# *Investigation into the macro-algae community of Pegwell Bay*

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## *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 20$^{th}$ 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.

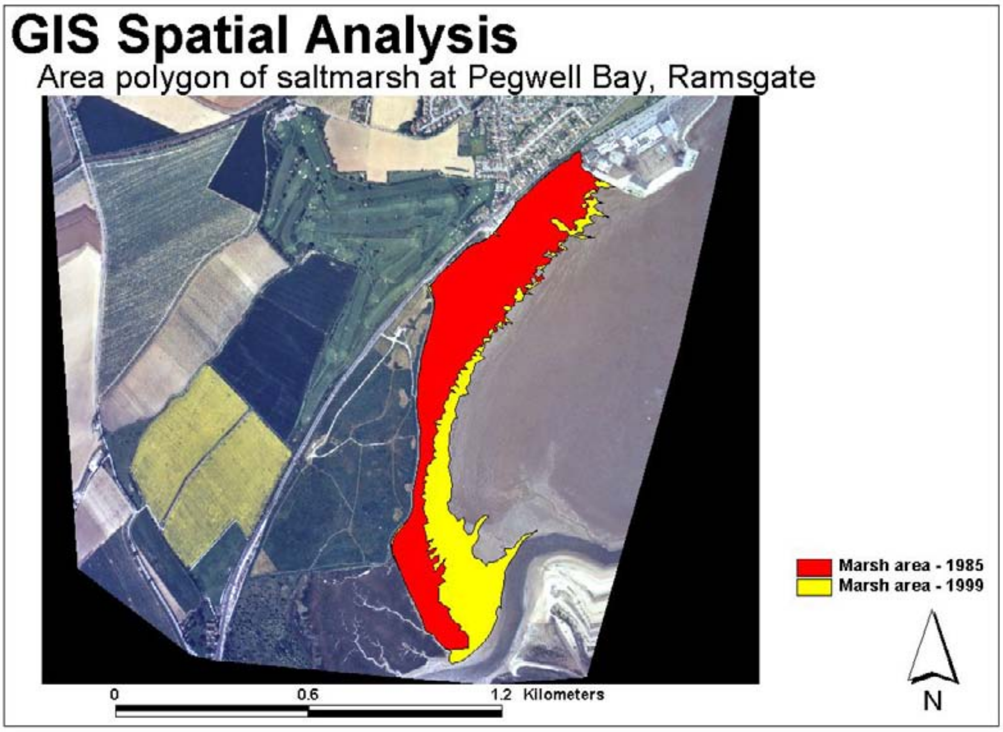


Figure 1. An aerial photograph taken in 1985. The image shows a GIS Rapid assessment map of saltmarsh cover in 1985 compared to that of 1999.

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.

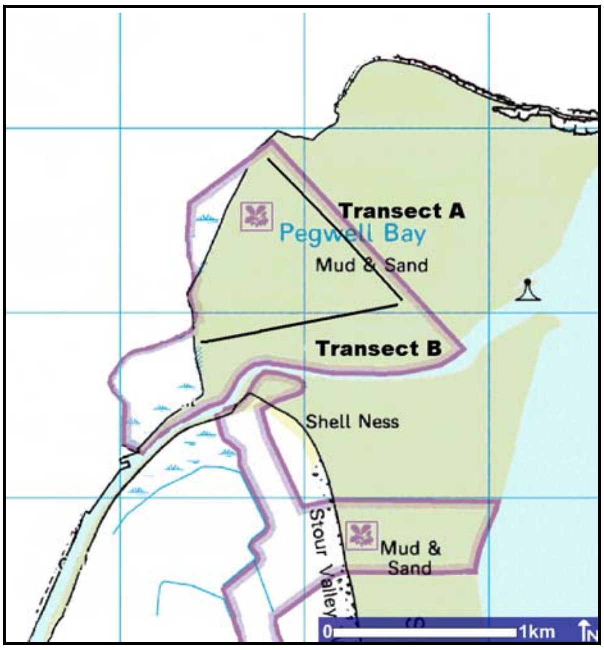


Figure 7. Position of transects on Pegwell Bay

## 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.

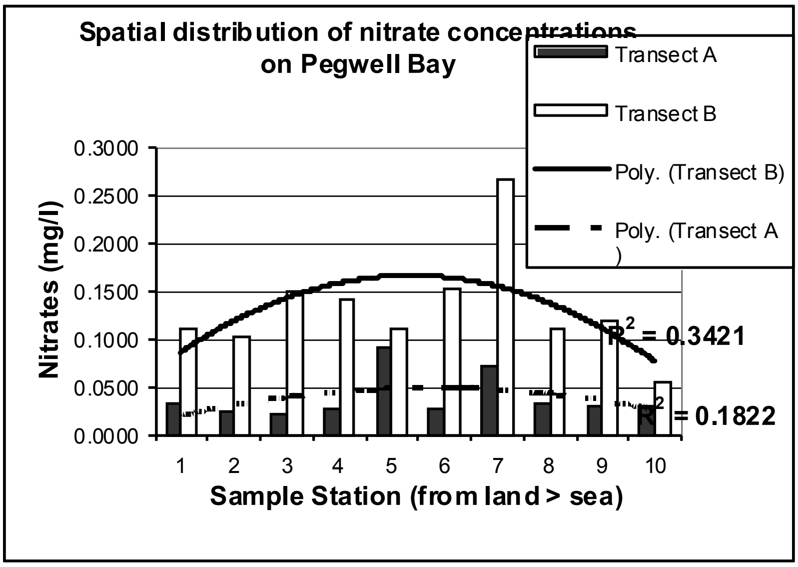


Figure 8. Histogram showing nitrate concentrations from two 1km transects across Pegwell Bay.

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.

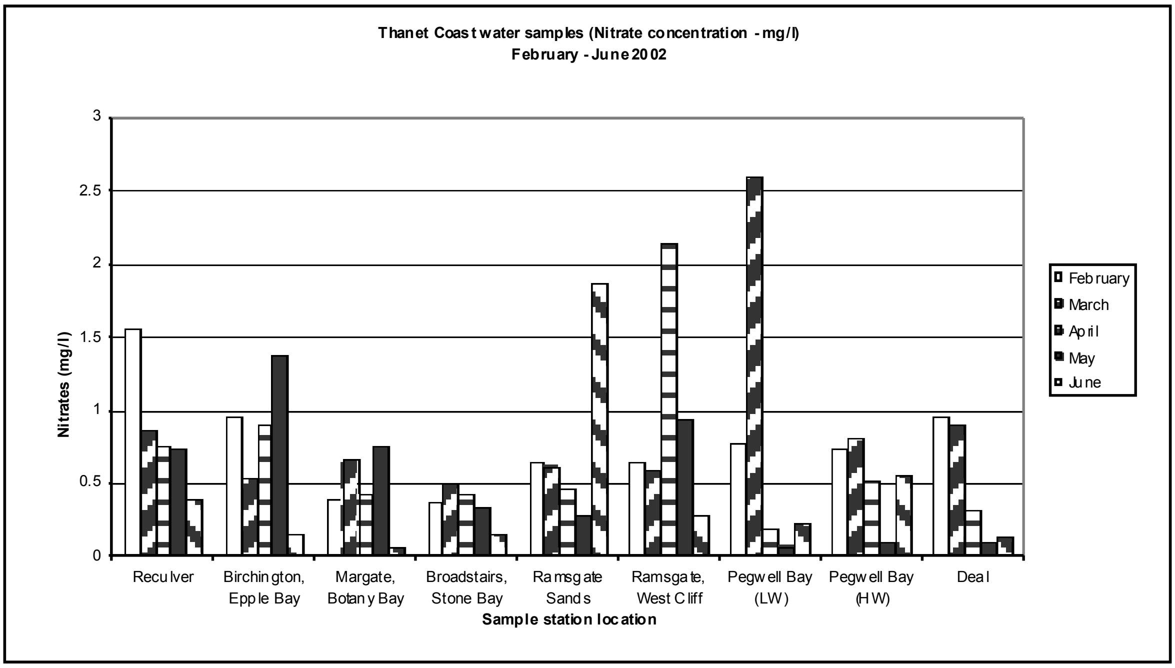


Figure 9. Nitrate concentrations (mg/l) from nine sample stations around the coast of Thanet.

## 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*

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## *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.

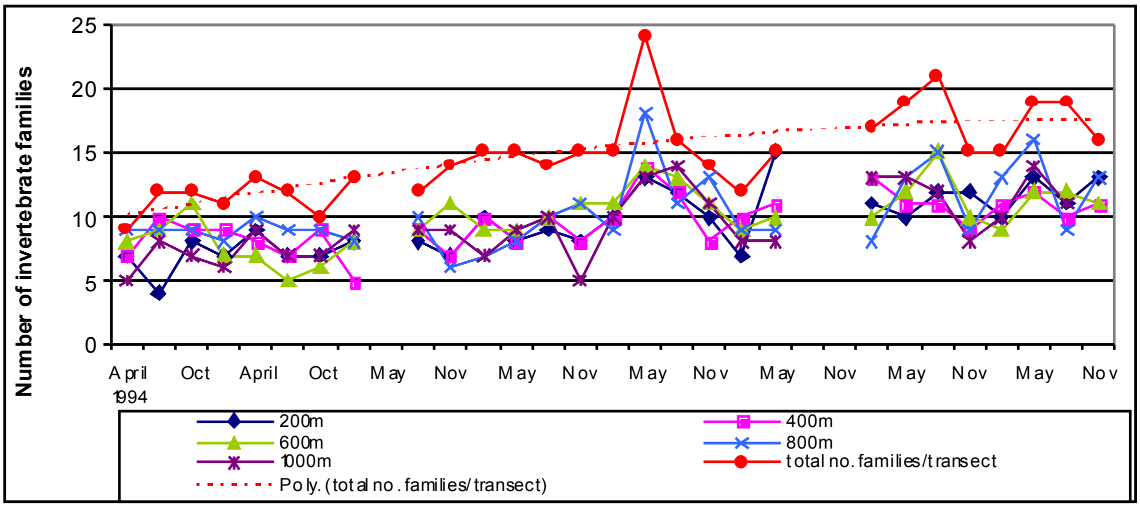


**Figure 1 Total number of invertebrate families**

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.

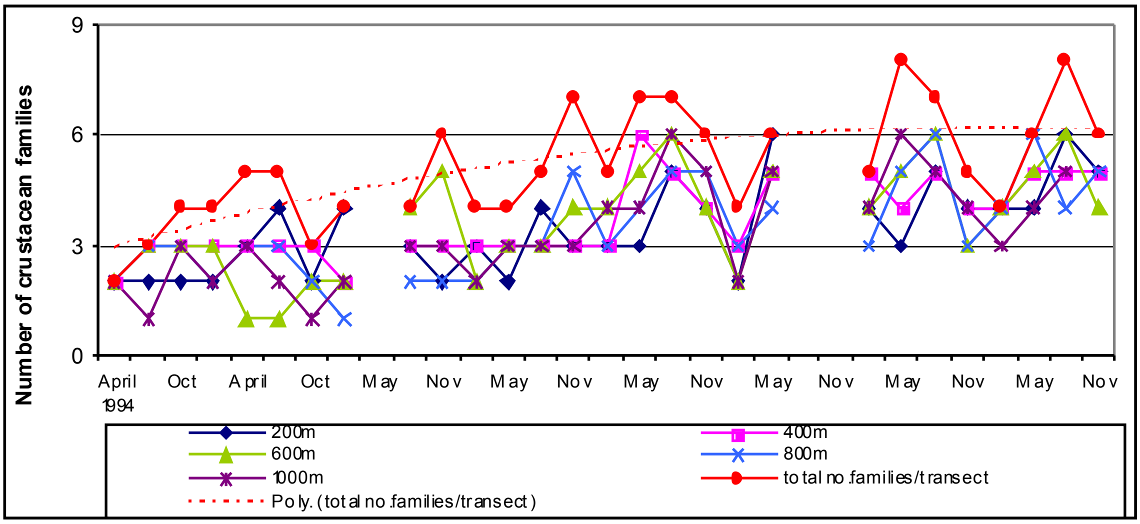


**Figure 2 Number of crustacean families**

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.

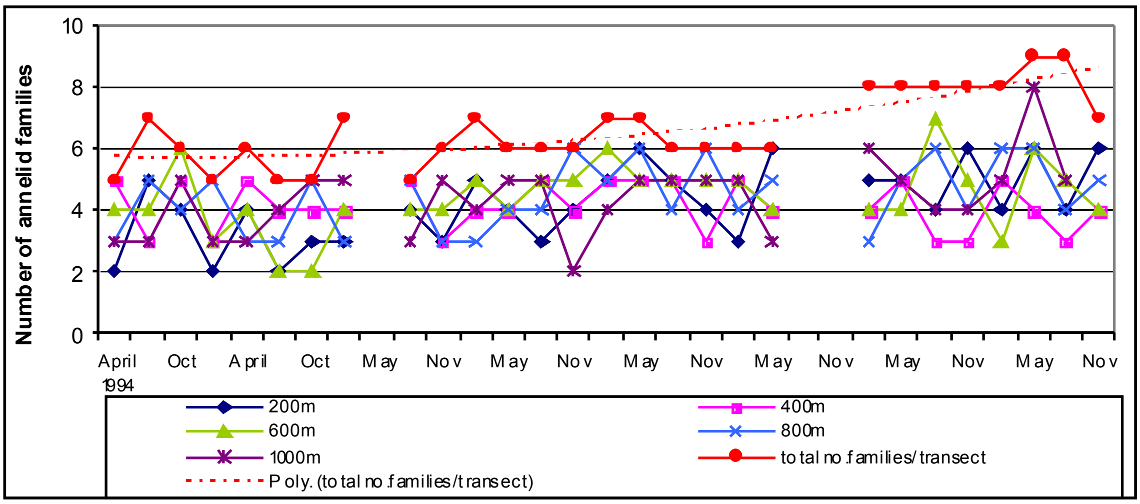


**Figure 3 Number of annelid families**

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.

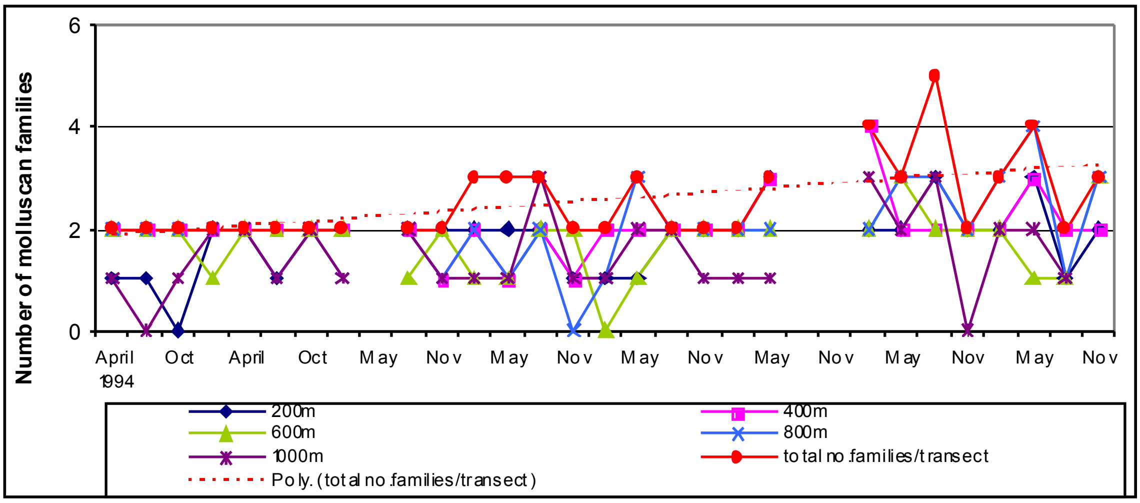


**Figure 4 Number of molluscan families**

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.

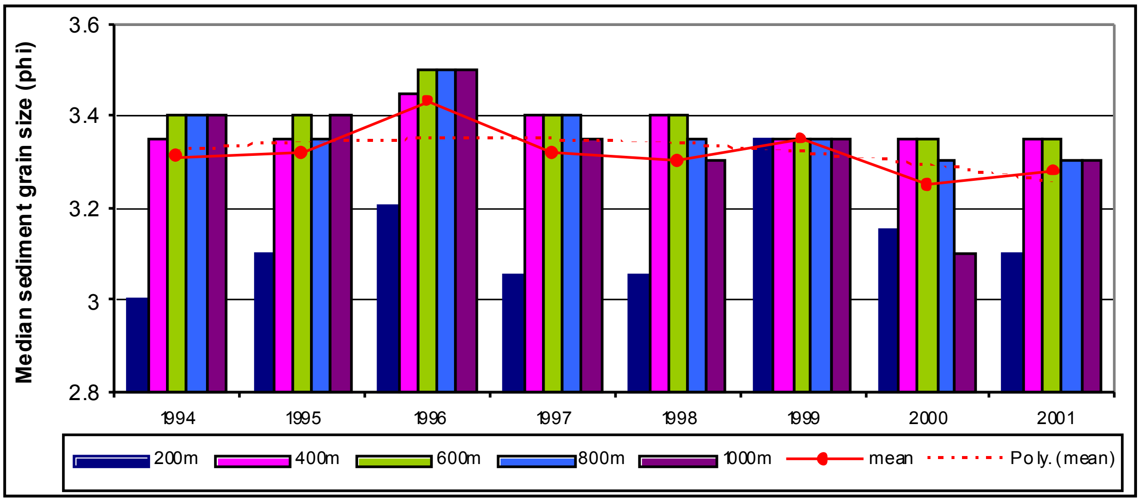


**Figure 5 Sediment particle size**

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.

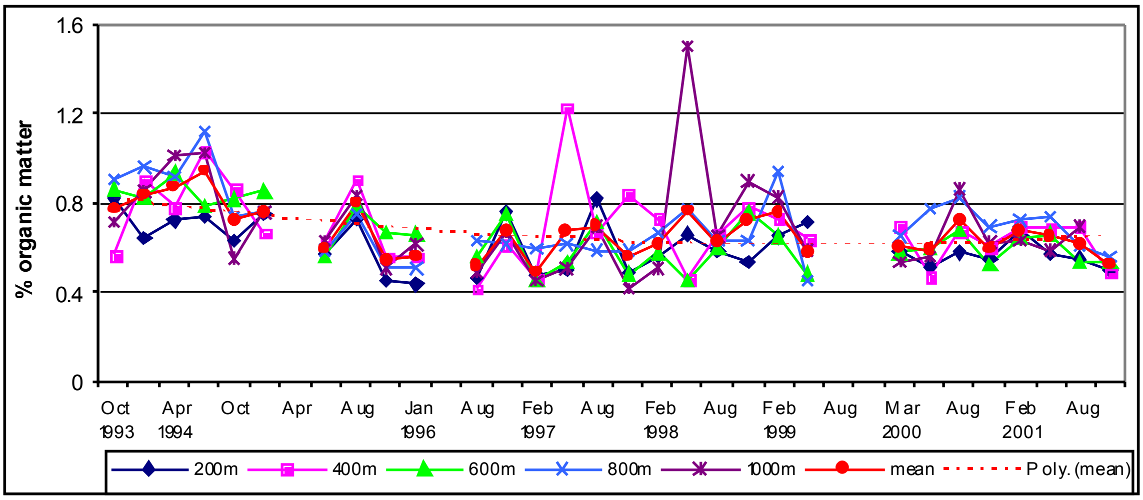


**Figure 6 % organic material in the sediments**

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.

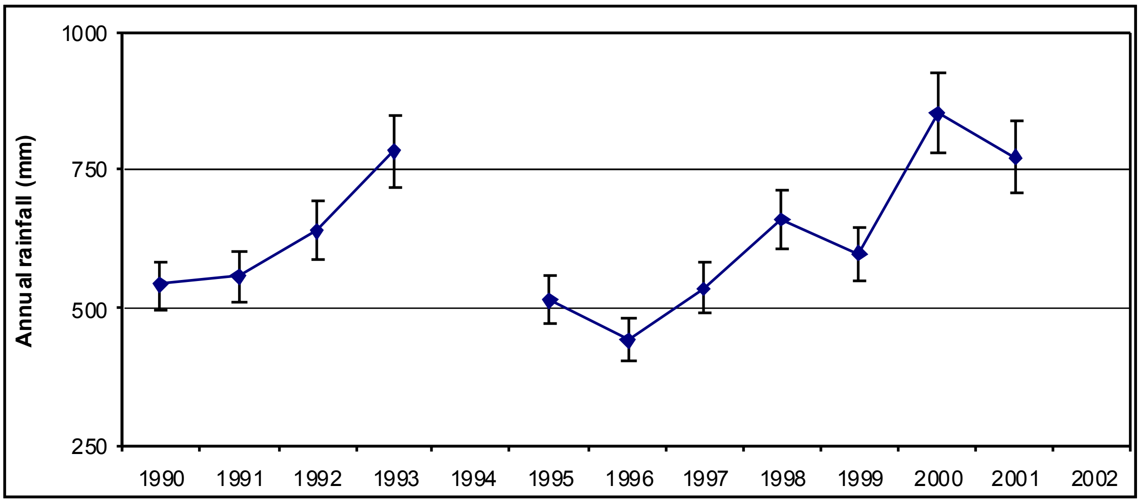


**Figure 7 Annual rainfall**

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

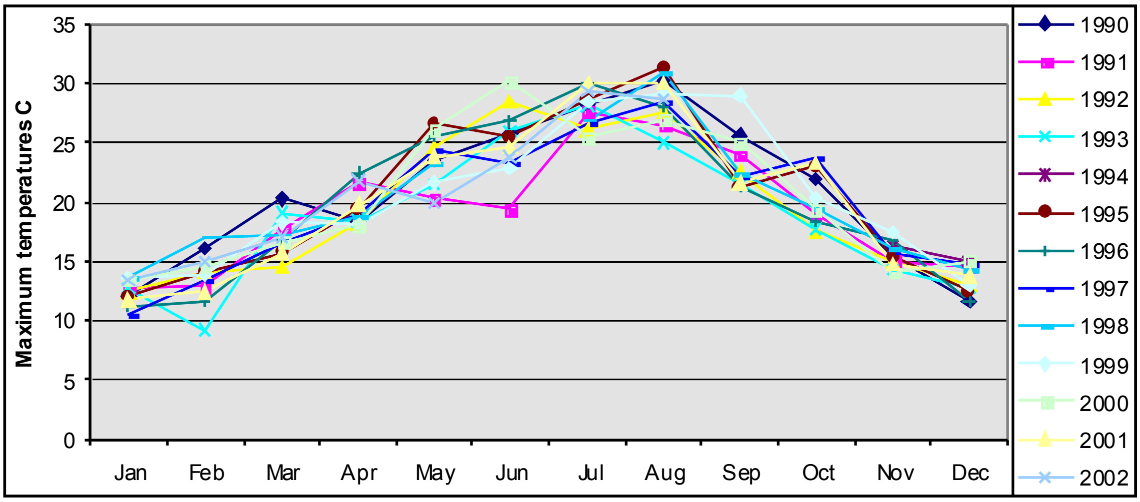


**Figure 8 Maximum monthly air temperature**

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

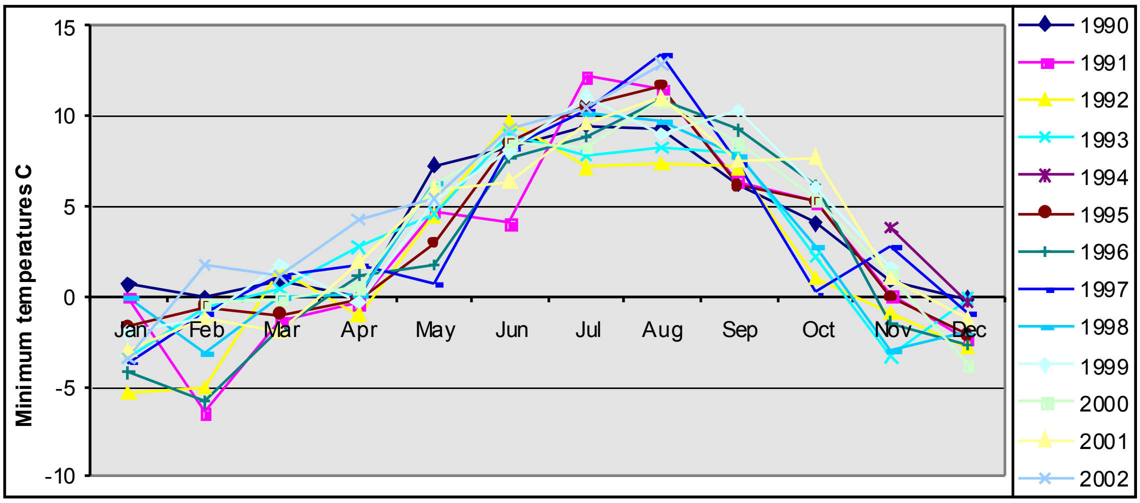


**Figure 9 Minimum monthly air temperature**

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)*

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## *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 |

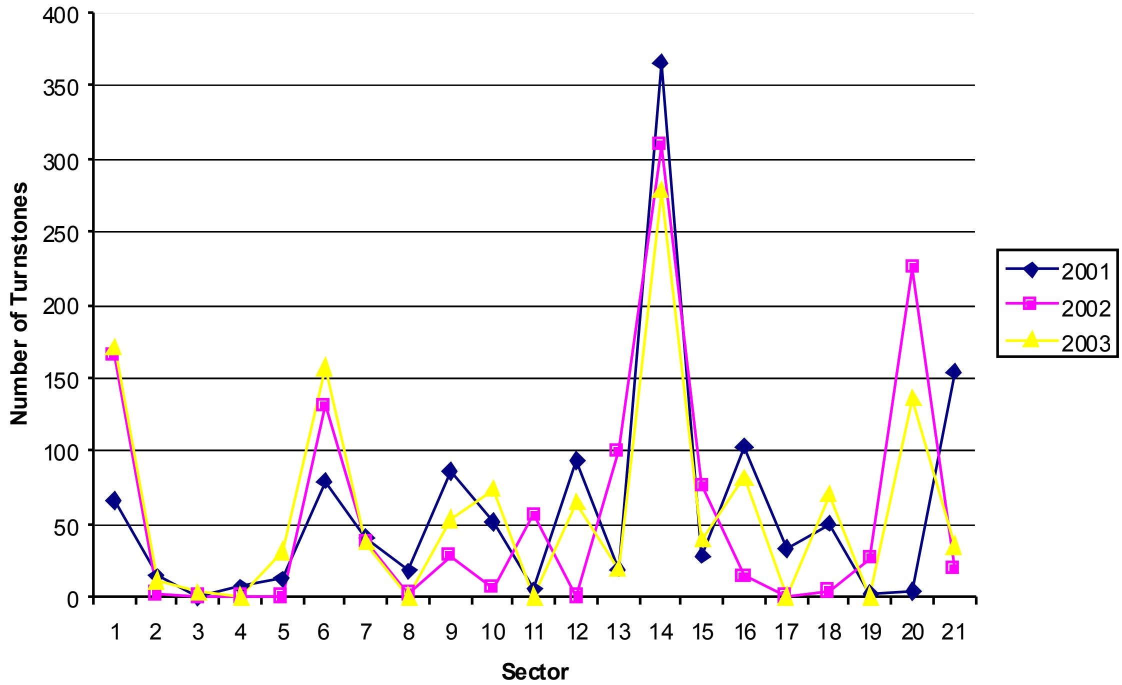


Figure 1. Distribution of Turnstones in the SPA 2001-3.

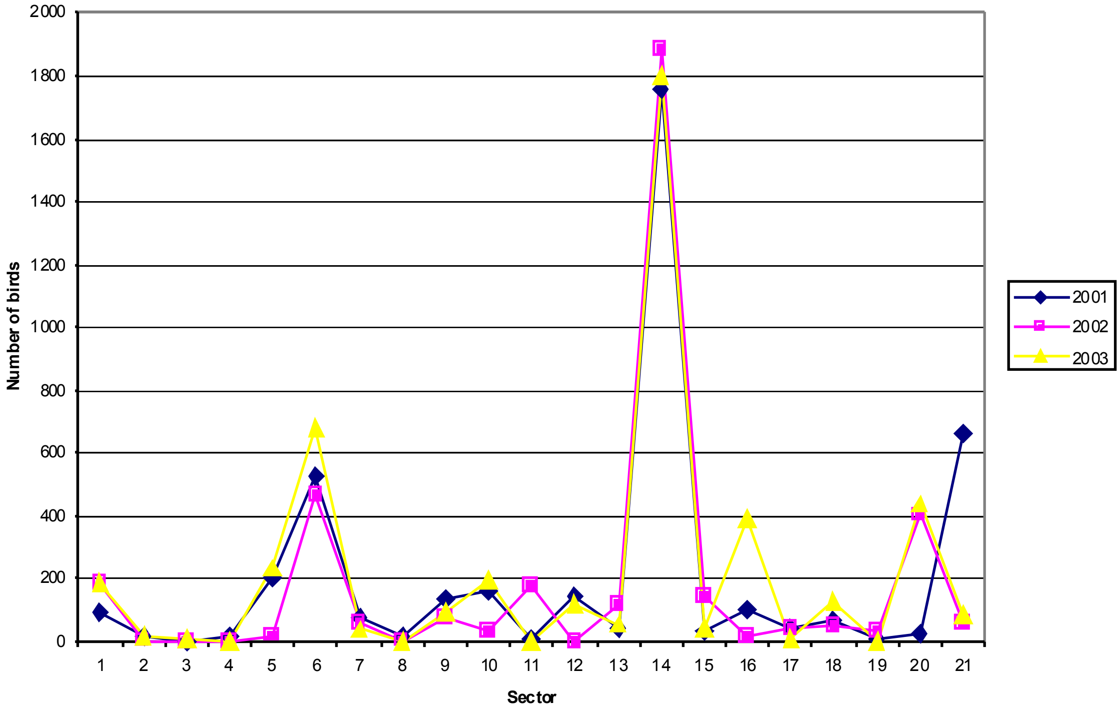


Figure 2. Distribution of wading birds in the SPA 2001-3.

## *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.

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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.
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