Natural England Commissioned Report NECR016

Pacific Oyster survey of the North East Kent European marine sites

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Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Background

Pacific oysters are native to south east Asia and Japan. In 1965 the Ministry of Agriculture, Fisheries and Food introduced them from Canada to their fisheries laboratory at Conwy to find an alternative species to supplement the shellfish industry following the decline of the native oyster.

The trials confirmed the hardiness and fast growth of Pacific oysters in UK waters and commercial hatcheries and cultivation sites were established around the UK.

Pacific oysters were not considered capable of proliferation in northern Europe as water temperatures in excess of 20°C are necessary for reproduction. However, rising sea temperature, warmer summers and milder winters may be factors contributing to the spread of the species and in 1994, wild populations of Pacific oyster were recorded in Devon and further populations were found in Essex and Kent.

Pacific oysters are regarded as invasive in Holland, where they have been recorded since the nineteen seventies. They form extensive biological reefs and in some places have covered common mussel beds.

In March 2007, Kent Wildlife Trust conducted a Shoresearch at Ramsgate's Western Undercliff to record inter-tidal species and their abundance. During this event, Pacific oysters were seen at levels not previously recorded.

This raised concern about their possible impact on the features of the North East Kent European marine sites (NEKEMS) and, as a result, this research project was commissioned to establish a baseline record of inter-tidal distribution and density.

The findings in this report will be used by Natural England and the North East Kent Scientific Coastal Advisory Group to inform future population monitoring and the future management of NEKEMSs.

Acknowledgements

Thanet Coast Project and Kent Wildlife Trust.

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Keywords - Pacific oysters, non-native invasive species, marine, North East Kent European marine sites

Further information
This report can be downloaded from the Natural England website: **www.naturalengland.org.uk**. For information on Natural England publications contact the Natural England Enquiry Service on 0845 600 3078 or e-mail **enquiries@naturalengland.org.uk**.

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Contents

1. Introduction

Background

In March 2007, Kent Wildlife Trust (KWT) conducted a Shoresearch event at Ramsgate's Western Undercliff. Shoresearch records inter-tidal species and their abundance. During this event, Pacific oysters *Crassostrea gigas* were seen at levels not previously recorded. This raised concern about their possible impact on the features of the North East Kent European marine sites (NEKEMS) and, as a result, the subject was discussed at the North East Kent Scientific Coastal Advisory Group (NEKSCAG) meeting in April 2007. Recommendation was made for a baseline study of species distribution and a research project was therefore commissioned.

Aim & Objectives

Aim:

- Establish a baseline record of inter-tidal distribution and density within the NEKEMS which will enable future population monitoring and inform future management.

Objectives:

- Record distribution
- Record density
- Record size
- Record biotope types infested
- Record attachment strata
- Produce a GIS record of distribution & density
- Produce management recommendations based on results
- Create a photographic record of infested sites
- Familiarise with the ecology, origins and commercial aspects of the species

Pacific Oyster

The Pacific oyster (Figure 1) is native to south east Asia and Japan. In 1965 the Ministry of Agriculture, Fisheries and Food (MAFF) introduced Pacific oysters from Canada to their fisheries laboratory at Conwy. Under quarantine, hatchery techniques were developed followed by cultivation trials at sites around the UK. The purpose was to find an alternative species to supplement the shellfish industry following the decline of the native oyster *Ostrea edulis* and the ending of imported American oysters *Crassostrea virginica* and Portuguese oysters *Crassostrea angulata*.

The trials confirmed the hardiness and fast growth of Pacific oysters in UK waters. Commercial hatcheries and cultivation sites now operate around the UK (Spencer 1990).

In 1994, wild populations of Pacific oyster were recorded near cultivation sites in Devon (Couzens 2006). Wild populations are also present in Essex and Kent. In Holland, wild oysters have been recorded since the nineteen seventies. Their progress has been monitored as they spread eastward into the Dutch and German Wadden Sea, where today, they form extensive biological reefs. In places, common mussel *Mytilus edulis* beds have been overlaid raising concern about ecological impacts. The species is regarded as invasive in Holland. Pacific oysters were not considered capable of proliferation in northern Europe as water temperatures in excess of 20°C are necessary for reproduction. However, rising sea temperature, warmer summers and milder winters may be factors contributing to the spread of the species (Nehls & Büttger 2007).

Figure 1

North East Kent European marine sites

The North East Kent European marine sites are located on the north east coast of Kent, on the south side of the Thames estuary, from Swalecliffe to just north of Deal but excluding Herne Bay town frontage. The coastal track distance is approximately 50Km. The sites consist of Thanet Coast SAC, Sandwich Bay SAC and Thanet Coast & Sandwich Bay SPA.

Thanet Coast SAC interest features:

- Reefs
- Sea Caves.

Sandwich Bay SAC interest features:

- Dune System.

Thanet Coast & Sandwich Bay SPA interest features:

- Breeding little tern *Sterna albifrons*
- Wintering golden plover *Pluvialis apricaria*
- Wintering turnstone *Arenaria interpris.*

The Thanet Coast Project (TCP) has been created to assist with the implementation of the management scheme for the sites.

2. Methodology

Area Management

The Thanet Coast Project has divided the area of the NEKEMS into 48 sections, each approximately 1Km in length (Appendix 1). These sections have been adopted to manage Pacific oyster surveys and future monitoring. This includes the use of the TCP section numbering scheme, boundaries and maps. Section maps are produced by Thanet District Council using ESRI MapExplorer 2.0 derived from Ordnance Survey. Scale varies per section with an average of approximately 1:4000. Estimated duration of site work was 14-18 months.

Survey Preparation

All surveys were planned to allow maximum on-site time around low tide. Typically, 4 – 4½ hours survey time could be achieved. Consideration was also given to reduced peroids of winter daylight and to extreme weather conditions. Neap tides were avoided when possible due to the reduced inter-tidal area available for survey.

Section maps were printed to enable location of boundaries when on-site.

Survey Preview

Prior to each section survey, a preview walkover was made of the section. The purpose was to:

- physically set the section boundaries from the map
- identify any health & safety issues including tidal escape routes
- identify section features such as groynes, sea walls, mussel beds, reefs, sediment etc
- prioritise features and plan the order of survey
- estimate on-site time.

Survey Techniques

The survey strategy was to walkover the entire area of each section in turn recording live, attached, Pacific oysters which were surface visible. No boulder, cobble or algae was moved to improve visibility. This ensured minimum disturbance of the environment. Section features were searched in order of priority as identified during the survey preview.

Linear features (groynes, sea-walls, break-waters, outflow pipes): These types of feature posed few recording problems. Survey poles were used to divide large surface areas and a hand tally counter was used to record oyster numbers.

Reefs (algal, grazed, flint outcrops, mussel beds): No oysters were seen within zones of dense algal canopy or turf. However, it was necessary to search such reefs to locate and survey any patches of bare chalk within the algal cover. This includes scoured gullys and vertical walls of upstanding chalk blocks. Where algal cover was rare or occasional, oysters were present and additional survey methods were necessary due to the irregular shape of the reef. A grid system was used to divide the reef surface area into manageable parts. Two sashlines, each 150M long and calibrated at 5M intervals, were loaded on to dispensers. The sashlines were laid on the reef, perpendicular from the shoreline towards the low water mark, parallel to each other and spaced approximately 20M apart. This enabled a progressive search with the dispensers “leap-frogging” across the surface of the reef.

Flint outcrops and mussel beds proved to be successful types of strata for oyster attachment and warrented careful inspection when encountered.

At sections 1, 11B, 11C, 12A, 12B and 13, oyster abundance on the mussel beds of the lower Mid Shore Zone and the Lower Shore Zone was too great for standard survey methods. In these circumstances, a random sample area was surveyed and registered as an oyster site whilst the greater area was recorded and mapped. Data recorded and analysed for these sections includes the sample sites. Therefore actual numbers for the whole sections will be much greater. Figure 2 shows the Lower Shore Zone at Section 12B where oyster density on the mussel beds was too great for standard survey techniques.

Figure 2

Other features (concrete spoil, pilings, posts): This type of feature was generally scattered across reefs, areas of sediment, harbour installations etc and offered few problems. At Ramsgate Harbour, permission was granted to survey the pontoons & walkways within the Marina and other commercial zones.

Survey Duration: On-site time varied considerably from section to section depending upon physical and biological features. Simple sections could be completed in a single tide whilst complex sections required several tides to complete.

Oyster site classification

An oyster site was registered only where a live, attached, Pacific oyster was observed. Oyster sites were classified according to population structure and density (Appendix 2). Classification was intended to aid site description and future monitoring.

Survey Parameters

Table 1 shows the parameters recorded at each oyster site:

Table 1:

Parameter	Description
Site Name	TCP section number + serial number used eg “21F/1”.
Site Type	Site Classification title used eg “Colony”.
Site Location	Includes TCP section address, Shore Zone, GPS fix and adjacent landmarks.
Site Description	A brief description of the site’s physical structure.
Biotope Affected	General description of the biological and physical site composition.
Site Aspect	General alignment of site.
Site Exposure	Estimated using the Ballantine Exposure Scale (Ballantine 1987).
Approx. Surface Area	An estimate of the total surface area in square meters within the site boundaries.
Peak Density	The maximum number of live, attached, Pacific oysters within any square meter.
Site Density	The average number of live, attached, Pacific oysters per square meter.
Total Live Oysters	Total number of live, attached, Pacific oysters within the site boundaries.
Lower Valve	Total number of dead Pacific oysters where only the lower shell is seen attached.
Drift	Total number of Pacific oyster shells seen unattched within the site boundaries.
Average Length	Estimate of the average length (mm) of site population of Pacific oysters.

Length Range	A measure of longest and shortest (mm) Pacific oyster seen within the site boundaries.
Attachment Stratum	Records the types of attachment seen. Appendix 3 defines attachment strata.
Attachment Posture	Records posture as “Prostrate”, “Overlay”, “Erect” to indicate population density.
Adjacent Species	Lists other species and their abundance within site boundaries + 5m surrounding buffer.

In addition, a photographic record was made of each site which included images of the site, general surrounding area, attachment strata and other points of interest. The aim was to aid future site access and location and display baseline conditions. A Nikon 4300 digital camera was used producing a typical file size of 1.2MB.

Data Collection

Collected data were transferred to Excel spreadsheets and Word documents following each survey session. A Spreadsheet titled “NEKEMS Baseline Status” was created to record:

- distribution per oyster site
- distribution per TCP section
- distribution per NEKEMS
- attachment strata.

A spreadsheet titled “Oyster Site Progression” was created to aid future site monitoring. A Word document titled “Oyster Site Status” was created for each registered oyster site. A word document titled “Section Status” was created for each TCP section. A Word document titled “NEKEMS Baseline Data” was created for the project area. Photographic images were stored in folders titled “Oyster Sites”, “Oyster Images” and “Oyster Issues”.

Demography

At site 11A/3, additional work took place to record the Pacific oyster population structure across an 80 meter section of reef between the sea wall and the low water mark. An area of 800 square meters was surveyed in a pattern of eight 10x10 meter compartments

(Figure 3).

Oyster numbers and length were recorded within each of the 100 square meter compartments.

The purpose of this additional work was to test observations which suggested that Pacific oysters were generally more abundant in the Mid Shore Zone.

Figure 3

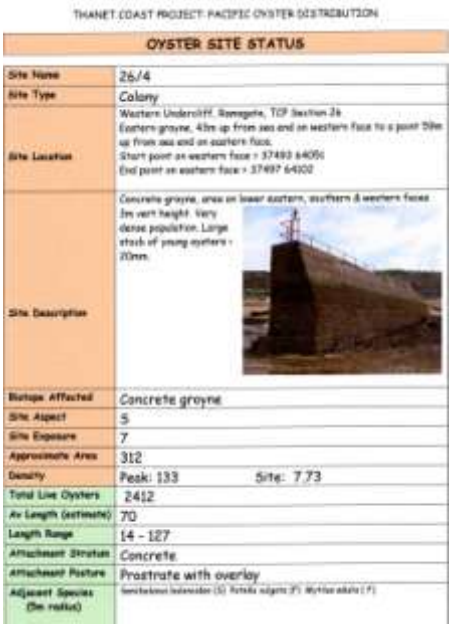
3. Results

Distribution & Density

Oyster Sites

A total of 160 individual oyster sites were registered. For each site, a 3 page “Oyster Site Status” document was produced. Figure 4 shows a typical example using oyster site 26/4. Appendix 4 shows example at full scale.

Figure 4



THANET COAST PROJECT: PACIFIC OYSTER DISTRIBUTION

OYSTER SITE STATUS

Site Name	26/4
Site Type	Colony
Site Location	Western Undercliff, Ramsgate, TCP Section 26 Eastern groyne, 40m up from sea end on western face to a point 50m up from sea end on eastern face. Start point on western face = 37493 64056 End point on eastern face = 37497 64102
Site Description	Concrete groyne, area on lower eastern, southern & western faces. 3m vert height. Very dense population. Large stock of young oysters - 20mm.
Biotope Affected	Concrete groyne
Site Aspect	S
Site Exposure	7
Approximate Area	312
Density	Peak: 133 Site: 7.73
Total Live Oysters	2412
Av Length (estimate)	70
Length Range	14 - 127
Attachment Stratum	Concrete
Attachment Posture	Prostrate with overlay
Adjacent Species (5m radius)	

Site Log

18.05.07 First recorded.
(3.4m Tide). Dense colony on lower shore section of groyne with a 3m vertical spread. Large numbers of small oysters - 20mm. Found a large detached block of concrete with a mass of small oysters attached, hence high peak density. (see photo.) Evidence of harvesting.

BASELINE ASSESMENT

Possibly TCP's worst blockspot. With a large number of young oysters, there is the potential to expand and recruit reefs & walls to the west. Harvesting occurs which may provide some control. The sea wall is not infested as it is buffered from all tides by sand.

Site Progression

Survey Date	Colony Totals	Cluster Zone Totals	Cluster Site Totals	Solitary Zone Totals	Solitary Site Totals	Total Area Affected (square meters sq)	Total Live Oysters	Total Lower Valves Only	Site Density	Peak Density	Attachment Stratum
18.05.07	1	0	0	0	0	312	2412	161	7.73	133.00	Concrete

Site Photos

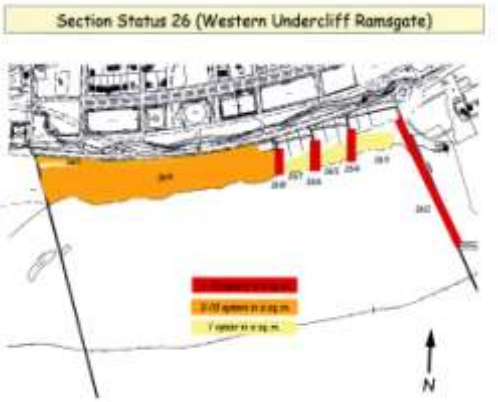
Page 1 Baseline Data

Page 2 Site Log

Page 3 Site Progression & Photos

TCP Sections

A total of 43 sections had Pacific oyster present. For each section, a “Section Status” document was produced. Figure 5 shows a typical example using section 26. Appendix 5 shows example at full scale.



Section Status 26 (Western Undercliff Ramsgate)

N

Figure 5

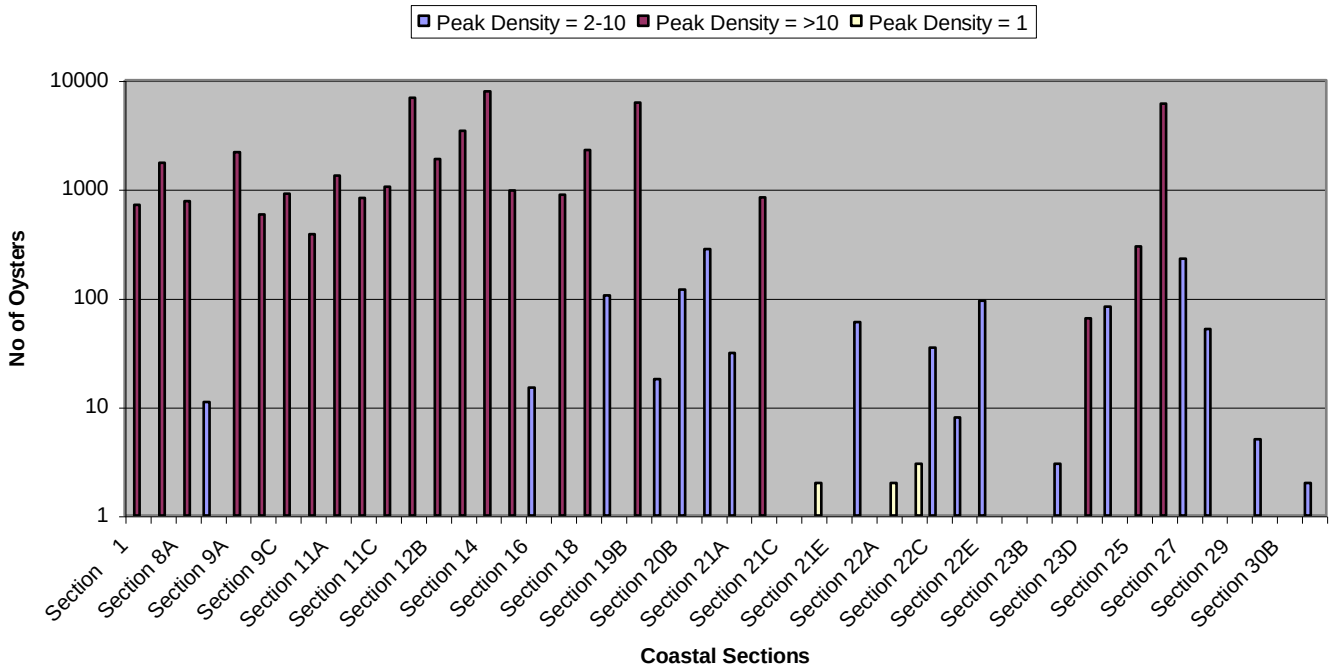
Oyster Site Number	Colony Totals	Cluster Zone Totals	Cluster Site Totals	Solitary Zone Totals	Solitary Site Totals	Total Area Affected (square meters sq)	Total Live Oysters	Total Lower Valves Only	Site Density	Peak Density	Attachment Stratum
Site 26/1	0	0	1	0	0	420	73	11	0.17	4.00	Concrete + Chalk
Site 26/2	1	0	0	0	0	442	2307	128	5.21	67	Concrete + Granite
Site 26/3	0	0	0	1	0	2125	14	8	0.01	1	Chalk
Site 26/4	1	0	0	0	0	312	2412	161	7.73	133.00	Concrete
Site 26/5	0	0	0	1	0	2125	13	8	0.01	1	Chalk
Site 26/6	1	0	0	0	0	60	1102	373	11.6	48	Concrete
Site 26/7	0	0	0	1	0	4440	11	0	0.01	1	Chalk
Site 26/8	1	0	0	0	0	84	147	67	1.75	15	Concrete
Site 26/9	0	1	0	0	0	16000	31	0	0.01	2	Concrete & Chalk

21.06.07

NEKEMS

Figure 6 shows distribution & density from Swalecliffe to Deal. Appendix 6 shows raw data.

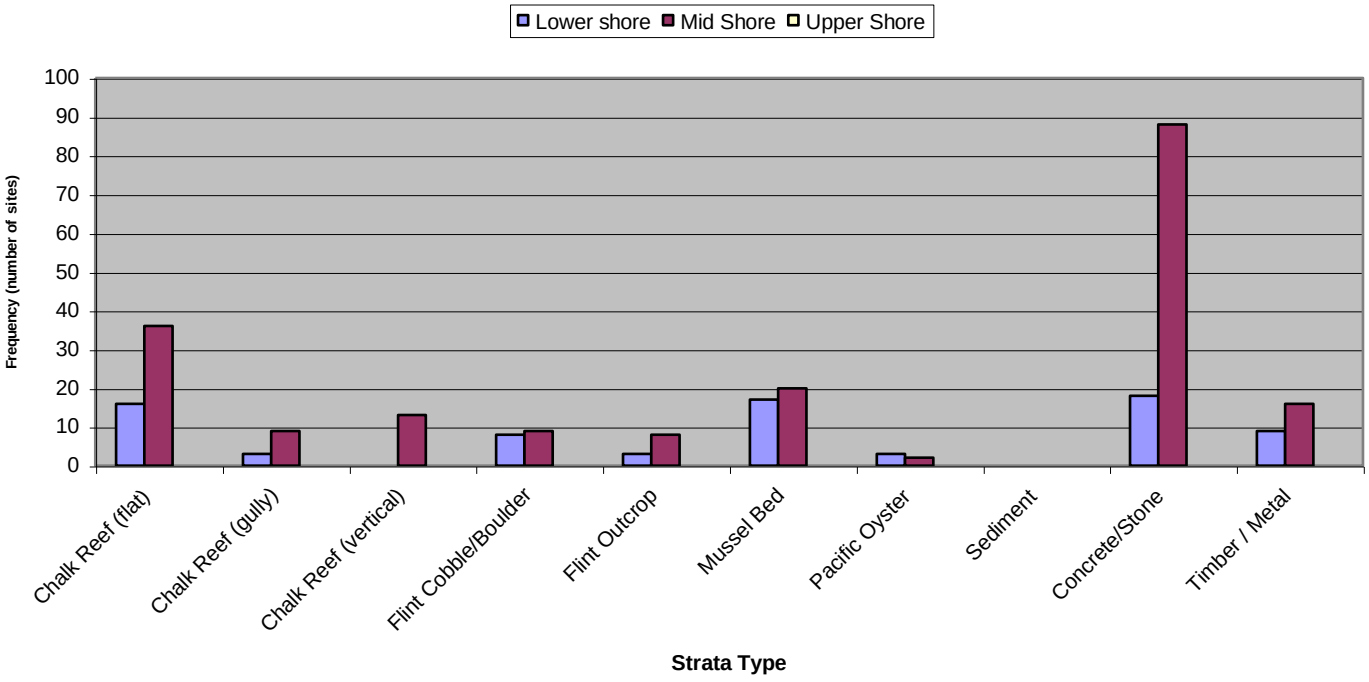
Figure 6: NEKEMS Baseline Distribution



Attachment

Figure 7 shows how often each type of attachment stratum occurred across all oyster sites. Appendix 7 shows raw data.

Figure 7: Attachment Strata: Frequency for All Sites



Demography

Figure 8 shows Pacific oyster number and average length across area of reef at oyster site 11A/3. Total oysters=222. Appendix 8 shows raw data.

Figure 8: Site 11A/3 Transect

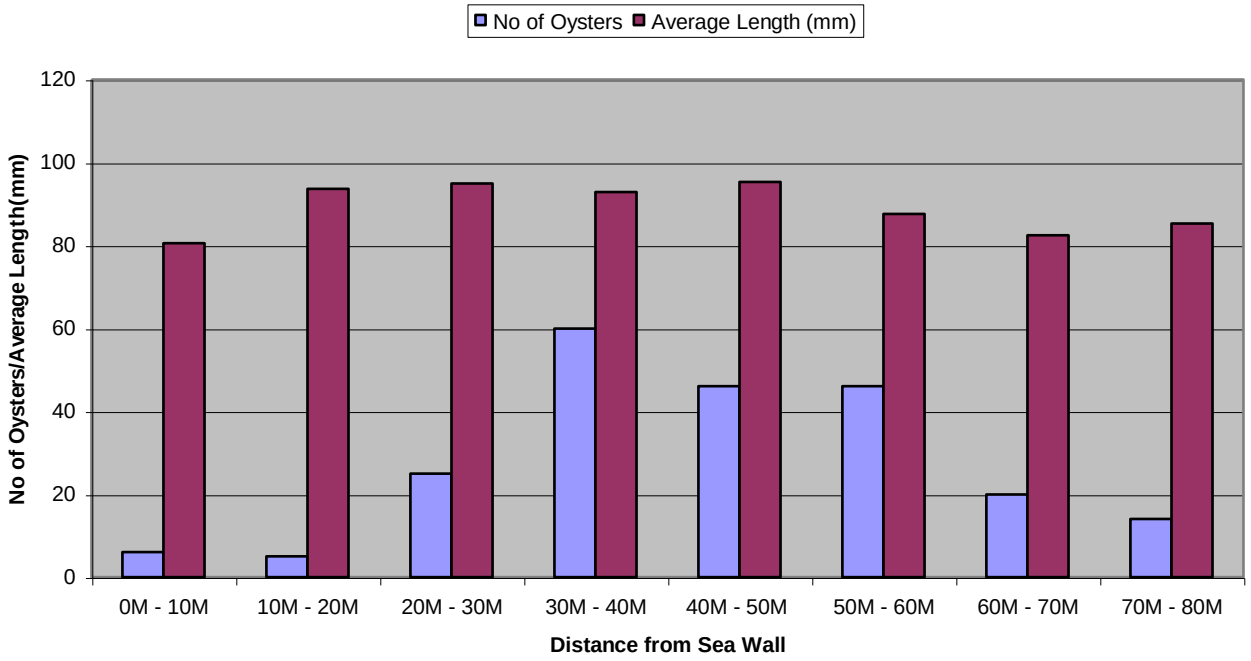
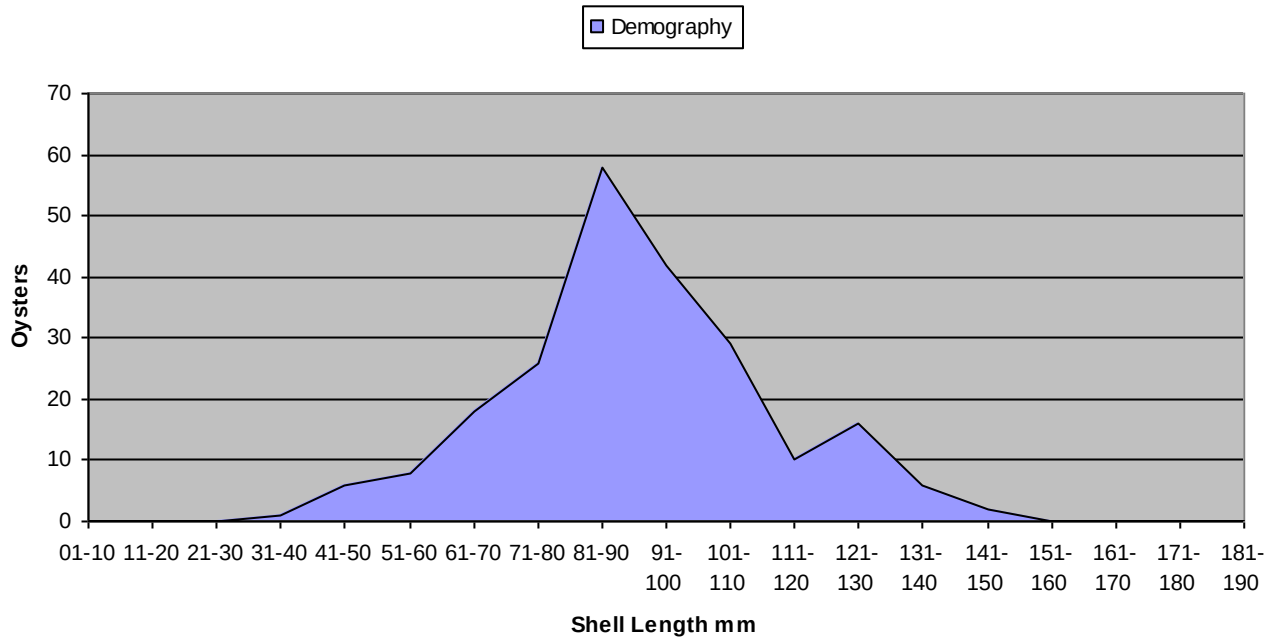


Figure 9 shows demography of Pacific oysters seen within survey area at oyster site 11A/3. Total =222. Appendix 8 shows raw data.

Figure 9: Demography by Shell Length



Photography

A total of 1547 image files (1.7GB) have been recorded on CD under the headings “Oyster Sites”, “Oyster Images” and “Oyster Issues”.

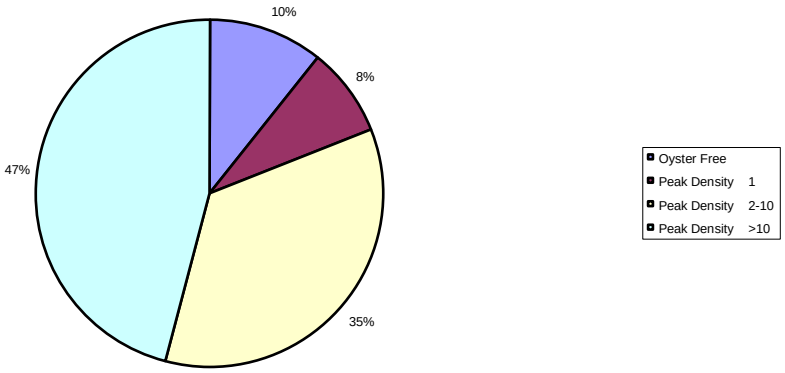
4. Analysis

Pacific oysters are present, in the inter-tidal zone, across the expanse of the NEKEMS. Of the 48 sections surveyed:

- 5 were Pacific oyster free
- 4 had a peak density of 1
- 17 had a peak density between 2-10
- 22 had a peak density greater than 10.
-

Figure 10 shows the distribution of peak density types across the sections (Appendix 9 shows raw data).

Figure 10: Peak Density Distribution

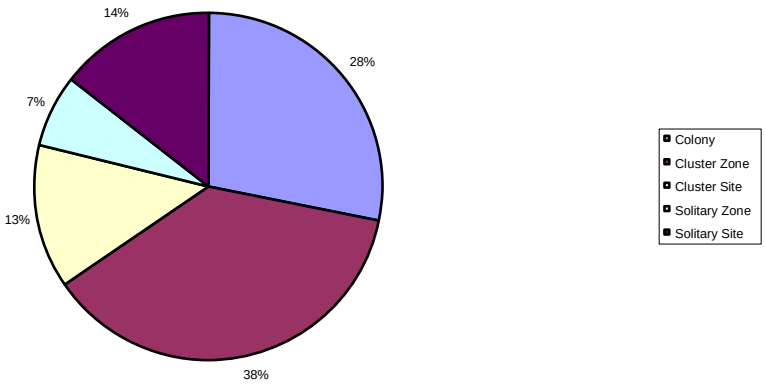


Within Pacific oyster sites, the population structure varies considerably with some oyster sites consisting of a single specimen whilst others contain several thousand oysters. A total of 160 Pacific oyster sites were registered. Of these:

- 45 were classified as Colony
- 60 were classified as Cluster Zone
- 21 were classified as Cluster Site
- 11 were classified as Solitary Zone
- 23 were classified as Solitary Site.

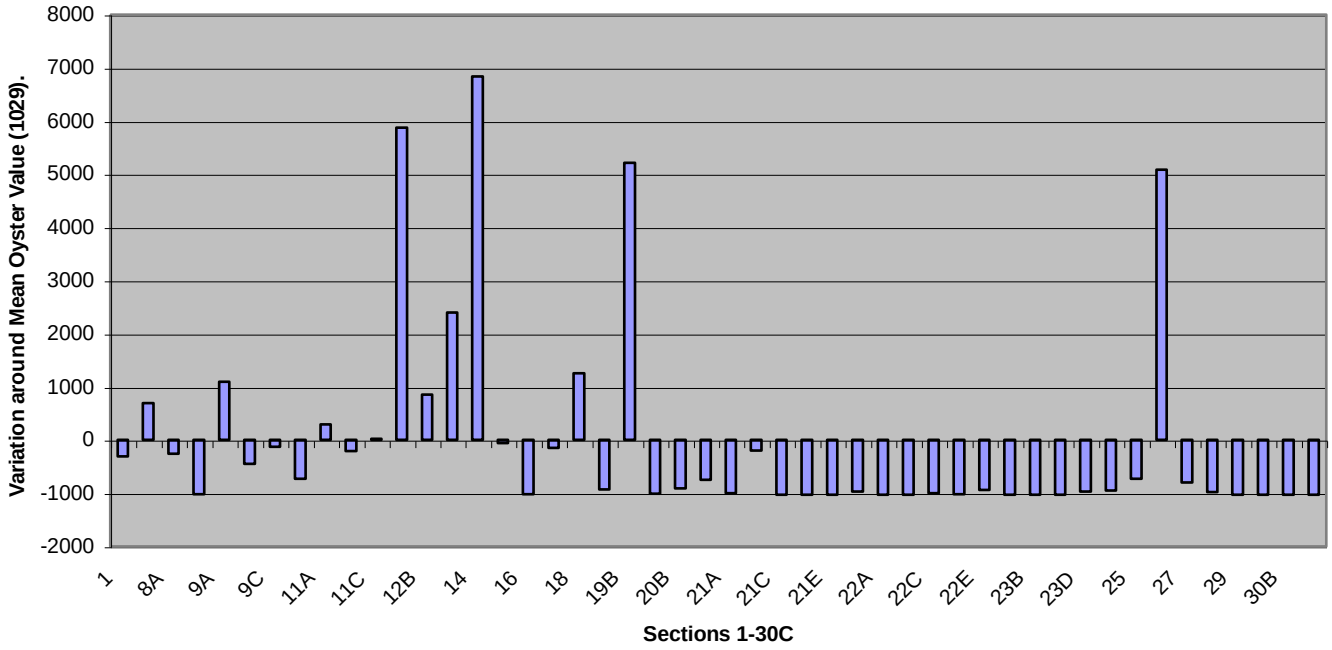
Figure 11 shows the distribution of Pacific oyster site types (Appendix 10 shows raw data).

Figure 11: Pacific Oyster Site Classification



Number and density of Pacific oysters are greatest on the area of coast between Swalecliffe and Nayland Rock, Margate. The remainder of the coast, from Margate Bay to Sandwich Bay South, exhibits a lesser population but does have peaks at Margate Harbour, Foreness and Ramsgate's Western Undercliff. Figure 12 represents the balance of distribution for the NEKEMS. Pacific oyster numbers are shown, per section, as a variation above or below the mean which is 1029 oysters per section (Appendix 11 shows raw data).

Figure 12: NEKEMS Distribution Balance



A key factor to successful colonisation would appear to be attachment stratum. The varying types of stratum used for attachment were recorded per Shore Zone at each Pacific oyster site. Hard, smooth, concrete, surfaces such as groynes, sea-walls and breakwaters were the most frequently observed mode per site. At some sites, sea-walls act as conduits extending the population range along the shoreline. Figures 13 and 14 show examples of a sea-wall projecting the Pacific oyster population at Section 27. Oysters were present along the concrete plinth of the wall but were not yet attached to the adjacent chalk reef.

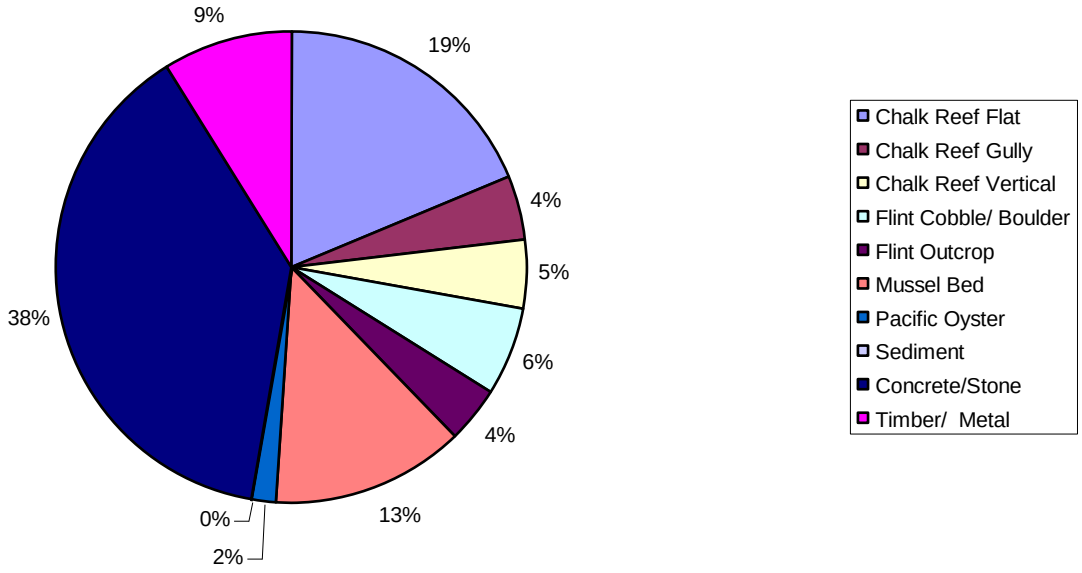
Figure 13

Figure 14

Attachment to the chalk reef is widespread across the NEKEMS but not in areas of dense algal turf or canopy. In such areas, Pacific oysters are restricted to local patches of bare chalk such as scoured gullys, vertical walls of chalk blocks and stable flint outcrops. This could perhaps explain the demarcation that occurs at Nayland Rock, Margate where Pacific oyster numbers are higher to the west on predominantly sparsely covered chalk reef, whereas, numbers to the east are lower on predominantly denser covered chalk reef.

Mussel beds *Mytilus edulis* provide a successful attachment medium and support the highest volume of Pacific oysters. This is evident across a continuous spread of mussels from Birchington to Westgate. At Epple Bay, density is such that Pacific oysters are overlaid and in erect posture. This represents the closest example of oyster reef formation seen within the NEKEMS. Other significant populations attached to mussels exist between Swalecliffe and Birchington and at Ramsgate's Western Undercliff. Figure 15 shows a summary of attachment mode frequency across all Pacific oyster sites (Appendix 12 shows raw data).

Figure 15 Attachment Mode Frequency



An interesting comparison corroborates concrete as the prime attachment mode. Figure 12, page 4.2, shows 2 distinct and similar population peaks east of the demarcation at Nayland Rock (Section 18). These peaks occur at Margate Harbour (Section 19B) and Ramsgate's Western Undercliff (Section 26). At both sections, Pacific oysters are attached to concrete, although,the Ramsgate site has a small number of Pacific oysters which are attached to the reef (total=69 or 1.1%). With these removed from analysis,the following similarity can be seen.

Margate Harbour:

- Pacific oysters = 6244
- Surface Area = 435sq.m.
- Section Density = 14.35

Ramsgate's Western Undercliff:

- Pacific oyster = 6041
- Surface Area = 359 sq.m.
- Section Density = 16.83

Within Pegwell Bay and Sandwich Bay National Nature Reserve (NNR), Pacific oysters are absent from 2 sections and present at low numbers in the remaining 3 sections. Ramsgate's Western Undercliff is adjacent and has an abundant population. Despite this, oyster numbers within the NNR are low. A limiting factor to recruitment into the NNR is likely to be the lack of hard, stable, strata available for attachment. Existing Pacific

oysters were restricted to the seaward edge of the concrete apron at the old Pegwell Hoverport site and to wooden and steel posts erected on the mudflats at Sandwich Bay.

Across the NEKEMS, observed Pacific oyster size varied from 12mm shell length to 168mm shell length. Juvenile specimens with shell lengths up to 30mm (Figure 16) were present in 65% of registered Pacific oyster sites. This suggests an established and dynamic population. Pacific oyster demography at site 11/3 is shown in Figure 9 page 3.3.

Figure 16

Distribution within Shore Zones reveals an interesting trend. No Pacific oysters were seen in the Upper Shore Zone and, generally, abundance was greater in the Mid Shore Zone than in the Lower Shore Zone. The exception being where dense mussel beds were present in the Lower Shore Zone. This was an unexpected finding since Pacific oysters, being filter feeders, may benefit from the extended feeding period available in the Lower Shore Zone. However, predation levels by shore crabs *Carcinus maenas* within the Lower Shore Zone may be a controlling factor. This trend can be seen in Figure 8 page 3.3.

A shellfish hatchery and nursery, producing Pacific oysters, operates from a site at Reculver (Section 9A) within the NEKEMS. Pacific oysters are also farmed on the sea bed in the Swale estuary at Whitstable & the Isle of Sheppey. In addition, commercial operations are sited on the Essex coast on the north side of the Thames estuary. There is no indication from baseline distribution data that there is a direct relationship between Pacific oyster density and the proximity of commercial sites.

5. Conclusions

A well established and dynamic population of Pacific oysters exists across the expanse of the NEKEMS. Density is greatest west of a demarcation at Nayland Rock, Margate. East of this, density reduces but peaks occur at Maragte Harbour, Foreness and Ramsgate's Western Undercliff.

This population has the capacity to expand in number, density and range aided by increasing sea temperature, warmer summers and milder winters. In Oosterschelde, Holland, during the warm summers of 1975 and 1976, natural reproduction occurred. This developed into the colonization of the Oosterschelde and other Dutch estuaries in the 1980's (Nehring 2006). Climate change with rising temperatures is likely to facilitate future population expansion in Kent.

Mussel beds in the Mid shore Zone and Lower Shore Zone situated between Birchington and Westgate host the peak volumes of Pacific oysters. Concentration is such that this area is likely to produce the first oyster reef within the NEKEMS. Progress towards reef formation is advanced with frequent patches of overlaid and erect oysters. Mussel beds at Swalecliffe, Coldharbour and Ramsgate, although infested, are in a less advanced condition. If mussels beds are replaced by oyster reefs then the consequences for the ecosystem are unpredictable.

Concrete is the most frequent mode of attachment seen per site and, in places, acts as a conduit to project distribution. This is apparent at Ramsgate where concrete groynes and sections of the sea wall may be supplying the adjacent chalk reef and mussel beds at the Western Undercliff.
The presence of Pacific oysters may pose a hazard to bathers, surfers and other shore users due to the extremely sharp edge on it's shell. In Holland, recreational activities have been affected in some areas of the Oosterschelde estuary (Nehring 2006).

6. Recommendations

Future Monitoring

A programme of future monitoring would enable management within the NEKEMS. Experience in Holland has shown that Pacific oysters can exist in an ecosystem over a long period with low abundances before the invasive character becomes obvious (Nehls & Büttger 2007).

With 160 oyster sites registered across 48 sections, priorities need to be established. Appendix 13 lists sections rated as “High” monitoring priority. Appendix 14 rates priority at all section based on standard priority features.

Control

Consideration should be given to possible control and management methods. The baseline sections and sites offer scope for experiment.

Reproduction

Investigation into the origin and reproductive attributes of the wild population may increase species knowledge and assist possible control and management.

Mortality

At several sites local patches of high/total mortality were seen. The areas surrounding these patches had a normal oyster population. Figure 17 shows an example of dead oysters with lower valve only attached. Figure 18 shows a dead oyster with valves gaping.

Figure 17

Figure 18

Investigation into mortalities may increase species knowledge and be of benefit to the shellfish industry.

7. Bibliography

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Appendix 1: Thanet Coast Project Sections

1 Swalecliffe	21A Palm Bay
7 Bishopstone	21B Foreness Bay & Point
8A Reculver West	21C Foreness to Botany Bay West
8B Reculver East	21D Botany Bay
9A Reculver to Coldharbour	21E Whiteness Bay
9B Coldharbour	21F Kingsgate Bay-Whiteness Pt
9C Plumpudding	22A Joss Bay
10 Minnis Bay West	22B North Foreland
11A Minnis Bay East to Grenham	22C Stone Bay
11B Grenham Bay	22D Broadstairs East Cliff
11C Beresford Bay	22E Viking Bay & Harbour
12A Epple Bay	23A Louisa Bay
12B Epple to Westgate	23B Dumpton Point S.Cliff to Dumpton Gap
13 Westgate Bay	23C Dumpton Gap
14 Westgate to St. Mildred's	23D Dumpton to Winterstoke
15 St. Mildred's Bay	24 Ramsgate Main Sands
16 St. Mildred's to Westbrook	25 Ramsgate Harbour
17 Westbrook Bay	26 Western Undercliff Ramsgate
18 Nayland Rock	27 Pegwell to Cliffsend
19A Margate Bay	28 Pegwell Bay
19B Margate Harbour	29 Pegwell Country Pk&Saltmarsh
20A Fulsam Rock Winter Gardens	30A Sandwich Bay North
20B Newgate Gap Lido to Walpole	30B Sandwich Bay Mid
20C Walpole Bay	30C Sandwich Bay South

Appendix 2: Oyster Site Classification

Site Type	Site Definition (by live, attached oyster)
Solitary Site Map Colour	**Population Structure** A single oyster observed. No others seen within 10m range. **Peak Density** 1 oyster within 1 square meter.
Solitary Zone Map Colour	**Population Structure** A group of Solitary oysters observed within a physical area. The zone boundary is identified by a change in peak density around the Solitary Zone perimeter. **Peak Density** 1 oyster within 1 square meter.
Cluster Site Map Colour	**Population Structure** A group of oysters observed where each is within 10m range of any neighbour within the group.The site boundary is identified by a change in peak density around the Cluster Site perimeter. **Peak Density** 2-10 oysters within 1 square meter.
Cluster Zone Map Colour	**Population Structure** 2 or more Cluster Sites situated within a physical area.The zone boundary is identified by a change in peak density around the Cluster Zone perimeter. **Peak Density** 2-10 oysters within 1 square meter.
Colony Map Colour	**Population Structure** A group of oysters where each is within a 10m range of any neighbour within the group The colony boundary is identified by a change in peak density around the Colony perimeter. **Peak Density** More than 10 oysters within 1 square meter.

Appendix 3: Attachment Strata

Code	Definition
CRF	CHALK REEF FLAT This describes an area of reef which is free of gullies and upstanding blocks of chalk.
CRG	CHALK REEF GULLY This describes an area of reef which is cut by a gully.
CRV	CHALK REEF VERTICAL This descibes an area of reef which is free of gullies but has upstanding blocks of chalk.
CS	CONCRETE / STONE This describes man made structures such as sea defences, harbour walls, breakwaters etc.
FC	FLINT COBBLE This describes individual flint cobbles or boulders.
FO	FLINT OUTCROP This describes stable areas of mass flint cobbles or boulders.
MU	MUSSEL BED This describes areas colonised by *Mytilus edulis.*
PO	PACIFIC OYSTER This describes areas colonised by *Crassostrea gigas*.
SED	SEDIMENT This describes areas of sand or mud.
TM	TIMBER / METAL This describes items such as pilings, poles, steps, wrecks, driftwood etc.

Appendix 4: Oyster Site Status page 1

Site Name	26/4
Site Type	Colony
Site Location	Western Undercliff, Ramsgate, TCP Section 26 Eastern groyne, 43m up from sea end on western face to a point 59m up from sea end on eastern face. Start point on western face = 37493 64051 End point on eastern face = 37497 64102 Mid Shore Zone.
Site Description	Concrete groyne, area on lower eastern, southern & western faces 3m vert height. Very dense population. Large stock of young oysters < 20mm. 
Biotope Affected	Concrete groyne
Site Aspect	S
Site Exposure	7
Approx. Surface Area	312sqm
Density	Peak: 133 Site: 7.73
Total Live Oysters	2412
Av Length (estimate)	70mm
Length Range	14 – 127mm
Attachment Stratum	CS
Attachment Posture	Prostrate with overlay
Adjacent Species (5m radius)	Semibalanus balanoides (S) Patella vulgata (F) Mytilus edulis (F)

Appendix 4: Oyster Site Status page 2

Site Log	18.05.07 First recorded (0.4m tide). Dense colony on lower shore section of groyne with a 3m vertical spread. Large numbers of small oysters < 20mm. Found a large detached block of concrete with a mass of small oysters attached, hence high peak density. (see photo.) Evidence of harvesting.  **BASELINE ASSESMENT** Possibly TCP's worst blackspot. With a large number of young oysters, there is the potential to expand and recruit reefs & walls to the west. Harvesting occurs which may provide some control. The sea wall is not infested as it is buffered from all tides by sand.

Appendix 4: Oyster Site Status page 3

Survey Date	Colony Totals	Cluster Zone Totals	Cluster Site Totals	Solitary Zone Totals	Solitary Site Totals	Approx Surface Area sq.m	Total Live Oysters	Total Lower Valve Only	Site Density	Peak Density	Attachment Stratum
18.05.07	1	0	0	0	0	312	2412	161	7.73	133	CS

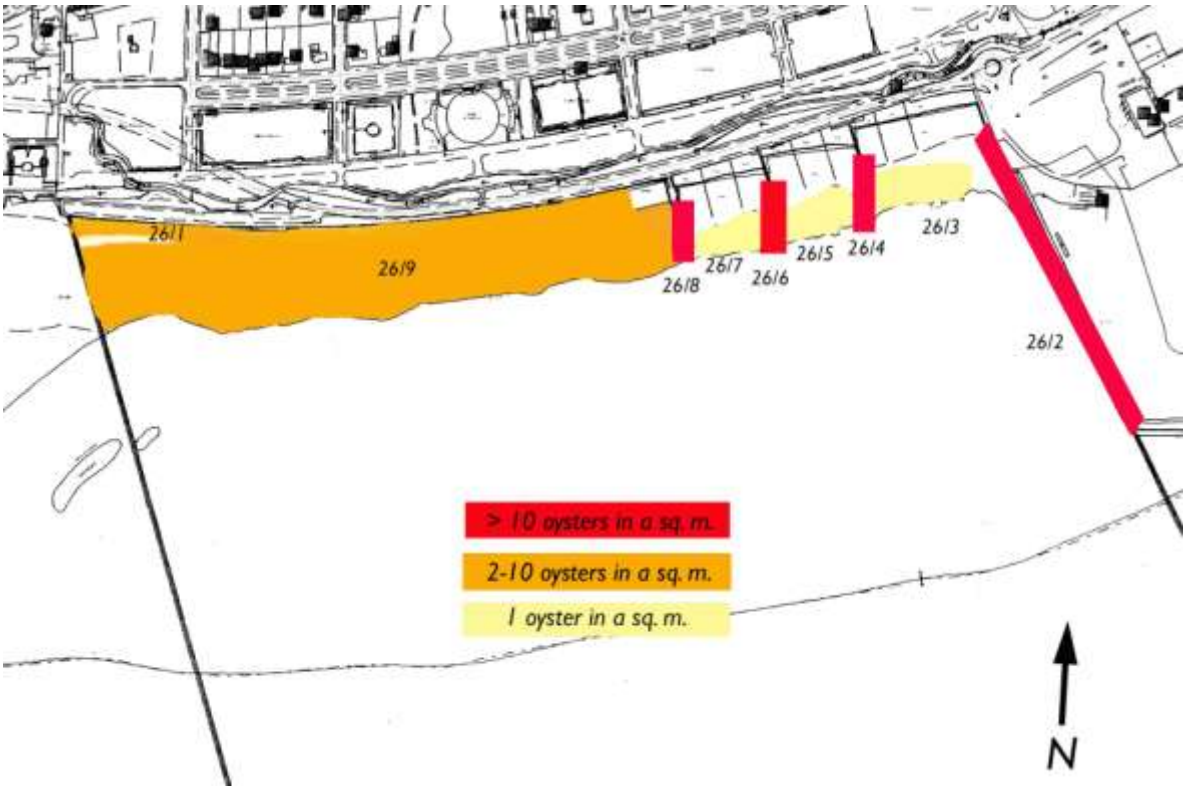
Site Photos

Appendix 5: Section Status

Section Status 26 (Western Undercliff Ramsgate)

Section Features

- Continuous sea wall. Tidal in the west & centre sections. Non tidal in the east(fronted by stable sand).
- Tidal pool.
- Granite boulder breakwater
- 3 concrete groynes from sea wall to lower Mid Shore Zone + 6 short timber groynes from sea wall.
- Bare flat chalk reef dominant with mussel beds on lower Mid Shore Zone.



Oyster Site Number	Colony Totals	Cluster Zone Totals	Cluster Site Totals	Solitary Zone Totals	Solitary Site Totals	Approx Surface Area sq.m	Total Live Oysters	Total Lower Valves Only	Site Density	Peak Density	Attachment Stratum
Site 26/1	0	0	1	0	0	420	73	11	0.17	4.00	CS CRF
Site 26/2	1	0	0	0	0	443	2307	128	5.21	47	CS PO
Site 26/3	0	0	0	1	0	2125	14	8	0.01	1	CRF
Site 26/4	1	0	0	0	0	312	2412	161	7.73	133.00	CS
Site 26/5	0	0	0	1	0	2125	13	8	0.01	1	CRF
Site 26/6	1	0	0	0	0	95	1102	373	11.6	49	CS
Site 26/7	0	0	0	1	0	4440	11	0	0.01	1	CRF
Site 26/8	1	0	0	0	0	84	147	67	1.75	15	CS
Site 26/9	0	1	0	0	0	18200	31	0	0.01	2	CS CRF MU

21.05.07

Appendix 6: NEKEMS Distribution and Density

TCP Section	Total Oysters at Peak Density 1	Total Oysters at Peak Density 2-10	Total Oysters at Peak Density >10
1 Swalecliffe			718
7 Bishopstone			1749
8A Reculver West			770
8B Reculver East		11	
9A Reculver to Coldharbour			2181
9B Coldharbour			583
9C Plumpudding			901
10 Minnis Bay West			386
11A Minnis Bay East to Grenham			1328
11B Grenham Bay			827
11C Beresford Bay			1054
12A Epple Bay			6902
12B Epple to Westgate			1886
13 Westgate Bay			3426
14 Westgate to St. Mildred's			7864
15 St. Mildred's Bay			973
16 St. Mildred's to Westbrook		15	
17 Westbrook Bay			885
18 Nayland Rock			2289
19A Margate Bay		105	
19B Margate Harbour			6244
20A Fulsam Rock Winter Gardens		18	
20B Newgate Gap Lido to Walpole		119	
20C Walpole Bay		279	
21A Palm Bay		31	
21B Foreness Bay & Point			835
21C Foreness to Botany Bay West	1		
21D Botany Bay	2		
21E Whiteness Bay			
21F Kingsgate Bay-Whiteness Pt		60	
22A Joss Bay	2		
22B North Foreland	3		
22C Stone Bay		35	
22D Broadstairs East Cliff		8	
22E Viking Bay & Harbour		94	
23A Louisa Bay			
23B Dumpton Point S.Cliff to Dumpton Gap			
23C Dumpton Gap		3	
23D Dumpton to Winterstoke			65
24 Ramsgate Main Sands		83	
25 Ramsgate Harbour			298
26 Western Undercliff Ramsgate			6110
27 Pegwell to Cliffsend		229	
28 Pegwell Bay		52	
29 Pegwell Country Pk&Saltmarsh			
30A Sandwich Bay North		5	
30B Sandwich Bay Mid			
30C Sandwich Bay South		2	

Appendix 7: Attachment Strata frequency at all sites.

(Upper Shore Zone free of oysters so not included)

TCP Section	Lower Shore Zone										Mid Shore Zone									
	CRF	CRG	CRV	CS	FC	FO	MU	PO	SED	TM	CRF	CRG	CRV	CS	FC	FO	MU	PO	SED	TM
1	1			1	1						1			2	3	1	1			2
7				2	2		2			2										2
8A	1					1	1				1					1	1			1
8B														2						
9A				1			1			1				10			1			1
9B					1		1							2	1		1			
9C				1	1									3	1					
10				1										2						1
11A	1			1			1				1			2			1			1
11B	2						2	1			5			3			4			
11C							1				6			7			1			
12A	2	1									4	2		4			2			
12B							1	1			1	1		4						
13	1						1				1	1		2			1			
14	1						1				1			2			1			
15	2						2				2		1	3			2			1
16												1		2						
17											1			2			1			
18	1	1				1	1			2	1	1		1		1	1			2
19A											1			2						
19B														1						
20A														4						
20B														4						
20C				2	1					2				3		1				2
21A	1													1						
21B				3							1			3						
21C											1									
21D												1	1							
21E																				
21F											1		4	1	2					
22A												1				1				
22B				1								1	1	0						
22C						1					1		1			2				
22D		1			1								1	1						
22E				1									1	1						
23A																				
23B																				
23C													1							
23D				2									2	2		1				
24				1																
25														2				2		2
26	2			1	1		1	1			5			6	2		1			
27	1						1				1			3			1			
28														1						
29																				
30A										1										1
30B																				
30C										1										

Appendix 8: Oyster site 11A/3 Demography

Distance fron Sea Wall	Number of Pacific oysters	Individual Shell Lengths (mm)	Average Shell Length (mm)
0-10 Meters	6	82: 94: 72: 51: 97: 87:	80.5
10-20 Meters	5	64: 109: 112: 107: 76:	93.6
20-30 Meters	25	92: 93: 68: 111: 95; 96; 88; 58; 136; 135; 116; 92; 102; 63; 97; 55; 90; 82; 104; 97; 87; 110; 130; 89; 86;	94.88
30-40 Meters	60	138; 38; 93; 96; 47; 104; 70; 103; 83; 92; 125; 94; 85; 88; 70; 129; 88; 66; 101; 103; 94; 80; 87; 104; 91; 85; 69; 87; 73; 106; 84; 47; 112; 78; 132; 74; 103; 102; 78; 89; 127; 95; 93; 86; 125; 94; 110; 78; 99; 78; 104; 148; 113; 88; 70; 68; 92; 95; 101; 121;	92.88
40-50 Meters	46	85; 126; 141; 102; 93; 103; 107; 116; 53; 105; 84; 88; 68; 87; 107; 86; 65; 103; 107; 86; 121; 112; 89; 87; 90; 132; 87; 68; 99; 85; 91; 89; 84; 80; 85; 92; 126; 91; 57; 123; 100; 93; 126; 112; 78; 78;	95.37
50-60 Meters	46	78; 80; 103; 84; 76; 101; 75; 82; 85; 103; 85; 68; 128; 95; 124; 99; 42; 116; 138; 84; 122; 89; 84; 76; 82; 103; 75; 84; 125; 100; 72; 82; 99; 74; 76; 45; 121; 98; 58; 85; 84; 63; 64; 96; 60; 68;	87.63
60-70 Meters	20	93; 97; 76; 90; 86; 95; 88; 85; 71; 81; 68; 85; 48; 78; 105; 92; 52; 86; 80; 93;	82.45
70-80 Meters	14	91; 96; 81; 81; 102; 80; 84; 82; 87; 61; 90; 113; 95;50;	85.21

Appendix 9: Peak Density Distribution

	Oyster Free	Peak Density 1	Peak Density 2-10	Peak Density >10
Number of Sections	5	4	17	22

Appendix 10: Pacific Oyster Site Classification

	Colony Totals	Cluster Zone Totals	Cluster Site Totals	Solitary Zone Totals	Solitary Site Totals
Number of Sites	45	60	21	11	23

Appendix 11: NEKEMS Distribution Balance

Section	Balance	Section	Balance
1	-311	21A	-998
7	700	21B	-194
8A	-259	21C	-1028
8B	-1018	21D	-1027
9A	1092	21E	-1029
9B	-446	21F	-969
9C	-128	22A	-1027
10	-724	22B	-1026
11A	299	22C	-994
11B	-202	22D	-1021
11C	25	22E	-935
12A	5873	23A	-1029
12B	857	23B	-1029
13	2397	23C	-1026
14	6835	23D	-964
15	-56	24	-946
16	-1014	25	-731
17	-144	26	5081
18	1260	27	-800
19A	-924	28	-977
19B	5215	29	-1029
20A	-1011	30A	-1024
20B	-910	30B	-1029
20C	-750	30C	-1027

Appendix 12: Attachment Type Frequency

Chalk Reef Flat	Chalk Reef Gully	Chalk Reef Vertical	Flint Cobble/ Boulder	Flint Outcrop	Mussel Bed	Pacific Oyster	Sediment	Concrete/Stone	Timber/ Metal
52	12	13	17	11	37	5	0	106	25

Appendix 13: High priority sections for future monitoring

Priority Order	Priority Rating	Section	Contributing Factors
1	High	12B Epple to Westgate	Oysters are abundant on the mussel beds of the lower Mid-Shore Zone through to the Lower-Shore Zone. In places, dense patches of oysters have replaced mussels or are in mixed communities. Oysters are overlain and erect. This Section represents the nearest to an oyster reef seen within the NEKEMS. If further recruitment occurs, oysters could become dominant.
2	High	1 Swalecliffe	The area to the west of Hampton Pier has a large population of oysters on a base of mussel, flint pebble & fine sediment within the Mid to Lower Shore Zones. Oysters are overlain but not yet erect. There is scope here for expansion to the west towards Long Rock flint outcrop at Swale cliffe.
3	High	11B Grenham Bay	Oysters are abundant on the mussel beds of the lower Mid-Shore through to the Lower-Shore Zones. In places, patches of oysters have replaced mussels or are in mixed communities. Oysters are overlain and erect. This Section has potential for reef formation.
4	High	11C Beresford Bay	Oysters are abundant on the mussel beds of the lower Mid-Shore through to the Lower-Shore Zones. In places, patches of oysters have replaced mussels or are in mixed communities. Oysters are overlain. This Section has potential for reef formation.
5	High	12A Epple Bay	Oysters are abundant on the mussel beds of the lower Mid-Shore through to the Lower-Shore Zones. In places, patches of oysters have replaced mussels or are in mixed communities. Oysters are overlain. This Section has potential for reef formation.
6	High	26 Western Undercliff Ramsgate	This Section contains the highest population beyond the north Kent coast. Oysters are overlain on breakwater & groynes but not yet on the mussel beds. With extensive mussel beds on the Lower Shore Zone, there is scope for population expansion. This Section may also be the source of recruitment for Sections within the NNR to the west & south.
7	High	13 Westgate Bay	Oysters are abundant on the mussel beds of the lower Mid-Shore through to the Lower-Shore Zones. In places, oysters & mussels or are in mixed communities. Oysters are overlain. This Section has potential for reef formation.

Appendix 14: Priority, all sections

Section	Priority Features				Priority Rating	Notes
	Signif. Location	Mussel Beds	Posture: **O**verlap **E**rect	Reef Forming Risk		
1		✔	**O**	✔	High	Area West of Hampton Pier very abundant.
7		✔			Low	Patchy mussel beds on Mid-Lower Shore Zones.
8A		✔			Low	Patchy mussel beds on Mid-Lower Shore Zones.
8B					Low	
9A	✔	✔			Medium	Mussels on flint outcrop close to Reculver Hatchery.
9B	✔	✔			Medium	Mussels on flint outcrop close to Reculver Hatchery.
9C					Low	
10			**O**		Low	
11A					Low	Occasional mussels present.
11B		✔	**O+E**	✔	High	Too dense to count. Overlap & erect on mussels.
11C		✔	**O**	✔	High	Too dense to count.Overlap on mussels.
12A		✔	**O**	✔	High	Too dense to count.Overlap on mussels.
12B		✔	**O+E**	✔	High	Too dense to count. Overlap & erect on mussel. Prime Section within NEKEMS.
13		✔	**O**	✔	High	Too dense to count. Overlap on mussels.
14	✔	✔	**O**		Medium	Located adjacent to Sections 11B-13 may be of future interest.
15		✔	**O**		Low	
16					Low	
17		✔	**O**		Low	Patchy mussel beds.
18		✔	**O**		Low	Patchy mussel beds.
19A					Low	
19B			**O**	✔	Medium	Very abundant on North face of outer harbour wall & adjacent groyne.
20A					Low	

20B					Low	
20C					Low	
21A					Low	
21B	✔		**O**		Medium	Shellfish Harvesting blackspot which may be of interest for future monitoring.
21C					Low	
21D					Low	
21E					Medium	Oyster free on baseline survey which may be of interest for future monitoring.
21F					Low	
22A					Low	
22B					Low	
22C					Low	
22D					Low	
22E					Low	
23A					Medium	Oyster free on baseline survey which may be of interest for future monitoring.
23B					Medium	Oyster free on baseline survey which may be of interest for future monitoring.
23C					Low	
23D					Low	
24					Low	
25	✔				Medium	Location is adjacent to large colonies at Western Undercliff which may be of interest for future monitoring.
26		✔	**O**		High	Few oysters on mussel beds. This Section may be the source of recruitment for Sections to the west & south which includes the NNR.
27		✔			Low	
28	✔				Medium	Location within NNR, so maybe of interest for future monitoring.
29	✔				Medium	Location within NNR & Oyster free on baseline survey which may be of interest for future monitoring.
30A	✔				Medium	Location within NNR, so maybe of interest for future monitoring.
30B					Medium	Oyster free on baseline survey which may be of interest for future monitoring.
30C					Low	