking at producing a code of conduct for coastal researchers, setting up a research database and setting up a shellfish harvesting sustainability study. The group plans to hold a second major event in 2004.

This report provides a brief summary of each workshop/discussion session together with the research papers presented. A full verbatim write-up of each workshop session is also available on request from English Nature's Kent Team.

Attendance list

Name	Organisation
John Badmin	Canterbury Christchurch University College
Fred Booth	Kent Field Club
Doug Brown	Thanet District Council
Alasdair Bruce	Geologist
Phil Buckley	Canterbury Christchurch University College
Tony Child	Thanet Coast Project
Nick Delaney	Dover District Council
Alastair Dussart	Canterbury Christchurch University College
Georges Dussart	Canterbury Christchurch University College
Diana Franks	Kent RIGS Group
Jon Ford	Environmental Consultant
Pete Forrest	Kent Wildlife Trust
Norman Foulkes	Thanet District Council
Mike Frost	Southern Water
Sam Gardner	University College London
Peter Golding	Kent RIGS Group
Martin Griffiths	Appletree Environmental
Ian Harding	Environmental Consultant
Phillipa Harrison	Environment Agency
Tim Hodge	Kent Ornithological society
Mike Humber	Thanet District Council
Ian Humpheryes	Environment Agency
Bernie Lambert	Thanet District Council
Raymond Lee	Marine Wildlife Assessments
Dave Lowthion	Environment Agency
Joe McCarthy	Thanet District Council
Sarah Maloney	Canterbury City Council
Geoff Meaden	Canterbury Christchurch University College
Jan Pritchard	Swale Wader Group
Severine Rees-Jones	Environment Agency
Philip Rogers	Canterbury Christchurch University College
Robin Shrubsole	Kent RIGS Group
John Stroud	Sea Fisheries Committee
Nick Tardivel	Lloyd Bore
Ian Tittley	Natural History Museum
Laurence Tricker	Kent County Council
Jackie Trigwell	Canterbury Christchurch University College
Jo Wadey	Thanet District Council
Brian Watmough	Canterbury City Council
Kevin Webb	Turnstone Researcher
Margaret Wright	Medway Swale Estuary Partnership
Mike Walkey	Durrell Institute of Conservation & Ecology, UKC

Summary of workshops and whole group sessions

Whole Group Session: Setting up a Coastal Research Database

The group addressed the following questions:

1. What research have we already got for Thanet and of relevance from elsewhere?

Research for the area was brainstormed and listed under a number of headings: human impacts, ecology, physical environment, fishing/harvesting, water quality and general sources of information. In most cases sources of the research were known and also listed.

2. What are the research topics/questions we would most like addressed?

This links to the first question. Writing the initial list helped with identification of 'gaps' in research, or further questions arising out of existing research. A 'wish list' of future research was produced under a number of headings: wider/underlying questions; water quality; geology; birds; human use; ecology; and coastal processes/management.

3. How do we improve science knowledge for this coast?

The group considered this question by firstly looking at barriers to improving science knowledge and then considering how to overcome these. Main barriers identified included poor communication, inaccessible information and lack of central co-ordination of research efforts. Suggested solutions included running regular seminars/events, setting up a central database for all North East Kent coastal research and making links to existing sources of data and research.

Workshop 1: Developing a Code of Practice for Coastal Researchers

This group looked at writing a specific code of practice for researchers on the North East Kent Coast. A number of organisations and research institutions already have their own codes but there are issues specific to this area which could be incorporated into a new code.

The group considered:

- Areas of research identified as relevant to this area of coast.
- Generic principles applicable to all research.
- Specific hazards relating to this area.
- Damage which could be caused to the special interest features of the North East Kent coast by researchers on site.

Since the workshop, a small sub-group has been formed and is producing the new code.

Workshop 2: The Habitats Directive & Water Framework Directive & biological monitoring: understanding the marine biotopes of North East Kent

This discussion considered the following questions:

- Why are some areas plant dominated and others animal dominated?
- Does succession occur?
- What can we use as indicators of man-influenced change?
- Are changes desirable or not?
- Invasive/non-native species issues.
- What to monitor & how; can we have a single set of information for Habitats Directive and Water Framework Directive monitoring?

More questions were raised that answered in this session & the issues need further consideration. There was no clear view as to whether monitoring under the two directives can be combined but it may be possible with some elements.

Workshop 3: A project to investigate the sustainability of shellfish harvesting on the North East Kent Coast

Relatively little is known about this, particularly in relation to harvesting of species like periwinkles and mussels undertaken by hand on the chalk reefs. It is therefore not known whether what happens takes place at sustainable levels or not.

The group considered:

- What existing research is there?
- What are our information needs?
- How would such a project be funded and set up?

Since the workshop, a small group has been formed to work up a proposal based on these initial discussions.

Whole group session: What would you like to happen next & how can you help achieve it?

At the end of the day, participants were asked to list the things they would like to see as next steps. The main suggestions were:

To receive feedback from the event – a verbatim summary of all the workshop sessions was sent to all participants.

- To set up a North East Kent coastal science group to co-ordinate action and move things forward – North East Kent Coastal Advisory Group is now in place.

- More workshops/events – a second major event is planned for 2004.
- Set up central research database – Database Working Group set up to take this forward.
- Progress code of conduct – underway.
- Progress shellfish harvesting sustainability study – underway.

The Thanet coast: A site with an exceptional history of marine study

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

Introduction

The Isle of Thanet is one of only a few places in Britain where there exists a long recorded history and continuity of marine research. The wealth of unpublished manuscript information, published literature, survey reports, specimen records, particularly for the marine vegetation, allows the creation of a historical profile for the past centuries. This paper will briefly consider this historical profile. While previous information was collected for personal interest or academic research, today it is required more for statutory purposes for decision-making and management of the coastal zone environment. The need for collating these data as a permanent record for future use is suggested.

Early period (1597-1799): the first records

Although man's contact with the sea around Thanet in Kent goes back a long time, the earliest reliable written records of marine plants are at most four centuries old. Earlier interest in marine plants concerned their social, medical and economic uses. For example, a local industry at Margate collected and burned kelp and wrack to produce 'potash'. Farmers gathered drift algae for use as manure, and fishmongers used algae to pack shellfish for transport and decorate shellfish stalls at markets (*Ulva lactuca* was known as 'Oister Greene').

In the late sixteenth century the first records of marine plants and animals were systematically collected and included marine algae from Kent and the Isle of Thanet. These species records are among the earliest published for the British Isles and probably for the world. Interest in the flora and fauna of the Kent coast reflected its cultural, economic, and geographical importance. The algae *Corallina officinalis* (red algae, Rhodophyta), *Fucus vesiculosus* (brown algae, Phaeophyta; see Figure 1A) and *Ulva lactuca* (green algae, Chlorophyta) were cited in a sixteenth century 'herbal' (Gerard, 1597). The author, John Gerard, stated "…These mosses grow in the sea upon the rocks, and are oftentimes upon Oyster shells, Muskell shells, and upon stones. I found verie great plentie therof under Reculvers and Margate, in the Isle of Thanet; and at other places in the sands from thence unto Dover…". 'Herbals' were systematic accounts of plants (and animals then mistaken for plants) believed to be of medicinal value that, as indicated above, also provided rudimentary ecological information. In a later 'herbal', Johnson & Gerard (1633) recorded key elements of the marine flora at Margate. Their book itemised *Fucus serratus*, *F. vesiculosus* (see Figure 1C), *Halidrys siliquosa*, *Laminaria digitata*, *Laminaria saccharina* (see Figure 2D), *C. officinalis*, *Palmaria palmata* and *U. lactuca*. These early literature records are confirmed by early specimen collections, the most important being the Sloane Herbarium at the Natural History Museum (BM; Figures 1A,B) and the Dillenian and Sherardian Herbaria at Oxford University (OXF). A recent survey of intertidal foreshores on Thanet (Tittley *et al.*, 1998) showed that these species today form the principal features of the intertidal vegetation at Margate and elsewhere. The confirmation of these early algal records suggests medium-term stability in the marine flora of Thanet. Similarly, persistence of key animal species is attested to by *Fucus spongiosus nodosus,* the soft coral *Alcyonium digitatum*, also in these early publications and specimen collections. *A. digitatum* is a species that characterises subtidal biotopes and is commonly washed ashore as drift.

Although Margate was cited by botanists of the seventeenth and eighteenth centuries (eg Hudson, 1798; Withering, 1776) in their lists of marine algae, many of their records were imprecise as earlier sources of information were repeated incorrectly. Early information should therefore be treated with caution and past records carefully checked; they should also be checked against modern nomenclatural and taxonomic concepts, and if voucher specimens are available they can be accurately authenticated.

Middle period (1800- 1930): flourishing of natural history

The growing of interest in natural history in the nineteenth century resulted many additional species records of marine algae in the published literature. This is shown in Table 1 that lists the algae recorded from Thanet in fifty-year intervals from 1550. The development and availability of the compound microscope in the nineteenth century facilitated more accurate appraisal of specimens collected especially smaller forms.

The main sources for algal records appeared were:

- Technical works (eg Buffham, 1888).
- Systematic accounts (eg Withering, 1830; Smith, Sowerby & Johnson, 1846).
- Compendia (eg Camden & Gough, 1806; Hasted 1799; Batters, 1902; Holmes, 1908).
- Floras (eg Holmes, 1881).
- Guides (eg Hunter, 1809; Allom 1841).
- Specimen collections (eg *Seaweeds of the Isle of Thanet*, Gisby collection -Ramsgate Museum; Walter collection – Rochester museum).
- Field notes (eg J.T. Neeve manuscripts – Folkestone museum).

An example of a local person with a keen interest in the coast and its natural history was R.E. Hunter, a surgeon resident at Margate, who published guides to the Isle of Thanet and contributed towards the study of the local flora. Hunter produced one of the most detailed local lists of algae in Kent (Hunter, 1809), citing 51 species from locations around Thanet. A keen amateur naturalist was Elizabeth Allom who lived at Ramsgate and recorded 36 species (Allom, 1841) of algae and illustrated these with pressed specimens.

By the mid nineteenth century specimen collecting and exchanging was at its peak facilitated by improved communication and networking (railways enabled easy and fast access to collecting locations and the postal system allowed speedy transmission and exchange of specimens and correspondence). Leading phycologists of the time built up extensive specimen collections, including material from Thanet supplied by local collectors. Many of the specimens collected are now at the Natural History Museum (BM). These specimens are important as, assuming they are accompanied by adequate information, they are verifiable records of a species' existence in space and time (see Huxley & Bryant, 1998).

Collecting and recording in Thanet in the early twentieth century in contrast to the late nineteenth century had declined considerably with only sporadic specimens gathered and few publications on the marine algae.

Later period (1930 – 1980); scientific studies

In the 1930s P.L. Anand (a PhD student at the University of London) undertook a detailed taxonomic and ecological study of the algal flora of the British chalk cliffs. This was the first thorough ecological study in Thanet as previously field-work had been largely concerned with species recording. Anand's study was undertaken on the cliffs at Westgate with comparison investigations at Ramsgate, and Beachy Head in Sussex. The field visits from which his published data were derived were made at fortnightly or monthly intervals from 1933 to 1935. His ecological studies (Anand, 1937a, b) involved:

- Descriptions of the algal communities.
- Factors affecting zonation, including water relations.
- Physical environmental effects such as salt concentration and temperature.
- Factors causing modifications on cliff faces.
- Special features of caves and tunnels.

Anand's ecological research resulted in the recognition of algal communities unique to chalk, while the taxonomic component (Anand, 1937c) resulted in the description of two new genera, 7 new species, and records of 48 species of red, brown and green algae, and 7 species of so-called 'Chrysophyceae'. Westgate and Ramsgate are thus the type locations for some of these algal taxa. Sadly, Anand's voucher collections of chalk cliff algae have been lost. However, it is known from brief published statements and a specimen in BM of *Apistonema carterae* collected from Margate in July 1845, that these unusual algal communities of chalk cliffs have probably been persistent feature on the Thanet coast.

In the late 1960s J.H. Price and I. Tittley of the Natural History Museum (BM) commenced a period of intensive marine studies on the marine algae of Thanet and Kent generally. This resulted in historical (Price & Tittley, 1972), floristic, distributional (Tittley & Price, 1977; Tittley *et al.,* 1985), and ecological (Tittley & Price, 1978) accounts, as well as an extensive specimen collection. 170 algal species (including drift and doubtful records) were mapped in Thanet. Contemporaneously R.L. Fletcher of the University of Portsmouth commenced detailed taxonomic studies on the small, crustose, species of brown algae (Fletcher, 1987).

In the late 1970s further study of the algal communities on chalk cliffs was undertaken (Tittley & Shaw, 1980); the occurrence of algae on natural chalk and man-made surfaces were compared with the results of Anand (1937a). The chalk cliff communities described by Anand, such as those characterised by *Chrysotila lamellosa*, *Apistonema carterae* were not found on non-chalk substrata, and other species listed by Anand were presumed locally extinct due to habitat loss.

Excessive growths of the green alga *Ulva lactuca* (a species that occurs naturally in Thanet) suggested that the inshore waters around the area were periodically high in nutrient levels (Fletcher, 1974).

Final period 1980 to date: statutory studies

The 1980s represent a transition period in which marine biological data were increasingly acquired for coastal management purposes, and habitat and species conservation. Statutory requirements arising from the EU *Urban Wastewater*, *Habitats* and *Water Framework Directives* require the regular collection of marine algal and also faunal information.

The ecological significance of the chalk cliff and foreshore species and communities at Botany Bay and White Ness led the former Nature Conservancy Council (NCC) to designate that area as a Site of Special Scientific Interest (the first marine SSSI in Britain). The extent and state of the chalk cliff habitat and algal communities of Thanet was undertaken for NCC (Tittley, 1985; Fowler & Tittley, 1993). Although the presence of most of the species recorded by Anand (1937c) was confirmed, the loss of extensive length of chalk cliff and cave microhabitats has, as mentioned above, caused the local extinction of some species. An Environmental Impact Assessment on the possible effects of an extension to Port Ramsgate and road link on the marine fauna and flora of the cliffs and foreshore was undertaken in the Pegwell Bay area (Anon. 1986) and identified the key species and communities.

The fauna, flora and communities of the subtidal environment around Thanet had long been overlooked. In the late 1980s the Marine Conservation Society undertook for NCC a first diving survey of sublittoral chalk habitats at Botany Bay (Wood, 1992) and recorded a depauperate fauna (17 species) and flora (1 species).

A comprehensive ecological study and assessment of marine biodiversity of chalk shores was undertaken at sites from Thanet to Brighton (Tittley *et al.*, 1986 for NCC); based on these data George & Fincham (1989) analysed the invertebrate communities in greater detail. In total, 69 species of algae and 105 species of invertebrates and Ascidea were listed for Thanet.

The *Habitats Directive* promotes the conservation of habitats and species in the EU and in 1995 the Thanet Coast was selected as a candidate Special Area of Conservation (cSAC) because of the conservation importance of its sea-caves and reef habitats. As a consequence, in 1997 a detailed survey of chalk cliff, cave, intertidal and subtidal reef biotopes in the Thanet cSAC was undertaken (Tittley *et al.*, 1998) for English Nature on behalf of all the Relevant Authorities, in order to assist the development of a management scheme for the site (Tittley *et al.*, 1998; Anon., 2001). The extent of intertidal reef and cave biotopes were mapped and sites were identified for monitoring. Mapping revealed for example, that the invasive brown alga *Sargassum muticum* first recorded at Margate in 1988, occupied less than 5% of the total intertidal area and therefore did not represent a threat to the site. Dense smothering growths of *Enteromorpha* spp. and *Ulva lactuca* reminiscent of a 'green tide' were recorded over red algal characterised biotopes. The *'Habitats Directive*' requires monitoring studies to confirm a 'favourably maintained status' of the Thanet Coast SAC, and thus in 2001 the condition of the sea-cave and reef biotopes were re-assessed (Tittley *et al.*, 2002). The study revealed little change in the principal biotopes in extent and species content since 1997; 54 species of algae were confirmed present at that time.

Natural history

Cultural and educational activities continue to make contributions to marine biological study. Regular field meetings in Thanet held by the Kent Field Club have created a pool of species records for the area while students of Dane Court Grammar School have undertaken intertidal biotope mapping surveys on the foreshore reef between Walpole Bay and Foreness Point (Anon., 1998). The planned *Seasearch* project for Kent will also yield additional intertidal and subtidal marine biological data.

Conclusion: Data, a resource for the future?

Marine biological data are acquired and required by many parties with an interest in the Thanet coast (national agencies; local and county authorities; industry; wildlife NGOs; educational establishments; research organisations). Of principal interest are monitoring study data that may identify stasis or change in local biodiversity and ecology. At present such data are dispersed and not easily accessible. As a general principle, and to avoid unnecessarily repeated research, is it not desirable that Thanet data where at all possible (some are private) be made freely and easily available to all users? It is predicted here that increasing amounts of marine biological information will be gathered from Thanet. Is it possible for interested parties to agree a means for the collation and maintenance of this potentially large amount of marine biodiversity data as a resource for future use?

Acknowledgement

I would like to thank Jim Price formerly of the Natural History Museum for his contributions to the field study of the marine algae of Thanet and the collation of past specimen and literature data.

References

ALLOM, E., 1841. *The seaweed collector.* Margate.

ANAND, P.L., 1937a. An ecological study of British chalk-cliffs part I. *Journal of Ecology,* **25**, pp.153-188.

ANAND, P.L., 1937b. An ecological study of British chalk-cliffs part II. *Journal of Ecology,* **25**, pp. 344-367

ANAND P.L., 1937c. A taxonomic study of the algae of the British chalk-cliffs. *Journal of Botany, London,* **75** (Supplement II), pp. 1-51.

ANON, 1986. Port Ramsgate Terminal Extension and road/rail link. *Effects on the flora and fauna of the Pegwell Bay area.* A report for Port Ramsgate Limited. London: Environmental Resources Limited.

ANON, 1998. *Coastal mapping of Walpole Bay to Foreness Point.* Broadstairs: Dane Court Grammar School.

ANON, 2001. The *North East Kent European marine sites. Management scheme.* Formal Conservation Draft. Peterborough: English Nature.

BATTERS, E.A.L., 1902. A catalogue of the British marine algae. *Journal of Botany, London,* **40** (Suppl.), [2]+ pp. 1-107.

BUFFHAM, T.H., 1893. Algological notes. *Grevillea*, **21**, pp. 86-93

FLETCHER, R.L., 1974. *Ulva* problem in Kent. *Marine Pollution Bulletin,* **5**, pp. 21.

FLETCHER, R.L., 1987. *Seaweeds of the British Isles Volume 3 Fucophyceae (Phaeophyceae) Part 1.* London: British Museum (Natural History).

FOWLER S.L. & TITTLEY, I., 1933. The marine nature conservation importance of British coastal chalk cliff habitats. Peterborough: *English Nature Research Reports,* No. 32.

GERARD J., 1597. *The Herball or generall Historie of Plantes…* London :J. Norton.

GEORGE, J.D. & FINCHAM, A.A., 1989. Macro-invertebrate communities of chalk shores in southeastern England. *Scientia Marina,* **53**, pp. 373-385.

CAMDEN, W. & GOUGH, R. 1806. *Britannia.* Ed. 2. 4 vols. London.

HASTED, E., 1799. *The history and topographical survey of the county of Kent.* Canterbury.

HOLMES, E.M., 1881. Kentish cryptogams. *Journal of Botany, London,* **19**, pp 374.

HOLMES E.M., 1908. Marine algae. *In*: Page W. (ed.) *The Victoria history of the counties of England Kent.* Vol.1. London.

HUDSON, W. 1798. *Flora anglica.* Ed. 2. London.

HUNTER, R.E., 1809. *The Thanet Flora being a catalogue of plants found wild in Thanet island Systematically arranged (with places of growth, as observed the author).* Ramsgate.

HUXLEY, R. & BRYANT, J.A., 1998. The value of museum collections and other information sources for assessing changes in marine flora. *In*: Scott G.W. & Tittley I. (eds) *Changes in the marine flora of the North Sea.* Scarborough: Centre for Environmental Research into Coastal Issues.

JOHNSON T. & GERARD J., 1633. *The Herball or generall Historie of plantes.* London: A.J.T.Norton & R.Whitakers.

PRICE, J.H. & TITTLEY, I., 1972. The marine flora of the county of Kent, Southeast England, and its distribution, 1597-1970. *Proceedings of the International Seaweed Symposium,* 7, pp. 31-34.

SMITH, J.E., SOWERBY, J. & JOHNSON, C., 1846. *English Botany.* Ed.2. London.

TITTLEY, I., 1985. *Chalk-cliff algal communities of Kent and Sussex, Southeast England.* A report to the Nature Conservancy Councul. British Museum (Natural History), London.

TITTLEY, I., FLETCHER, R.L. & PRICE, J.H., 1985. Additions to an atlas of the seaweeds of Kent. *Transactions of the Kent Field Club,* **10**, pp. 3-11.

TITTLEY, I. GILLILAND, P. & POUND, D., 1998. Marine flora of the Thanet Coast marine SAC: a conservation and management perspective. *In:* Scott G.W. & Tittley I. (eds) *Changes in the marine flora of the North Sea*. Scarborough: Centre for Environmental Research into Coastal Issues.

TITTLEY, I. & PRICE, J.H., 1977. An atlas of the seaweeds of Kent. *Transactions of the Kent Field Club,* **7**, pp. 1-80.

TITTLEY, I. & PRICE, J.H., 1978. The benthic marine algae of the eastern English Channel: a preliminary floristic and ecological account. *Botanica Marina,* **21**, pp. 499-512.

TITTLEY, I., PRICE, J.H., FINCHAM, A.A. & GEORGE, J.D., 1998. *The macrobenthos of chalk and greensand shores in southeastern England.* A report to the Nature Conservancy Council. London: British Museum Natural History.

TITTLEY, I., SPURRIER, C.J.H., CHIMONIDES, P.J., GEORGE, J.D., MOORE, J.A., EVANS, N.J. & MUIR, A.I., 1998. Survey of chalk cave, cliff, intertidal and subtidal reef biotopes in the Thanet coast cSAC. Peterbkorough: *English Nature Research Reports*, No. 325.

TITTLEY, I., SPURRIER, C.J.H. & CHIMONIDES, P.J., 2002. *Thanet intertidal survey: Assessment of favourable condition of reef and sea-cave features in the Thanet coast cSAC.* A report to English Nature. London: The Natural History Museum.

WITHERING W., 1776. *A botanical arrangement of all the vegetables naturally growing in Great Britain. vol 2*. Birmingham.

WITHERING, W., 1830. *An arrangement of British plants.* Ed7, vol. 4. London.

WOOD C., 1992. *Sublittoral chalk habitats in southern England*. Report of the Marine Conservation Society, South East group Chalk Cliffs Project 1985-1991. Ross-on-Wye: Marine Conservation Society.

Table 1. Algae recorded from Thanet 1550 – 2000

Records from: **Chlorophyta species:**	**1550**	**1600**	**1650**	**1700**	**1750**	**1800**	**1850**	**1900**	**1950**
Acrosiphonia arcta								■	■
Blidingia minima								■	■
Bryopsis hypnoides						■			
Chaetomorpha ligustica									■
Chaetomorpha linum									■
Chaetomorpha melagonium							■		■
Cladophora albida 3/4							□		
Cladophora fracta 4							□	□	
Cladophora hutchinsiae 4							■		
Cladophora laetevirens 4							■		
Cladophora lehmanniana 3						■			
Cladophora pellucida 4							■		
Cladophora rupestris						■	■		■
Cladophora sericea							■		■
Codiolum polyrhiza									■
Ectochaete wittrockii 4							■		
Enteromorpha clathrata						■	■		
Enteromorpha compressa						■	■	■	■
Enteromorpha intestinalis						■		■	■
Enteromorpha linza							■		■
Enteromorpha muscoides 4							■		
Enteromorpha prolifera								■	■
Enteromorpha torta									■
Epicladia perforans								■	■
Epicladia viridis								■	
Eugomontia sacculata									■
Gomontia polyrhiza								■	
Prasiola stipitata									■
Pringsheimiella scutata								■	■
Pseudendoclonium submarinum									■
Pseudulvella applanata								■	■
Rhizoclonium tortuosum							■	■	■
Ulothrix implexa 3								■	
Ulothrix pseudoflacca 3								■	
Ulothrix subflaccida 3								■	
Ulva lactuca		■				■	■	■	■
Ulvaria obscura								■	
Urospora penicilliformis									■
Urospora speciosa								■	
Urospora wormskioldii								■	
Total 39 (out of 95 for the British Isles)	0	1	0	0	0	7	13	18	22
Drift/doubtful spp.							2	1	
Cumulative totals (incl. drift spp.)	0	1	1	1	1	7	18	31	40

Records from:		1550	1600	1650	1700	1750	1800	1850	1900	1950
Rhodophyta species:										
Acrochaetium daviesii										■
Acrochaetium secundatum								■		■
Acrochaetium sparsum	4								■	
Ahnfeltia plicata							■	■	■	■
Antithamnion cruciatum										□
Antithamnion plumula									■	■
Apoglossum ruscifolium	1							■		■
Bangia fuscopurpurea							■			■
Bostrychia scorpioides	3							□		
Calliblepharis ciliata							■	■		■
Calliblepharis jubata	3						□	□		
Callophyllis laciniata	3/4						□	□		
Catenella caespitosa								■	■	■
Ceramium ciliatum	4						□			
Ceramium diaphanum								■		■
Ceramium deslongchampii								■	■	■
Ceramium echionotum								■		
Ceramium fastigiatum							■	■		
Ceramium gaditanum								■	■	■
Ceramium rubrum							■	■	■	■
Ceramium shuttleworthianum	4						■	■		
Chondria dasyphylla							■	■		
Chondria tenuissima	4					■	=			
Chondrus crispus							■	■		■
Coccotylus truncatus	1/4							□		
Corallina officinalis		■	■	=				■		■
Cryptopleura ramosa							■	■		■
Cystoclonium purpureum								■		■
Delesseria sanguinea	1						■	■		□
Dilsea carnosa	4						■	■		
Dumontia contorta								■		■
Erythropeltis discigera										■
Erythrotrichia carnea										■
Erythrotrichia ciliaris								■		
Furcellaria lumbricalis							■	■		■
Gastroclonium ovatum	3							□		
Gelidium crinale/pusillum								■	■	■
Gelidium latifolium	3							□		
Gracilaria 'verrucosa'								■		■
Griffithsia corallinoides										■
Gymnogongrus crenulatus							■	■		■
Halopitys incurvus	1							□		
Halurus equisetifolius							■	■		■
Halurus flosculosus							■	■		■
Haraldiophyllum bonnemaisonii	1									□
Heterosiphonia plumosa	1						■	■		■
Hildenbrandia rubra									■	■
Hypoglossum hypoglossoides							■	■		■
Jania rubens	4							□		
Lomentaria articulata							■	■		■
Lomentaria clavellosa	3/4							□		
Lomentaria orcadensis	3/4							□		
Mastocarpus stellatus							■	■		■
Osmundia hybrida								■		■
Osmundia pinnatifida							■	■		■
Membranoptera alata							■	■		■

Records from: **Rhodophyta species:**	**1550**	**1600**	**1650**	**1700**	**1750**	**1800**	**1850**	**1900**	**1950**
Naccaria wiggii 4							□		
Nitophyllum punctatum 1									□
Nitophyllum versicolor 1/4							□		
Palmaria palmata		■		■		■	■		■
Phyllophora crispa					■	■			■
Phyllophora pseudoceranoides						■	■		■
Phymatolithon lenormandii									■
Plocamium cartilagineum						■	■		■
Plumaria elegans							■		■
Polyides rotundus							■		■
Polyneura bonnemaisoniae						□	■		□
Polysiphonia elongata 4							■		■
Polysiphonia elongella 3/4							□		
Polysiphonia fibrillosa 3								□	
Polysiphonia foetidissima								■	
Polysiphonia fucoides							■	■	■
Polysiphonia lanosa 1						□	□		
Polysiphonia nigra							■		■
Polysiphonia spiralis								■	
Polysiphonia stricta							■	■	■
Porphyra leucosticta									■
Porphyra linearis						■			■
Porphyra purpurea						■	■		■
Porphyra umbilicalis									■
Ptilothamnion pluma 4							□		
Rhodomela confervoides						■	■		■
Rhodophyllis divaricata 1/4							■		
Rhodymenia nicaeensis							■		■
Rhodymenia pseudopalmata						■	■		■
Rhodochorton purpureum						■	■	■	■
Rhodothamniella floridula							■		■
Scinaia forcellata 4							■		
Spermothamnion repens 4						■	■		
Total 89 (out of 341 for the British Isles)	1	2	0	1	2	31	54	14	54
Drift/doubtful spp.						5	15	1	5
Cumulative totals (incl. drift spp)	1	2	2	2	4	39	74	80	89

Records from:		1550	1600	1650	1700	1750	1800	1850	1900	1950
Phaeophyta species:										
Acinetospora crinita										■
Arthrocladia villosa	1							□		
Ascophyllum nodosum	1						□	□		
Asperococcus fistulosus	4						■			
Chorda filum	4						■	■		
Chordaria flagelliformis	1						□			
Cladostephus spongiosus							■	■		■
Compsonema saxicolum										■
Cutleria multifida								□		■
Cystoseira baccata	1							□		□
Cystoseira foeniculacea	1						□	□		
Desmarestia aculeata	1							□		□
Desmarestia ligulata	1							□		
Desmarestia viridis								■		■
Dictyota dichotoma							■	■	■	■
Ectocarpus fasciculatus								■		■
Ectocarpus siliculosus								■		■
Elachista flaccida	1									□
Elachista fucicola										■
Feldmannia globifera										■
Feldmannia irregularis									■	
Fucus ceranoides	2						□	□		
Fucus serratus			■	=	=	=	■	■	■	■
Fucus spiralis							■		■	■
Fucus vesiculosus		■	■	■			■	■	■	■
Halidrys siliquosa			■			■		■	■	■
Hecatonema terminale										■
Himanthalia elongata	1						□	□		□
Hincksia granulosa								■		■
Hincksia ovata										■
Hincksia secunda										■
Hincksia sandriana										■
Isthmoplea sphaerophora								■	■	■
Kuetzingiella holmesii	5								■	
Laminaria digitata			■	=	=		■	■		■
Laminaria saccharina			■	=	=		■	■		■
Leathesia difformis										■
Microspongium gelatinosum										■
Mikrosyphar polysiphoniae									■	
Mikrosyphar porphyrae										■
Myriactula clandestina										■
Myrionema corunnae										■
Myrionema strangulans										■
Padina pavonica	2						■	■	=	
Pelvetia canaliculata	3						□		□	
Petalonia fascia								■		■
Petalonia filiformis										■
Petroderma maculiforme										■
Phycocoelis foecunda										■
Pleurocladia lacustris									■	■
Pseudolithoderma extensum										■
Punctaria latifolia										■
Pylaiella littoralis								■	■	■
Ralfsia verrucosa									■	■

Records from: Phaeophyta species:		1550	1600	1650	1700	1750	1800	1850	1900	1950
Saccorhiza polyschides	1							□		
Sargassum bacciferum	1							□		
Sargasum muticum	6	o	o	o	o	o	o	o	o	■
Scytosiphon lomentarius								■		■
Sphacelaria cirrosa	4							■		
Sphacelaria nana										■
Sphacelaria plumigera	4							■		□
Sphacelaria plumosa	4							■		
Sphacelaria radicans										■
Spongonema tomentosum								■	■	■
Sporochnus pedunculatus										■
Stictyosiphon soriferus										■
Stragularia clavata										■
Stypocaulon scoparium		■	=	■	=	=	■	■	=	■
Taonia atomaria										■
Ulonema rhizophorum										■
Waerniella lucifuga										■
Total 71 (out of 200 for B.I.)		2	5	2	0	1	17	33	15	54
Drift species							11	11	1	5
Cumulative totals (incl. Drift species)		2	5	6	6	6	17	37	42	71

Records from: Other algae:	1550	1600	1650	1700	1750	1800	1850	1900	1950
Apistonema carterae							■	■	■
Chrysonema littorale								■	■
Chrysotila lamellosa								■	■
Chrysotila stipitata								■	
Prasinocladus marinus								■	
Ruttnera litoralis								■	
Ruttnera maritima								■	
Thallochrysis littoralis								■	

1 = Drift

2 = Misidentified

3 = Uncertain

4 = Not found recently

5 = Recent locally extinction

6 = Recent local invader

= = Repeated record

* = Specimens require re-determination

■ = Valid record

□ = Drift/doubtful record

Plate 1A *Calliblepharis ciliata,* Sloane Herbarium (BM), early 18th century

Plate 1B *Halurus flosculosus,* Sloane Herbarium (BM), early 18th century

Plate 1C *Fucus vesiculosus,* Johnson & Gerard (1633)

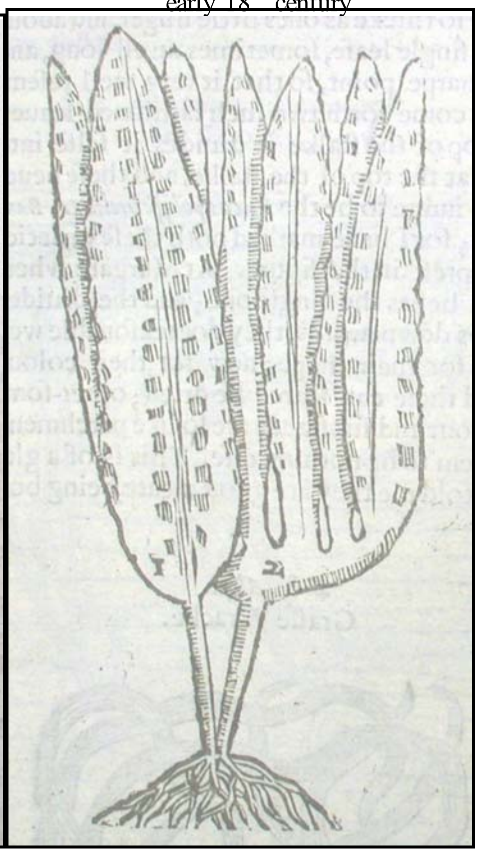

Plate 1D *Laminaria saccharina,* Johnson & Gerard (1633)

Changes in the near-shore biotope at Foreness Point Margate in relation to harvesting of the common periwinkle Littorina littorea

Ian Humpheryes
Environment Agency, Addington, West Malling ME19 5SH

Introduction

The chalk reefs that surround the Thanet coastline have two distinct patterns of biotope in the upper and mid-shore zones; these are either algal dominated or grazing dominated reefs. High densities of edible periwinkles *Littorina littorea*, scattered limpets and mussel beds characterize the grazing dominated areas. These areas are often adjacent to algal dominated reefs (these are usually blanketed in *Fucus serratus* with fewer grazers present). An ecological study conducted by Carol Torry in 1994 (BSc project for Christ Church University College Canterbury) investigated the impact of periwinkle grazing upon the chalk reef. The survey area was at Foreness Point at Margate (Figure 1).

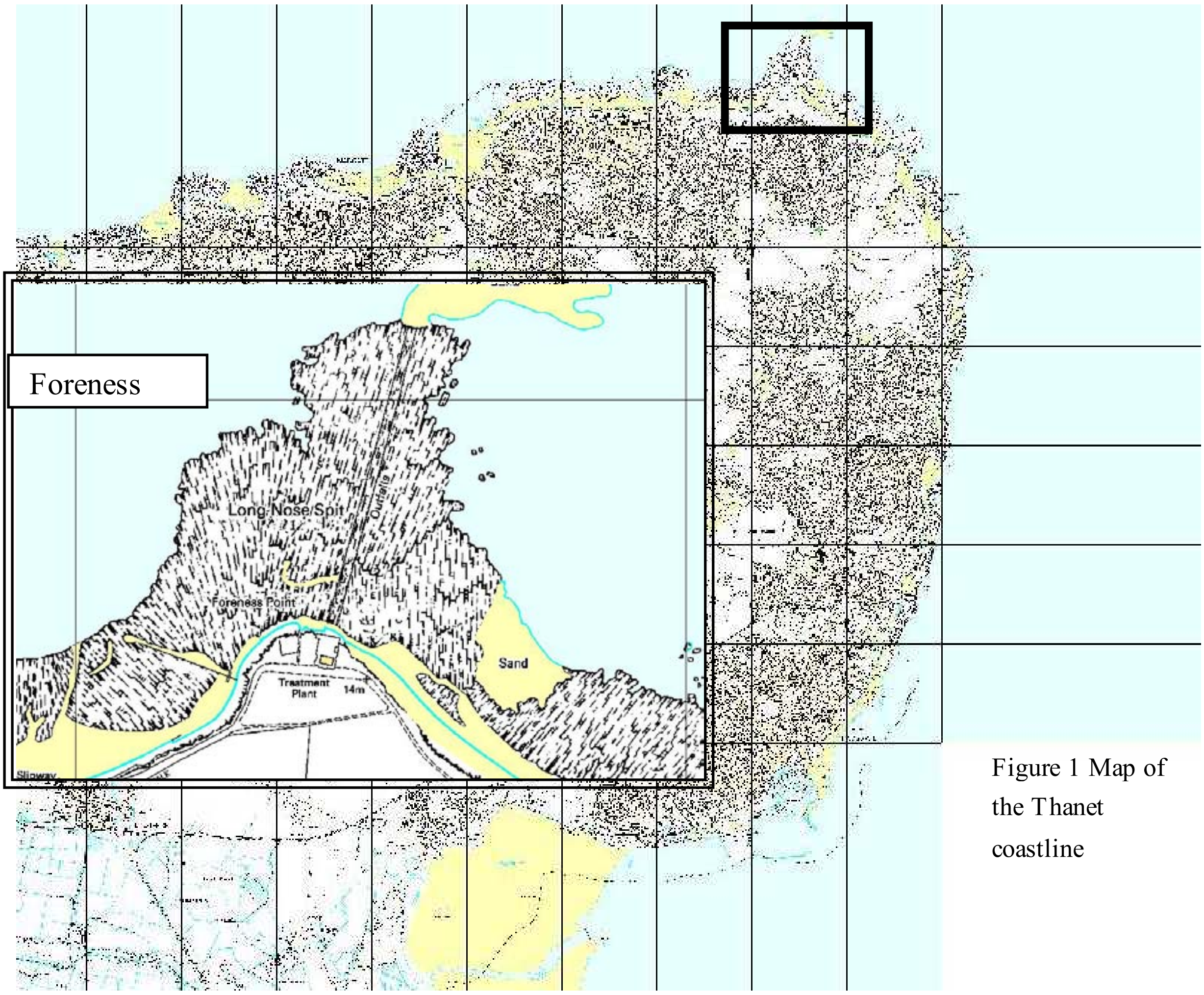

Figure 1 Map of the Thanet coastline

Previous study

The periwinkle study was designed to minimize the impact of the experiment upon the foreshore. Other studies had used exclusion cages to manipulate the density and number of grazing animals, however, these cages are expensive and liable to vandalism (especially so in areas where the public have unrestricted access).

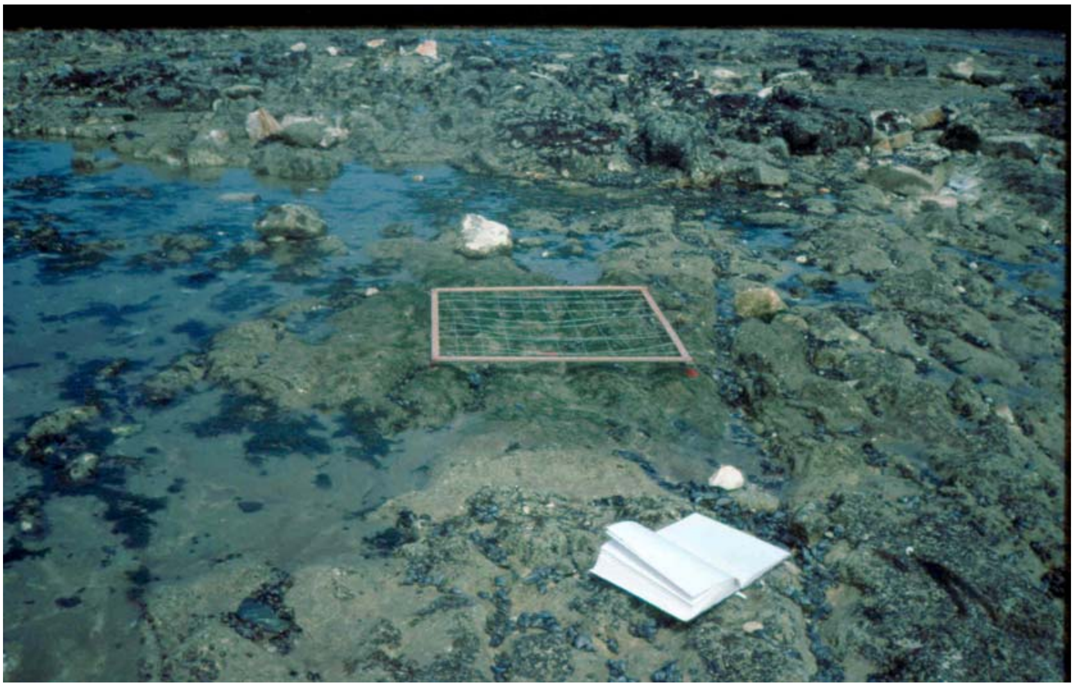

Plate 1. Upper shore Foreness Point in 1994

The placing of an artificial enclosure upon the rocky reef will alter the conditions within the treatment area such that eventual results might be difficult to disentangle from the environmental variances created. The method chosen was simple but extremely labour intensive, four painted galvanized nails were hammered into the chalk to form the corners of a $1m^2$ quadrat. Eight quadrats were located on the high-shore section of the reef and eight in the mid-shore (refer to Figure 2). The quadrats were randomized to divide them into control and treatment areas (four of each at both shore levels).

The quadrat was divided into 100 squares (Figure 3) and the percentage cover of all algal species and numbers of grazers were recorded on each transect. The treated squares had all *Littorina spp*. removed from within the quadrat square, and from within a buffer zone that extended for one metre around every quadrat. The control areas were counted but not cleared of any species. This process was repeated everyday at low tide for four weeks during the summer in 1994. The density of *Littorina spp*. was extremely high: 200 m^2 in upper and mid-shore-areas.

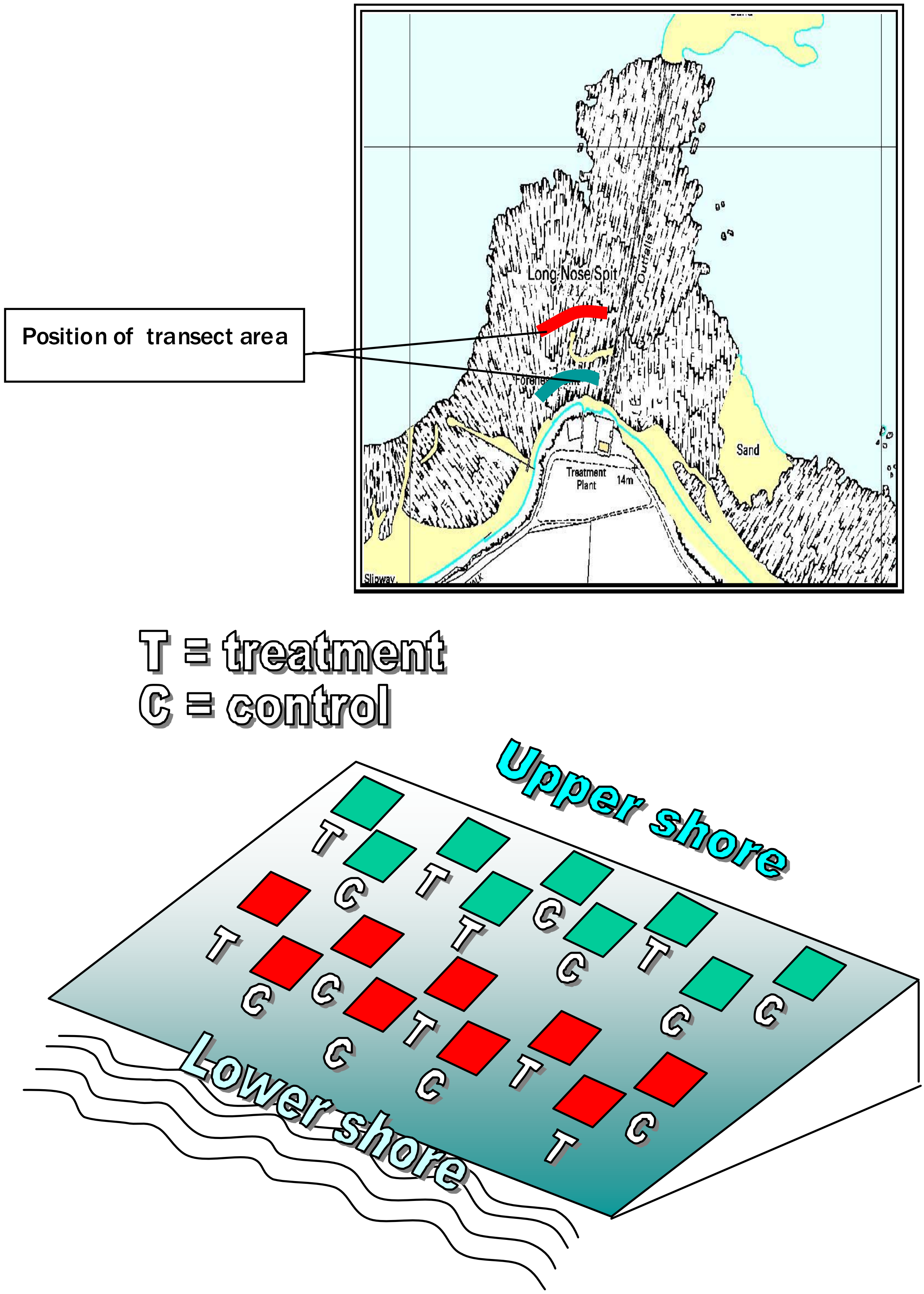

Figure 2. Experimental design used by Carol Torry in 1994 to assess the impact of periwinkle grazing upon the chalk reef

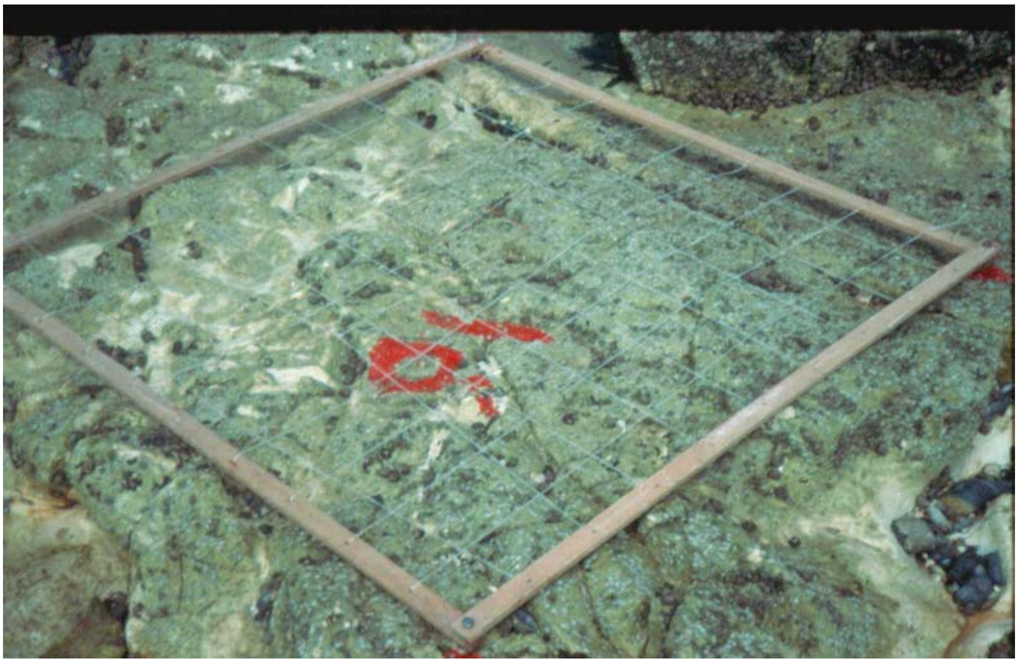

Plate 2. Quadrat divided into 100 (10cm x 10cm) squares

Within two weeks, the treatment areas showed a marked difference from the control areas. A thick layer of *Enteromorhpa spp*. quickly carpeted the reef within the quadrat area in the treatment squares (Plate 4). Within the control squares, the reef remained largely free of *Entermorpha spp.* and the remaining algae did not significantly change in percentage cover. Daily clearance was sufficient to maintain the treatment areas free of littorinids throughout the experiment; the buffer zone worked extremely well protecting the inner square.

Plate 3. Treatment area two weeks into experiment

During the experimental period, large groups of people were regularly observed collecting high numbers of periwinkles around the reef immediately adjacent to and within the experimental area. An intermediate level of harvesting on numerous occasions impacted one control quadrat. This square developed a slight growth of *Entermorpha* spp. (Plate 4). This indicated that complete removal of grazers was not essential to change the balance in algal cover. One year after the experiment, it was noted that some treatment areas had not returned to the pre-treatment condition (bare reef with high densities of periwinkles).

Plate 4. A control area affected by harvesting

Present survey

In the summer of 2002, the near-shore reef at Foreness Point was markedly different to that observed in 1994. Extensive growths of algae covered the reef adjacent to the seawall and up to 80m from the shore (Plate 5).

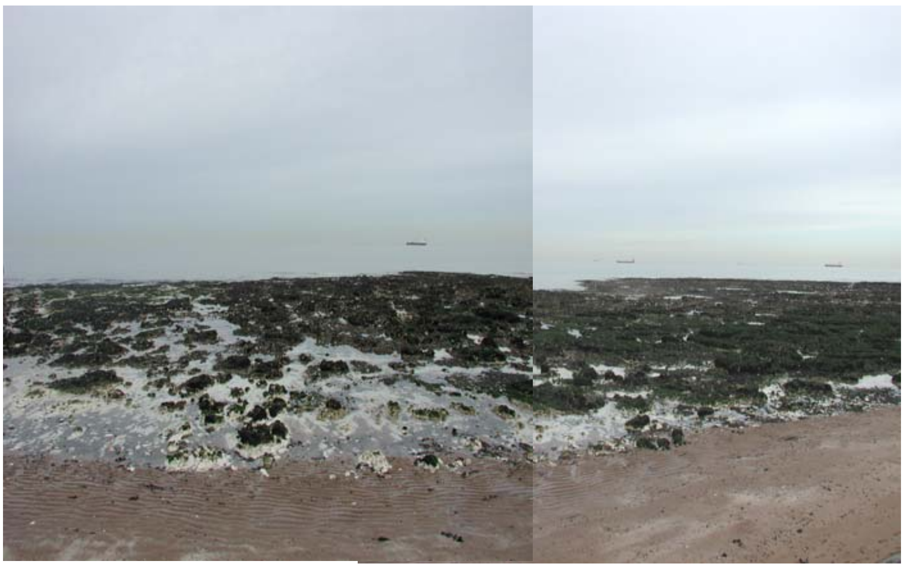

Plate 5. Reef at Foreness Point in 2002

The area to the East of the reef was examined and was found to be dominated by grazing molluscs. There were large numbers of mussels (approximately 1 year old) covering the reef but the density of periwinkles was still high.

Plate 6. Intertidal reef to the east of the 1994 survey area - summer 2002

The exposure to wave action is likely to be similar to that of the reef where new algal growth was observed. There were no significant stands of *Fucus sp*. or mats of *Entermorpha spp.* This set of rocks appeared to be (at least superficially) very similar to the reef where the grazing experiment was conducted in 1994.

Plate 7. Close-up of chalk reef shown in Plate 6

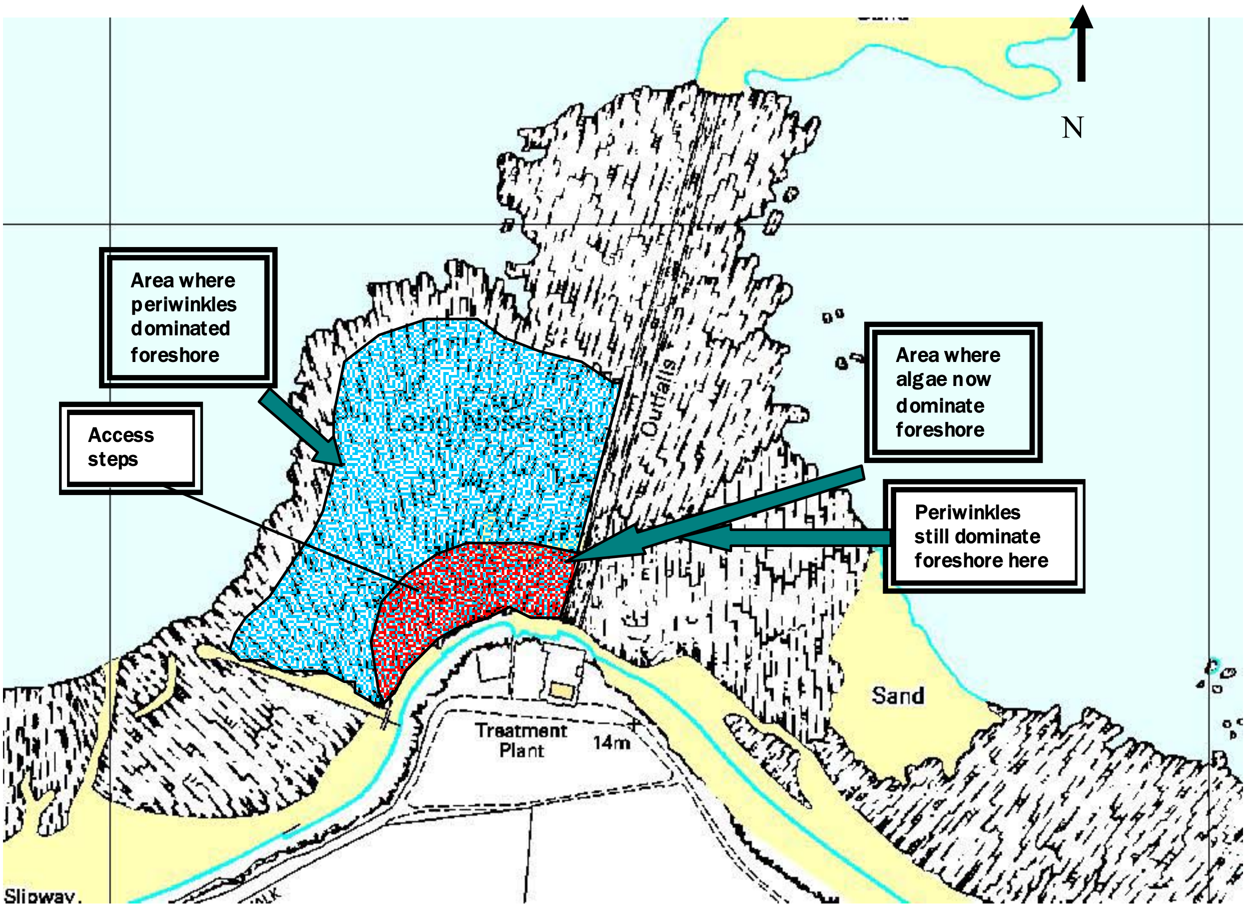

Figure 3. Foreness Point reef to show area (red) where periwinkle grazing habitat has been lost between 1994 and 2002

Figure 3 shows the area where periwinkles dominated the mid and upper shore reefs in 1994 and the area in 2002 where algae have replaced the grazing molluscs. An estimated 20% of grazing habitat has been lost on this section of reef. This probably equates to the loss of several million periwinkles between 1994-2002.

Discussion

Since 1994, the frequency of harvesting by members of the public has not appeared to decrease. The concrete promenade provides easy access for cars to park beside the steps to the beach. The numbers of harvesters can be as many as to sixty at one time and usually of family groups (personal observation). The harvested shellfish are both eaten and cooked on the beach or taken away.

Most harvesters use the steps shown in plate 8 or an adjacent slipway to get on to the beach. It is likely that the greatest impact of harvesting will be near to these accesses until the local mollusc population in sufficiently depleted. This appears to already be the case at Foreness Point as there is a large area (Figure 2 – red area on map) that has been lost the high densities of periwinkles that were observed in 1994 and where algal cover has dramatically increased. *Fucus vesiculosus* (not usually abundant on the chalk reefs) and *Enteromorpha sp.* have covered most of the rock surface in this near shore zone. However, the further one moves to the north or east of this area, the greater the periwinkle population becomes. The area of rocks to the west did not have high densities of periwinkles in 1994 or 2002.

The importance of the grazing molluscs for the annual clearance of seasonal growths of green algae was demonstrated by the 1994 student project. Within two weeks of the complete removal of the numerically dominant grazing species (the periwinkles), opportunistic algal species quickly became established and formed a dense carpet several inches thick. However, intermediate levels of grazing allowed some algal growth. The creation of intermediate grazing areas was accidental and resulted from the harvesting of periwinkles by groups of people on a regular basis.

In 2002, when the site was revisited, the reef area that was used in 1994 for the experimental manipulation of periwinkle populations had dramatically altered. The once bare chalk reef was covered in dense growths of fucoid and green algae. Periwinkles that were in 1994 averaging 200 m^2 had largely disappeared from a significant area of the near-shore reef. This altered area was centered on the access steps from the concrete promenade. An adjacent chalk reef (to the east and not so readily accessible) looked identical to the situation observed in 1994 with periwinkles dominating the near and mid shore.

The area of reef shown in the photographs in Plates 8 - 10 (below) is virtually devoid of periwinkles and has established growths of fucoid algae. The remaining chalk surface is densely covered with *Enteromorpha* sp. This area radiates out from the steps for approximately 80 metres.

Plates 8 –10, area of chalk reef where periwinkles have largely disappeared and have been replaced by macroalgae

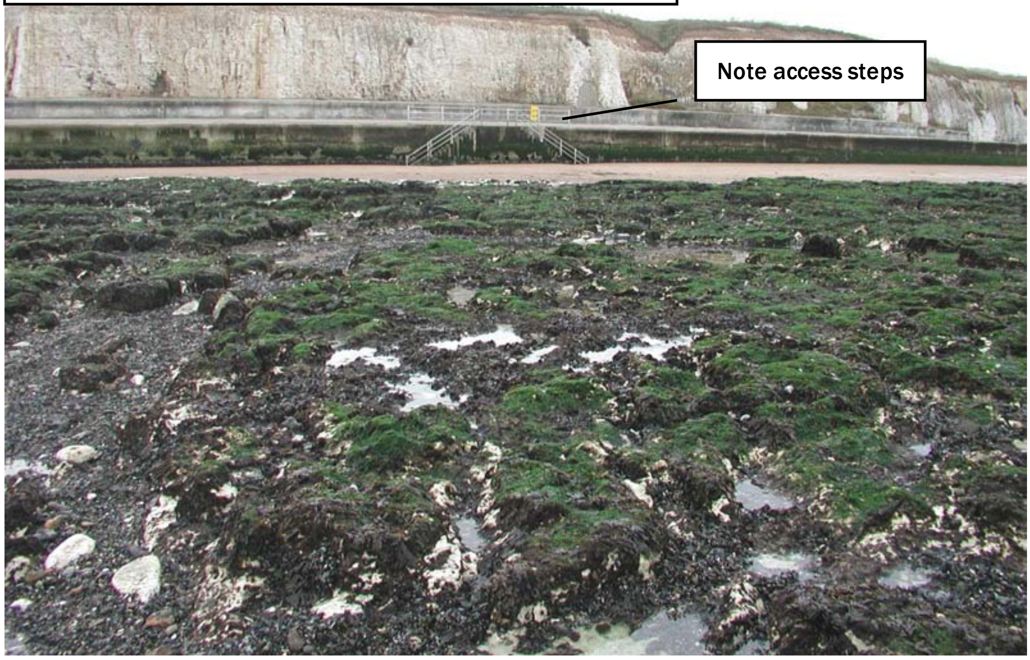

Plate 9

Plate 10

.

Conclusion

This evidence strongly suggests that the continual harvesting of periwinkles from the chalk reef has shifted the equilibrium from a grazing community to an algal dominated one. The change might (in the medium to short term at least) be permanent and has affected a large area of chalk reef. If the harvesting were to continue at the present rate, the impacted area would become larger because the periwinkles appear be unable to recolonise the reef once fucoid algae have become established. The estimated loss of several million periwinkles from the intertidal area at Foreness Point and the potential loss of several million more could have important consequences for bird feeding. If there are bird species that depend upon the periwinkles at these sites then a significant loss of feeding ground is possible.

The importance of Ostracoda and their relationship with the marine near shore environment of Thanet

Alasdair Bruce

Introduction

The Isle of Thanet is surrounded on three sides by water. A wide range of littoral to sub-littoral environments exists around the island. Principally these can be divided into chalk reef systems, muddy/sandy open beaches and estuarine/salt marsh. All these environments support a rich and varied assemblage of micro-organisms including ostracods.

Ostracoda

The use of ostracods as an environmental interpretation tool has been a relatively recent application, and to date has not been applied on Thanet. The following comments do not constitute a survey of any kind of this group's distribution in and around Thanet, rather they are merely a loose collection of observations spread over an unspecific time period. As such they give a poor guide as to what ostracods might be expected in certain locations.

Ostracods offer a powerful tool in assessing the current and past condition of certain aquatic environments. They are small crustaceans (average 1mm) enclosed in a carapace made up of two hinged calcitic valves (see Figure 1). They inhabit a wide variety of aquatic environmental niches, with well-known taxonomy and ecology. During the life cycle an ostracod will pass through up to eight growth stages or instars. In common with other crustaceans, an ostracod grows by shedding its carapace up to eight times before reaching adult size. Thus, during its life it leaves behind a large number of potentially identifiable fossil indicators for each individual (see Figure 2).

Ostracods are sensitive to environmental factors such as salinity, temperature, water chemistry, substrate and pollution. As such, many ostracod species are very niche specific and are excellent indicators of the health of an ecosystem.

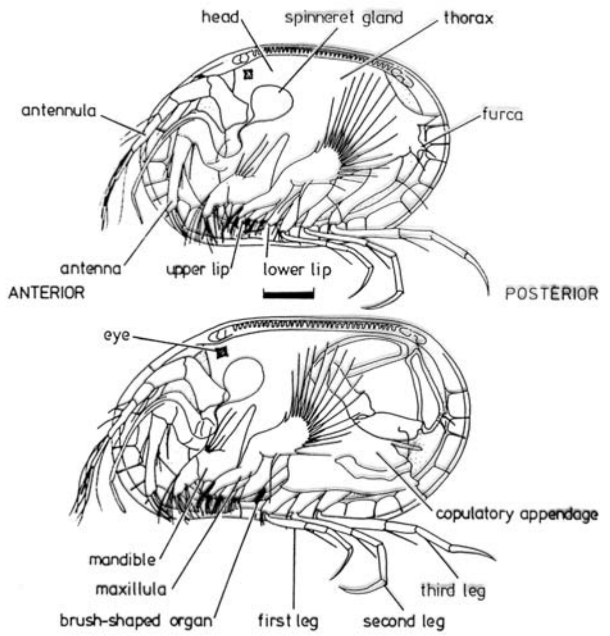

Fig. 1. *Loxoconcha elliptica*, adult female (above) and adult male (below), seen from the left side with left valves removed, to show the general arrangement of the appendages in a typical cytheracean podocopid ostracod (only one of each pair of appendages shown for clarity). Scale bar = 100 µm.

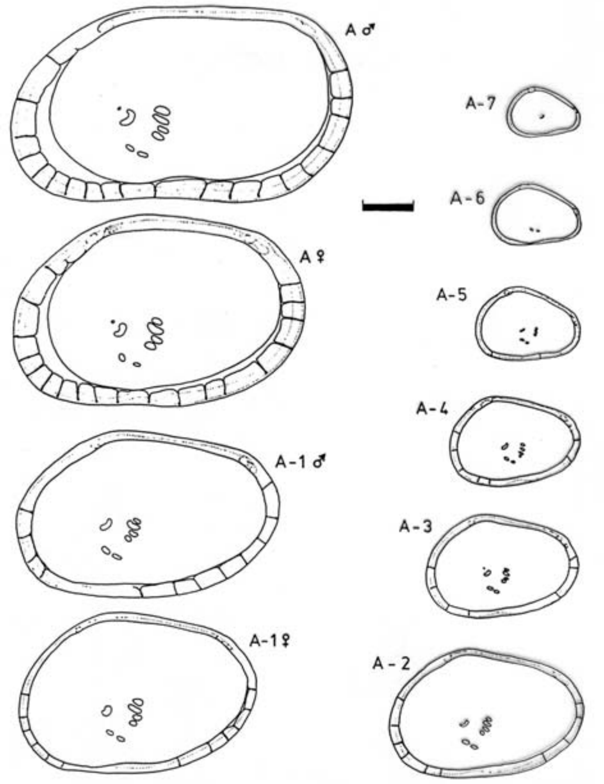

Fig. 2. Ontogeny of a cytheracean podocopid ostracod, *Loxoconcha elliptica*. All external lateral views of left valves, seen in transmitted light (anterior to the left). Scale bar = 100 µm.

Figures 1 and 2 amended after Athersuch *et al.*, 1989

Case study

A six-year environmental project on the Fleet lagoon in Dorset used ostracods as the interpretation tool to reconstruct the evolution of the lagoon through the Holocene to the present day. Below is a brief summary of the findings and their implications.

The linear-shaped Fleet lagoon in Dorset is Britain's largest macrotidal lagoon, and has a unique environment brought about by a very restricted link to the sea. The Holocene evolution of this lagoon is not fully understood. This project allowed the acquisition of material to assist in addressing that fact. A number of mechanically collected Holocene sediment cores from the Fleet lagoon, Dorset were analysed for their Ostracoda and Foraminifera content. In addition, nine hand-recovered cores were collected along the length of the lagoon and a year -long study of the living ostracods of the Fleet was completed. The palaeo-environmental analyses of these three different types of material indicate that significant environmental changes have occurred to the Fleet lagoon over the last *circa* 5000 years. The earliest sampled sediments in the cores are of a sandy nature and contain a faunal assemblage indicative of a shallow marine embayment. Thesegrade upwards into silts and clays with a progressively more lagoonal faunal assemblage. Increasing evidence of salt marsh culminates in the presence of a peat bed. The top of the peat bed shows evidence of a rapid incursion of the sea with an associated shell bed, followed by a return to lagoonal silts. These contain a fauna that indicates the west and east Fleet had similar environments until quite recently. Occasional sand beds within these silts contain deeper water marine ostracod taxa indicative of catastrophic storm events and seawater overtopping of Chesil Beach. The impact of storm events and man-made alteration to the Fleet during the last 500 years are discussed. The year- long live ostracod survey confirms that there is seasonal migration of certain ostracods within the Fleet. This, compared to a similar survey taken thirty years ago, shows there have been a number of major changes in the ostracod distribution of the Fleet lagoon. Implications for a sustainable management strategy for the Fleet lagoon are discussed in Bruce *et al.* (in press).

The Ostracod environments of Thanet

The only known studies of Thanet's ostracod populations have been undertaken by the present author during the last five years. This has consisted of sampling for ostracod assemblages around the island at selected locations. The locations were chosen for their differing environments in order to ascertain whether the known ostracod assemblages from other similar environments in Britain would be found here. The study of marine and brackish water ostracods undertaken by Athersuch *et al.* (1982) indicated what should be expected and in many cases this was true. However, there were a number of anomalies which will be mentioned later.

Again, It must be noted that what is written below in no way constitutes a full and detailed survey of the ostracods of Thanet. To my mind there is a great need to fill this gap in our knowledge of this group and its local distribution in Thanet. This is made all the more necessary by the unusual presence/absence of certain ostracods from particular assemblages. Plate 1 shows some of the more common ostracods to be observed around Thanet.

Chalk reefs

The large chalk reef platforms support a wide range of marine ostracods. Most species are phytal, living on and around the root anchorages of *Laminaria* sp and in the tufts of *Corallina offinalis*. These two structures are the most often sampled sites on these reefs; however, there is evidence from observations in other parts of Britain that certain ostracods may prefer to dwell in the old borings of piddock shells. This is but one example of the niche specific nature of certain species of ostracod. Those species so far recorded are listed below:

Leptocythere tenera
Semicytherura nigrescens
Paradoxostoma ensiforme
Paradoxostoma sp
Heterocythereis albomaculata
Hemicythere villosa
Hirschmannia viridis
Cythere lutea
Loxoconcha rhomboidea
Hemicytherura cellulosa
Aurila convexa.

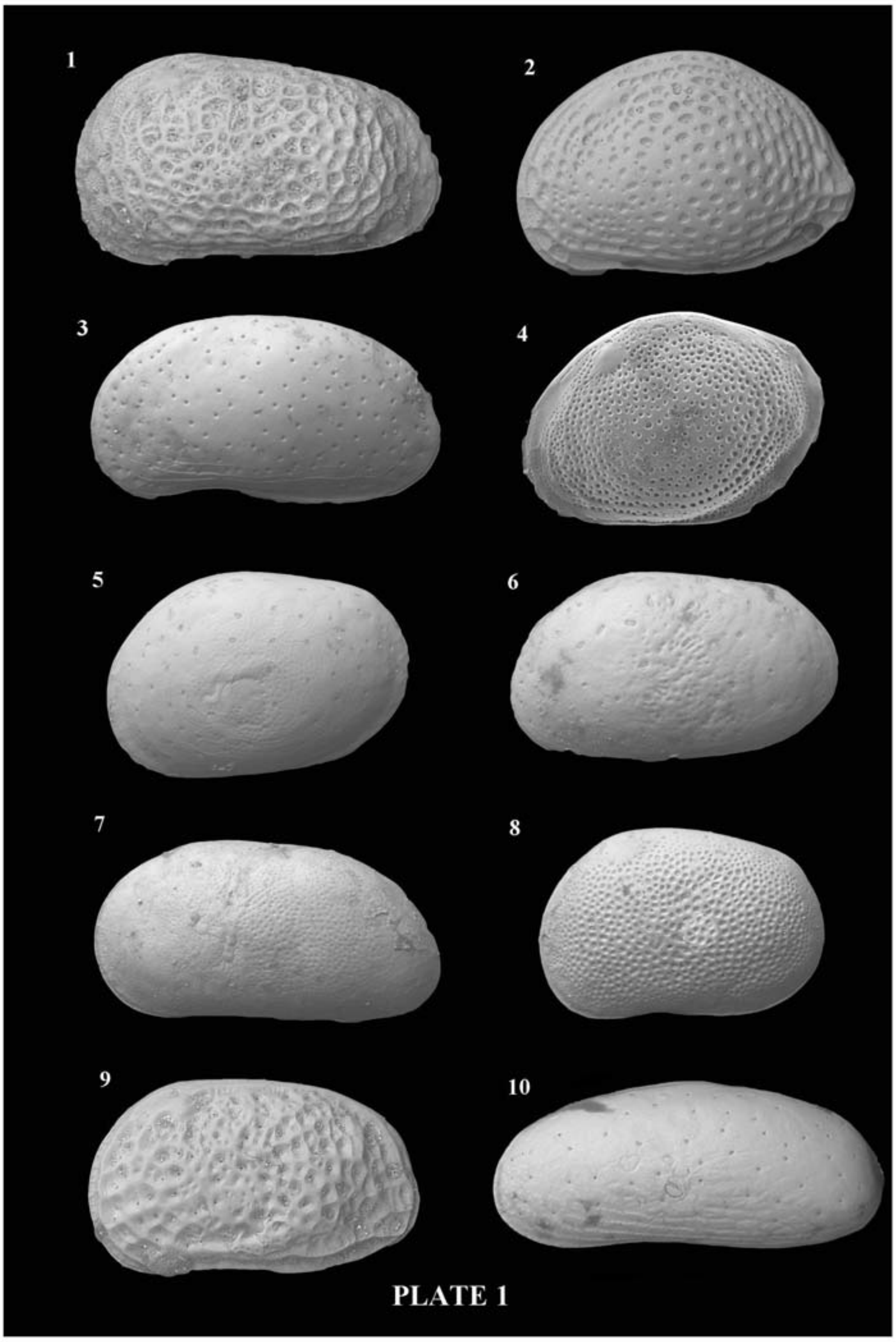

Plate 1 Ostracods from the Thanet coast

1 *Hemicythere rubida* (Brady), male (?) left valve. Foreness reef, Thanet, Kent. Specimen size 680 µm, x95.
2 *Aurila convexa* (Baird), female (?) left valve. Foreness reef, Thanet, Kent. Specimen size 760 µm, x79.
3 *Heterocythereis albomaculata* (Baird), female left valve. Foreness reef, Thanet, Kent. Specimen size 830 µm, x77.
4 *Loxoconcha rhomboidea* (Fischer), female left valve. Foreness reef, Thanet, Kent. Specimen size 625 µm, x90.
5 *Loxoconcha elliptica* Brady, female left valve. Minnis Bay, Thanet, Kent. Specimen size 600 µm, x90.
6 *Elofsonia baltica* (Hirschmann), female (?) left valve. Pegwell Bay, Thanet, Kent. Specimen size 490 µm, x120.
7 *Cyprideis torosa* (Jones), male left valve. Pegwell Bay, Thanet, Kent. Specimen size 1000 µm, x65.
8 *Hirschmannia viridis* (O.F. Müller) female right valve. Foreness reef, Thanet, Kent. Specimen size 525 µm, x105.
9 *Hemicythere villosa* (Sars), female left valve. Foreness reef, Thanet, Kent. Specimen size 740 µm, x88.
10 *Pontocythere elongata* (Brady), female left valve. Foreness reef, Thanet, Kent. Specimen size 980 µm, x70.

Beach

The open storm beaches of Thanet support a limited assemblage of ostracods that are dominated by the benthonic forms listed below. There are certain species which are also found on the reef systems. Among the species noted below are a number which appear to exist in close relationship with the sand tubes of the marine worm *Sabellaria alveolata*; in some cases I have witnessed their gruesome incorporation in these tubes whilst still alive. This is particularly true of *Pontocythere elongata.* Species of ostracod recorded are:

Leptocythere tenera
Aurila convexa
Pontocythere elongata.

Estuarine salt-marsh

Pegwell Bay is the best-developed example of this environment in Thanet, although parts of the foreshore around Minnis Bay might be considered estuarine in nature. In Pegwell Bay three areas have been studied in particular. These are:

1. The salt ponds between the old Hoverport site and the petrol station.
2. The drainage channels feeding the River Stour by the bird reserve.
3. The root areas of sea grass in the north of the bay.

The salt ponds were sampled as part of my recent work on establishing more precisely the environmental parameters of two very common British brackish water ostracods. *Cyprideis torosa* and *Loxoconcha elliptica* are found all around Britain in marsh and estuarine environments (Horne & Boomer, 2000). What is not yet fully understood is whether they both flourish in the same space within these extreme environments or simply overlap here. The salt ponds at Pegwell Bay are perhaps the most extreme environments to be found in the bay. For long periods during the summer they dry out and during the winter they are often full of freshwater. In between they are prone to flooding during sea storm events. It therefore comes as no surprise to discover that only one or two very robust and euryhaline species dominate here. One species (*C. torosa*) at least has been proved to have the ability to withstand desiccation events.

Loxoconcha elliptica has, surprisingly, not been found in association with *C. torosa* at this location. Another location behind Minnis Bay between the shingle and the sea wall also only contains *C. torosa*. Other similar locations around Britain have been found to contain both species. *Loxoconcha elliptica* has been collected around Thanet, but not in locations where it would be expected. These observations are not expanded on here as they are the subject of continued study and any statements would be premature. However, these observations illustrate the need for further research into the relationship of these two common and environmentally important species. Plate 1 shows a number of the more common ostracods encountered around the shores of Thanet.

Species seen in the salt ponds, creeks and drainage channels are:

Cyprideis torosa
Leptocythere castanea
Elofsonia baltica.

Additional species observed out on the main part of the bay were:

Pontocythere elongata
Loxoconcha rhomboidea
Hirschmannia viridis.

Conclusion

A wide range of environments is available for exploitation by ostracods around Thanet. The above lists are a rough and ready look at some of these, but do hint at the future potential of understanding ostracod distribution. This is particularly true of those that rely on algae. The distribution of algae on the reef systems of Thanet is well known, but it has been noted (personal observations) that in certain places the controlling factor on distribution is strongly affected by the type and hardness of the chalk substrate rather than tidal position on the shore. Ostracods are affected by substrate, salinity temperature and, to a lesser extent, exposure time within the tidal cycle (Whittaker, 1972). It is important to understand how these parameters alter the distribution of ostracods in differing circumstances such as the chalk reefs of Thanet. Ostracods as a food source is not well understood. Studies from the Fleet lagoon show that bass will feed on certain species of ostracod up to a particular size, when they shift their attention to other foods, but little else is known. A better understanding of the role ostracods play in the diet of fish and possibly birds is long overdue.

References

ATHERSUCH J., HORNE D.J. & WHITTAKER J.E., 1989. Marine and Brackish Water Ostracods. *In*: Kermack D.M. & Barnes R.S.K. (eds.), *Synopses of the British Fauna* (New Series), no. 43. E.J. Brill, Leiden (for the Linnean Society of London and The Estuarine and Brackish Water Sciences Association).

HORNE D.J. & BOOMER I., 2000. The role of Ostracoda in saltmarsh meiofaunal communities. *In:* Sherwood B.R., Gardiner B.G. & Harris T. (eds.), *British Saltmarshes.* Cardigan: Forrest Text (for the Linnean Society of London)
.
WHITTAKER J.E., 1972. *The taxonomy, ecology and distribution of recent brackish and marine Ostracoda from localities along the coast of Hampshire and Dorset (Christchurch Harbour, The Fleet and Weymouth Bay).* Unpublished PhD Thesis, University College of Wales, Aberystwyth.

The following references were used for background research and are not cited within the text

BARNES, R.S.K.,1991. European estuaries and lagoons: a personal overview of problems and possibilities for conservation and management. *Aquatic Conservation: Marine and Freshwater Ecosystems,* **1**, pp. 9-87.

HORNE D.J. & WHITTAKER J.E., 1985. A revision of the genus *Paradoxostoma* Fischer (Crustacea; Ostracoda) in British waters. *Zoological Journal of the Linnean Society of London,* **85,** pp. 131-203.

KILENYI T.I., 1969. The problems of ostracod ecology in the Thames Estuary. *In*: Neale J.W. (ed.), *The Taxonomy, Morphology and Ecology of Recent Ostracoda.* Edinburgh: Oliver & Boyd.

THEISEN, B.F., 1966. The life history of seven species of ostracods from a Danish brackish-water locality. *Meddelelser fra Danmarks Fiskeri- og Havundersøgelser,* (New Series), **4**, pp. 215-270.

WAGNER, C.W., 1964. Ostracods as environmental indicators in Recent and Holocene estuarine deposits of the Netherlands. *Pubblicazioni della Stazione Zoologica di Napoli,* Supplement, **33**, pp. 480-495.

WHATLEY, R.C. & WALL, D.R., 1975. The relationship between Ostracoda and algae in littoral and sublittoral marine environments. *In:* Swain, F.M. (ed.), Biology and Palaeobiology of Ostracoda. *Bulletin of American Paleontology,* **65**, pp. 173 .

Investigation into the macro-algae community of Pegwell Bay

Philip Rogers and Georges Dussart
Ecology Research Group, Department of Geography and Sciences, Canterbury Christ Church University College, Canterbury, Kent CT3 4AQ

Introduction

The research project described here is an ecological investigation to establish the spatial dimensions of the algae community at Pegwell Bay. It focuses on factors that may have caused a recent increase in plant abundance, recorded in 2000 (Figure 1). An outline of how the project developed, together with the research aims is presented here. Finally, data is also presented which represents work-in-progress to monitor nutrients within the water column in Pegwell Bay.

The 1990's saw the introduction of EU Directives to reduce effluent discharged into coastal waters. Primarily, these were the *Dangerous Substances in Water Directive*, *Bathing Water Directive* and *Urban Waste Water Treatment Directive* (Rees-Jones, 1998). As a consequence, coastal release of raw sewage at Ramsgate and Deal ceased. Southern Water began treating sewage at Weatherlees on the Stour Estuary in 1995. Pfizer Ltd installed their own trade Effluent Treatment Works (ETW) that went on-line in 1998. The Stour estuary has been monitored for Pfizer by the Ecology Research Group (ERG) based at Canterbury Christ Church University College. As part of this group, Rees-Jones (1998) noted that, *"...Southern Water's Weatherlees Hill sewage treatment works has had a significant detrimental effect on the estuary, and has increased the levels of phosphate and nitrite ... "*. Rees-Jones (1998) also stated that *"...Nutrient concentrations are already high in the estuary, and further increases could result in the proliferation of plant growth and the first signs of eutrophication... "*.

Extra nutrient loads may lead to an increase in primary productivity (O'Riordan, 2000). Nedwell *et al.* (2002) state *"...The over-abundance of benthic algae and phytoplankton in estuarine and coastal waters is often blamed on excessive inputs of nutrients…"*. Nedwell *et al.* (2002) described the nutrient status of 93 UK Estuaries including the Stour. In 1995/96 nitrate and phosphate concentrations in the Stour were similar to the nearby Medway estuary, Kent. Large quantities of macro-algae occur in certain places on the Medway estuary. For example, the two photographs below (Figures 2 and 3) show how rapid algal development can be within a short seasonal period. Species such as *Ulva lactuca* and *Enteromorpha* sp. dominate. However, to what extent is this a problem? Burrows (1971) noted at the beginning of the 20th century, *"...the correlation between sewage pollution of estuaries and the presence of extensive sheets of Ulva..."*. However, Burrows (1971) also noted the work done by Cotton (1911) indicating that *Ulva* can occur in non-polluted areas or because of natural pollution.

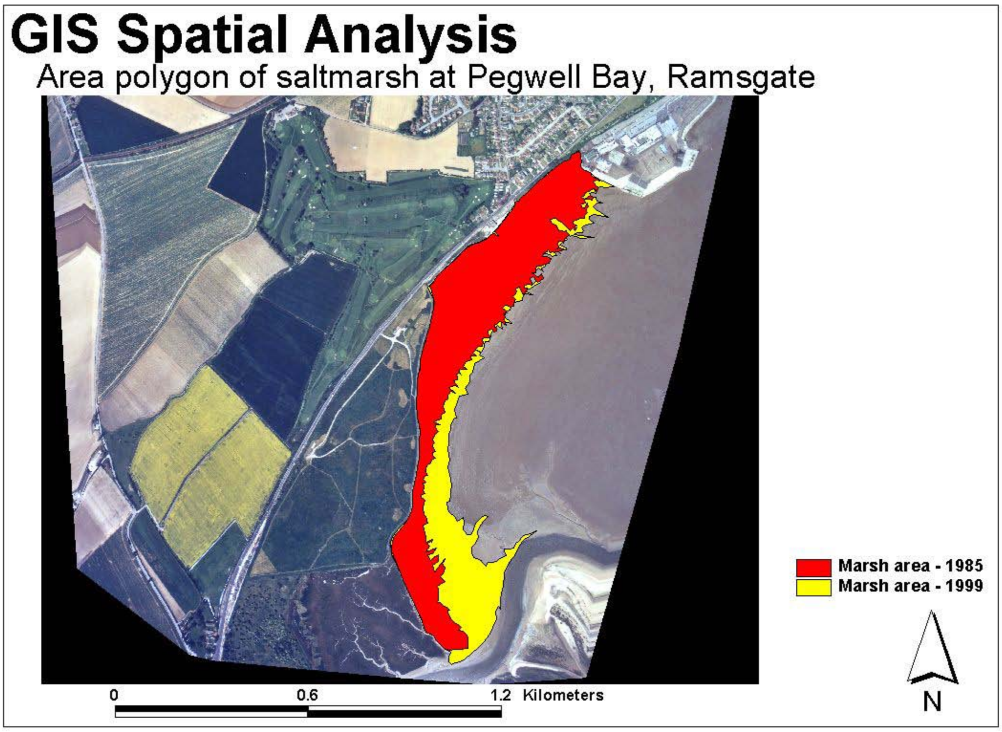

Figure 1. An aerial photograph taken in 1985. The image shows a GIS Rapid assessment map of saltmarsh cover in 1985 compared to that of 1999.

Figure 2. Bedlam's Bottom on the Medway estuary (TQ 88 68). The photograph was taken in April 2002. The mudflats were clearly visible. Macro-algae abundance was minimal.

Figure 3. Same location at Bedlam's Bottom on the Medway estuary but photograph taken in August 2002. The mudflats were covered in 10-20cm in thickness of loose and fixed *Ulva lactuca.*

The ERG has also conducted long-term surveys on the plant dynamics of the saltmarsh since 1983. In 2000, an investigation using aerial photographs covering 15 years revealed the development of an algal mat over the salt marsh (Rogers, 2001). However, no in-depth study has investigated either this phenomenon or the marine algal community at Pegwell Bay. Compared with parts of the Medway, there has not been an over-abundance of *Ulva lactuca* and *Enteromorpha sp.* at Pegwell Bay. Differences in the type of estuary may be responsible for this. For example, the Medway estuary is enclosed by the Isle of Sheppey and the Isle of Grain. These islands may shelter the estuary and reduce influences from the open sea. The Stour estuary, however, is directly open to the sea. Environmental conditions at Pegwell Bay are therefore extreme. Indeed, Rees-Jones (1998) noted these factors in relation to the macrobenthos, stating that, *"...Tidal flats are highly stressed environments with fluctuating environmental factors (tidal currents, temperature, windforce, salinity)..."*.

Thus the:

- Stour estuary is open to influential currents from the English Channel and North Sea,
- the Stour estuary and mudflats are continuously 'flushed' (tidal range, 0-5m) with water,
- a high degree of suspended sediment occurs,
- dynamic geomorphic conditions prevail,dynamic relationships between tidal currents and changes in mudflat geomorphology compared to sheltered areas or tidal flats can occur,
- there are fluctuating temperature regimes,
- changes in salinity,
- and there is a high amount of drift weed present.

These environmental conditions may mean that Pegwell Bay is not conducive to large quantities of common 'nuisance' algal species such as *Ulva lactuca*. The algal mats at Pegwell Bay have been identified possibly as *Vaucheria* sp. (Figures 4 and 5). This species is highly suited to the stresses described above. Hay (1981) noted that, "…many seaweeds occur in physically stressful habitats….". An example of such a habitat is a rocky shore.

However, can the occurrence of *Vaucheria* sp. be an example of a species adapted to extreme estuarine conditions?

Various morphological features make *Vaucheria* sp. more adapted to the exposed and stressful conditions at Pegwell Bay. The alga is a s
hort turf-or-carpet forming species (5mm in height). *Vaucheria* is present all year with the exception of mid-summer. It is also more evident in moist conditions than in dry. It appears to be resistant to winter storm erosion and inundation of sediment from recent observations. Hay (1981) also notes that, "…Turf-forming species are specialised for areas that are subject to moderate physical stresses…". It is also likely that algae regeneration can vary, dependent upon the levels of disturbance (Hay, 1981).

Figure 4. Recently established algal mat growths at Pegwell Bay, Ramsgate**.**

Figure 5. Close-up of *Vaucheria* sp. with other algae present (Scale represented by a 10p coin).

Pegwell Bay

Barnes (1979) states that there are nine major habitats around the coastline of Great Britain. For example, intertidal mudflats and sandflats, saltmarsh, chalk cliffs and caves, shingle beaches, intertidal reefs (dominated in areas by both molluscs and algae), sandy beaches and sand dunes. All of these are present at Pegwell Bay, within a small area.

Because the River Stour drains into Pegwell Bay, an estuarine ecosystem predominates. However, Pegwell Bay is uniquely rich in coastal habitats compared to other estuaries in southern England and thus the following protection measures have been applied:

- cSAC (candidate Special area of Conservation),
- SPA (Special Protection Area),
- Ramsar site,
- SSSI (Site of Special Scientific Interest ,
- Sensitive Marine Area (SMA),
- National Nature Reserve (NNR, 610 ha),
- Local Nature Reserve (LNR) (Kent's largest).

Pegwell Bay is situated on the Isle of Thanet's south-east corner (Figure 6) where the Great River Stour meets the sea.

Figure 6. Ordnance Survey Map showing the research area at Pegwell Bay, Isle of Thanet, Kent. Reproduced from Ordnance Survey map data by permission of Ordnance Survey, © Crown copyright.

The current research project

The research project title is "An investigation into the extent and degree of eutrophication at Pegwell Bay in relation to macro-algae". The aims are as follows:

1. To measure/assess the quality of water in the Pegwell Bay area.

2. To investigate the role of estuarine and marine flora, including algae, in relation to nutrient enrichment.

3. To understand the processes of algal colonisation, interaction and association with other species.

This paper presents data that relates to the first of these aims. The objective was to measure the nutrient quality of water at Pegwell Bay. My research on nutrients in the water has concentrated on nitrates and phosphates and whether there are localised spatial patterns on Pegwell Bay. The investigation of such patterns may provide greater understanding of "..the functioning and circulation patterns of the system…" .(Boyer *et al.*, 2000). Various studies have investigated estuarine and marine plumes (Delhez & Carabin, 2001 and Morris *et al.*, 1995); however, not many have this on a localised scale and in relation to interactive ecosystems such as saltmarshes. Boyer *et al.* (2000) used GIS techniques to visualise various environmental parameters off the coast of Florida. Similar methods will be used to generate GIS maps of water nutrients at Pegwell Bay.

Methods

Water samples were collected at high water from the tidal flats at Pegwell Bay. The samples were taken on the 12 August 2002 in relatively calm conditions. Two 1 kilometre transects were set up across the tidal flats. Sample bottles were placed every 100 metres, ten per transect. The first transect (Transect A, Figure 7) covered flats dominated by invertebrates. The second transect (Transect B) was nearer to the estuary and covered flats dominated by plants (mainly *Spartina anglica* and the algal turf *Vaucheria* sp.). Nalgene sample bottles (125ml) were attached to sticks and secured in the mud. On the next high tide a sample of water was collected. The samples were measured for pH and conductivity and then filtered and frozen. At a later date, the samples were tested for Nitrates ($NO3^-$) using a Tecator Aquatic Auto-analyser.

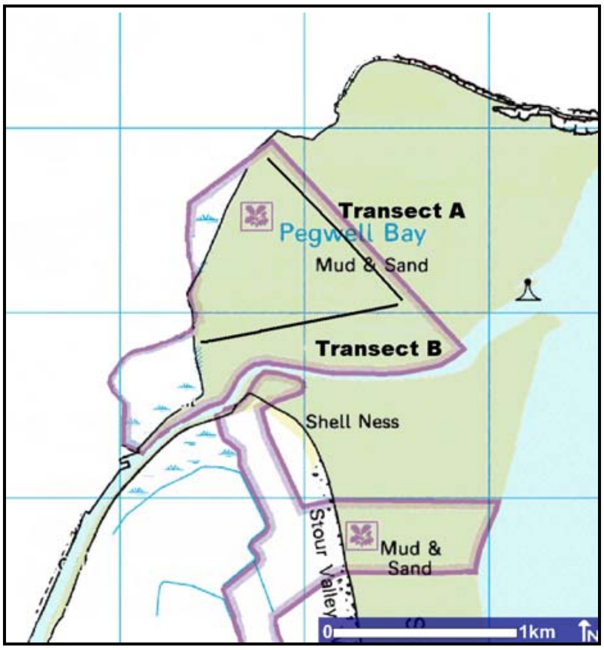

Figure 7. Position of transects on Pegwell Bay

Results

Preliminary results suggest that nitrate concentrations nearer to the estuary (transect A) are lower compared to the animal dominated area of Pegwell Bay (transect B). Concentrations of nitrates are consistently low along transect B with the exception of sample station five and seven. Transect A, however shows higher variation, sample station seven being an example (see Figure 8). Nitrate concentrations on all ten stations along transect A are higher than those along transect B.

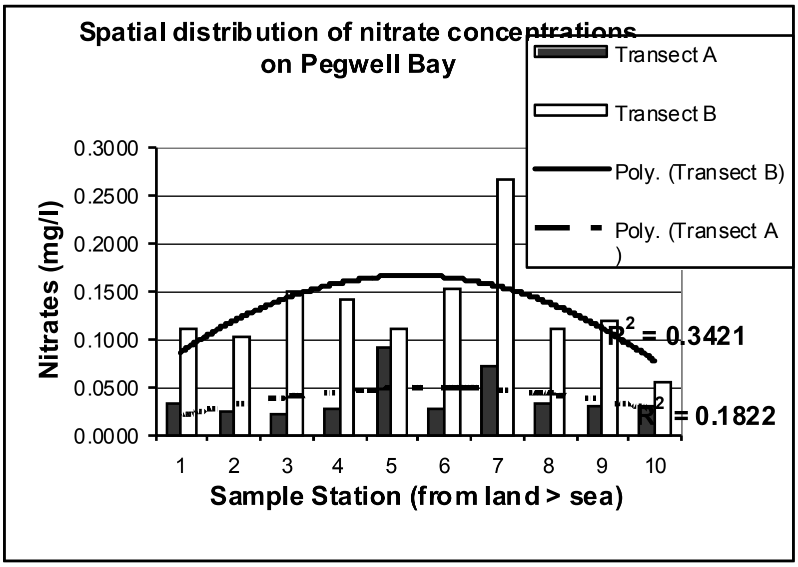

Figure 8. Histogram showing nitrate concentrations from two 1km transects across Pegwell Bay.

Mean nitrate concentrations recorded were 0.038 mg/l (Standard Deviation of 0.23 mg/l) for Transect A and 0.131 mg/l (Standard Deviation of 0.055 mg/l) for Transect B. Statistical analysis shows that there is a significant difference (df=18 $P<0.05$) between between transects A and B for Nitrates ($NO3^-$). Mann-Whitney Confidence Interval and Test was used.

It must be noted that this represents only one survey. A replicate survey was conducted one month later and analysis is continuing on these samples. Monthly surveys will be conducted from November 2002 onwards.

Discussion & conclusion

Overall, concentrations of nitrates on Pegwell Bay are low. The results for the two transects in Pegwell Bay suggest that nitrate concentrations differ. Transect A is situated further away from the river and dominated by invertebrates. The water column here showed significantly higher nitrate concentrations. The animal activity on the mudflats could be releasing nutrients by bioturbation (the process, whereby invertebrate activity disturbs or moves sediments) from the sediment and therefore increasing concentrations in the water column.

Transect B is situated nearest the river and is dominated by plant communities. Results from this transect suggest significantly lower concentrations of nitrates in the water column. The reason for lower nitrate concentrations could be a result of plant uptake of nutrients in the water column. If this is the case, then nitrates from either the open sea or the river are influencing saltmarsh plant growth. However, more results are required before any conclusion can be made as the survey only provides a limited profile of nutrient concentrations on Pegwell Bay.

Coastal water samples have also been collected monthly from various stations around the Thanet coast. It is hoped that these will provide comparison data for Pegwell Bay. Samples from February 2002 to June 2002 have been analysed for nitrates ($NO3^-$). These reflect similar concentrations of nitrates recorded over Pegwell Bay (Figure 9).

It is hoped that further analysis can be completed to show better comparisons between the Estuary, the Thanet coast and Pegwell Bay occurring over the same period of time.

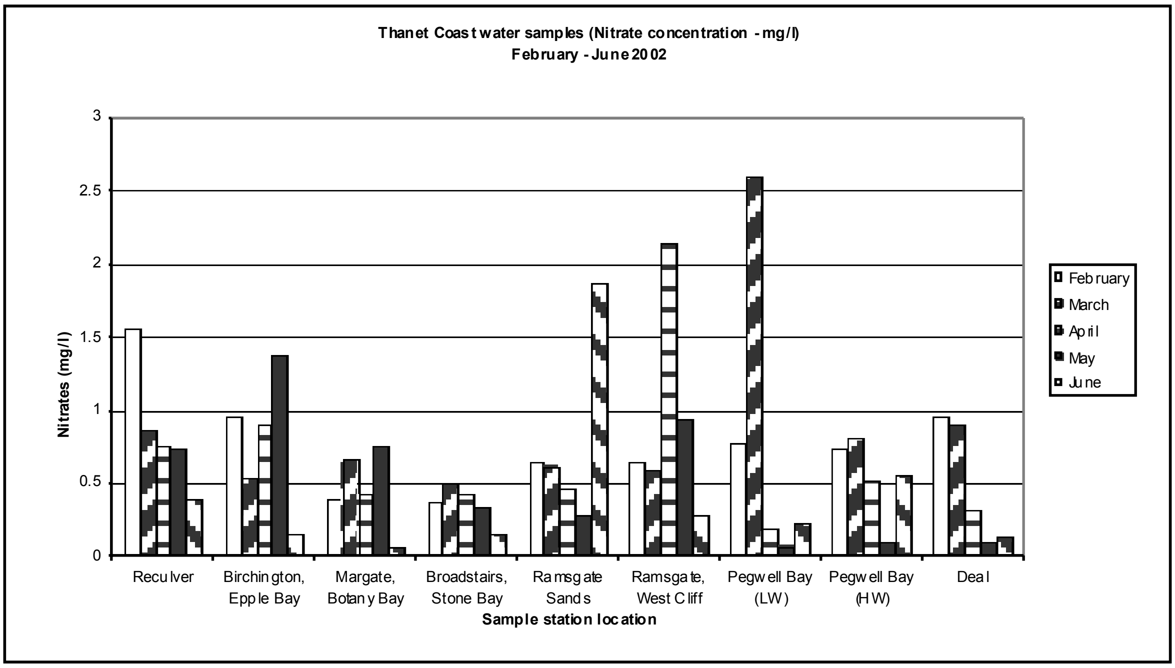

Figure 9. Nitrate concentrations (mg/l) from nine sample stations around the coast of Thanet.

Future developments

It is hoped that a two-dimensional (2D) map (Boyer *et al.*, 2000) might be produced to show spatial differences in the water column. For example, suspended sediment levels and nutrient concentrations could be described. Over a period of time, a $2D_t$ (where t equals time) might also be produced. A GIS baseline map of the algal community at Pegwell Bay is being produced and may provide some grounds for further analysis. A comparison with spatial/temporal water nutrient data, marine algae and sediment analysis will also be completed.

References

ANON, 1997. *East Kent Coast – Natural Area Profile.* Wye: English Nature.

BARNES, R. 1979. *Coasts and Estuaries,* London: Book Club Associates.

BOYER, J.N., STERLING ,P. & JONES, R.D., 2000. Maximizing information from a water quality monitoring network through visualization techniques. *Estuarine, Coastal and Shelf Science,* **50**, pp. 39-48.

BURROWS, E.M., 1971. Assessment of Pollution Effects by the use of Algae, *Proceedings of the Royal Society of London, Series B, Biological Sciences A, discussion on biological effects of pollution in the sea*, **177** (1048), pp. 295-306.

DELHEZ, E.J.M. & CARABIN, G., 2001. Integrated modelling of the Belgian coastal zone. *Estuarine, Coastal and Shelf Science*, **53**, pp. 477-491.

HAY, M.E., 1981. The function morphology of turf-forming seaweeds: persistence in stressful marine habitats. *Ecology,* **62** (3): pp. 739-750.

MORRIS, A.W., ALLEN, J.I., HOWLAND, R.J.M., & WOOD, R.G., 1995. The estuary plume zone: source or sink for land-derived nutrient discharges? *Estuarine, Coastal and Shelf Science,* **40**, pp. 387-402.

NEDWELL, R.C., 2002. Variations of the Nutrient loads to the mainland UK Estuaries: Correlation with Catchment areas, Urbanization and Coastal Eutrophication. *Estuarine, Coastal and Shelf Science,* **54**, pp. 951-970.

O'RIORDAN, T., 2000. Environmental Science for Environmental Management, Harlow: Prentice Hall.

REES-JONES, S., 1998. *The Stour Estuary – Report on field surveys from January 1994 to April 1996*. Sandwich: Pfizer Ltd.

ROGERS, P.J., 2001. *Spartina anglica within a spatial and temporal context at Pegwell Bay, Ramsgate, Kent.* Canterbury: Undergraduate dissertation.

Website:

Ordnance Survey (2001) Get-a-Map
URL: http://www.ordsvy.gov.uk/get-a-map/

Pegwell Bay: 1994-2001

Jackie A. Trigwell, P. Buckley & Georges B.J. Dussart
Ecology Research Group, Department of Geography and Sciences, Canterbury Christ Church University College, Canterbury, Kent CT1 1QU.

Introduction

Pegwell Bay and Sandwich Nature Reserve are important areas for over-wintering birds such as the Sanderling, Golden Plover and Grey Plover; breeding grounds for the Little Tern and resting places for migrating birds in the spring and autumn. Additionally, Sandwich Bay supports the growth of orchids, Broomrape and Sea-holly. Because of these features, Pegwell Bay and the surrounding areas have variously been designated a Site of Special Scientific Interest (SSSI), a Local Nature Reserve (LNR), a National Nature Reserve (NNR), a candidate Special Area of Conservation (cSAC), Special Protection Area (SPA) and a Ramsar site.

A total of 22 public and 16 private sewage treatment works discharge into the Stour Catchment (Environment Agency (EA), 1999), with six discharging directly into the section of the River Stour monitored by the Ecology Research group (ERG). In order to comply with the *Urban Waste Water Treatment Directive* (91/271/EEC), Weatherlees Hill sewage treatment works was built by Southern Water and commissioned in 1995. Sewage from the pumping station at Sandwich, and the sea outfalls at Ramsgate and Deal, were then redirected to Weatherlees Hill. In 1997 Pfizer built and commissioned its own effluent treatment works, which takes all the trade waste and sewage from their site at Sandwich. Both Weatherlees Hill and the Pfizer works discharge into the River Stour, Weatherlees Hill downstream of Minster and Pfizer upstream of the Pfizer sports ground.

The ERG has been surveying the Stour Estuary since 1993. Biological, chemical and physical parameters are measured at eleven sites along the River Stour, from Grove Ferry to Shell Ness, and at five sites along a 1000 m transect in Pegwell Bay. Only results from the Pegwell Bay surveys are reported here.

Methods

Since 1994, samples were collected four times a year from the sites in Pegwell Bay, during spring, summer, autumn and winter. Four large and three small sediment cores were taken from five sites sited 200 m apart along a 1000 m transect (Figure 1). The large sediment cores (10 cm diameter x 30 cm deep) were individually sieved, through a 0.5 mm mesh sieve *in situ*. The organisms retained by the sieve were washed into plastic tubs, one core per tub, together with 200ml of water collected from the site. The smaller cores (3 cm diameter x 15 cm deep) were collected and sealed into separate plastic bags. On return to the laboratory, 200 ml of 8 percent formalin was added to the plastic tubs (to give a final concentration of 4 percent) and the samples were stored to await identification of the macrobenthos. All invertebrates were identified to family level and retained for reference by storing in 70 percent methanol (Industrial Methylated Spirit, IMS) in labelled bottles. The smaller sediment cores were stored in the freezer; one was later analysed for organic content, one for sediment particle size and the third for heavy metals (not reported here). Untransformed data were analysed by polynomial regression analysis.

Results

Total numbers of invertebrates

The number of invertebrate families found at each of the sites (Figure 1) ranged from four, at the 200 m site in July 1994, to 17 at the 800 m site in May 1998. Analysis of the data showed that the number of invertebrate families varied significantly over time ($F_{(27,139)}$ 5.7, P<0.0001) but not between sites. The total number of invertebrate families identified along the 1000 m transect varied between nine, in April 1994, and 24, in May 1998. A polynomial regression line fitted to these data suggests that recruitment of new families to the area in which the transect is sited may be slowing.

Crustacea

Between one and six crustacean families were identified at each of the five sites (Figure 2), with the lowest numbers of families collected from the 600 m site in April and July 1995, the 800 m site in January 1996 and the 1000 m site in July 1994 and October 1995. The highest numbers of crustacean families were collected from the 200 m site in May 1999 and August 2001, the 400 m site in May 1998, the 600 m site in August 1998, 2000 and 2001, the 800 m site in August 2000 and May 2001, and the 1000 m site in August 1998 and May 2000. Analysis of the data showed that the number of crustacean families collected varied significantly over time ($F_{(27,139)}$ 8.14, P <0.0001) but not between sites. The total number of crustacean families identified along the 1000 m transect ranged from two, in April 1994, to eight, in May 2000 and August 2001. A polynomial regression line fitted to these data indicate that recruitment of crustacean families to these sites may have peaked.

Annelida

The number of annelid families found at sites along the 1000 m transect (Figure 3) ranged between two, at the 200 m site in April 1994 and January and July 1995, the 600 m site in July and October 1995, and the 1000 m site in November 1997, and eight at the 1000 m site in May 2001. Analysis of the data showed significant variation in the number of annelid families over time ($F_{(27,139)}$ 1.73, P <0.03) but not between sites. The total number of annelid families identified along the 1000 m transect varied between five, in April 1994, January, July and October 1995, and August 1996, and nine in May and August 2001. A polynomial regression line fitted to these data suggests that annelid families may still be recruiting to the area.

Mollusca

The number of molluscan families found at each of the fives sites (Figure 4) varied between none, at the 200 m site in October 1994, the 600 m site in February 1998, the 800 m site in November 1997 and the 1000 m site in November 2000, and four at the 400 m site in March 2000 and the 800 m site in May 2001. Analysis of the number of molluscan families identified at each site during each survey showed significant variation over time ($F_{(27,139)}$ 2.71, P <0.0002) and between sites ($F_{(4,139)}$ 3.998, P<0.005). Between April 1994 and November 1996 only two molluscan families were found along the 1000 m transect during each survey. After that, the number identified varied between two and five, with the highest number found in August 2000. A polynomial regression line fitted to these data suggests that recruitment of molluscan families may be ongoing.

Sediment particle size

The particle size of the sediments (Figure 5) were classified using the Wentworth scale, which expresses the grain size in phi units – the larger the phi unit the smaller the particle size of the sediments. Analysis of the data showed that the median grain size of the sediments varied significantly, both over time: ($F_{(7,39)}$ 2.95, P<0.02) and between sites ($F_{(4,39)}$ 20.30, P<0.0001). In general, sediments with a particle size of 4 phi dominated at the 400 m, 600 m, 800 m and 1000 m sites each year. At the 200 m site, however, similar quantities of sediments with a particle size of 3 and 4 phi predominated. Thus, larger sediments were usually found at the 200 m site.

Organic matter in the sediment

The amount of organic material in the sediments (Figure 6) ranged from 0.42 percent at the 400 m site in August 1996 and the 1000 m site in November 1997, to 1.58 percent at the 1000 m site in May 1998. The percentage of organic matter in the sediments varied significantly over time ($F_{(27,139)}$ 3.36, P <0.0001) but not between sites. A polynomial regression line fitted to the mean percentage of material in the sediments indicates a slight decrease in the level of organic material since surveys began.

Rainfall

Annual rainfall recorded at the Met Office Weather Station (No. 58398), Kingsgate, Kent, between 1990 and 2001 (Figure 7) ranged from 443 mm in 1996 to 852 mm in 2000. Even though annual rainfalls varied so much, they were not statistically different. Particularly high levels of rainfall in the spring and autumn of 2000 (over 200 mm in March/April and almost 400 mm in September/October/November) resulted in significant flooding along the Stour valley.

Temperature

Maximum monthly temperatures (Figure 8) recorded at the Kingsgate Met Office Weather Station (No. 58398), ranged from 9.2^{0}C in February 1993 to 31.3^{0}C in August 1995, with temperatures reaching between 30 and 31 ^{0}C in June 2000, July 1996 and 2000, and August 1990, 1998 and 2000. Analysis of the data, however, showed no significant variation in maximum monthly temperatures from year to year.

Minimum monthly temperatures (Figure 9) recorded at the Kingsgate Met Office Weather Station (No. 58398), varied between –6.5^{0}C in February 1991 and 13.5^{0}C in August 1997. In addition, temperatures dropped to –5.1^{0}C and –5.4^{0}C in January and February 1992, and between 0^{0}C and –1^{0}C in April 1990, 1991, 1992 and 1997. However, there was no significant variation in the minimum monthly temperatures recorded between 1999 and 2002.

Discussion

At the Estuarine and Coastal Shelf Science Association 'ECSA 21' symposium on Marine and Estuarine Gradients (McLusky, 1993), it was suggested that spatial, chemical, temporal and physical gradients influence the biota of estuaries, either individually or in combination, many of which are listed below.

- The particle size of the sediments
- The size of the interstitial spaces
- Bioturbation
- Turbidity
- Salinity
- Light
- Duration of submersion and emersion
- The amount of organic material present in the sediments and water column
- Invertebrate interactions (predator/prey interactions & resource competition)
- The Redox potential (Redox discontinuity layer)
- Heavy metals in the sediments
- Weather conditions
- Nutrients - P, NO_3, NO_3, Silica; Particulate Organic Carbon (POC), Particulate Inorganic Carbon (PIC)
- Organic chemicals
- Riverine and land drainage inputs

Tidal cycle

One cycle of the tide is an example of a short-term temporal gradient. Tides around Great Britain are semi-diurnal and subject to changes in amplitude related to the phase of the moon (Newell, 1972). Water levels fluctuate more on a spring tide than a neap tide; consequently they are higher and lower on a spring tide than a neap tide. Thus, periods of faunal immersion and emersion are longer during a spring tide than a neap tide and this can define the boundaries of an organism's habitat. In addition, water flows higher up the shore during a high spring tide, covering a greater expanse of land and thus immersing a greater number of organisms under water. A high spring tide in Pegwell Bay places a greater area of saltmarsh under water than a neap tide, whilst a low spring tide recedes further out to sea, exposing more of the mudflat.

Particle size of the sediments

Pegwell Bay is flat with a saltmarsh on the north/north-west side and the bed of the River Stour running across the bay from west to east. The river cuts deeply into the mudflats where it enters Pegwell Bay and then gradually rises, so that eventually it levels with the surface of the mudflat and boats are able to enter the sea.

Sediment washed down the river is eventually deposited on the bottom end of the estuary and in Pegwell Bay, gravels first, then sand, silt and finally fine clay particles. According to Rees Jones (1998), the sediments in Pegwell Bay comprise fine to very fine sands and this accords with the results reported here. Within the bay, fine surface sediments are re-suspended, moved around in the water column as the tide ebbs and flows and eventually deposited elsewhere. There is also highly visible evidence of sediment deposition around the plants on the saltmarsh. Silts and clays that have been laid down around swards of *Spartina*, have the effect of raising the level of the saltmarsh around the plant stems. During periods of stormy seas, these sediments are re-suspended in the water column and eventually deposited elsewhere.

Bioturbation

Bioturbation occurs when infauna turn over and mix the sediments, either by burrowing through it or by passing it through their guts. Crustaceans, such as *Corophium*, and molluscs, such as *Cerestoderma*, move the sediments around when they burrow down, whilst *Arenicola marina* builds permanent burrows, moving the sediment through its gut and leaving a spiral cast on the surface of the mudflat. Many such casts are visible on the mudflats of Pegwell Bay at low tide. These casts are blown level by the wind and the sediment resuspended by the incoming tide for eventual deposition in other areas of the bay.

Organic material

Although some of the macroinvertebrates living in the estuarine environment are predators, for example, the polychaetes *Nereis* and *Nephtys*, many others feed upon organic material suspended in the water column, settled on the surface of the mudflat or trapped in the sediments. Suspension feeders, such as polychaete worms from the family Sabellidae, use feathery tentacles to trap organic particulate matter suspended in the water column. Some bivalve molluscs, such as *Cerestoderma*, are filter feeders; water is drawn into the animal through the inhalent siphon and passed across gill fillaments which trap organic material suspended in the water. Other bivalves, such as *Macoma* and *Scrobicularia*, are deposit feeders, removing material that has settled on or in the sediment (Newell, 1972).

Newell (1965) and Longbottom (1968) found a logrithmic increase in the amount of organic nitrogen as the particle size of the sediments decreased. Longbottom (1968) found seasonal variation in the percentage of organic carbon in intertidal deposits from the North Kent coast. He also found there was a higher percentage of organic matter in sediments with a smaller median grain size. Sediments in Pegwell Bay consist of a high percentage of organic matter; this is an important factor in determining the abundance of deposit, suspension and filter feeding macroinvertebrates the environment can support.

Weather conditions

Temperature, precipitation, humidity, evaporation and wind all affect the environment and can have an indirect as well as a direct effect on the organisms living therein.

A long, dry summer can result in low levels of water in the aquifers and commensurably low water levels in the River Stour. In addition, a substantial volume of water is abstracted from both the groundwater and the river each year for public water supply and industrial and agricultural use (EA, 1999). Although consents are in place for effluent discharges into the River Stour, and these result in an increase in the amount of water in the river, almost 60 percent of available water can be abstracted under licence.

Maximum temperatures in excess of 25^{0}C were recorded at the Kingsgate Weather Station in June, July and August of each year, except June 1991 and 1999. Average daily temperatures in July and August of these years, however, was between 20^{0}C and 25^{0}C.

Rainfall recorded at Kingsgate in 1993 and 2000 was twice that recorded in 1996. Periods of high rainfall raised water levels in the River Stour to such an extent that localised flooding resulted. The River Stour is tidal as far upstream as Fordwich. When the river flooded in April 2000, the banks and bed of the river scoured and, as a result, high levels of sediment were carried downstream and deposited in Pegwell Bay. Following this, there was an increase in the number of invertebrate families found along the survey transect. However, it should be noted that this increse may or may not be attributable to sediment changes.

Salinity

Freshwater invertebrates have an internal salt water concentration higher than that of the surrounding environment and their hypertonic internal environment has to be maintained in some way. Conversely, the internal salt water concentration of marine invertebrates is similar to that of seawater (ie they are isotonic with seawater) which eliminates the problem of maintaining osmotic potential.

An estuarine environment is highly variable in terms of salinity and organisms living there-in can be euryhaline or stenohaline. Euryhaline organisms are osmoregulators, able to control the salt/water balance of their bodies and therefore tolerate a wide range of salinities. The shore crab, *Carcinus maenas* and the polychaete worm *Nereis* are examples of euryhaline organisms. Stenohaline organisms, such as the polychaete worms *Nephtys* and *Arenicola*, are osmoconformers, unable to regulate their salt/water balance and therefore able to live only in areas with no freshwater penetration. *Nephtys* is more often found in Pegwell Bay at sites furthest away from the shore. *Arenicola* casts are can be seen in similar numbers at all the sites, although numbers do vary according to the season. The fact that *Nephtys* and *Arenicola* are both found in Pegwell Bay suggests that the salinity of the aquatic environment is not significantly changed by freshwater entering the bay from the River Stour.

Redox potential (Redox discontinuity layer)

Oxygen diffuses from the air or overlying water across the top layer of sediment. If the sediment contains a lot of organic material, it will be relatively impermeable and oxygen will not penetrate very far. Thus the aerobic or oxic layer of sediment will be shallow and the anaerobic sediments will be close to the surface. If, however, the top layer of sediment has very little organic material, oxygen will readily diffuse through to a greater depth and the anaerobic or anoxic layer will be found further down. The depth of the aerobic layer at sites along the 1000 m transect in Pegwell Bay varies according to the time of year and prevailing weather conditions.

Nutrients

To date, quantification of nutrients, such as phosphate, nitrate and nitrite, in Pegwell Bay has not formed part of the research protocol. However, this is now the subject of a PhD which is investigating the relationship between nutrients and the growth of macroalgae around the south east coast, from Reculver to Deal.

Conclusions

There has been a steady increase in the number of invertebrate families along the 1000 m transect in Pegwell Bay but this appears to be levelling off over time. There is a similar trend in the numbers of crustacean families, whilst the number of annelid and molluscan families continues to increase. The particle size of the sediments appears to be increasing slightly whilst the percentage of organic matter in the sediments has decreased over time and appears to have stabilised.

Because the factors affecting invertebrate diversity and abundance in estuaries are many and varied, it is not possible to state with certainty whether the increases so far seen will continue. Spatial, temporal, physical and chemical gradients of the Stour Estuary may mean that the carrying capacity of the system, in relation to invertebrate species and numbers has been reached. However, because these gradients are in a state of constant flux, the carrying capacity of the system could change, but that change may be upward *or* downward.

References

BARNES, R.S.K. & HUGHES, R.N., 1988. *An introduction to marine ecology*. Second edition, Blackwell Scientific.

ENVIRONMENT AGENCY, 1999. *Local Environment Agency plan: Kentish Stour environmental overview.*

FAIRBRIDGE R.W., 1980. The estuary; its definition and geochemical role. *In* Olausson E. and Cato I. (eds.) *Chemistry and Biogeochemistry of Estuaries.* New York: Wiley.

LONGBOTTOM M.R., 1968. *Nutritional factors affecting the distribution of* Arenicola marina *L*. PhD Thesis, University of London.

McLUSKY, D.S., 1993. Marine and estuarine gradients – an overview. *Netherlands Journal of Aquatic Ecology*, **27**(2-4), pp. 489-493.

NEWELL, R.C., 1967. The role of detritus in the nutrition of two marine deposit-feeders, the prosobranch *Hydrobia ulvae* and the bivalve *Macoma balthica*. *Proceedings of the Zoological Society of London*, **144**, pp. 25-45.

NEWELL R.C., 1972. *Biology of intertidal animals*. Second edition. Paul Elek (Scientific Books) Limited, Great Britain.

PRITCHARD, D.W., 1967. What is an estuary: Physical viewpoint. *In*: Lauff, G.H. (ed.) *Estuaries*. American Association for the Advancement of Science, **83**, pp. 3-5.

REES JONES, S., 1998. *An investigation of the environmental impact of a new waste water treatment scheme on the ecology of the Stour Estuary, Kent.* PhD Thesis, University of Kent at Canterbury.

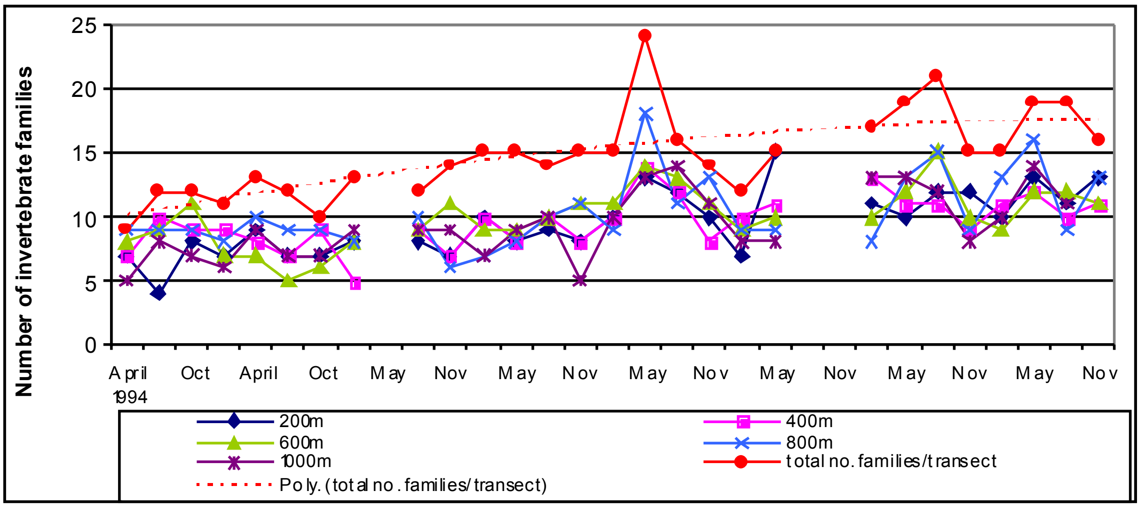

Figure 1 Total number of invertebrate families
Total numbers of invertebrate families found at each of the five sites along the 1000 m transect, together with the total number of families identified along the transect.

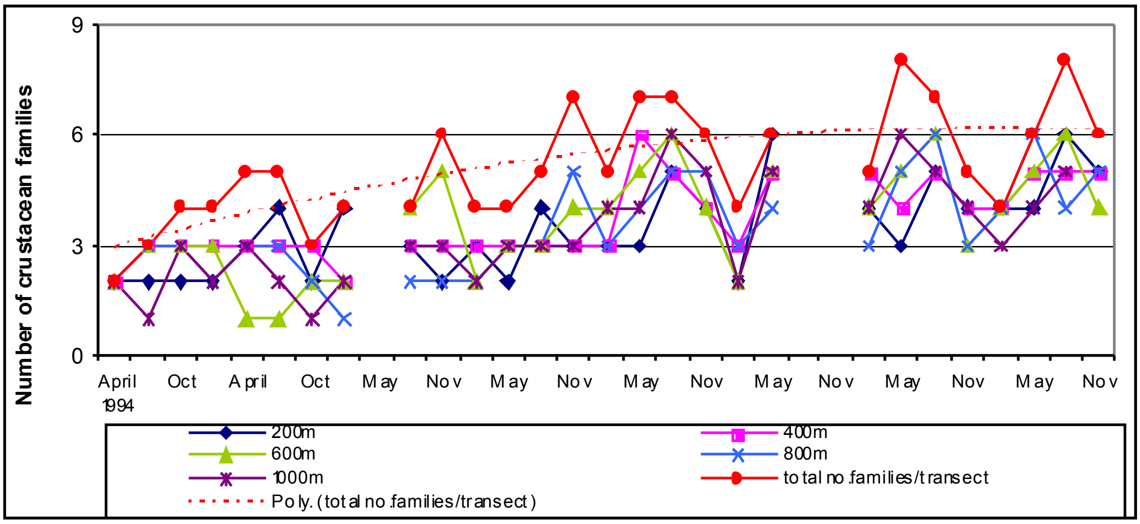

Figure 2 Number of crustacean families
The number of crustacean families found at each of the five sites along the 1000 m transect, together with the total number crustacean families identified along the transect.

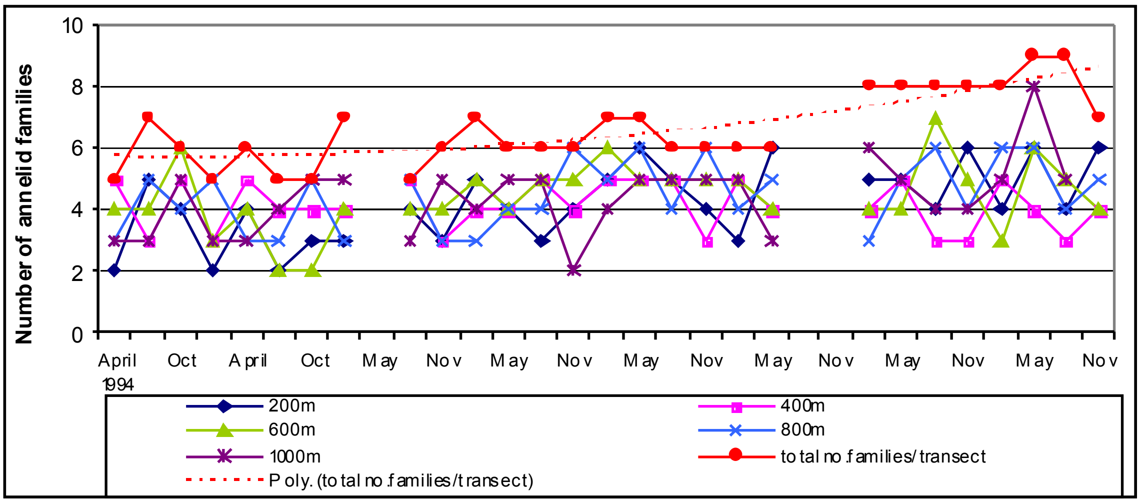

Figure 3 Number of annelid families
Figure 3. The number of annelid families found at each of the five sites along the 1000 m transect, together with the total number annelid families identified along the transect.

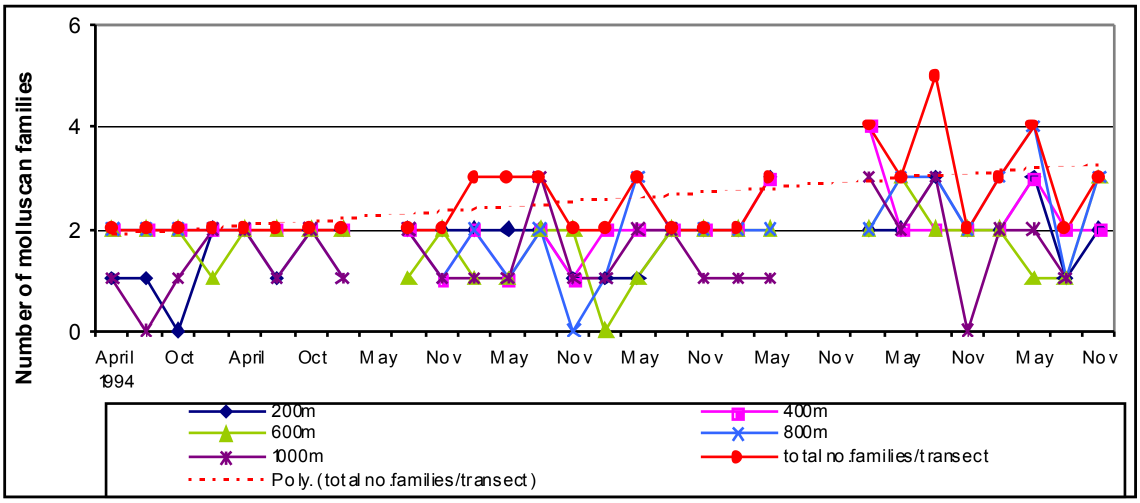

Figure 4 Number of molluscan families

Figure 4. The number of molluscan families found at each of the five sites along the 1000 m transect, together with the total number molluscan families identified along the transect.

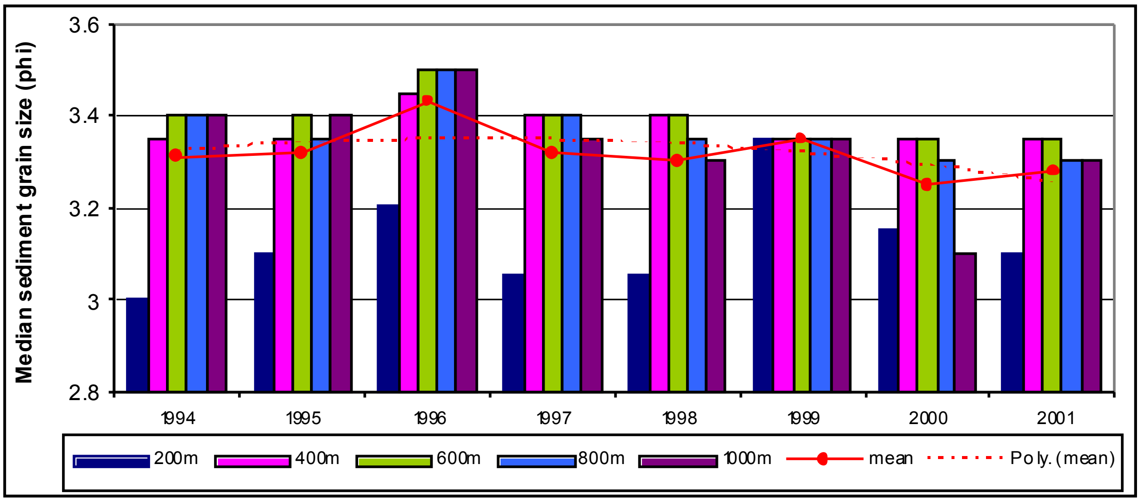

Figure 5 Sediment particle size

Figure 5. The median particle size of the sediments, expressed as phi units, at each site, together with the mean median particle size of the sediment along the 1000 m transect.

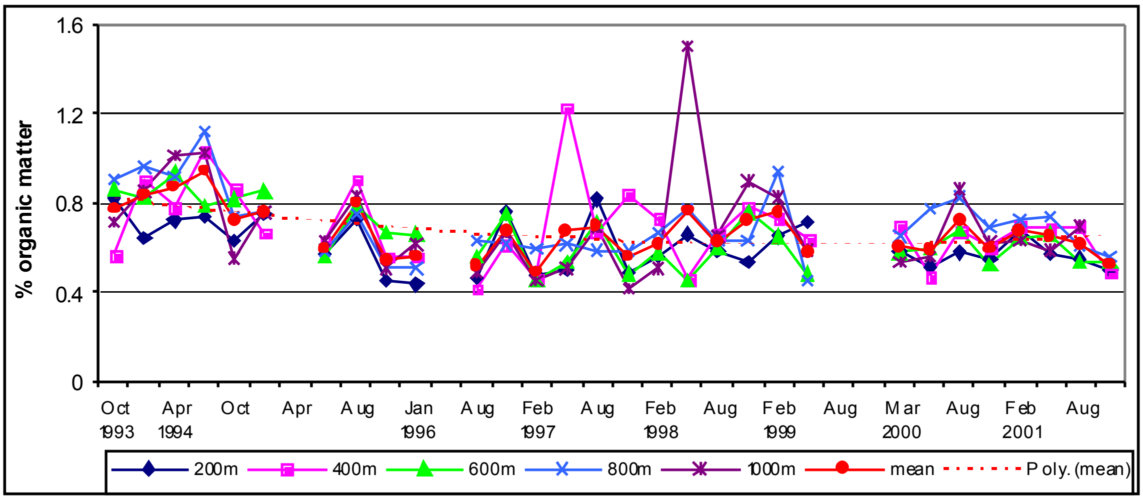

Figure 6 % organic material in the sediments

Figure 6.The percentage of organic matter in the sediments at each site together with the mean percentage of organic matter along the 1000 m transect.

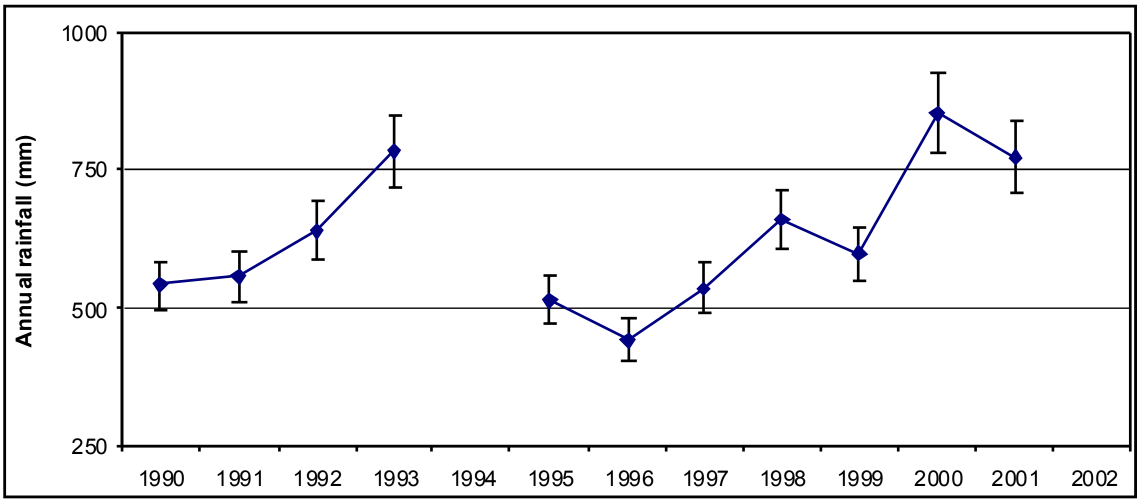

Figure 7 Annual rainfall

Figure 7.Total annual rainfall recorded at the Met Office Weather Station (No. 58398), Kingsgate, Kent, between 1990 and 2002.

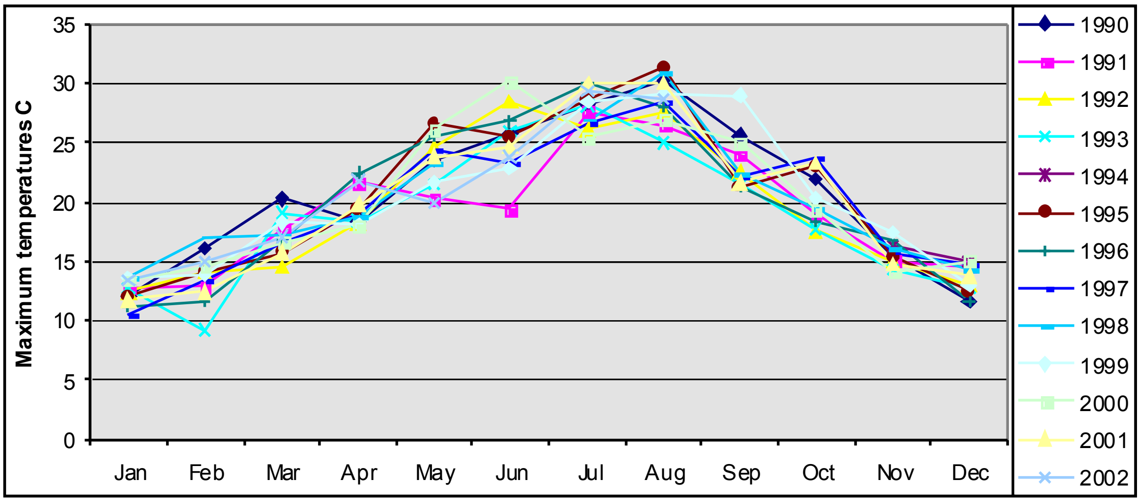

Figure 8 Maximum monthly air temperature

Figure 8. Maximum monthly temperatures recorded at the Met Office Weather Station (No. 58398), Kingsgate, Kent, between 1990 and 2002.

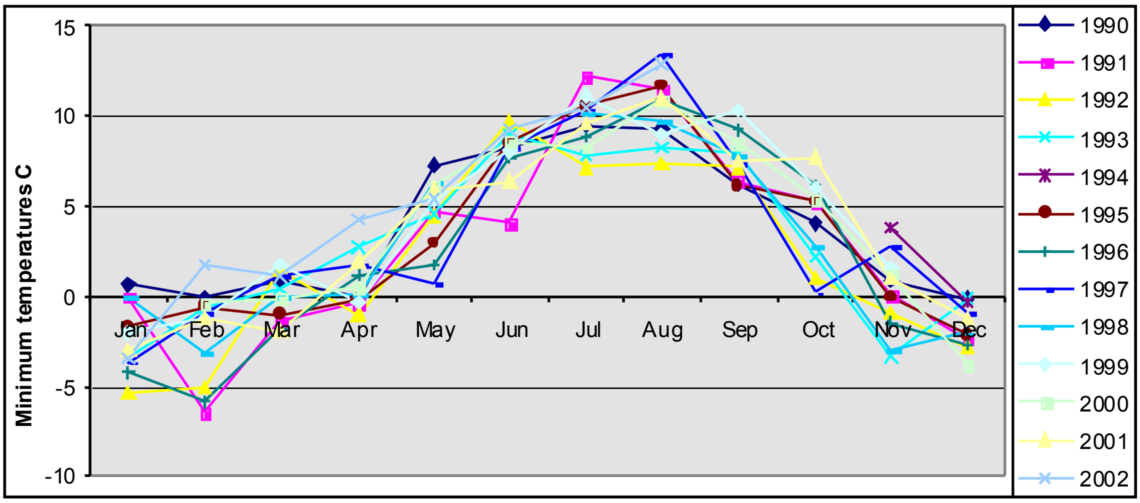

Figure 9 Minimum monthly air temperature

Figure 9. Minimum monthly temperatures recorded at the Met Office Weather Station (No. 58398), Kingsgate, Kent, between 1990 and 2002.

The effects of human activity on turnstones and other wading birds within the Thanet and Sandwich Bay Special Protection Area (SPA)

Kevin Webb
Sandwich Bay Bird Observatory, Guilford Road, Sandwich CT13 9PF

Aims of the research

This research project funded by English Nature sought to investigate four main issues affecting Turnstone populations in the Isle of Thanet and Sandwich Bay SPA:

- what Turnstones require in an over-wintering site;
- measures to protect Turnstones and other waders that regularly return to Thanet;
- are Turnstones struggling to survive on Thanet?
- the effects of human activity on Turnstones and other wading birds.

Background

Turnstones are an important component of Thanet wading bird populations because:

- Thanet has the mildest winter weather in Britain,
- there is a good food supply,
- it is a longstanding wintering site,
- it lies within the East Atlantic flyway.

Turnstones breed in Canada, spend the winter on the same beach each year, eat shellfish, crabs, bread and carrion, and live 15-25 years.

Wading bird use of the Thanet coast

Co-ordinated wader count

Large-scale counts using 36 volunteers were undertaken on three occasions (25 February 2001, 3 March 2002, 2 March 2003). The SPA was divided into short sections and a volunteer counter was assigned to each. Counting began half an hour before high tide and all birds present in the sector were counted. All bird movements into or out of the sector were also recorded to ensure that none were counted twice. The results are given in Tables 1 and 2. Overall Turnstone numbers differed little, with 1201 counted in 2002 compared to 1231 previously.

Table 1. Results of the co-ordinated wader count on 3 March 2002.

	Sector																					
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Total
Turnstone	66	14	0	7	12	79	41	18	86	51	5	93	19	366	28	103	33	50	2	4	154	1231
Sanderling	24	0	0	6	5	137	34	0	25	58	0	49	0	35	0	0	6	0	0	0	25	404
Redshank	0	0	0	0	0	6	0	0	22	47	1	3	12	404	0	0	0	10	2	16	2	525
Curlew	0	0	0	0	41	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	59
Oystercatcher	0	0	0	0	143	214	0	0	0	0	0	0	0	261	0	0	0	0	0	0	110	728
Purple Sandpiper	0	0	0	2	1	14	0	0	0	0	0	0	0	3	0	0	0	1	0	2	0	23
Grey Plover	0	0	0	0	0	44	0	0	0	0	0	0	0	54	0	0	0	0	0	1	40	139
Ringed Plover	0	0	0	0	0	16	0	0	0	3	0	0	2	100	0	0	3	0	0	0	27	151
Knot	0	0	0	0	0	0	0	0	0	0	0	0	0	45	0	0	0	0	0	0	25	70
Dunlin	0	0	0	0	0	0	0	0	1	0	0	0	5	488	0	0	0	6	0	0	276	776
Spotted Redshank	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Fulmar	9	6	0	1	2	17	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	37
Rock Pipit	1	0	0	0	0	2	5	1	2	3	1	3	2	3	2	5	0	0	0	0	1	31
Black Redstart	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total	100	20	0	16	204	547	81	19	136	162	9	148	40	1760	30	108	42	67	4	23	660	4176

The co-ordinated wader count undertaken on 2 March 2003 (Table 2) was as previously in favourable weather conditions with the coastline busy with people. In March 2003 more Turnstones were recorded than in the two previous counts (1261 compared to 1201 in 2002 and 1231 in 2001). The total number of wading birds recorded in 2003 was higher than in previously (Table 3). All species counted, apart from Knot, Grey Plover and Spotted Redshank, occurred in greater numbers in 2003 (Table 4). The distribution of all species around Thanet including turnstones is similar for each of the three years sampled (Figs 1, 2); site 14 consistently supported the largest number of roosting birds with three times as many recorded at site 6 the next most populous.

Table 2. Results of the co-ordinated wader count on 2 March 2003.

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Total
Turnstone	171	11	3	0	31	157	37	0	53	74	0	65	19	278	39	82	0	70	0	136	35	1261
Sanderling	11	3	0	0	31	140	0	0	29	72	0	15	32	98	0	17	0	25	0	0	14	487
Redshank	4	0	0	0	0	41	0	0	6	32	0	39	0	278	0	154	0	26	0	86	0	666
Curlew	0	0	0	0	53	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	69
Oystercatcher	0	0	0	0	110	189	0	0	0	0	0	0	0	320	0	132	0	0	0	0	0	751
Purple Sandpiper	0	1	0	1	6	39	0	0	0	0	0	0	0	0	0	0	0	6	0	0	4	57
Grey Plover	0	0	0	0	0	37	0	0	0	0	0	0	0	55	0	0	0	0	0	14	0	106
Ringed Plover	2	0	0	0	2	36	0	0	0	2	0	0	2	87	0	4	5	0	0	2	28	170
Knot	0	0	0	0	0	0	0	0	0	0	0	0	0	49	0	0	0	0	0	15	0	64
Dunlin	0	0	0	0	0	36	0	0	0	11	0	0	0	620	0	0	0	0	0	183	0	850
Spotted Redshank	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fulmar	5	9	0	2	2	13	0	0	4	0	3	16	0	0	0	0	0	0	0	0	0	54
Rock Pipit	3	1	2	0	0	1	3	1	1	0	0	2	2	2	2	5	2	1	0	1	1	30
Black Redstart	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Total	196	26	5	3	235	689	42	1	93	191	3	137	55	1803	41	394	7	128	0	437	82	4568

Table 3. Distribution of Turnstones in the SPA 2001-2003.

	Sector																					
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
2001	66	14	0	7	12	79	41	18	86	51	5	93	19	366	28	103	33	50	2	4	154	1231
2002	165	2	0	0	0	131	38	2	28	6	56	0	100	309	76	14	0	4	26	225	19	1201
2003	171	11	3	0	31	157	37	0	53	74	0	65	19	278	39	82	0	70	0	136	35	1261

Table 4. Numbers of wading bird species counted in the SPA 2001-2003.

Species	2001	2002	2003
Turnstone	1231	1201	1261
Sanderling	404	326	487
Redshank	525	614	666
Curlew	59	40	69
Oystercatcher	728	642	751
Purple Sandpiper	23	56	57
Grey Plover	139	106	106
Ringed Plover	151	139	170
Knot	70	11	64
Dunlin	776	613	850
Spotted Redshank	1	1	0

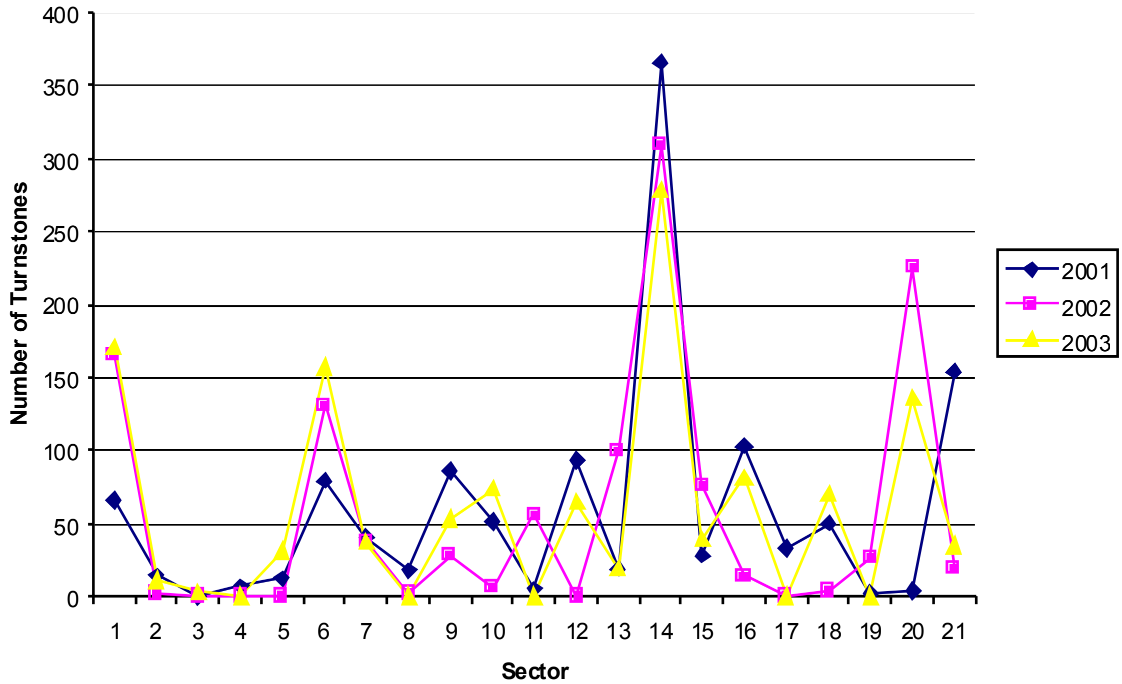

Figure 1. Distribution of Turnstones in the SPA 2001-3.

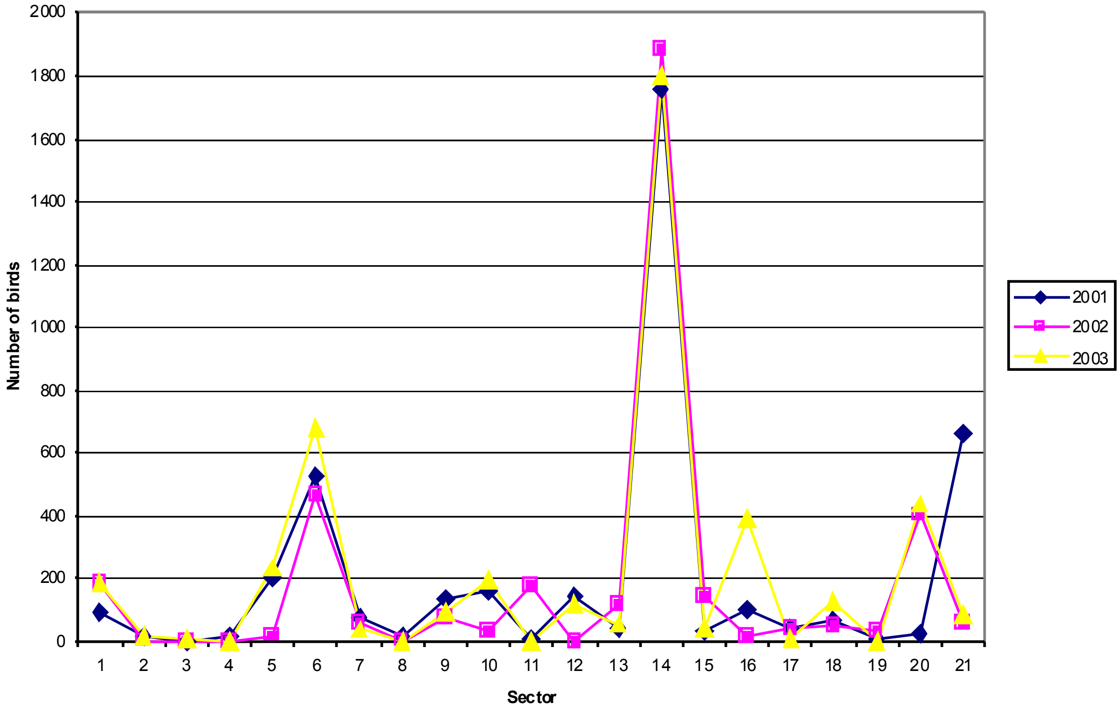

Figure 2. Distribution of wading birds in the SPA 2001-3.

Turnstone studies

Roost sites

All roost sites located in 2001 were monitored throughout the winter of 2002 together new sites that were utilised more regularly in 2002. As in 2001, roost sites were assigned primary, secondary or occasional status according to the level of use (primary >70% use; secondary 30 – 69% use; occasional <30% use). A description of each roost site within the SPA is given in Appendix 1.

More time was spent in winter 2002 observing roosting Turnstones at large to small roost sites and Margate main roost was observed in greatest detail. Turnstones arrived early at a roost site two and a half hours before high tide for the following reasons:

- good feeding opportunities at or close to the roost site (often strand-line or rotting weed exploitation);
- regular disturbance at their feeding beaches;
- inclement weather;
- good feeding during the previous low tide period.

The behaviour of Turnstones at a roost site is determined by:

- species composition; roosts with large numbers of Curlew, Oystercatcher, Dunlin, Redshank, Grey-Plover are more easily disturbed by human activity than those dominated by Turnstone or Sanderling;

- inclement weather (rain, strong wind, prolonged cold) causing roosts to be more stable due to the greater degree of tolerance shown to human activity by Turnstones in poor weather;
- proximity to human activity; Turnstones at roost sites closer to human activity are more tolerant to disturbance than those further away. For example, Turnstones roosting on Margate harbour slipway will tolerate a steady stream of people walking by at a distance of less than ten metres whilst at Kingsgate Bay a single person approaching the edge of the cliff will disturb roosting Turnstones 40 metres away.

The number of Turnstones using a roost site is also affected by:

- wind direction, a site is more likely to be used if there is a degree of shelter from prevailing wind; winds from the north or the east tend to produce large concentrations of birds in the few roosts that provide adequate shelter;
- night, and when human activity is low on the foreshore, Turnstones will roost in small groups spread regularly around the coast. Greater levels of disturbance to small roosts affect the number of birds joining a large roost;
- time of year; in September, October and November roosts are smaller and more evenly distributed while in December and the first months of the new year there are fewer large roosts.

Study beaches and turnstone prey

Sixteen study and eight control beaches were selected for an investigation of Turnstone prey. At these sites invertebrates and algae were identified and their abundance assessed in order to produce a predictive index of prey abundance. Sites were visited once a month at low tide, and plants and animals were recorded in a $50cm^2$ quadrat thrown at ten metre intervals from the low tide up. A summary of results for 2002 is given in Table 5. Initial results identified important prey items to include the edible periwinkle *Littorina littorea*, rough periwinkle *Littorina saxatilis*, common mussel *Mytilus edulis*, shore crab *Carcinus maenas* and various species of worm. At several locations at least two species of barnacle (*Balanus balanus* and *Semibalanus balanus*) existed in good numbers (most commonly on concrete sea defences).

Table 5.Turnstone prey items (based on a monthly observation at each of the study beaches).

Site/Species	Shore Crab	Winkle sp	Barnacle sp	Rockworm	Common Mussel	Limpet sp	Shrimp sp
Pegwell Bay		✔✔			✔✔		✔✔
Ramsgate main beach		✔	✔		✔	✔	✔
Dumpton Bay	✔	✔✔✔	✔✔	✔	✔✔	✔	✔✔
Viking Bay	✔	✔✔✔	✔✔	✔✔	✔✔✔	✔✔	✔✔
Joss Bay	✔	✔	✔		✔	✔	✔
Kingsgate Bay	✔	✔✔✔	✔✔	✔✔✔	✔✔✔	✔	✔✔
Whiteness Bay	✔	✔✔✔	✔✔	✔✔	✔✔	✔✔	✔✔
Botany Bay		✔✔✔	✔	✔	✔✔✔	✔	✔✔
Palm Bay	✔	✔✔✔	✔✔	✔✔✔	✔✔	✔✔	✔✔
Margate main beach							
Westbrook Bay	✔	✔✔✔	✔✔	✔✔✔	✔✔	✔	✔✔
St Mildreds Bay	✔	✔✔✔	✔✔	✔✔	✔✔	✔	✔✔✔
Westgate Bay	✔	✔✔✔	✔✔	✔✔✔	✔✔✔	✔	✔
Epple Bay	✔	✔✔✔	✔✔	✔✔✔	✔✔		✔✔✔
Grenham Bay	✔	✔✔✔	✔✔	✔✔✔	✔✔	✔✔	✔✔
Minnis Bay		✔	✔	✔	✔	✔	✔

Site/Species	Shore Crab	Winkle sp	Barnacle sp	Rockworm	Common Mussel	Limpet sp	Shrimp sp
Plumpudding Island			✔	✔	✔	✔	✔
Coldharbour			✔	✔		✔	✔
Reculver West		✔	✔	✔	✔	✔	✔
Hampton Pier	✔	✔✔✔	✔✔	✔✔	✔✔	✔✔	✔✔
Long Rock	✔	✔	✔	✔	✔	✔	✔

Blank = Present in 0 – 25% of quadrats; ✔ = Present in 26 – 50% of quadrats; ✔✔ = Present in 51 – 75% of quadrats; ✔✔✔ = Present in 76 – 100% of quadrats.

Disturbance studies

Effects of human activity

The ranking system developed in 2001 was used in 2002. This applied an arbitrary score to the different types of human activity (Table 6).

Table 6. Ranking system for assessing human disturbance on turnstone behaviour.

Rank	Turnstone behaviour
0	No discernible effect on Turnstones normal behaviour.
1	Increased vigilance, but no movement away from human activity. Feeding of majority of group normal.
2	Considerable increase in vigilance throughout group, combined with walking movement away from human activity. Feeding rate decreased significantly from normal.
3	Considerable increase in vigilance, followed by short flight, (or flights) of some of the birds away from the human activity. Feeding only occasional.
4	Considerable increase in vigilance, combined with whole flock taking flight and moving a short distance away from the human activity. Distance moved less than 100m.
5	Whole group vigilant and flock forced to move considerable distance out of the way of the human activity. Distance moved usually in excess of 100m.

In 2002, 1129 human activity events were observed and each assigned a rank. The results of this compared with 2001 are shown in Table 7.

Table 7. The mean rank assigned to the main types of human disturbance in the SPA.

Type of human activity	Number of observations		Mean rank (0 – 5)	
	2001	2002	2001	2002
Dog walking within intertidal zone.	198	352	4.6	4.7
Dog walking above intertidal zone.	76	153	2.8	2.3
Walking within intertidal zone. *	81	103	3.1	2.9
Walking above intertidal zone.	155	271	0.8	0.9
Cycling above intertidal zone.	66	95	0.8	0.8
Bait digging.	22	62	1.3	1.0
Shore fishing.	3	25	1.0	1.3
Jet skiing.	7	21	2.0	2.4
Sailing / Windsurfing.	5	8	1.2	2.5
Kite boarding / Carting. **	17	39	4.3	2.0

*Includes activities such as shellfish harvesting crab collection and beach combing as well as walking for recreation.
** Incidences of kite boarding using a cart on dry land also included. Only activities in direct proximity to the coastal zone are included (includes grassed area above Palm Bay).

Seasonal observations of human – Turnstone interactions were refined further to allow a more detailed assessment of the effects of different disturbance activities. In addition, high-ranking activities were targeted to see if a minority of activity was causing high ranks to be scored overall. The results of this study are summarised in Table 8.

Table 8. The mean rank assigned to the main types of human activity in the SPA in 2002.

Type of human activity	Number of observations	Mean rank (0 – 5)
Dog walking within intertidal zone[1].	133	5
Dog walking within intertidal zone[2].	219	4.2
Dog walking above intertidal zone[1].	45	1.3
Dog walking above intertidal zone[2].	108	2.7
Walking within intertidal zone.	86	2.8
Walking above intertidal zone.	203	0.9
Jogging above intertidal zone.	68	0.4
Cycling above intertidal zone.	95	0.8
Shellfish/crab harvesting.	17	3.1
Bait digging.	62	1.0
Shore fishing.	25	1.3
Jet skiing.	21	2.4
Sailing / Windsurfing.	8	2.5
Kite boarding / Carting[1].	4	5
Kite boarding / Carting[2].	35	0.5

Dog walking within intertidal zone[1] = Dog actively pursuing turnstones.
Dog walking within intertidal zone[2] = Dog not actively pursuing turnstones.
Dog walking above intertidal zone[1] = Dog on lead (including extendable long lead).
Dog walking above intertidal zone[2] = Dog off of lead.
Kite boarding / Carting[1] = Activity taking place within the intertidal zone.
Kite boarding / Carting[2] = Activity taking place well outside the intertidal zone (eg Palm Bay cliff top).

In 2002 dog walking, especially within the intertidal zone, was the main cause of disturbance to both feeding and roosting turnstones. The only activities to score a 5 disturbance score were cart boarding within the intertidal zone (four incidents in the period of observation), and dog walking events where birds were actively pursued by dogs (133 incidents representing 12% of all human-Turnstone interactions).

The effect of human activity varied according to weather, tide, month of the year and day of the week. Tide was considered to be the most important single variable that would affect the behaviour of the Turnstones when encountering human activity and was selected for investigation. All sixteen study beaches and control beaches were divided into three equal sections related to high, medium and low tide levels (measurements were taken from the mean low tide line to the mean high tide line). Individual observation events were scored for each zone. Table 9 shows the results of this study. Mean rank was calculated as in Table 8.

Table 9. Mean rank assigned to the main types of human activity at three tidal levels and all interactions totalled within the SPA in 2002.

Type of human activity	No. of observations	High tide mean rank	Medium tide mean rank	Low tide mean rank	Mean rank (0 – 5)
Dog walking within intertidal zone¹	133	5	5	5	5
Dog walking within intertidal zone²	219	5	4.2	3.1	4.2
Dog walking above intertidal zone¹	45	1.4	1.3	1.1	1.3
Dog walking above intertidal zone²	108	4.7	2.3	0.8	2.7
Walking within intertidal zone.	86	4.1	3	1.6	2.8
Walking above intertidal zone	203	1.3	0.8	0.4	0.9
Jogging above intertidal zone	68	1	0.1	0	0.4
Cycling above intertidal zone	95	2.1	0.4	0	0.8
Shellfish/crab harvesting	17	0#	3.3	3.0	3.1
Bait digging	62	0#	1.3	0.9	1.0
Shore fishing	25	1.4	1.1	0#	1.3
Jet skiing	21	2.7	2.3	2	2.4
Sailing / Windsurfing	8	3	2	0#	2.5
Kite boarding / Carting¹	4	0#	0#	5	5
Kite boarding / Carting²	35	1.1	0.4	0	0.5

Dog walking within intertidal zone¹ = Dog actively pursuing turnstones.
Dog walking within intertidal zone² = Dog not actively pursuing turnstones.
Dog walking above intertidal zone¹ = Dog on lead (including extendable long lead).
Dog walking above intertidal zone² = Dog off of lead.
Kite boarding / Carting¹ = Activity taking place within the intertidal zone.
Kite boarding / Carting² = Activity taking place well outside the intertidal zone (eg Palm Bay cliff top).
0# represents no data being gathered for this activity at this particular tidal state.

All human activities scored a higher disturbance rank at high rather than at medium and low tide levels. The main exception was dog-walking in which the dog was seen to actively pursue birds, and this scored the highest possible rank at all tide states. The study suggested that the most critical time for Turnstones is during the high tide period when safe roost sites are required.

Turnstone condition

Colour-ringing and body condition

In 2001-2 75 Turnstones were colour-ringed (a total of 89 over two years). Of those ringed seventy-six have been re-sighted. 70 birds have been seen on more than three occasions after ringing and 43 were re-sighted on more than 10 occasions. One of the 12 individuals colour-ringed during 2000-1 was observed on 16 September 2002 near Durham (presumably returning to Thanet). All Turnstones fitted with colour-rings had departed Thanet by 15 April (the last sighting of a colour-ringed individual was on the 14 April, roosting in Margate harbour). Turnstones were however present throughout April and May. The origin of these birds is unclear, they possibly represent individuals from the Thanet population and/or others that had wintered further south and were using Thanet as a staging post on their way north.

All birds caught and colour-ringed were weighed (using digital balances correct to 0.1g) and physical measurements were taken including fat and muscle scores (fat is scored on a scale from 0 – 8 with 0 being no fat and eight being complete body fat coverage. Breast muscle is scored on a scale from 0 – 3 with 0 being close to starvation and 3 being full pre-migration muscle). The scoring systems follow the protocol set out by the 1998 European Songbird Foundation (ESF) and all scores were assigned by this author to ensure continuity. Every Turnstone measured scored either 0 or 1 for breast muscle. Apart from three individuals (with scores of 2) Turnstones scored a 0 or 1 for fat. This was a cause for concern, particularly at pre-migration time when both fat and muscle scores would be expected to be higher. Turnstone weights reflected this apparent lack of fat and muscle and were lower than expected. Compared with a sample of eighty turnstones from a similar spread of ringing dates close to Aberdeen from 1992 – 1995, weights were lower in Thanet (Aberdeen mean weight 103.7g; Thanet mean weight 77.4g). Although this provides no firm evidence of Turnstones struggling to survive on Thanet, it suggested a possible problem. As further data is being gathered from other Turnstone ringing projects in the U.K., a full comparison with other sites has not been done.

In 2002-3 another 51 turnstones were colour-ringed making a total of 138 for the project. All newly ringed birds have been subsequently re-sighted. In 2003 turnstones were again weighed and checked for the condition of breast muscle and amount of visible body fat. Mean weights were up on the previous year (2002 - 77.4g; 2003 – 89.7g). Reasons for this are at present unclear. Body fat and breast muscle were also higher with almost 50% of individuals scoring 2 compared to only three birds scoring 2 previously. This remains low compared with the sample of 80 birds weighed between 1992 and 1995 near Aberdeen (103.7g). The difference may be explained by differences in climate and exposure at the two sites.

Turnstone conservation

Protection initiatives

In 2001-2 initiatives were introduced to reduce the impact of human activity on Turnstones at roost and whilst feeding. Public (beach-user) awareness was heightened by, (i) a poster campaign in Thanet that indicated the international importance of the coastline for Turnstones and the need to keep disturbance to a minimum, (ii) an article published in a local newspaper, and (iii) information leaflets. A low fence was erected to protect one of the largest and most regular Turnstone roost sites on Margate main beach and signboards requested the public to avoid the area at high tide when the birds were roosting. Signboards were also placed by another regular roost site at Kingsgate Bay also requesting the area to be avoided at high tide. In an endeavour to encourage roosting, sites at Westgate Bay and the old “Lido” area to the east of Margate harbour (hitherto not regularly used by roosting Turnstones) were fenced off and the reasons for this explained on sign-boards. Unfortunately, none of these measures were effective. Posters were largely ignored and the fence on Margate main beach was erected in the wrong place! The fenced sites at Westgate and the Lido were also not successful in attracting roosting Turnstones. Voluntary codes of conduct for beach users are under development with the help of user-groups and their effectiveness will be reviewed in the future.

In the winter of 2002-3 measures were introduced to prevent disturbance to roosting waders. Signs were displayed by the Thanet Coastal Wildlife Project (TCWP) at most of the important roost sites requesting the avoidance of selected areas around high tide level. In addition, two part-time wardens were recruited by the TCWP to patrol the coastline close to established wader roosts to talk to people and request their avoidance of areas at high tide and at night, to allow the birds to roost undisturbed. Coastal Codes of Conduct Leaflets were distributed widely. These measures aimed at improving public awareness of roosting birds; subsequent studies on disturbance have indicated a reduction at some roost sites.

Disturbance during maintenance and building work near the coast

The study has also taken the opportunity to observe the effects on Turnstone populations of building and heavy machinery operation close to the foreshore. The following general recommendations may help avoid unnecessary disturbance to Turnstones but every potential disturbance event merits specific appraisal.

- Activity within one hundred metres of a turnstone roost site be avoided during an hour and a half before and a half hour period after high tide.
- Activity be avoided during the hours of darkness within one hundred metres of a Turnstone roost site.
- Irregular activity (noise or movement) be avoided. For example ongoing drilling work in Margate harbour disturbed the Turnstones very little whilst brief lighting maintenance work to the east of Margate harbour displaced all of the local birds for the duration of the activity.
- Avoid activity during periods of prolonged cold weather within one hundred metres of a turnstone roost site for two and a half hours before and one hour after high tide.

Conclusions

Conclusions that can be drawn from three years of study are:

- Dog walking has the greatest cumulative negative effect on Turnstones within the Thanet SPA.
- Different types of dog walking have very different effects on the Turnstones.
- Although walking within the intertidal zone has an effect on Turnstones it represents only 7.7% of activity recorded compared to 44.7% for dog walking.
- Human activity at higher tide states has a greater effect on Turnstones than at medium and low tide states.
- The availability of regularly spaced safe roost sites is the most important consideration when planning conservation measures for Turnstones in the SPA.

Appendix. Descriptions of roost sites

- **Pegwell Bay** – Turnstones roost at the northern end of the hover port on the large flat rocks. When disturbed they occasionally use the beach on the western end of the undercliff instead.
- **Ramsgate Main Beach** – Birds use either end of the available exposed beach depending on prevailing wind direction and disturbance. Occasionally birds move into the harbour to roost on various parts of the breakwater.
- **Dumpton Bay** – Birds use either end of the available exposed beach depending on prevailing wind direction and disturbance.
- **Viking Bay** – Birds use either end of the available exposed beach depending on prevailing wind direction and disturbance. The southern end is favoured if not disturbed.
- **Joss Bay** - Birds use either end of the available exposed beach depending on prevailing wind direction and disturbance. The southern end is favoured if not disturbed.
- **Kingsgate Bay** - Birds use either end of the available exposed beach depending on prevailing wind direction and disturbance. The southern end is favoured if not disturbed.
- **Whiteness Bay** – Birds use all of this small beach, especially when disturbed from Kingsgate and Botany Bay North.
- **Botany Bay South** - Birds use either end of the available exposed beach depending on prevailing wind direction and disturbance. The southern end is favoured if not disturbed. This beach is cut off at high tide so disturbance is generally minimal.
- **Botany Bay North** - Birds use either end of the available exposed beach depending on prevailing wind direction and disturbance. The southern end is favoured if not disturbed. This is a very busy public beach and is rarely used by birds for roosting.
- **Foreness Point** – Birds roost immediately to the east of the pumping station either on the beach under the cliffs or on the concrete foundations of the pumping station.
- **Palm Bay** – A complicated roost site with the entire length from the west of Foreness Point to the eastern end with the café and Jet Ski concession. Birds favour the eastern bay where disturbance allows but also regularly use the promenade at the western end of the long bay.
- **Margate Main Beach** – Another complicated roost site. The slipway within the harbour, and the eastern end of the main beach underneath the promenade are both regularly used depending on weather, time of year and disturbance. In addition the pier is used as a backup roost site when considerable disturbance occurs.
- **Westbrook Bay** - Birds use either end of the available exposed beach depending on prevailing wind direction and disturbance. The eastern end is favoured if not disturbed. Birds also use the sea defence rocks that are positioned just to the east of the old sea bathing hospital underneath "Leisuretime" when disturbed from either Westbrook or Margate.
- **St Mildreds Bay** – Birds use any of the available groynes or the small amounts of available beach between depending on disturbance.

- **Westgate Bay** – Birds favour the large slipway situated just west of the middle of this bay. The slipway situated towards the eastern end of the bay is used as a backup in case of disturbance.
- **Epple Bay** – Birds use the brick built sea defence at the western end of the bay. When disturbed they can utilise the first section of isolated sea defence immediately to the west of the bay below the cliff.
- **Grenham Bay** – Birds use this site during neap tides when beach is exposed. The beach is small and all can be utilised depending on disturbance. This site also acts as the first stop for birds leaving the large Plumpudding Island roost to the east.
- **Minnis Bay** – Birds favour the western end of the bay where they either sit on the promenade or on the beach between the large wooden groyne and the rocks at the western end of the bay.
- **Plumpudding Island** – Birds gather on and just below the ridge of the beach on the seaward side of the brackish lagoon. Small groups of birds roost all along this stretch of beach from Minnis Bay in the east to Reculver in the west.
- **Coldharbour** - Birds gather on and just below the ridge of the beach on the seaward side of the brackish lagoon.
- **Hampton Pier** – Birds roost on the rocks along the side of the road running inland in direct line with the pier. Birds also use the beach to the west for high tide feeding or when disturbed from the rocks.
- **Long Rock Swalecliffe** – Birds roost on either side of the large spit, which sticks out into the sea to the north.

Small parties of roosting birds are likely to be encountered anywhere within the SPA. Regular disturbance of roosting birds has probably forced the birds that inhabit this area to be very adaptable and utilise many different sites on different days.

English Nature is the Government agency that champions the conservation of wildlife and geology throughout England.

This is one of a range of publications published by:
External Relations Team
English Nature
Northminster House
Peterborough PE1 1UA

www.english-nature.org.uk

Cover printed on Character Express, post consumer waste paper, ECF.

ISSN 0967-876X

Cover designed and printed by Status Design & Advertising, 2M, 5M, 5M.

Front cover photographs:
Top left: Using a home-made moth trap.
Peter Wakely/English Nature 17,396
Middle left: Co_2 experiment at Roudsea Wood and Mosses NNR, Lancashire.
Peter Wakely/English Nature 21,792
Bottom left: Radio tracking a hare on Pawlett Hams, Somerset.
Paul Glendell/English Nature 23,020
Main: Identifying moths caught in a moth trap at Ham Wall NNR, Somerset.
Paul Glendell/English Nature 24,888

Awarded for excellence